Project Identification

1. **Project Title:** Creating a Weed Suppression Mulch by Terminating Organic Cover Crops using a Roller-Crimper
2. **Project Number:** 20200433
3. **Producer Group Sponsoring the Project:** Saskatchewan Conservation Learning Centre (CLC)
4. **Project Location:** Project was located near the CLC (River Lot 36, 46, 26 W 2nd) on certified organic land owned by cooperating producer Garth Beddome.
5. **Project Start and End Dates:** April 2021 to February 2023
6. **Project Contact Person and Contact Details**
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Objectives and Rationale

7. Project Objectives

This project was intended to examine the benefits of using a roller-crimper to terminate organic cover crops as a technique to reduce tillage in organic production in north-central Saskatchewan.

8. Project Rationale

The CLC was approached by a neighboring organic producer looking to learn more about the benefits and potential uses of his roller-crimper. A roller crimper is a cylindrical drum covered in chevron-shaped blades that is driven over the crop to bend plants at the base of the stem, terminating them while leaving them anchored to the soil (Knight, 2012). The folded plants create a weed-suppressing and moisture-retaining mulch that can be direct seeded the following spring. Organic producers are searching for additional ways to reduce tillage and the roller crimper has the potential to be an important component of organic no-till systems.

Between 2015 and 2018, the total number of organic farmers in Saskatchewan increased by 30% (Arnasen, 2020). As more conventional farmers transition into organic operations, they will be searching for alternatives to tillage and ways to improve their soil fertility and health under their new organic system. Cover crops can be used in organic farming as green manure. Green manure serves to replenish soil nutrients, improve soil quality, reduce nitrogen leaching, manage diseases, and control weeds. In many cases, these cover crops are incorporated into the soil by tillage. It has been demonstrated that continuously repeated tillage can reduce soil quality and water retention (Carr et al., 2011). Frequent tillage also increases labour inputs and costs associated with additional fuel usage and equipment wear. Most conventional producers are familiar with continuous no-till methods. For organic producers, continuous no-till

management is not sustainable without the use of herbicides. However, the use of herbicides in organic production is prohibited (Mirsky et al., 2012).

Tillage can be reduced in organic production by incorporating periods of no-till into the crop rotation. Direct seeding cash crops into the residue from a previous season's cover crop allows organic producers to skip tillage for a growing season. This practice has been shown to help reduce input costs and may even help farmers turn a bigger profit. When target mulch biomass is reached, rotational no-till organic farming has been shown to increase cash crop yields (Halde and Entz, 2014). Higher crop yields contribute to a positive return on producer investment despite fluctuating prices due to an increasingly competitive organic market. This is especially important as organic farmers have been seeing smaller profit margins in recent years (Arnasen, 2020).

Western Canadian studies have examined the use of mechanical no-till strategies such as the roller-crimper to terminate cover crops and prepare the seedbed for subsequent cash crops. A 2013 study from Manitoba concluded that cover crops flattened by a roller-crimper were effective at suppressing weeds if the cover crop reached a target mulch density of 6-8 Mg/ha (Halde and Entz, 2014). Using an intercrop of cereal and annual legume (barley and hairy vetch) can provide sufficient biomass while replenishing soil nutrients via nitrogen fixation (Halde et al., 2013; Halde and Entz, 2014). Legumes can provide a valuable service in organic production systems where mineral fertilizers are not used; legumes used as cover crops help fix atmospheric nitrogen (Halde and Entz, 2014). Non-leguminous cover crops have generally been used to reduce soil erosion and nitrate leaching. Although it is recommended to have an N-fixer like peas, growers find that pea-straw breaks down too quickly the following year; farmers would not benefit from the weed and the moisture control potential that grass cover crops offer. A mix of slowly decomposing cereal with high biomass, and an N-fixing legume has the potential to become a widely utilized cover crop. This mulch combination may enrich the soil and act as a weed suppressor. These benefits address two major areas of concern for farmers in organic production systems: improving soil health and nutrition, and weed prevention and control (SaskOrganics, 2019).

