Transformation of Phosphorus in Agricultural Soils

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Abstract

To understand the bioavailability and fractionation of P in different soil phases, we performed sequential extraction of P phases in soil samples collected during three growth stages of a corn crop. Our results showed that the residual P concentrated in top 35 cm depth in the clay- and organic-rich soil layer. $NaHCO_3$-P and NaOH-P were dominant P phases in the soil due to the continuous application of fertilizer over years. An increase in NaOH-P and HCl-P over time both in P fertilizer and manure amended soils suggested an active transformation of originally bioavailable P into moderately or non-available P phases. Transformation of P was found to be active in a single crop cycle. This transformation was insignificant in the unfertilized field where $NaHCO_3$-P decreased significantly due to continuous removal of P by plant.

Background

Phosphorus (P) is one of the essential nutrients for plant growth. Agricultural soil is regularly and widely amended by P fertilizers to enhance crop yield. However, crops uptake only a limited amount of P for their growth which results in increased residual P in the soil (Read et al., 1977). This residual P may undergoes transformation from bio-available to moderately available to unavailable forms. The study is focused on identifying different P phases and understanding their interspecies transformation at three different growth stages of corn:- (before, middle and end of cropping) of a single crop cycle in fertilized and unfertilized soils.

Methodology

Soil samples were collected from control, fertilizer and manure applied plots at Georgetown, University of Delaware. The samples were collected at three growth stages of a corn crop: before (March), middle (June) and end of cropping (September). Samples were collected at an interval of 15 cm up to a total depth of 84 cm.

Samples were freeze dried, mixed homogeneously and grounded into fine particles and then passed through 200 micron sieve. The soil pH was measured at 1:1 soil/water ratio. Samples were dissolved at 1000 °C in a Katanax (K1) fluxer and the concentration of different elements was measured using Inductively coupled plasma mass spectrometry (ICPMS). The soil was sequentially extracted using modifield Hedley's et al. (1982) method. It included DDI water, 0.5 M $NaHCO_3$, 0.1 M NaOH and 1 M HCl extractants to extract P phases at 1:100 solid to solution ratio. DDI water wash was performed after 0.5 M $NaHCO_3$ extraction. Likewise, DDI water and 0.5 M $NaHCO_3$ wash was performed after 0.1 M NaOH and 1 M HCl extractions, respectively. P concentration in each extracted phase was measured colorimetrically by using phospho-molybdate blue method (Murphy and Riley, 1962).

Results

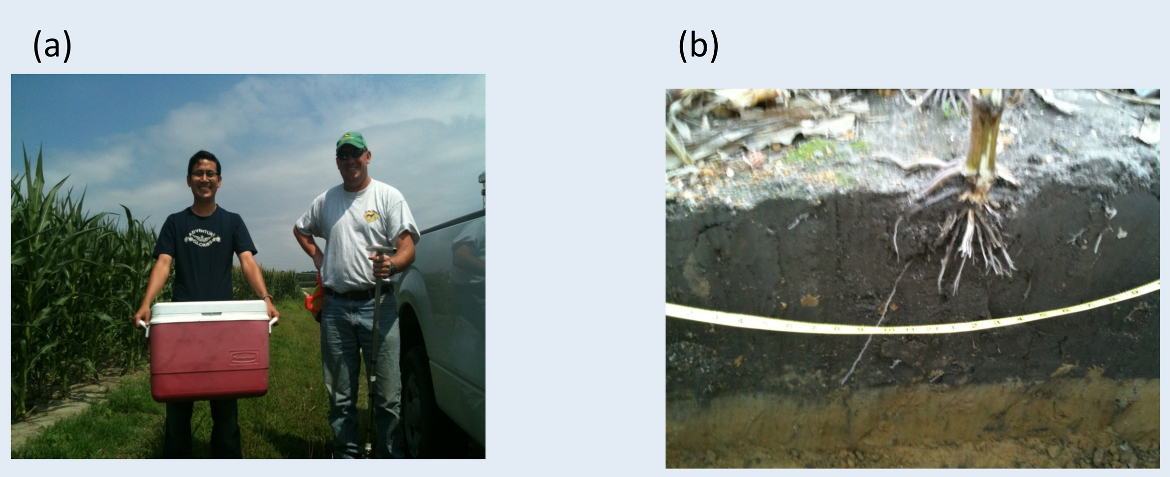

Fig 1. (a) Soil sampling and (b) changes in soil type at 35 cm depth.

