Extension Bulletin E-2763 • New • August 2001

Managing Cover Crops to Recycle Nitrogen and Protect Groundwater

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MICHIGAN STATE UNIVERSITY EXTENSION

Seasonal inorganic nitrogen (N) availability often limits Michigan rowcrop productivity. Soil N losses from coarse-textured soils are often high in the fall or before spring tillage and may result in groundwater contamination. Growing cereal rye (*Secale cereale*) cover crops after harvesting a corn crop provides several benefits, including:

- reduced nitrogen losses
- weed suppression
- erosion control
- carbon sequestration
- pest management, and
- improved soil quality

Additionally, rye cover crops reduce the risk of groundwater contamination by capturing nitrate and preventing it from leaching. Nitrogen retained in the soil can be used by successive crops, decreasing the need for added fertilizer while increasing overall nitrogen use efficiency.

Cover crop establishment

Growers may incorporate rye cover crops into their cropping systems using one or more of the following approaches:

a) *Overseeding annual rye grass*
The annual rye grass cover crop is seeded between growing corn rows immediately before or after the last cultivation, Fig. 1.

b) *Frost seeding*
The cover crop is seeded into established crop stands in late winter or early spring (e.g., red clover/wheat in March).

c) *Bulk spreading*
This is done immediately following early fall season crop harvest, Fig. 2.

d) *Aerial seeding or spreading*
The cover crop is seeded/spread aerially before harvesting the row crop, Fig. 3.

Current recommendations for Michigan farmers involve adopting a system that includes a 10-inch band herbicide treatment followed by two cultivations with the annual rye cover crop overseeded at the second cultivation. Alternatively, cereal rye can be successfully seeded aerially from mid-to-late August.

Source: Todd Martin

Fig. 1 - A rye crop following potatoes for residual nitrogen uptake and winter crops.

Fig. 2 - Rye in seed corn stubble.

Fig. 3 - Rye seeded aerially into mature corn stand.

Rye cover crop management

Some cover crops may fail to survive Michigan winters, reducing the need for mechanical or chemical control. Moldboard plowing the residues has been an effective means for controlling cover crops. Chemical control offers maximum control, when applied at the correct stage for both the rye and Roundup Ready® corn.

Nitrogen management

- Manage soil nitrogen to minimize N losses while increasing availability for corn uptake.
- Michigan soils may contain 2,000-6,000 lbs organic N per acre.
- One to three percent of organic soil N is converted to inorganic N, which is taken up by corn.
- Legume crops biologically fix N, making it available to succeeding crops.
- Rye cover crops reduce N losses and increase availability to crops for a longer time, providing a slower release of usable N than from inorganic fertilizers.

Nitrogen sources

- Decomposing shoots and roots of rye cover crops
- N fertilizers, legumes, compost and manure

Rye cover crops enhance N release

Rye residue provides a slow N release. Decomposing above- and below-ground rye plant parts release the N that was taken up when the rye plant was growing.

Rye cover crops reduce nitrate leaching

In a three-year study, researchers at Michigan State University and Kellogg Biological Station reported that rye cover crops conserved 20 to 50 lbs more nitrate-N than plots with no rye cover that received recommended N fertilizer rates on coarse-textured soils (Table 1). Farmers adopting moderate N applications appear to be at less risk of N loss, however corn yields are likely to be lower than for a management program that integrates adequate N fertilization with cover crop farming, Fig. 4.

Increase N-use efficiency when goal is maximum corn yields

When corn production demands heavy N applications, recovering excessive soil N with rye cover crops provides farmers with additional options for recycling their N fertilizer investments. Cover crop recycling increases N-use efficiencies with little or no yield reduction and less nitrate leaching, Table 1 and Fig. 4.

