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Effect of Incubation Period on Phosphate Sorption from Three P Sources in Morelos Soil

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Abstract: The phosphorus incubation was conducted for 0, 3, 7, 14, 28, 56 and 90 days in a Completely Randomized Design with three fertilizer treatments Triple Super Phosphate (TSP) Phosphate Rock (PR) and Bone Material (BM) applied @ 40 and 80 mg kg^{-1} in an alkaline calcareous soil. Generally maximum phosphorus was available at d0(day zero) and decreased with increase in incubation time. At day 0, the mean available phosphorus was 42.5% in TSP treatment followed by 5.5 and 4.8% P solubility in phosphate rock and bone material treatment. At day 90, only 10.12% phosphorus was available in TSP treatment followed by 0.0% phosphorus availability in PR and BM treatments. The minimum TSP sorption was observed at d0 and increased with the increase in incubation time. The results indicated a rapid initial sorption of TSP and the decrease in the sorption intensity with time. The sorption saturation (maximum sorption) was attained at 14 days incubation of 80 mg P kg^{-1} as TSP. The increase in incubation time did not further affect P fixation of upper TSP level however the lower level (40 mg P kg^{-1}) decreased constantly up to 90 days incubation.

Key words: Morelos soil, bone material, triple super phosphate, phosphate rock, incubation, sorption

INTRODUCTION

Phosphorus is primary nutrient and it is required to maintain its optimum supply in the soil for better plant nutrition. Therefore, it is the most studied element but the least understood due to its complex chemistry in the soil. Plough layer soil may contain several hundred to thousands pounds of phosphate per acre. However, much of the phosphate in soil is not available to growing plants. Alkaline calcareous soils retain phosphorus as higher calcium compounds of lower solubility through a chemical reaction with soil constituent especially Ca and free lime and cause severe loss of this nutrient[1]. Therefore, Soluble phosphorus added to soil in the form of chemical fertilizer is converted to unavailable compounds for the plant uptake.

The phosphorus losses are rapid during initial stages but the intensity of P fixation decreased with the increase in time. The higher soluble phosphate fertilizers are more prone to their fixation because they are more active to chemical reaction with the constituent of the soil. The available phosphorus content decreased with the increase in time[2,3].

The lower phosphate availability is a problem of grave concern under alkaline calcareous soil. A major part of the soluble fertilizer sharply became unavailable to plant and heavy fertilization is practiced in the developed world to maintain optimum soil phosphorus, that is not only expensive but also is unsustainable[1].

The study of phosphorus sorption of calcareous soils is an important factor for the development of successful fertilizer and manure management practices[4]. This study was, therefore, undertaken to determine the effect of incubation time on the availability of phosphorus from a variable solubility P sources in an alkaline calcareous soil.

MATERIALS AND METHODS

Experiment site and soil description: Soil (0-30) was brought from a field station of CIMMYT in Tlaltizapan, Morelos. The soil was alkaline classified as Ustic Petrocalcid[5]. The incubation was conducted for three months in the summer, 2003 in the Soil Physics Laboratory, Colegio de Postgraduado, Texcoco, Edo de Mex. The soil was air dried, ground and passed through 2 mm sieve. The physical and chemical analysis were carried out for various parameters (Table 1). Soil Saturated paste was prepared to determine water holding capacity and field capacity of the soil[6]. The soil texture

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Table 1: Physical and chemical characteristics of the studied soil

Determination	Units	Value
pH	------	7.95
EC	dS m^{-1}	0.30
OM	%	2.60
$CaCO_3$ total	%	19.43
HCO_3^{-1}	Me L^{-1}	4.00
P	mg kg^{-1}	14.50
Clay	%	6.00
Silt	%	44.00
Sand	%	36.00
Textural class		silt loam
Density	kg m^3	1.13

Source: Laboratories of soil fertility and soil physics of soil science of the College

was determined by the hydrometer method. The soil saturated extract was obtained and some chemical parameters were determined like pH[7], Electrical conductivity, soluble carbonates and bicarbonates and total calcium carbonate[8]. The organic matter contents were determined by Walkley and Black[7]. Phosphorus was extracted by 0.5 N $NaHCO_3$ and was determined using spectrophotometer[9].

