PRACTICAL farmers of Iowa
working together, always learning

Field Crops Research

Green Manure Cover Crops Established with Small Grains

Staff Contact:

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

Web Link:

http://bit.ly/pfi_fieldcrops

Cooperators:

- **Dick Sloan – Rowley**
- **Vic Madsen – Audubon**
- **Bill Buman – Harlan**

Funding By:

This project is supported in part by the **Iowa Department of Agriculture and Land Stewardship - Division of Soil Conservation,** **the Leopold Center for Sustainable Agriculture** and the **Walton Family Foundation**

In a Nutshell

- Extending and diversifying a crop rotation to include a small grain presents farmers with the opportunity to also include green manure cover crops.
- Three farmer-cooperators grew a small grain + red clover and a small grain + cover crop mix preceding corn in their crop rotations.

Key findings

- Red clover frost-seeded with the small grain put on more aboveground biomass and contained more N than the cover crop mix seeded after small grain harvest on one farm.
- Corn yields following red clover were greater than those following the cover crop mix at only one farm.
- If sufficiently terminated, red clover and the cover crop mix preceding corn in rotation can result in yields comparable to county yield averages.

Project Timeline
2012-2014

Corn emerging through the cover crop mix at Dick Sloan's farm near Rowley, Iowa.

Background

The Iowa Nutrient Reduction Strategy, released in 2012, outlined several practices farmers can implement to reduce nonpoint source pollution (Iowa Department of Agriculture and Land Stewardship et al., 2012). Two such practices are the diversifying and extending of corn-soybean rotations with small grains and cover crops. 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 be warranted in typical corn-soybean systems. These warm season cover crop species include brassicas and legumes (sometimes referred to as "green manures") that need more time than cool season grasses 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. Research has shown that corn yields can be improved when following brassica and legume cover crops, by themselves or in mixtures, compared to when following grass cover crops (Vyn et al., 2000; Miguez and Bollero, 2005).

The objective of this research project was to quantify the agronomic effect on corn yields of green manure cover crops frost-seeded with a small grain or seeded following small grain harvest. Comparisons are made between corn that followed a small grain + red clover or a cover crop mix seeded after small grain harvest.

Method

This study was implemented by three farmer-cooperators: Dick Sloan near Rowley in Buchanan County; Vic Madsen near Audubon in Audubon County; Bill Buman near Harlan in Shelby County.

Treatments included corn grown following one of two green manures established with a small grain crop. The green manures were red clover or a mixture of legumes, a brassica, and a grass.

Each farmer grew a small grain crop in 2013. In randomized and replicated paired strips, the farmers either interseeded the

small grain with red clover (5-15 lb/ac) or planted a cover crop mix after small grain harvest. The cover crop mix was comprised of cowpeas (11.5 lb/ac), crimson clover (4.4 lb/ac), berseem clo ver (3.3 lb/ac), sunn hemp (2.5 lb/ac), oilseed radish (3.5 lb/ac) and oats (3 lb/ac). Aboveground biomass samples of the red clover and cover crop mix were collected at each site prior to a hard freeze and were dried, weighed and analyzed for C and N concentration at the Soil and Plant Analysis Laboratory at Iowa State University in Ames. Biomass samples were also collected the following spring but unfortunately they were discarded before they were weighed. Corn was grown by all farmers in 2014.

Small grains grown and dates of field operations for each farm are presented in **Table 1**.

Following rye harvest and prior to seeding the cover crop mix, Dick Sloan applied liquid hog manure to the entire field at a rate of 2,000 gal/ac on July 25, 2013 resulting in 85 lb N, 29 lb P and 46 lb K/ac applied. The next spring, Dick planted corn to all strips on May 21, 2014 with a starter fertilizer at a rate of 24 lb N, 18 lb P, 5 lb K and 5 lb S/ac. On June 14, 2014, Dick sidedressed 80 lb N/ac to the corn that followed the cover crop mix (see discussion of aboveground biomass and N content below). Dick also collected stalk samples when corn had reached physiological maturity to determine stalk nitrate concentrations after Blackmer and Mallarino (1996).

