Horse Creek Area Watershed Cover Crop Test Plot

2023 Annual Report

The Horse Creak Area Watershed Council continues to operate the tillage and cover crop test plot. The 2023 growing season was the ninth year in the corn-soybean system. The test plot analyzes 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

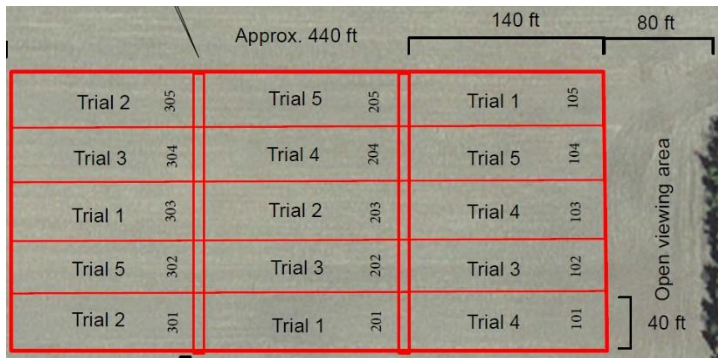

Figure 1: Plot Layout

The fall 2022 cover crop was broadcast seeded into standing soybean on September 7th, 2022. September and October were drier than normal with about normal temperatures. Cereal rye establishment in the conventional plots appeared less uniform than the no-till plots (Figures 2 and 3). The first substantial rain was 13 days after planting. This delay in germination left the cover crop seed vulnerable on the soil surface. As discussed in the 2022 test plot report, soybean plant populations were substantially lower than previous years, especially in the conventional plots. The lack of soybean plants provided less protection to the cover crop seed laying on the soil surface. It is likely that some seed was preyed upon by birds or other predators prior to germination. Fall cover crop growth appeared similar to previous years of the study even though cover was less due to fewer plants being established.

Figure 2: Fall Cereal Rye Establishment November 8th, 2022

Figure 3: Fall Cereal Rye Establishment November 8, 2022

Spring conditions favored cover crop growth and good biomass was produced prior to planting corn (Figures 4 and 5). Tillage of the conventional plots was completed with a rotovator type attachment several days prior to planting. Tillage terminated the cover crop in the conventional plots. Pioneer 9466AML and Legacy 3517R corn was planted with a no-till planter with 30-inch row spacing on May 10th at a rate of 34,000 seeds per acre. Eight

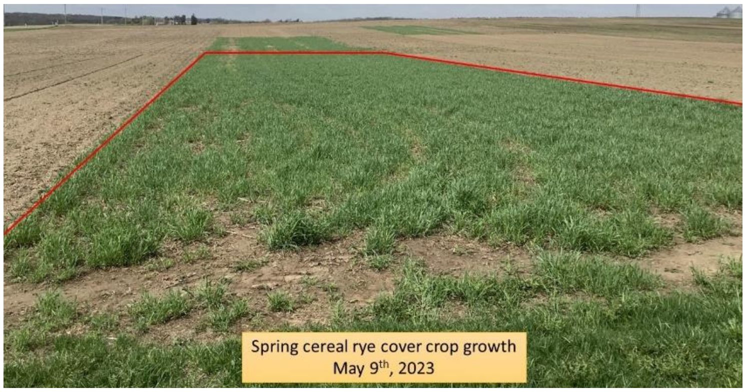

Figure 4: No-Till Cereal Rye Plot

Figure 5: Spring Cover Crop Growth

rows of each variety were planted per plot. Corn was planted into the live cover crop (planted green). The herbicide program included two applications. The first application (May 16) terminated the cover crop and killed any weeds prior to corn emergence. The second application (May 30th) provided contact and residual control of weeds after corn emergence.

The council held a field day at the test plot on June 1st to discuss topics about nitrogen. Information was shared about the nitrogen cycle, how nitrogen changes forms, and available soil tests for measuring nitrogen. Nitrogen availability to plants and potential avenues for nitrogen loss was also discussed. Finally, options for nitrogen protection (stabilizers and inhibitors) were presented.

Several tests were completed in the test plot during the growing season to evaluate variability between the five trials. Standard soil tests were taken in each plot prior to planting. Once again producers across the northwest region of Wisconsin participated in a "Soil Your Undies" challenge to test how fast soil microbes in their soils could decompose a pair of cotton underwear. This test attempts to visually determine soil microbial activity by comparing cotton decomposition in different fields or in the same field but with different management practices. A pair of cotton underwear was "planted" in each of the five trials on June 1st and "harvested" on August 1st. The no-till with multi species cover crop had the highest amount of decomposition. The conventional plot without cover crops appeared to have the least decomposition. This suggests that no-till plots and plots with cover crops had higher microbial activity.

