PRACTICAL FARMERS OF IOWA
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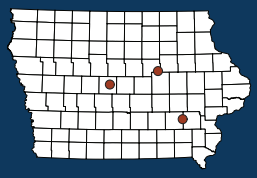

2018

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RESEARCH REPORT

No-till vs. Strip-till Corn and Soybeans Following a Cereal Rye Cover Crop

In a Nutshell:

- A successful management strategy for corn and soybeans following a cereal rye cover crop may differ across farms in terms of tillage, N fertilizer application or both.
- Farmer-cooperators Jack Boyer, Tim Sieren and Jeremy Gustafson compared no-till and strip-till when planting their corn or soybeans following a cereal rye cover crop.

Key Findings

- No-till and strip-till resulted in similar corn yields at Boyer's and similar soybean yields at Gustafson's. Compared to strip-till, Boyer scored greater returns by $28/ac and Gustafson scored greater returns by $1/ac with no-till.
- Boyer saw similar corn yields between two N fertilizer rates (150 and 190 lb N/ac) regardless of tillage.
- Strip-till resulted in greater corn yields (by 15 bu/ac) and returns (by $31/ac) at Sieren's compared to no-till.

Cooperators

Jack Boyer, Reinbeck
Tim Sieren, Keota
Jeremy Gustafson, Boone

Funding

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BACKGROUND

With proper management, a cereal rye cover crop can maintain, or improve, corn and soybean yields compared to when no cover crop is used.[1] Because cereal rye cover crops can result in early season soil and fertilizer N immobilization that can negatively affect crop yields, [2,3] proper management includes considerations for cover crop termination date and a sufficient N fertilizer program. On-farm research conducted by PFI cooperators Jack Boyer and Jeremy Gustafson has shown no yield penalty to soybeans that were planted directly into a living cereal rye cover crop that was terminated within the next few days.[4,5] Attempting the same approach with corn, PFI cooperators Dick Sloan and Tim Sieren saw corn yields reduced by 5–21 bu/ac compared to when the cover crops were terminated at least two weeks prior to planting the corn.[6,7] When a cereal rye cover crop is terminated two weeks prior to planting corn, research by PFI cooperators[7,8] and scientists at Iowa State University[9] suggests that higher N fertilizer rates are not required for optimal yields. Those studies found that applying the same amount of N fertilizer as one would with no cover crop resulted in similar corn yields. Finally, research in southeast Ontario found that equivalent corn yields can be achieved among full-width tillage, strip-till and no-till systems when a cereal rye cover crop is terminated two weeks prior to corn planting.[10] Costs among tillage regimes, however, can vary and farmers often wonder about the ultimate impact of tillage passes on returns on investment.

Objective: Determine the effect of no-till and strip-till on corn and soybean yields and economic returns when planting into a cereal rye cover crop. Jack Boyer also compared two N fertilizer rates and Tim Sieren also compared two side-dress N fertilizer application methods in addition to their comparisons of no-till and strip-till.

"I've been noticing higher yields when strip-tilling corn into rye cover crops," Sieren said about his motivation for conducting this trial. "I wanted to do a comparison with no-till to see just how much a difference there is in yield between the two." Boyer was curious to learn about any yield differences between no-till and strip-till as well. "Hopefully I can also learn if my N fertilizer rate can be reduced," he said.

At left, corn was no-till planted into a cereal rye cover crop. At right, corn was planted following as strip-till pass. Photo taken on Apr. 30, 2018 at Tim Sieren's.

METHODS

This study was conducted by Jack Boyer near Reinbeck in Tama County; Tim Sieren near Keota in Washington County; and Jeremy Gustafson near Boone in Boone County. All three cooperators seeded a cereal rye cover crop in Fall 2017 and evaluated the effect of no-till planting or strip-till planting on the succeeding cash crop in 2018. Boyer and Sieren planted corn; Gustafson planted soybeans.

The experimental design at Boyer's was a randomized complete block and the treatment arrangement was a split-plot. Main plot treatments were no-till and strip-till. Main plots were divided into two, side-by-side split-plots. The split-plot treatments were two N fertilizer rates: 150 and 190 lb N/ac (difference achieved at side-dress). Each main × split-plot treatment was replicated four times. The main plot treatment strips measured 30 ft wide and ran the length of the field. The experimental design at Sieren's was a randomized complete block with a split-plot treatment arrangement. Main plot treatments were no-till and strip-till. The split-plot treatments were two side-dress N application methods: coulter-injection and Y-drop. Each main × split-plot treatment was replicated four times. Regardless of side-dress

TABLE 1. Field operations at Jack Boyer's, Tim Sieren's and Jeremy Gustafson's in 2018.

