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Field Crops Research

Effect on corn of green manure cover crops established with cereal rye seed crop

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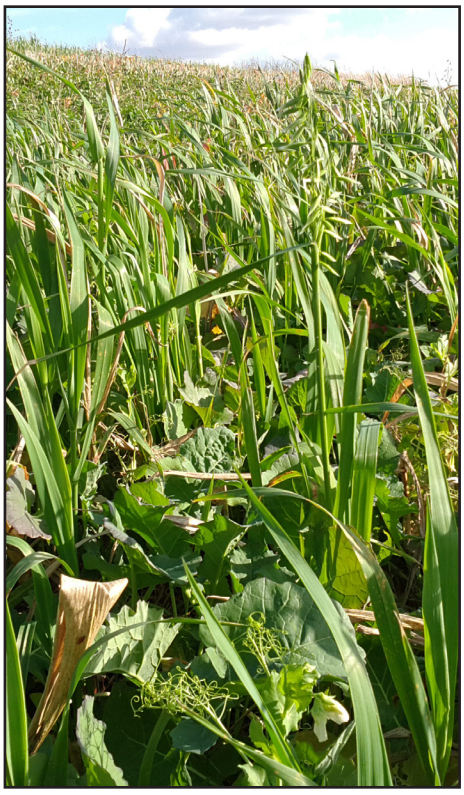
In a Nutshell

- Green manure cover crops best fit into extended and diversified crop rotations between the small grain and corn phases of the rotation.
- Farmer-cooperator Wade Dooley compared corn following two green manure strategies: a red clover + sweet mix interseeded with a cereal rye seed crop vs. a mix of oats + sorghum-sudangrass + peas + rapeseed mix established after cereal rye seed harvest.

Key Findings

- The two green manure mixes produced similar amounts of biomass and N.
- Corn yields were greater by nearly 30 bu/ac following the clover mix (corn in both treatments received 100 lb N/ac as purchased N fertilizer).
- Financial returns on investment per acre were greater by $123.90 with the clover mix treatment.

Project Timeline
2015-2016



Red clover + sweet clover on Apr. 15, 2016 (left) and oats + sorghum-sudangrass + peas + rapeseed green manure mixes on Nov. 6, 2015.

Background

Including a small grain such as cereal rye into a cropping system offers the opportunity to also seed a green manure cover crop comprised of legumes. These cover crops can either be interseeded with the cereal rye or seeded after cereal rye harvest in July. In both instances, the cover crops grow in the field for the remainder of the growing season with ample time for biological N fixation. Recent on-farm research conducted by Practical Farmers has shown the promise of green manures established with small grain crops ahead of corn. In 2015, PFI farmer-cooperator Dick Sloan compared red clover interseeded to cereal rye and a mix of legumes and brassicas he seeded following rye harvest. The corn following red clover out-yielded the mix (209 vs. 186 bu/ac) but Dick did accomplish these yields with only 100 lb N/ac of purchased N fertilizer applied (Gailans and Sloan, 2015). Moreover, several university researchers from the Upper Midwest have shown that using clovers established with small grain crops can substantially reduce the amount of N fertilizer necessary for a succeeding corn crop in rotation (Vyn et al., 2000; Liebman et al., 2012; Gaudin et al., 2013). With this work in mind, Wade Dooley wanted to investigate mixes of green manures seeded with or after harvest of a cereal rye seed crop in the summer ahead of his next corn crop.

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. Dooley lists gaining knowledge, improving soil quality and improving profitability as goals for this on-farm project.

Methods

This study was conducted by Wade Dooley near Albion in Marshall County in central Iowa.

Treatments included a red clover + sweet clover mix (clover mix) interseeded with cereal rye and an oats + sorghum-sudangrass + peas + rapeseed mix (OSPR mix) seeded following cereal rye harvest. In both instances, the seed was drilled. Treatments were replicated five times in randomized strips measuring 30 ft wide and 1,100 ft long. Management of the mixes and the corn is presented in **Table 1**.

Table 1

Green manure mix and corn management at Wade Dooley's in 2015 and 2016.