A series of multi-year Manitoba trials compared tillage, roller-crimpers, and haying strategies and their effect on weeds, available soil N, and crop performance (Halde et al., 2015; Halde and Entz, 2014). These studies trialled intercropped barley (cv. Cowboy) and hairy vetch and confirmed that short-term no-till mechanical termination strategies could lead to higher crop yields and lower weed biomass when compared to tilled treatments (Halde et al., 2015; Halde and Entz, 2014).

Similar research using 4010 field peas occurred in Saskatchewan (Shirtliffe and Johnson, 2012; Knight, 2012). Terminating field pea cover crops using a roller-crimper led to little or no reduction in the yield of the subsequent cash crop. The study found that a roller-crimper was a feasible alternative to tillage in the Saskatchewan growing environment (Shirtliffe and Johnson, 2012; Knight, 2012). If a cover crop can reach target biomass, then the mulch can suppress weed growth by reducing soil temperature and light transmission (Teasdale and Mohler, 1993).

Barley is a cereal that degrades more slowly than field peas, as demonstrated by Halde and Entz (2016). Like the barley/hairy vetch cover crops used in Manitoba, a cash crop seeded into a mulch of barley/field peas would benefit from the nitrogen accumulation from the rapidly decomposing peas as well as the long-lasting weed suppression and slow nutrient release from the barley residue (Halde and Entz, 2016; Knight, 2012).

With increasing interest in cover cropping by conventional and organic producers, this demonstration will be of value to a larger scope of producers than strictly organic farmers. As more farmers incorporate cover crops into their rotation, there will be a greater need to find alternative methods to tillage for cover crop termination, particularly for no till operations.

Methodology and Results

9. Methodology

This two-year trial was located on certified organic land neighbouring the CLC. A cover crop was seeded in 2021 with a plan to seed a cash crop in 2022. Due to intense weed pressure, low soil moisture, sandy soil, minimal precipitation, and very high temperatures, establishment of the barley and hairy vetch cover crop was very poor in 2021. Poor crop emergence and stunted growth resulted in very low biomass that would not have been sufficient to act as a weed-suppressing mulch for direct seeding in the 2022 growing season. The decision was made to re-seed year one of the trial in 2022, and not seed the cash crop in year two as originally planned.

The treatments for this trial consisted of 3 different methods to terminate the cover crop. The first was to terminate by tillage with a cultivator. The second was to swath (Fig. 2) and remove residue to mimic haying, and the third method was to terminate with a roller-crimper (Table 1; Fig. 1). The plan for year 2 of the trial was to till both treatments 1 and 2 prior to seeding a cash crop, but to direct seed into the roller crimped plots. However, year 2 was not carried out, since Year 1 was repeated instead. This trial was designed as a randomized complete block design with four replicates. Plots measured 8.75m wide by 9m long to accommodate the cooperating producers' equipment. Prior to seeding the cover crop, the whole trial area was tilled. On July 19, 2022, the trial was seeded with the CLC's Fabro Plot Seeder (Fig. 3). No herbicides, fungicides, or insecticides were used in the demonstration. All seed and inoculant used in the trial was certified for organic production. An agronomic summary can be found in Table 2.

Table 1. Treatment list and descriptions of the treatments used in the "Creating a Weed Suppression Mulch by Terminating Organic Cover Crops using a Roller-Crimper" demonstration.