FARM (LOCATION)	BOYER (REINBECK)	SIEREN (KEOTA)	GUSTAFSON (BOONE)
Cover crop	Cereal rye	Cereal rye	Cereal rye
Cover crop seeding date	Nov. 7, 2017	Oct. 26, 2017	Early September 2017
Cover crop seeding rate	61 lb/ac	60 lb/ac	56 lb/ac
Cover crop seeding method	Broadcast + incorporation with Great Plains turbochopper	Broadcast + incorporated with Phoenix rolling harrow	Aerial
Strip tillage date	Apr. 26, 2018	Apr. 13, 2018	Apr. 28, 2018
Cover crop termination date	May 5	May 8	May 12
Cover crop termination method	Gramoxone (2 qt/ac); Outlook (10 oz/ac); Atrazine 4L (32 oz/ac)	Trizmet II (2 qt/ac); Metolachlor (0.7 pt/ac); 2,4-D LV-6 (0.4 pt/ac); Glystar 5+ (32 oz/ac)	Roundup (32 oz/ac); Boundary (1.5 pt/ac); Sonic (2 oz/ac)
Cash crop	Corn	Corn	Soybeans
Planting date	Apr. 29	Apr. 30	May 12
Planting population	34,000 seeds/ac	35,000 seeds/ac	140,000 seeds/ac
N program	Apr. 29: 120 lb N/ac as anhydrous ammonia; May 5: 30 lb N/ac as UAN(28); June 1: 40 lb N/ac as anhydrous ammonia (high rate strips only)	Apr. 13: 90 lb N/ac as anhydrous ammonia (strip-till only); May 8: 79 lb N/ac as UAN(32) (no-till only); June 5: 67 lb N/ac as UAN(32) side-dressed to all strips with coulter injection or y-drops	--
Weed control	May 31: Impact (1 oz/ac); Atrazine (16 oz/ac); Roundup Powermax (32 oz/ac); Zaar (16 oz/ac)	May 31: Generic Callisto (3 oz/ac); ATZ 90 DF (0.5 lb/ac); Crop oil concentrate (1 pt/ac)	June 10: Flexstar GT (3.5 pt/ac); Fusilade (4 oz/ac)
Disease control	July 22: Headline (10 oz/ac)	--	--
Crop harvest date	Nov. 10	Oct. 4	Sept. 27

method, no-till strips received a total of 147 lb N/ac as fertilizer and strip-till strips received a total of 157 lb N/ac as fertilizer. Main plot treatment strips measured 20 ft wide and 894 ft long (0.4 ac each). The experimental design at Gustafson's was a randomized complete block with four replications. Treatments were no-till and strip-till. Each treatment strip measured 25 ft wide and ran the length of the field. Cover crop and crop management details for each farm are provided in **Table 1**.

Field sampling

Cover crop aboveground biomass samples were collected shortly before termination at the Sieren and Gustafson farms. Low amounts of cover crop growth precluded sampling at Boyer's.

Incidence of corn seedling disease was assessed in late May at Boyer's and Sieren's by Dr. Alison Robertson's lab team from the ISU Department of Plant Pathology and Microbiology. This assessment occurred before the split-plot treatments were established at either farm.

Soil samples were collected to a depth of 6-in. in mid-June at the Boyer and Sieren farms. Samples were sent to AgSource Laboratories (Ellsworth, IA) to determine the burst of CO_2-C following rewetting of dried soil using the Solvita assay. Corn stalk samples were collected for NO_3-N concentration analysis after the corn reached physiological maturity at Sieren's on Sept. 13.

Corn was harvested individually from each strip at Boyer's and Sieren's and corrected to 15.5% moisture. Soybeans were harvested individually from each strip at Gustafson's and corrected to 13% moisture.

Data were analyzed using JMP Pro 13 (SAS Institute Inc., Cary, NC) statistical software. Means separations are reported using Tukey's Least Significant Difference (LSD). Statistical significance was determined at the 95% confidence level.

TABLE 2. Incidence of corn seedling disease observed in late May at Boyer's and Sieren's in 2018.

