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Field Crops Research

Nitrogen Rate Comparison in Corn Following Green Manure Cover Crop Mixes

Staff Contact:
Stefan Gailans – (515) 232-5661
stefan@practicalfarmers.org

Web Link:
http://bit.ly/pfi_fieldcrops

Cooperator:
- **Tim Sieren - Keota**

Funding By:
This project is supported in part by
Walton Family Foundation

In a Nutshell

- Various green manure cover crop mixes can successfully be established following the harvest of a small grain crop in mid-summer.
- Following cereal rye seed harvest in July 2015, farmer-cooperator Tim Sieren seeded a brassica mix into one field and a legume mix into another field. He then compared 2016 corn yields resulting from a Low and High N fertilizer rate that followed the green manure mixes in the separate fields.

Key Findings

- Regardless of the green manure mix it followed, corn yields were significantly greater with the 145 lb N/ac (High) rate compared to the 95 lb N/ac (Low) rate.
- Wet summer months likely contributed to the superiority of the High N rate in terms of both yield and financial returns in 2016.

Project Timeline
2015-2016

Field 1 containing the radish+rapeseed+cereal rye (brassica mix) at left and Field 2 containing the hairy vetch+Austrian winter pea+cereal rye (legume mix) on the right. Photos taken on Nov. 17, 2015.

Background

Extending crop rotations to include a small grain species such as cereal rye, wheat or oats that are harvested for grain in July, presents farmers with opportunities to seed brassica and legume cover crop species. When either seeded with the small grain in the spring or after small grain harvest in the summer, these "green manure" cover crops take advantage of the rest of the growing season to establish, provide ground cover, sequester soil nutrients, and, in the case of legumes, fix atmospheric nitrogen that will eventually be cycled for succeeding cash crops. The cover crop growth between July and the fall can also provide a source of forage for grazing livestock. In a previous on-farm research trial, farmer-cooperator Tim Sieren interseeded red clover into a cereal rye seed crop in March. Tim observed the nitrogen replacement value of that red clover to his succeeding corn to amount to at least 43 lb N/ac (Gailans and Sieren, 2014). Building on that project, Tim wanted to investigate the N replacement potential of cover crop mixes seeded after cereal rye harvest in July ahead of his next corn crop: "I had a good stand of two mixes of cover crops after harvesting cereal rye [in 2015], and I wanted to find out how to maximize the potential crop profit by fully utilizing the nitrogen sequestration and production in legume and brassica cover crops."

The objective of this on-farm research was to quantify the agronomic and economic effect on corn yields receiving a Low and High nitrogen fertilizer rate following two different green manure cover crop mixes seeded after cereal rye harvest. In designing the trial, Sieren says, "I hope to gain experience and confidence when cutting nitrogen rates for corn following legume and brassica cover crop mixes."

Methods

This research project was conducted by Tim Sieren of Green Iron Farms near Keota in Washington County in southeast Iowa. Green Iron Farms is a small, diversified crop and livestock family farm.

Treatments included a Low and High N fertilizer rate applied to corn following two different green manure mixes. The project took place in two separate fields; both were in a cereal rye seed crop in 2015 that was seeded the previous fall. In each field, the treatments were replicated four times in randomized strips running the length of a field.

Upon harvest of the rye seed in mid-July 2015, one field was seeded to a mix of oilseed radish, rapeseed and cereal rye (brassica mix). The other field was seeded to a mix of hairy vetch, Austrian winter pea and cereal rye (legume mix). Both of these mixes were seeded with a drill in mid-August 2015. In mid-November, Sieren let cattle graze the fields with two mixes until the end of February 2016. Crop management for both fields is listed in **Table 1**.

Tim collected aboveground biomass of the green manure mixes from each field on Nov. 19, 2015 prior to the onset of winter dormancy and on Apr. 17, 2016 just prior to termination. Samples were sent to the Iowa State University Soil & Plant Analysis Lab in Ames to determine dry weight, C concentration and N concentration.

Both mixes were terminated with herbicide and corn was no-till planted in both fields.

Soil nitrate concentration (late-spring soil nitrate test) was determined to a depth of 12 in. when corn was six to eight inches tall on May 24. Cornstalk nitrate concentration (fall stalk nitrate test) was assessed when the corn reached physiological maturity on Sept. 17.

Corn was harvested from all strips individually and corrected for 15.5% moisture.

Data were analyzed separately by field (brassica mix, legume mix) using JMP Pro 12 (SAS Institute Inc., Cary, NC). Statistical significance is determined at $P \leq 0.05$ level and means separations are reported using Tukey's Least Significant Difference (LSD).

