CLIMATE CHANGE ADAPTATION PROGRAM

Demonstration of innovative corn production technologies:

Interseeding cover crops (relay cropping), variable rate planting and strip tillage

Project Report

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Executive Summary

This project demonstrated and provided local experience with innovative corn production management strategies including intercropping annuals (relay cropping), variation to plant population and strip tillage. The trials were located east of Vernon and were conducted over four growing seasons. Intercropping was successful with the production of up to 0.5t/ac of dry matter when measured post harvest, although challenges such as inadequate moisture and timing of seeding could cause a failure to establish. Yield and margin was responsive to increases in plant population when grown under adequate moisture and fertility. Strip tillage was very successful with savings in time and fuel use, improvements in soil structure. Some reductions in yield and maturity were noted especially in the first year.

1. Introduction

The main objective of this project was to demonstrate and provide local data / experience with innovative corn production management strategies. With climate change and environmental concerns, it is increasingly important for producers to identify the challenges and opportunities of new technologies and practices that will affect their operations profitability, water use and nutrient management. The project demonstrates and researches three innovative practices for corn production; inter-seeding cover-crops (relay cropping), variable rate plant population, and strip tillage and examines their impacts through a number of sub-objectives.

These practices are used in other regions but have not had testing or extensive adoption in the Okanagan or BC interior. Strip tillage is gaining popularity as a practice in eastern Canada, and the northern corn belt states, relay cropping is well utilized in the lower mainland of BC and Whatcom County, Washington.

Identified Okanagan CCAP climate change and weather-related risk adaptation sub-objectives of this project includes: Increasing yields and profitability, improved utilization of soil and applied moisture, reduction of erosion, improved nutrient use and reduction of nutrient loading, improved soil health and structure, forage production for extending the growing and grazing season, agronomic resilience, cost-benefit analysis and reduction of fuel use / emissions. A background of each technology /practice and a description of how it meets these objectives follows.

2. Practices

Intercropping Cover Crops (Relay Cropping):

This research demonstration was conducted by interseeding cover-crops into corn that is at the V4-V6 growth stage (after herbicide application but before canopy closure). This is also referred to as relay cropping and is based on work done a the AAFC Agassiz research station by Shabtai Bittman and Derek Hunt. The cover crop would germinate and grow slowly under the corn canopy until after harvest when full sunlight will allow fall growth. Extensive research has been done on the benefits of cover-crops and their popularity in other regions in many crops has been increasing rapidly. Benefits identified include increasing soil health, organic matter and structure by having a crop growing in the otherwise unused inter-row space, reducing erosion in the inter-row space both in-season and after the crop is harvested, and increased fall soil nitrate uptake to reduce potential for nitrate leaching. The impact on soil moisture will be examined. The additional benefit primarily for beef producers is to produce fall grazing capacity and extend their growing and grazing season.

Variable Rate Plant Population:

The science behind variable rate population is based on the spatial variability of productive capacity (zones) within the field and matching resources to this variability. Primarily zones are based on soils with better nutrient and moisture holding capacity that can produce higher yields and conversely soils without the nutrient and moisture holding capacity that often do not utilize all the nutrients provided. Zones can also include difference in aspect, irrigation system coverage, or solar potential (along irrigation row edges). Once zones are developed fertilizer and water inputs could be varied as well, but this is beyond the scope of this demonstration. Corn plants are very responsive to plant population and are an excellent crop to test and demonstrate this practice. A producer who can utilize variable rate population will be able to increase yields on zones that have under-utilized capability and will be able to save inputs within zones that are not as productive. This same technology allows planter row-shut offs to prevent overlap when planting into the headlands, resulting in seed savings and increased yield/quality as these double planted areas often have agronomic issues.

Strip Tillage:

Strip Tillage is a reduced tillage replacement for conventional tillage practices. It utilizes row units with row cleaners, coulters and rolling basket to till a strip 8" (20cm) wide that the corn is later planted into. This gives many of the benefits of full zero-till while allowing for soil within the strip to warm enough for proper germination and stand establishment. The previous crops residue is maintained in the inter-row spaces which can help reduce erosion, maintain soil moisture, and soil structure as compared to conventional tillage. Although not to be measured directly in this demonstration some versions of strip tillage equipment can be modified to apply fertilizer or liquid manure only into the strip, improving fertilizer use efficiency and along with the reduction in erosion lowering the risk of environmental loss of phosphorus. Additionally the reduced number of passes on the field compared to conventional tillage will have significant savings of time and fuel use and a reduction in emissions. It is expected that a producer with strip tillage will be able to plant earlier in the spring, allowing the use of longer season hybrids for higher yields, or alternatively having a longer fall growth period for use of cover-crops.

3. Research Methods

This project evaluated the three practices individually, evaluation and monitoring of each component was planned to be conducted as follows:

Intercropping cover crops (Relay cropping):

Trial Design and Methodology: Two Sites with six treatments each. Treatments include two hybrids with Check, Cover-Crop, Solar Pathway with Cover-Crop. If possible differing hybrids will have different leaf orientation or number / heat units to explore differences in light interception potential on the cover crops. Each demonstration treatment was at least 0.25acre in total, for the research component a sub-site within the demonstration of 1/1000acre (44sq ft -4sq m) was harvested.

Treatment 1: Check was the normal producer practice at recommended planting population (32-36k plants/acre depending on hybrid selected) with no inter-seeded cover crop.

Treatment 2: Cover-crop treatment was seeded with a cover crop of Italian ryegrass, a clover and a forage brassica seeded after spraying (typically V4-V6 growth stage). Cover crop was seeded using broadcast and drilled methods.

Treatment 3: Cover crop with solar pathways explored standard width (30”) corn rows seeded to a row number multiple of the harvest equipment (2, 4 or 6 rows) followed by a skipped row (resulting in 60” solar pathway) then repeat. The inter row space and 60” space was inter-seeded with a cover crop at the same time and composition as treatment 2. Additionally, the rows of corn adjacent to the 60” space (edge rows) was seeded at a higher plant population (utilizing AgLeader Sure Drive electric planter drives) to optimize light capture using the edge row effect. For example, for a 4 row treatment, individual row populations would be; 54k, 36k, 36k, 54k, solar corridor and repeat to achieve a 36k average field plant population.

