OPTIMIZING PHOSPHORUS MANAGEMENT TO MAXIMIZE YIELD AND REDUCE LOSS IN CORN SOYBEAN SYSTEMS

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Phosphorus (P) is an essential plant nutrient for optimizing yield in corn-soybean systems in Minnesota. This nutrient is a critical component in all biological and genetic transfer processes in the plant. Throughout the Midwest, P fertilizer is used to supplement corn and soybean growth to maximize yields. However, the over application of this nutrient has led to environmental impacts especially to freshwater systems (Sharpley, Mcdowell, & Kleinman, 2001). Excessive P in freshwater systems may lead to eutrophication, or large algal blooms in lakes and rivers. The transfer of P to water sources is thought to be largely from agricultural systems mainly through leaching and runoff (MPCA and Barr Engineering Company, 2004). Runoff has been highly researched and established to be a significant source of P pollution (Heckrath, Brookes, Poulton, & Goulding, 1995; Pote et al., 1999). On the contrary, P loss via leaching has been considered inconsequential by many researchers due to low P concentrations in leachate (King et al., 2015). However, this source of P loss is highly understudied, and some work indicates dissolved P may be a greater threat to freshwaters than previously indicated (Allen, Mallarino, Klatt, Baker, & Camara, 2002; Hooda et al., 2000; King et al., 2015; Kleinman et al., 2015).

Management of P on farm can be a significant tool to reduce P loss from agricultural systems. Two management philosophies largely determine P application methods: 1) Build and Maintenance (Removal), and 2) Sufficiency. The former method, Build and Maintenance, consists of building the soil test P (STP) level to a medium or high level to ensure yield loss will not occur. Each consecutive year, P is applied for crop “removal,” the amount a crop would remove throughout the growing season. Soil testing is needed every 4 to 5 years to monitor the STP levels. This method is designed to maximize yields, but creates an environment more susceptible to P loss with high soil test values (Allen et al., 2002; Zheng et al., 2015). The second P management philosophy is Sufficiency. This method is highly reliant on soil testing and on previous correlation and calibration of soil test levels with yield, often completed by land grant universities (Extension). This method does not encourage building soil test P levels, but supplying adequate P fertilizer according to the initial P concentrations in the soil. Soil testing is needed more regularly in this philosophy, every 1-2 years, to provide adequate predictions to farmers (Macnack et al., n.d.). The Sufficiency method focuses on maximizing return on investment, rather than maximizing yield. Being that the Sufficiency method does not build STP levels, it poses less of a threat to P loss (Allen et al., 2002). However, the Build and Maintenance strategy tends to provide growers with a greater assurance in their fertilizer application.

The objective of this study was to identify the optimal P management strategy for corn-soybean rotations in Minnesota, and identify the potential for P leaching based on initial STP in such systems.

To identify an optimal phosphorus management system, we aimed to determine optimum phosphorus fertilizer application rates for 2-year corn and soybean, and evaluate the timing of broadcast fertilizer application on corn and soybean yield. In addition, in-furrow starter fertilizer was applied in corn with broadcast P before soybean can to determine if a starter strategy could maintain yield of both crops. The removal based P fertilization strategy was also tested to determine if it would maintain STP levels over time. This study was conducted at three sites in Minnesota as side by side plots established in 2009. The plots were replicated 4 times and varied in P rate applied and timing of application. Soil samples 0-15 cm were taken initially and at the end of each growing season. Yield was also recorded each year. Many hypotheses were developed for this experiment, most prominently that response to P fertilizer would largely depend on initial STP soil levels. We also predict applying exact P removal rate will maintain STP, rate of application in two-year rotation will have a greater influence on yield than the time it was applied, and split application will be more beneficial for soils with a high fixation potential. Starter fertilizer is hypothesized to maintain yield for corn in responsive soils if broadcast P fertilizer is applied before soybean.

Leaching of P from soils was initiated to determine how building soil test P levels across contrasting soils influenced the loss of soluble P in the topsoil. The study was also aimed to determine if P loss potential decreased as time between leaching event and fertilization increased, dependent on initial STP level and soil physical and chemical properties. These results would then be used to determine if P leaching potential could be predicted with environmental or agronomic soil P tests. This study included intact soil cores from 9 sites across Minnesota, leached at different time intervals based on time of fertilization. Soil cores ranged in initial STP level and soil texture. In addition, 0-15 cm soil samples were taken from consecutive plots and tested for various forms of P with both environmental and agronomic tests. We hypothesize P load will be greater from soils with higher initial STP values or with coarser textures, due to a higher rate of infiltration (Allen et al., 2002). It is also hypothesized that greater amounts of P will leach with a shorter time between leaching and P fertilization.

This study is designed to optimize recommendations for Minnesota growers based on current P methods used by growers in Minnesota. In addition, the leaching study aims to quantify the potential of P leaching and identify the significance of leaching loss potential in Minnesota soils. The overreaching goal is to develop a comprehensive understanding of P in corn-soybean systems to allow for optimal use of P and lower P losses from agricultural systems.

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