Figure 6: "Harvested" Underwear

Surface residue cover was counted in each plot on June 13th. Variations in surface residue cover can be seen in figures 7 and 8. A simulated rainfall study was completed on June 15th and 16th to quantify how the different trials respond to a rainfall event. The study collected data to determine infiltration, runoff, soil erosion, and total phosphorus loss. Plant population counts were conducted on June 16th. Residue cover and plant population data are presented in Tables 2 and 4. The growing season progressed with below normal rain totals (approximately 6 inches) between May 15th and September 15th. The cover crop was hand seeded on September 8th using a cyclone bag seeder. The plots were harvested on November 1st. Each trial plot was harvested individually. Grain from each plot was offloaded and weighed in a weigh wagon. Grain moisture and test weight were also measured.

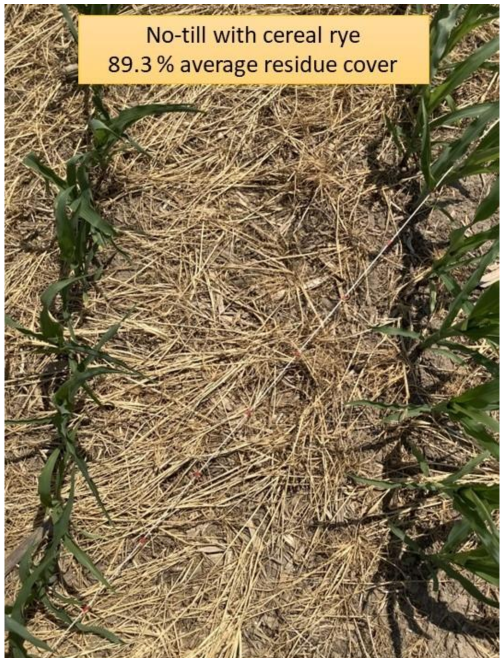

Figure 7: Trial 3 Residue Cover June 15, 2022

Figure 8: Trial 4 Residue Cover June 15, 2022

The council has had discussions about soil biology and are curious to learn how different management practices affect soil biology. While some council members have used soil biology tests in the past, it was difficult to interpret how the results should be used to adjust crop management practices like nutrient recommendations. The council has partnered with Water Resources Monitoring Group LLC, NRCS soil health staff, and UW-Extension to run a variety of tests in the test plot to better understand available soil tests and to quantify any differences between the five trials. Tests include soil compaction, soil CO_2 Efflux, soil infiltration, earthworm count, soil bulk density, slake test, aggregate stability, nitrate, electrical conductivity, pH, soil nutrients, soil organic matter, POxC, 24-hour microbial respiration, water stable aggregates, soil texture, and soil phosphorus stratification. Data will be shared as results become available.

2023 Data Analysis

Rainfall infiltration and runoff testing was conducted in June by Water Resources Monitoring Group, LLC. Corn had emerged and was at approximately V5 to V7 growth stage (5 to 7 leaf collars visible). Testing was performed in four of the five trials (Trials 1, 3, 4, and 5). The no-till multispecies plots were not tested. A simulated rainfall was applied to the test area at a known rate. Once runoff occurs, the simulated rainfall continues for thirty

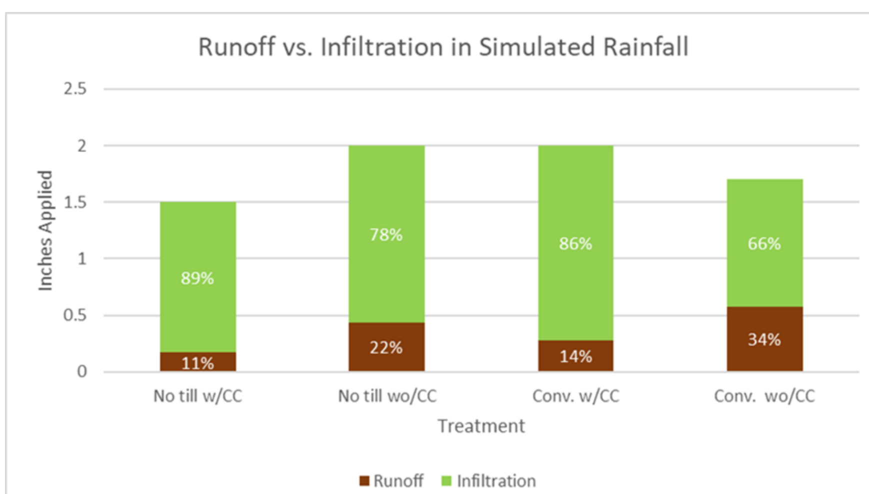

Figure 9: Runoff vs. Infiltration in Simulated Rainfall Produced by Water Resources Monitoring Group, LLC