Table 1

Crop management among the treatments at Tim Sieren's in 2016.

	Brassica mix[a] (Field 1)	Legume mix (Field 2)
Green manure seeding date	Aug. 17, 2015	Aug. 14, 2015
Green manure seeding rates	Radish (9.7 lb/ac) Rapeseed (3.3 lb/ac) Cereal rye (36 lb/ac)	Hairy vetch (3.3 lb/ac) Austrian winter pea (19.6 lb/ac) Cereal rye (33 lb/ac)
Grazing period	Mid-Nov. 2015 – Feb. 2016	Mid-Nov. 2015 – Feb. 2016
Green manure termination date	Apr. 18, 2016	Apr. 18, 2016
Corn planting date	Apr. 23	Apr. 23
Corn planting population	32,600 seeds/ac	32,600 seeds/ac
At-plant N rate	55 lb N/ac	55 lb N/ac
Side-dress N (June 2) Low rate High rate	 40 lb N/ac 90 lb N/ac	 40 lb N/ac 90 lb N/ac
Low total N rate	95 lb N/ac	95 lb N/ac
High total N rate	145 lb N/ac	145 lb N/ac
Corn harvest date	Oct. 21	Oct. 21

[a] The brassica mix and legume mix were seeded to two separate fields.

Results and Discussion

Total monthly rainfall and mean monthly temperature are presented in **Table 2**.

Closeup of radishes in the brassica mix. Seeded on Aug. 17, 2015. Photo taken on Nov. 17.

Table 2

Total monthly rainfall and mean monthly temperature for 2016.

Month	Rainfall (in.)[a]		Temperature (°F)[b]	
	2016	*5-yr Avg.*	*2016*	*5-yr Avg.*
March	2.5	--	43	38
April	2.8	4.9	50	51
May	6.2	5.7	60	62
June	4.6	5.9	74	71
July	5.7	3.6	74	76
August	13.6	5.1	74	73
September	1.7	3.3	69	66
October	1.6	--	58	54

[a] Rainfall recorded from Sieren's rain gauge at the farm. 2016 was the first year he recorded rainfall for March and October.

[b] Mean monthly temperature accessed from Washington weather station, ~12 mi. from Sieren (Iowa Environmental Mesonet, 2016).

Green manure cover crop biomass

Fall and spring aboveground biomass characteristics of the two green manure cover crop mixes are presented in **Table 3**.

Table 3

Aboveground biomass, C and N concentrations, C and N contents and C:N ratios for the two green manure cover crop mixes prior to the onset of winter dormancy and just prior to termination ahead of corn planting.

	Nov. 17, 2015		Apr. 17, 2016	
	Brassica mix (F1)	*Legume mix (F2)*	*Brassica mix (F1)*	*Legume mix (F2)*
Biomass (lb/ac)	3,860	4,087	753	1,446
C conc. (%)	38	42	38	40
C content (lb C/ac)	1,481	1,726	286	578
N conc. (%)	2	4	2	3
N content (lb N/ac)	73	163	15	43
C:N ratio	20	11	19	13

Both mixes produced around 4,000 lb biomass/ac in Fall 2015. The legume mix produced twice as much biomass the following spring just prior to termination and corn planting. The N content of the legume mix was more than twice that of the brassica mix in both the fall and following spring (N content is the product of biomass x N conc.). The C:N ratio (which governs microbial decomposition and N release) of the aboveground biomass was less for the legume mix but all were less than 25. These ratios all fall within the range suitable for microbial decomposition and release of N to a succeeding cash crop given ideal conditions (Sullivan, 2003).

Late-spring soil nitrate test and fall stalk nitrate test

After corn had emerged and was six to eight inches tall, Sieren conducted the late-spring soil nitrate test (LSNT) by collecting soil samples from both fields to determine the nitrate concentration of the soil in late May. Recall that both fields received the same amount of N fertilizer at the time of corn planting on Apr. 23 (**Table 1**). Mean soil nitrate concentration was 20 ppm for the field with the brassica mix and 30 ppm for the field with the legume mix. According to Blackmer et al. (1997) these LSNT results would have warranted the side-dressing of no additional N to the corn. Even so, Sieren decided to side-dress rates of 40 and 90 lb N/ac in each field to achieve the total N rates of 95 and 145 lb N/ac, respectively (**Table 1**).