Harvest of treatments: The demonstration treatments were harvested at two different stages. It was attempted to harvest a portion of the plots at silage timing to allow for longer fall growth, this was not always logistically possible. At minimum an area within the demonstration of 1/1000acre (44sq ft -4sq m) was harvested by hand as silage, a wood chipper used to create silage sub-samples. The remainder was harvested as grain after black layer and some drydown has occurred. At the end of the growing season the cover-crop within the research component will be harvested by hand, weighed, dried and ground for sub sample analysis.

In-season Data: Soil analysis will be taken prior to planting for a baseline. Qualitative analysis of plant health done in season with attributes including: difference between the treatments in plant growth, leaf firing from nutrient translocation, moisture stress, standability, potential disease or pest pressures, and weed control.

Harvest Data: Grain yield and moisture from weigh scale calibrated yield monitor, Silage yield from 1/1000ac harvested plot, cover crop yield in both silage yield and grain harvested areas, forage quality of both corn and cover-crop. Forage quality will consist of reports including protein, fibers, digestibility, minerals (cover crop) and energy calculations done by a NFTA certified lab.

Post-Harvest data: Soil samples will be taken of each treatment to evaluate nutrient use including 2ft depth samples to evaluate residual nitrate differences between treatments. Qualitative evaluation of soil tilth and structure was conducted. Plant stand count of cover-crop treatments will be performed. If the cover-crop over-winters, spring growth will be evaluated and measured if possible.

Post-harvest analysis: Cost benefit analysis will be done to consider cost of cover crop treatments compared to forage value (AUM). Forage quality of the cover crop will be considered for nutritional needs of various classes of beef cattle (cow-calf, yearlings).

Variable rate population:

Trial Design and Methodology: Four sites total, with 4 fixed population treatment in addition to the variable rate population treatment. The specific populations per acre selected for the treatments will depend on the hybrid selected and the suppliers recommended planting population. For example: if recommended population is 34,000 plants per acre (check population), other populations would be selected below and above check (30k, 38k, 42k). Each treatment will be 6 - 30” wide rows wide to facilitate planting and harvest. Due to differing field lengths the 4 sites will have different treatment sizes ranging from 0.25ac to 0.4ac. The entire plot of 5 treatments will range from 1.25ac to 2ac. The site will be selected for minimal variation between treatments but normal variation along the length of the treatment will be desired. The initial variable rate prescription will be developed using a Veris EC machine which measures soil electro-conductivity at two depths. The soil EC values will be used along with ground-truthing to help identify spatial zones with differing soil texture, moisture and nutrient holding capacity and thus potential yield. Each year's yield and calculated return data from the single rate populations will be used to further refine the variable rate prescription the following year based on the field zones. In order to facilitate the population rate changes and the variable rate prescription, my existing corn planter will be modified with electric row unit drives from Ag Leader Technology (Sure Drives) which will be controlled by the GPS.

Harvest: The sites were harvested as grain after black layer and some drydown using a combine mounted yield monitor with weigh scale calibration, this will give data that encompasses all spatial soil zones developed above. Two of the sites had a component harvested as silage. For silage 1/1000 of an acre (44 sq ft or 4sq meter) in each soil zone will be hand cut at 6" cutting height, targeting a 35% DM harvest date. Each large sample of hand harvested silage will be weighed and run through a wood chipper to create a subsample for further analysis or moisture and quality.

In-season data: Qualitative analysis of plant health done in season. Attributes that can be evaluated include: difference between the strips in plant height, growth, leaf firing from nutrient translocation, moisture stress, standability, potential disease or pest pressures, and weed control. Plant tissue tests will be taken at 3 stages (V3-V5, VT and R2), frozen and shipped for analysis.

Harvest data: Grain yield and moisture, Silage yield and moisture, Silage quality - Full report including protein, fibers, digestibility and energy calculations done by a NFTA certified lab (Fraser Valley Analytical / CVAS).

Post-harvest analysis: Cost benefit analysis was be done to consider additional seed cost and cost of modifications.

Strip Tillage:

Trial Design and Methodology: Two sites with four treatments, strip tillage, strip tillage with cover crop, strip tillage with cover crop and variable rate and check. Each treatment was a minimum of 0.5acres, and wider on some plots to facilitate tillage operations. The strip tillage treatment was planned to be strip tilled 8-10days before anticipated planting date (conditions allowing). The check treatment was full conventional tillage consisting of moldboard plow, multiple disk passes and cultipacking. The strip tillage – cover crop treatment incorporated the inter-seeded cover crops. A final treatment of incorporation of all these technologies, strip tillage, cover crop and variable rate plant population was conducted when possible. The strip tillage equipment utilized Dawn Pluribus strip till row units added onto an existing corn cultivator, and also required GPS guidance to ensure proper alignment for planting on the strips.

Harvest of treatments: The majority of the plot was harvested as grain after black layer and some drydown. 1/1000ac (44sq ft) was hand harvested as silage with a target of 35%DM. As in the other plots, the hand harvested corn silage was chipped and sub-sampled. The cover crop portion of the cover crop treatments was harvested before final freeze up, weighed, sub-sampled and sent for forage quality analysis.

In season data: Soil temperature will be monitored before and following planting date to compare between on-strip, off strip and the check treatment. Qualitative observations will be taken to compare treatments for growth, plant health, pests, disease and weed pressure.

