2020 Field Summary Report

for

Conservation Innovation Grant Project

Comparison of Conventional Fall Tillage System with
Cover Crop/Fall Herbicide/Spring Tillage System
on
Potato Yield and Soil Health in Maine

Hillacre Farms - Corinna, ME

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The 2020 season marked the second, and final, potato crop in the rotation cycle of this Conservation Innovation Grant project. Treatments were applied alternately across the field on October 22, 2019 (Fig. 1). Soil type map is in Figure 1 and descriptions are in Table 1.

Figure 1. Soil type map (left) and project field with treatments applied (right).

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BRB	Brayton-Colonel complex, 0 to 8 percent slopes, very stony	0.1	0.5%
CrB	Corinna-Penobscot complex, 3 to 8 percent slopes, rocky	0.4	1.6%
KeB	Kenduskeag silt loam, 3 to 8 percent slopes	13.5	53.3%
PCC	Peru-Colonel-Tunbridge association, 3 to 15 percent slopes, very stony	0.0	0.1%
SpB	Sebasticook-Penobscot association, 3 to 8 percent slopes	11.2	44.5%
Totals for Area of Interest		**25.3**	**100.0%**

Table 1 Soil type descriptions at project site.

Soil Monitoring

Field work commenced with deployment of Spectrum Watchdog soil temperature/moisture monitors on April 1st (Fig. 2). Four monitoring stations were deployed on the west side of the field at treatment breaks. Probes were attached to monitoring stations via 20-foot-long cables and were inserted 6 inches deep into the soil. Loggers recorded soil temperature and moisture levels (VWC, volumetric water content) every hour. Season weather data relative to 30-year averages, including accumulated precipitation, daily precipitation, and daily high/low temperatures can be viewed at the back of the report in Appendix 1. The same data set for 2018 can be found in Appendix 2.

Pre-planting data was collected between April 1 and April 30. Loggers were then pulled for tillage and planting.

Figure 2. Spectrum WatchDog soil monitors deployed on April 1, 2020.

Table 2 shows average values for all four monitoring stations during the 2020 pre-plant period. Differences show relation of spray to plow treatments. If value is positive, then fall spray treatment is either wetter or warmer than fall plow treatment; if value is negative, then spray treatment is either drier or cooler than plow treatment.

Spray treatment averaged 0.84 percent wetter and 0.08 °F cooler than plow treatment. There was considerable variance in soil moisture between monitoring units, with spray treatment ranging from 16.29 percent wetter to 14.58 percent drier than plow treatment. Interestingly, the spray treatment was wetter on the lightest part of the field (16.29% wetter) and drier on the heaviest part (14.58% drier).

Table 2. Soil moisture (VWC) and temperature during pre-plant period, April 1 - April 30, 2020.

	Logger	VWC (%) - Plow	VWC (%) - Spray	VWC Difference (%)	Temp. (°F) - Plow	Temp. (°F) - Spray	Temp. Difference (°F)
Pre-Plant (April 1st - April 30th, 2020)	1	2.57	18.86	16.29	41.94	41.60	-0.35
	2	N/A			41.16	41.58	0.41
	3	6.21	7.03	0.82	44.37	44.10	-0.26
	4	28.24	13.66	-14.58	40.89	40.76	-0.13
	AVERAGE			0.84			-0.08

Logger 2 was not reading soil moisture after deployment

This is the same pattern as in 2018, during the first potato crop of this project, where the spray treatment was slightly wetter (1.12%) and cooler (0.59 °F) than the plow treatment (Table 3).

Table 3. Soil moisture (VWC) and temperature during pre-plant period, April 12 - May 14, 2018.

	Logger	VWC (%) - Plow	VWC (%) - Spray	VWC Difference (%)	Temp. (°F) - Plow	Temp. (°F) - Spray	Temp. Difference (°F)
Pre-Plant (April 12th - May 14th, 2018)	1	2.42	4.93	2.51	49.65	49.74	0.09
	2	4.49	8.69	4.20	49.18	47.54	-1.64
	3	6.14	7.81	1.67	45.80	45.52	-0.28
	4	17.89	13.98	-3.91	48.64	48.12	-0.51
	AVERAGE			1.12			-0.59

Between planting and hilling, the spray treatment averaged 2.38 percent wetter and 0.37 °F cooler than plow treatment (Table 4). Again, this is the same pattern observed in 2018, with spray treatment being wetter and cooler than the plow treatment (Table 5).

Table 4. Soil moisture (VWC) and temperature between planting and hilling, May 7 - June 17, 2020.

	Logger	VWC (%) - Plow	VWC (%) - Spray	VWC Difference (%)	Temp. (°F) - Plow	Temp. (°F) - Spray	Temp. Difference (°F)
Plant - Hill (May 7th - June 17th, 2020)	1	N/A			N/A		
	2	3.70	3.86	0.16	53.00	53.82	0.82
	3	1.28	2.37	1.09	63.11	59.92	-3.20
	4	2.86	6.53	3.67	57.82	59.09	1.27
	AVERAGE			2.38			-0.37

Logger 1 was pulled for repair

Table 5. Soil moisture (VWC) and temperature between planting and hilling, May 29 - June 29, 2018.