Trt #	Description	Year 1	Year 2
1	Till / Cultivator	Tilled prior to seeding cover crop and tilled with cultivator when barley reaches flowering stage	Tilled prior to seeding
2	Till / Swathing	Tilled prior to seeding cover crop, swathed when barley reaches flowering stage and residue collected	Tilled prior to seeding
3	No-Till / Roller-Crimping	Tilled prior to seeding cover crop, roller crimped by Smith Welding & Machining 5-point hitch crimper CRS 10 when barley reaches flowering stage	Direct seeded

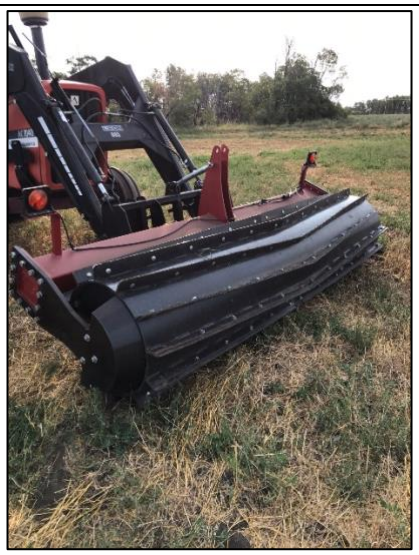

Figure 1. Roller crimper used in study.

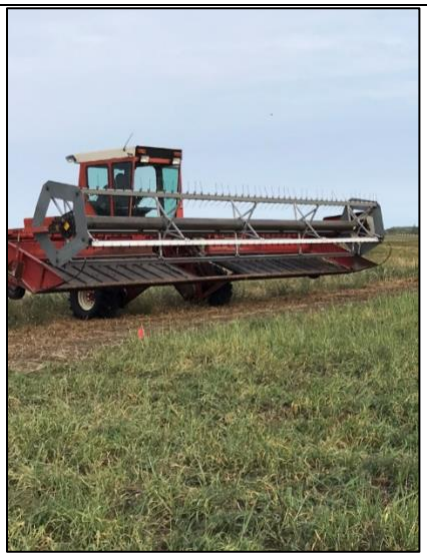

Figure 2. Swather used in study.

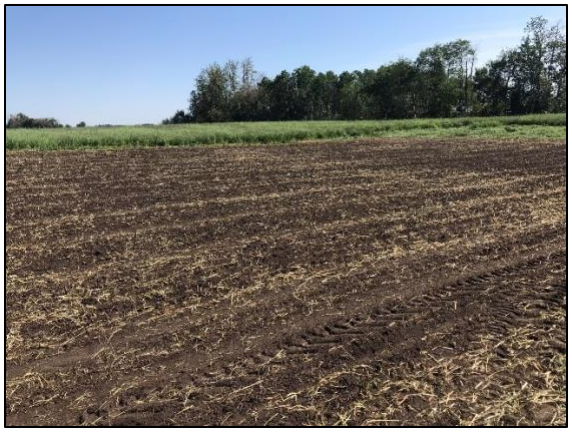

Figure 3. Trial area immediately after seeding the cover crop on July 19, 2022.

Table 2. Soil Characteristics and agronomic summary for the organic roller-crimper trial in 2022.

Soil Type	Sandy clay loam
Soil Zone	Black
Seeding Date	July 19, 2022
Seeding Equipment	Fabro plot seeder with double disc openers and 10-inch row spacing
Seeding Rate	Barley 134 kg/ha Hairy vetch 54 kg/ha
Soil Temp at Seeding	25.4°C @10:45 am
Seedbed Preparation	Rototilling
Seed Depth	Hairy vetch 1 in and barley 1.5 in
Inoculant	AGTIV Pulse Granular Inoculant
Crop Staging	Aug 5th – Barley 4lf or BBCH 14 Aug 19th – Barley BBCH 26-30 and vetch vegetative Sept 13th – stunted barley range between 41-51 and vetch flowering

Biomass data was collected in 2022 to determine if target mulch densities of 6-8Mg/ha as reported by Halde and Entz in 2014 had been reached and to determine any variability across reps. Two 1/4m^2 quadrats of biomass were taken, one from the back of the plot and one from the front. The cover crop was separated from weeds.

Cover crop termination occurred on September 13, 2023. Treatment 3 was rolled 2 times with a Smith Welding & Machining 5-point hitch crimper.

