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Field Crops Research

Corn Following Green Manure Cover Crops Established with Small Grain

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- **Dick Sloan - Rowley**

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In a Nutshell

- Extending and diversifying a crop rotation to include a small grain presents farmers with the opportunity to generate biological soil nitrogen using forage legume (green manure) cover crops seeded in the spring and summer.
- Farmer-cooperator, Dick Sloan grew corn following red clover that was frost-seeded into a cereal rye seed crop and also after a mix of forage legumes and other species established mid-summer after the cereal rye seed crop was harvested.

Key Findings

- In his second iteration of investigating these cropping systems, Dick improved his corn yields from the first time he tried this system in 2014.
- In 2015, corn that followed red clover out-yielded corn that followed the mix.
- Net returns were approximately $95 greater per acre when corn followed red clover compared to the mix.

Project Timeline
2013-2015

Corn emerges through the mix (L) and the red clover residues on Dick Sloan's farm in May 2015.

Background

Extending crop rotations to include a small grain species such as rye, wheat or oats that are harvested for grain in July, presents farmers with opportunities to try cover crop species that would otherwise not have enough time to establish and grow in typical corn-soybean systems. This tactic also pairs two practices (diversified crop rotation and cover crops) that are proven to reduce nutrient loss to rivers and streams outlined in the Iowa Nutrient Reduction Strategy (Iowa Department of Agriculture and Land Stewardship et al., 2012). This on-farm project conducted by Dick Sloan in 2015 builds upon previous work done on extended crop rotations and green manure cover crops by farmer-cooperators in recent years (Gailans et al. 2014; Gailans and Sieren 2014). In one of those past projects, Dick, Vic Madsen and Bill Buman compared yields of corn that followed red clover or a mix of forage legumes and brassicas (Gailans et al., 2014). Similar to the present trial, the red clover in those trials was interseeded with a small grain while the forages were seeded in the summer after small grain harvest. At each farm, corn yields following the clover and the mix were generally similar in 2014. In the other previous project, Tim Sieren was able to determine that red clover frost-seeded with cereal rye was able to supply roughly 43 lb N/ac to the ensuing corn crop (Gailans and Sieren, 2014). For 2015, Dick decided to conduct the paired strip trial once again.

The objective of this research project was to determine the agronomic effect on corn yields of green manure cover crops established with a cereal rye seed crop. Dick ultimately wants to evaluate the payback from adding cereal rye and green manures to his corn and soybean rotation. He raises cereal rye seed to use as a cover crop on the rest of his acres. "[Raising my own cover crop seed] sure cuts the cost of my covers." Comparisons are made between corn that followed cereal rye + red clover or a mix of species seeded after cereal rye harvest in paired strips.

Methods

This project was implemented by farmer-cooperator Dick Sloan near Rowley in Buchanan County. Dick conducted the project in the 2013-14 and 2014-15 seasons.

Dick harvested a cereal rye crop in July of 2014 and 2015 that was seeded the previous fall. To implement the treatments, he either interseeded red clover with the cereal rye in March at a rate of 15 lb/ac or planted a mix of species after cereal rye harvest in July in three replicated paired strips. The mix was comprised of cowpeas (11.5 lb/ac), crimson clover (4.4 lb/ac), berseem clover (3.3 lb/ac), sunn hemp (2.5 lb/ac), oilseed radish (3.5 lb/ac) and oats (3 lb/ac).

Dick collected aboveground biomass samples of the green manures in the fall that were dried, weighed and analyzed for C and N concentration at the Soil and Plant Analysis Laboratory at Iowa State University in Ames.

The mix (light green) and red clover growing in strips after cereal rye seed harvest. Photo taken on Sept. 22, 2014.

Table 1

Rainfall and growing degree days (GDD, base 50˚F) for 2014 and 2015 at Dick Sloan's as well as historical averages.