Procedure: The behavior of P sources such as Triple Super Phosphate (TSP), Bone Material (BM) and Phosphate Rock (PR) was studied in an alkaline calcareous soil. The three phosphate sources were incubated along with one kg of soil in a completely randomized design with three replications and having treatments of P @ 0, 40 and 80 mg P kg^{-1} soil from each of TSP, BM, and PR. The incubation was carried out at lab-temperature (20-25^{0}C) and moisture contents were maintained at 70% water holding capacity and deficient water was replenished by weighing the vessels every week. Phosphorus was extracted by $NaHCO_3$ in all the samples at 0, 3, 7, 14, 28, 56 and 90 days after the incubation of the soil and P was determined by ascorbic acid blue color method[9]. The results were expressed on oven dry weight basis. The adsorbed P was calculated by deducting the available from the total phosphorus. The studies provided information about the behavior of P in alkaline soil in the absence of the crop.

RESULTS AND DISCUSSION

Soil contained 36.0, 44.0 and 6.0% of sand, silt and clay particles respectively (Table 1) and was placed in silt loam according to USDA system of nomenclature for soil texture. It has rather small amounts of sand and clay and is composed mostly of silt-sized particles. Soil was found alkaline calcareous due to alkaline pH (7.95) and high $CaCO_3$ content (19.43%).

The analysis of phosphate sources (Table 2) showed that TSP contain highest P_2O_5 (46%) followed by

Table 2: Principle characteristics of triple super phosphate (TSP), phosphate rock (PR) and bone meal (BM)

Material	Presence	% P_2O_5	%P-WS[1]	%P-CS[2]	%P-CIS[3]	ON[4]
TSP	Granular	46	85	15	------	Ca, S
PR	Powder	29.2	Traces	8.7	91.3	Ca
BM	Powder	22.9	------	Traces	------	Ca

[1]water soluble, [2]citrate soluble, [3]citrate insoluble,[4]Other nutrient TSP-triple Super Phosphate, PR- Phosphate Rock, BM-Bone Material

PR (29.2%) and BM (22.9%). Triple super phosphate was readily soluble in water (85%) and citrate (15%) followed by phosphate rock partial (traces) water solubility and 8.7% citrate solubility. Bone material was not soluble in water due to organic origin however traces were found soluble in citrate. TSP was observed superior phosphate source due to more phosphorus concentration and higher solubility index[10].

The available P contents from three phosphate sources after incubation for 0, 3, 7, 14, 28, 56 and 90 days are described in Table 3. Generally maximum phosphorus was available at day zero and decreased with increase in incubation time. Initially Triple super phosphate (TSP) yielded higher Olsen P content might be due to higher solubility index of TSP[10] however the phosphorus content decreased sharply with the increase in incubation time. At day zero, the mean available phosphorus was 42.5% in TSP treatment followed by 5.5 and 4.8% availability of phosphorus under phosphate rock and bone material addition. The availability of phosphorus declined with incubation time, therefore only 10.12% phosphorus was available in TSP treatment followed by 0.00% phosphorus availability from PR and BM at d90. In many studies, it was indicated that soluble phosphate ions generally reacted with soil constituent such as calcium (Ca) and free lime in alkaline conditions and formed lower solubility phosphate compounds. Gradually the phosphate compounds were converted into insoluble compound that cause the soluble phosphate immobility in the soil[11,12]. Indiati[2] found the same results on incubating phosphorus for different time period. He observed that the available phosphorus content decreased with the increase in incubation time. The similar results of phosphorus loss were found by Afif *et al.*[13] on incubation of 19 soils. They found that in all soils and at all P rates, availability index decreased with time.

Triple super phosphate is a soluble fertilizer, there fore, its lower solubility was considered the fixation of the fertilizer in alkaline soil conditions. The minimum TSP sorption was observed at day zero and increased with the increase in incubation time (Fig. 1). The results are in agreement with Akhtar and Alam[14] who studied the behavior of P under alkaline calcareous soil and found that P fixation increased with increase in time of incubation. Yaseen *et al.*[15] also reported that phosphorus

Table 3: Effect of incubation on the available phosphorus (mg kg^{-1}) from three phosphate sources in calcareous soil