FARM	NO-TILL	STRIP-TILL	DIFF.	LSD (0.05)
Boyer	43%	58%	15%	16%
Sieren	48%	43%	5%	28%

By farm, because differences between the treatment means is less than the least significant difference (LSD), the treatments are considered statistically equal with 95% confidence.

RESULTS AND DISCUSSION

Cover crop biomass

Air temperatures during the February–April period at all farms were below the long-term normal (**Figure A1**). This, along with a very dry April at each farm, likely contributed to low amounts of cover crop growth observed during the spring. As such, Boyer and Sieren terminated their cover crops approximately one week after planting corn (**Table 1**). Gustafson terminated his cover crop the same day he planted soybeans. Though Boyer did not collect samples, he estimated the cereal rye cover crop was approximately 4 in. tall at the time of termination. The average amount of cover crop biomass prior to termination at Sieren's was 348 lb/ac (eight days after planting corn). At Gustafson's, the average amount of cover crop biomass at termination was 832 lb/ac.

Corn seedling disease incidence

There was no difference in corn seedling disease incidence between tillage treatments at either farm (**Table 2**). Approximately half of all seedlings sampled at either farm showed signs of seedling disease (root rot) regardless of tillage. Planting corn into the strip-till zone

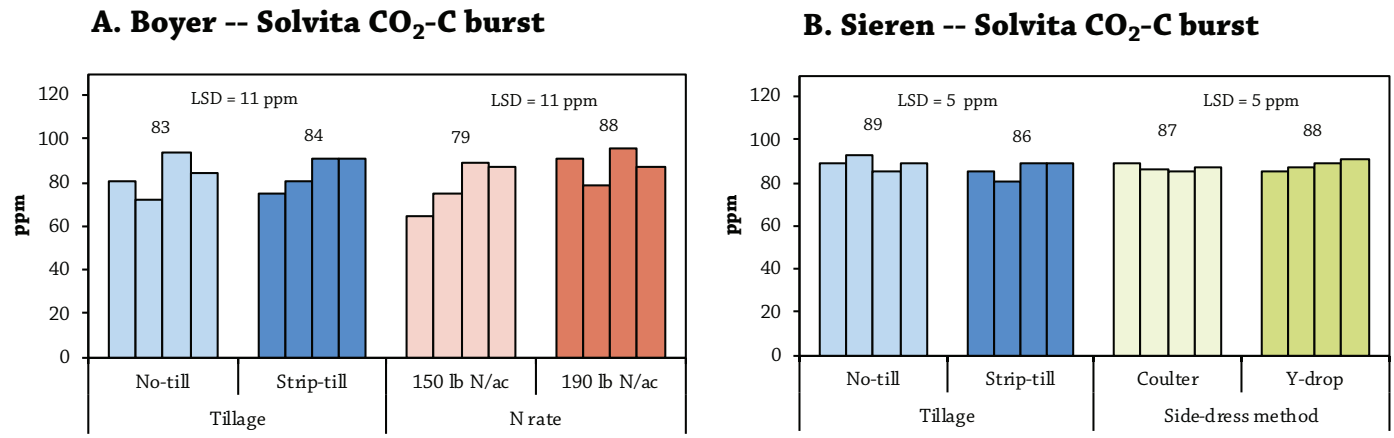

FIGURE 1. CO_2-C burst from the soil as determined by the Solvita assay in mid-June at **A)** Boyer's as affected by tillage and N rate and **B)** Sieren's as affected by tillage and side-dress method. Columns represent individual strip values. Above each set of columns is the treatment mean. By farm, because the differences between the treatment means is less than the least significant difference (LSD), the treatments are considered statistically equal at the 95% confidence level.

was hypothesized to reduce the likelihood of seedling disease following a cereal rye cover crop that has been documented in lab and field studies in Iowa.[11] Strip-till did not reduce the amount of seedling disease observed in the present study.

Solvita soil CO_2-C burst

The Solvita assay determines soil microbial activity by measuring the amount of CO_2-C respired over a 24-hour period from a dried soil sample that has been rewetted and held at an ideal temperature. Neither the tillage treatments at both farms nor the N rate at Boyer's or side-dress method at Sieren's had any effect on the CO_2-C soil burst (**Figure 1**).