Soil samples were collected per treatment to determine if any variability were present at the site and to determine a starting point to better interpret results should year 2 of the trial be completed.

10. Results

Weather

The growing season of 2022 at the CLC started off cooler than the long-term average but ended warmer (Table 3). Compared to the 8-year averages of May and October, the mean temperature of May 2022 was 0.9°C cooler while October had a mean temperature double the long-term average. Average temperature for this growing season was just 0.8°C warmer than the historical average. This year was drier compared to past years but not as dry as 2021. All months of 2022 received less precipitation than the historical averages; there was a total of 66.5 mm less precipitation this year. The first light frost occurred on September 10 (-0.4°C), prior to termination of the cover crop. The first heavy frost occurred October 5 (-4°C). Complete monthly weather summaries can be viewed/downloaded at src.sk.ca/download-weather-summaries.

Table 3. Weather conditions in the 2022 and 2021 growing seasons at the CLC from the onsite SRC weather station.

Year	May	June	July	August	September	October	Average/Total
			--- Mean Temperature (°C) ---				
2022	10.5	15.5	18.3	18.5	13.3	6.2	13.7
2021	10.1	18.3	20.3	17.0	13.5	4.9	14.0
2012-2020	11.4	15.9	18.5	17.1	11.4	2.9	12.9
			--- Precipitation (mm) ---				
2022	17.9	75.7	63.7	37.8	26.3	11.5	232.9
2021	29.8	84.0	9.6	57.0	9.5	13.9	202.3
2012-2020	40.4	79.6	84.6	42.9	31.2	20.7	299.4

Soil Test Results

Soil samples of the trial area were collected on September 12. Samples were collected from each treatment using a Dutch soil auger and sent to Agvise Laboratories for analysis. Soil test results indicated that the treatments were mostly consistent with each other. Levels of K, Zn, and OM were high in all three treatments. Treatments 2 and 3 were more similar than treatment 1. Treatment 1 had moderate levels of available N, low levels of S, and very low levels of salts. The other two treatments differ in that they had high levels of available N, and moderate S in the first 15cms.

Table 4. September 2022 soil test results.

TRT	Depth (cm)	N (lb/ac)	P (ppm)	K (ppm)	S (lb/ac)	Zn (ppm)	OM (%)	pH	Salts (mmho/cm)
	0-15	14	4	203	12	2.08	5.7	5.8	0.17
1	15-30	21			12			6.2	0.22
	0-30	35							
	0-15	28	4	219	30	1.15	4.9	6.3	0.32
2	15-30	28			14			6.4	0.23
	0-30	56							
	0-15	30	3	252	18	1.18	5	6.2	0.3
3	15-30	18			14			6.5	0.24
	0-30	48							

Timing

In 2022 the decision was made to seed the cover crop mid season vs early spring. There were concerns that early spring seeding would result in early termination allowing for decomposition of the cover crop to commence and weed growth to occur for the remainder of the growing season. However, a later seeding date of July 19 appeared to be too late in 2022. The cover crop did not mature as planned, timing of termination was not ideal and there was not sufficient biomass. Cover crop termination was supposed to occur when barley was at the flowering stage. Maturity of barley was very uneven and barley crop was stunted from the dry conditions experienced in August. The decision to terminate the cover crop prior to full flowering since some barley was already at the appropriate stage, and freezing night time temperatures were forecasted. Visually, for reps 1 and 2 it did not appear there was enough biomass to warrant use of a roller crimper. However, treatments were still applied in order to gather some information on the performance of the roller crimper.

