PRACTICAL farmers of Iowa

Field Crops Research

Underseeded vs. Mid-Summer-Seeded Green Manures for Corn

Staff Contact:

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

Web Link:

http://bit.ly/pfi_fieldcrops

Cooperator:

- **Doug Alert & Margaret Smith - Hampton**
- **Vic Madsen - Audubon**
- **David Weisberger and Mary Wiedenhoeft - ISU, Ames**

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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. They can either be underseeded with a small grain crops in early spring or planted in the summer following small grain harvest.
- Farmer-cooperators Doug Alert & Margaret Smith and Vic Madsen compared corn following two green manure strategies: red clover or alfalfa underseeded with oats (US) vs. a mix of sunn hemp, sweet clover, red clover and radish planted in mid-summer after oat harvest (MSS).

Key Findings

- Weed biomass in oats in mid-July was no different with or without the underseeding at both farms.
- By mid-October 2016, the US (red clover) produced more aboverground biomass than the MSS by almost 1,000 lb/ac at Alert/Smith's. The opposite was true at Madsen's: the MSS produced more biomass than the US (alfalfa) by approx. 800 lb/ac.
- Corn yields were no different between the two green manure treatments at both farms.

Project Timeline
2016-2017

Alert comparison: The mid-summer-seeded cover crop mix (on left) and the underseeded red clover (on right) at Doug Alert and Margaret Smith's farm on Oct. 14, 2016. Photo courtesy of David Weisberger.

Background

Incorporating a small grain such as oats into a cropping system offers the opportunity to seed a green manure cover crop comprised of legumes. These cover crops can either be underseeded when the oats are planted or seeded after oat grain and straw 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 these trials, the farmers scored better corn yields by about 30 bu/ac when preceded by interseeded clover rather than a mid-summer-seeded mix (Gailans and Sloan, 2016; Gailans and Dooley, 2017). In both cases, the farmers applied only 100 lb N/ac of fertilizer and saw yields ranging from 190-209 bu/ac with the corn following the clover. Recent research in Pennsylvania also reported greater corn silage yields when following interseeded red clover (winter wheat) compared to green manures seeded after wheat harvest (Snyder et al., 2016). 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). Organic farmers are particularly interested in which strategy can provide the most nitrogen fertility but also sufficient weed suppression.

The objective of this research project was to quantify the agronomic effect on organic corn yields by green manure cover crops that are either 1) underseeded with oats or 2) seeded in mid-summer following oat harvest. This project was a continuation of on-farm trials started by David Weisberger (graduate student, Dept. of Agronomy, ISU) and Dr. Mary Wiedenhoeft (professor, Dept. of Agronomy, ISU) working with in collaboration with the Iowa Organic Association.

Methods

This study was conducted by Doug Alert & Margaret Smith near Hampton in Franklin County and Vic Madsen near Audubon in Audubon County. It began with the seeding of the green manures in 2016 (Weisberger et al., 2017) and continued in the 2017 corn year.

Treatments included two green manure strategies seeded in 2016: red clover or alfalfa underseeded with oats (US) vs. a mix of sunn hemp, sweet clover, red clover and radish planted in mid-summer after oat harvest (MSS). Treatments were replicated five times at each farm in randomized strips measuring 15-24 ft wide and 370-500 ft long. Management of the green manures and the corn is presented in **Table 1.** The corn at Alert/Smith's was originally planted on May 16, 2017 but had to be re-planted on May 31 due to a seed corn maggot infestation.

Aboveground biomass of weeds was collected just before oat harvest at both farms. Aboveground biomass of the green manures was collected just after a killing frost on Oct. 14, 2016 at Alert/Smith's and Oct. 16, 2016 at Madsen's. Biomass samples of weeds and green manures were collected by clipping all aboveground shoot and leaf material from five quadrats (5.3 ft2 ea.) randomly placed in each strip (Weisberger et al., 2017).

Corn was harvested from each strip individually in November 2017 at both farms and corrected for 15% 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.

Table 1

Green manure mix and corn management at Alert/Smith's and Madsen's in 2016 and 2017.