Month[a]	Rainfall (in.)			GDD		
	2014	*2015*	*Average*	*2014*	*2015*	*Average*
April	5.83	3.52	3.43	131.0	174.5	165.3
May	2.85	4.26	4.16	347.5	367.0	366.2
June	9.07	8.34	5.13	530.0	551.5	561.5
July	2.73	3.14	4.49	527.0	657.5	671.4
August	2.70	4.09	4.35	610.5	568.0	614.1
September	2.71	4.82	3.28	376.0	546.5	416.6
October	2.70	1.77	2.37	144.5	214.5	212.2
TOTAL	28.59	29.94	27.21	2,666.5	3,079.5	3,007.3

[a] Rainfall and temperature data were accessed from the Independence (11 mi. from Sloan's) weather station (Iowa Environment Mesonet, 2015).

After the green manures, Dick planted corn on May 21, 2014 and on May 2, 2015. Dick side-dressed 80 lb N/ac to the cover crop mix plots only on July 14, 2014 and side-dressed 100 lb N/ac as UAN (32%) to corn in all strips on July 6, 2015 following results from the Late Spring Nitrate Test (LSNT) (Blackmer et al., 1997).

In Nov. 2014 and Oct. 2015, Dick harvested grain from the individual strips of corn following red clover and corn following the mix. Corn yields were corrected for 15.5% moisture.

Data were analyzed using JMP Pro 10 (SAS Institute, Inc., Cary, NC). Means separations between treatments are reported using the least significant difference (LSD) generated from a t-test. Statistical significance is reported at the $P \leq 0.05$ level with tendencies noted at the $0.05 < P \leq 0.10$ level.

Results and Discussion

Rainfall during the period of April 1-October 31, as well as the historical average, for both years presented in **Table 1**. Rainfall in July and August at Dick Sloan's in 2014 was approximately 60% of the long-term average (5.4 vs. 8.8 in.). June was exceptionally wet at Dick's in both years. Growing degree days accumulated in both years was near-normal.

Green manure establishment year

Dick seeded cereal rye in the fall that was harvested for seed in July. Red clover was frost-seeded into cereal rye in March while the mix was seeded following cereal rye seed harvest in July. The red

clover seed cost $32/ac and the seed mix cost $37/ac.

Aboveground biomass and N content of red clover and the mix for Fall 2013 and Fall 2014 at Dick's is presented in **Figure 1**. The red clover produced more pounds per acre of aboveground biomass and contained more pounds of N than the mix in both years. In Fall 2013, these differences were significant, but in Fall 2014 not enough samples were collected to determine whether or not this was statistically significant.

The C:N ratio (which governs microbial decomposition and N release) of the aboveground biomass of the red clover and mix was 23 in Fall 2013 and 17 and 22, respectively, in Fall 2014. These ratios fall within the range suitable for microbial decomposition and release of N to a succeeding cash crop given ideal conditions (Sullivan, 2003).

The red clover biomass and N content observed at Dick's in 2013 and 2014 was roughly the same as what Tim Sieren observed in a previous PFI Cooperators' Program project in which he established red clover with a cereal rye crop (5,210 lb/ac; 113 lb N/ac) (Gailans and Sieren, 2014). Additionally, Dick observed twice as much biomass and N content that was observed by researchers in south-central Ontario, Canada (Vyn et al., 2000) and approximately the same that was observed by researchers in northeast Iowa (Liebman et al., 2012). The researchers in these previous studies established red clover with wheat (frost-seeded) and oat (companion sown) crops.