When the corn reached physiological maturity ("black layer") in mid-September, Sieren assessed cornstalk nitrate concentration, as part of the fall stalk nitrate test, from each strip in both fields (**Table 4**). Stalk nitrate concentrations did not differ between the N rates applied in either field with the green manure mixes. According to Blackmer and Mallarino (1996), these stalk nitrate concentrations fall into the "low" category. This suggests that the corn following both mixes could have received and used more N to ensure maximum yield potential. The likely cause for these "low" values was the very wet conditions in July and August (**Table 2**) that could have caused N to leach from the soil.

Table 4

Mean cornstalk nitrate concentration (ppm) for the Low (95 lb N/ac) and High (145 lb N/ac) N-rate treatments from the fields containing the brassica and legume mix.

	95 lb N/ac	145 lb N/ac	Diff.	LSD (0.05)[a]
Brassica mix (Field 1)	63	97	34	75
Legume mix (Field 2)	31	31	0	6

[a]By mix, if the difference between the two N-rate treatment means is greater than the LSD, the treatments are considered significantly different.

Closeup of the legume mix. Seeded on Aug. 14, 2015. Photo taken on Nov. 17.

Figure 1

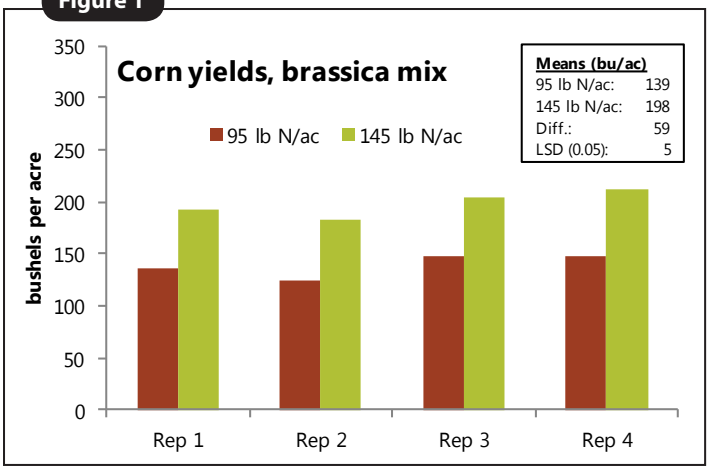

Figure 1. Corn yields from each Rep as affected by N rate in the field that had the brassica green manure mix (radish-rapeseed-cereal rye). Mean yields and the least significant difference (LSD) at the $P \leq 0.05$ level are indicated in the inset table. Because the difference between the two treatment means is greater than the LSD, the treatments are considered significantly different.

Figure 2

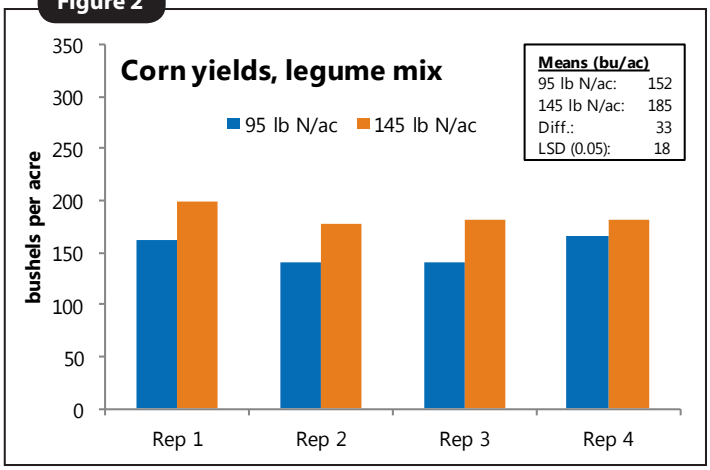

Figure 2. Corn yields from each Rep as affected by N rate in the field that had the legume green manure mix (hairy vetch-Austrian winter pea-cereal rye). Mean yields and the least significant difference (LSD) at the $P \leq 0.05$ level are indicated in the inset table. Because the difference between the two treatment means is greater than the LSD, the treatments are considered significantly different.

Corn yields

Corn yields were analyzed separately for the brassica and legume mixes and are presented in **Figures 1** and **2**. Following both green manure mixes, corn yields were significantly greater with the 145 lb N/ac rate compared to the 95 lb N/ac rate.