Vic Madsen is an organic farmer and raised winter wheat in 2013 (seeded in Oct. 2012) as the small grain in rotation. Red clover was broadcast frost-seeded into strips of dormant wheat at a rate of 6 lb/ac. Vic harvested the wheat on June 21, 2013 and seeded the cover crop mix on August 1, 2013. On November 21, 2013, Vic harvested the aboveground biomass of the red clover and cover crop mix. The red clover and cover crop mix was terminated/incorporated with a sweep chisel plow in late April 2014, two tons per acre of turkey compost was applied, disked and field cultivated, and corn was planted shortly thereafter.

Bill Buman applied 53 lb N/ac as UAN (32%) to all strips in late March 2014 prior to corn planting. On June 4, 2014, Bill collected soil samples to a depth of 12 in. from all strips in accordance with protocols set by Blackmer et al. (1997) to conduct the Late Spring Nitrate Test (LSNT) in order to get an estimation of soil N availability for the corn in both treatments.

In Fall 2014, farmers harvested grain from strips of corn following red clover and corn following the cover crop mix individually and weighed grain using a weigh wagon or yield monitor. Corn yields were corrected for 15% moisture.

Data were analyzed using JMP Pro 10 (SAS Institute, Inc., Cary, NC) and comparisons among measured variables employ least squares means for accuracy. Means separations between treatments at each location 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.

Table 1

Number of replications and planting, harvesting, & sampling dates at cooperating farms								
Location	**No. reps.**	**Small grain 2013**	**Red clover seeding**	**Small grain harvest**	**Cover crop mix seeding**	**Fall biomass sampling date**	**Red clover & Cover crop mix termination**	**Corn planting**
Sloan (Rowley; NE Iowa)	3	Winter rye (seeded Oct. 2012)	April 20, 2013; drilled	July 15, 2013	July 28, 2013	Nov. 20, 2013	May 18, 2014; herbicides	May 21, 2014
Madsen (Audubon; west-central Iowa)	4	Winter wheat (seeded Oct. 2012)	Early March, 2013; broadcast	July 21, 2013	August 1, 2013	Nov. 21, 2013	Mid-April, 2014; sweep chisel plow	May 18, 2014
Buman (Harlan; western Iowa)	6	Oats (seeded April 2013)	Mid-April, 2013	Aug. 7, 2013	Aug. 12, 2013	Late Nov., 2013	April 12, 2014; herbicides	April 10, 2014

Results and Discussion

Total rainfall during the period of April 1-October 31 for 2013 and 2014, as well as the historical average, for each location is presented in **Table 2**. Rainfall at all farms in 2013 exceeded the historical averages but it should be noted that much of that rainfall occurred early in the season (April and May) with very little rainfall after June.

Small grain & green manure establishment year

At Dick Sloan's farm near Rowley, winter rye grain and straw yields in 2013 were 21 bu/ac and 0.8 t/ac, respectively. At Vic Madsen's farm near Audubon, winter wheat grain yields in 2013 were 46 bu/ac. At Bill Buman's farm near Harlan, oat grain and straw yields in 2013 were 130 bu/ac and 1 t/ac, respectively.

Fall aboveground biomass and N content of red clover and the cover crop mix at each farm are presented in **Figure 1**. Only at Dick Sloan's farm did red clover produce more aboveground biomass, and consequently more N content as well, compared to the cover crop mix. Because of this, Dick decided to sidedress 80 lb N/ac to the corn that followed the cover crop mix in mid-June 2014 as the cover crop mix provided much less N to the system than the red clover (**Figure 1B**). Furthermore, red clover biomass and N production was greatest at the Sloan farm, and this may be a result of greater rainfall in 2013 (particularly in the spring) compared to the other locations (**Table 2**).

The C:N ratio (which governs microbial decomposition and N release) of the aboveground biomass of the red clover and cover crop mix did not differ at any of the farms. Mean C:N ratio by farm was 23 at Sloan; 15 at Madsen; 24 at Buman. 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). Dick Sloan also observed far less weeds in the strips containing red clover compared to those planted to the cover crop mix after rye harvest (Gailans and Carlson, 2013). Vic observed quite a bit of weed pressure in all strips primarily due to unsubstantial growth of the clover and cover crop mix on account of very little rainfall after June 2013.

Corn year

Aboveground regrowth of red clover and cover crop mix was assessed at each farm prior to termination and corn planting. While this was not quantified due to the unfortunate discarding of samples prior to weighing, cooperator observations indicated that the amount of aboveground biomass prior to termination reflected that

Table 2

Location[a]	Total rainfall during the period April 1-Oct. 31		
	2013	2014	Historical avg.
Sloan	34.2 in.	32.6 in.	27.2 in.
Madsen	26.6 in.	38.2 in.	26.5 in.
Buman	28.2 in.	39.2 in.	26.6 in.