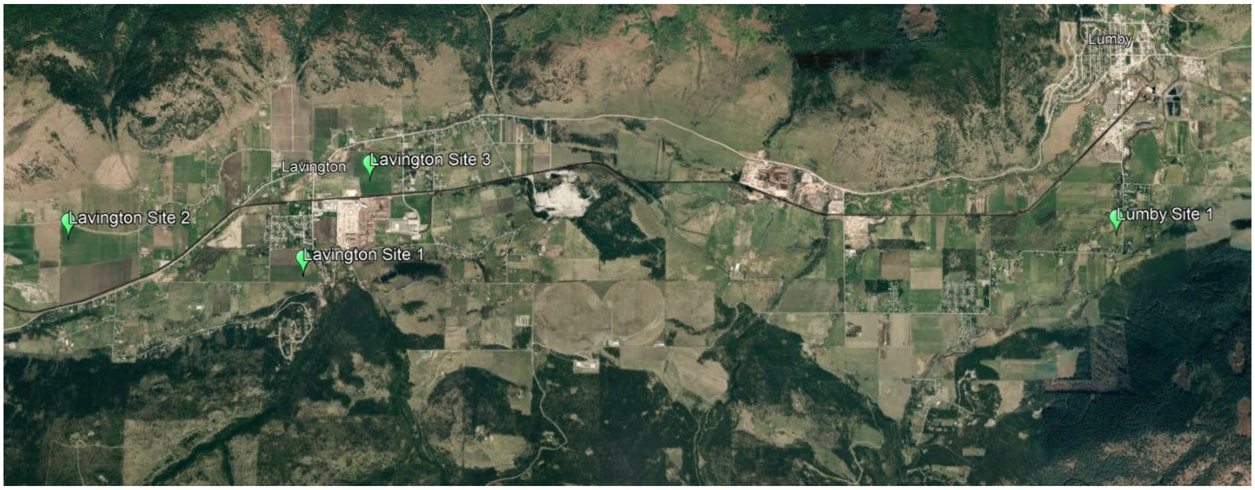
Harvest data: Grain yield and moisture, Silage yield and moisture, Silage quality - Full report including protein, fibers, digestibility and energy calculations done by a NFTA certified lab.

Post-Harvest data: Soil samples were taken of each treatment to evaluate nutrient use including 2ft depth samples to evaluate residual nitrate differences between treatments. Samples were taken on and off strip to help alleviate spatial variability. Soil organic matter was measured as well as qualitative evaluation of soil tilth and structure. Plant stand count of cover-crop treatments was performed. In cases where the cover-crop over-wintered, spring growth was evaluated and measured, if possible, prior to pre-plant herbicide application.

Post-harvest analysis: Cost benefit analysis was conducted to consider the cost of strip tillage compared to conventional tillage. Soil health parameters was compared between the treatments.

4. Demonstration/Research sites:

There were two primary demonstration/research sites:



Lavington Site 1: 50d13.5N, 119d7W, 540m elevation, Class 1 soil irrigated Kalamalka Sandy Loam. Approximately 160 frost free days, 2050 GDD base5, with 5” (12.5cm) growing season precipitation. Typically grows corn with 2600CHU for grain, 2800CHU for silage.

Lumby Site 1: 50d13.6N, 118d58W, 505m elevation, Class 2 soil irrigated Lumby Sandy Loam. Approximately 135 frost free days, 1950 GDDbase5, with 6.5” (17.25cm) growing season precipitation. Typically grows corn 2100CHU for grain, 2400CHU for silage.

These sites are representative in season length of 75% of the corn growing acres in the southern interior of BC.

Additional Sites:

Lavington Site 2: 50d13.75N, 119d9W, 550m elevation. Class 1 soil irrigated Kalamalka Sandy Loam. Similar to Site 1 but with south aspect.

Lavington site 3: Irrigated class 1 Spallumcheen Silty Clay. A cooler microclimate from a nearby side valley and valley bottom location reduces the typical heat unit selection to 2450CHU for grain, 2650CHU for silage.

5. Results

Intercropping cover crops (Relay cropping):

2019

Lavington site: The corn was planted on May 7th, and the cover crop was seeded by hand at V4-V5 stage, June 23rd. Effort was taken to broadcast and leave on the surface in some areas, and lightly incorporate with a steel garden rake in other areas to compare differences in establishment, none were observed. Where the intercrop was seeded, there was a slight decrease in grain yield (5.62mt/ac vs 5.88mt/ac in check, no change in moisture. (table1) Yield of the intercropped forage ranged from 670-930lbs/ac DM for the Italian ryegrass alone to 1485-1844lbs/ac for the brassica-Italian ryegrass blend. (Table 2) In season tissue tests did not show differences however fall soil nutrient levels were lower in the intercrop compared to the check. Establishment of the cover crop in strip till was not very good, so no additional measurements were taken.

Table 1: 2019 Lavington Grain Yield

	Check	Intercrop	Solar Corridor	Strip Till
mt/ac	5.88	5.62	5.82	5.32
mt/ha	14.5	13.9	14.4	13.1

Table 2: 2019 Lavington Cover Crop Yield

ryegrass only		blend		solar corridor	
lbs/ac	kg/ha	lbs/ac	kg/ha	lbs/ac	kg/ha
670	752	1485	1667	2300	2582
770	865	1580	1774	2550	2863
850	954	1620	1819	2800	3144
930	1044	1844	2070	3100	3480
average					
805	904	1632	1833	2688	3017

The solar corridor was seeded as plant 2 skip 1, plant 4 skip 1 and plant 6 skip 1, with higher populations on the edge rows to maintain overall field plant population. The edge rows were able to compensate in yield and create in-row yields of up to a 50% increase over the check. The forage in the solar corridor was harvested with a yield of 2300-3100lbs/ac DM. Feed quality analysis showed protein of 18-22% and TDN of 60-64% although ash levels were high (16-18%), likely due to the method of sample collection. There was a noticeable strip of reduced cover crop yield due to shading of the corn plants on the south edge of the solar corridors that were oriented E-W

Lumby Site: Silage yield increased in the intercrop cover plot vs check (9.5t/ac dry vs 8.55t/ac). The interseeded cover crop was not harvested as it had minimal yield. Once again in season tissue tests did not show significant differences however fall soil nutrient levels in the intercrop were lower than check.

The solar corridors were also a success in Lumby, each row was harvested individually on a 4row strip to examine the yield contribution of each as silage (Table 3). Grain yield was not measured separately as this field was harvested as silage but grain ears were weighed to compare their contribution with similar results to the silage.

Table 3: 2019 Lumby Silage Yield (dry matter weight)

	Check	Intercrop	Solar corridor	strip till	Check #2
t/ac	8	9.5	9.14	7.33	7.89
mt/ha	18.0	21.3	20.5	16.5	17.7

	Solar Corridor (silage)			
	row1	row2	row3	row4
t/ac	9.6	6.9	8.1	11.9
mt/ha	21.6	15.6	18.2	26.8

2020

Lavington site: The corn was planted May 6th, and the cover crop was seeded by hand and broadcast at V4-V5 stage, June 20rd. Minimal corn yield difference was measured between the check and cover crop plots harvested as either silage or grain. The intercropped forage yields ranged from 650-780lbs/ac for Italian Ryegrass and 820-1060lbs/acre as the Italian ryegrass, brassica, and clover blend. Overall harvest was later this season likely resulting in less fall growth.