Figure 1

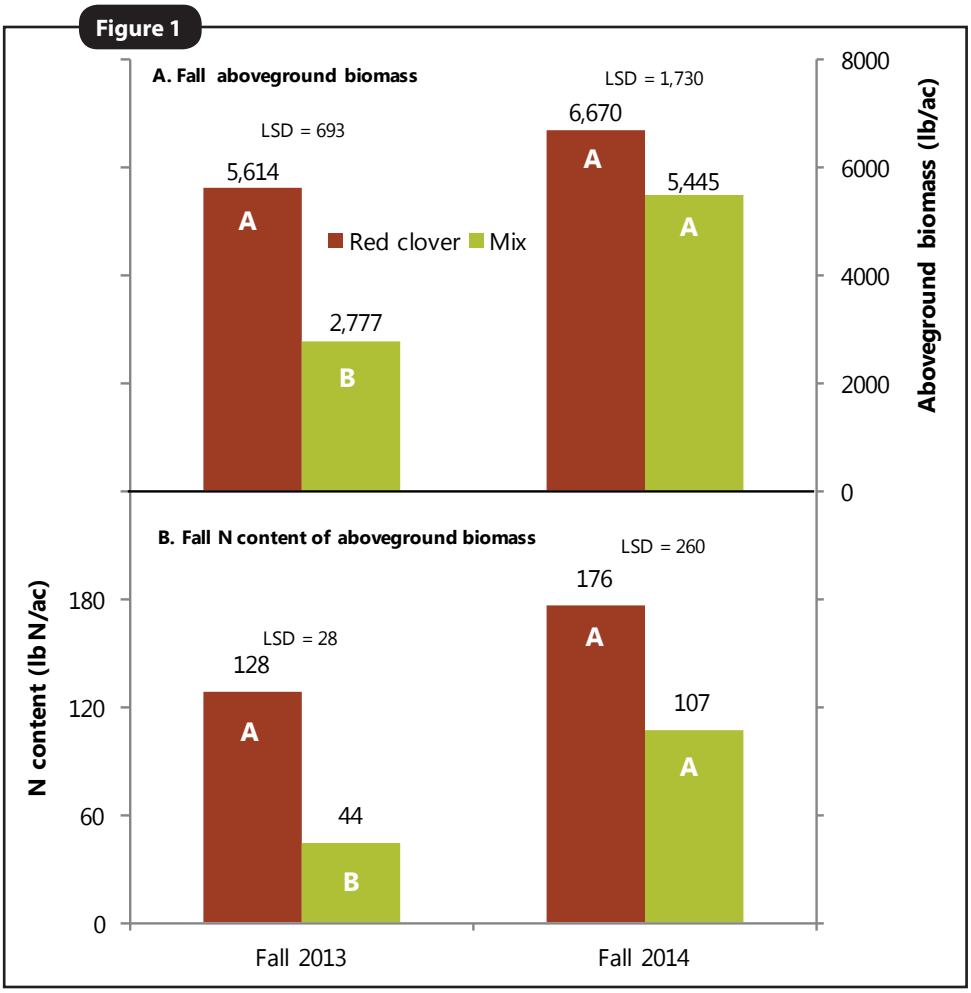

Figure 1. Mean aboveground biomass (A) and N content (B) of red clover and the cover crop mix observed at Dick Sloan's in Fall 2013 and Fall 2014. Samples were collected on Nov. 2, 2013 and Oct. 14, 2014. By panel, columns with different letters are significantly different at the $P \leq 0.05$ level. The least significant difference (LSD) is indicated above each pair of columns.

Corn year

After corn had emerged and was six to eight inches tall, Dick conducted the LSNT by collecting soil samples from strips to determine the nitrate concentration of the soil in early June both years. In 2014, mean soil nitrate concentration was 8.2 ppm where the corn followed red clover and 7.0 ppm where the corn followed the mix. In 2015, mean soil nitrate concentration was 10.0 ppm where the corn followed red clover and 4.3 ppm where the corn followed the cover crop mix. In both years, these were not significantly different.

Dick also collected stalk samples from corn in both treatments in October of both years when the corn had reached physiological maturity. In 2014, mean nitrate concentrations were <20 ppm for both treatments. Dick accounted this to heavy rains in June that washed much of the N from the soil profile. In 2015, mean nitrate concentration for the cornstalks from the red clover treatment was 731 ppm and from the mix treatment was 29 ppm. According to Blackmer and Mallarino (1996), 700–2,000 ppm is "optimal" while <250 ppm is considered "low." This suggests that in 2015 the corn following red clover had enough nitrogen to reach optimum yields while the corn following the mix could have used more nitrogen.