[a] Rainfall data were accessed from the Independence (11 mi. from Sloan), Audubon (4 mi. from Madsen) and Harlan (6 mi. from Buman) weather stations (Iowa Environmental Mesonet, 2014).

of the aboveground biomass measured the previous fall (**Figure 1**).

After corn had emerged and was six to eight inches tall, Dick Sloan and Bill Buman conducted the LSNT by collecting soil samples from strips to determine the nitrate concentration of the soil in early June 2014. At Dick's farm, mean soil nitrate concentration was 8 ppm for corn that followed red clover and 7 ppm for corn that followed the cover crop mix. Replicate samples were not collected so no analysis could be made. According to Blackmer et al. (1997) these LSNT results would have warranted the sidedressing of 90 lb N/ac to the corn. However, because these test results were not made available to Dick in time, he was not able to comply with these recommendations. Instead, Dick sidedressed 80 lb N/ac to the corn that followed the cover crop mix on June 14, 2014 in an attempt to account for the less amount of N provided by the aboveground biomass of the cover crop mix compared to the red clover (**Figure 1**). At Bill's farm, the LSNT showed the mean soil nitrate concentration was 16 ppm for corn that followed red clover and 13 ppm for corn that followed the cover crop mix. There was no statistical difference between these values (LSD = 6 ppm). Given the field's history of legumes and the normal amount of spring rainfall at Bill's farm, the LSNT indicated that 60 lb N/ac should be added to the corn in both treatments (Blackmer et al., 1997).

Dick Sloan collected stalk samples from corn in both treatments in October when the corn had reached physiological maturity. Mean nitrate concentration for the cornstalks from both treatments was <20 ppm suggesting the corn had a "low" potential to reach optimum yields and could have used more nitrogen (Blackmer and Mallarino, 1996).

Corn yields at each farm are presented in **Figure 2**. At Dick Sloan's farm, the corn that followed the cover crop mix out-yielded the corn that followed the red clover. Yields were quite low, reflective of the cornstalk nitrate concentrations that suggested that the corn could have used additional nitrogen. Yields were also well below the 10-year corn yield average for Buchanan County of 169 bu/ac (USDA-NASS, 2014). Dick attributed this to planting corn later than he would have liked into tall, thick clover residue that seemed to negatively affect corn emergence and that this was his first time attempting this system. "I can't have beginner's luck with everything I do!" he confided. Previous research in Canada has showed that red clover, if not sufficiently terminated seven to 10 d prior to planting corn, can act like a weed to early emerging corn thus negatively affecting yields (Vyn et al., 2000). The LSNT results in the <10 ppm range and the "low" stalk nitrate concentrations were also telling. Late or insufficient termination of the red clover and cover crop mix may have resulted in less N turning over and becoming available to the corn throughout the season.

Vic Madsen saw his corn that followed red clover out-yielded the corn that followed the cover crop mix: 144 vs. 134 bu/ac, respectively, which were both less than the 10-year average for Audubon County of 164 bu/ac (USDA-NASS, 2014). Vic also