The solar corridors performed very well; orientation was changed to N-S to alleviate the shaded strip experienced in 2019. Harvested as grain check, 2row skip 1, 4row skip 1 all had similar yields while 6row skip 1 had a reduced yield. The edge row plants at the higher population were again able to adequately yield compensate for the skipped corridor rows. The forage produced within the solar corridor weighted 2500-3200lbs/ac when harvested at ground level, the higher yield over last year is expected to be due to the change in row orientation. The Italian ryegrass in the solar corridor rows over-wintered, resulting in a small amount (200-300lbs/ac) of potential forage use in 2021, it did require additional tillage to terminate. Similar to 2020, forage quality was very high in the cover crop due to its largely vegetative state, 18-20% CP, ad 60-62% TDN.

Table 4: 2020 Lavington Grain Yield

	Check	Intercrop	Solar Corridor	Strip Till
mt/ac	5.2	5.15	5.17	5.02
mt/ha	12.84	12.72	12.77	12.4

Table 5: 2020 Lavington Cover Crop Yield

ryegrass only		blend		solar corridor	
lbs/ac	kg/ha	lbs/ac	kg/ha	lbs/ac	kg/ha
650	730	970	1089	2560	2874
720	808	820	920	2850	3200
700	786	950	1067	3200	3593
780	876	1060	1190	2670	2998
average					
712	800	950	1065	2820	3165

Lavington site #2: Trial was moved to a second Lavington site due to a mechanical breakdown preventing timely seeding in Lumby, but there was not a good establishment of the cover crop due to a lack of irrigation capacity and a hot spell shortly after seeding.

Lavington site #3: After the success in 2019, it was decided to try another visual demonstration site on a separate field in Lavington, it had a good catch of cover crop forage, but the cover crop forage was not weighed. The field was harvested as grain with no significant change in yield between intercropped and check.

Table 6: 2020 Lavington Site 3 Yield

	Check	Intercrop	Solar Corridor	Strip Till
mt/ac	5.2	5.15	5.17	5.02
mt/ha	12.84	12.72	12.77	12.4

2021

The sites were planted to corn on May 3rd. Due to the timing of heat dome reaching 44.2C on June 29, the intercrop that was seeded in the Lumby and Lavington sites on June 20 did not survive and was a complete failure. The species that are used (Italian ryegrass, clover and forage brassicas) are all very small seeded cool season species that require shallow seeding into moist soils with cooler temperatures for optimal establishment. Irrigation to meet evapotranspiration needs was a significant challenge during the heat dome as the systems are not sized for the high temperature and wind that was experienced.

2022

Lavington site #1 and #2:
The Lavington sites were planted May 8th with interseeding completed on June 25th at V4-V5 stage.
Establishment was good of both the interseeded and solar corridors. Fall was abnormally dry and hot with zero precipitation between September 14th and October 20th, unfortunately irrigation district water was also turned off September 15th, and the cover crop yield could have benefitted from some more fall irrigation. Resulting dry matter yields were between 500-900lbs/acre for intercropped and up to 2000lbs/ac in the solar corridor. Only 2 row skip 1 and 4row skip 1 solar corridors on a North-South orientation were used.
There was no impact on grain or silage yield from the cover crop or solar corridor. Minor differences in post harvest soil nitrogen were measured again with lower levels in the cover crop than the check.

Table 7: 2022 Lavington Silage Yield (dry matter weight)

	Check	Intercrop	Solar corridor
t/ac	6.93	7.01	6.96
mt/ha	18.82	19.04	18.91

Table 8: 2022 Lavington Cover Crop Yield (dry matter)

ryegrass only		blend		solar corridor	
lbs/ac	kg/ha	lbs/ac	kg/ha	lbs/ac	kg/ha
580	651	720	808	1945	2184
650	730	740	830	2000	2245
500	561	860	966	1910	2144
620	696	900	1010	1980	2223
average					
587	660	805	904	1958	2199

Lumby site #1:
There was an opportunity to plant early on April 30th although the cold spring temperatures resulted in slow growth throughout the month of May and June with minimal benefit to the early start. Interseeding was completed June 24th at V5 stage. There was no solar corridor test. Results were lower than Lavington in yield but still had good establishment overall.

Table 9: 2022 Lumby Silage Yield (dry matter weight)

	Check	Intercrop
t/ac	5.51	5.48
mt/ha	14.1	14.88

Table 10: 2022 Lumby Cover Crop Yield

ryegrass only		blend	
lbs/ac	kg/ha	lbs/ac	kg/ha
435	488	660	740
480	540	640	720
390	438	570	640
540	606	620	696
average			
461	517	622	698

Plant Population:

2019

Lavington: Five different hybrids of varying maturity from 2300-2800 corn heat units were planted May 7th in 6row wide strips at populations varying from 29k plants/acre to 42k plants/acre. When harvested as grain the three shorter season hybrids saw an increase in yield with population but the two longer season ones did not. Within the main hybrid yield increased from 5.53mt/ac to 5.93mt/ac with minimal difference between the three highest populations. Moisture and grain quality (bu weight) was not affected. Nutrient use from tissue tests and soil samples was also not affected.

Table 11: 2019 Lavington population yield

	Population (average of all hybrids)				
	29k	32k	35k	38k	42k
mt/ac	5.53	5.62	5.85	5.9	5.93
mt/ha	13.7	13.9	14.4	14.6	14.6

Lumby: A single hybrid was harvested as silage at three different populations (28k, 35k, 42k). There was a large increase in yield 6.48t/ac to 9.45t/ac DM with increased population. This could have been a sampling issue as it was much more than expected. Feed quality analysis showed a slight increase in fiber but minimal affect on overall forage quality (Total digestible nutrients and crude protein).