The LSNT conducted in late May suggested no further application of N fertilizer was necessary for the corn following both green manure mixes in the separate fields. Despite Sieren side-dressing 40 and 90 lb N/ac (well above the 0 lb N/ac suggested by the LSNT) to both fields in early June, cornstalk nitrate concentrations in September came back as being "low" (**Table 4**). For both green manure mixes, corn receiving the 95 lb N/ac total N rate (40 lb N/ac side-dress) yielded well below the 5-year corn yield average for Washington County of 167 bu/ac (USDA-NASS, 2016), while corn receiving the 145 lb N/ac total N rate (90 lb N/ac side-dress) exceeded the county average. It is likely that the strips receiving the 145 lb N/ac total rate probably had just enough N to produce 198 bu/ac and 185 bu/ac following the brassica mix and legume mix, respectively. "Late season N paid big time for corn this year because of the wet summer," Sieren says. "From July 20 to Sept. 10 we had 17.3 in. of rain. Anthracnose started showing up in mid-August and shut the plants down early before they could finish filling the kernels."

Economic considerations

Table 5 provides a summary of costs and returns for the fields that contained the brassica and legume green manure mixes. By field, only the differences between the two N rate treatments are considered: cost of N fertilizer applied and resulting corn yields. The costs of planting the green manure mixes as well as planting, protecting and harvesting the corn are equivalent between the two N rate treatments in both fields. For reference, total seed cost for the brassica mix was $44.65/ac and for the legume mix was $30.78/ac, as reported by Sieren.

At a nitrogen fertilizer cost of $0.40 per lb N (Plastina, 2016), the 145 lb N/ac total rate cost an additional $20/ac compared to the 95 lb N/ac total rate. Considering only the difference in N fertilizer cost and corn grain returns with a price of $3.42/bu on Nov. 10 (CME Group, 2016), corn yields from the 145 lb N/ac rate netted an additional $181.78/ac in the field with the brassica mix and netted an additional $96.16/ac in the field with the legume mix.

Table 5

Nitrogen fertilizer costs and corn grain returns for the two N rate treatments in the fields that contained the brassica and legume mix.

	95 lb N/ac	145 lb N/ac
Brassica mix (Field 1)		
N fert. cost ($/ac)[a]	$16.00	$36.00
Corn yield (bu/ac)	139	198
Returns ($/ac)[b]	$475.38	$677.16
Returns – N fert. cost ($/ac)	**$459.38**	**$641.16**
Legume mix (Field 2)		
N fert. cost ($/ac)[a]	$16.00	$36.00
Corn yield (bu/ac)	152	185
Returns ($/ac)[b]	$535.04	$651.20
Returns – N fert. cost ($/ac)	**$519.04**	**$615.20**

[a] N fertilizer cost = $0.40/lb N (Plastina, 2016).
[b] Corn grain price = $3.42/bu on Nov. 10 (CME Group, 2016).

Conclusions and Next Steps

Tim Sieren compared corn yields resulting from a Low and High N fertilizer rate that followed either a brassica or legume green manure mix. The green manure mixes were seeded in mid-August 2015 after cereal rye seed harvest in July 2015 in two separate fields with the Low and High N rates implemented in strips in each field. The brassica mix contained radish, rapeseed and cereal rye. The legume mix contained hairy vetch, Austrian winter pea and cereal rye. The N fertilizer rates compared in each field were 95 lb N/ac (Low) and 145 lb N/ac (High). These rates were achieved by applying 55 lb N/ac at the time of corn planting and side-dressing 40 lb N/ac and 90 lb N/ac in strips in early June, respectively.

Regardless of the green manure mix it followed, corn yields were significantly greater with the 145 lb N/ac rate (**Figure 1**). The LSNT conducted in both fields in late May did suggest that no N fertilizer needed to be side-dressed. Put another way, the N contributed from the green manures and fertilizer applied at planting was estimated to be sufficient for optimal yields. But the extremely wet summer conditions (**Table 2**) likely played a part in some N leaching from the soil profile mid-season nullifying the LSNT estimation. Thus, the 90 lb N/ac side-dress (145 lb N/ac total) paid off in both fields of green manure cover crop mixes (**Table 5**).

"I usually plan for 190 lb N/ac to grow 200 bu/ac corn." Sieren says. "I generally credit 40 lb N/ac from soybeans, and about 75 lb N/ac from pit manure, so that leaves 75 lb N/ac left to split between planting and side-dress fertilizer applications. I didn't have beans or manure on the research plots in this trial, so used 145 lb N/ac and planned on the 40-50 lb N/ac from the green manure cover crop mixes. Probably would've been enough, if July and August wouldn't have been so wet.

"In the future, I plan to use different combinations of these mixes to optimize soil biology, and utilize them as a forage source for cows in the fall grazing season, and not as much as a nitrogen source for corn."

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