Farmer (location)	Alert/Smith (Hampton)	Madsen (Audubon)
Underseeding (lb/ac)	Red clover (12)	Alfalfa (12)
Underseeding date	Apr. 16, 2016	Apr. 2, 2016
Oat harvest date (swathing date)	Aug. 17 (Aug. 3)	July 26
Mid-Summer-Seeding (lb/ac)	Sunn hemp (3) Sweet clover (3) Red clover (3) Radish (2)	Sunn hemp (3) Sweet clover (3) Red clover (3) Radish (2)
Mid-Summer-Seeding date	Sept. 5	*Aug. 9*
Soil fertility amendments	Apr. 10, 2017: chicken manure, 3 t/ac; Apr. 27: potassium sulfate, 300 lb/ac	Dec. 1: turkey compost, 1.5 t/ac; May 31, 2017: chicken manure crumbles, 250 lb/ac
Green manure termination date, method	Apr. 27: tandem disk; May 15: soil finisher	Apr. 12: sweep chisel plow
Corn seedbed prep, pre-plant tillage	May 30: soil finisher x2	May 16: field cultivate; May 30: field cultivate
Corn planting date	May 31	May 31
Interrow cultivation	June 3: rotary hoe; June 6: rotary hoe; June 28-July 5: cultivation as rain permitted	June 10: rotary hoe; June 19: cultivation; July 3: cultivation
Corn harvest date	Nov. 21	Nov. 8

Figure 1

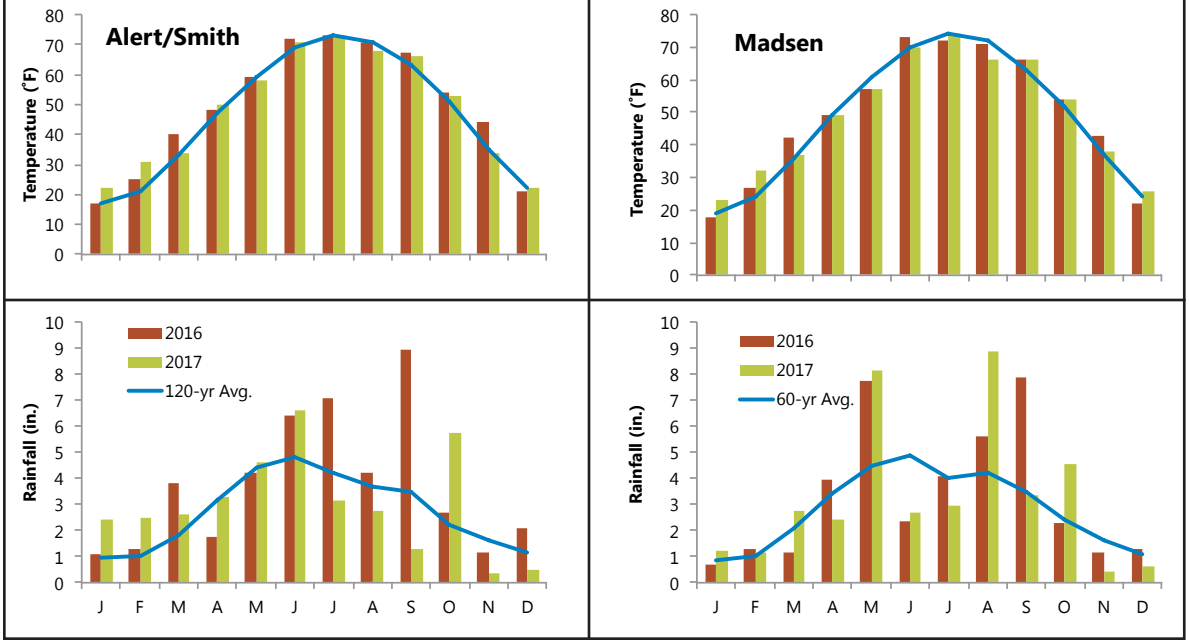

Figure 1. Mean monthly temperature and rainfall for 2016–Oct. 2017 and the long-term averages at the Hampton (Alert/Smith) and Audubon (Madsen) weather stations (Iowa Environmental Mesonet, 2018).