	Logger	VWC (%) - Plow	VWC (%) - Spray	VWC Difference (%)	Temp. (°F) - Plow	Temp. (°F) - Spray	Temp. Difference (°F)
Plant - Hill (May 29th - June 29th, 2018)	1	5.69	7.23	1.54	65.90	65.68	-0.21
	2	15.75	6.28	-9.46	65.35	64.51	-0.84
	3	6.52	24.24	17.71	65.83	65.22	-0.61
	4	3.42	5.81	2.39	65.81	66.89	1.08
	AVERAGE			3.04			-0.15

Between hilling and harvest, the spray treatment averaged 0.79% drier and 2.51 °F cooler than the plow treatment (Table 6). In 2018, the spray treatment averaged 0.43 percent wetter and 0.48 °F cooler than the plow treatment (Table 7).

Table 6. Soil moisture (VWC) and temperature between hilling and harvest, June 20 - Oct. 3, 2020.

Hill - Harvest	Logger	VWC (%) - Plow	VWC (%) - Spray	VWC Difference (%)	Temp. (°F) - Plow	Temp. (°F) - Spray	Temp. Difference (°F)
(June 20th - Oct. 3rd, 2020)	1	4.75	3.92	-0.84	69.33	69.19	-0.13
	2	4.88	2.76	-2.12	72.73	68.48	-4.25
	3	6.34	4.67	-1.66	76.12	71.68	-4.45
	4	4.14	4.26	0.12	71.21	70.02	-1.19
	AVERAGE			-0.79			-2.51

Table 7. Soil moisture (VWC) and temperature between hilling and harvest, July 11 - Oct. 4, 2018.

Hill - Harvest	Logger	VWC (%) - Plow	VWC (%) - Spray	VWC Difference (%)	Temp. (°F) - Plow	Temp. (°F) - Spray	Temp. Difference (°F)
(July 11th - Oct. 4th, 2018)	1	4.64	6.16	1.52	40.87	39.50	-1.38
	2	3.28	2.43	-0.85	68.62	67.71	-0.92
	3	3.90	5.86	1.96	71.41	69.94	-1.47
	4	2.88	1.95	-0.93	68.24	70.09	1.85
	AVERAGE			0.43			-0.48

Stand Counts

Stand counts were performed on June 15th. Plants from four rows of each treatment block, one-thousandth of an acre per row (14 ft. 6 in.) were categorized as small (under 6 in.), medium (6-12 in.), and large (over 12 in.). Table 8 shows number of plants and percentage of total count for each category. Percent stand values are based upon an expected population of 82 plants from an 8.5-inch spacing. Overall stands in the project field were quite good, but the spray treatment averaged a higher percentage of large plants, more total plants, and slightly better stands than the plow treatment.

Table 8. Stand count data from June 15, 2020.

Trt.	S (under 6")			M (6-12")			L (over 12")			Total Plants		% Stand	
Plow 1	4	5.0%	4.3%	12	15.0%	23.5%	64	80.0%	72.1%	80	320	98.4	97.9
Plow 2	2	2.6%		10	13.2%		64	84.2%		76		93.5	
Plow 3	4	4.8%		25	30.1%		54	65.1%		83		100.0	
Plow 4	4	4.9%		29	35.8%		48	59.3%		81		99.6	
Spray 1	1	1.2%	2.4%	12	14.6%	22.1%	69	84.1%	75.4%	82	330	100.0	98.3
Spray 2	0	0.0%		11	14.1%		67	85.9%		78		95.9	
Spray 3	2	2.2%		21	23.1%		68	74.7%		91		100.0	
Spray 4	5	6.3%		29	36.7%		45	57.0%		79		97.2	

Petiole Analysis

Petiole samples were collected July 16th during the vegetative stage of growth, approximately 50 to 60 petioles per treatment block. Samples were analyzed by Spectrum Analytic, Inc. (Washington Court House, OH). Table 9 shows test results for each sample as well as treatment averages. Plant nutrition was similar between treatments.

Table 9. Petiole test results from July 16, 2020; analyzed by Spectrum Analytic, Inc. (Washington Court House, OH).

Trt.	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Na (ppm)
Plow 1	3.97	0.24	11.6	1.33	0.31	0.16	34	11.8	54	1027	108	65
Plow 2	3.31	0.21	11.63	1.4	0.38	0.17	33.4	8.3	74	926	77	72
Plow 3	3.65	0.2	11.61	1.43	0.35	0.16	32.1	8.7	72	877	70	65
Plow 4	3.47	0.2	10.29	1.61	0.47	0.17	31.8	7	56	965	55	60
AVG	**3.60**	**0.21**	**11.28**	**1.44**	**0.38**	**0.17**	**32.8**	**9.0**	**64**	**949**	**78**	**66**
Spray 1	3.63	0.26	12.39	1.38	0.36	0.19	34.1	11.1	83	874	88	59
Spray 2	3.4	0.23	10.8	1.26	0.32	0.16	33.3	9.1	81	922	69	63
Spray 3	3.38	0.23	10.15	1.51	0.35	0.17	32.7	9.1	177	834	81	66
Spray 4	3.17	0.21	11.61	1.48	0.38	0.17	31.3	7.5	61	735	50	53
AVG	**3.40**	**0.23**	**11.24**	**1.41**	**0.35**	**0.17**	**32.9**	**9.2**	**101**	**841**	**72**	**60**

Tuber Count, Yield, and Grade

We harvested the trial on September 18th using a 24-horsepower McCormick X1.25H tractor with a one-row digger (Fig. 3). Twenty-one feet, nine inches of row was dug per treatment block. Number of hills and stalks were counted prior to digging. Tubers were graded using chipping/tablestock standards: under 2 inches, 2 to 3 inches, and over 3 inches.

