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Quantifying Nitrogen Scavenging Benefits of Cover Crops in the Mississippi River Basin

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Abstract

The sandy soils of Muscatine County, Iowa, are prone to erosion and leaching. In the fall, leftover fertilizer applied to the corn and soybean crop is highly susceptible to leaching. Cover crops have been widely acclaimed to mitigate such issues as they prevent erosion and scavenge residual nitrogen. Although these attributes are widely known, adoption of cover crops has been slow. Information on cover crop planting dates, performance, and advantages are available, but few data are available that is applicable to Iowa soils and growing conditions.

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Quantifying Nitrogen Scavenging Benefits of Cover Crops in the Mississippi River Basin

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Introduction

The sandy soils of Muscatine County, Iowa, are prone to erosion and leaching. In the fall, leftover fertilizer applied to the corn and soybean crop is highly susceptible to leaching. Cover crops have been widely acclaimed to mitigate such issues as they prevent erosion and scavenge residual nitrogen. Although these attributes are widely known, adoption of cover crops has been slow. Information on cover crop planting dates, performance, and advantages are available, but few data are available that is applicable to Iowa soils and growing conditions.

Growers in Iowa are interested in integrating cover crops that are quick growing and are short duration, for example, oilseed radish and yellow mustard, but lack knowledge, expertise, and information on those cover crops. There also is a need to better quantify benefits of those cover crops. For example, if a grower is utilizing a brassica cover crop (oilseed radish, yellow mustard, etc.) to scavenge residual nitrogen after a corn or soybean crop, the grower should be able to estimate the amount of nitrogen scavenged and assign a dollar value to the benefit achieved using those cover crops. This study investigated the use of oilseed radish, yellow mustard, and cereal rye, and documented the impact on nitrogen leaching and movement in the soil. The specific objective of the study was to numerically quantify benefits of those cover crops under Iowa growing conditions by measuring the amount of nitrogen scavenged, weeds suppressed, and organic matter added.

Materials and Methods

The study was conducted at the Muscatine Island Research Farm, Fruitland, Iowa. Soil type was Fruitfield coarse sand with 0 to 2 percent slope and less than 1.5 percent soil organic matter. Late summer, after the final harvest of sweet corn, plots were tilled and cover crops were drilled on August 28, 2014. Yellow mustard, oilseed radish, and cereal rye seeds (GreenCover Seeds LLC, Bladen, NE) were drilled using a 10.5-ft-wide seed drill (International 510). A control plot also was established that did not receive any cover crop treatment. The preceding sweet corn crop received a pre-plant fertilizer application of 250 and 400 lb/acre of 0-0-60 and 13-13-13, respectively, which is typical in this region. Each plot measured 30 ft × 20 ft with 5 ft alleyways. Experimental design was a randomized complete block design with four replications.

Four soil cores from a 6-in. depth were collected from each plot and thoroughly mixed to make a composite soil sample. Soil samples were collected twice, first at the time of cover crop seeding and the second at the time of cover crop biomass sampling on November 6, 2014. Soil samples were sent to Solum Soil Testing Lab in Ames, Iowa, for estimation of organic matter, cation exchange capacity, nitrate-N, P, K, Ca, Mg, and pH. For cover crop biomass samples, four cover crop biomass samples were collected from each treatment using a 50 cm × 50 cm quadrat. Samples were oven-dried and weighed to quantify cover crop dry weight. After dry weight determination, cover crop samples were ground using a Wiley® Mill (Thomas

Scientific, Swedesboro, NJ). Ground plant samples were sent to the Plant and Soil Testing Laboratory at Iowa State University for total nitrogen, total carbon, P, K, Ca, and Mg analysis. At the time of cover crop sampling, weed biomass also was collected to assess the impact of cover crop on weed suppression.

Results and Discussion

Adequate soil moisture is critical for a good cover crop establishment. Given the sandy soils in the Fruitland area, soil water holding capacity is not high enough to provide a steady moisture level for seeds to germinate. Cover crop seeding was scheduled just before a rain event on August 28, 2014 to ensure a uniform establishment of cover crops. Table 1 shows the cover crop biomass (root + shoot) that was collected from individual cover crop plots. Data collected in the control plot are weed biomass. For easy interpretation, data have been converted into lb/acre. Figure 1 illustrates the condition of the plots at the time of cover crop sampling.