Corn emerging through desiccated red clover in May 2015.

Corn was harvested from randomized and replicated strips. Yields for each strip and the means are presented in **Figure 2**. In 2014, mean corn yields from both treatments were quite low; 92 bu/ac following red clover and 116 bu/ac following the mix. The 5-year corn yield average for Buchanan County is 167 bu/ac (USDA-NASS, 2015). In 2015, yields were much improved for both treatments. The corn that followed the red clover out-yielded the corn that followed the mix (209 vs. 186 bu/ac, respectively).

Figure 2

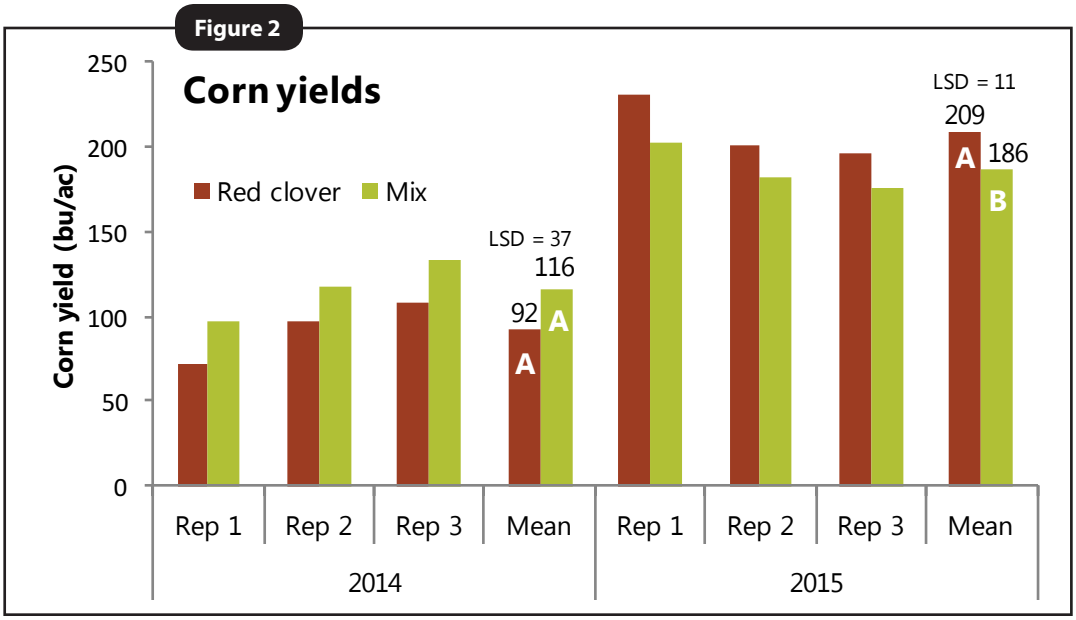

Figure 2. Corn yields for each rep as well as the means for the red clover and mix treatments at Dick Sloan's, harvested on Nov. 6, 2014 and Oct. 16, 2015. For the means, columns with different letters are significantly different at $P \leq 0.05$. The least significant difference (LSD) is indicated above both pairs of mean columns for both years.

Dick attributed the improved yields in 2015 to experience with the cropping system. In 2014, he planted corn later than he would have liked (May 21) and into thick residue that was not yet completely dessicated. It is also important to keep in mind that the corn yields Dick observed in this project in 2015 were achieved with only 100 lb N/ac of added synthetic fertilizer. Normally, Dick would expect to apply 135 lb N/ac to his corn crop that followed soybeans in rotation. In a previous PFI Cooperators' Program study, farmer-cooperator Tim Sieren observed that a red clover green manure could replace at least 43 lb N/ac of N fertilizer (Gailans and Sieren, 2014). The university researchers mentioned earlier calculated that a red clover green manure can replace N fertilizer at a rate of 100 lb N/ac in south-central Ontario (Vyn et al., 2000) and in northeast Iowa 90–190 lb N/ac (Liebman et al., 2012).

