Fact Sheet Series

19-1 NO-TILL SOYBEAN TRIAL 2018

Introduction

The organic cover crop-based rotational tillage cropping system trial was initiated in 2017 at the Arlington Agricultural Research Station. The trial is a four-year rotation including corn, soybean, fallow and a small grain (see Figure 1). Prior to our trial, the four 6-acre fields were the site of an organic soil-balance (Ca/Mg) fertility trial from 2006 through mid-2014, with a rotation of corn – soybeans - alfalfa/oats - alfalfa. The fields were under alfalfa from fall 2014 through 2016 and have been certified organic since 2009. Every field is split in twenty 450 ft long by 30 ft wide plots, allowing us to use 15 ft wide farming implements for our different treatments.

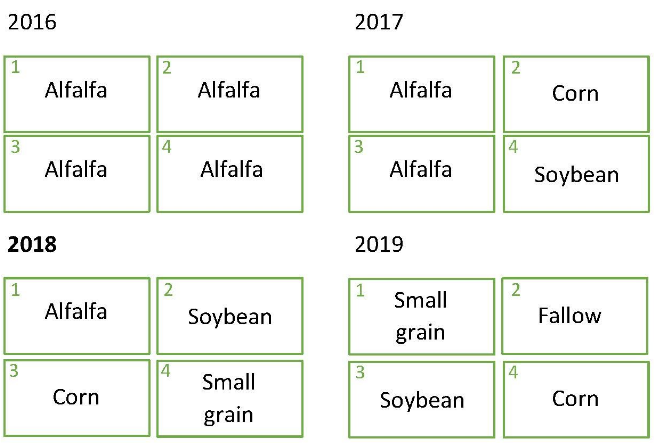

Figure 1 - Rotation on the 4 fields since 2016

Description of the trial

The field used for the 2018 no-till soybean trial was under alfalfa for 2 years before it was planted with corn in 2017. We harvested the corn for silage at the end of September 2017 and planted the cover crops on October 2, 2017. We applied 10,427 gals/ac of liquid manure in the fall of 2016 after termination of alfalfa. No fertilizer of any kind has been applied since then.

Climate

The diagram on Figure 2 shows the minimum and maximum temperature as well as the monthly rainfall from December 2017 until October 2018. Historic average temperature and precipitation values from 1971 to 2000 were found on the Wisconsin State Climatology Office's website (http://www.aos.wisc.edu/~sco/clim-history/stations/470308.html).

December, January and February were comparable to the 1971-2000 averages in terms of temperature and rainfall. March was drier than historical averages. The month of April was drier than historical averages, and the minimum temperature was cooler than usual. However, both minimum and maximum temperature in May were greater than historical averages. This temperature difference between early and late spring played a key role in rye biomass accumulation and maturity. For the remainder of the year, the temperatures were close to historic averages. In May, June, September and October the research station received more rainfall than usual.

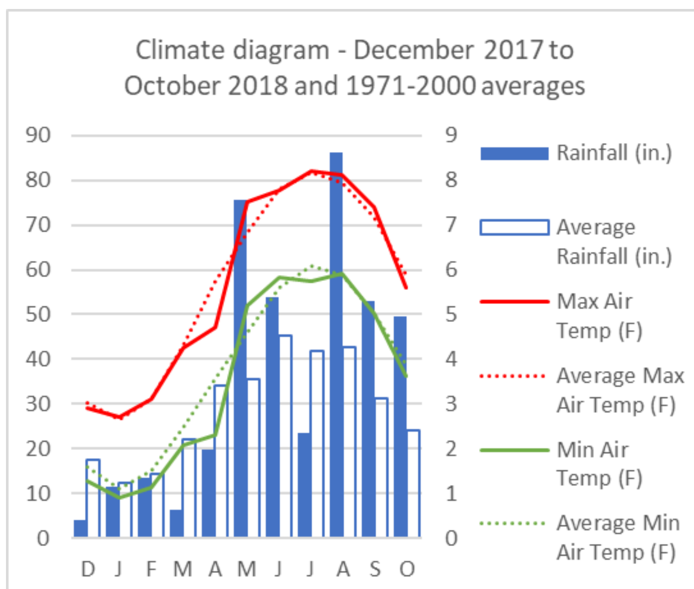

Figure 2 - Climate diagram

This publication is made possible by a grant from the USDA Beginning Farmer and Rancher Development Program. OGRAIN is a collaborative effort of the UW-Madison/UWEX Organic and Sustainable Cropping Systems lab, UW-Madison Center for Integrated Agricultural Systems (CIAS), Farm and Industry Short Course (FISC), and Midwest Organic and Sustainable Education Service (MOSES).

Organic and Sustainable Agriculture Research and Extension
DEPARTMENT OF PLANT PATHOLOGY
UNIVERSITY OF WISCONSIN–MADISON

Treatments

To optimize the organic no-till soybean production system, we modified four variables: cover crop varieties, soybean planting strategy into the cover crop, planting equipment (drill vs. planter), and different sets of closing wheel.

Whole plot factor – Cover crops
Every cover crop was planted at the same rate of 3bu/acre on October 2, 2017 and terminated at full cover crop anthesis independently of the soybean planting strategy. See figure 3 for roller-crimping dates.

- Two varieties of winter cereal rye: 'Aroostook' and 'Spooner'
- One variety of winter triticale: 'NE426GT'
- One variety of winter wheat: 'Emerson'
- No cover-crop

Mechanical weed control for the no cover treatment consisted of one pass with a tine weeder the day of or day after planting; two or three passes with a rotary hoe; and three to four passes with a row cultivator.