	Clover mix	OSPR mix
Green manure seeding date	Apr. 4, 2015	Early Aug., 2015
Green manure seeding rates	Red clover (8 lb/ac) Sweet clover (8 lb/ac)	Oats (60 lb/ac) Sorghum-Sudangrass (15 lb/ac) Field peas (75 lb/ac) Rapeseed (2 lb/ac)
Green manure termination date	Apr. 16, 2016	Apr. 16, 2016
Corn planting date	May 6, 2016	May 6, 2016
Corn planting population	33,000 seeds/ac	33,000 seeds/ac
Total N rate	100 lb/ac	100 lb/ac
Corn harvest date	Oct. 13, 2016	Oct. 13, 2016

Dooley collected aboveground biomass of the cover crop mixes from each field on Nov. 19, 2015 prior to the onset of winter dormancy and again on April 14, 2016 just prior to termination and planting corn. Biomass samples were collected by clipping all aboveground shoot and leaf material from two quadrats (1 ft x 1 ft) randomly placed in each strip. 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 Sharpen+Harness Xtra+atrazine+Roundup PowerMax. Corn was no-till planted in both fields a few weeks later. Balance Flexx+atrazine was applied within one week of planting for weed control. UAN(32%) was included as a carrier for both the green manure burn down and weed control after corn planting. Total N rate was 100 lb N/ac as a result.

In early June, Wade 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.

Corn was harvested from the middle six rows of each 12-row strip individually and corrected for 15.5% moisture.

Data were analyzed using JMP Pro 12 (SAS Institute, Inc., Cary, NC). 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.

Results and Discussion

Mean monthly temperature and total monthly rainfall near Dooley's farm compared to the long-term averages is presented in **Figure 1**. Rainfall in August and September 2015 was adequate for establishing the OSPR mix following cereal rye seed harvest in July of that year. Mostly mild winter 2015-16 conditions were sufficient for the clovers and the peas and rapeseed in the OSPR mix to successfully overwinter. Total growing degree-days (base 50 ˚F) for the period of April 1-October 31, 2016 were 3,710 compared to the long-term average of 3,035 at Marshalltown near Dooley's farm (Iowa Environmental Mesonet, 2017).

Figure 1

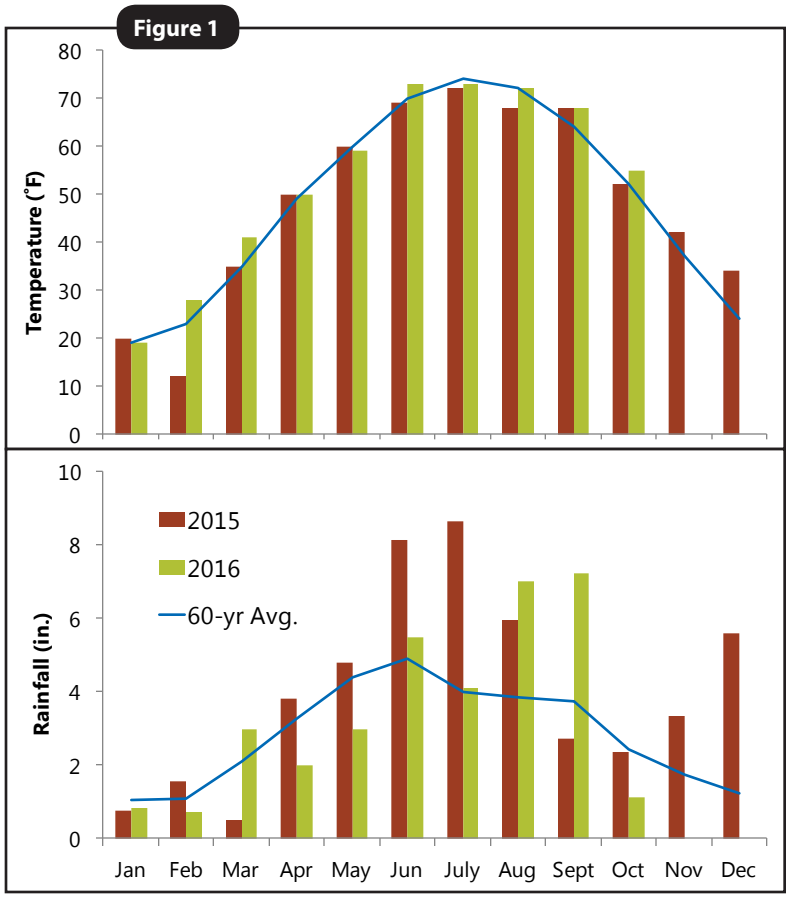


Figure 1. Mean monthly temperature and rainfall for the period Jan. 2015–Oct. 2016 and the 60-year averages at the Marshalltown weather station (approx. 9 mi. from Dooley's; Iowa Environmental Mesonet, 2016).