Biomass

Biomass collection was completed just prior to termination of the cover crop and is an indication of whether the cover crop itself would have been sufficient in providing the benefits of a cover crop. The differences between the plots are a result of the environment rather than the treatments. On average, the cover crop biomass did not meet the target mulch density (Table 5; Fig. 4) of 6-8 Mg/ha dry weight. Since our results are reported as wet weight, at least 35% reduction in weight could be anticipated with drying. Adding 35% to our targeted dry weight gives us a biomass goal of 8.1-10.8 Mg/ha wet weight. This minimum weight was achieved in 5 of the 12 plots. Biomass was lowest with a mean weight of 3.9 Mg/ha in rep 1 (Fig. 5) and increased with increasing reps, with all treatments in rep 4 meeting the targeted weight (mean weight of 10.8 Mg/ha). This transition from low to high biomass is likely due to decreasing sand content.

Figure 4. Biomass of cover crop on September 13 just prior to termination.

Figure 5. Cover crop biomass shown here on September 13, 2022 was poorest in Rep 1.

Table 5. Cover crop and weed biomass within each plot reported as fresh/wet weight.

Plot	Cover Crop Biomass (kg/ha)	Cover Crop Biomass (Mg/ha)	Weed Biomass (kg/ha)
101	5202	5.2	402
102	2950	3.0	118
103	3612	3.6	14
201	5066	5.1	216
202	10192	10.2	102
203	5738	5.7	550
301	3134	3.1	3226
302	9048	9.0	488
303	7512	7.5	2302
401	9928	9.9	296
402	11754	11.8	1022
403	10632	10.6	678
Mean	7064	7.1	785

*Average % dry matter was determined on a subset of forage biomass samples at the CLC in 2019 and was 35% of total weight. These forage samples included both grasses and legumes and can provide us with an estimate of loss expected due to drying for better comparison.

