Aluminum Water Treatment Residual Effects on Soil Phosphorus Retention and Forage Quality

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Introduction

Cultural eutrophication from excess phosphorus (P) is negatively impacting many of Florida's aquatic systems. Phosphorus applied in animal manures is often spread based on nitrogen (N) agronomic rates resulting in higher P application rates than necessary. Continual over application results in P accumulation and can decrease the soil's capacity to retain P. Phosphorus loss by surface runoff has been recognized and partially managed by erosion control measures but little has been done to prevent P loss from leaching. Many soils in Florida are characterized by poor P sorbing abilities. In addition, shallow groundwater and extensive ditching result in movement of P via lateral subsurface flow. Water treatment residuals (WTRs) are by-products of the drinking water purification process that contain amorphous iron (Fe) or aluminum (Al) with substantial P-fixing capabilities. While many greenhouse studies have shown the ability of WTR to sorb P in controlled environments, there is concern that WTR may reduce P availability resulting in tissue P deficiencies. In addition, there is further need to examine the effects of WTR under field conditions to ensure the acidic conditions of Florida's soils do not result in Al toxicity.

Methods and Materials

Fig 2: Plot design layout.

➢The study site was an established bahiagrass pasture at the University of Florida Range Cattle Research and Education Center in Ona, FL. The soil was a Myakka fine sand (sandy, siliceous, hyperthermic Aeric Alaquod). A split-plot design was used with application method (surface applied versus soil incorporation to a 15 cm depth) as the main plot and WTR rate (0, 35 or 70 Mg ha^{-1}) as the subplot (see Fig. 2).

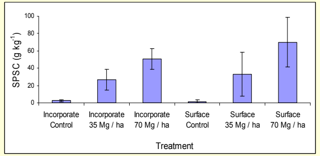
Fig. 3: Sieving WTR.

➢The Al-WTR was obtained from the Manatee County Water Treatment Plant, sieved to 0.64 cm (Fig. 3) and applied in January 2007. Triple superphosphate was applied to all treatments at 224 kg P ha^{-1} to simulate high P loads.

Soil Response

Soil samples were taken by soil horizon before any amendment was added in August 2006 and again in August 2007. Two profiles per plot were sampled to a depth of 1 m (Fig. 1). Mehlich-1 extractions were performed to determine P, Fe and Al values. A 1:2 soil to solution (distilled deionized water) ratio was used to measure pH. Water soluble P (WSP) values were obtained using a 1:10 ratio. All P samples were analyzed using a Technicon^{TM} semi-automated colorimetric analyzer using EPA Method 365.1. Data will be presented for the A horizon only.

Fig. 1. Representative soil profiles (Myakka fine sand).

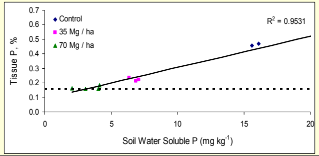


➢The soil P storage capacity (SPSC) increased as the WTR application rate increased. The SPSC expresses the remaining safe P loading capacity and the existing risks from previous loadings. The increase was likely due to the Al in the WTR.

A Horizon pH

Treatment	2006	2007
Control Inc.	4.54	4.62
35 Mg ha^{-1} Inc.	4.63	4.85
70 Mg ha^{-1} Inc.	4.69	5.20
Control Surface	4.48	4.47
35 Mg ha^{-1} Surface	4.68	4.70
70 Mg ha^{-1} Surface	4.59	4.95

➢WTR application method and rate did not affect soil pH. Average pH was 4.60 and 4.80 in 2006 and 2007, respectively. The pH of the WTR was 6.75.

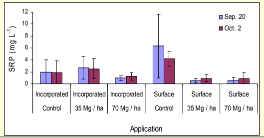


➢Forage P content was correlated with WSP concentrations. This suggests that WTR did affect P availability for bahiagrass. However, all P percentages were at or above deficiency levels (0.16%) for bahiagrass.

Water Quality

Wells were placed in the center of each plot just above the spodic horizon to collect water samples for soluble reactive P (SRP) determination.

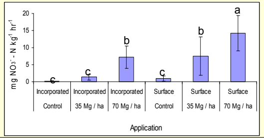
➢SRP concentrations were reduced by WTR application only on surface applied treatments. Tillage may have initially reduced SRP concentrations.



Nitrification Potential

There has been little research into the effects of WTR on microbial activity. Nitrification rates were evaluated as one measure of the effect of WTR on microbial activity.

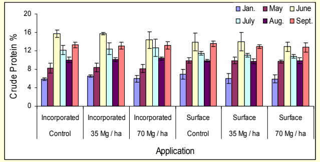
➢Negative impacts of WTR application were not observed. Instead, nitrification potential increased as WTR application rate increased.



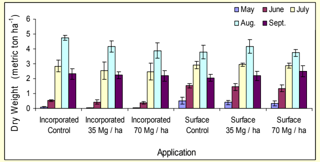
Forage Quality

Forage samples were collected in January 2007 (before WTR application) and at every monthly harvest after WTR application. Samples were analyzed for neutral detergent fiber (NDF) and crude protein to help determine forage quality. Total N and P content were determined using a modified Kjeldahl digestion.

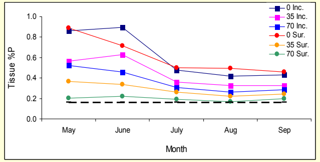
➢NDF levels (not shown) and crude protein percentage were not affected by the WTR application rates.



➢Forage yield was not affected by WTR application rate. Early season forage yield was lower in the WTR-incorporated plots, likely due to effects of the incorporation process.



➢Tissue P decreased in response to the increasing WTR application rate. The limiting concentration for bahiagrass is 0.16% P. None of the average tissue samples fell below this level and tissue levels appear to have stabilized.



➢Tissue Al concentrations were not affected by WTR application and were below 366 μg g^{-1} for all samples. Calcium and magnesium concentrations in tissue were also not affected indicating there were no problems in cation uptake or cation ratios (data not shown).

Conclusions

Soil Response

Application of WTR increased the soil's P storage capacity by increasing the amount of Al present in the system. This may be helpful in preventing P from leaching into Florida's aquatic systems.

Water Quality

WTR decreased groundwater SRP in the surface applied treatments. Tillage appears to have decreased SRP concentrations. This may be a temporary effect.

Nitrification Potential

Applying WTR did not negatively impact nitrification rates, suggesting that the nitrifying microbial population did not experience toxic effects from the WTR.

Forage Quality

Forage yield and quality were not affected by the addition of WTR. However, forage P concentrations decreased with increasing WTR application rates but were still above deficiency levels.

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