Table 2

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

		Clover mix	OSPR mix	Diff.	LSD (0.05)
Nov. 19, 2015	Biomass (lb/ac)	2,793	3,210	417	1,994
	C content (lb C/ac)	1,121	1,273	52	766
	N content (lb N/ac)	59	67	8	45
	C:N ratio	19.0	19.6	0.6	5.6
Apr. 14, 2016	Biomass (lb/ac)	743	804	61	297
	C content (lb C/ac)	335	311	24	116
	N content (lb N/ac)	24	22	2	9
	C:N ratio	12.9	15.7	2.8	2.5

The least significant difference (LSD) is provided for each characteristic as generated by a t-test ($P \leq 0.05$). If the difference between the two treatments is greater than the LSD, then the two treatments are considered significantly different with 95% certainty.

Green manure cover crop biomass

Fall and spring aboveground biomass characteristics are presented in **Table 2**. There were no differences in biomass produced or C and N contents between the two green manures. The C:N ratio of the clover mix was significantly less than that of the OSPR mix just prior to termination in April 2016. Lower C:N ratios will result in more rapid breakdown and release of nutrients to the soil. The C:N ratios for both mixes do fall within the range suitable (<25) for microbial decomposition and release of N to a succeeding cash crop given ideal conditions (Sullivan, 2003).

Dooley noticed some differences in weed pressure among the treatment strips in the summer of 2015. "Thanks to the existing ground-cover provided by the clover mix at rye harvest, the late summer weeds were nearly non-existent. In the post-harvest seeded plots (OSPR), there was a noticeable increase in weed pressure. Some of those weeds were able to go to seed, adding to the seed bank."

Figure 2

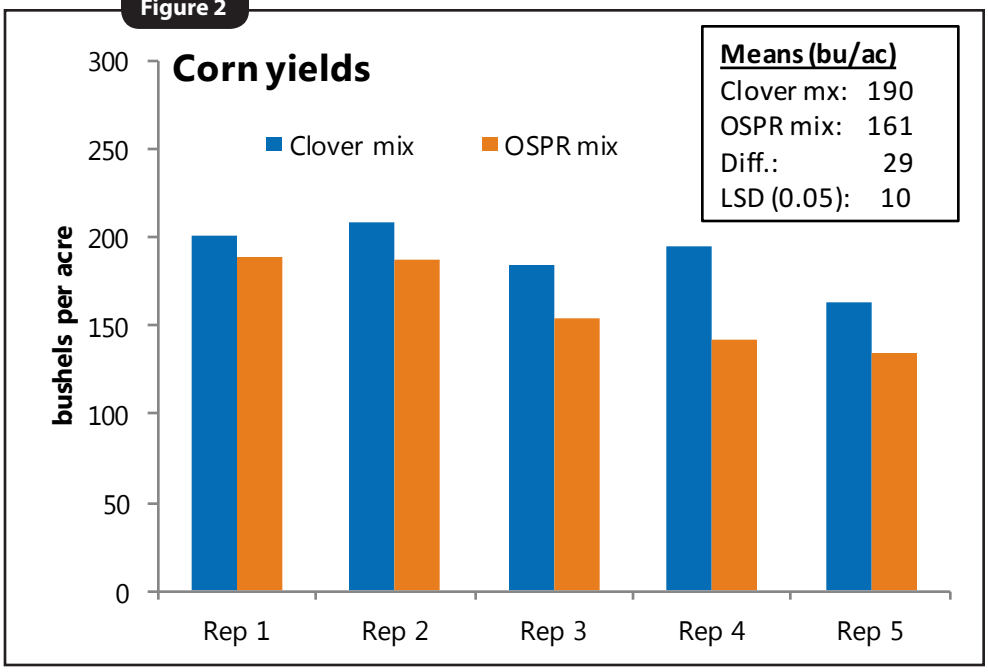


Figure 2. Corn yields for the clover mix and oats+sorghum-sudangrass+peas+rapeseed (OSPR) mix treatments from each Rep at Wade Dooley's in 2016. Mean yields and the least significant difference (LSD) at the $P \leq 0.05$ level are indicated in the inset table. Because the mean difference is greater than the LSD, the treatments are considered different with 95% certainty.

Corn year

After corn had emerged and was six to eight inches tall, Dooley conducted the LSNT by collecting soil samples from strips to determine the nitrate concentration of the soil in early June 2016. Results for both treatments came back >20 ppm which indicates an adequate level of nitrate-nitrogen in the soil for corn at this stage following forage legumes in rotation (Blackmer et al., 1996). The test signaled to Dooley that he did not have to side-dress any supplemental N fertilizer.