Sub plot factor 1 – Soybean planting strategy
Seeding rate for the soybeans ('Viking O.1706N', Albert Lea Seed) was 225,000 seeds/acre for each treatment. See calendar in Figure 3 for planting dates. Row spacing was 30" for the planter and 7.5" for the drill.

- Early planting (EP): the soybeans are "planted green" in the standing cover crop when it reaches boot stage
- Early drilling (ED): same timing as early planting but using a no-till drill
- Late planting (LP): the soybeans are planted in the rolled cover crop at the same time as rolling (optimal) or a few days later if soil and weather condition are not favorable

Sub plot factor 2 – Closing wheel
Applied to the late planted soybeans only, see Figure 4 for pictures.

One rubber, one 6200 Paddle™ (*Yetter farm equipment*)
One rubber, one Martin Spikes (*Martin-Till*)
One rubber, one M-Series Curvetine™ (*Dawn equipment*)

Figure 4 – Closing wheels used for the trial - from left to right - Yetter Paddle, Martin Spikes and Dawn Curvetine

Data collected

- Cover crop canopy cover
- Cover crop biomass
- Soybean stand count
- Soybean leaves and soil nutrient status prior to initial flowering (R1)
- Nodule count, vegetative stage, plant height and number of pods when seeds are just visible in pods (R5)
- Weed count and biomass on August 1st and September 21st
- Yields
- Cover crop tillering
- Volunteer cover crop the subsequent year

		May 24	May 29	June 4	June 6	June 11	June 14
Early Planting	Aroostook	P			C		
	Spooner	P			C		
	Control	P					
	Triticale		P			C	
	Wheat			P			C
Late Planting	Aroostook				PC		
	Spooner				PC		
	Control				P		
	Triticale					PC	
	Wheat						PC

P Planting **C** Crimping **PC** Planting and crimping

Figure 3 - Cover crop termination and soybean planting calendar

Results

Cover crop development

The percent of ground covered by the cover crop was measured every 5 to 7 days between the end of April and the end of May shortly before crimping the rye (Figures 5 and 6). The two varieties of rye performed similarly, resulting in greater ground coverage as compared to wheat. Triticale ground cover was inconsistent, potentially attributable to an uneven cover crop development through the fields due to winter injury. Drone photographs of the same trial were taken in 2017, where winterkilled triticale was easily identified. Overall, the linear regression of the triticale data shows that the ground covered by the triticale is more than the wheat and less than the rye cover.

Rye – 85%

Triticale – 85%

Wheat – 85%

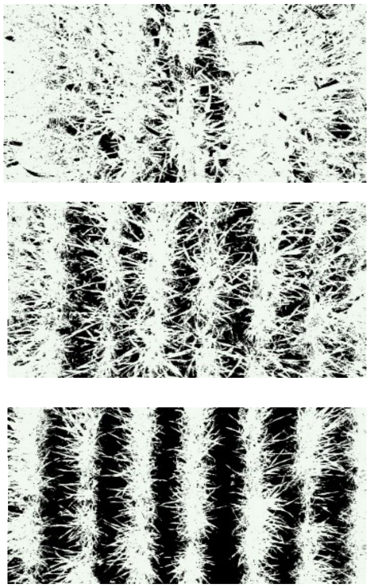

Figure 5 - Ground cover, May 16th – white shows cover or green, black shows ground or brown

Rye biomass in 2018 was much lower than historic values, with 5,892 and 5,466 pounds of dry matter/acre for Aroostook and Spooner respectively. Reviewing rye biomass data at Arlington over the last 4 years, amounts ranged from a low of 8,617 lbs DM/ac (2016) and to a high of 11,315 lbs DM/ac (2017) (Table 1). Comparing the different cover crop species, the wheat had the greatest biomass (6,188 lbs DM/ac) and the triticale biomass was similar to the two rye varieties (5,832 lbs DM/ac).

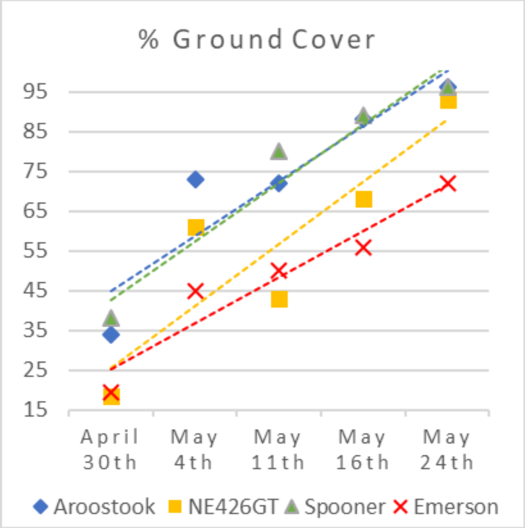

Figure 6 - % Ground cover provided by the different cover crops between April 30th and May 24th

However, no statistically significant differences were observed between the biomass of any of these cover crop species. When comparing the cover crop height before rolling, the trends were reversed – the rye was taller (52”) and both triticale and wheat were significantly shorter (31”).

Soybean development

Throughout the growing season, we collected data to monitor the soybean development. First, soybean establishment was assessed by counting the soybean plants. Just prior to flowering (R1 stage), trifoliate soybean leaves along with corresponding soil samples were sent to the UW Soil and Forage Analysis Lab for nutrient analysis. Finally, when the seed started to be visible in the pods (R5 stage), the number of trifoliate leaves, number of pods, plant height and number of nodules were recorded.

