RETENTION BEHAVIOR OF PHOSPHATE IN SANDY REGOSOL

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Abstract

The Sandy regosols are found along the coastline of Sri Lanka. These soils receive heavy organic as well as inorganic fertilizers, in excess to the proposed guidelines. Continuous applications of phosphate(P) in excess of plant requirements results in the upper soil layers becoming enriched, and eventually saturated, with P. Large amounts of P could then be leached into deeper soil profiles and even into ground water, or P could be transported in surface runoff. A laboratory leaching experiment was conducted to understand the adsorption- desorption behavior of phosphate in sandy regosol for different types of fertilizers. . For this study six treatments and three replicates were tested. These treatments were; cow dung (T1), poultry manure (T2), Triple super phosphate (T3), vegetable mixture (T4) tuber and onion mixture (T5) and control (T6) fertilizers applied at the rate of proposed guideline of Department of Agriculture, Sri Lanka . Columns were leached with water at an application rate of 21.82 cm/ day for up to 9 to 10 days. Phosphate in leachate and soil was measured using spectrophotometer. In the study P leached in the order of T3> T1 > T2 > T5> T4>control. Triple super phosphate (T3) leached the highest amount of phosphate (48.45 mg kg^{-1}). P retained is in the order of T1> T2 > T6 > T3> T4>control.

Keywords: Columns, Leaching, phosphate, Retention, Sandy regosol

1. Introduction

Sri Lanka has a diversity of soil types. The regosol is one of the major soil groups in dry zone. It is found along or near the coastline of Sri Lanka in places such as Kalpitiya, Nilavelly and the most parts of Batticaloa district (Panakokke, 1996).These soils are often characterized as being of a light sandy texture with very low exchange properties (CEC <2 $cmo_cl\ kg^{-1}$) and therefore a low nutrient supplying capacity (Imsamut and Boonsompoppan, 1999). Sandy regosols have weak humiferous horizons overlying yellowish or brown coloured sand. They are composed mainly of quartz sand and support distinctive vegetation.

Batticaloa district is one of the intensive agricultural areas in the eastern province of Sri Lanka. Paddy is a major food crop in these areas. In southern part of Batticaloa district farmers intensively cultivate other vegetable food crops such as tomato, brinjal, okra and cash crops such as chilli and onion. According to the characteristics of the sandy regosol it is low in agricultural value. But texture of the soil provides good rooting condition for extensive root growth of the coconut palm and cashew trees especially in Batticaloa where annual mean rainfall is 1450-1700 mm (Vaheesar, 2000).

In sandy regosol generally, crops can be grown with high management and with heavy application of organic matter and inorganic fertilizers (Kuruppuarachchi & Fernando, 1999). However, in sandy soils, the P retention capacity can be poor due to low Fe- and Al-oxides (McPharlin et al. 1994), so that P can leach (Harris et al. 1996). In addition, the low ionic sorption capacities and high hydraulic conductivities of sandy soils contribute to the potential for large amounts of water and nutrients to pass beyond the rooting zone of plants.

The rates of movement of nutrients through soil are determined by a combination of sorption/desorption and fixation processes occurring mainly at surfaces of the soil particles (Robert 1995), as well as the flow of water. Sorption/desorption characteristics have frequently been used to evaluate the nutrient supply capacity of soils (Brar and Vig 1988). Regosols are highly porous. With shallow water table their nutrient and water holding capacities are very low. It also has low organic matter content. These factors are known to have a marked effect on phosphate behavior in these soils.

Keeping in view the above a study was conducted to understand the adsorption- desorption behavior of phosphorus in sandy regosol. Sandy regosol was amended with different types of fertilizers and the phosphate movement and retention in soil was evaluated.

2. Materials and Methods

2.1 Study area and Soil core sampling

The experiment was conducted in the soil chemistry laboratory of the Eastern University. Geographical features of this area is about 7.62 m above mean sea level and annual rainfall is about 1450 mm. Eighteen undisturbed soil columns were hand excavated in a zig-zag manner from undisturbed site of Vantharumoolai, Batticaloa. Each lysimeter core was 5.4 cm in diameter and 33cm in length. Sampling method involved placing a lysimeter casing on the soil surface and digging a small trench around it to expose a small depth of soil monolith below the casing cutting edge.

