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Impacts of Cover Crops on Phosphorus and Nitrogen Loss with Surface Runoff

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Abstract

Iowa research has demonstrated that cover crops can improve soil productivity and water quality by increasing soil organic matter and reducing nitrate nitrogen (N) leaching. Other research has investigated and is investigating the agronomic and economic viability of using cereal rye cover crops in continuous corn or corn-soybean rotations. However, no Iowa research has evaluated under natural rainfall the impact of cover crops on phosphorus (P) and N loss with surface runoff interacting with other management practices. The need for this type of research was indicated in the Iowa Nutrient Reduction Strategy documents. This effort assessed what would be needed to reduce N and P exports from point and nonpoint sources by 45 percent, which is what EPA estimates is needed to reduce the size of the hypoxic zone in the Gulf of Mexico.

Keywords

Agronomy, Agricultural and Biosystems Engineering

Disciplines

Agricultural Science | Agriculture | Agronomy and Crop Sciences | Inorganic Chemicals | Natural Resources and Conservation

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Introduction

Iowa research has demonstrated that cover crops can improve soil productivity and water quality by increasing soil organic matter and reducing nitrate nitrogen (N) leaching. Other research has investigated and is investigating the agronomic and economic viability of using cereal rye cover crops in continuous corn or corn-soybean rotations. However, no Iowa research has evaluated under natural rainfall the impact of cover crops on phosphorus (P) and N loss with surface runoff interacting with other management practices. The need for this type of research was indicated in the Iowa Nutrient Reduction Strategy documents. This effort assessed what would be needed to reduce N and P exports from point and non-point sources by 45 percent, which is what EPA estimates is needed to reduce the size of the hypoxic zone in the Gulf of Mexico.

Field-scale experiments for comparing the effects of various management systems on water quality with adequate replication are useful but costly. In late 2013, we obtained a grant from the recently created Iowa Nutrient Research Center to establish a long-term experiment to investigate some of the issues related to cover crop impacts on water quality.

Materials and Methods

The overall goal of the study is to acquire data to document the value of cover crops in reducing soil and nutrient losses of surface runoff and alleviate water quality impairment. The specific objectives are to determine the impact of a cereal rye cover crop on soil, N, and P loss with surface runoff in a field that has soil very high in P and is managed in corn-soybean rotations with no-tillage or tillage.

Field characteristics. The experiment was established at a field owned by the Committee for Agricultural Development located seven miles south of Ames, known as the Hermann Farm, that until recently was operated by a custom farmer with broadcast P fertilization in a corn-soybean rotation. This was the best site available based on landscape characteristics and proximity to campus that allows for measuring and collecting runoff samples from various management systems. Soil sampling and testing done in fall 2013 showed large soil-test P variation (20 to 75 ppm by the Bray-P1 test, 6-in. sampling depth), although most of the experimental area tested more than 50 ppm (very high interpretation category). The soil type is primarily Clarion.

Treatments and procedures. The systems under study are 1) no-till without cover crop for corn and soybean, 2) no-till with a cereal rye cover crop each year, 3) chisel-plow/disk tillage without a cover crop, and 4) chisel-plow/disk tillage with a cereal rye cover crop each year.

Corn was planted in 2013, and the rotation has continued by switching the crop each year. We used GIS-based information for the field and site measurements to delineate 12 small

watersheds ranging from 1 to 2 acres to accommodate the four systems replicated three times. We broadcasted different P fertilizer rates to bring the soil P level of the lowest-testing areas to the level of the highest-testing areas (50 to 75 ppm). In spring 2014, we implemented the tillage systems for the first time by disking and field cultivating the six areas corresponding to the systems managed with tillage and planted soybean across the entire area.

The cereal rye cover crop was first seeded in September 2014 about a week before soybean leaves began turning yellow. Elbon rye was overseeded to the six areas assigned to have cover crop using a Gandy seeder mounted on the three-point hitch of a tractor using a seeding rate of 2.5 bushels/acre. After soybean harvest, a non-limiting uniform potassium fertilizer rate was applied with no P application because we wanted to study remediation of a high-testing soil. The rye established very well, and the biomass yield measured just before the first killing freeze averaged 661 lb dry matter/acre. This rye biomass growth in the fall was higher than usually observed in central Iowa because of a timely seeding and favorable weather.

Soil of all 12 areas were sampled from depths of 0–2, 2–6, 6–12, 12–24, and 24–36 in. and will be analyzed for texture, several soil P fractions, total N, organic matter, and other fertility measurements.

By early spring 2015, we had installed the runoff monitoring and collection equipment in all 12 areas, which consisted of H-flumes, wood wingwalls, runoff monitoring and sampling devices, rain gauges, and solar panels to provide electric power. Also, earthen berms were built to extend for several more feet the wingwalls of the flumes.

By the time this report is written in late April 2015 no runoff from snowmelt or rainfall had occurred in the experimental area or surrounding farmers' fields. Future runoff will be analyzed for total solids, dissolved P, total P, dissolved ammonium and nitrate N, and total N.

The rye cover crop biomass and nutrient uptake will be measured by cutting small swaths before it is terminated by glyphosate application during the second week of April to allow for sufficient growth and plant corn about two weeks later, but not later than early May. Tillage for the six areas managed with tillage will be done about a week after spraying the glyphosate by disking and field cultivating as needed. The N management for the corn will be uniform across all areas. Starter N will be applied with the planter at 30 lb N/acre (UAN) about 2 in. beside and below the seed. Additional UAN will be injected between corn emergence and the V6 growth stage so that the total N applied is the economically optimum rate according to the ISU N Rate Calculator. Grain yield will be harvested from each area, and grain samples will be taken to measure amounts of N and P removed.

Acknowledgements

We expect to continue securing funding in the future so this useful experiment can be evaluated for several years. The research team gratefully acknowledges the support of the Iowa Nutrient Research Center, the Committee for Agricultural Development, and the Ag Engineering/Agronomy Research Farm.