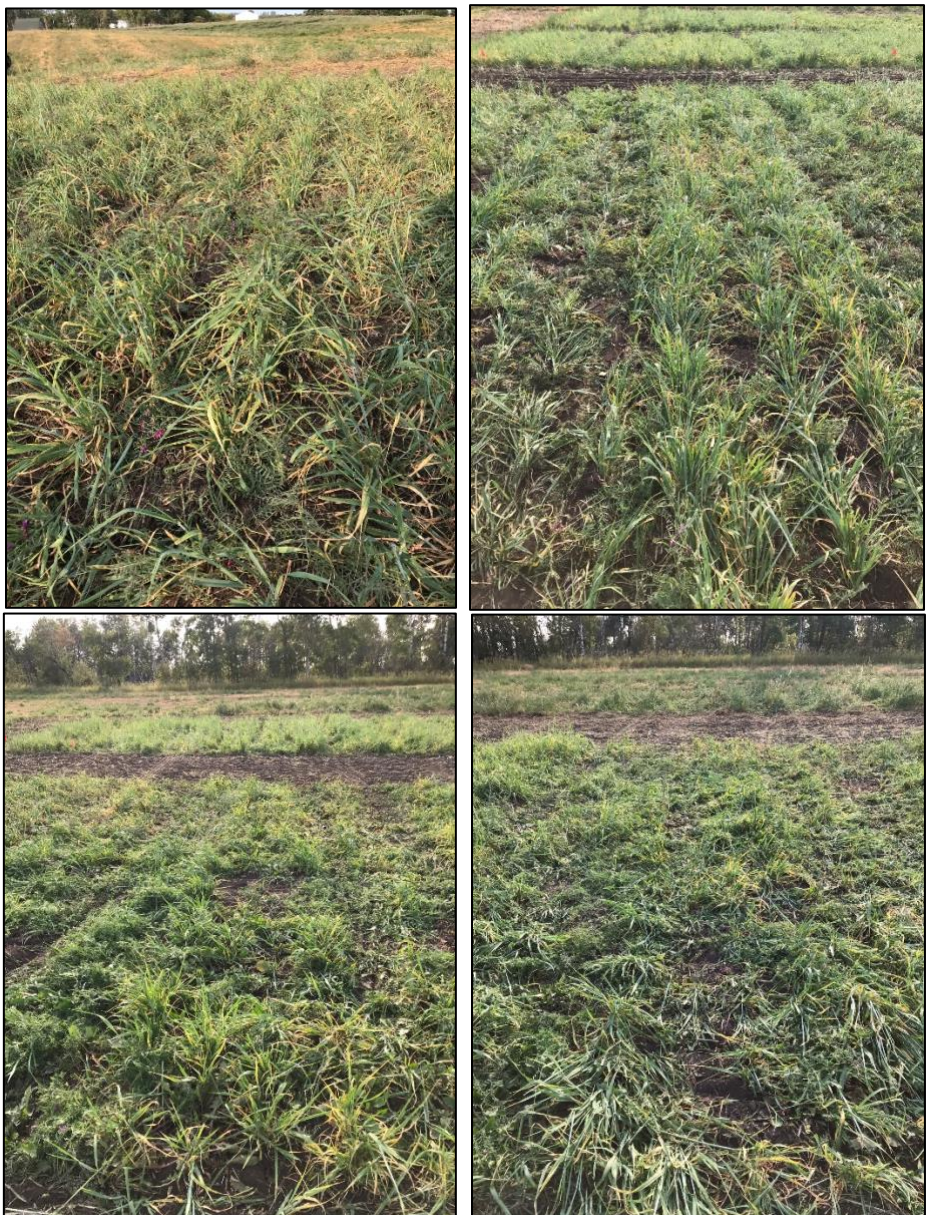

Figure 6. Barley and vetch cover crop after roller crimping. Top left is Rep 1, top right is Rep 2, bottom left is Rep 3 and bottom right is Rep 4. The roller crimper appeared to be most effective for reps 3 and 4 as the crop is laying flat to the ground. This is most likely due to greater biomass.

Cover Crop Termination Observations

At time of cover crop termination, visually it appeared that reps 1 and 2 had less biomass than 3 and 4 (Figure 6). The barley in reps 1 and 2 appeared shorter and after being rolled, some barley plants appeared to stand upright again. In some instances, the barley and hairy vetch plants may have been small enough to avoid direct contact with the crimper blade. However,

there were instances where the roller crimper completely severed the barley stems (Fig. 7). Reps 3 and 4 appeared to be more effectively crimped as the cover crop laid flat to the ground when compared to adjacent uncrimped plots (Fig. 6). This may prove to be beneficial as more ground cover could reduce spring moisture losses under drought conditions and prevent weed growth. While the timing was selected to ensure a good barley kill, hairy vetch timing is also an important consideration. Hairy vetch needs to be terminated at full bloom to early pod set to ensure a good kill (PennState Extension, 2022). Like barley, the hairy vetch was not maturing uniformly and ranged between start of flowering to end of flowering.

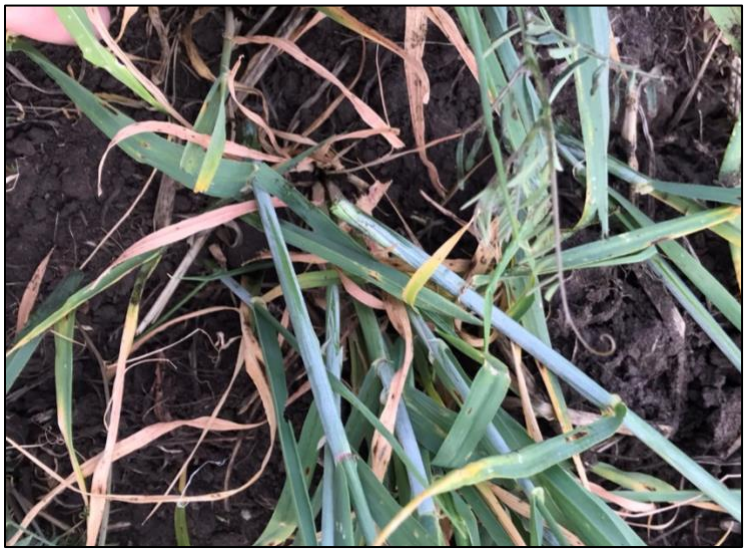

Figure 7. Close up of barley that has been severed by the roller crimper.