Table 12: 2019 Lumby population yield

	Population (average of all hybrids)		
	28k	35k	42k
t/ac	6.48	7.52	9.45
mt/ha	17.6	20.43	25.68

2020

Lavington

Three hybrids were planted at 4 different populations (6rows each) from 29 to 42k plants/acre and one hybrid was planted as a variable rate. Grain yield increased with population, moisture and quality were no affected.

Table 13: 2020 Lavington population yield

	Population (average of all hybrids)					
	29k	32k	35k	38k	42k	VR
mt/ac	5.12	5.2	5.2	5.26	5.28	5.22
mt/ha	12.65	12.84	12.84	12.99	13.04	12.89

Lavington site 2:

Two hybrids were planted at 4 different populations from 29 to 42k plants/acre. This farm had limited irrigation and the higher populations were visibly more stressed during the growing season. It was harvested as silage and there was no observed yield difference between strips; they were all lower than expected.

2021

All three locations had two hybrids planted at 5 populations from 29-42k plants/ac as well as a variable rate strip of 6rows. Only the Lavington site #2 had a positive response to the higher population at harvest both as silage and grain, likely as it had the best irrigation capability to keep up during the heat dome. Yields throughout the farm were down 30-40% from long term averages. There was again a negative visible response to the higher populations during times of moisture and heat stress.

Table 14: 2021 Yields Lavington Site #1 population grain yield

	Population (average of all hybrids)					
Lavington Site 1						
	29k	32k	35k	38k	42k	VR
mt/ac	3.56	3.7	3.4	3.62	3.5	3.6
mt/ha	9.67	10.05	9.23	9.83	9.50	9.78
Lavington Site 2						
	29k	32k	35k	38k	42k	VR
mt/ac	3.77	3.94	4.06	4.5	4.4	4.10
mt/ha	10.24	10.7	11.03	12.22	11.95	11.14
Lumby						
	29k	32k	35k	38k	42k	VR
mt/ac	3.5	3.67	3.53	3.46	3.57	3.62
mt/ha	9.51	9.97	9.59	9.40	9.7	9.83

2022

Two hybrids were planted at the three sites at 5 populations from 29-42k plants/ac as well as a variable rate strip of 6rows. Again, we saw an increase in yield with population. The variable rate strips had a yield comparable to the average population. Moisture and quality were unaffected over the different strips.

Table 15: 2022 Population grain yield

Population (average of all hybrids)

Lavington Site 1

	29k	32k	35k	38k	42k	VR
mt/ac	4.7	4.78	4.92	5.01	5.13	4.96
mt/ha	9.67	10.05	9.23	9.83	9.50	9.78

Lavington Site 2

	29k	32k	35k	38k	42k	VR
mt/ac	5.3	5.31	5.43	5.48	5.62	5.46
mt/ha	10.24	10.7	11.03	12.22	11.95	11.14

Table 16: 2022 Population silage yield

Population (average of all hybrids)

Lavington Site 1

	29k	32k	35k	38k	42k	VR
t/ac	6.41	6.45	6.93	7.1	7.05	6.84
mt/ha	17.4	17.52	18.82	19.29	19.12	18.58

Lumby

	29k	32k	35k	38k	42k	VR
t/ac	5.24	Bear	5.51	5.78	5.73	5.63
mt/ha	14.24	damaged	14.97	15.7	15.56	15.32

Strip Till:

<u>2019</u>
Lavington site:
Strip till using Dawn Pluribus row units was conducted May 6 right ahead of planting. The check strip was moldboard plowed, disced and culti-packed before seeding. Fertilizer was broadcast on all treatments. The short time between strip till and planting was not the intention but with some delays in equipment arrival it was the only option. Soil temperatures were measured as 1-2deg Celsius cooler between the strip tilled strips than in the conventional tillage throughout the spring. Temperature was not measured in season to compare if there was additional nighttime cooling.

When harvested as grain the strip till yielded 10% less than the check (5.32mt/ac vs 5.88mt/ac) and had 1.4% higher moisture content. Fall nutrient levels were lower in the strip tilled than in the check, however in season tissue testing did not show any significant differences. The combination of strip till and intercrop was not weighed separately although the yield monitor showed no change from the strip till. Establishment of the cover crop was lower in the strip tilled area.

It is also important to note that the timing of weed flushes shifted: an early flush of weeds came in the inter-row area between the strips, normally these would have been controlled with tillage, then another flush of weeds came in the area that was strip tilled. The result was that multiple passes of herbicide are required, or use of a residual product to ensure the corn is without excessive competition during its critical weed free period.

Lumby site:
The strip till silage yield was higher than the adjacent check strip (7.89t/ac vs 7.33t/ac DM), and similar to the grain site it was 2% wetter. There were no significant differences in forage quality. Soil nutrient levels were lower in the strip till than the check. The combination strip till / cover crop did not establish well enough to harvest separately.

Lavington additional site:
As a demonstration the strip till units were used in a standing rye cover crop that was approximately 3ft tall, the cover crop was then terminated with roundup and corn was planted into the strips. Overall it was a success although there was significant nitrogen tie up from the rye biomass which required an additional 80lbs/ac of Nitrogen to be applied for crop growth. There were a couple large thunderstorms; and it was observed that while a neighboring sloped and fully tilled property had significant erosion with soil being deposited out onto the roadway, on this field the biomass of rye residue was able to intercept the downpour and there was no erosion or runoff.

2020

Lavington site:

The strips were able to be made April 19th moving over 15" from the previous years rows to ensure better residue flow, with corn planting on May 6th. This timing did allow for some warm-up within the strips. Temperature checks made comparing the tilled (moldboard plow – disc – cultipack) check vs the strips showed temperatures within 1deg C, the interrow of the strip was cooler by 1-2deg C.

Unfortunately, the strip till row units were broken on a large, buried rock before reaching the Lumby site, thus necessitating the move to a secondary Lavington site for the demonstration plot. While it was hoped that the disc type strip till row units would handle rocks better than a shank type, damage from rocks is still an issue.

This site was harvested as grain, and the yield was closer to the check yield than least season, although it was still wetter with a delayed maturity. Nutrient levels did not show any significant differences in soil or tissue tests. Establishment of the interseeded cover crop was much better this season than last.

Lavington site #2:

The substitute site selected had dry cattle manure spread onto it before strip tilling so it became a good opportunity to tests its performance in a system with manure. While there was concern regarding adequate incorporation of the manure for stand establishment, it did not turn out to be a problem as stand counts were the same as within the check area.