Results and Discussion

Mean monthly temperature and total monthly rainfall near Alert/Smith's and Madsen's farms compared to the long-term averages is presented in **Figure 1.** Rainfall in August and September 2016 was adequate for establishing the MSS green manure following oat harvest in July of that year at both farms. Temperatures were near-normal for fall and winter 2016 as well as spring 2017 to permit the survival and re-growth of green manures. Rainfall at Madsen's in 2017 was approximately half the normal in June and July but nearly twice the average for May and August.

Weed and green manure cover crop biomass

Weed biomass at the time of oat harvest in summer 2016 did not differ between the strips that were underseeded in the spring compared to those that were not underseeded (i.e., those strips eventually seeded with the MSS after oat harvest). At Alert/Smith's weed biomass was 196 lb/ac for the US vs. 113 lb/ac for the MSS; at Madsen's, weed biomass was 310 lb/ac for the US vs. 302 lb/ac for the MSS (Weisberger et al., 2017).

Green manure biomass in fall 2016 at Alert/Smith's was 1,152 lb/ac for the US vs. 190 lb/ac for the MSS; at Madsen's it was 508 lb/ac for the US vs. 1,299 for the MSS (Weisberger et al., 2017). Differences in MSS biomass between the two farms were probably most attributable to Alert/Smith's seeding date (Sept. 5) occurring a month later than Madsen's (Aug. 9) **(Table 1).** The majority of Madsen's MSS biomass was radish and volunteer oats. While these species have been shown to provide soil health benefits like erosion control and alleviating compaction, they do not provide atmospherically fixed nitrogen like clover, alfalfa or sunn hemp.

Corn yields

Corn yields at both farms did not differ between the two green manure strategies **(Table 2).** At Alert's the red clover US was disked in the spring to terminate it before mid May corn planting. Early in the season, Alert noticed a more uniform stand in the corn following the MSS than following the US. Seed corn maggots had laid eggs in the decaying biomass, and newly hatched larva affected germinating corn seeds in the US plots. Plant stands were so poor that the entire field was reworked and corn replanted on May 31. In previous Practical Farmers of Iowa on-farm trials, cooperators have observed superior corn yields with underseeded red clover compared to a summer-seeded mix of legumes, brassicas and grasses (Gailans and Sloan, 2015; Gailans and Dooley, 2017). Both of those studies saw equal amounts of biomass produced and N in the biomass between the underseeded red clover and the summer-seeded mixes. They were also conducted on conventional farms with 100 lb N/ac applied in a synthetic form.

Table 2

Corn yields (bu/ac) at Alert/Smith's and Madsen's in 2017

Treatment	Alert/Smith	Madsen
US[a]	223 a	162 a
MSS	219 a	171 a

[a] Red clover at Alert/Smith's; alfalfa at Madsen's.
[b] By farm, corn yields followed by the same letter are considered to not be significantly different with 95% certainty.

In the present study, yields at Alert/Smith's were well above the 5-year average for Franklin County of 180 bu/ac and yields at Madsen's were on par with the 5-year average for Audubon County of 171 bu/ac (USDA-NASS, 2018). "In spite of being on a field with a Corn Suitability Rating in the low 60s and mid-summer dry spell **(Figure 1)**, the corn didn't look too bad," Madsen said. "Certainly not 'Story County good' but okay for me."

Economic considerations

Costs associated with the two green manure strategies at both farms are presented in **Tables 3 and 4**. These cost tables only consider the differences between the two scenarios: cost of US seed vs. MSS seed and seeding. The cost of seeding the US was effectively $0.00 because this occurred in the same pass through the field as drilling the oats in April 2016 **(Table 1)**. On the other hand, a cost is assessed to seeding the MSS because this occurred as a separate pass through the field after the oats were harvested in mid- or late summer **(Table 1).** The costs of terminating the green manures as well as planting, fertilizing, protecting and harvesting the corn are equivalent between the two scenarios and as such are not considered in these tables. Because corn yields between the two green manure treatments were equivalent at both farms **(Table 2)** revenues generated are also not considered.