Crop yields

Strip-till improved corn yields by 15 bu/ac at Sieren's, but tillage did not affect corn yields at Boyer's or soybean yields at Gustafson's (**Figure 2**). Nitrogen fertilizer rate had no effect on corn yields at Boyer's and side-dress method had no effect on corn yields at Sieren's. The total amount of N fertilizer applied at Sieren's differed between the strip-till and no-till main plot strips (157 and 146 lb N/ac, respectively). Corn stalk nitrate levels at Sieren's did not differ among treatments and fell into the "low" (<250 ppm) according to ISU Extension and Outreach.[12] This suggests that the corn in both tillage treatments could have benefited from more N fertilizer than Sieren applied.

Corn yields at Boyer's and Sieren's far exceeded their respective five-year county averages of 192 bu/ac and 195 bu/ac.[13] Soybean yields at Gustafson's fell below the five-year Boone County average of 52 bu/ac.[13] June through September was exceptionally wet at Gustafson's (**Figure A1**) and he noted substantial ponding in the field which may have reduced yield potential.

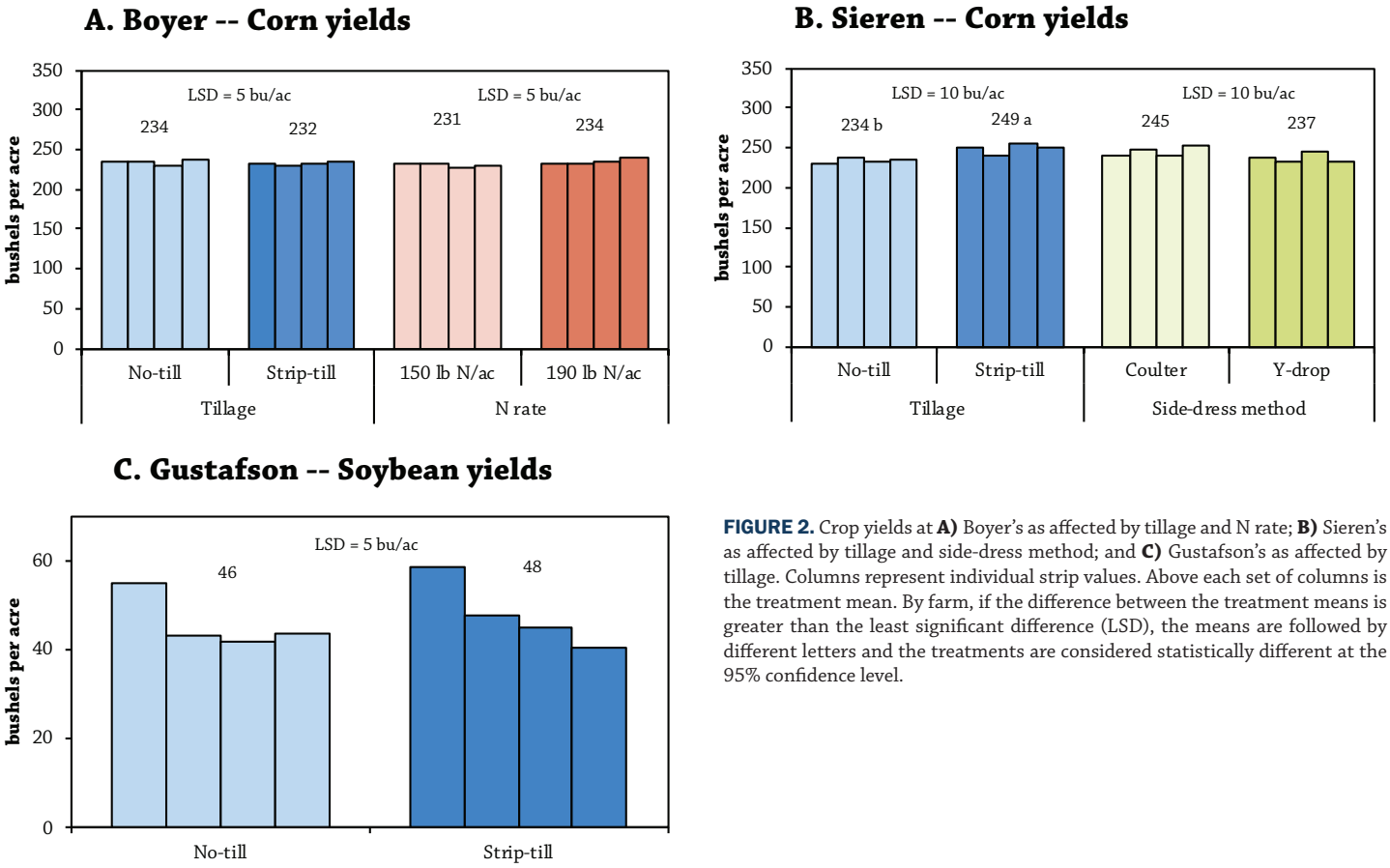

FIGURE 2. Crop yields at **A)** Boyer's as affected by tillage and N rate; **B)** Sieren's as affected by tillage and side-dress method; and **C)** Gustafson's as affected by tillage. Columns represent individual strip values. Above each set of columns is the treatment mean. By farm, if the difference between the treatment means is greater than the least significant difference (LSD), the means are followed by different letters and the treatments are considered statistically different at the 95% confidence level.

Economic analysis

Tables 3–5 provide partial budget summaries of the costs, receipts and returns on investment for the treatments at the three farms. Costs associated with cover crop seeding, cover crop termination, crop planting, in-season weed control, fertilizer application and crop harvest were incurred among all treatments and are thus not considered when calculating the returns on investment. Rather, only the costs that differed among the treatments at each of the three farms are considered in the partial budget summary tables. Because tillage did not affect yields at Boyer's or Gustafson's (**Figure 2**), strip-till reduced returns compared to no-till at both farms (**Tables 3 and 5**). At Boyer's, the high fertilizer rate (190 lb N/ac) also reduced returns as he saw no difference in corn yield