Corn yields for each rep are presented in **Figure 2**. The corn that followed the clover mix consistently out-yielded the corn that followed the OSPR mix across the field. The clover mix provided nearly a 30 bu/ac yield advantage over the OSPR mix. Yields resulting from the clover mix (190 bu/ac) were greater than the 10-year average for Marshall County of 179 bu/ac (USDA-NASS, 2017). "Making a corn yield of 190 bu/ac with only 100 lb N/ac applied is incredible!" Dooley says. Recall that corn in both treatments received only 100 lb N/ac near the time of planting (**Table 1**). Other PFI farmer-cooperators have shown the ability of clover green manures established with small grains crops to reduce the amount of purchased N fertilizer required for corn in recent on-farm trials (Gailans and Sieren, 2014; Gailans and Sloan, 2015).

Table 3

Partial budget comparing costs and returns on investment (ROI) between the two green manure treatments at Wade Dooley's in 2016.

Clover mix		**OSPR mix**	
Costs	*$/ac*	*Costs*	*$/ac*
Red clover seed (8 lb/ac @ $1.84/lb)	$14.72	oats (60 lb/ac @ $0.19/lb)	$11.40
Sweet clover seed (8 lb/ac @ $2.84/lb)	$22.72	sorghum-sudangrass (15 lb/ac @ $1.04/lb)	$15.60
		field peas (75 lb/ac @ $0.28/lb)	$21.00
		rapeseed (2 lb/ac @ $2.70/lb)	$5.04
TOTAL COSTS	$37.44	TOTAL COSTS	$53.04
Returns	*$/ac*	*Returns*	*$/ac*
Corn (190 bu/ac @ $3.75 /bu)	$712.05	Corn (161 bu/ac @ $3.75 /bu)	$603.75
RETURNS - COSTS (ROI)	$712.05 - $37.44 = **$674.61**	RETURNS – COSTS	$603.75 - $53.04 = **$550.71**

Seed costs were provided by Dooley. Corn price was accessed from the CME Group on Feb. 13, 2017.

Economic considerations

A partial budget was constructed to compare the costs and returns on investment (ROI) of the two green manure treatments Dooley investigated (**Table 3**). The partial budget only considers the differences between the two scenarios: cost of clover vs. OSPR mix seed and resulting corn yields. Both the clover and OSPR mixes were drilled and terminated in the same manner. The costs of planting, fertilizing, protecting and harvesting the corn are equivalent between the two scenarios and as such are not considered in the partial budget. A corn price of $3.75/bu on Feb. 13, 2017 was used in the analysis (CME Group, 2017).

The clover mix cost Dooley $15.60 less per acre than the OSPR mix. When factoring in the greater corn yield (**Figure 2**) and revenue generated from the clover mix treatment, Dooley comes out ahead by $123.90 per acre on the investment. In the previous year, farmer-cooperator Dick Sloan, of Rowley, found a similar ROI benefit to interseeding clover to a small grain in early spring compared to a summer-seeded mix following small grain harvest (Gailans and Sloan, 2015). Both Dooley and Sloan reaped these benefits with only 100 lb N/ac of purchased N fertilizer applied to their corn in these experiments.

Conclusions and Next Steps

Farmer-cooperator Wade Dooley compared corn yields following a red clover + sweet mix interseeded with a cereal rye seed crop and a mix of oats + sorghum-sudangrass + peas + rapeseed (OSPR) mix established after cereal rye seed harvest. Though the two mixes appeared to produce the same amount of biomass and N in their aboveground portions (**Table 2**), corn following the clover mix was far superior in terms of yield (**Figure 2**) and financial ROI (**Figure 3**).

"Interseeding a clover mix into rye in the spring is not as convenient for me as seeding a cover crop after rye harvest. The workload in July and August is much lower than in late March," Dooley says. "However, it is obvious the available N and superior weed control of that interseeding out-weigh the inconvenience."

Given recent PFI farmer-cooperator success with interseeding (or frost-seeding) clover to a winter small grain in early spring, this practice appears to be a verified go-to green manure cover crop ahead of corn.

Dooley admits that he was hoping that a post-harvest cover crop, like the OSPR mix, would provide as much N for the succeeding corn as the clover interseeding. "This would have allowed me more options for cover crops while keeping corn yields at decent levels," he says, pointing to the fact that an August seeding time does present farmers with several cover crop options. "But because of this trial, I'm going to interseed clover into rye going to corn, and use post-harvest seeded covers going to soybeans."

Wade Dooley harvesting corn from the experimental strips on Oct. 13, 2016.

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