minutes. All runoff is collected. Total runoff volume is measured, and a sample is taken to analyze soil erosion and phosphorus loss. Infiltration is determined by taking the total volume applied and subtracting the runoff volume. Data is collected for all three trial replications and a trial average is calculated. Data collected and analyzed by Water Resources Monitoring Group LLC is presented in figures 9, 10, and 11. Raw data is presented in Table 1. The data shows that plots with cereal rye cover crop infiltrated a higher percentage of applied water resulting in less runoff (percentage and volume) than the plots without cover crops. The no-till without cover crop plots infiltrated a higher percentage of applied water with less runoff than the conventional plots without cover crops. The collected runoff water was used to calculate the amount of soil erosion representing a single storm event. The conventional plots without cover crops had six times the amount of soil erosion as the next highest trial (conventional with cereal rye cover crop). The no-till plots had the lowest soil erosion with the no-till with cereal rye cover crop reducing erosion fivefold compared to the no-till without cover crop. Runoff was also analyzed to determine total phosphorus loss. The plots with cereal rye cover crops had the lowest total phosphorus loss. The conventional without cover crop plots had the highest total phosphorus loss. No-till with cereal rye cover crop reduced phosphorus loss by more than fifty percent as compared to the no-till without cover crops. Conventional till with a cereal rye cover crop reduced total phosphorus loss by forty percent compared to no-till without cover crop.

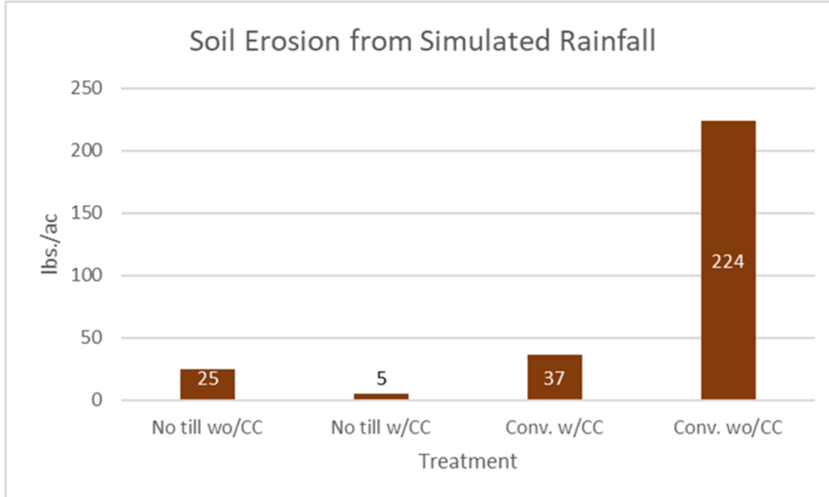

Figure 10: Soil Erosion from Simulated Rainfall
Produced by Water Resources Monitoring Group, LLC

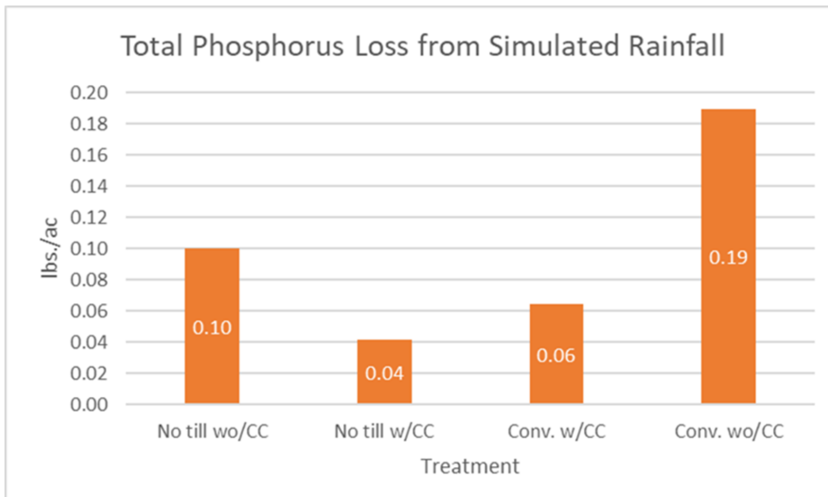

Figure 11: Total Phosphorus Loss from Simulated Rainfall
Produced by Water Resources Monitoring Group, LLC