The biomass shown is the combined dry weight of shoots and root. Oilseed radish and yellow mustard produced similar amount of biomass. Biomass amount produced by these two crops is lower than what our research group has observed at Ames, Iowa, which ranges from 3,000–5,000 lb/acre. This could be attributed to heavier soils with higher clay and organic matter content in central Iowa. Cereal rye produced the highest amount of biomass. There were statistically significant differences between cover crop biomass with cereal rye producing the highest followed by yellow mustard and oilseed radish. There were no statistically significant differences in cover crop biomass between oilseed radish and yellow mustard. The control plot had biomass statistically similar to oilseed radish and yellow mustard. Control plot biomass comprised of volunteer sweet corn that came up in the fall.

There was a large amount of nitrate nitrogen (NO3-N) that was either taken up by the cover crop or leached. At the time of cover crop planting, NO3-N in the soil ranged from 18.5 ppm to 22.8 ppm (Table 2). This shows there was a considerable amount of nitrate nitrogen left over after the harvest of the sweet corn crop. At the time of cover crop sampling, control plots had the highest amount of NO3-N left over in the soil.

Cover crops played a significant role in scavenging residual nutrients from the soil. One of the many reasons for planting cover crops is to reduce soil erosion and reduce leaching of plant nutrients, especially nitrate nitrogen. Cover crops absorbed a number of essential plant nutrients and reduced their loss from the soil in this study (Table 3). Amount of P, K, Ca, and Mg levels were the highest in oilseed radish. Among the treatments tested, cereal rye had the least amount of P, K, Ca, and Mg concentration in its tissues. Percentage of total carbon was higher in yellow mustard and oilseed radish followed by plants in the control plot. As indicated earlier, plant biomass in control plots were weeds (predominantly volunteer sweet corn that came up after tilling of the plot).

Amount of nitrogen scavenged ranged from 17.2 lb/acre to 20.2 lb/acre. Highest amount of nitrogen scavenged was by cereal rye (Table 4). Even though percentage total nitrogen in cereal rye is lowest, it could scavenge higher amounts of N due to the amount of biomass generated.

We were able to demonstrate through this experiment that cover crops have tremendous potential in sequestering residual nitrogen, which could otherwise leach at the end of the season. Cereal rye cover crop sequestered 20 lb/acre nitrogen in the fall, which is beneficial both environmentally and economically. Given the soil type (Fruitfield coarse sand) and the location of this study, Fruitland, Iowa, which is in the Mississippi River basin, nitrogen leaching can detrimentally affect water and other natural resources in this area. In the fall, leftover fertilizer applied to the corn and soybean crop is highly susceptible to leaching and erosion. Planting a cover crop such as cereal rye, yellow mustard, or oilseed radish has the potential of not only preventing soil erosion but also reducing nitrogen leaching into the Mississippi River.

Acknowledgements

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Table 1. Cover crop biomass (dry weight basis) collected from treatment plots on November 6, 2014.

Treatment	Cover crop biomass (dry weight; lb/A)
Cereal rye	4,916 a[z]
Control*	907 b
Oilseed radish	1,500 b
Yellow mustard	1,508 b

*Weed biomass collected from the control plot.

[z]Different letters within a column indicate significant differences at $P < 0.05$ by Fisher's LSD test.

Table 2. Nitrate nitrogen (NO_3^-N) levels (6 in. depth) in the soil at the start and end of the study.

Treatment	Soil NO_3^- N at cover crop planting (ppm)	Soil NO_3^-N cover crop biomass sampling (ppm)
Cereal rye	19.8	1.9
Control*	22.8	2.9
Oilseed radish	18.5	1.9
Yellow mustard	22.8	2.6

Table 3. Nutrient concentration in plant tissues at cover crop sampling.

	P	K	Ca	Mg	Total C	Total N
Treatment	mg/kg				(%)	
Cereal rye	1,201 c[z]	4,076 c	2,797 c	1,560 c	8.79 c	0.38 c
Control*	3,715 b	16,835 b	4,791 c	2,899 b	30.41 b	1.60 a
Oilseed radish	5,059 a	29,255 a	17,695 a	3,491 a	30.76 b	1.24 b
Yellow mustard	3,498 b	17,590 b	13,525 b	2,910 b	39.03 a	1.14 b

*Weed biomass collected from control plots.