		Days after incubation						
Fertilizer treatments	mg P kg^{-1} soil	0	3	7	14	28	56	90
Control		14.0 AB	14.9A	14.4 AB	15.1 A	11.4 D	12.3 DC	14.0BC
TSP	40	33.15	25.83	23.57	22.97	19.30	18.03	15.37
	80	46.00	34.23	30.57	28.07	24.07	26.83	28.70
	Mean	39.5 A	30.0 B	27.1 BC	25.5 BC	21.7 C	23.4 C	22.1 C
PR	40	16.33	15.97	14.90	13.57	14.37	15.57	14.17
	80	18.33	18.07	17.07	16.07	14.47	16.10	13.70
	Mean	17.3 A	17.0 BC	15.9 BC	14.8 BC	14.4 BC	15.8 BC	13.9 C
BM	40	16.23	16.97	14.73	15.13	16.40	15.60	13.67
	80	17.57	17.80	16.47	16.40	17.97	16.63	13.83
	Mean	16.9 A	17.4 A	15.6 AB	15.7 AB	17.2 A	16.1 A	13.7 B

Tukeys test = 0.05 TSP=triple Super Phosphate, PR=phosphate Rock BM=bane Material

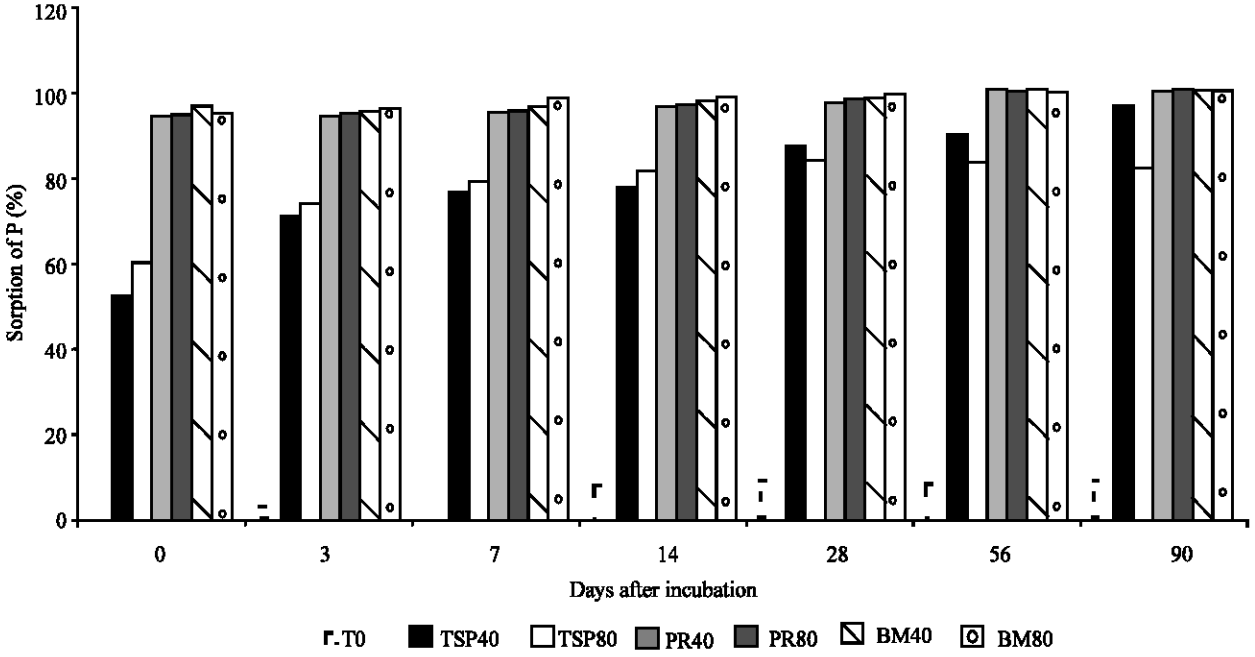

Fig. 1: P loss (%) in alkaline calcareous soil form phosphorus sources of varying solubility

sorption increased with increase in incubation time. The results indicated that maximum sorption was attained at 14 days incubation of 80 mg P kg^{-1} as TSP. The increase in incubation time did not further affect P fixation of upper TSP level however the lower level decreased constantly up to 90 days incubation. The maximum sorption might be attributed to the saturation of fixation sites through the reaction of soluble phosphorus with soil constituents. Tisdale *et al.*[10] reported that the amount of P sorbed by soil depend on the saturation of sorption complex or the number of sorption sites available for reaction with added P.

The results indicated a rapid initial sorption of TSP and the decrease in the sorption intensity with time. Agbenin and Tiessen[16] found during a time dependent P sorption studies of five soils and found a rapid initial sorption followed by a slower later phase. At 50 days, the sorption reached saturation (maximum sorption) of the fixation sites in all soils. In an other study, chand *et al.*[17] found that the steady state equilibrium in low P alluvial soil is attained with in two days.

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