Table 10 shows that the spray treatment had significantly more total tubers (15.6% increase), tubers per hill (16.1% increase), and tubers per stalk (13.3% increase) than the plow treatment.

Figure 3. Trial harvest with one-row digger, Sept. 18, 2020.

Table 10. Tuber counts at harvest, September 18, 2020.

Trt.	# Hills	# Stalks	# Tubers	Tubers/Hill	Tubers/Stalk
Plow 1	27	95	157	5.8	1.7
Plow 2	24	120	156	6.5	1.3
Plow 3	25	102	175	7.0	1.7
Plow 4	26	92	139	5.3	1.5
AVERAGE			**156.8**	**6.2**	**1.5**
Spray 1	26	112	195	7.5	1.7
Spray 2	25	109	186	7.4	1.7
Spray 3	24	95	174	7.3	1.8
Spray 4	26	114	170	6.5	1.5
AVERAGE			**181.3**	**7.2**	**1.7**

Table 11 shows yield and grade of individual treatment strips as well as treatment averages. The plow treatment had a larger tuber size profile than the spray treatment, with an average 30.3% of tubers over 3 inches versus 19.4%, respectively. The plow treatment also averaged greater marketable yield per acre, 420.7 cwt versus 414.2 cwt for the spray treatment. However, the spray treatment had higher average total yield per acre, 450.8 cwt versus 444.8 cwt for the plow treatment. These yields were under irrigation. For comparison, a plow treatment dig sample from outside the irrigation circle yielded 352.5 cwt per acre. Tuber pictures from each treatment strip can be seen in Appendix 3 at the back of the report.

Table 11. Yield and grade, September 18, 2020.

	under 2" (lbs)		2-3" (lbs)		over 3" (lbs)					
Trt.	lbs	%	lbs	%	lbs	%	Marketable Yield (lbs)	MY/acre (cwt)	Total Yield (lbs)	TY/acre (cwt)
Plow 1	5.7	8.9%	41.1	64.5%	16.9	26.5%	58.0	387.2	63.7	425.3
Plow 2	3.9	5.8%	44.4	66.4%	18.6	27.8%	63.0	420.6	66.9	446.6
Plow 3	3.2	4.6%	46.6	67.5%	19.2	27.8%	65.8	439.3	69	460.6
Plow 4	1.6	2.4%	39.3	58.7%	26	38.9%	65.3	435.9	66.9	446.6
AVG	**3.6**	**5.4%**	**42.9**	**64.3%**	**20.2**	**30.3%**	**63.0**	**420.7**	**66.6**	**444.8**
Spray 1	7.2	10.2%	52.4	74.0%	11.2	15.8%	63.6	424.6	70.8	472.7
Spray 2	8	13.2%	41.5	68.4%	11.2	18.5%	52.7	351.8	60.7	405.2
Spray 3	4.2	5.8%	50.4	70.1%	17.3	24.1%	67.7	452.0	71.9	480.0
Spray 4	2.5	3.7%	51.6	77.4%	12.6	18.9%	64.2	428.6	66.7	445.3
AVG	**5.5**	**8.1%**	**49.0**	**72.5%**	**13.1**	**19.4%**	**62.1**	**414.2**	**67.5**	**450.8**

Related to increased tuber set, the spray treatment had a lower average tuber size at 5.98 ounces compared to 6.84 ounces for the plow treatment (Table 12). The non-irrigated sample averaged 6.21 ounces.

Table 12. Average tuber size.

Trt.	# Tubers	Total Yield (lbs)	Avg. Tuber Wt. (oz)	
Plow 1	157	63.7	6.49	6.84
Plow 2	156	66.9	6.86	
Plow 3	175	69	6.31	
Plow 4	139	66.9	7.70	
Spray 1	195	70.8	5.81	5.98
Spray 2	186	60.7	5.22	
Spray 3	174	71.9	6.61	
Spray 4	170	66.7	6.28	

Table 13 shows yield and grade data from the 2018 season for comparison. Size profile was almost identical between treatments. The spray treatment had a yield advantage over the plow treatment, nearly 10 cwt per acre in marketable yield and 12 cwt per acre in total yield.