This area was also affected by the lack of late season irrigation availability and was harvested as silage. No differences in yield or quality were found between the check and the strip tilled area harvested as silage, although yields were lower than average overall.

There was a 3rd field where some strip tillage was tried, it was on heavier soils in the valley bottom and the corn when in the V3-V5 stage experienced significant damage from a pest called the "corn leaf miner". It is not something that there was a previous issue with, but the higher residue combined with the heavier soil type created an excellent habitat for it to flourish. While the corn was growing out of the leaf miner, a flooding issue from the nearby creek inundated the field and seriously impacted its yield.

2021

Lumby and Lavington sites were again both strip tilled April 18th and planted May 3rd. It was very interesting to see where the strip tillage strips passed into the check area (full tillage) there was a noticeable soil colour difference from the lower moisture level. The strip till was retaining much more moisture than tilled. While this paid off during the first couple days of the heat dome with less visible plant wilting and leaf rolling than the check, the duration and intensity was too much as soon all the treatments had excessive visible moisture stress.

At harvest both as silage and grain there were no significant differences in yield or moisture between the strip tilled and check. The interseeded strip till area was not weighed separately as the cover crop had not established. As mentioned earlier overall yields were down 30-40%.

2022

Strip till was conducted April 18th with planting May 8th in Lavington and April 30th in Lumby. The yields as silage and grain were comparable between the treatments and more in line with farm averages than the previous season. Moisture was also comparable between the treatments however there was an abnormally dry October which sped drydown along compared to previous years.

During the field day we held in June, a soil infiltration demonstration was conducted with a measured amount of water poured into a 6” ring both on the check and within the strip tilled area. The majority of the producers predicted that the conventional tilled would infiltrate the water quicker than the strip tilled: it wasn’t even close. Within 10 minutes the strip tilled had fully infiltrated the water, while the conventional check took over twice as long.

The additional field that had corn leaf miner issues in 2020 was strip tilled also and had even worse corn leaf miner damage. It is apparent that this pest is going to be an issue for back-to-back corn production on heavier wet soils with minimum tillage.

For the Lavington site the soil organic matter was relative high to start (4.9-5.5%), after continuous use of strip tillage and conventional practices (soil results from 2021 and 2022), we found that the strip tillage and cover crop was consistently 0.2-0.4% higher than conventional. The Lumby site had lower soil organic matters at the start (3.7-3.8%) and soil tests in 2022 also showed similar values, no conclusion can be drawn at the intensity of sampling that we were doing on that location.

4. Discussion

Interseeding

The interseeding of cover crops was overall a success, both seeded within the crop and using solar corridors. Critical success factors that were identified in the process were: timing of seeding - earlier is better, adequate weed control beforehand to minimize competition and adequate moisture while the cover crop is small to ensure establishment. While some different species were tried in the first season, it was settled on a blend of 8lbs/ac Italian ryegrass, 2lbs/ac berseem clover and 2lbs/ac of mixed forage brassicas. This gave some diversity of plant type and root habit as well as kept the seed size easy to blend and meter and cost low.

While the economics of utilizing this as a cover crop for soil health is difficult to quantify, considering it as a grazing use is more straightforward.

For this study we will assume that a custom interseeding operation would cost $25/acre, the seed cost for the 3-way blend that was utilized was $35/acre for a total cost per acre of $60. Assuming that we are looking at extending fall grazing for beef cattle and the alternative is feeding them conserved feed at a cost of $3/hd/day, there would need to be 20 days or 2/3 of an AUM to breakeven. An AUM is 990lbs (450kg) of forage dry matter. This study produced more than that quantity 3 out of 4 years assuming a 70% utilization of the forage. The forage tests were also of higher quality than required by beef cows in 2^{nd} trimester. When it is considered that many beef producers graze their corn stalks and field edges after corn silage harvest, interseeding has excellent potential to extend this grazing period and improve the quality and livestock performance at the same time. The additional feed quality can also provide potential for gains in classes of growing stock as part of a larger rotational grazing program.

Also of great potential is the solar corridors, as it was possible to maintain the overall field yield both as silage and grain and gain more than double the forage grown in the solar corridor as grown inter-row. These practices are also combinable with inter-row seeding within the rows of corn as well. A key requirement is to be able to seed the “edge rows” at a higher-than-normal corn population, this requires modification of the corn planter drives either with sprockets or alternative individual row drives. It also requires planting at a slower speed so that the seed meters are not overrun. If a producer was going to plant in a 2row skip 1 configuration it would be simpler as the rate could just be set high and rows disengaged for the skips. There was concern that there would be lodging and other issues from crowding these higher population rows but over the length of the project none were observed at populations up to double the normal seeding rate.

More than half of the locations had Italian ryegrass overwinter, this offered the potential for some spring grazing and spring ground cover. It did however need to be terminated before planting corn again (or another crop), creating another management point.

Variable Rate Population

The variable rate population results were not as conclusive as the other practices. The hybrids that were selected, when grown under adequate water and nutrients continued to increase their yield with higher population. In situations where the weather and climate conditions were challenging there was no benefit to the higher plant populations. While we did not lose any yield with the variable rate, further refinement of soil zones would be necessary to fully capitalize on it. It is possible that we did not vary the population up and down enough to be able to compensate for the good vs. poor production areas identified. One of the other challenges is that each hybrid has a different response curve to population and that response is environment driven, hybrids also turn over on the marketplace quickly and are often changed on an operation every few years.

With a corn seed cost of $250 / bag, incremental seed costs are approximately $10 per acre for each 3000 seeds of population, at a silage value of $65 per ton (factoring in $15/ton for incremental harvesting costs); an increase in yield of 0.15T/ac for each 3000 seeds is required. This was only achieved a few times in this project. Similarly, a grain value of $250/tonne (factoring in incremental harvesting, drying and trucking costs); an increase in yield of only 0.04mt/acre is required. Once again, the seasons with a positive yield response exceeded this and were more profitable at a higher population.