Soybean stand count

As shown by the soybean stand count data, the establishment was affected both by the cover crop and the soybean planting strategy (Figure 7, next page). The different closing wheels had no impact on the stand count. The late planted soybeans in bare ground showed the best establishment (183,667 plants/ac), while the early

	2014	**2015**	**2016**	**2017**	**2018**
Rye biomass (lbs of dry matter/acre)	9,203	10,567	8,617	11,315	5,679

Table 1 - Rye cover crop biomass before rolling for the 2014 - 2018 period in pounds of dry matter/acre

planted and early drilled soybeans into triticale had the poorest (103,583 and 96,416 plants/ac). The average stand count was 148,506 plants/ac, which represent 66% of the target seeding rate (225,000 seeds/ac).

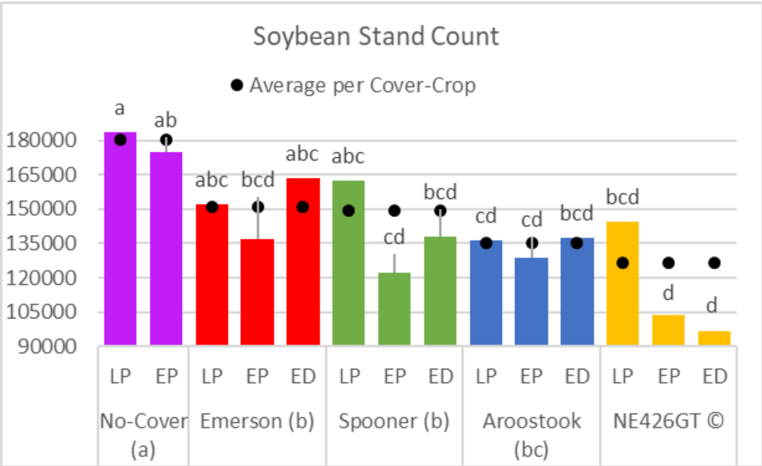

Figure 7 - Soybean Stand Count in plant/acre (p-value = 0.05)

Stand count per planting strategy

Late planted – 155,750 a

Early planted – 140,278 b

Early drilled – 133,685 b

The no cover, 'Emerson' wheat and 'Spooner' rye treatments averaged above 148,506 plants/ac while 'Aroostook' rye and 'NE426GT' triticale resulted in lower stand counts. Early planting and drilling soybeans resulted in significantly lower stand counts as compared to planting into the rolled cover crop (133,685 and 140,278 vs. 155,750 plants/ac).

Evaluating treatments individually, late- and early-planted without cover crops, late- and early-drilled soybeans into rolled-crimped wheat, and late-planted soybeans into 'Spooner' rye resulted in greater soybean stand counts as compared to all other treatments. However, it is important to note that the wheat cover crop was not effectively terminated by the roller crimper at anthesis – much of the stand began to regrow. Thus, the soybeans were established into a standing wheat cover crop as opposed to a flat, rolled cover crop mat in every other cover crop treatment.

Soybean growth at R5

In order to collect the data at the same stage (beginning seed formation, R5) for each treatment, data collection occurred on three different dates. On August 9th, we collected the data on the early-planted treatments: no-cover, rye and triticale. On August 15th, the early-planted wheat treatments as well as the late-planted control and rye treatments were measured. Finally, on August 22nd we finished the R5 data collection with the late-planted triticale and wheat treatments.

Soybean plant height, number of trifoliate leaves and number of pods/plant

Soybean plants grown in the early-planted no-cover treatment had the same number of trifoliate leaves (12) on July 9th (data not shown) and on August 9th (Table 2). Soybean plants grown in the early-planted no-cover treatments had fewer trifoliate leaves on July 9th (data not shown) but had developed the same number of trifoliate leaves (12) as the late-planted treatments on August 9th. Both cover crop treatment and soybean planting strategy had an impact on the number of trifoliate leaves (Table 2 & Figure 8).

On average, 19 trifoliates/plant were counted on the soybeans no-tilled into 'Aroostook' rye, which was significantly higher than the counts observed in the wheat, the triticale and no-cover treatments. The soybeans in the no-cover treatment had 12 trifoliate leaves/plant, which was the lowest number observed. While this was significantly lower than the number of trifoliates on the soybean no-tilled into both varieties of rye, it was not significantly lower than the number of trifoliates counted on the soybeans no-tilled into the wheat and the triticale.

Soybeans grown in the early-drilled treatments had more trifoliate leaves than the late-planted treatments, although not different from the two other planting strategies.

The soybeans in the early-planted 'Aroostook' rye treatments had significantly more leaves than all the other treatments except the early-drilled soybeans into 'Aroostook' rye and both the early-planted and early-drilled soybeans into 'Spooner' rye. The early- and late-

Cover-Crop Variety	Number of Pods/Plant	Plant Height (In)	Number of Trifoliate/ Plant
No Cover	50 ab	37 a	12 c
Aroostook	56 a	32 b	19 a
Spooner	49 ab	33 b	16 ab
Emerson	45 bc	25 c	15 bc
NE426GT	37 c	25 c	13 bc

Table 2 - Number of pods/plants, plants height in inches and number of trifoliate leaves/plants at R5 (R5= reproductive stage 5, characterized by the first appearance of seeds in the pods)

