Fluctuating Water Table Effects on Phosphorus Release and Availability in a Florida Spodosol

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Introduction

Spodosols in Florida exhibit a unique hydrology with fluctuating water table that can often reach the surface Ap horizon during the summer months. The sandy nature of the upper horizons provides limited nutrient holding capacity, and leaching or sub-surface flow can be the predominant pathway for nutrient loss. The spodic layer (Bh horizon) has high sorptive capacity for P leached from the overlying layers. However, P sorption by the Bh can be reversible with time. Thus, release of some fractions of the P sorbed by the Bh is possible and may increase the amount of P in the soil solution. We hypothesize that under high water table conditions, the P released from the Bh may be carried to surface horizons and increase the amount of P available for plant uptake.

Objectives

1. To evaluate the effects of rising water table depth on P movement from the Bh horizon.
2. To investigate the effects of water table depth on soil P bioavailability.

Materials and Methods

The experiment was conducted on an established bahiagrass field on Smyrna sand (Sandy, Siliceous, hyperthermic Aeric Alaquods) in the summer of 2007 and 2008. Treatments consisted of three P rates (0, 5 and 10 kg ha^{-1}) arranged in a completely randomized design with each plot receiving a basal N and K application of 56 and 47 kg ha^{-1}, respectively. The treatments were annually applied in May during the 2-yr study. Bahiagrass was clipped at 28-d intervals for dry matter determination and tissue P concentration. Five suction cup lysimeters were installed in each plot at depths of 15, 30, 60, 90 and 150 cm. The top two lysimeters (15 and 30 cm depth) were located above the spodic (Bh) horizon while the remaining lysimeters (60, 90 and 150 cm) were below the Bh horizon. Leachate samples were collected at each rainfall event > 10 mm using a hand vacuum pump (~60 kPa) and stored at 4^{O}C until they were analyzed for ortho-P, using a Seal AQ$_2$ discrete auto analyzer. In 2008, two anion exchange membranes (2 x 6 cm) were inserted on each plot at 15 cm depth to determine *in-situ* phosphorus availability during the growing season. The membranes were collected bi-weekly and soluble P determined after extraction in 1 *M* NaCl solution. A pressure transducer was installed at the center of the experimental site to monitor changes in water table depth. Soil samples were also collected at six depths (15, 30, 45, 60, 90 and 150 cm) and analyzed for Mehlich-1 P.

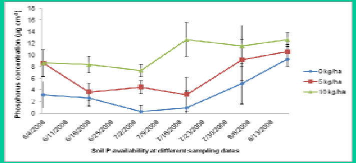

Fig. 1. Changes in soil P bioavailability with time as measured by anion exchange membranes

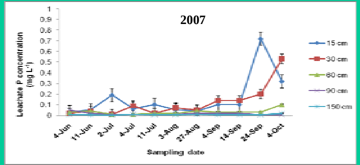

Fig. 2. Leachate P concentration at various soil depths in 2007. Data represent the average across P rates.

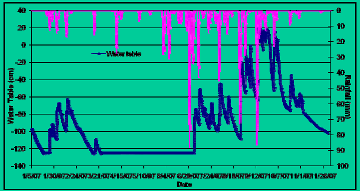

Fig. 4. Rainfall and water table fluctuations rainfall in 2007.

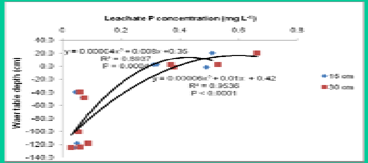

Fig. 6. Relationship between water table depth and leachate P concentration in the 15 and 30 cm Lysimeters during the 2-yr period.

Table 1. Average Mehlich-1 soil P concentration at various soil depths. Data represent average across P rates.

Soil depth	P concentration
cm	mg kg^{-1}
0- 15	3.2 c†
16-30	2.6 c
31-45	46. 8 a
46-60	16.1 b
61-90	10.4 b
91-150	15.1 b

† Same letters within a column are not statistically significant at $P \leq 0.05$ according to the PDIFF procedure

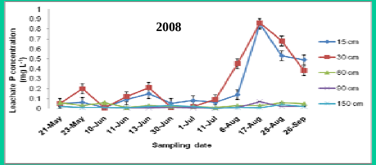

Fig. 3. Leachate P concentration at various soil depth in 2008. Data represent average across P rates.

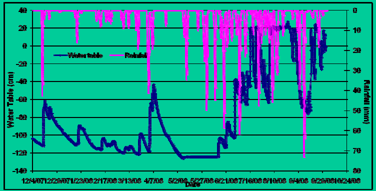

Fig. 5. Rainfall and water table fluctuations rainfall in 2008.

References

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Results and Discussions

Phosphorus availability was generally greater for treatments receiving 10 kg P ha^{-1}; however, no treatment effect was observed in August (Fig. 1). No differences in P availability between control and treatments receiving 5 kg P ha^{-1} were observed across the sampling period. Soil P bioavailability for the control plots increased from 3.8 µg cm^{-2} in June to 9.4 µg cm^{-2} in August with changes in water table depth. These observations were probably due to the high water table conditions which might have increased P availability.

Averaged across treatments, leachate P in lysimeters above the Bh horizon (15 and 30 cm) increased with increasing water table depth in the months of August and September (Figs. 2 and 3). However, leachate P concentrations in lysimeters below the Bh horizon (60, 90 and 150 cm) remained relatively constant (0.02 mg L^{-1}) during the entire growing season in 2007 and 2008. Increasing P concentrations in the 15 and 30 cm lysimeters coincides with periods of high water table conditions in August and September (Figs. 4 and 5). The high water table might have transported P released from the Bh horizon into the overlying water column. There was quadratic relationship between water table depth and leachate P concentration in the 15 and 30 cm lysimeters with R^2 of 0.89 and 0.98, respectively (Fig. 6). However, the relationship between water table depth and leachate P concentration in lysimeters below the Bh horizon was not significant ($P > 0.05$). Mehlich-1 P concentration in the Bh was ten times greater than the Ap horizon and three times > than layers below the Bh (Table 1). Although the Bh has high P sorptive capacity, some of the P held in the Bh is desorbable, and once released into solution, the desorbed P can be transported to the soil surface under high water table conditions. This explains the relatively high P concentration in the lysimeters above the Bh when the water table rises.

Conclusions

Our results showed that rising water table depth increases P release from the Bh horizon which can be transported to the upper layers of the soil. The high water table conditions experienced in the summer months in Florida affects P bioavailability.