Strip Tillage

This was the most successful of the practices demonstrated for us. After four seasons of use, the practice was refined to work with our soils and management, yields improved from a slight yield and maturity drag to comparable to the check practices. It was also shown that it can be adapted into a dry manure system with minimal issue, although a negative is that it is likely that some nitrogen from the manure is lost due to volatilization as not all manure is incorporated. It was also demonstrated that it is possible to use strip tillage into standing winter cereal cover crops, although producers must be cognisant of the possibility of nutrient tie up from the residue.

From a management standpoint, there was an adjustment period to utilizing this practice. Changes need to be considered to herbicide timing to control flushes of weeds that are outside the regular timings and in particular over-wintering winter annuals that would normally be terminated with tillage. Changes also need to be considered around nutrient management as broadcasting granular fertilizer before the final tillage pass and incorporating is not possible. As this was the farm’s normal practice it was attempted for the first couple seasons, however nutrient tie up in the residue was likely one of the main culprits for the slightly reduced yield and delayed maturity of the strip till vs check. This operation has changed to banding granular fertilizer during the strip till operation to get more effective use and placement along with reduced losses compared to broadcast. Finally, while back-to-back corn is a common practice due to irrigation systems throughout the interior and can usually work without yield penalty; on the heavier wet soil the corn leaf miner will necessitate a more agronomically sound crop rotation to non-susceptible crops. It is also important to note that these pieces of equipment are not immune to rocks, having broke it twice during the four-year period on buried boulders.

As this demonstration included fields that were corn on corn for the entire four years of the period it was interesting to observe the improvements to soil structure year to year. Areas where harvest was previously a challenge to due getting the combine stuck had developed structure to where it was not an issue. It was also amazing how fast the high level of grain corn residue (stalks and stover from the previous year) would break down over the growing season. We were concerned that there would be some buildup of residue year over year but with a healthy microbial system and adequate moisture the breakdown was keeping ahead of it.

Strip tillage resulted in significant economic benefits in time and financial savings during the busy spring season. A single pass with the strip tillage replaced four field passes with conventional tillage equipment. This is just an example, not all producers are moldboard plowing and some others are using power harrows in place of the disc harrow – cultipacker. However for producers growing grain corn or earlage, moldboard plowing is still a common practice if they are not able to harvest the stover after harvest.

Considering an economic analysis of this practice strip tillage saved at least $80/acre, utilizing local custom farming rates:

Check (Conventional practice)		
	Moldboard Plow	$70 / acre
	Disc Harrow (2 passes)	$40 / acre
	Cultipacker	$25 / acre
		$135 / acre
Strip Tillage		
	Estimated Operating Cost	$55 / acre
Net Benefit		$80 / acre

The estimated cost of strip till is based on a strip till purchase price of $125,000 amortized over 8 years at 7% with a 50% residual value. It is operated over 250acres per year (in this example a producer is covering 125ac of their own and 125ac custom for neighbors) with a 180hp tractor consuming 35litres of $1.50/l diesel per hour, a $30/hour operator wage, $80/hour tractor capital / repairs and maintenance, and $10/acre strip till machine repairs. Average productivity is estimated at 12acres / hour with 85% efficiency and 10% operating margin.

It is important to consider the timeliness of operations within this calculation as well. Using typical sized equipment for this area and operating speeds, over a typical 125ac corn growers' operation there is a savings of over 75 hours of field work. This can be critical in short spring planting windows or when utilizing hybrids that require a full growing season.

Check (Conventional practice)			
4 btm Moldboard Plow	4mph	2.5ac/hour	50 hours / 125ac
20ft Disc Harrow twice	5mph	6ac/hour	21 hours / 125ac
15ft Cultipacker	6mph	7ac/hour	17 hours / 125ac
			88 hours
Strip Tillage	8mph	12ac/hour	10.5 hours / 125ac
Time Savings over 125acre example farm			77.5 hours

In order for strip tillage to be successful it must be done with GPS guidance and to a high level of accuracy, it is critical that the planter is able to plant into the center of the strip tillage rows and having a different number of rows of strip tillage vs planter further complicates this. Any places where the planting strayed off the strip till row, emergence and plant vigour was greatly affected. Additionally, we operated row cleaners on the planter to push any residue that could blow onto the strip out of the way of planter row operation and in the future would consider narrower planter gauge wheels to help maintain even depth control on the strip.

Integration of Practices within a rotation:

Stacking of these practices and integration within a rotation is achievable and likely will compound the benefits of them. We were able to successfully establish cover crops within the strip till residues. Within the residues the C:N ratio is high so the blend perhaps should be altered to include more legumes, residue flow also proved to be a challenge for seeding methods other than broadcast. Variable rate population can also be equally successful within the strips and by year 3 and 4 the population strips were done within the strip tilled area as most of the operations acres had shifted to strip till, the only conventional tillage conducted was for the check strips. With the challenges of the leaf miner in continuous corn production the field will be rotated to another crop for 2023, done as minimum till, it will be interesting to see if it is possible to reduce the pest pressures after one year or if multiple years are required.

5. Future Research Directions

Interseeding Cover Crops:

With the success of interseeding cover crops into standing corn, it is possible to move this forward as an accepted practice; moisture allowing. Future research could include further evaluation of the cover crop's ability to take up and hold nutrients in the shoulder season on soils that have a higher residual nutrient level. Many of the fields used in this demonstration were inherently low in nutrients and applications closely matched crop removal rates. Additionally, we did not do intensive cover crop species evaluations and this may be a spot for future work, as well as incorporating it with "bio-strips" as discussed further below. Also, it could be further examined as to the over-wintering capabilities of the Italian ryegrass and alternative summer cropping programs if it is allowed to grow out to forage harvest maturity. One option could be following with a BMR sorghum or sorghum-sudan instead of corn silage.

The solar corridors are also a place of potential future research, if they were integrated with a producer who is doing fall corn grazing, they could be utilized for increased volume and quality needs, as well as giving an area to run electric fencing down to limit access.

Variable Rate Population

For variable rate population to be successful and have wide adoption, better understanding of spatial variability on individual farms in necessary. Over the last couple of years, more of the custom silage harvesters are getting setup with yield monitoring and there are more options for intensive soil mapping and testing to help build the necessary maps. Once a number of years of data has been collected on individual fields more success is likely.

