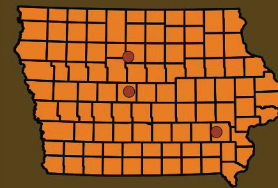
Field Crops Research



Side-dressing Corn following a Winter Rye Cover Crop -- Updated 2014

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Cooperators:
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In a Nutshell

- Using cover crops and side-dressing nitrogen fertilizer is a common bundle being investigated by Iowa farmers concerned about soil health, water quality and return on investment of cover crops.
- Cooperators grew corn following a winter rye cover crop and applied a low and high rate of N fertilizer in a side-dress application.

Key Findings

- In only one of six site-years did the high side-dress N rate result in greater corn yields.
- In most cases, by not applying the high N rate the cooperators nearly recouped the cost of establishing the cover crop with savings in N fertilizer.

Project Timline:

2010; 2012; 2013; 2014

Tim Smith applying side dress nitrogen fertilizer on May 31, 2012.

Background

The Iowa Nutrient Reduction Strategy, released in 2012, outlined several practices farmers can implement to reduce nonpoint source pollution (IDALS et al., 2012). Two such practices are cover crops and side-dressing N fertilizer in corn-soybean production systems.

Cover crops like winter rye are a rising trend with corn and soybean farmers due to their ability to reduce soil erosion (Kaspar et al., 2001) and nitrogen leaching (Kaspar et al., 2007). Nitrogen fertilizer is often applied at the time of corn planting to maximize crop performance. Once the corn is a bit taller, fertilizer can be side-dressed to provide additional N. One method of measuring the nitrogen needed post-planting is by the late-spring soil nitrate test (LSNT), which measures plant-available nitrogen in the soil just prior to the period in corn development of rapid uptake (Blackmer et al., 1997).

With the increased use of cover crops in Iowa, there is concern about possible changes to N fertilizer management in corn production. While the effect of winter rye cover crops on corn yields has been primarily neutral, there have been some instances of the cover crop negatively affecting corn yields (Gailans and Juchems, 2014). This effect is possibly due to N immobilization, caused by an addition of plant matter with a high C:N ratio (like winter rye). With N immobilization, less N is available to the succeeding cash crop. Because of this possibility, more careful management of available N is needed after using winter rye. Side-dressing N fertilizer in the late spring after corn emergence can potentially be used to mitigate the risk of low N availability in the soil.

This study compared the effects of low and high N rates, applied in a combination of at-plant and side-dress field passes, on corn yields following a winter rye cover crop. Trials were conducted in 2010, 2012, 2013, and 2014 by three farmer-cooperators: Rob Stout (near West Chester in Washington County), Tim Smith (near Eagle Grove in Wright County), and Jeremy Gustafson (near Boone in Boone County).

Methods

Cover crop and nitrogen rate treatments implemented on the three cooperator farms are listed in **Table 1**. Only at Rob Stout's farm was a "no cover" treatment included in the trial. Cooperators managed the corn in all strips similarly at each location (i.e., weeds were managed the same across all strips in a field).

Table 1 Replications, cover treatments, and side-dressed nitrogen rates and forms implemented on cooperator farms.

Location	Year	Reps	Cover treatment	Side-dressed N rates (lb N/a)	Side-dressed N form
West Chester (SE Iowa)	2010	3	With and without winter rye	0 and 50	UAN (28% N)
West Chester (SE Iowa)	2012	3	With and without winter rye	0 and 50	Urea (with AGROTAIN®)
Eagle Grove (North central Iowa)	2012	4	With winter rye	100 and 140	UAN (32% N)
Boone (Central Iowa)	2013	5	With winter rye	110 and 150	UAN (32% N)
Smith (Eagle Grove; north-central Iowa)	2014	4	With winter rye	70 and 100	UAN (32% N)
Gustafson (Boone; central Iowa)	2014	4	With winter rye	110 and 150	UAN (32% N)

Cover crop seeding dates, termination dates, termination methods, tillage operations, and corn planting dates are listed in **Table 2**.