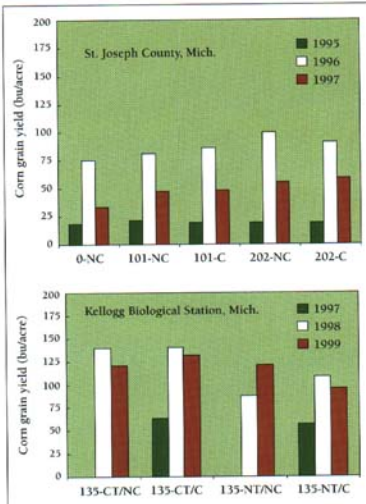

Fig. 4 - Graphs show effects of tillage, fertilizer and rye cover crops on subsequent corn yields on coarse-textured soils in southwest Michigan. Cover (C), no cover (NC), continuous tillage (CT) and no tillage (NT). Numbers at bottom of graphs represent lbs of N per acre.

Soil carbon provides an added source of available soil nitrogen

- Soil carbon (C) is a primary resource for farmers. In the form of soil organic matter (SOM), it contributes to soil quality and becomes a major source of plant nutrients, including N, in low-input cropping systems.
- Cover crops improve soil C management and maximize benefits to subsequent crops. Extending cover crop growth through the fall and early spring will fix more C by converting atmospheric CO_2 into plant biomass within the cover crop.
- Increased C fixation by fall-seeded cover crops increases N absorption from wet soils. Living cover crop plants in wet soils absorb more N, reducing nitrate leaching into groundwater.
- Cover crop residues on the soil surface protect the soil and slowly decompose, releasing N more slowly than do cover crops that are moldboard-plowed into the soil, Fig. 5.
- SOM contains more than 90 percent of the organic N in soil. SOM mineralization and plant residue decomposition are excellent N sources that are readily available to subsequent crops.

Table 1. Rye cover cropping decreased nitrate leaching by 23 to 48 lbs/acre.

Fertilizer management	Reduction in leaching (comparison with no rye cover)	Season	Soil type
High (178 lbs/acre)	23 lbs NO_3–N/acre	1995-96	Sandy loam
High (178 lbs/acre)	47.5 lbs NO_3–N/acre	1996-97	Sandy loam
Moderate (89 lbs/acre)	0 lb NO_3–N/acre	1995-97	Sandy loam
Source: D. Rasse, J. Ritchie, W. Peterson, J. Wei and A.J.M. Smucker (1998)			
High (135 lbs/acre)	25-40 lbs N/acre	1997-98	Loam
High (135 lbs/acre)	24 lbs N/acre	1998-99	Loam
Source: A.J.M. Smucker and Y. Kavdir (1998)			

Fig. 5 - No-till planting corn into spray-killed rye.

Rye cover crops improve soil and water quality

Living and/or decomposing rye roots plug large pores in the soil known as macropores. These large channels support the rapid movement of nitrates and other solutes, resulting in groundwater contamination. Rye roots both absorb N and reduce the losses of nitrate pollutants to groundwater, minimizing the environmental hazards associated with soil water movement. A single season of a rye cover crop increased the stability of soil aggregates by several fold in the sandy loam soil of the Kellogg Biological Station, leading to better soil tilth.

Residue quality and the ratio of C:N

Crops differ in the amount of N contained in their tissue. Fifty to 60 percent of N in the reproductive parts, such as grain, is removed from the field. The balance of plant N is returned to the soil as crop residue. Residue quality is determined by the ratio of carbon to nitrogen (C:N) and is important in controlling N availability. Residues with high (>30:1) C:N have less N relative to C available to micro-organisms for decomposing plant litter. Low C:N (<20:1) ratios provide sufficient N for microbial growth and the excess N is available as mineralized N which is then taken up by a growing corn crop.

Economics of cover crops

Studies at the Kellogg Biological Station show a $40 per acre gross return, minus costs, when rye cover crops are integrated into a first-year corn rotation. Longer-term data are not yet available.

Future considerations

Recommended crop diversity patterns optimize soil quality, pest management and increase yields. There is need for long-term economic evaluations to explain trade-offs between sustainable yields and profits.

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