2.2 Physio- chemical characteristics of the study soil

The soil samples were selected at depths of 0-20 cm. air-dried, and ground to pass through a 2mm sieve. Soil samples were air dried, sieved to 2 mm, and characterized for parameters: pH, particle size distribution, organic C, initial soil available P, and cation exchange capacity. Soil pH was measured using a glass electrode at a 1:2.5 soil/water ratio by weight. Particles size distribution was measured after oxidation of the organic matter with hydrogen peroxide (H_2O_2) of a soil sample sieved through 2 mm mesh, followed by particles dispersion with a sodium hexametaphosphate solution ($NaPO_3$)6 (Van, 1993). Organic matter was determined by the potassium dichromate and sulfuric acid digestion method (Walkley and Black 1934). Initial soil P was determined using the ammonium molybdate–ascorbic acid method (Murphy and Riley, 1962). Soil cation exchange capacity was determined by leaching with 1 M ammonium acetate at pH 7 (Blakemore *et al.*1987). The measured properties of the soils under investigation are presented in the Table 1

Table 1: *Soil analysis before the start of the study*

Parameters	**Value**
Texture	Sand
Sand (%)	91.8
Silt (%)	4.9
Clay (%)	3.3
Soil pH	6.85
CEC (cmol kg-1)	2.56
Initial soil available P (mg kg-1)	96.12
Organic matter content (mg kg-1)	2.26

2.3 Experimental Design and Treatments

The experiment was conducted in a complete Randomized Design (CRD) with three replicates. The treatments were;

Table 2 : *Treatments and application rates*

Treatment	Application Rate (Kg/ha)	Amount applied in to column (g)
T1 (cow dung)	7500	42.8
T2 (poultry manure)	2500	14.28
T3 (Triple super phosphate)	100	0.84
T4 (vegetable mixture)	150	1.26
T5 (tuber and onion mixture)	200	1.71
T6 (control)	00	00

2.4 Column leaching Experiment

Column leaching study was conducted using 18 plastic columns (5.4 cm inner diameter and 33 cm long). Each column was fitted with fine netting at its bottom for leachate to pass through and to prevent soil loss. Columns were saturated with distilled water. The treatments were applied and mixed with top soil at depth about 3cm and every columns was maintained at field moisture content for three weeks to allow complete bio-degradation and soil reaction of fertilizers. Then these columns were leached with water at an application rate of 21.82 cm/day and uniformly throughout the day leachate were collected. The leaching was continued for up to 9 to 10 days until 14.35 pore volumes of effluent were collected. Leachate samples from each leaching event were filtered through a Whatman 42 filter paper prior to analysis for phosphate levels.

2.5 Leachate Analysis

The every leachate was taken and examined for phosphate. Phosphate in solution was quantified colorimetrically with the ammonium molybdate–ascorbic acid method (Murphy and Riley, 1962) by a spectrometer.

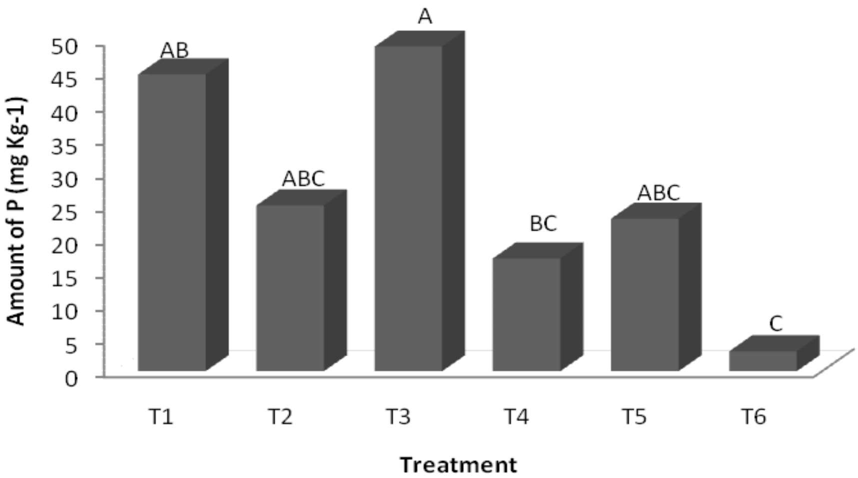
2.6 Data analysis

Analysis of variance (ANOVA) for a completely randomized design (CRD) was performed using SAS (SAS Institute 2001) and the LSD test was applied to test the significant difference between treatments (Steel and Torrie, 1980)

3. Result and Discussion

3.1 Phosphate in leachate

At 5% probability level there is a significant difference among the treatment and control in phosphate leachate. But altogether there is low amount (below 50 mg kg-1) of phosphate leachete in all treatments. Figure (1) shows the amount of phosphorous in soil leachate for different treatments.