All farms were in a soybean-corn rotation with cover crops established in fall following harvest of the soybean crop and sampled for biomass the following spring just prior to termination.

At Rob Stout's farm, liquid swine manure was injected following soybean harvest in the fall prior to corn planting both years. Additionally, 30 lb N/ac as UAN (28% N) was applied with corn at planting. At Tim Smith's, 40 lb N, 46 lb P, 93 lb K, and 25 lb S/ac as ammonium sulfate (AMS), diammonium phosphate, and potash was deep banded with the strip till pass in the fall following cover crop establishment each year. At Jeremy Gustafson's, 30 lb N/ac and 44 lb N/ac as AMS and starter fertilizer was applied pre-plant in 2013 and 2014, respectively. Thus, final N rates at each farm were as follows: Stout 2010 and 2012: 30 and 80 lb N/ac + swine manure; Smith 2012 and 2014: 110 and 140 lb N/ac; Gustafson 2013: 140 and 180 lb N/ac; Gustafson 2014: 154 and 194 lb N/ac.

Soil samples were collected in spring after corn emergence when corn was six to eight inches tall both years at Rob Stout's and in 2012 at Tim Smith's in accordance with protocols set by Blackmer et al. (1997) to conduct the Late Spring Nitrate Test (LSNT). Soil samples were analyzed at the Iowa State University Soil and Plant Analysis Lab.

Corn grain yields were corrected for 15.5% moisture.

Data were analyzed using JMP Pro 10 (SAS Institute Inc., Cary, NC) and yield comparisons employ least squares means for accuracy. Statistical significance is determined at $P \leq 0.05$ level and means separations are reported using Tukey's Least Significant Difference (LSD).

Table 2 Cover crop seeding dates, termination dates, termination methods, tillage operations, and corn planting dates, and side-dressing dates on cooperator farms.

Location	Cover crop seeding date	Cover crop termination date	Termination method	Tillage	Corn planting date	Side-dress date
Stout (West Chester; SE Iowa)	Sept. 16, 2009	April 12, 2010	Roundup WeatherMAX® (32 oz/ac)	No-till	April 17, 2010	June 7, 2010
Stout (West Chester; SE Iowa)	Sept. 13, 2011	April 26, 2012	Roundup WeatherMAX® (40 oz/ac)	No-till	May 21, 2012	June 25, 2012
Smith (Eagle Grove; north-central Iowa)	Fall 2011	April 2, 2012	glyphosate (30 oz/ac)	Strip-till	April 26, 2012	May 31, 2012
Gustafson (Boone; central Iowa)	Sept. 1, 2012	April 20, 2013	glyphosate (32 oz/ac) + 2,4-D (16 oz/ac)	Strip-till	May 10, 2013	June 25, 2013
Gustafson (Boone; central Iowa)	Sept. 2014	April 19, 2014	glyphosate (32 oz/ac)	Strip-till	May 5, 2014	Late June, 2014

Results and Discussion

Total rainfall during the period of April 1-September 30 for all years, as well as the historical average, for each location is presented in **Table 3**. Rainfall in 2012 (Stout and Smith) reflects the extreme heat and drought conditions that predominated across the state that year. Rainfall in 2010 (Stout) and in 2014 (Smith and Gustafson) reflect particularly wet years.

At Rob Stout's, an average of 2,074 lb/ac and 3,592 lb/ac cover crop dry matter was measured in spring 2010 and 2012, respectively, just prior to cover crop termination. At Tim Smith's, an average of 806 and 573 lb/ac cover crop dry matter was collected in spring 2012 and 2014, respectively. In 2014, that cover crop contained 251 lb C/ac and 28 lb N/ac in the aboveground portion at Smith's. At Jeremy Gustafson's, an average of 910 lb/ac of cover crop dry matter was observed in spring 2013.