Table 13. Yield and grade, 2018.

	under 2"		2" to 3"		over 3"					
Trt.	lbs	%	lbs	%	lbs	%	Marketable Yield (lbs)	MY/acre (cwt)	Total Yield (lbs)	TY/acre (cwt)
Plow 1	3.0	6.5%	38.0	83.0%	4.8	10.5%	42.9	291.6	45.8	311.9
Plow 2	1.4	3.3%	31.3	74.3%	9.4	22.4%	40.7	271.1	42.1	280.4
Plow 3	2.9	6.5%	33.2	75.1%	8.1	18.4%	41.4	263.1	44.2	281.3
Plow 4	1.7	4.1%	31.5	77.0%	7.7	18.9%	39.2	256.2	40.9	267.1
AVG	**2.2**	**5.1%**	**33.5**	**77.4%**	**7.5**	**17.5%**	**41.0**	**270.5**	**43.3**	**285.2**
Spray 1	1.5	3.6%	29.1	67.3%	12.6	29.1%	41.7	287.2	43.2	297.8
Spray 2	3.6	7.9%	35.3	78.8%	6.0	13.3%	41.2	287.7	44.8	312.5
Spray 3	2.3	5.7%	32.7	80.8%	5.5	13.5%	38.2	290.3	40.5	307.8
Spray 4	2.0	5.4%	30.3	81.5%	4.9	13.2%	35.2	255.3	37.2	269.7
AVG	**2.3**	**5.6%**	**31.9**	**77.1%**	**7.2**	**17.3%**	**39.1**	**280.1**	**41.4**	**297.0**

Fry Analysis and Specific Gravity

Twelve-to-thirteen-pound samples of mid-grade tubers (2-3 in.) were collected from each treatment strip. Samples were processed for fry analysis and specific gravity by Hancock Agricultural Research Station (Hancock, WI).

Table 14 shows fry analysis and specific gravity for individual treatment strips as well as treatment averages. Figures 4 and 5 provide description of fry analysis metrics. The plow treatment had better averages across all metrics: brighter chips (L-value), less scorching (a-value), whiter chips (b-value), and specific gravity.

Fry pictures from Hancock can be seen in Appendix 4 at the back of the report.

Table 14. Fry analysis and specific gravity, Hancock Agricultural Research Station (Hancock, WI).

Trt.	L	a	b	SED 0	SED 1	SED 2	SED 3	SED 4	SED 5	Sp. Grav.
Plow 1	62.55	3.98	23.81	89	3	0	8	0	0	1.015
Plow 2	60.48	4.28	23.43	69	0	17	14	0	0	1.009
Plow 3	63.11	3.75	24.08	92	0	8	0	0	0	1.015
Plow 4	62.79	4.13	23.67	97	3	0	0	0	0	1.020
AVG	**62.23**	**4.04**	**23.75**	**86.8**	**1.5**	**6.3**	**5.5**	**0**	**0**	**1.015**
Spray 1	61.56	4.11	24.11	84	8	8	0	0	0	1.015
Spray 2	61.81	4.16	24.39	89	0	3	8	0	0	1.011
Spray 3	63.08	4.49	24.91	92	8	0	0	0	0	1.011
Spray 4	61.23	4.09	23.43	63	6	14	17	0	0	1.019
AVG	**61.92**	**4.21**	**24.21**	**82.0**	**5.5**	**6.3**	**6.3**	**0**	**0**	**1.014**

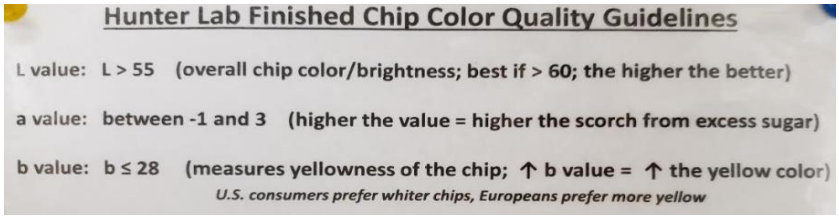


Figure 4. Hunter Lab chip color quality guidelines.

Figure 2. Stem end scoring (SED).

Soil Respiration and Mineral Analysis

Samples were collected for testing soil respiration (i.e., Solvita) as well as standard mineral composition. These were processed by Spectrum Analytic, Inc. (Washington Court House, OH).

Solvita test results were similar between both treatments with a slight edge for the plow treatment (Table 15). Test interpretation from the lab suggests color index values from 3.01 to 4.00 would have an approximate annual nitrogen release of 38 – 58 lbs per acre. Given this scale and treatment average color index values, the difference in nitrogen release between treatments may only be 1-pound per acre. A Solvita test run by the University of Maine Soil Lab in 2018 shows a similar pattern of the plow treatment having greater soil respiration than the spray treatment (Table 16).

Mineral composition test results show that the spray treatment had higher organic matter, phosphorous, potassium, magnesium, and calcium levels (Table 17).

Table 15. 2020 Solvita soil respiration test results, Spectrum Analytic, Inc. (Washington Court House, OH).

Trt.	Solvita CO2 Index	Solvita ppm
Plow 1	3.88	60.93
Plow 2	3.48	42.84
Plow 3	3.19	33.1
Plow 4	3.31	37.08
AVG	**3.47**	**43.49**
Spray 1	3.35	38.43
Spray 2	3.35	38.43
Spray 3	3.68	51.37
Spray 4	3.31	37.08
AVG	**3.42**	**41.33**

Table 16. 2018 Solvita soil respiration test results, Univ. of Maine Soil Lab (Orono, ME).

