Project Identification

1. **Project Title:** Cover Crop Variety and Seeding Date Trial for Weed Suppression Under Organic Management System
2. **Project Number:** 20211087 (continuation of 20190427)
3. **Producer Group Sponsoring the Project:** Saskatchewan Conservation Learning Centre (CLC)
4. **Project Location:** near the CLC on an organic producer collaborators land (River Lot 32, 46, 26 W 2^{nd})
5. **Project Start and End Dates:** March 2022 to February 2023
6. **Project Contact Person and Contact Details:**

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Objectives and Rationale

7. Project Objectives

The objective of this trial was to demonstrate how no till management works in an organic setting by direct seeding into 6 different types of cover crops.

8. Project Rationale

The CLC was directly approached by local organic producers in the Prince Albert area who were interested in cover-cropping. The organic farmers were searching for an annual grass that would grow tall and thick enough to fall and form a mat to suppress weeds and retain moisture. Sustainable cropping practices, such as cover crops, can improve soil health and suppress weeds. Cover crops are increasing in popularity throughout the United States and Europe thanks in part to their benefits and agricultural producers' continuing efforts to farm more sustainably. Studies conducted in these regions have found that cover crops reduce soil erosion and add organic matter and carbon to the soil, which improves soil structure, tilth, and water permeability (Dabney et al., 2007; Hartwig and Ammon, 2002; Teasdale, 1996). Cover crops have been recognized for many years as a sustainable cropping practice that can improve soil health and supress weeds. Winter cover crops have been shown to increase soil moisture in northern latitudes because they act as a snow trap and provide soil cover in the spring, which slows water runoff and allows water to infiltrate soil. Local producers were also interested in direct seeding into the mat for continued weed cover, improved soil health, and reducing tillage. Legume cover crops can fix atmospheric nitrogen which can then be utilized by the subsequent crop. Non-leguminous crops are generally used to reduce soil erosion and nitrate leaching. Although it is recommended to have an N fixer like peas in a cover crop mix, growers have found that the pea straw breaks down too quickly the following year. However, when grown together with fast growing cereals, legumes can help to close the canopy and further supress the weed growth.

Additionally, many cover crop varieties are capable of supressing annual and perennial weeds. For example, Sudan-grass can reduce Canada thistle by up to 20% (Bicksler and Masiunas, 2017). When planted in the fall, Sudan-grass can quickly emerge and outcompete late season weeds. It is also capable of quickly producing a large amount of biomass that naturally terminates in the fall, forming a thick mat that covers the ground. This thick mat has the potential to reduce weed seed germination in the spring and help conserve moisture. The extensive root system typical of cover crops like Sudan-grass has been shown to break up and reduce soil compaction. Similar results have been found for other large biomass producing cover crops such as winter and spring oats (Brennan and Smith, 2005).

In August 2019, a local producer near the CLC seeded a few small plots of annual grasses in their garden. It appeared that spring forage oats would be a good candidate for weed control and direct seeding. The producer was also interested in sorghum-Sudan grass but found that an August seeding date was too late in the season. It was hypothesized that an earlier seeding date would increase biomasses for the annual cover crops. The producer was involved with the creation of this project and aided the CLC with the trial. This demonstration is very relevant and has a high potential to be adopted and incorporated into local producers' operations.

This study benefits local organic producers in the region, as well as organic producers throughout the province. Organic farming is on the rise; from 2014 to 2017 the number of organic producers in Saskatchewan rose 25% (Arnasen, 2018). This is likely due to the consumer demand for organic products and a premium offered to organic crops. In 2020, there were 938 organic farmers in Saskatchewan and they managed over 1.17 million acres of certified organic land. Among this certified land, 686,756 acres (over 58%) were seeded to field crops, such as wheat, oats, barley, lentils, pea, and flax. According to the 2018-19 Saskatchewan provincial survey of organic producers, the top priorities for growers were related to soil health, fertility, and nutrient balancing. As synthetic fertilizers are not permitted in the organic production systems, many organic producers face nitrogen limitations, in particular those who do not have livestock operations on their farms. Managing cover crops in order to balance the input and outputs costs has become a major concern. The second production issue brought up by producers was weed control. Weeds of particular concern were perennial including Canada thistle, quack grass, and others. Other issues identified by organic producers included increasing soil biodiversity, managing crop rotations, and adopting environmentally-friendly farming systems (personal communication with Dunling Wang).