Corn yields

At Rob Stout's, mean corn yields were less in 2010 than in 2012 (137 vs. 171 bu/ac; **Figure 1**). Mean corn yields for Washington County in 2010 and 2012 were 133 and 132 bu/ac, respectively, and the 10-year corn yield average for Washington County is 163 bu/ac (USDA-NASS, 2014). In both years at Stout's, neither cover crop nor N rate had any effect on corn yield. Corn yields were equivalent regardless of cover crop presence or side-dressed nitrogen rate. The results of the LSNT recommended that both strips with cover and without cover receive 40 lb N/ac in both 2010 and 2012 (Blackmer et al., 1997). Our results suggest the LSNT was overestimating the amount of side-dressed N necessary; strips that received no side-dress N yielded the same as those that received 50 lb N/ac each year.

At Tim Smith's in 2012 and 2014, corn yield following a winter rye cover crop was similar between the high (100 lb N/ac) and low (70 lb N/ac) side-dress treatments (**Figure 2**). Mean corn yield between the two treatments was 169 bu/ac in 2012 and 155 bu/ac in 2014. The average corn yield for Wright County in 2012 was 154 bu/ac and the 10-year corn yield average for Wright County is 173 bu/ac (USDA-NASS, 2014). The results of the LSNT in 2012 recommended a side-dress application of 140 lb N/ac (Blackmer et al., 1997).

Given that no yield difference was observed between the two side-dress N rates, our results again suggest that the LSNT was underestimating the amount of plant-available nitrogen and overestimating the amount of side-dressed N necessary, just as the LSNT

Table 3

Total rainfall (in.) during the period April 1-Sept. 30 compared to the historical average

Location[a]	2010	2012	2013	2014	Historical average
Stout (West Chester)	47.1	20.6	-	-	23.2
Smith (Eagle Grove)	-	18.1	-	34.7	24.1
Gustafson (Boone)	-	-	24.5	34.8	25.5

[a] Rainfall data were accessed from the Washington (12 mi. from Stout), Clarion (13 mi. from Smith) and Boone (Gustafson) weather stations (Iowa Environmental Mesonet, 2014).

Figure 1

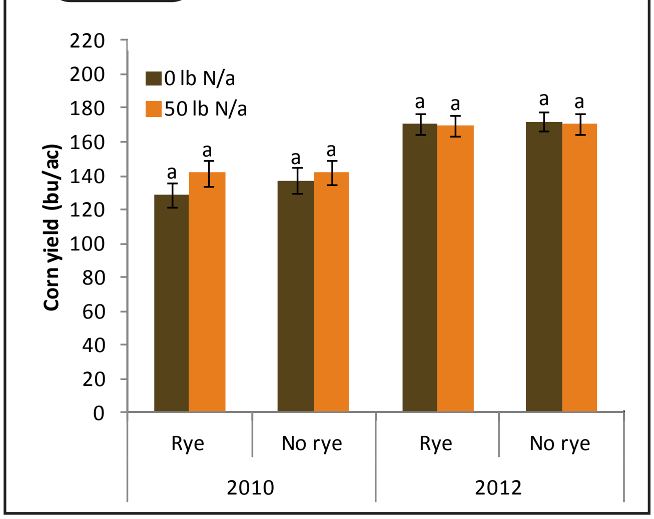

Figure 1: Mean corn yields at Rob Stout's farm in 2010 and 2012 that received 0 and 50 lb N/ac as a side-dress. By year, columns with the same letters above them are not significantly different. Black bars about the means represent the least significant difference among treatments for each year (2010 LSD = 15 bu/ac; 2012 LSD = 12 bu/ac)