Trt.	ppm CO2-C	Microbial Biomass (ppm)	Microbial Biomass (lbs/acre)
Plow 1	52	1040	2080
Plow 2	50	1000	2000
Plow 3	23	460	920
Plow 4	20	400	800
AVG	**36.25**	**725**	**1450**
Spray 1	38	760	1520
Spray 2	42	840	1680
Spray 3	26	520	1040
Spray 4	18	360	720
AVG	**31**	**620**	**1240**

Table 17. Soil mineral composition test results, Spectrum Analytic, Inc. (Washington Court House, OH).

Trt.	Soil pH	Buffer pH	OM (%)	P (m3-ppm)	K (m3-ppm)	Mg (m3-ppm)	Ca (m3-ppm)	CEC	K Sat. (%)	Mg Sat. (%)	Ca Sat. (%)	K/Mg Ratio	Ca/Mg Ratio	S (m3-ppm)	B (m3-ppm)	Cu (m3-ppm)	Fe (m3-ppm)	Mn (m3-ppm)	Zn (m3-ppm)
Plow 1	5.7	6.6	2.6	338	128	62	721	8.2	3.3	5.5	32.8	2.1	11.6	45	0.6	10.1	138.5	49	5.8
Plow 2	5.9	6.7	2.7	302	145	71	823	7.5	4.2	6.9	41	2	11.6	37	0.5	9.7	134.6	50	5.3
Plow 3	6.2	6.7	2.5	331	148	89	899	7.9	4	8.2	42.4	1.7	10.1	45	0.7	9.1	156	61	5.8
Plow 4	5.7	6.5	2.6	344	98	66	711	9.4	2.3	5.2	28.5	1.5	10.8	35	0.5	9.3	163.6	55	5.1
AVG	**5.9**	**6.6**	**2.6**	**329**	**130**	**72**	**789**	**8.3**	**3.5**	**6.5**	**36.2**	**1.8**	**11.0**	**40.5**	**0.6**	**9.6**	**148.2**	**53.8**	**5.5**
Spray 1	5.9	6.8	2.6	394	140	82	806	6.3	4.8	9.5	47.8	1.7	9.8	37	0.6	11.4	159.5	54	5.5
Spray 2	5.8	6.6	3	339	147	79	793	8.7	3.7	6.7	34.3	1.9	10	43	0.5	10	147.7	53	5.8
Spray 3	5.9	6.8	3.1	347	141	73	846	6.4	4.7	8.3	49.5	1.9	11.6	33	0.6	10.5	149.5	55	5.4
Spray 4	5.8	6.7	2.7	358	132	81	833	7.6	3.7	7.8	41.1	1.6	10.3	41	0.7	9.1	169	52	5.1
AVG	**5.9**	**6.7**	**2.9**	**360**	**140**	**79**	**820**	**7.3**	**4.2**	**8.1**	**43.2**	**1.8**	**10.4**	**38.5**	**0.6**	**10.3**	**156.4**	**53.5**	**5.5**

Results and Conclusion

It was determined that spring soil conditions were slightly cooler and wetter in ground that had fall-sprayed cover versus that which was fall-plowed. This did not hinder spring field operations. Most importantly, in both 2018 and 2020 planting date was not delayed significantly when tillage was postponed until spring.

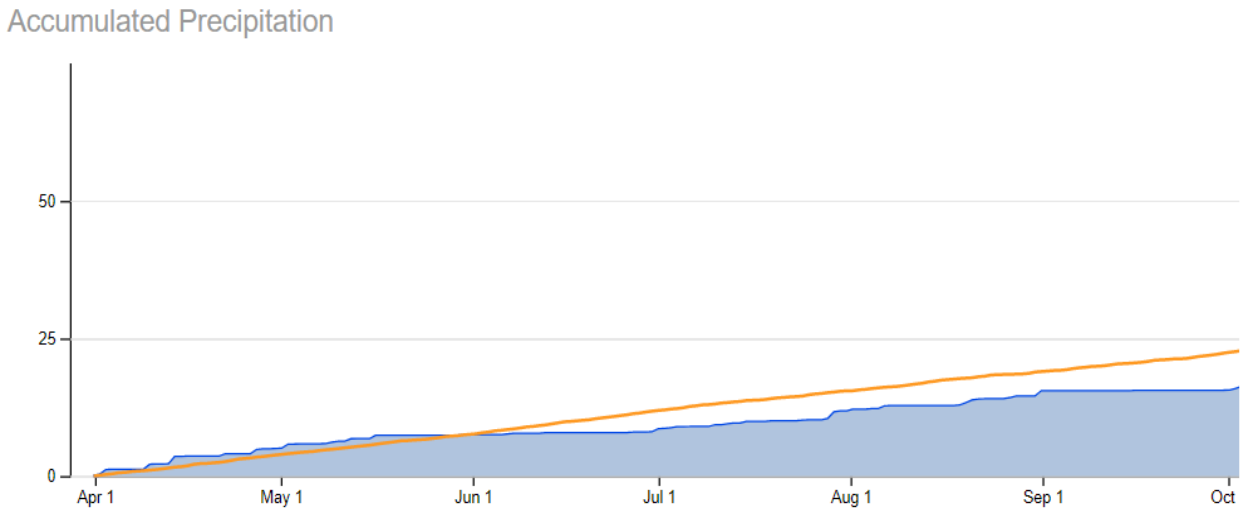
Increased soil moisture in fall-sprayed/spring-tilled ground promoted earlier canopy closure and increased tuber set. Tuber counts between treatments differed by 15.6 percent and were found to be statistically significant. Also, yield was not negatively affected by delaying tillage until spring. In both years, total yield was higher on the fall-sprayed/spring-tilled ground.