The direct seeding component of this demo was especially of value to organic producers as organic farms often rely heavily on tillage to control weeds and to terminate cover crops or green manures. Reducing tillage can decrease fuel and labour costs, and improve soil and water quality. As a result, interest in direct seeding into cover crops has grown. In the United States, it is estimated that a producer's total expense input can be reduced by 20% when growing corn and 30% when growing soybeans in an organic no-till system versus an organic tilled system. While tillage is not completely discontinued in these organic no-till systems, the frequency and intensity of tillage has been reduced.

Not only are cover crops are a great tool for organic producers, they are also being promoted to all farm types as a best management practice to store carbon and reduce greenhouse gases. Producers can currently apply for On-Farm Climate Action Fund (OFCAF) funding by the federal government to aid in the adoption of cover cropping. The lack of demonstrations in the Prince Albert region has limited the amount of relevant information on cover cropping for local producers. This project demonstrated cover crop varieties that may be suitable for the region, along with evaluating seeding dates.

Methodology and Results

9. Methodology

This was a continuation of a previously established demo (ADOPT 20190427). This 2-year project was designed to showcase the potential cover crop options for the region and show how seeding dates could affect their success and subsequently the success of direct seeding a cash crop into them. The trial was located on certified organic land on a neighbouring property to the CLC. This small plot design was set up in a randomized complete block design with 4 replicates. Each plot was approximately 5.25m by 7m. In year 1 of the study (2021) various cover crop combinations were established and split into two blocks: an early seeded block and a later seeded block (Table 1). In year 2 (2022), a cash crop of barley was direct seeded into the cover crop mulches. This was managed as an organic demonstration. A complete agronomic summary can be found in Table 2.

Table 1. Treatment list detailing cover crop type, seeding date, and seeding rate for "Cover Crop Variety and Seeding Date Trial for Weed Suppression Under Organic Management System" located near Prince Albert, SK.

Treatment #	Cover Crop Type	Seeding Date	Seeding Rate (kg/ha)
1	Spring forage oats	Early	150
2	Spring forage oats 2x seeding rate	Early	300
3	Silage peas	Early	200
4	Spring forage oats with silage peas	Early	150 and 200
5	Sudan grass	Early	45
6	Sudan grass with silage peas	Early	45 and 200
7	Spring forage oats	Delayed	150
8	Spring forage oats 2x seeding rate	Delayed	300
9	Silage peas	Delayed	200
10	Spring forage oats with silage peas	Delayed	150 and 200
11	Sudan grass	Delayed	45
12	Sudan grass with silage peas	Delayed	45 and 200

Table 2.

Observation/Activity	**2021**	**2022**
Soil Type	Clay Loam	
Soil Zone	Black	
Seeding Equipment	Fabro plot seeder with double disc openers and 10 in row spacing	Haybuster no-till Drill
Seeding Date	Early Seeded: June 30 Late Seeded: July 16	June 3, 2022
Seeding Rate	See Table 1	150 lb/ac
Emergence Date	Early Seeded: July 16 Late Seeded: July 26	June 13, 2022
Stubble	4 years in Alfalfa/Bromegrass hay	Cover crop treatments
Seed Depth	Intercrops midrow banded Peas: 2 in Sudan-grass/oats: 1 in	1.5-2 in
Soil Temperature at Seeding	Early Seeded: 23.5°C Late Seeded: 24.3°C	Early Seeded: 21.5°C Late Seeded: 22.5°C
Seed Bed Preparation	Disced 2x and cultivated 3xd in 2020 Cultivated 4x in 2021	N/A

Pea Inoculant	XiteBio PulseRhizo Liquid at 40mL/15kg seed	N/A
Harvest Date	N/A	September 8
Harvest Equipment	N/A	Wintersteiger Quantum plot combine

Data collection during the cash crop year consisted of a spring composite soil test per treatment gathered prior to seeding using a Dutch soil auger and sent to Agvise Laboratories for analysis. Soil temperature was determined per plot on seeding date. Barley emergence was determined by counting plants within 4 x 1m rows. A weed count, identification and biomass were collected for 2 x 0.25m^2 quadrats per plot at timing of plant counts. Harvest occurred with a Wintersteiger Quantum plot combine and was corrected to 13.5% moisture. Weather data is available from the SRC climate station located on site of the CLC. Statistical analysis was completed by ANOVA using Statistix 10 software. Post-hoc test used was LSD.

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 9-year averages of May and October, the mean temperature of May 2022 was 6.6°C cooler while October had a mean temperature double the long-term average. Average temperature for this growing season was just 0.3 cooler than the historical average. 2022 was drier, but not as dry as 2021, the year prior when cover crops were established. All months of 2022 received less precipitation than the historical averages; there was a total of 49.3mm less precipitation this year. May received less than half the amount of precipitation than the historical average. The first frost occurred on September 10 (-0.4). The complete monthly weather summaries can be viewed/downloaded at src.sk.ca/download-weather-summaries.