11. Conclusions and Recommendations

Original plans were to reapply for funding in November 2022 to conduct year 2 of the trial in 2023. However, data analysis had yet to be completed and in field observations suggested cover crop was not enough to warrant continuation. After further deliberation, it has been decided to re-evaluate the cover crop demo in spring of 2023 to determine effectiveness of hairy vetch termination. If cover crop looks sufficient, then treatments 1 and 2 will be tilled, and a wheat cash crop will be direct seeded into treatments 1, 2 and the remaining roller crimped cover crop. While not all plots reached the desired biomass yield, it could be possible to demonstrate this cover crops potential by evaluating rep 4 and could also help verify the minimum required biomass for success as reported by Halde and Entz, 2014. The CLC will self fund spring work and may apply for the June ADOPT deadline seeking funds to cover the cost of the remaining data collection, analysis and report writing.

The Manitoba trial this demo was based off used an earlier seeding date so cover crop would have a full year growth in order to reach a sufficient level of biomass (minimum 6-8 Mg/ha). In Southern Manitoba, late summer or fall seeded cover crops do not produce enough biomass due to a short growing season and low soil moisture. A full year growth of cover crop is the

standard use of cover crops by organic growers in that region. Barley and hairy vetch have been identified as the best mulches for organic rotational no-till systems in southern Manitoba as they can produce high biomass of 9.1-11.5 Mg/ha dry mulch matter in one full year (Halde and Entz, 2014). The demo near the Conservation Learning Centre was able to reach these levels of biomass production with a later seeding date under unusual dry conditions. This indicates there is potential for later seeded cover crops in the Prince Albert area due to higher annual precipitation, but this can be challenging under moisture limiting conditions.

A continuation of the trial would be desired as it is unknown how effectively the cover crop was terminated. The barley would have eventually been terminated by frost, but how effective was the roller crimper at terminating the hairy vetch? In Manitoba, roller crimping did not terminate hairy vetch, however, the hairy vetch was winterkilled. It is likely the hairy vetch will not overwinter in our more northern growing region. This implies that utilizing a roller crimper to terminate cover crops this late in the season may not have value, unless there is another benefit such as flattening the crop to provide greater ground cover. Roller crimping is a technology that is more appropriate for spring seeded cover crops. Additionally, there are concerns that crimping and not incorporating cover crops will result in N availability not synching correctly with the cash crop, reducing yields and competitiveness of the crop to outcompete weeds (Halde and Entz, 2014). Hairy vetch as a cover crop mulch in a no till system has had variable results and cannot be relied on fully to provide sufficient weed control in flax as the following cash crop if the cover crop mulch is not greater than 6.7 Mg/ha at the time of seeding (Halde and Entz, 2014). Direct seeding a cash crop into this trial in 2023 could validate these results for our region and provide insight into how the different termination methods would affect a wheat crop.

References:

Arnasen, R. 2020. Organic producers looking at slim profits. The Western Producer. Available at: https://www.producer.com/2020/03/organic-producers-looking-at-slim-profits/

Carr, P. M., R. L. Anderson, Y. E. Lawley, P. R. Miller, and S. F. Zwinger. 2011. Organic zero-till in the northern US Great Plains Region: Opportunities and obstacles. Ren. Ag. and Food Sys. 27:12-20.

Halde, C., K. C. Bamford, and M. H. Entz. 2015. Crop agronomic performance under a six-year continuous organic no-till system and other tilled and conventionally-managed systems in the northern Great Plains of Canada. Ag., Ecosystems and Env. 213:121-130.

Halde, C., and M. H. Entz. 2016. Plant species and mulch application rate affected decomposition of cover crop mulches used in organic rotational no-till systems. Can. J. Plant Sci. 96: 59-71.