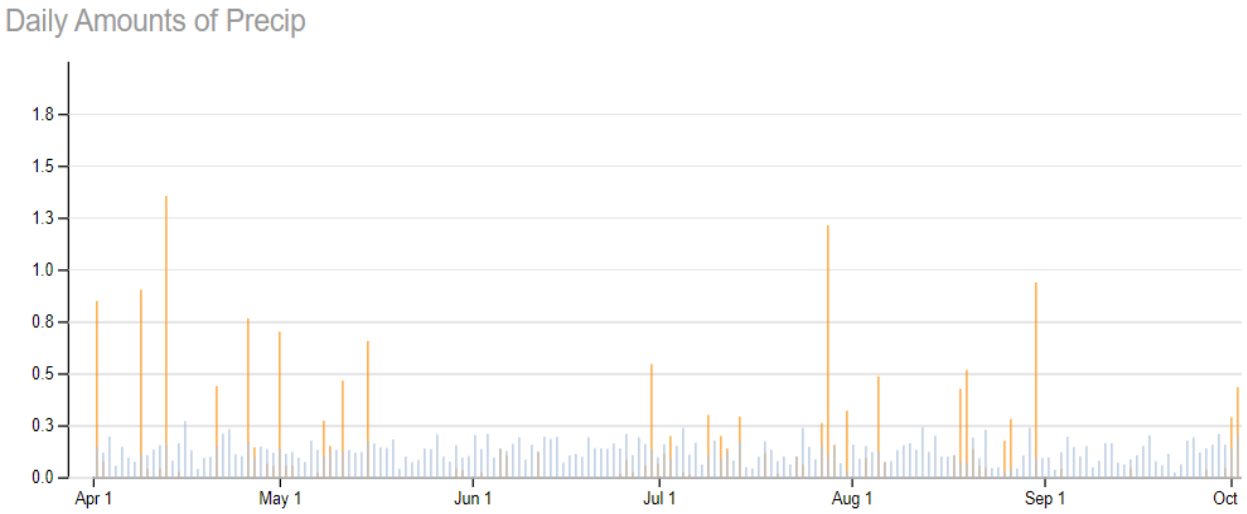
We determined that by establishing a cover crop, browning it out with herbicide in fall, and delaying tillage until spring has proven to be an effective alternative practice to traditional fall-plowing. Implementing these practices in potato production offers great benefits to growers, including:

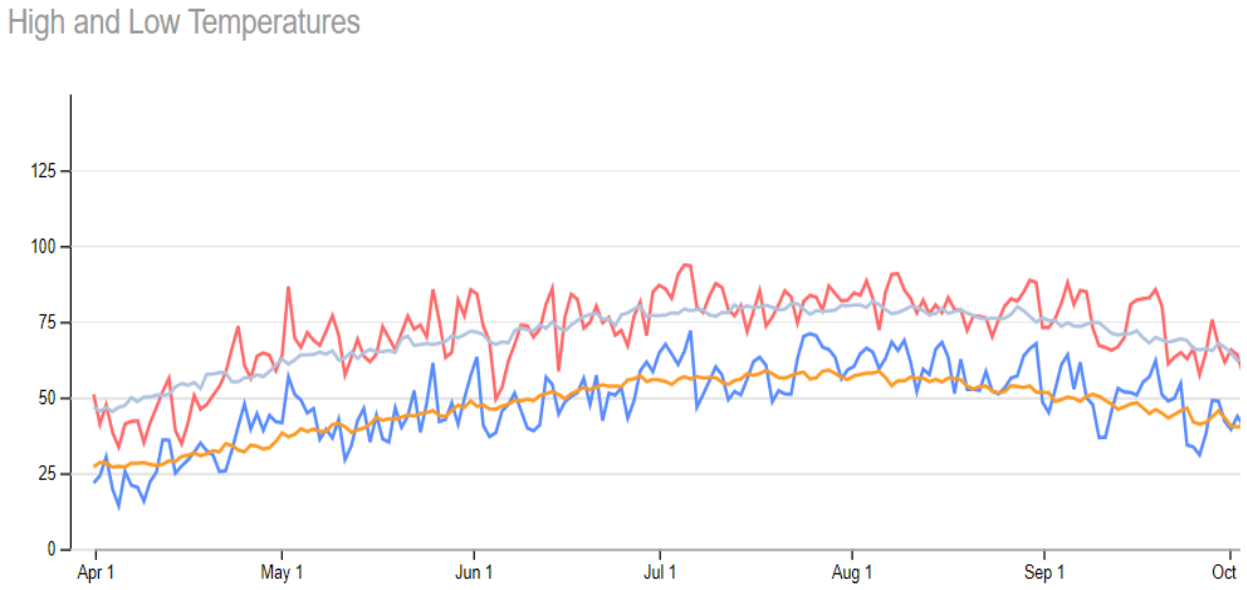
- Saving a tillage pass
- Soil surface is left intact fall through spring, thus reducing risk for erosion
- Less erosion preserves valuable agricultural topsoil and water quality

The findings of this project support these practices as a long-term strategy for improving soil health and structure in potato systems.