Costs and returns: partial budget

A partial budget was constructed to compare the costs and returns of the two green manure treatments Dick investigated in 2015 (**Table 2**). The partial budget only considers the differences between the two scenarios: cost of clover vs. mix seed, cost of frost-seeding clover vs. drilling the mix, and resulting corn yields. The costs of planting, fertilizing, protecting and harvesting the corn are equivalent between the two scenarios and are thus not considered in the partial budget.

Table 2

Partial budget comparing costs and returns between the two green manure treatments at Dick Sloan's in 2015.

Red Clover		**Mix**	
Costs	***$/ac***	***Costs***	***$/ac***
Red clover seed (15 lb/ac @ $2.10/lb)	$32	Seed mix	
Frost-seed red clover	$5	cowpeas (11.5 lb/ac @ $0.85/lb)	$9.78
		crimson clover (4.4 lb/ac @ $1. 50/lb)	$6.60
		berseem clover (3.3 lb/ac @ $2.15/lb)	$7.10
		sunn hemp (2.5 lb/ac @ $1.95)	$4.88
		oilseed radish (3.5 lb/ac @ $2.25/lb)	$7.88
		oats (3 lb/ac @ $0.27/lb)	$0.81
		Total mix	$37.03
		Drill mix	$9
TOTAL COSTS	$37	TOTAL COSTS	$46.03
Returns	***$/ac***	***Returns***	***$/ac***
Corn (209 bu/ac @ $3.72/bu)	$777.48	Corn (186 bu/ac @ $3.72/bu)	$691.92
RETURNS - COSTS	$777.48 - $37 = **$740.48**	RETURNS – COSTS	$691.92 - $46.03 = **$645.89**

Seed costs were provided by Dick while frost-seeding and drilling costs were accessed from ISU Extension's "Estimated costs of crop production in Iowa, 2015" (Plastina, 2015). Corn price was accessed from the CME Group on Dec. 1, 2015.

Growing red clover as a companion crop with the cereal rye crop cost Dick about $9 less per acre than drilling the mix following cereal rye seed harvest. The resulting corn yields following red clover grossed $85.86 more per acre than those following the mix. Net returns were thus $94.59 greater per acre for the corn following red clover.

Using a mix solely as a green manure ahead of corn production may be inferior to using red clover. However, drilling a mix of species following small grain harvest in mid-summer may be more appropriate to farmers with grazing livestock. In such a scenario, the mix serves as both late-season forage and green manure ahead of corn. When considering his farm production system (only crops, no grazing livestock), Dick insists, "It's pretty hard to beat the reliability of frost-seeding red clover."

Conclusions and Next Steps

The present project adds to a recent body of work assembled by PFI farmer-cooperators that shows that a well-managed red clover green manure cover crop can produce an exceptional succeeding corn crop (Gailans and Sieren, 2014; Gailans et al., 2014). In 2015, red clover frost-seeded with cereal rye put on more aboveground biomass and contained more N than the mix seeded after cereal rye seed harvest. Moreover, corn yields following red clover were greater than those following the mix. When considering the costs and returns of the two treatments, the corn following red clover netted approximately $95 more per acre.

Dick saw very low corn yields when he first tried this in 2013-2014 but admitted that was his first attempt at such a crop rotation, "I can't have beginner's luck with everything I try!" In his second attempt using this system in 2014-2015, Dick realized he had much better luck with frost-seeding medium red clover under a rye crop as compared to seeding mixes in late July or early August. Ever looking ahead and wanting to try new things, though, Dick ponders, "I may experiment with summer-seeded covers each year until I am ready to compare a different mix with clover."

Red clover prior to chemical termination in May at Dick Sloan's farm.

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