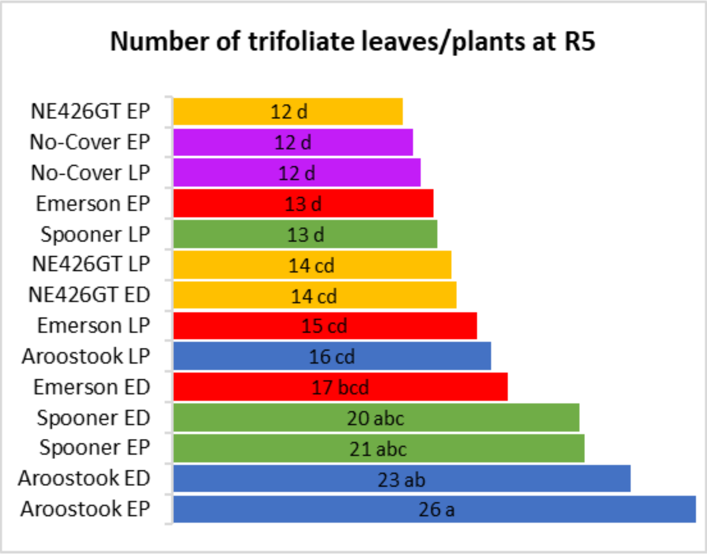

Figure 8 - Number of trifoliate leaves/plants at R5 (R5 = reproductive stage 5, characterized by the first appearance of seeds in the pods)

Number of trifoliate leaves per planting strategy -

Early drilled – 18 a

Early planted – 16 ab

Late planted – 14 b

planted no-cover treatments, the early-planted soybeans into triticale and wheat, as well as the late-planted soybeans into 'Spooner' rye, had the lowest number of leaves. However, statistically significantly fewer leaves were only observed in the early-drilled and planted soybeans into 'Aroostook' and 'Spooner'-rye.

The cover crop was the only variable which affected the number of pods/plants and the plant height (Table 2). The tallest plants (37 inches) occurred in the plots without a cover crop. Planting the soybeans into rolled rye resulted in plants between 32 and 33 inches tall, which is significantly taller than the ones planted into wheat or triticale (25 inches).

The soybeans planted into 'Aroostook' rye had the greatest number of pods (56 pods/plant); however, this value was not significantly greater than the number of pods found on the soybeans planted into bare ground or into 'Spooner' rye (50 and 49 pods/plants respectively). No-tilling the soybeans into triticale reduced the number of pods/plants to 37, which is significantly lower than all the other treatments except wheat at 45 pods/plants.

Nodule count

Soybean nodulation peaks when the plant is in the 5th reproductive stage (R5), the stage characterized by the beginning of seed formation in the pods (For more information, see the UW Extension webpage "Soybean Growth and Development", http://corn.agronomy.wisc.edu/Crops/Soybean/L004.aspx).

To count the number of nodules/plant, we dug 3 plants with their full rooting systems, brought them back to the laboratory, extracted and counted all the nodules found on the roots, and divided this number by 3 to get the average/plant.

Figure 9 - Pictures of soybean rooting systems extracted at R5 (beginning seeds) in order to count the nodules. On the left roots of no-tilled soybeans into rolled cover crop; on the right roots of soybeans planted into bare ground

Figure 9 shows the rooting system of a no-tilled soybean plant and the rooting system of a soybean planted into bare ground. While the no-tilled soybean plant was composed of a taproot, four or five secondary roots, and few fine roots, the soybean plants growing in bare ground had greater numbers of roots. This structural difference may be related to the difference observed in the number of nodules/plant (Table 3). The no-tilled soybeans had between 33 and 45 nodules/plant and the soybeans growing without cover significantly greater numbers at 86 nodules/plant.

Table 3 - Number of nodules/plants at R5 (beginning seeds)

	No Nodule/Plant
No Cover	86 a
Aroostook	45 b
Spooner	42 b
Emerson	41 b
NE426GT	33 b

In depth chemical analysis of soil and soybean leaves prior to R1 (initial flowering)

In early August, the status of eleven soybean leaf nutrients (nitrogen (Leaf N), phosphorus (Leaf P), potassium (Leaf K), calcium (Leaf Ca), magnesium (Leaf Mg), sulfur (Leaf S), zinc (Leaf Zn), manganese (Leaf Mn), boron (Leaf B), iron (Leaf Fe) and copper (Leaf Cu) and four soil properties: pH, % organic matter (% Soil OM), phosphorus (Soil P) and potassium (Soil K)) were measured.

The leaf's nitrogen content was the only nutrient measured that was only affected by the cover crop (Table 4). The soybeans with the highest leaf nitrogen content were the ones planted in 'Aroostook' rye. Their nitrogen content (5.5%) was significantly higher than that of the soybeans planted into triticale and bare ground. The soybeans planted into bare ground had the lowest nitrogen content (5.0%) and significantly less leaf N than the ones planted into both varieties of rye.

	% Leaf N
Aroostook	5.5 a
Spooner	5.4 ab
Emerson	5.2 abc
NE426GT	5.1 bc
Control	5.0 c

Table 4 - Soil and soybean leaves nutrient status only affected by the cover crop treatment. % Leaf N = % of nitrogen in the soybean leaves. p-value = 0.05

Six soybean leaf nutrients (phosphorus, calcium, manganese, boron, iron and copper) as well as the four soil properties measured were only impacted by the planting strategy (Table 5). Both the manganese and iron content in the leaves were greater in the early-planted soybeans (77.9 vs. 61.3 mg/kg and 125.7 vs. 80.9 mg/kg respectively). Similarly, three soil properties measured were greater in the early-planted plots. These plots had a higher percent of organic matter (4.8 vs. 3.5%), higher soil phosphorus (110 vs. 63 ppm) and higher potassium (191 vs. 106 ppm).

The opposite trend was observed for the other three leaf nutrients and the soil pH. The soybeans in the late-planted treatments had a higher percent phosphorus (0.61 vs. 0,48%), higher boron content (43.7 vs. 34.9mg/kg) and a higher copper content (7.2 vs. 4,9). The pH was also higher in the late-planted treatments (6.8 vs 6.4).