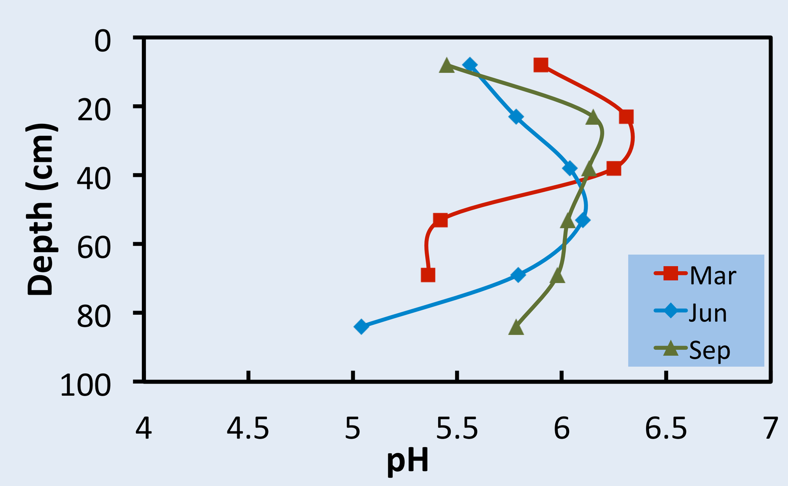

Fig 2. Changes in soil pH with depth in fertilizer applied plot.

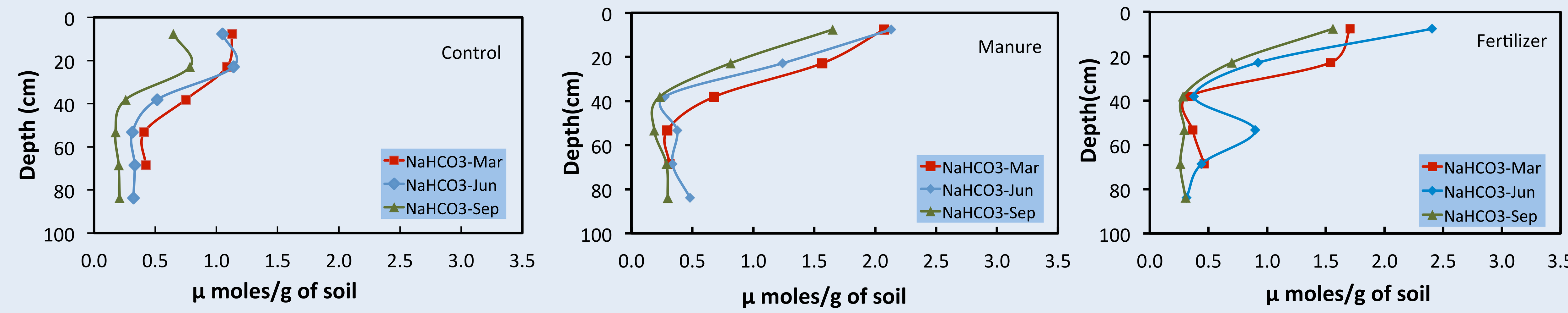

Fig 3. Changes in $NaHCO_3$-P in control, manure, and fertilizer applied plots.

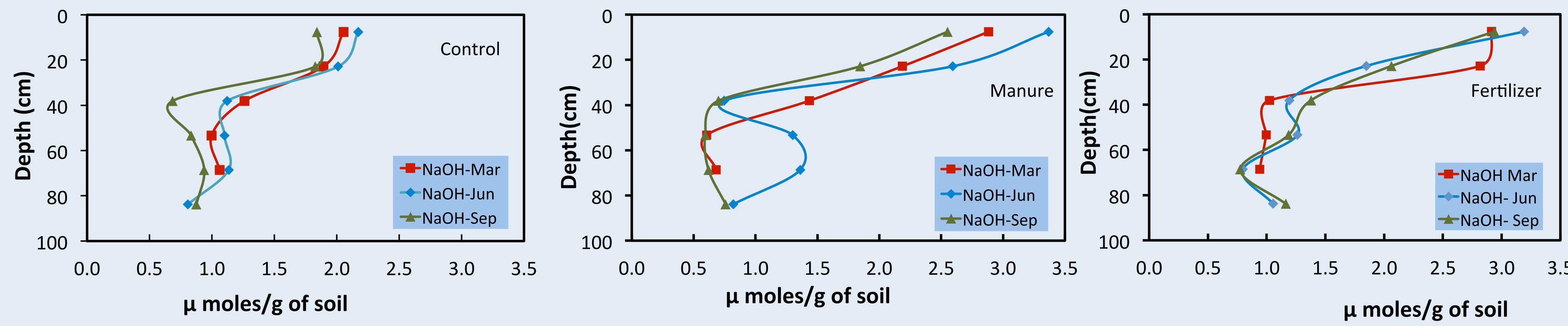

Fig 4. Changes in NaOH-P in control, manure and fertilizer applied plots.