The US cost between $7.50-$11.10 less per acre than the MSS across the two farms. This difference in cost can be attributed to the additional pass through the field to seed the MSS as well as the greater seed cost associated with the MSS. Previous on-farm researchers have also documented cost savings ranging between $9.00-$15.00/ac when underseeding clover with a small grain compared to seeding a mix following small grain harvest in mid-summer (Gailans and Sloan, 2015; Gailans and Dooley, 2017).

Table 3

Partial budget comparing costs between the two green manure treatments at Doug Alert and Margaret Smith's.

Underseeding		Mid-summer-seeding	
Costs	*$/ac*	*Costs*	*$/ac*
Broadcast underseeding while drilling oats Red clover seed (12 lb/ac @ $2.20/lb)	$0.00 $26.40	Drill-seeding after oat harvest Sunn hemp (3 lb/ac @ $1.75/lb) Sweet clover (3 lb/ac @ $1.95/lb) Red clover (3 lb/ac @ 2.20/lb) Radish (2 lb/ac @ $1.85/lb)	$16.10 $5.25 $5.85 $6.60 $3.70
TOTAL COSTS	$26.40	TOTAL COSTS	$37.50

Cost of drilling cover crop accessed from Iowa Custom Rate Survey (Plastina et al., 2016). No cost was assessed to the underseeding because this occurred while drilling the oat crop in April 2016.
Seed costs were accessed from Green Cover Seed on Jan. 4, 2018.

Table 4

Partial budget comparing costs between the two green manure treatments at Vic Madsen's.

Underseeding		Mid-summer-seeding	
Costs	*$/ac*	*Costs*	*$/ac*
Broadcast underseeding while drilling oats Alfalfa seed (12 lb/ac @ $2.50/lb)	$0.00 $30.00	Drill-seeding after oat harvest Sunn hemp (3 lb/ac @ $1.75/lb) Sweet clover (3 lb/ac @ $1.95/lb) Red clover (3 lb/ac @ 2.20/lb) Radish (2 lb/ac @ $1.85/lb)	$16.10 $5.25 $5.85 $6.60 $3.70
TOTAL COSTS	$30.00	TOTAL COSTS	$37.50

Cost of drilling cover crop accessed from Iowa Custom Rate Survey (Plastina et al., 2016). No cost was assessed to the underseeding because this occurred while drilling the oat crop in April 2016.
Seed costs were accessed from Green Cover Seed on Jan. 4, 2018.

On left, red clover at Doug Alert and Margaret Smith's that was underseeded with oats on Apr. 16, 2016. On right, the mix of sunn hemp, sweet clover, red clover and radish (and volunteer oats) that was seeded on Sept. 5, 2016. Photo taken Oct. 14, 2016 courtesy of David Weisberger.

On left, alfalfa at Vic Madsen's that was underseeded with oats on Apr. 2, 2016. On right, the mix of sunn hemp, sweet clover, red clover and radish (and volunteer oats) that was seeded on Aug. 9, 2016. Photo taken Oct. 16, 2016 courtesy of David Weisberger.

Conclusions and Next Steps

Two farms compared corn yields following two green manure system established with a preceding oat crop. One green manure system involved underseeding red clover (Alert/Smith) or alfalfa (Madsen) with the oat crop. The other green manure system consisted of a mix of sunn hemp, sweet clover, red clover and radish seeded after the oats were harvested in mid-summer. At both farms, corn yielded similarly different between the two green manure treatments **(Table 2)**. In previous on-farm trials, however, the red clover underseeding has resulted in greater corn yields than a mid-summer mix (Gailans and Sloan, 2015; Gailans and Dooley, 2017). Given these contrasting findings, selection of a green manure cover crop (when establishing during the small grain year) likely will be determined by grower preference and end goals. For example, a mid-summer-seeded mix could serve as forage for grazing in the early fall in addition to being a green manure for the succeeding corn crop. This strategy is dependent on timely rains in July and August after seeding the summer mix. On the other hand, underseeding red clover or alfalfa while also seeding a spring small grain accomplishes two tasks in a single pass through the field and is less costly than a mid-summer-seeded mix.

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