The percent potassium and magnesium, as well as zinc content in the soybean leaves, were affected by both the cover crop and the planting strategy (Table 6).

	% Leaf K	% Leaf Mg	Leaf Zn (mg/Kg)
Spooner LP	2.2 a	0.42 abc	47.2 a
Aroostook LP	2.2 a	0.43 abc	45.7 ab
NE426GT LP	2.1 ab[2]	0.44 ab	39.0 cd
Emerson EP	2.0 abc[2]	0.40 bcd	37.5 cd
NE426GT EP	2.0 abc[2]	0.38 cdef	33.6 d
Emerson LP	2.0 abc[2]	0.47 a	39.1 cd
Aroostook EP	1.9 abc[2]	0.35 def	39.1 cd
Spooner EP	1.8 bc[2]	0.34 ef	36.9 cd
No-Cover LP	1.8 bc[2]	0.40 bcde	45.4 ab
No-Cover EP	1.7 c[2]	0.34 f	39.9 bc

Table 6 - Soil and soybean leaves nutrient status affected by both the cover crop and the soybean planting strategy. % Leaf K = % of potassium in the soybean leaves; % Leaf Mg = % of magnesium in the soybean leaves; Leaf Zn = zinc content in the soybean leaves. p-value = 0.05

Planting the soybeans late into rolled rye resulted in 2.2% leaf potassium, which was significantly higher than the percent potassium found in the early- and late-planted soybeans into bare ground and the early-planted soybeans into 'Spooner' rye. According to the UW Soil and Forage Analysis Lab, the sufficient range for soybean leaf potassium at this specific development stage is 2.15 to 3.25%. With 2.2% leaf K, the soybeans planted into rye were on the lower end of the range, but

	Leaf Mn (mg/Kg)	Leaf Fe (mg/Kg)	% Soil OM	Soil P (ppm)	Soil K (ppm)	% Leaf P	Leaf B (mg/Kg)	Leaf Cu (mg/Kg)	Soil pH
Early Planting	77.9 a	125.7 a	4.8 a	110 a	191 a	0.48 b	34.9 b	4.9 b[1]	6.4 b
Late Planting	61.3 b	80.9 b	3.5 b	63 b	106 b	0.61 a	43.7 a	7.2 a	6.8 a

Table 5 - Soil and soybean leaves nutrient status only affected by the soybean planting strategy. % Leaf P = % of phosphorus in the soybean leaves; % Leaf Ca = % of calcium in the soybean leaves; Leaf Mn = manganese content in the soybean leaves; Leaf B = boron content in the soybean leaves; Leaf Fe = iron content in the soybean leaves; Leaf Cu = copper content in the soybean leaves. p-value = 0.05

all the other treatments were below the sufficiency level. The early-planted soybeans into bare ground had the lowest percent potassium (1.7%), which is significantly lower than what was measured in the late- planted rye and triticale treatments.

The magnesium content of the leaves was within the sufficient range, but there were significant differences between the treatments. The late-planted soybeans into wheat had the highest percent magnesium (0.47%), which was significantly higher than the percent magnesium found in all the early- planted treatments as well as the late-planted soybeans into bare ground. The early-planted soybeans into 'Spooner -rye and into bare ground had 0.34% magnesium which was significantly lower than the magnesium content of both early- and late-planted soybeans into wheat and late-planted soybeans into triticale and rye.

The leaf zinc content was higher in the late planted soybeans into rye, and in the plants growing without cover (from 45.4 to 47.2 mg/kg) compared to what was measured in the early- and late-planted soybeans into wheat and triticale and the early-planted soybeans into rye (from 33.6 to 39.1 mg/kg).

Finally, the percent sulfur in the soybean leaves was not affected by any of the treatments. On average, the leaves had 0.267% sulfur, which is insufficient according to the UW Soil and Forage Analysis Lab's sufficiency range (0.38 to 0.5% sulfur).

Yields

The cover crop treatment had a significant impact on the yields, but the planting strategy did not (Table 7). The no-cover treatment had the greatest yield (57 bu/ac), which was significantly higher than the yields with 'Spooner' rye, wheat and triticale cover crops, but not different from the yields with 'Aroostook' rye. The 'Spooner' rye treatment yielded less than the 'Aroostook' rye treatment (49 vs. 54 bu/ac) but the difference was not significant. The wheat treatment yielded significantly less than the rye and the no-cover treatments (35 bu/ac) and the triticale significantly less than any other treatment (26bu/ac).

	Yield (bu/ac 13%moist)	Bushels/ 10,000 plants
No Cover	57 a	3.2 bc
Aroostook	54 ab	4.1 a
Spooner	49 b	3.4 ab
Emerson	35 c	2.5 cd
NE426GT	26 d	2 d

Table 7 - Soybean yields in bushels/acre at 13% moisture and bushels/10,000 plants

Looking at the number of bushels produced by 10,000 plants is a way to correlate the yields and the stand count. The soybeans planted into 'Aroostook' rye produced significantly more bushels/10,000 plants than the ones planted into bare ground. Soybeans planted into triticale produced significantly fewer bushels/10,000 plants than those planted into rye and bare ground.

Weed control

Weed count and biomass data were collected on August 1st and September 21st, 2018.