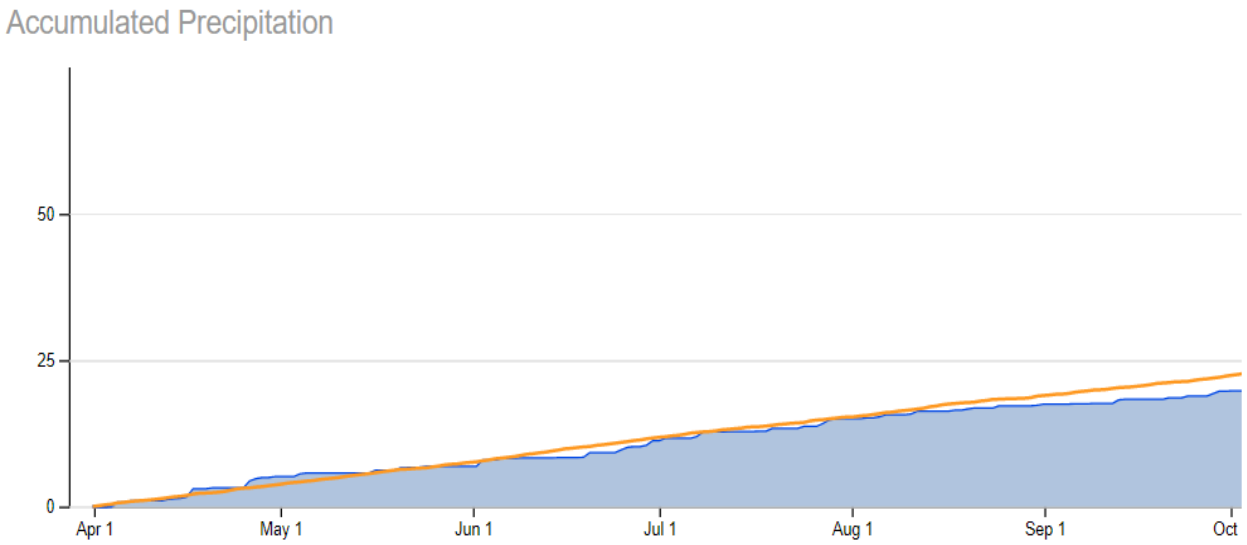
Appendix 1: 2020 weather data at project site compared to 30-year averages, source Climate.com.