[z]Different letters within a column indicate significant differences at $P < 0.05$ by Fisher's LSD test.

Table 4. Amount of soil nitrogen scavenged by individual cover crops.

Treatment	% plant Total N	Plant dry weight (lb/A)	Amount of N scavenged (lb/A)
Cereal rye	0.38	5,325	20.2
Control*	1.60	907	14.5
Oilseed radish	1.24	1,500	18.6
Yellow mustard	1.14	1,508	17.2

*Weed biomass collected from control plots.

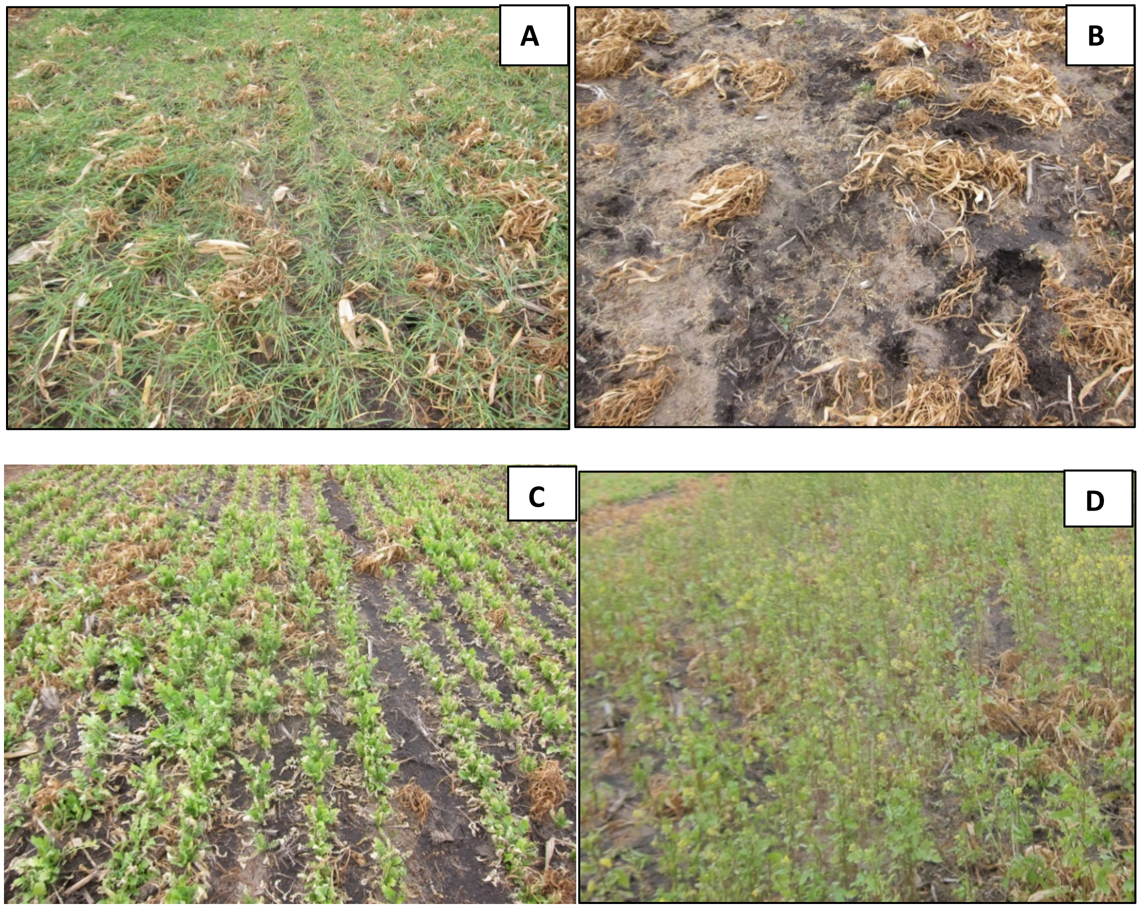

Figure 1. Vegetable plots at the time of sampling, November 6, 2014.
A = Cereal rye, B = Control, C = Oilseed radish, D = Yellow mustard.