Figure 2

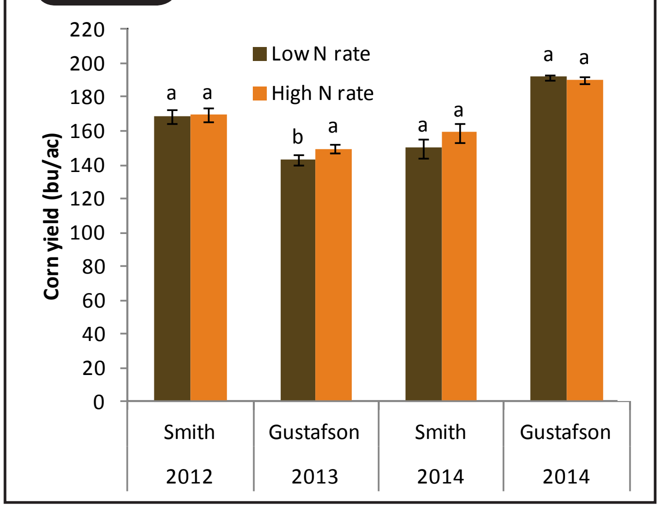

Figure 2. Mean corn yields at Tim Smith's farm in 2012 and 2014 that received 70 (low) and 100 (high) lb N/ac as a side-dress and at Jeremy Gustafson's in 2013-2014 that received 110 (low) and 150 (high) lb N/ac as a side-dress. By farm and year, columns with the same letters above them are not significantly different. Black bars about the means represent the least significant difference among treatments for each farm and year combination (Smith 2012 LSD = 8 bu/ac; Gustafson 2013 LSD = 5 bu/ac; Smith 2014 LSD = 11 bu/ac; Gustafson 2014 LSD = 4 bu/ac).

overestimated N needed at Rob Stout's in 2010 and 2012.

At Jeremy Gustafson's farm, corn yield following a winter rye cover crop was greater at the high (150 lb N/ac) than at the low (110 lb N/ac) side-dress rate in 2013 but yields were equivalent in 2014 (**Figure 2**). Corn yields were 144 bu/ac and 150 bu/ac at the low and high rates, respectively, in 2013. The mean yield across the low and high rates in 2014 was 191 bu/ac. The average corn yield for Boone County in 2013 was 155 bu/ac and the 10-year corn yield average for Boone County is 173 bu/ac (USDA-NASS, 2014).

Economic considerations

Economic considerations of the N rates and corn yields are presented in **Table 4**. The cost of N was accessed from ISU's Ag Decision Maker (Duffy, 2014) and the price of corn was accessed from the National Agricultural Statistics Service (USDA-NASS, 2014) and the Chicago Board of Trade (CME Group, 2014). The cost of the difference between the low and high N rates applied at each farm each year is presented in terms of $/ac and bushels of corn/ac. Essentially, the cost in bu/ac is the additional amount of bushels the farmer purchased by applying the higher N rate. As there was no difference in corn yield between the low and high N rates applied at the Stout farm in 2010 and 2012, the Smith farm in 2012 and 2014, and the Gustafson farm in 2014, the cost of the additional N applied was unnecessary. Only at the Gustafson farm in 2013 was the expense of the extra N in the high vs. low rate warranted. Jeremy "purchased" 5 bu/ac with the extra 40 lb N/ac applied between the high and low N rates and yielded 6 bu/ac more with the high rate (**Table 4**).

Conclusions and Next Steps

In only one of the six site-years included in this study did the corn that received the high side-dress N out-yield the corn that received the low side-dress N rate—Gustafson's in 2013. Although the results of the LSNT encouraged 40 lb N/ac as a side-dress application to corn in 2010 and 2012 at Rob Stout's farm, no difference in corn yield was observed between field strips that received no side-dress and 50 lb N/ac as a side-dress. Similarly, while 140 lb N/ac was recommended by the LSNT at Tim Smith's in 2012, no difference in corn yield was observed between strips receiving side-dress applications of 100 lb N/ac and 140 lb N/ac. These results suggest that the LSNT was underestimating the amount of plant-available nitrogen and overestimating the amount of side-dressed N necessary.