between the two N fertilizer rates compared (**Figure 2A**). Greatest returns on investment at Boyer's were achieved with no-till and 150 lb N/ac (**Table 3**). Unlike at Boyer's and Gustafson's, however, strip-till improved yields at Sieren's (**Figure 2B**). The cost of strip tillage (and the additional 11 lb N/ac as anhydrous ammonia Sieren applied to that treatment) appears warranted at Sieren's as he saw returns increased by more than $31/ac in the strip-till treatment (**Table 4**). Though he applied an additional 11 lb N/ac to the strip-till treatment, N fertilizer costs were nearly identical between the tillage treatments at Sieren's. The corn yield improvement achieved with strip-till more than paid for the higher costs incurred in that treatment in Sieren's case.

TABLE 3. Partial budget comparing returns on investment among the treatments at Jack Boyer's in 2018.

	NO-TILL		STRIP-TILL	
COSTS ($/ac)[a]	**150 lb N/ac**	**190 lb N/ac**	**150 lb N/ac**	**190 lb N/ac**
Strip tillage	--	--	19.20	19.20
30 lb N/ac as UAN(28) with burndown	11.10	11.10	11.10	11.10
120 lb N/ac as anhydrous ammonia pre-plant	34.80	34.80	34.80	34.80
40 lb N/ac as anhydrous ammonia at side-dress	--	11.60	--	11.60
Tillage + N fertilizer	45.90	57.50	65.10	76.70
RETURNS				
Corn yield (bu/ac)	233	235	229	234
Corn price ($/bu)[b]	3.41	3.41	3.41	3.41
Yield × Price ($/ac)	794.53	801.35	780.89	797.94
ROI: Returns - Costs ($/ac)	748.63	743.85	715.79	721.24

[a] Strip tillage cost accessed from 2018 Iowa Farm Custom Rate Survey.[14] N fertilizer costs provided by Boyer.

[b] Corn price is the Iowa average for 2018 accessed from ISU's Ag Decision Maker.[15]

TABLE 4. Partial budget comparing returns on investment among the treatments at Tim Sieren's in 2018.

COSTS ($/ac)[a]	NO-TILL	STRIP-TILL
Strip tillage	--	19.20
90 lb N/ac as anhydrous ammonia with strip-till	--	29.64
79 lb N/ac as UAN(32) with no-till planting	29.66	--
67 lb N/ac as UAN(32) at side-dress	25.20	25.20
Tillage + N fertilizer	54.86	74.04
RETURNS		
Corn yield (bu/ac)	234	249
Corn price ($/bu)[b]	3.41	3.41
Yield × Price ($/ac)	797.94	849.09
ROI: Returns - Costs ($/ac)	743.08	775.05

[a] Strip tillage cost accessed from 2018 Iowa Farm Custom Rate Survey.[14] N fertilizer costs provided by Sieren.

[b] Corn price is the Iowa average for 2018 accessed from ISU's Ag Decision Maker.[15]

TABLE 5. Partial budget comparing returns on investment among the treatments at Jeremy Gustafson's in 2018.

COSTS ($/ac)[a]	NO-TILL	STRIP-TILL
Strip tillage	--	19.20
RETURNS		
Soybean yield (bu/ac)	46	48
Soybean price ($/bu)[b]	9.05	9.05
Yield × Price ($/ac)	416.30	434.4
ROI: Returns - Costs ($/ac)	416.30	415.20

[a] Strip tillage cost accessed from 2018 Iowa Farm Custom Rate Survey.[14]

[b] Soybean price is the Iowa average for 2018 accessed from ISU's Ag Decision Maker.[15]

CONCLUSIONS AND NEXT STEPS

This study evaluated the effect of no-till and strip-till on corn and soybeans when following a cereal rye cover crop. The three farmers involved wanted to know if corn or soybean yields, and returns on investment, could be improved with strip tillage in a cover crop system.

Strip-till both improved corn yields and returns at the Sieren farm only. Sieren suspected he was achieving better yields on his farm with strip tillage: "This trial confirmed the yield increases [I've been seeing on my farm] with my strip-till practices." Corn yields at Boyer's and soybean yields at Gustafson's, however, were no different between the no-till and strip-till treatments. At those two farms strip-till reduced returns; no-till proved the better system. Moreover, Boyer saw similar corn yields between two N fertilizer rates (150 and 190 lb N/ac). He credits this trial with helping him realize the opportunity to reduce crop input costs: "I believe that I can reduce N application and no-till plant corn without reducing yield." As a result of this project, Boyer and Gustafson plan to further expand their use of no-till when planting corn and soybeans, respectively, following a cover crop. Sieren, having achieved better yields and returns with strip-till, plans to try strip-till in more of his fields with cover crops to see if he can reap similar results as those he observed in 2018.

APPENDIX - WEATHER CONDITIONS

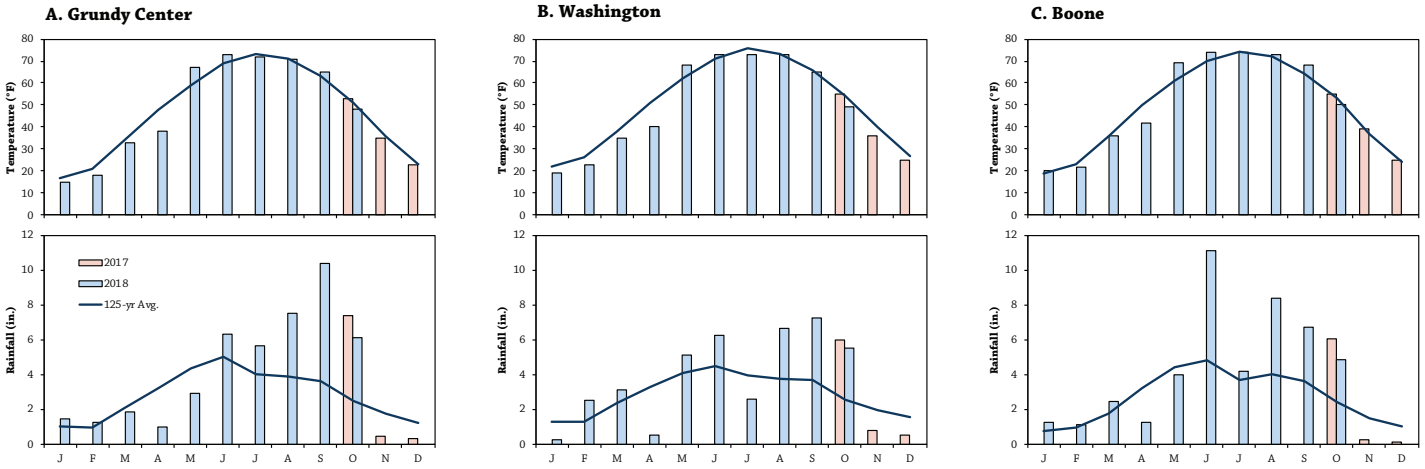

FIGURE A1. Mean monthly temperature and rainfall for Oct. 1, 2017 through Oct. 31, 2018 and the long-term averages at the nearest weather stations to each farm.[16] **A)** Grundy Center (Boyer, about 9 miles away); **B)** Washington (Sieren, about 9 miles away); **C)** Boone (Gustafson, about 2 miles away).

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PFI's Cooperators' Program gives farmers practical answers to questions they have about on-farm challenges through research 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.