Weed biomass *in* and *between* the rows on August 1st
In August, the weed biomass *in the row* was influenced by both the cover crop and the soybean planting strategy, but the weed biomass *between the rows* was only influenced by the cover crop (Table 8 & Figure 10). With 1 lbs of DM/ ac, the no-cover treatment had the lowest weed biomass *between the rows*. However, while being significantly lower than the biomass *between the rows* of soybeans planted into triticale and 'Spooner' rye (702 and 315 lbs of DM/ ac respectively) it was not significantly different from the weed biomass *between the rows* in the wheat and 'Aroostook' rye plots (139 and 19 lbs of DM/ac respectively). The triticale plots had significantly more weed biomass *between the rows* compared to any other treatments.

	Weed Biomass *Between Rows* (lbs DM/ac)
NE426GT	702 a
Spooner	315 b
Emerson	139 bc
Aroostook	19 bc
No Cover	1 c

Table 8 - Weed biomass between the rows in August, average per cover crop treatment in pounds of dry matter/acre (lbs DM/ ac)

With respect to the average weed biomass *in the rows* per cover crop, the triticale treatments had significantly more weeds than all the other cover crop treatments (925 vs. 149 to 525 lbs DM/ac); however, in-row weed biomass was not significantly different from the no-cover treatment (525 lbs DM/ac).

Overall, the late-planted treatments were less weedy than the early-drilled treatments *in the rows* (319 vs. 730 lbs of DM/ ac). With 443 lbs of DM/acre, the early-planted treatments were not significantly different from the two other planting strategies.

Early- and late-planted soybeans into 'Aroostook' rye, as well as late-planted soybeans into wheat, had the lowest weed biomass *in the rows* (35, 86 and 163 lbs of DM/ ac respectively). However, this was only significantly lower than the weed biomass found *in the rows* in the early-planted and drilled triticale plots (1,057 and 1,389 lbs of DM/ac respectively). The weed biomass *in the rows* of the early-drilled soybeans into triticale was the greatest and significantly higher than in every 'Aroostook' rye and wheat treatments as well as early and late planted into 'Spooner' rye.

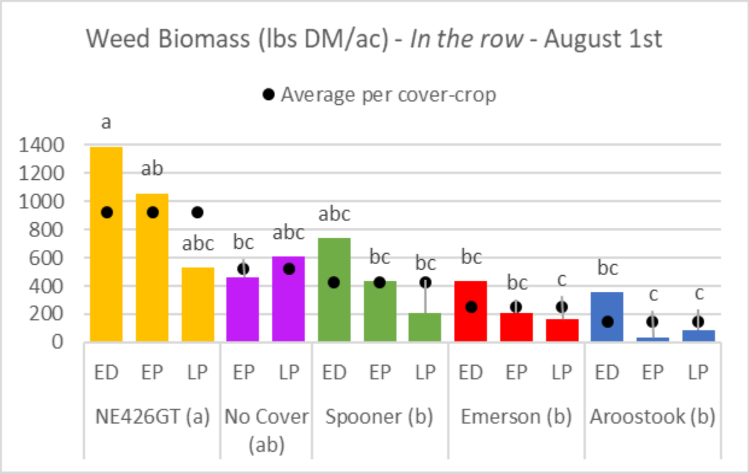

Figure 10 - Weed biomass in the rows on August 1st in pounds of dry matter/acre (lbs DM/ac)

Weed Biomass (lbs DM/ac) – *In the row* – August 1st - per planting strategy

Early drilled – 730 a

Early planted – 443 ab

Late planted – 319 b

Weed Biomass (lbs DM/ac) – September 21st - per planting strategy

Early drilled – 911 a

Early planted – 661 ab

Late planted – 381 b

Weed population description and weed biomass on September 21st

In September, weeds growing in the rows were not differentiated from those growing between the rows. However, we differentiated broadleaf weeds from grassy weeds (Figure 12, next page).

The total weed biomass in pounds of dry matter/acre was influenced both by the cover crop and the planting strategy (Figure 11).

Overall, the triticale had a significantly higher weed biomass than any other treatment (1,397 vs. 207 to 592 lbs of DM/ ac). As in August, the late-planted treatments had less weeds on average than the early-drilled ones, and the early-planted treatments were not significantly different from the two other planting strategies (late, 381 lbs DM/ ac; early-drilled, 911 lbs DM/ ac; and early-planted, 661 lbs DM/ ac).

Early- and late-planted 'Aroostook' rye treatments and the no-cover treatment, as well as late-planted 'Spooner' rye and early-drilled wheat treatments, had the lowest total weed biomass (from 48 to 423 lbs DM/ ac). These biomasses were only significantly lower than those found in the early-planted and drilled triticale plots (1,635 and 2,090 lbs DM/ac respectively). With 2,090 lbs DM/ ac, the early-drilled triticale treatment had significantly more weed biomass than any other treatment other than its early- planted equivalent.

With respect to differences in weed populations, the percent of broadleaf vs. grass weeds was only influenced by the cover crop (Figure 12). The no cover treatment had significantly fewer broadleaves and more grasses than the soybeans planted or drilled into 'Spooner' rye (24% vs. 63% broadleaf.; 76% vs. 37%

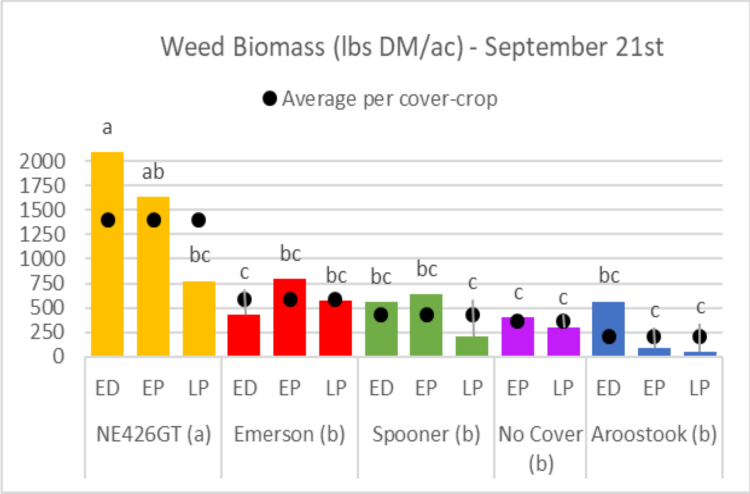

Figure 11 - Weed biomass on September 21st in pounds of dry matter/acre (lbs DM/ac). p-value = 0.05

grass). 'Aroostook' rye, wheat, and triticale were not significantly different from the two other treatments, but the no-till treatments tended to have proportionally less grasses than the no-cover treatment.