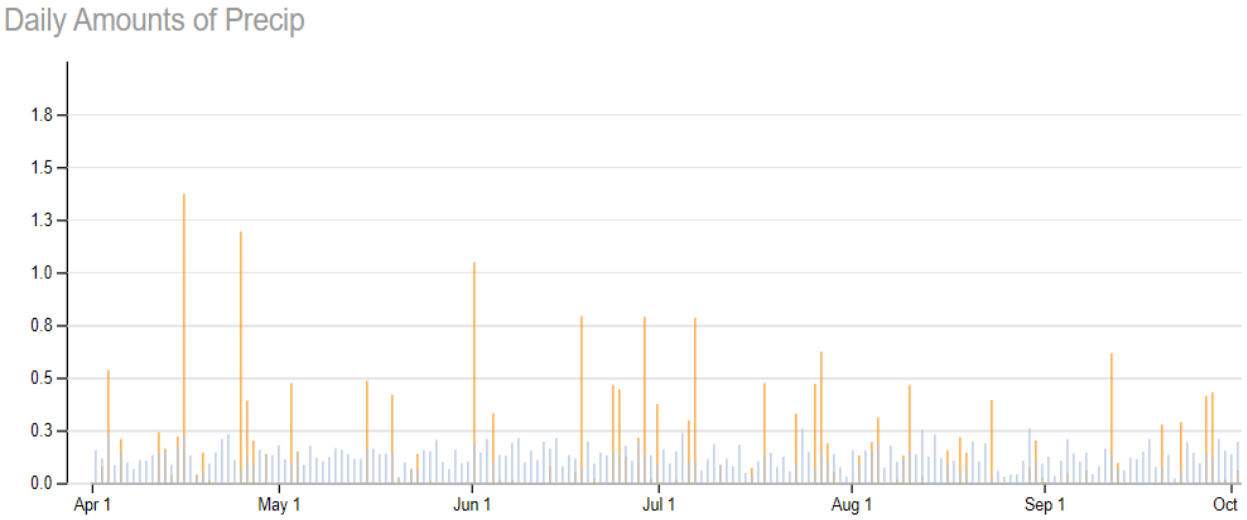


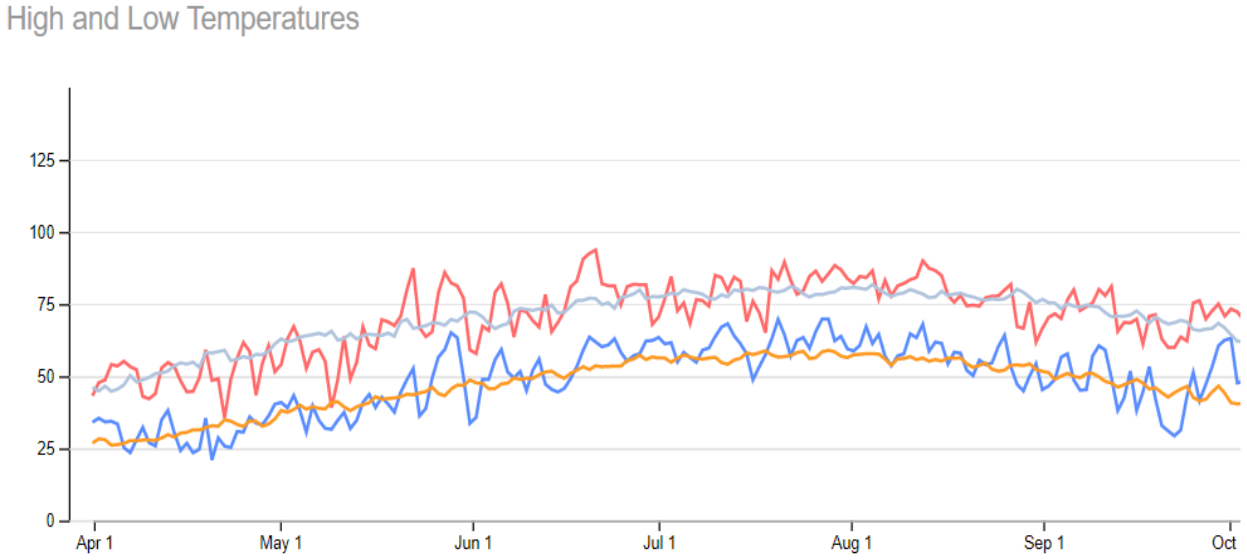




Appendix 2: 2018 weather data at project site compared to 30-year averages, source Climate.com.







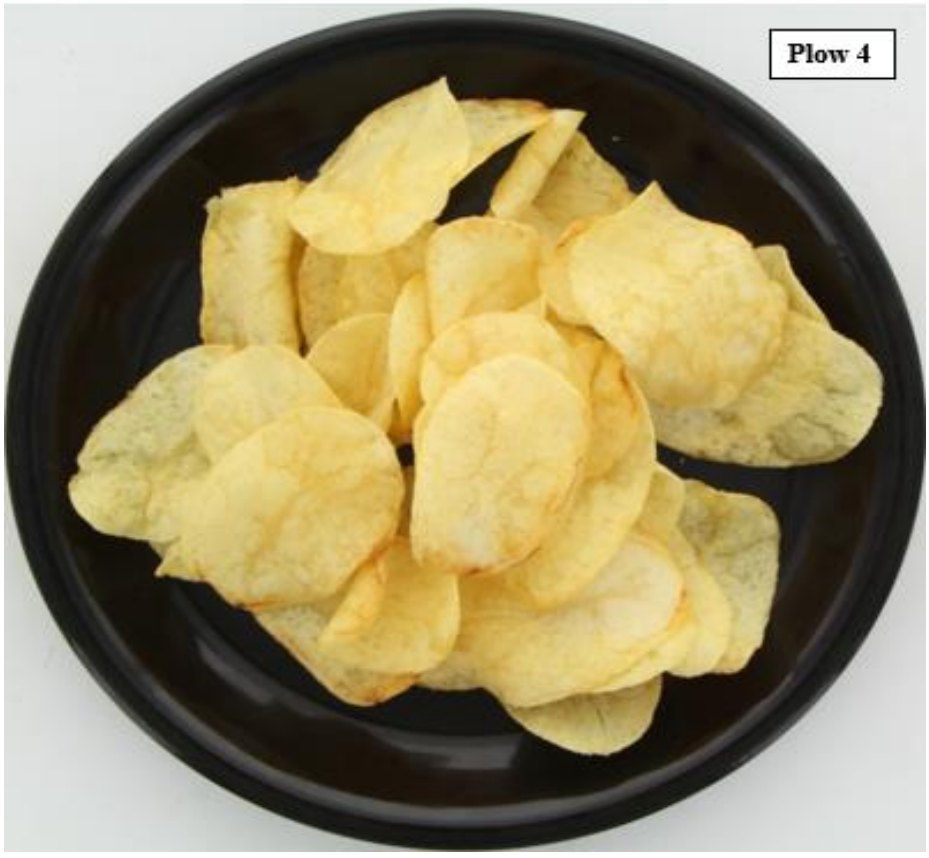
Appendix 3. Tuber pics at harvest, September 18, 2020.


Spray 1
472.7 cwt/ac
Spray 2
405.2 cwt/ac


Spray 3
480.0 cwt/ac
Spray 4
445.3 cwt/ac

Appendix 4: Fry pictures from Hancock Agricultural Research Station (Hancock, WI).


Plow 3


Plow 4


Spray 1


Spray 2


Spray 3


Spray 4

Appendix 5: In-season drone images of project field.