Figure 1

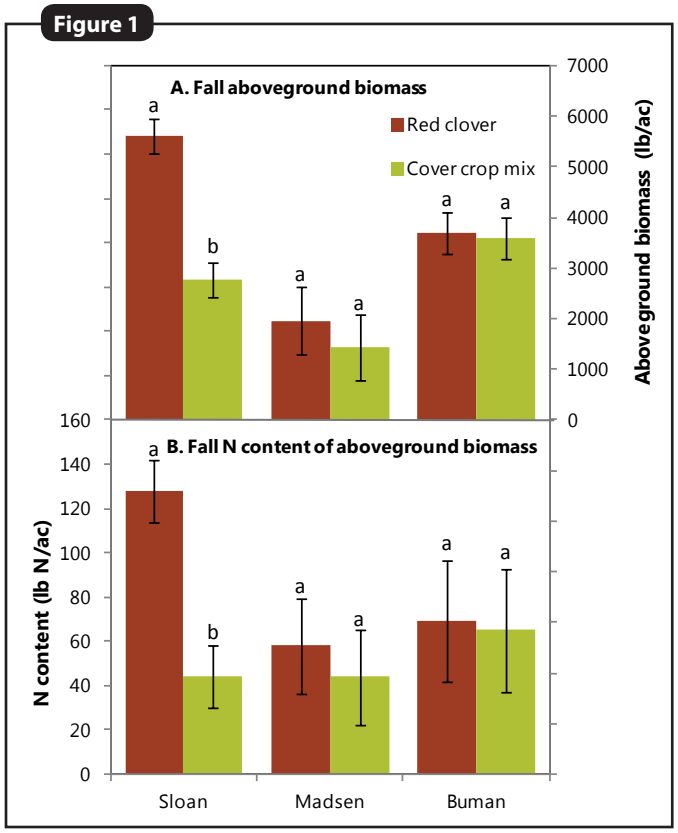

Figure 1. Mean aboveground biomass (A) and N content (B) of red clover and the cover crop mix observed at the farms in Nov. 2013. By panel and farm, columns with different letters above them are significantly different. Black bars about the means represent the least significant difference between treatments at each farm (Biomass: Sloan LSD = 693 lb/ac; Madsen LSD = 1,325 lb/ac; Buman LSD = 831 lb/ac; N content: Sloan LSD = 28 lb N/ac; Madsen LSD = 43 lb N/ac; Buman LSD = 55 lb N/ac).

mentioned that this was the first corn field he planted in 2014 and noticed that the soil was loose and very mellow which likely resulted in the corn getting planted too deep, thus, negatively affecting yields. As an organic farmer, Vic relies solely on biological forms of N like decomposing plant matter and manure to feed his crops. Using tillage to terminate the red clover and cover crop mix, Vic likely sufficiently prevented either from becoming weeds to his corn. There is also evidence that terminating green manure cover crops with tillage encourages faster decomposition of the residue and release of N to the succeeding cash crop (Gaudin et al., 2013). The red clover and cover crop mix at Vic's farm produced the least amount of aboveground biomass and N among all farms (**Figure 1**). It is conceivable that with better growing conditions in 2013 (with particular respect to rainfall after wheat harvest), the red clover and cover crop mix would have put on more growth and contributed more N to the system, thus resulting in greater corn yields than Vic observed in 2014.

Bill Buman saw no difference between yields of corn following red clover or the cover crop mix (**Figure 2**). Mean yield across treatments was 188 bu/ac which is greater than the 10-year corn yield average for Shelby County of 171 bu/ac (USDA-NASS, 2014). Bill's yields were also greater than those of Dick's and Vic's. Bill's red clover and cover crop mix aboveground biomass and N content were intermediate to Dick's and Vic's (**Figure 1**). Bill did not report any difficulties terminating the red clover or cover crop mix and the LSNT results were approximately twice than those at Dick's (14.5 vs. 7.5 ppm). It is conceivable that with better termination and planting conditions than at Dick's farm, the N in the red clover and cover crop mix became plant-available more in

Figure 2

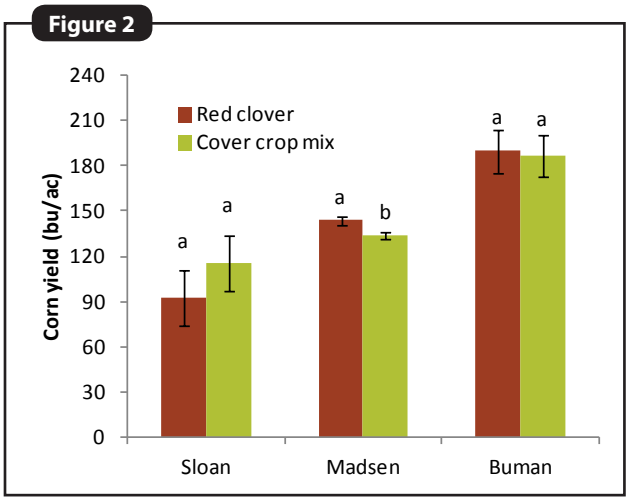

Figure 2. Mean yields of corn following red clover and the cover crop mix at the farms, harvested in Nov. 2014. By farm, columns with different letters above them are significantly different. Black bars about the means represent the least significant difference between treatments at each farm (Sloan LSD = 37 bu/ac; Madsen LSD = 5 bu/ac; Buman LSD = 28 bu/ac).