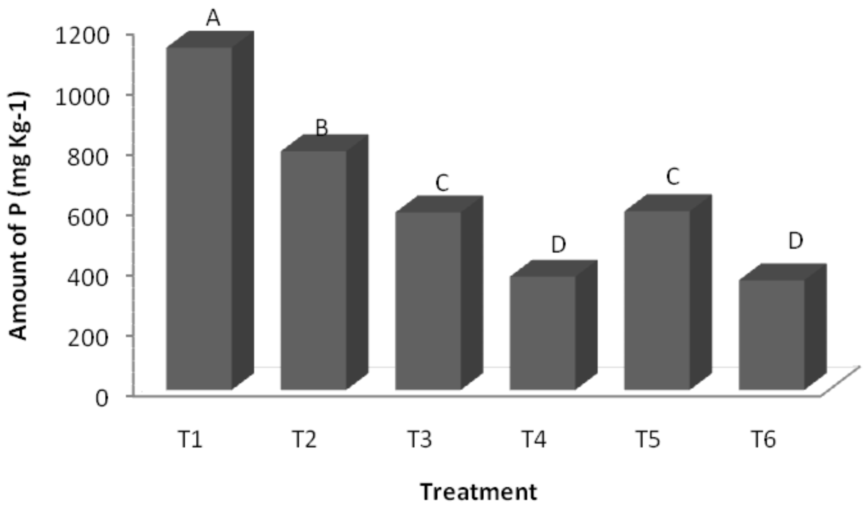
The mean of same letter in column is not significantly different at p <0.05 according to DMRT

Figure 1: *Concentration of P in leachate*

Leaching of P from the control soils was small compared with other treatments (Figure I). Triple super phosphate treated soil has highest amount (48.95 mg kg-1) of phosphate in leachate that significantly differ from control. Sandy soils are characterized by low organic matter content, low CEC, and high risk of leaching (Noble *et al.* 2000) and therefore, surplus P from fertilizer application is subjected to intensive leaching losses. Vegetable mixture (T4) and tuber and onion mixture (T5) treated soil leached lowest amount of phosphate. But there were no significant differences among them. These inorganic fertilizers have low content of phosphate than triple superphosphate fertilizer and this might be the reason for low content of phosphate in leachate. Although a large portion of phosphate leached with organic manure added soil. The type of manure used for soil amendment is an important variable with respect to the amount of P contributed to the soil. The cow dung treated soil has a significant difference of leachate (44.77 mg kg-1) than control. However, application of poultry manure showed a low amount of phosphate. The reason might be that cow dung was applied at a higher rate (42.8g) than other treatments it also may be due to the mineralization of organic matter occurred during leaching, and the release of organic matter bound P resulted in a high amount of phosphate in leachate because of low adsorption capacity of sandy regosols.

3.2 Retention of phosphate

In this experiment retention of phosphate among the treatments shows highly significant at 5 % probability level. Figure (2) shows amount of phosphorous retained within soil particles and on soil surface.



The mean of same letter in column is not significantly different at p <0.05 according to DMRT

Figure 2: *Amount of P retain by soil*

Soil analysis data obtained from the organic and inorganic fertilizer applied soil columns showed that a substantial amount of soil phosphate accumulated in cow dung, poultry manure, TSP, tuber and onion applied soil column.

When considering the mean comparison, the cow dung treated soil highly differ from the other treatments and control. The highest retention of P was recorded in cow dung treated soil while the least was observed in control. Poultry manure added soil also retained a considerable amount of phosphate but it was lower than in cow dung treated soil. The reason may be the application of organic matter, provides additional P adsorbing sites to the soils.

According to the Burgoa et al (1993), phosphorous in soil exist as organic and inorganic compounds. Humus, manure, and other types of non-humified organic matter are the major sources of organic phosphorous in soil. In general, the inorganic P content in soil is higher than the organic P content. Phosphate in an anionic in nature, so it is easily adsorbed by soil and colloidal particle. Furthermore, the phosphate ions are adsorbed by the particles which are weathered by changes in environmental condition that is called specific adsorption like other processes, such as chemisorptions, anion exchange, sorption, physical adsorption and non-specific adsorption which help to retain more phosphorous in soil particles (Penas and Sander, 1993). By this process the available phosphates are mostly retained than leached.

Conclusion

Phosphorus in the sandy soils is subjected to intensive P leaching losses. in this study, the impact of inorganic and organic amendment on sandy soil phosphorus leaching and retention were evaluated. Application of inorganic fertilizers greatly enhances this leaching process and raises P concentrations in leachate. Based on the results of this column leaching study, it can be concluded that organic manure application reduces P loss from sandy regosol soils.s

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