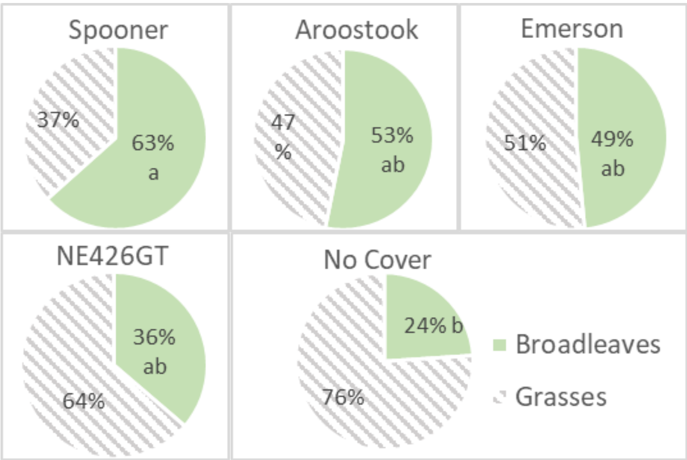

Figure 12 - Percent of the total weed biomass represented by broadleaves and grasses un every cover crop treatment. p-value = 0.05

Cover crop control

We collected two types of data to assess the risk of contamination of the subsequent crop by cover crop volunteer plants. The first was to count the number of new tillers growing after cover crop termination. These tillers, here called "regrowth", are different from the old tillers which bounce back after rolling. While the tillers which bounce back were present prior to termination, the regrowth were not present prior to termination and grew from the crowns.

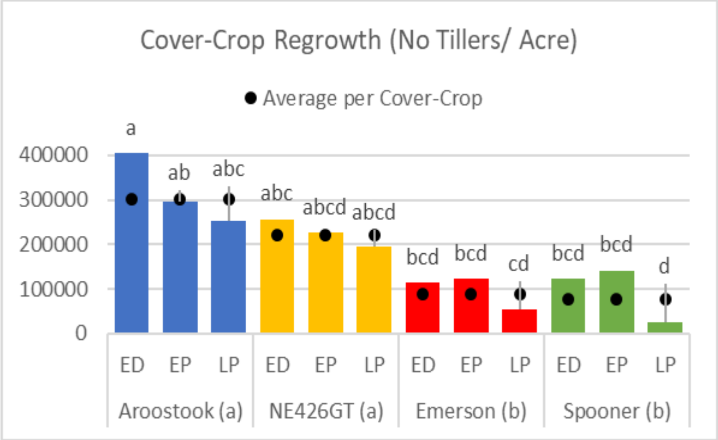

Figure 13 - Cover-crop regrowth measured as the number of tillers/ acre. p-value = 0.05

The second, more direct data collection was to count the number of heads of volunteer cover crops from 2017 in the spring planted oats and barley in 2018.

Cover crop regrowth or tillering

Both the cover crop and the planting strategy had an impact on the abundance of cover crop regrowth (Figure 13). Overall, 'Aroostook' rye and the triticale produced significantly more tillers than the wheat and 'Spooner' rye (301,996 and 220,737 vs. 87,513 and 78,407 tillers/acre).

With respect to the impact of the planting strategy, early-drilling generated significantly more regrowth than planting late (240,499 vs. 127,611). The early-planted treatment was not significantly different from the two other planting strategies and had an average or 181,299 tillers/acre. The treatment which generated the lowest amount of regrowth was late-planting the soybeans into rolled 'Spooner' rye (24,281 tillers/ac). The amount of regrowth in that treatment was significantly lower than what was observed in any of the 'Aroostook' rye plots or the early-drilled triticale plots. Early-drilling into 'Aroostook' rye generated more regrowth than any planting strategy into wheat and 'Spooner'-rye (404,686 vs. 24,281 to 141,640 tillers/ac).

Volunteers in the subsequent small grain

As with the number of regrowth tillers, the number of heads of volunteer cover crop from 2017 found into the 2018 spring oats and barley was influenced both by the cover crops and the planting strategy (Figure 14).

In 2017, we used the same two varieties of rye as in 2018 ('Aroostook' and 'Spooner'). We also used the 'NE426GT' variety of triticale, but instead of 'Emerson' wheat we used a second variety of triticale ('815'). The two varieties of triticale produced less volunteer plants than 'Aroostook' rye (579 and 1,352 vs. 7,800 heads/acre). 'Spooner' rye produced 4,313 heads, not significantly different from any of the other cover crops.

Cover-Crop Regrowth – No Tillers/ Acre - Per Planting Strategy

Early drilled – 240,499 a

Early planted – 181,299 ab

Late planted – 127,611 b

On average, planting the soybeans early in 2017 resulted in more regrowth in 2018 (6,252 vs. 966 heads/acre). The treatments that produced the least volunteers were early- and late-planting into '815' triticale and late-planting into 'NE426GT' triticale and 'Spooner' rye (from 386 to 815 heads/acre). The number of volunteers generated by these treatments was significantly lower than the number of volunteers counted after planting the soybeans early into both 'Aroostook' and 'Spooner' rye (13,411 and 7,811 heads/acre respectively). With 13,411 heads/acre, early-planting into 'Aroostook' produced significantly more volunteers than any other treatments except early planting into 'Spooner' rye.