Strip Tillage

Future direction with strip tillage would be to incorporate it with liquid dairy manure usage. This would best be done with a producer who can inject on 30" centers with GPS guidance and then come back and strip till either over top of or between the manure injection rows.

There is also some producers in the Midwest using bio-strip till, which is an incorporation of both cover crops and strip tillage, planting different species in the area that will be strip tilled, or actually no-tilling into the "bio-strip".

6. Conclusion

Intercropping (relay cropping) of annuals was found to be successful. Although we did not produce enough forage to harvest in the fall, there was potential to graze it or leave it for soil improvement. The solar corridors were enjoyable to work with and create opportunity for further integration of livestock.

Variable rate population was less conclusive; while we did have increases in yield with limited impact on quality from higher populations, we need more data on building the soil management zones and the response of particular hybrids to higher and lower populations. The capacity of irrigation systems is also a limiting factor that needs to be considered in challenging years such as 2021.

Strip tillage was shown to be an excellent practice, it greatly reduced potential for erosion, improved soil structure and has significant savings in time and labour. Challenges that were identified including

After four seasons of utilizing these practices improvements to our operation were apparent. These include the savings in time and labour from the strip tillage, improvements to our soil structure from the cover crops and strip tillage, and the confidence to push populations higher in areas of more yield potential. We will continue to refine these practices as part of our whole operation.

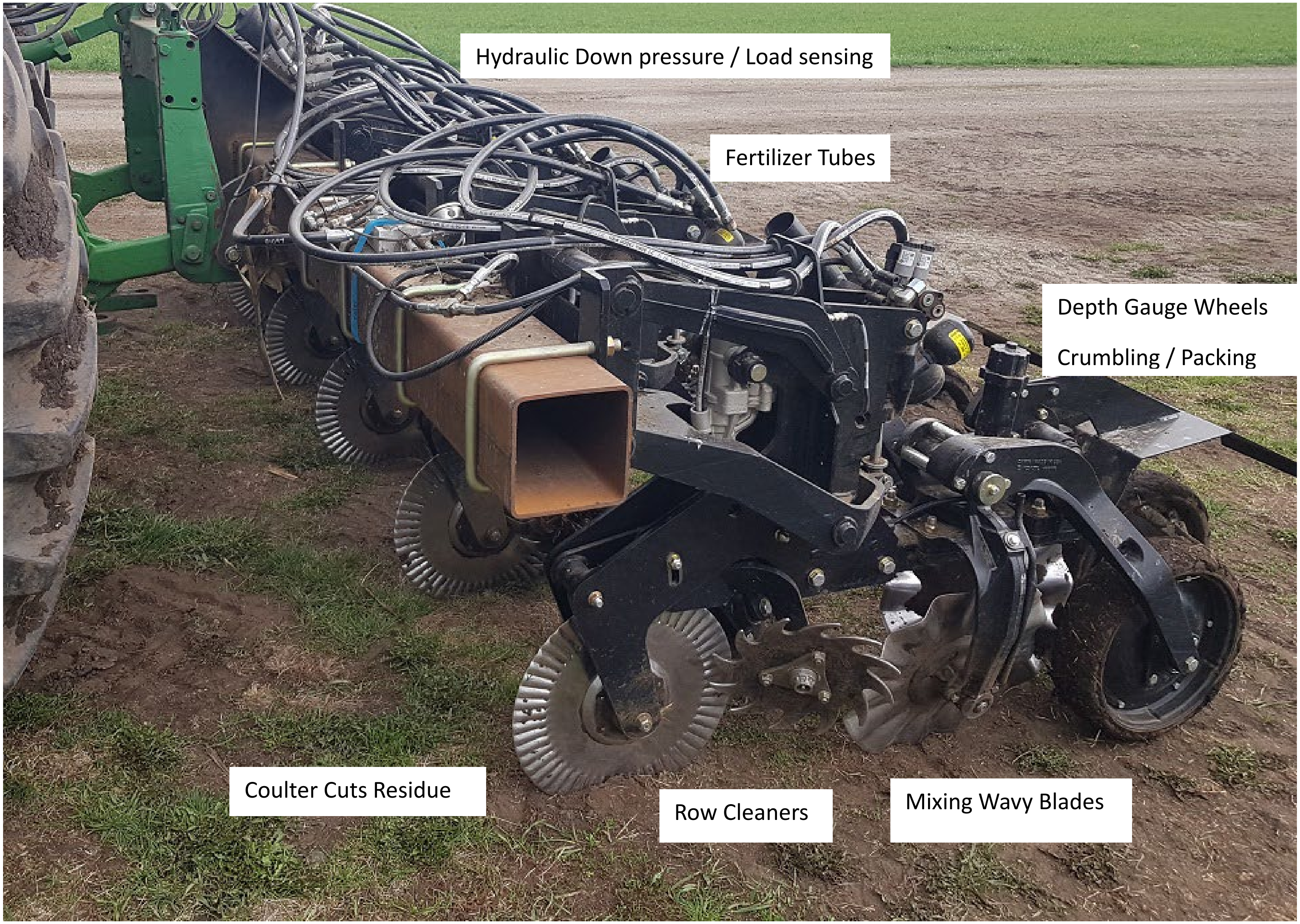
7. Photos

Examples of erosion (snow-melt and wind) that we are looking to reduce

Conventional tillage practices (Check):

And the results of poor soil structure (STUCK!):

Strip Tillage row unit (Dawn Pluribus Gen V):



Strip Tillage:

Strip Tillage: Lower portion of the photo the “strip” crosses over into the check conventional tillage area, showing the change in soil moisture by colour that the conventional tillage passes caused compared to the previously un-touched strip till area.

Planting into Strips

Strip Tillage in season:

Strip Tillage in season:

Strip Tillage post silage harvest (into cereal stubble)

Approaching grain harvest moisture, note the residue breakdown

Agronomic challenges:

Corn Leaf Miner damage

Weed flushes with different timing than conventional practices

Strip Tillage into standing fall rye:

Strip Tillage into standing fall rye:

Strip Tillage into standing fall rye:

Interseeding:

Interseeding

Interseeding post harvest:

Interseeding post harvest (overwintered Italian ryegrass)

Solar Corridors:

Solar Corridors:

Solar Corridors:

Integrating strip tillage with fall seeded cover crops: