Nov 28th, 12:00 AM

Nitrogen and tillage management for corn following alfalfa

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Yield boost when corn follows alfalfa

Rotating alfalfa with corn can increase corn yield potential through improved soil physical properties that enhance water infiltration and root extension, a reduction in disease and pest pressure (i.e., corn rootworm), and an enhanced soil microbial community. For example, over 15 years on a silt loam soil in southwestern Wisconsin with nitrogen (N) fertilizer applied at rates high enough to maximize corn yield in all crop rotations, yield was 19% (27 bushels/acre) higher for first-year corn after alfalfa than continuous corn, while second-year corn after alfalfa and corn after soybean yielded similarly and 10% (16 bushels/acre) higher than continuous corn (Stanger et al., 2008). In comparison, over 26 years on a loam soil in northeastern Iowa with N fertilizer rates sufficient for maximum yield, corn grain yields were highest for first-year corn after alfalfa and corn after soybean, intermediate for second-year corn after alfalfa, and lowest with continuous corn and second- or third-year corn after soybean (Mallarino and Ortiz-Torres, 2006). Conversely, high water removal by alfalfa can reduce the yield of the following corn crop in dry years if there is insufficient recharge of water in the soil profile during the fall or spring prior to corn.

Substantial nitrogen credits from alfalfa to corn

Another benefit from alfalfa is the N that is supplied to the following corn crops. When compared to continuous corn, guidelines from universities in the Midwestern U.S. suggest that fertilizer N needs following the termination of a good stand of alfalfa (at least four plants/square foot) can often be reduced by up to 100% for first-year corn and by up to 50% or more for second-year corn (Table 1). These N credits from alfalfa to corn are largely the result of N-rich inputs to the soil organic matter pool. These inputs which include alfalfa leaves and stems lost during harvest, alfalfa leaves abscised during regrowth, alfalfa stand losses over time, turnover of thin alfalfa roots, and exudation of substances from alfalfa roots, can rapidly mineralize after alfalfa stand termination and release N for at least two years.

Table 1. Nitrogen (N) credit recommendations from universities in the Midwestern U.S.

State	1st-year N credit	2nd-year N credit
	-------- lb N/acre --------	
Illinois	100	30
Indiana	140	---
Iowa	*	*
Kansas	120	---
Michigan	140	---
Minnesota	150	75
Missouri	100	---
Nebraska	150	---
North Dakota	150	75
Ohio	140	---
South Dakota	150	75
Wisconsin	150	50

*Guidelines from Iowa State University suggest 0 to 30 lb N/acre for first-year corn following alfalfa, and 0 to 60 lb N/acre for second-year corn following alfalfa.

Previous research in the northern U.S. found that the grain yield of first-year corn following alfalfa was not increased with fertilizer N in 91% of 140 fields (cited in Yost et al., 2012). These fields had good alfalfa stands at the time of termination, were in alfalfa production for at least one full year prior to termination, were typically terminated in the fall and with tillage, and generally had deep soils with medium to fine texture. Fields with the most frequent N response tended to have fine-textured soils that were inadequately drained or course-textured soils, coupled with excess rainfall between the time of alfalfa termination and early-season corn growth.

Recent on-farm research confirms first-year nitrogen credits from alfalfa to corn

To determine whether alfalfa N credit guidelines for first-year corn still apply with contemporary, high-yielding corn crops, we conducted research on 31 farms across Minnesota and western Wisconsin from 2009 to 2011. The first study evaluated the response of first-year corn yield to fertilizer N applied near planting on five farms in 2009 and on five farms in 2010 that had good alfalfa stands at the time of termination and medium- to fine-textured soils (Yost et al., 2012). First-year corn yield averaged over 195 bushels grain/acre on seven of the ten farms and over 24 tons silage/acre (at 65% moisture content) on seven of the nine farms where it was measured, yet first-year corn grain and silage yields were not increased when fertilizer N rates up to 160 lb N/acre were applied. On seven of these ten farms, residual soil nitrate-N was measured to a depth of four feet in the fall after corn harvest. Results showed minimal increase in residual soil nitrate-N when 40 lb N/acre was applied near planting, likely due to luxury consumption by the corn crop. However, residual soil nitrate-N increased rapidly when more than 40 lb N/acre was applied. A high amount of residual soil nitrate-N remaining after harvest is a concern because the N is susceptible to loss through leaching and denitrification.

The second study that we conducted evaluated the response of first-year corn to fertilizer N, and whether this was affected by the amount of alfalfa regrowth in the fall and the timing of tillage (disk-chiseling) for alfalfa termination (Yost et al., 2012). This research was conducted on six farms in southern and central Minnesota in 2010 with medium- to fine-textured soils and good alfalfa stands at the time of termination. Surprisingly, the presence of fall alfalfa regrowth did not affect first-year corn grain or silage yields or their response to fertilizer N applied near

planting (0-160 lb N/acre), even though this alfalfa regrowth ranged from 4 to 18 inches with 9 to 52 lb N/acre among the six farms. Similarly, there was no effect of tillage timing on first-year corn grain and silage yields. These results indicate that growers should harvest alfalfa regrowth in the last year on medium- to fine-textured soils with good alfalfa stand densities, and that growers have some flexibility in tillage timing when terminating alfalfa. In this study, first-year corn grain yield responded to fertilizer N at only one of six farms, even with average yields of 180 to 231 bushels/acre. On the one responsive farm where 70 to 81 lb N/acre were needed to economically optimize grain yield, there was fine-textured soil, abundant early-season rainfall, and inadequate drainage, which likely slowed N mineralization due to low oxygen levels in the soil. However, across all farms fertilizer N was needed (42-64 lb N/acre) to economically optimize corn silage yield, even though silage yield was increased by just 3% with fertilizer N.

No-till can work well for first-year corn after alfalfa

In 2010 and 2011, we conducted a third study on seven no-till farms across southern Minnesota and western Wisconsin to evaluate the response of first-year, no-tillage corn grain and silage yields to N fertilizer applied near planting (0-160 lb N/acre) (Yost et al., 2012). These farms had medium- to fine-textured soils and good alfalfa stands at the time of alfalfa stand termination, and the cooperating farms applied a small amount of starter fertilizer N at planting. Grain yield on these seven farms averaged 199 to 220 bushels/acre and silage yield averaged 21.1 to 30.3 tons/acre (at 65% moisture content) on the four farms where it was measured, yet grain and silage yields were not increased with fertilizer N. On one of these farms with clay loam soil in southwestern Minnesota we also compared no-till with fall disk-chiseling, but found no differences in grain yield or its response to fertilizer N.

When nitrogen is needed for first-year corn after alfalfa, a small sidedress rate can suffice

In 2011, a fourth study was conducted on eight farms in southern and central Minnesota with medium- to fine-textured soils and good alfalfa stands at the time of termination with tillage. In this study, we evaluated the response of corn grain yield to fertilizer N applied near planting or as a sidedress application when corn was at the six leaf collar stage. Grain yield was increased with fertilizer N on just two of these eight farms. When N fertilizer was applied near planting, the economically optimum N rate was 40 lb N/acre on one farm and 80 lb N/acre on the other, but equivalent yields were obtained on both farms with a sidedress application of only 40 lb N/acre. Response to fertilizer N on these two farms in 2011 was likely related to above-average early-season precipitation and low oxygen levels in the soil that limited mineralization of N.

Management summary

- There is increased yield potential when corn is planted after alfalfa compared to other crops.
- If possible, harvest alfalfa regrowth in the fall before stand termination, especially if the alfalfa stand density is good.
- No-till can work well for first-year corn after alfalfa, even on fine-textured soils.
- In recent trials in Minnesota and western Wisconsin on medium- to fine-textured soils with good alfalfa stands at termination, first-year corn grain yield was increased with fertilizer N on only 3 of 31 farms (Figure 1).
- For first-year corn after alfalfa, it may be more common for silage corn to respond to a small amount of N than grain corn.
- Soil nitrate-N after harvest can increase greatly if rates above 40 lb N/acre are applied to first-year corn after alfalfa when supplemental N is not needed to optimize yield.
- The chance of first-year corn after alfalfa responding to N can increase if there is significant rainfall between alfalfa termination and early-season corn growth on coarse-textured soils or on fine-textured soils that are inadequately drained.
- If one anticipates that N fertilizer will be needed for first-year corn after alfalfa, consider a small amount of N in a starter fertilizer, or consider a small sidedress application (around 40 lb N/acre) depending on early-season weather and crop conditions rather than a high N rate applied near planting.

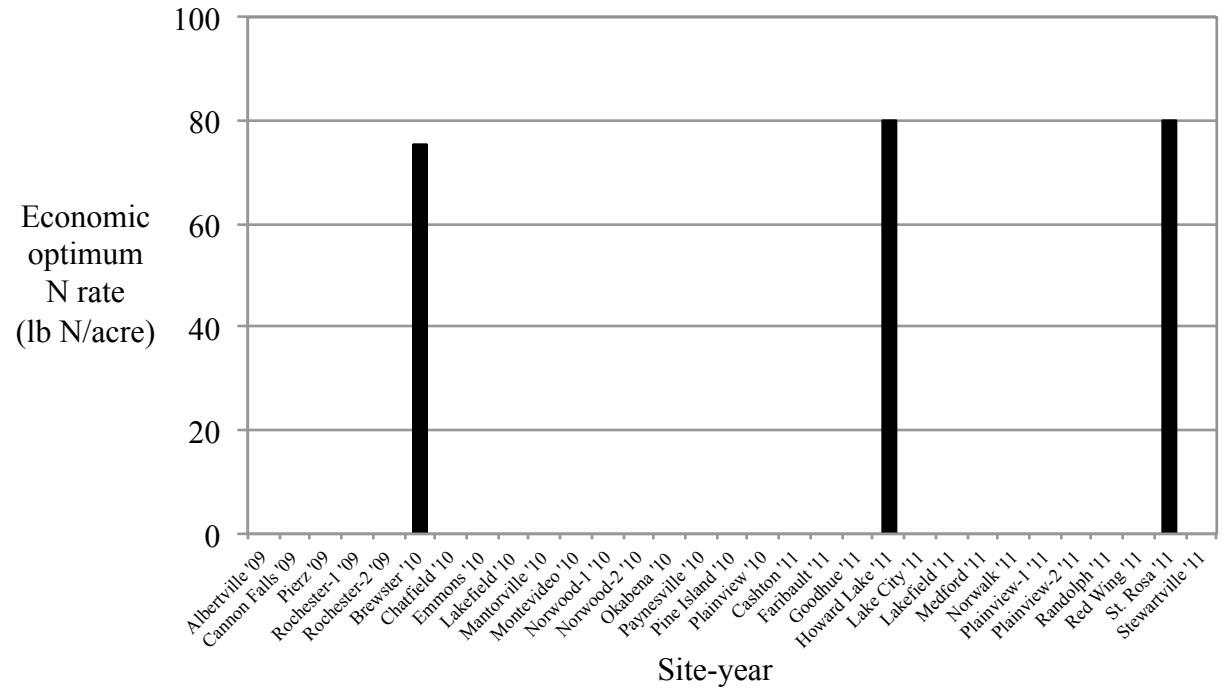

Figure 1. Economically optimum fertilizer nitrogen (N) rate for N applied near planting on 31 farms in Minnesota and western Wisconsin from 2009 to 2011, based on a fertilizer N cost ($/lb N)/grain price ($/bu) ratio of 0.07. Fertilizer N increased corn grain yield on just 3 of 31 farms.

Acknowledgements

The authors greatly appreciate the financial support for this research, which was provided by the Minnesota Corn Growers Association, the Minnesota Agricultural Fertilizer Research and Education Council, the USDA-Sustainable Agriculture Research and Education Program, the Minnesota Agricultural Water Resource Center, the Hueg-Harrison Fellowship, and the USDA-Agricultural Research Service.

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