Horse Creek Area Watershed Cover Crop Test Plot

2022 Annual Report

The 2022 growing season proved to be another interesting year for the Horse Creek Area Watershed Council's cover crop test plot. 2022 completed the eighth year, fourth rotation, in the corn-soybean system. The test plot continues to test five different trials determining potential variations resulting from the implementation of different tillage practices and the use of cover crops. Soil mapped within the plot is Rosholt sandy loam with 2-6% slopes. The multi-species cover crop is a mix of cereal rye, daikon radish, red clover, crimson clover, berseem clover, wheat, rapeseed/canola, and oats. All other agronomic practices are consistent across each plot. Trials are randomly placed, triplicated, and have remained in the same location each year of the trial (Figure 1).

The five trials are as follows:

Trial 1. No-till without cover crop
Trial 2. No-till with a multispecies cover crop
Trial 3. No-till with cereal rye cover crop
Trial 4. Conventional till with cereal rye cover crop
Trial 5. Conventional till without cover crop

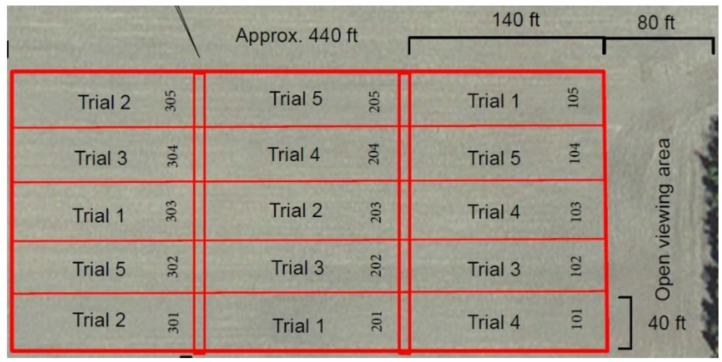

Figure 1: Plot Layout

Figure 2: No-till Cereal Rye Plot

The fall of 2021 provided warm temperatures and a late first frost resulting in optimum growing conditions for cover crops. This produced good cereal rye growth in the spring of 2022 (Figure 2). Tillage of the conventional plots was completed with a rotovator type attachment several days prior to planting. Pioneer 11A50 non-gmo food grade soybeans were planted with a no-till planter with 30-inch row spacing on May 17th at a rate of 140,000 seeds per acre. The herbicide program included two applications. The first herbicide application terminated the cover crop and any weeds prior to soybean emergence and provided residual control. The second herbicide application, June 21st (post soybean emergence), included herbicides that provided control of emerged and pre-emerged weeds plus residual control.

Several tests were completed in the plots during the growing season to evaluate variability between the five trials. One new test attempted to visually determine differences in soil microbial activity. Producers across the northwest region of Wisconsin participated in a "Soil Your Undies" challenge to test how fast soil microbes in their soils

Figure 3: Soil Your Undies Challenge

could decompose a pair of cotton underwear. Participation in the challenge seemed like a great fit for the test plot. A pair of underwear was "planted" in each of the five trials on June 1st and "harvested" on July 22nd (figure 3). The plots with a cereal rye cover crop appeared to have better decomposition indicating higher microbial activity. The five pairs of decomposed underwear were displayed at the Polk County Fair and proved quite the conversation starter. Infiltration and surface runoff testing was completed on June 4th in the no-till with cereal rye cover crop and the conventional till without cover crop plots. Data was collected to quantify how the two trials responded to a simulated rainfall event. Surface residue cover was counted in each plot on June 15th. Differences in surface residue cover can be seen in Figures 4 and 5. Plant population counts were conducted on June 23rd. Residue cover and plant population data can be seen in Tables 2 and 4. Observations of poor soybean emergence and establishment was observed while collecting residue cover data and became obvious after collecting plant population counts. This led to the investigation of potential causes. Soybean fields in the watershed were surveyed on July 8th to compare plant populations at the field scale to the test plot. The council hosted a field day at the test plot on July 11th to discuss these observations. The cover crop was hand seeded on September 7th using a cyclone bag seeder. The plots were harvested on October 11th. Each trial plot was harvested individually. Grain from each plot was offloaded and weighed in a weigh wagon. Grain moisture and test weight was also measured.

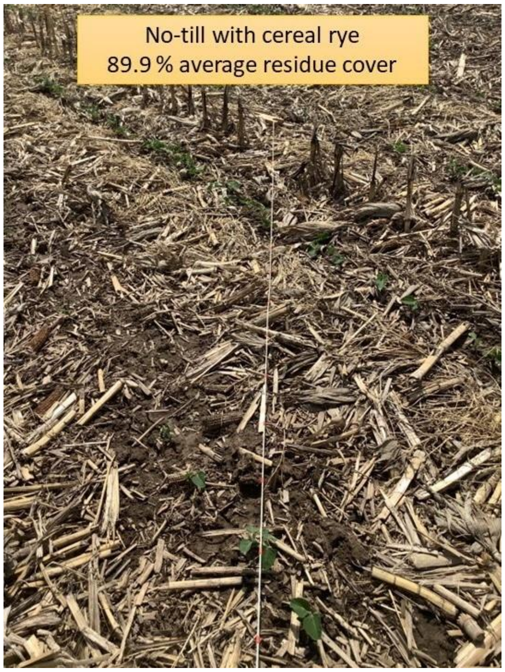

Figure 4: Trial 3 Residue Cover June 15, 2022

Figure 5: Trial 4 Residue Cover June 15, 2022

Emergence, Plant Population, and Possible Causes

Based on visual observations at the test plot, soybeans started emerging nine to fifteen days after planting (between May 26th and June 1st). Soybeans typically need 130 growing degree days (GDD) to emerge. Based on local daily high/low temperatures, this threshold was reached on May 30th. Figures 6 and 7 show emerged

Figure 6: Trail 4 Emergence June 1, 2022

Figure 7: Trial 2 Emergence June 1, 2022

soybeans on June 1st in the conventional till cereal rye cover crop and no-till multi species cover crop plots. More plants had emerged in the no-till plots as compared to the conventional till plots. This contrasts with a typical year where the crop in the conventional till plots emerge first. Soil crusting was observed in the conventional plots. Soybean plants were observed pushing through the crust and raising clods of soil (Figures 6 and 8). Some stems appeared damaged (Figure 8). Some crusting was observed in the no-till plots, but it was much harder to find and soil clods were smaller. Visual differences in soil moisture could also be seen. Soil in the conventional till plots were generally lighter in color showing that the surface was drying out. Soil in the no-till plots were darker in color showing that they were holding more moisture.

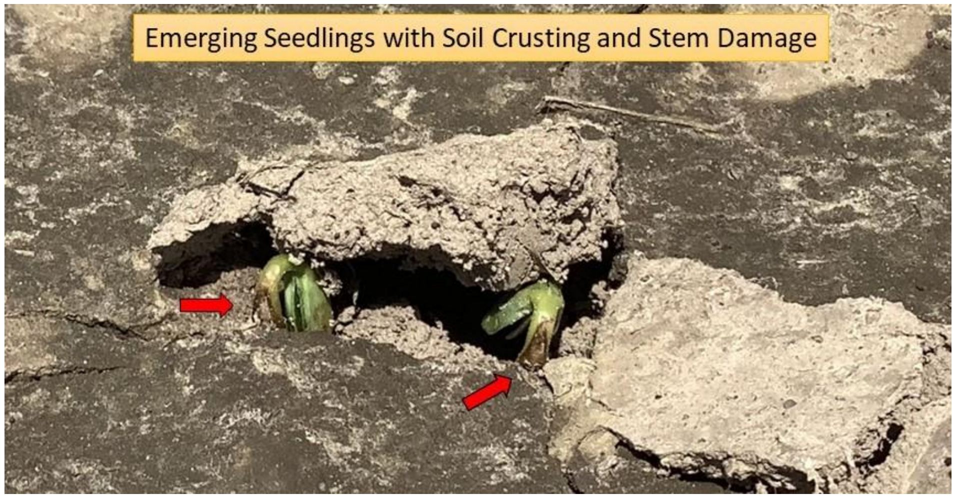

Figure 8: Emergence June 1, 2022

Visual differences in plant population were observed on June 15th when surface residue data was collected. Plant population counts were conducted on June 23rd. The no till no cover crop plots averaged the highest plant population (81,556 plants/acre) while the conventional till cereal rye cover crop plots had the lowest average (22,222 plants/acre). All plots were planted at 140,000 seeds per acre. Plant population averages for each trial are listed in Table 2 while individual plot data is listed in Table 4. Damaged soybean plants were observed while conducting plant population counts. Some plants were broken off above the soil surface and did not have cotyledons or leaves. Some plants had stems that were bent in a "J" or twisted in a spiral. Other plants were without cotyledons but had a main stem with unifoliate and trifoliate leaves. Figures 9, 10, and 11 show examples of damaged plants. The low plant population numbers and damaged plants led to the question of why this occurred.

Figure 9: Plant Damage June 23, 2022

Figure 10: Plant Damage June 23, 2022

Figure 11: Plant Damage June 23, 2022

Plant population counts were conducted in producer's fields to help determine if the observations of poor plant population and plant damage in the test plot were happening across the watershed. Eight fields with different planting dates (May 11th-17th), tillage and planting practices were investigated. There seemed to be a correlation to the planting date. Fields planted between May 11th-14th had higher plant populations than fields planted on May 16th or 17th. A field that was no-till planted the same day as the test plot with the same soybean variety and equipment had a plant population of 80,000 plants/acre in one section of the field and 60,667 plants/acre in a different section of the filed. This correlates well with the plant population in the no-till plots suggesting the test plot is representative of field scale results. Another field planted the same day with the same equipment and soybean variety had a plant population of 106,833 plants/acre in areas of the field that had fall vertical tillage and 80,500 plants/acre in areas of the field that had both fall and spring vertical tillage. Even though this field did not have a plant population as low as the conventional tilled plots, the additional tillage (spring and fall vs fall only) in this field appeared to result in a lower plant population indicating tillage reduced plant population.

Weather and soil conditions prior to and following planting can influence seed germination and crop establishment. When soil temperatures are 50°F or lower, germination and seedling emergence is delayed. Cold temperatures also expose the germinating seedling to the risk of imbibitional chilling or cold injury. Imbibition is the process of the seed taking up water in the first 24-48 hours after planting and occurs in both cold and warm soils. The imbibed water rehydrates the cotyledons and embryo of the soybean seed, and germination begins. If soils are cold, or a cold rain occurs in this time frame, the cold temperatures interfere with the proper rehydration of the seed's cell membranes and imbibitional chilling may occur. Soybeans are most prone to imbibitional chilling 24 hours after planting. Severe symptoms include dead tissue on the exterior of the plant, uneven emergence, reduced seedling vigor, and seedling death ultimately resulting in poor crop establishment. Cold injury occurs when soil temperatures become cold after imbibition but prior to seedling emergence. The seed successfully germinates but growth is slow due to cool temperatures or growth slows or speeds up as soil temperatures fluctuate. Cold injury symptoms are similar to but less severe than imbibitional chilling.

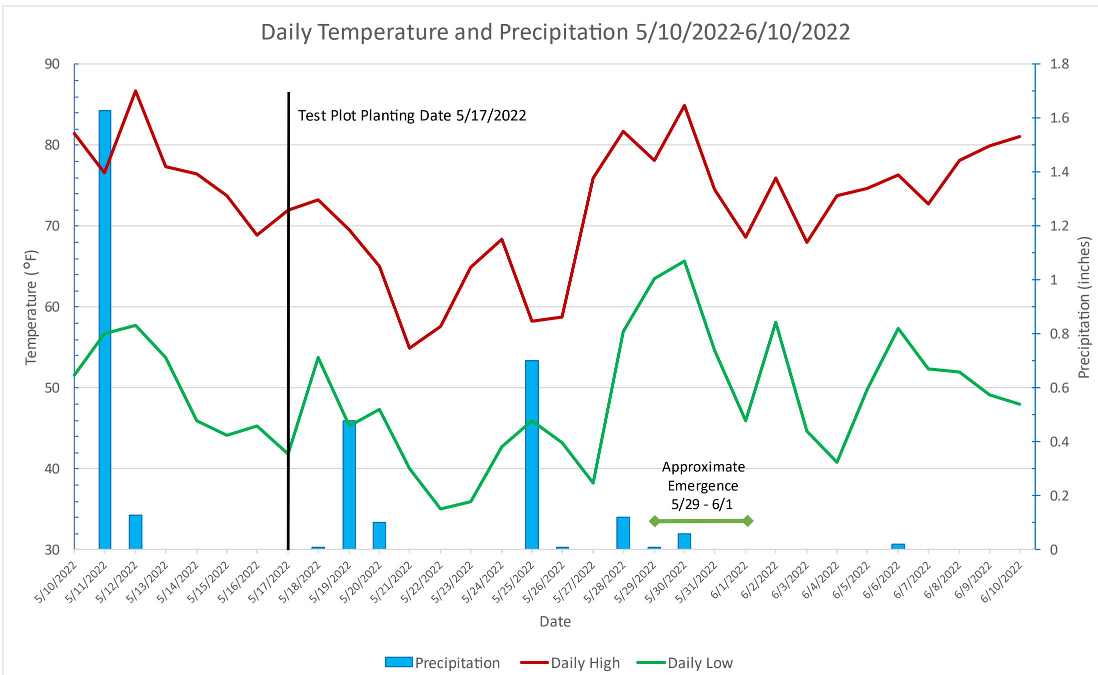

Figure 12: Weather Data

Crowd sourced historical weather data was gathered from a local weather station to help determine if imbibitional chilling or cold injury may have contributed to the poor plant population in the test plot. Daily high/low temperatures and precipitation totals are plotted in Figure 12. Prior to planting, daily highs were 70°F or above, with lows in the 50's and mid 40's. Approximately 1.6 inches of rain fell six days before planting. The 48 hours after planting saw daily temps with highs in the low 70's and lows in the 40's and 50's. Another rain event occurred on the afternoon of May 19th, with about 0.5 inches falling. According to the weather station, the rain on the 19th was a quick and intense event. Approximately 0.4 inches fell in a 20-minute period with rainfall rates reaching a maximum of 2.17 inches per hour. Air temperature was 58°F during the rain event. The next morning 0.1 inches fell with air temperatures at 52°F. During the 48 hours after planting, daily temps dropped to highs in the mid 50-60's and lows in the 40's dipping to the mid-30s and stayed in this range for about a week. On May 27th, temperatures rose with highs in the upper 70's to low 80's and lows climbing from the 50's into the 60's. Based on the recorded weather data, cold injury may have contributed to the delayed emergence, poor establishment, and plant damage that was observed in the test plot. Fields that were planted earlier than the test plot may have been further along in development and less affected by the cool temperatures.

Soil crusting is another factor that can impact crop establishment and may have led to the low plant population observed in the test plot. Soil crusting occurs when weakly aggregated soil particles become dislodged during an intense rain event. The lighter silt and clay particles are then deposited and fill the spaces between the larger sand particles. When the soil dries, a hard cement like curst is formed. Soil crusting reduces infiltration, inhibits gas exchange between the air and soil atmosphere, and increases the force needed for seedlings to emerge. The extra strength needed to break through a crusted soil may deplete the seedling's carbohydrate reserves and the plant dies before emergence can occur. If the seedling does emerge, the hypocotyl (stem) and/or cotyledons may be damaged or broken off when pushing through the soil crust. If the force needed to emerge is too great, the hypocotyl snaps and the plant dies. If one or both cotyledons break off the plant can survive if the unifoliate leaf and apical growing point are intact. These types of damage were observed in the test plot and are shown in Figures 8, 9, and 11. Excessive tillage, little surface residue cover, and high silt content soils can lead to a higher probability of soil crust formation. Crusted soils can also delay emergence which would explain why the plants in the no-till plots emerged before the conventional tilled plots.

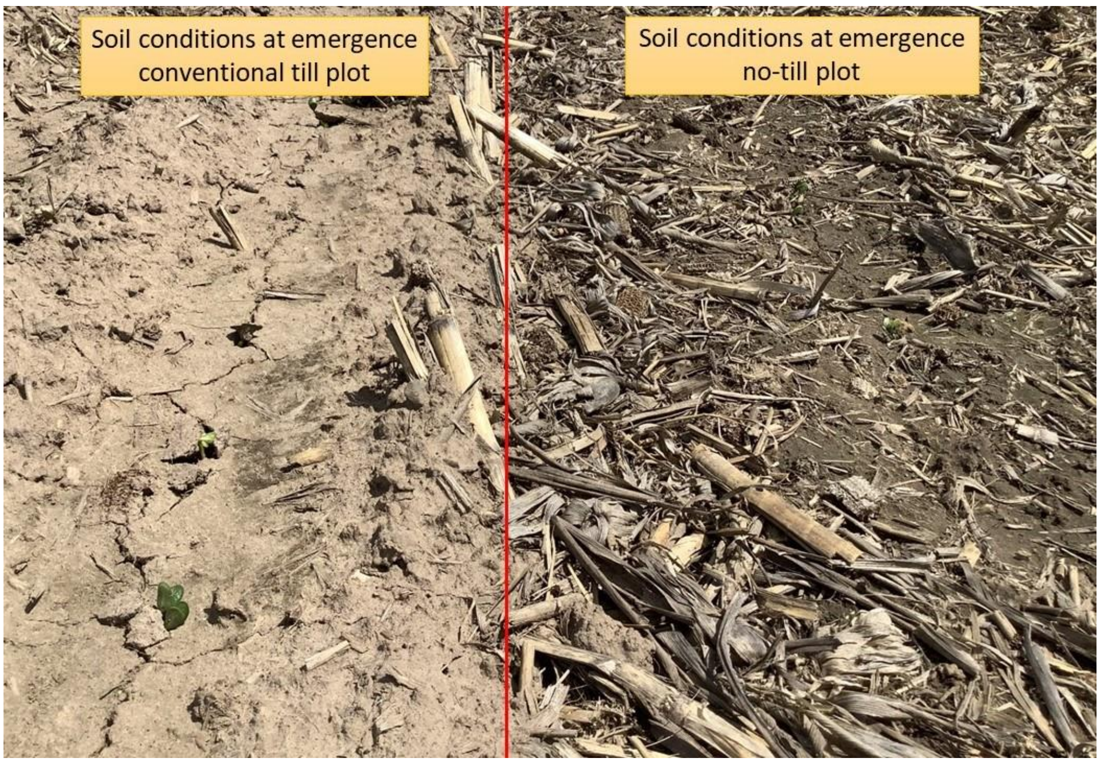

Figure 13: Soil Crusting and Moisture Differences on June 1, 2022

A field day was held at the test plot on July 11th to view and discuss the emergence and plant population problems that had occurred. Local farmers, agronomists, UW Extension educators, and conservation staff attended the field day. A good discussion exploring multiple causes ensued. The consensus was that a variety of causes likely resulted in the extremely poor plant population counts in the conventionally tilled plots and played a factor in the no-till plots too. The cold weather a few days after planting likely delayed the development of the soybean seedlings. The twisted stems are a good indicator that the fluctuating temperatures caused the plants to start and stop growing as air and soil temps changed. When soil temps are warmer than air temps, the soybean plant can grow laterally following the warmth in the soil rather than emerging. This leads to the twisting of the stem. Soil crusting, especially in the conventionally tilled plots, was likely another contributing factor. Poor soil structure caused by intense tillage with the rotovator type tiller and lack of surface residue cover left the soil in the conventional plots susceptible to erosion. The short but intense rain event two days after planting likely led to the crust formation. Emerging soybeans likely had difficulty breaking through the soil crust, never emerged, or were damaged, resulting in plant death. The no-till plots offered higher residue cover and improved soil structure leading to better emergence and increased plant survival. The characteristics of the soybean variety that was planted could be another factor that contributed to the emergence and plant population issues that occurred.

Different varieties of soybean can have different cold tolerance or seedling vigor. Low cold tolerance and vigor could have added to the plant population problems that were observed. Conversations during the field day concluded that agricultural practices that reduce or eliminate tillage provide the crop a more resilient system that can adapt to adverse environmental conditions.

2022 Data Analysis

Rainfall infiltration and runoff testing was conducted in the test plot during the fall of 2021 and spring of 2022. The fall testing was performed in all five trials (all 15 plots). The spring testing was performed in just the no-till with cereal rye and conventional till with no cover crop plots (Trial 3 and 5). Fall data is presented in Figure 14. Spring data is presented in Table 1 and Figure 15. In the spring, the no-till cereal rye plots infiltrated rainfall at a greater rate than the conventional no cover plots. This resulted in less surface runoff in the no-till cereal rye plots. Soil erosion was roughly forty-eight times higher in the conventional no cover plots as compared to the no-till cereal rye plots. Total phosphorus loss from the conventional no cover plots was double the amount from the no till cereal rye plots.

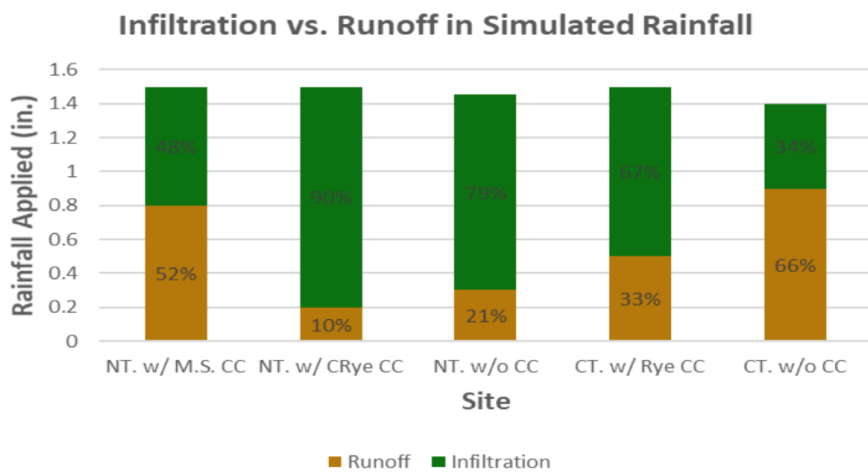

Figure 14: Fall 2021 Infiltration and Runoff Data

	Infiltration (inches)	Infiltration (%)	Runoff (inches)	Runoff (%)	Soil Erosion (lbs./acre)	Total Phosphorus Loss (lbs./acre)
Trial 3 – no-till, cereal rye cover	1.4	90	0.2	10	8	0.24
Trial 5 – conventional, no cover	0.8	56	0.6	44	383	0.49

Table 1: Spring 2022 Infiltration and Runoff Data

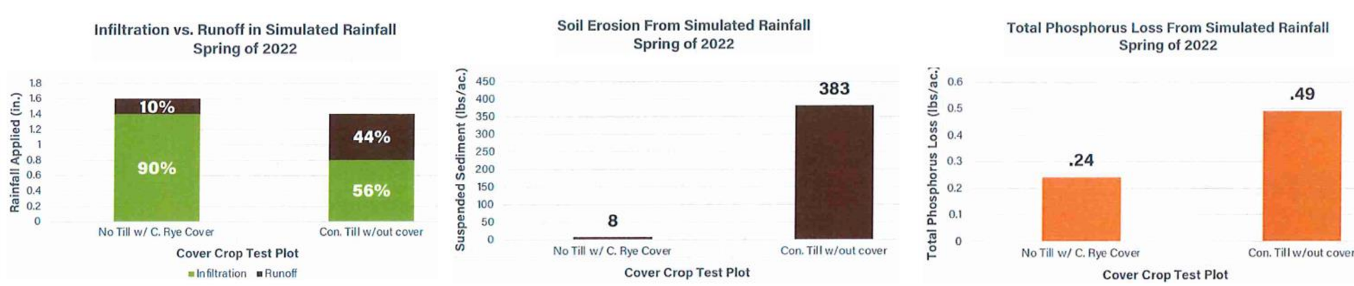

Figure 15: Spring 2022 Infiltration and Runoff Data

Plant population, percent residue cover, and yield data are presented in the following four tables. Table 2 summarizes trial averages for plant population, residue cover, and yield. Individual plot harvest data is shown in Table 3. Individual plot data is displayed in Table 4 with each column of data color coded from highest value (green) to lowest value (red). The plots in Table 4 are grouped by trial, with each trial sorted from highest yield to lowest yield. Finally, all eight years of yield data is highlighted in Table 5.

Data for 2022 shows statistical differences in plant population between all but two of the trials. Plant population for trial 2 (no-till, multi species) was statistically the same as trial 3 (no-till, cereal rye). All other trials were statistically different from each other. The differences between the no-till plots and the conventional plots can be attributed to the challenges from the cold weather and soil crusting. This was the first year there has been a statistical difference in soybean plant population between the three no-till plots with trial 1 (no-till, no cover) having a higher plant population than trials 2 and 3 (no-till, multi species and no-till, cereal rye).

	Plant Population (Plants/Acre)	Residue Cover (%)	Yield Average (Adjusted to 13% Moisture)
Trial 1 – no till, no cover	81,556	81.4	48.4
Trial 2 – no till, multi species cover	74,222	86.6	46.8
Trial 3 – no till, cereal rye cover	72,833	89.9	55.0
Trial 4 – conventional, cereal rye cover	22,222	20.5	36.2
Trial 5 – conventional, no cover	37,500	16.1	45.3

Table 2: Trial Average Data

Tillage practice continues to drive the stark difference in surface residue cover (Figures 4 and 5). No-till plots averaged 86% surface reside cover while the conventional plots averaged 18.3%. The conventional plots (trial 4 and 5) were statistically different with cereal rye cover crop adding 4.4% residue cover. The no-till plots had residue cover of 81.4% (no cover), 86.6% (multi species), and 89.9% (cereal rye). Residue cover in the no-till no cover plots (trial 1) were statistically different from the no-till plots with covers (trials 2 and 3). The no-till with multi species cover (trial 2) was statistically the same as the no-till with cereal rye (trial 3). For the fourth year in a row the presence of a cover crop is adding residue in the no-till plots. The multi species cover crop added 5.2% residue cover. The cereal rye cover crop added 8.5% residue cover.

Data collected during crop harvest is presented in Table 3. Grain moisture ranged from 9.9% to 11.6%. Test weight ranged from 55 to 58 pounds per bushel. Plot yield is adjusted to a standard moisture of 13%. Individual plot yields ranged from a low of 31.6 bushels/acre to a high of 59.6 bushels/acre. Based on the trial averages, no-till with cereal rye cover crop resulted in the highest average yield. Conventional tillage with cereal rye cover crop resulted in the lowest average yield. There was statistical difference between some of the trials. Trial 1 (no-till, no cover) had a yield that was statistically higher than trial 4 (conventional, cereal rye). Trial 3 (no-till, cereal rye) yielded statistically higher than trial 4 (convention, cereal rye). There was no statistical difference between the other trials.

Plot #	Tillage	Cover Crop	Moisture (%)	Test Weight	Yield (Wet)	Adjusted Yield (13 % moisture)
101	Conventional	Cereal Rye	11.6	57	31.1	31.6
102	No-Till	Cereal Rye	9.9	56	57.6	59.6
103	Conventional	Cereal Rye	10.2	55.5	40.2	41.5
104	Conventional	No Cover	10.6	56	46.4	47.7
105	No-Till	No Cover	10.8	57	44.9	46.0
201	No-Till	No Cover	10.2	57	44.1	45.5
202	No-Till	Cereal Rye	10.3	55	52.4	54.0
203	No-Till	Multi-species	10.6	57	51.1	52.5
204	Conventional	Cereal Rye	10.5	57.5	34.5	35.5
205	Conventional	No Cover	11.3	56	38.1	38.9
301	No-Till	Multi-species	10.7	55	43.8	45.0
302	Conventional	No Cover	10.1	58	47.7	49.3
303	No-Till	No Cover	10.5	57	52.1	53.6
304	No-Till	Cereal Rye	10.9	58	50.1	51.3
305	No-Till	Multi-species	10.7	58	41.8	42.9

Table 3: Individual Plot Harvest Data

The yield difference (28 bushels/acre) between the highest and lowest yielding plots (plots 102 and 101) was the largest range in soybean yield observed over the eight years of the study. When looking at trial averages, higher plant population led to higher yield. The only exception to this was the no-till cereal rye plots which had the highest yield but had a lower plant population than the other no-till trials. When looking at the five trials individually, the trend of higher plant population leading to higher yield can be seen. Table 4 ranks the individual plots within each trial by highest to lowest yield. Except for the plots in trail 5, yield increased as plant population increased.

Summary

The cover crop test plot continues to offer producers a local source of data testing the use of different agricultural practices. After eight growing seasons the data may be showing some trends. However, factors outside of the study's control, like weather, also play a role. Continuing the trial, collecting more data, and analyzing the data will be key to showing outcomes of the study.

The data continues to show that the use of cover crops is adding surface residue to the plots. The cover crop and its residue help protect the soil from erosion and is eventually incorporated into the soil by tillage or organisms like earthworms. This adds organic matter into the soil profile. One of the benefits of cover crops is they improve soil health by improving soil structure and adding organic matter which can increase the soil's ability to infiltrate water and hold moisture. The infiltration and runoff data that was collected in the fall of 2021 (figure 14) and spring of 2022 (figure 15) shows that the implementation of no-till and the use of cover crops is allowing more rainfall to infiltrate and reducing surface runoff. The reduction of runoff is also reducing soil erosion and total phosphorus loss.

2022 proved to be a challenging year to determine causal relationships between the trial treatments and yield due to poor emergence and low plant population. Low plant population was likely caused by a mixture of factors including cool weather conditions, soil crusting (especially in the conventional till plots), and possibly soybean variety. Plant population appears the be the driving cause of differences in yield with more plants producing more yield. Soybean plants are very adaptive to changes in plant population. If plant populations are low, soybean plants tend to branch out and become bushier. These branches result in more pods per plant and can recover some of the lost yield due to having less plants per acre. It is quite an amazing feat that 10,667 soybean plants/acre still produced 31.6 bushels/acre.

Implementing no-till and cover crops have many different goals and outcomes. Implementing no-till can reduce inputs, reduce erosion, and improve soil structure. Implementing cover crops can reduce compaction, scavenge nutrients, improve soil health, reduce erosion, and suppress weeds. Some changes like reducing fuel and equipment cost by parking the tillage equipment are immediate. Other changes like improving soil structure and soil health take time to show benefits. After eight years of using no-till and cover crops these benefits may be starting to show. Conditions during any given year are unique and place different stresses on agricultural systems. These stresses affect overall crop production and can impact yield. Different agricultural practices will perform better or worse depending on a given year's stresses. In 2022 the stresses of cool temperatures and intense rainfall that caused soil crusting appear to have led to poor plant population and reduced yields. Soils with better structure that were protected from erosion by a layer of crop residue led to higher plant populations and more yield. Table 5 shows average yield for each year in the study. Yield for each year is color coded with highest yield in green and lowest in red. Based on eight years of yield data, no trial has consistently had the highest or lowest yields. Each year produces different results. As weather patterns and other stresses change, building a soil that is resistant to these stresses is important to ensure the resiliency of agricultural systems and ensure long term success. Systems that reduce soil erosion, improve water use efficiency, and provide an overall stable system will increase resiliency and help protect yield over a long-term scale. Continuing the study will help show how over time the use of different management practices affect crop productivity. Looking at factors other than yield may also show how changes in management can improve agricultural systems.

Trail #	Tillage	Cover Crop	Plot #	Plant Population*	Residue*	Yield*
Trial 1	No-Till	No Cover	303	86,833	87.2	53.6
			105	80,833	76.7	46.0
			201	77,000	80.3	45.5
Trial 2	No-Till	Multi-species Blend	203	83,167	86.5	52.5
			301	75,667	88.3	45.0
			305	63,833	85.0	42.9
Trial 3	No-Till	Cereal Rye	102	75,833	85.3	59.6
			202	76,500	90.3	54.0
			304	66,167	94.0	51.3
Trial 4	Conventional	Cereal Rye	103	32,667	15.3	41.5
			204	23,333	28.0	35.5
			101	10,667	18.2	31.6
Trial 5	Conventional	No Cover	302	38,667	13.5	49.3
			104	52,000	14.0	47.7
			205	21,833	20.7	38.9

* Each column above is color coded from highest value (green) to lowest value (red)

Table 4: 2022 Individual Plot Data

		Harvest Year	2015	2016	2017	2018	2019	2020	2021	2022
		Crop	Corn	Soybean	Corn	Soybean	Corn	Soybean	Corn	Soybean
Trial #	Treatment		Yield Average (Bu/Acre)							
Trial 1	No-Till	No Cover	187.2	66.5	194.0	45.2	188.0	55.7	219.6	48.4
Trial 2	No-Till	Multi-species Blend	184.3	66.3	186.1	45.8	190.9	55.0	225.9	46.8
Trial 3	No-Till	Cereal Rye	184.6	66.3	189.9	45.7	187.8	57.1	229.0	55.0
Trial 4	Conventional	Cereal Rye	191.8	65.3	194.5	43.5	182.1	59.1	236.8	36.2
Trial 5	Conventional	No Cover	194.8	66.5	191.8	41.9	186.8	62.1	209.8	45.3

	2015	2016	2017	2018	2019	2020	2020	2022
High (Individual Plot)	197.7	67.9	205.0	49.1	196.6	64.8	249.9	59.6
Low (Individual Plot)	165.5	64.6	181.0	41.1	177.3	52.4	198.0	31.6
Mean (average)	188.5	66.2	191.3	44.4	187.1	57.8	224.2	46.3
Standard Deviation	10.6	0.9	7.8	2.6	5.5	3.3	15.1	7.5
Median	191.7	66.0	188.4	44.2	186.2	57.8	223.0	46.0
Range	32.3	3.4	24.0	8.1	19.3	12.4	51.8	28.0

Table 5: Yearly Trial Average Yield and Statistics