Halde, C., and M. H. Entz. 2014. Flax (Linum usitatissimum L.) production system performance under organic rotational no-till and two organic tilled systems in a cool subhumid continental climate. Soil & Tillage Res. 143:145-154.

Halde, C., R. H. Gulden, A. M. Hammermeister, K. H. Ominski, M. Tenuta, and M. H. Entz. 2013. CSSS-MSSS Joint Ann. Meet., Winnipeg, MB. 22-25 July 2013. U of M, Winnipeg, MB.

Knight, J.D. 2012. Evaluation of novel crops as green manures in organic agriculture. Agriculture Development Fund Rep. 20080072. University of Saskatchewan, Saskatoon, SK.

Mirsky, S. B., M. R. Ryan, W. S. Curran, J. R. Teasdale, J. Maul, J. T. Spargo, J. Moyer, A. M. Grantham, D. Weber, T. R. Way, and G. G. Camargo. 2012. Conservation Tillage Issues: Cover crop-based organic rotational no-till grain production in the Mid-Atlantic Region, USA. Ren. Ag. and Food Sys. 27:31-40.

PennState Extension. 2022.Terminating Cover Crops with a Roller Crimper in Organic Grain Rotations. Retrieved February 2, 2023 from: https://extension.psu.edu/terminating-cover-crops-with-a-roller-crimper-in-organic-grain-rotations#:~:text=We%20recommend%20roll%2Dcrimping%20when,lower%20leaves%20start%20to%20senesce.

SaskOrganics. 2019. SaskOrganics Releases Organic Research Priorities Report. Available at: http://saskorganics.org/saskorganics-releases-organic-research-priorities-report/

Shirtliffe, S. J., and E. N. Johnson. Progress towards no-till organic weed control in western Canada. Ren. Ag. and Food. Sys. 27:60-67.

Teasdale, J. R., and C. L. Mohler. 1993. Light transmittance, soil temperature, and soil moisture under residue of Hairy Vetch and Rye. Agron. J. 85:673-680.

Supporting Information

12. Acknowledgments

The Conservation Learning Centre graciously acknowledged the Ministry's support through signage directly in field with the project, verbally during the Field Day, and on the Field Day, agenda handed out to all visitors. The CLC thanks Claude Sander for donation of inoculant.

Abstract

13. Abstract/Summary

This trial aimed to demonstrate the potential benefits of using a roller-crimper to terminate cover crops in organic production to reduce tillage. A roller-crimper is a technology that mechanically terminates crops by bending the plants, folding the crop down into a weed-suppressive and moisture-retaining mulch that producers can direct-seed a cash crop into. Barley and hairy vetch were seeded at 134 kg/ha and 54 kg/ha, respectively, on July 19, 2022 near the Conservation Learning Centre near Prince Albert, SK. The cover crop was terminated in September by one of three treatments: with a cultivator, a swather, or a roller-crimper. The 2022 growing season was hotter and drier (66.5mm less precipitation) than the long term

average. This trial was attempted in 2021, but the cover crop did not produce sufficient biomass due to drought conditions and poor site selection. In 2022, the target mulch density of 6-8 Mg/ha (Halde and Entz, 2014) was achieved in 5 of 12 plots. All treatments in rep 1 were below target (3.9 Mg/ha), but all treatments in rep 4 met the target weight (10.8 Mg/ha). The 2022 July seeded cover crop had unevenly matured, was stunted, and did not appear to have sufficient biomass to warrant roller crimping, but the roller crimper was still used to gather some information on the performance of the roller crimper. The roller crimper appeared to work best at flattening the crop in reps 3 and 4 that had the greatest accumulation of biomass. The crimper did not appear to perform well for reps 1 and 2 that were below 6 Mg/ha. Despite not all plots reaching the target biomass, the CLC will revaluate the cover crop in spring of 2023 and may direct seed a wheat cash crop. This demonstration was discussed at an organic producer meeting in February of 2022 with approximately 20 people in attendance.