	Infiltration (inches)	Infiltration (%)	Runoff (inches)	Runoff (%)	Soil Erosion (lbs./acre)	Total Phosphorus Loss (lbs./acre)
Trial 1 – no-till, no cover	1.56	78	0.44	22	25	.10
Trial 3 – no-till, cereal rye cover	1.33	89	0.17	11	5	.04
Trial 4 – conventional, cereal rye cover	1.72	86	0.28	14	37	.06
Trial 5 – conventional, no cover	1.12	66	0.58	34	224	.19

Table 1: June 2023 Infiltration and Runoff Data
Produced by Water Resources Monitoring Group, LLC

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. Letters following the data indicate statistical significance (95% confidence). Data with the same letters are statistically the same. Data with different letters indicate a statistically significant difference with 95% confidence the difference is caused by the treatment applied. 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 nine years of yield data are highlighted in Table 5.

FarmStat, a web-based statistical analysis tool designed to analyze agricultural experiments was used to run statistical analysis for plant population, residue cover, and yield. FarmStat is provided by the University of Nebraska-Lincoln. Tukey's HSD analysis was used to determine statistical differences between the five plot treatments at a 95% confidence level. No statistical difference in plant population was observed between any of the trials. A statistical difference in residue cover was observed. The no-till cereal rye cover crop treatment resulted in a statistically significantly higher residue cover than the other four trials. All three no-till treatments (trials 1, 2, and 3) resulted in a statistically higher residue cover than both conventional plots (trials 4 and 5). Finally, there was no statistical difference in yield between any of the trials.

	Plant Population (Plants/Acre)	**Residue Cover (%)**	**Yield Average (Adjusted to 15.5% Moisture)**
Trial 1 – no till, no cover	31,722 *a*	73.7 *a*	170.9 *a*
Trial 2 – no till, multi species cover	32,389 *a*	69.6 *a*	173.4 *a*
Trial 3 – no till, cereal rye cover	32,167 *a*	89.3 *b*	185.2 *a*
Trial 4 – conventional, cereal rye cover	32,611 *a*	8.1 *c*	187.9 *a*
Trial 5 – conventional, no cover	32,944 *a*	3.9 *c*	169.5 *a*

Table 2: Trial Average Data (letters indicate significant difference)

Tillage practice continues to drive the stark difference in surface residue cover (Figures 7 and 8). No-till plots averaged 77.5% surface residue cover while the conventional plots averaged 6.0%. The conventional plots (trial 4 and 5) were statistically the same but adding cereal rye cover crop increased residue cover by adding 4.2%. The no-till plots had residue cover of 73.7% (no cover), 69.6% (multi species), and 89.3% (cereal rye). Cereal rye added 15.6% and 19.7% residue as compared to the no-till no cover and no-till multispecies cover plots. While trial 3 has historically had higher average residue, this year' large, statistically significant difference was likely a result of terminating the cereal rye cover crop after planting. The cover crop had more time to grow, resulting in higher residue.

Figure 12: Corn Harvest November 1st, 2023

Data collected during crop harvest is presented in Table 3. Grain moisture ranged from 17.8% to 20.0%. Test weight ranged from 57 to 58 pounds per bushel. Plot yield is adjusted to a standard moisture of 15.5%. Individual plot yields ranged from a low of 153.8 bushels/acre to a high of 203.1 bushels/acre. Based on the trial averages, conventional till with cereal rye cover crop resulted in the highest average yield. Conventional tillage without cover crop resulted in the lowest average yield. The yield difference (49.2 bushels/acre) between the highest and lowest yielding plots (plots 101 and 302) was the second largest range in corn yield observed over the nine years of the study. There was no statistical difference in yield between the five trials.

Plot #	Tillage	Cover Crop	Moisture (%)	Test Weight (lbs/bu)	Yield (bu/acre) (Wet)	Adjusted Yield (bu/acre) (15.5 % moisture)
101	Conventional	Cereal Rye	17.8	54	208.7	203.0
102	No-Till	Cereal Rye	19.1	57	206.5	197.7
103	Conventional	Cereal Rye	19.0	58	195.4	187.3
104	Conventional	No Cover	18.7	57	179.0	172.2
105	No-Till	No Cover	18.7	58	172.0	165.5
201	No-Till	No Cover	20.0	57	197.6	187.1
202	No-Till	Cereal Rye	19.1	57	206.5	197.7
203	No-Till	Multi-species	18.6	58	187.3	180.5
204	Conventional	Cereal Rye	19.1	58	181.2	173.5
205	Conventional	No Cover	19.8	57	192.3	182.5
301	No-Till	Multi-species	18.4	57	167.3	161.6
302	Conventional	No Cover	19.5	58	161.5	153.8
303	No-Till	No Cover	18.9	58	166.8	160.0
304	No-Till	Cereal Rye	19.7	57	168.7	160.3
305	No-Till	Multi-species	19.3	57	186.5	178.1