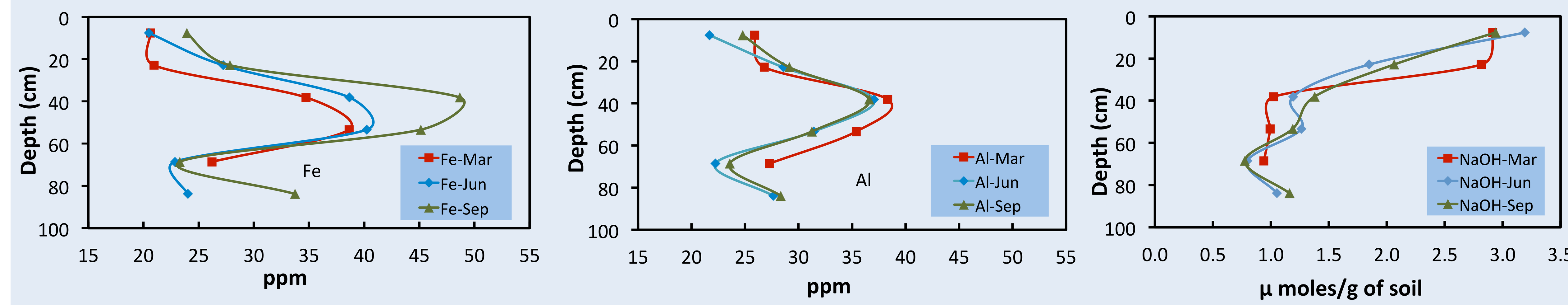

Fig 5. Relationship of Fe and Al with NaOH-P in fertilizer applied plot.

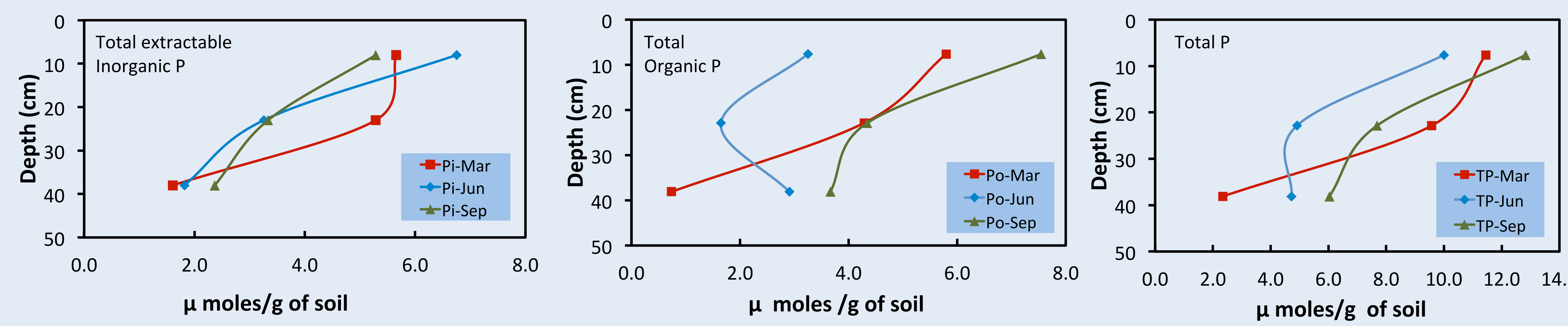

Fig 6. Changes in total extractable inorganic P, total organic P and total P at top 40 cm depth in fertilizer applied plot.

Conclusions

Increase in NaOH-P and HCl-P phase in the fields treated with fertilizer and manure suggested the gradual interspecies transfer of applied P into NaOH-P and HCl-P phases. This effect was also observed in the control plot, but was insignificant. Higher Fe and Al and the decrease in soil pH (by ~0.5 units) after soil treatment might have promoted the build-up of NaOH-P phase.

Our results showed the decrease in organic P at the middle stage of corn growth and the overall increase in the latter stage. High concentration of organic P at the end of corn cycle probably resulted from the increased root exudation and/or inability of roots to take more nutrients.

References

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