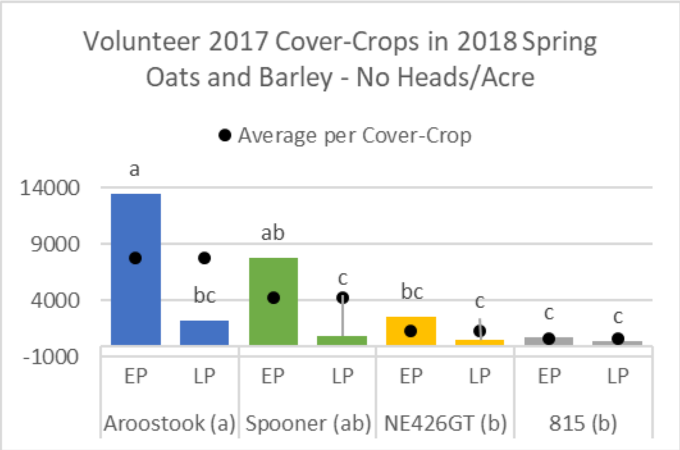

Figure 14 - Number of heads of volunteer cover crops from 2017 organic no-till soybeans found in the 2018 spring oats and spring barley. Number of heads/acre. p-value = 0.05

Volunteer 2017 Cover-Crop in 2018 Spring Cereal – No. Heads/Acre - Per Planting Strategy

Early planted – 6,252 a

Late planted – 966 b

Summary

In 2018 at the Arlington Agricultural research station we conducted an organic no-till soybean trial. The trial had four different cover crops, a no-cover control, two planting strategies and three different planter closing wheels. This last factor, the closing wheel, had no impact on any of the data collected.

All the cover crops produced the same biomass before termination, but the rye was taller and covered the ground faster in the spring. The wheat grew slowly, and the triticale development was uneven.

No-tilling the soybeans generally lowered the stand count compared to planting in bare ground, especially into triticale. Within the no-till treatments, early-planting had a negative impact on stand count as well. No-tilling the soybeans slowed down the vegetative growth in June for every cover crop and planting strategy.

In general, the late-planted soybeans grew faster than the early-planted soybeans during that same time period. At the end of the vegetative stage, the no-till soybeans had more trifoliate leaves, more so when planted into rye. Early-drilling also increased the number of trifoliate leaves compared to late planting.

The planting date neither impacted the number of pods/plant nor the plant height. The no-cover control produced the tallest plants, but the number of pods was similar to the one in the rye treatments. Wheat and triticale produced shorter plants with fewer pods.

No-till soybeans had fewer fine roots and less nodules than the plants grown in the tilled treatments. Both the cover crop and the planting strategy impacted the soybean nutrient status and surrounding soil nutrient profile. While it confirms the need for further research on the impact of organic no-till on plant and soil fertility, the differences observed in this study should not be generalized.

The no-cover and 'Aroostook' rye treatments resulted in the greatest yields, but on a per-plant basis, plants growing into 'Aroostook'-rye produced more bushels than the same number of plants grown on the tilled plots. No-tilling soybeans into wheat and triticale significantly reduced soybean yields.

In August, the weed control between the rows in 'Aroostook' rye and 'Emerson' wheat was comparable to what was achieved with mechanical weeding. In the rows, the weed pressure was higher in the triticale treatments, while 'Aroostook' rye had the lowest of all treatments, including no-cover. In September, the weed control in all the 'Aroostook' rye and some of the 'Spooner' rye treatments was as good as the weed control in the no-cover control. The triticale provided the poorest weed control. In general, the no-cover treatments had proportionally more grassy weeds than the no-tilled treatments.

With more tillers during the soybean year and more volunteers in the subsequent year, Aroostook seems to be a riskier variety choice if there is a small grain crop in the rotation. While producing a significant amount of regrowth, the triticale does not produce many volunteer plants.

Soybeans planted into 'Aroostook' rye at Arlington Research Station

Conclusions and plans for next growing season

This year, the best no-till treatment was late planting the soybeans into rolled 'Aroostook' rye, which was competitive with the traditionally managed, no-cover treatment in every aspect including yields and weed suppression. Planting the soybeans into 'Spooner' rye was also competitive with traditional organic practices with respect to many aspects, with less issues than 'Aroostook' rye when growing a small grain crop in the rotation due to more limited regrowth.

The wheat and the triticale generally did not provide good results in our system; thus, we discontinued these treatments for 2019.

Planting the soybeans earlier into the standing cover crop is a newer technique with inconsistent but promising results which we will continue to explore.

Finally, the closing wheels didn't have any impact this year, but we will try different settings again in 2019.

The ultimate goal of our research is not to provide the perfect combination of factors which will be successful every year and everywhere. However, exploring as many different options as possible and gathering a range of production information will aid in our understanding of the dynamics of the system. We hope this will help guide farmers interested in the technique to build their system in their specific context.

OGRAIN is housed in the Organic and Sustainable Agriculture Research and Extension Program within the UW-Madison Department of Plant Pathology under the leadership of assistant professor Dr. Erin Silva.

Léa Vereecke is a research associate working with the program.

To contact us, email Erin at emsilva@wisc.edu, Léa at vereecke@wisc.edu or call the lab at (608) 890-1503.