Table 3: Individual Plot Harvest Data

Summary

The cover crop test plot continues to offer producers a local source of data testing the use of different agricultural practices. After nine 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 winter of 2022-23 had record level snow totals with minimal frost. This allowed for good soil moisture conditions early in the growing season. Rain was minimal starting in May and dry conditions lasted throughout the summer. Some producers in the area who planted corn following a cereal rye cover crop observed poor looking corn early in the summer. The consensus was that termination timing of the cereal rye played a role in available soil moisture. Earlier termination helped preserve soil moisture which the crop needed during drought conditions. In the test plot, the use of cover crops has increased surface residue cover. In 2023 cereal rye added a significant amount of residue compared to the other trials. This was likely due to allowing the cover crop to grow longer in the spring with termination occurring after the corn was planted. With both cereal rye trials having the highest average yield, termination timing of the cover crop didn't appear to have a negative effect on yield.

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. Previous infiltration and runoff data showed that the implementation of no-till and the use of cover crops is allowing more rainfall to infiltrate and reduced surface runoff. The 2023 data also showed this correlation. Additionally, the data showed that implementing a cereal rye cover crop in the conventional tillage system had better infiltration and lower runoff than no-till without cover crops. Again, the cereal rye plots had the highest average yield. On the other hand, the conventional plot without a cover crop had the lowest infiltration, highest runoff, and lowest average yield. While the data suggested no statistical difference in yield in a drought year, differences in infiltration rates may play a role in preventing yield loss.

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 nine 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 2023 the stress of drought conditions likely influenced corn yield. While average yield between the five trials couldn't be attributed to any treatment effect, there was an 18.4-bushel difference between the highest and lowest yielding trial averages. This numerical difference can make a difference in profitability in years with drought conditions. 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 nine 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 affects crop productivity. Looking at factors other than yield may also show how changes in management can improve agricultural systems.

Trial #	Treatments		Plot #	Plant Population* (plants/acre)	Residue* (%)	Yield* (bu/acre)
Trial 1	No-Till	No Cover	201	31,167	61.0	187.1
			105	31,833	82.7	165.5
			303	32,167	77.3	160.0
Trial 2	No-Till	Multi-species Blend	203	31,833	72.7	180.5
			305	32,167	68.8	178.1
			301	33,167	67.2	161.6
Trial 3	No-Till	Cereal Rye	102	31,500	94.5	197.7
			202	32,000	85.7	197.7
			304	33,000	87.8	160.3
Trial 4	Conventional	Cereal Rye	101	33,167	10.7	203.0
			103	32,500	7.8	187.3
			204	32,167	5.7	173.5
Trial 5	Conventional	No Cover	205	32,167	3.5	182.5
			104	33,167	4.7	172.2
			302	33,500	3.5	153.8

Table 4: 2023 Individual Plot Data

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

			2015	2016	2017	2018	2019	2020	2021	2022	2023
		Harvest Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
		Crop	Corn	Soybean	Corn	Soybean	Corn	Soybean	Corn	Soybean	Corn
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	170.9
Trial 2	No-Till	Multi-species Blend	184.3	66.3	186.1	45.8	190.9	55.0	225.9	46.8	173.4
Trial 3	No-Till	Cereal Rye	184.6	66.3	189.9	45.7	187.8	57.1	229.0	55.0	185.2
Trial 4	Conventional	Cereal Rye	191.8	65.3	194.5	43.5	182.1	59.1	236.8	36.2	187.9
Trial 5	Conventional	No Cover	194.8	66.5	191.8	41.9	186.8	62.1	209.8	45.3	169.5

	2015	2016	2017	2018	2019	2020	2021	2022	2023
High (individual plot)	197.7	67.9	205.0	49.1	196.6	64.8	249.9	59.6	203.0
Low (individual plot	165.5	64.6	181.0	41.1	177.3	52.4	198.0	31.6	153.8
Mean (average of all plots)	188.5	66.2	191.3	44.4	187.1	57.8	224.2	46.3	177.4
Standard Deviation (all plots)	10.6	0.9	7.8	2.6	5.5	3.3	15.1	7.5	15.3
Median (individual plot)	191.7	66.0	188.4	44.2	186.2	57.8	223.0	46.0	178.1
Range (all plots)	32.3	3.4	24.0	8.1	19.3	12.4	51.8	28.0	49.2

Table 5: Yearly Average Yield and Statistics (all plots)