Dick Sloan planting corn into red clover that had recently been terminated in May 2014.

sync with the corn at Bill's farm. The only problem Bill reported in 2014 was that his corn sustained considerable hail damage from a storm in June that reduced yields below 200 bu/ac, which is what he would normally expect on his farm.

Conclusion and Next Steps

Farmer-cooperators compared corn yields following red clover and cover crop mix green manures established during the small grain phase of their crop rotations. Red clover frost-seeded with the small grain put on more aboveground biomass and contained more N than the cover crop mix seeded after small grain harvest at Dick Sloan's farm. Corn yields following red clover were greater than those following the cover crop mix at Vic Madsen's organic farm. At Bill Buman's farm, corn yields following either green manure were equivalent.

Dick Sloan saw very low corn yields but admitted that this was his first attempt at such a crop rotation and that "this was my practice field." Dick credits the low corn yields in 2014 to "late planting into too tall clover" and receiving his LSNT results too late from the lab to make the necessary side-dressings of N fertilizer. On a positive note, Dick did have very good late-season weed control in 2013 after rye harvest with the red clover compared to the cover crop mix. Not giving up, he looks forward to another round of this study as he planted strips of frost-seeded red clover and seeded the cover crop mix in his winter rye field again in 2014 and will plant corn in 2015.

Vic Madsen saw better corn yields where corn followed red clover compared to the cover crop mix seeded after wheat harvest in 2013. Vic did not have much luck with the red clover or cover crop mix putting on much aboveground growth and credits this to very little rainfall following wheat harvest in July 2013. This resulted in weedy patches and less N produced by the green manures than at the other farms.

Bill Buman saw the greatest corn yields among all three farms. Bill did note that a hail storm in June 2014 resulted in shredded leaves that reduced corn yields below his farm average but yields were still above the 10-year county average. Sufficient rainfall for green manure establishment and growth in Summer 2013 coupled with good conditions for termination in Spring 2014 were likely the cause for Bill's decent corn yields.

An economic analysis of extended crop rotations that contain small grains and green manures is to follow including additional farmer-cooperators conducting similar on-farm trials.

References

Blackmer, A. and A. Mallarino. 1996. Cornstalk testing to evaluate nitrogen management. PM 1584. Iowa State University Extension, Ames, IA.

Blackmer, A., R. Voss, and A. Mallarino. 1997. Nitrogen fertilizer recommendations for corn in Iowa. PM 1714. Iowa State University Extension, Ames, IA.

Gailans, S. and S. Carlson. 2013. Interseeding winter rye with red clover. Practical Farmers of Iowa Cooperators' Program. Ames, IA. http://practicalfarmers.org/farmer-knowledge/research-reports/2014/interseeding-winter-rye-red-clover/ (accessed Dec. 1, 2014).

Gaudin, A., S. Westra, C. Loucks, K. Janovicek, R. Martin, and W. Deen. 2013. Improving resilience of northern field crop systems using inter-seeded red clover: A review. Agronomy. 3:148-180.

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, Ames, IA. http://www.nutrientstrategy.iastate.edu/ (accessed Aug. 20, 2014).

Iowa Environmental Mesonet. 2014. Climodat Reports. Iowa State University, Ames, IA. http://mesonet.agron.iastate.edu/climodat/ (accessed Nov. 21, 2014).

Miguez, F. and G. Bollero. 2005. Review of corn yield response under winter cover cropping systems using meta-analytic methods. Crop Sci. 45:2318-2329.

Sullivan, P. 2003. Overview of cover crops and green manures. NCAT-ATTRA. Fayetteville, AR.

US Department of Agriculture-National Agricultural Statistics Service. 2014. Quick stats. USDA-National Agricultural Statistics Service, Washington, DC. http://quickstats.nass.usda.gov/ (accessed Nov. 22, 2014).

Vyn, T., J. Faber, K. Janovicek, and E. Beauchamp. 2000. Cover crop effects on nitrogen availability to corn following wheat. Agron. J. 92:915-924.

PFI Cooperators' Program

PFI's Cooperators' Program gives farmers practical answers to questions they have about on-farm challenges through research, record-keeping, and demonstration projects. The Cooperators' Program began in 1987 with farmers looking to save money through more judicious use of inputs. If you are interested in conducting an on-farm trial contact Stefan Gailans @ 515-232-5661 or stefan@practicalfarmers.org.