Understanding nitrogen dynamics in wet and dry years is critical when cover crops are added to the farming system. Drought conditions in 2012 may have affected crop responses to N from the cover crop and side-dressed nitrogen. At Rob Stout's in 2012, the corn receiving the low side-dress rate yielded the same as the corn receiving high rate but cost $31.50/ac less, which nearly offset the generally accepted cost of successfully establishing cover crops (approximately $35/ac). In 2013 at Jeremy Gustafson's, an extremely wet and then dry year, an extra $23.20/ac worth of N applied to corn following a winter rye cover crop resulted in an increase of 6 bu/ac of corn which was enough to account for the cost of the N at a corn price of $4.49/bu but not enough to also offset the cost of establishing the cover crop.

Results from these trials show that adding a winter rye cover crop to a corn production system may be an economical way to more efficiently use N fertilizer. The other realized benefits from a winter cover crop, like reductions in soil and phosphorus loss, make this practice a must for farmers looking to reduce negative externalities of crop production.

Table 4

Cover crop seeding dates, termination dates, termination methods, tillage operations, and corn planting dates, and side-dressing dates on cooperator farms.

Location	Year	Difference between low and high N rate	Cost of N difference/ac[a]	Cost of N in corn bu/ac[b]	Yield difference between N rates applied[c]
Stout	2010	50 lb N/ac	$16.50/ac	3 bu/ac	0 bu/ac
Stout	2012	50 lb N/ac	$31.50/ac	5 bu/ac	0 bu/ac
Smith	2012	30 lb N/ac	$18.90/ac	3 bu/ac	0 bu/ac
Gustafson	2013	40 lb N/ac	$23.20/ac	5 bu/ac	6 bu/ac
Smith	2014	30 lb N/ac	$13.20/ac	3 bu/ac	0 bu/ac
Gustafson	2014	40 lb N/ac	$17.60/ac	5 bu/ac	0 bu/ac

[a] Cost of N fertilizer was $0.33, $0.63, $0.58, and $0.44/lb N in 2010, 2012, 2013, and 2014 as accessed from ISU Ag Decision Maker (Duffy, 2014).
[b] Price of corn in Iowa was $5.23, $6.92, $4.49, and $3.78/bu in 2010, 2012, 2013, and 2014, respectively (USDA-NASS, 2014; CME Group, 2014).
[c] Figures 1 and 2.

References

Andraski, T.W. and Larry G. Bundy. 2005. Cover Crop Effects on Corn Yield Response to Nitrogen on an Irrigated Sandy Soil. Agronomy Journal. 97:1239-1244.

Carlson, Sarah. 2012. Winter Rye Cover Crop Effect on Cash Crop Yields: Year 4. Practical Farmers of Iowa, Ames, IA.

Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and Iowa State University College of Agriculture and Life Sciences. 2012. Iowa nutrient reduction strategy. Iowa State University of Science and Technology, Ames, IA.

Kaspar, T.C., D.B. Jaynes, T.B. Parkin, and T.B. Moorman. 2007. Rye cover crop and gamagrass strip effects on NO3 concentration and load in tile drainage. J. Environmental Quality 36:1503-1511.

Kuo, Shiou and E.J. Jellum. 2002. Influence of Winter Cover Crop and Residue Management on Soil Nitrogen Availability and Corn. Agronomy Journal 94:501-508.

National Agricultural Statistics Service. 2013. Iowa annual statistical bulletin. Available at http://www.nass.usda.gov/Statistics_by_State/Iowa/Publications/Annual_Statistical_Bulletin/indei.asp (accessed 4 Dec. 2013). NASS, USDA, Washington, D.C.

Scott, T.W., J. Mt. Plesant, R.F. Burt and D.J. Otis. 1987. Contributions of Ground Cover, Dry Matter, and Nitrogen from Intercrops and Cover Crops in a Corn Polyculture System. Agronomy Journal. 79:792-798.

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