Table 3. Weather conditions for 2021/2022 growing season 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
2012-2021	17.1	16.2	18.7	17.1	11.6	3.1	14.0
			--- 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
2012-2021	38.3	77.6	75	43	28.3	20	282.2

Soil Test Results

Composite soil tests for the whole trial area were conducted in 2020 and 2021, the years the cover crop were established (Tables 4 and 5). In 2020, biomass was not sufficient, and so the trial was restarted in 2021. Increases in N, S and salts may be a result of these soluble nutrients and salts moving closer to the surface after multiple drought years. There was no change in P availability.

Table 4. Basic composite soil test results from Agvise Laboratories.

Year	Depth (cm)	N (lb/ac)	P (ppm)	K (ppm)	S (lb/acre)	Zn (ppm)	OM (%)	pH	Salts (mmho/cm)
2020	**0 to 15**	19	5	293	50	3.26	6.5	6.8	0.57
	15 to 30	13			30			7.4	0.47
2021	**0 to 15**	54	4	284	20	1.52	5.3	6.3	0.42
	15 to 30	43			120+			6.7	0.73

Table 5. 2020 micronutrient, cation exchange capacity (CEC) and calcium carbonate equivalent (CCE) soil analysis at a depth of 0-15cm.

Cl (lb/ac)	B	Fe	Mn	Cu (ppm)	Mg	Ca	Na	CEC (meq)	Carbonate (CCE) (%)
10	0.9	116.1	4.8	0.74	891	4216	31	30.4	3.4

Prior to seeding in 2022, soil tests were conducted on each cover crop treatment (Table 6 and Fig. 1-3). Since these results are composites of all 4 reps per treatment, they cannot be statistically analysed, but provide some insight into potential trends. Soil test results indicated high levels of nitrogen (N), potassium (K), zinc (Zn), and organic matter (OM) across all treatments. There did not appear to be any clear trends in soil moisture (Figure 1). For available N, sudan grass and pea cover crop treatments tended to have more soil N than oats alone. In 2021, the early seeded oats/peas had been more dominated by oats, which may explain why this treatment with peas had lower available N; whereas the late seeded oats/peas were more dominated by peas. There was a very clear trend that available soil P was greater in cover crops that had been seeded earlier in 2021. Since the seeding dates had been arranged in blocks, it is possible this trend could be a result of the earlier seeding date's soil being inherently higher than the soil to the east where the later seeded block was placed. However, the trial area was uniform. Alternatively, there is growing evidence that cover cropping can improve P cycling by increasing P acquisition during growth and releasing the P to the subsequent crop during decomposition (Hansen et al., 2022). For most cover crops there was not a greater biomass accumulation in earlier seeded vs later seeded (Fig. 4). However, plant P content had not been determined and the earlier seeded cover crops may have had more time for greater uptake of P to then release in the second year of the trial.

Table 6. June 2022 soil test results by cover crop seeded in 2021.

Rep	Depth (cm)	N (lb/ac)	P (ppm)	K (ppm)	S (lb/ac)	Zn (ppm)	OM (%)	pH	Salts (mmho/cm)
1	0-15	29	13	329	20	3.37	6.6	6	0.22
	15-30	20			28			6.6	0.2
2	0-15	37	10	319	12	3.1	6.8	5.8	0.29
	15-30	35			56			6.6	0.5
3	0-15	56	12	304	10	2.65	5.9	6.1	0.37
	15-30	49			18			6.7	0.47
4	0-15	35	11	303	10	3.38	6.5	6	0.25
	15-30	24			12			6.8	0.3
5	0-15	42	10	335	12	2.21	6.5	6.1	0.28
	15-30	48			18			6.3	0.39
6	0-15	38	13	357	16	2.43	6.6	5.8	0.33
	15-30	51			34			6.6	0.75
7	0-15	32	5	326	10	2.23	7.3	5.8	0.29
	15-30	38			16			6.8	0.63
8	0-15	36	4	314	32	2.64	7.6	5.9	0.28
	15-30	28			120+			6.9	0.8
9	0-15	45	5	293	20	1.39	5.9	6.1	0.34
	15-30	49			42			7	0.58
10	0-15	49	5	322	6	2.14	7.8	5.7	0.34
	15-30	48			4			6.4	0.45
11	0-15	63	4	308	10	1.96	6.9	6.2	0.38
	15-30	68			12			6.5	0.57
12	0-15	40	4	301	12	1.17	5.6	6.1	0.33
	15-30	43			12			6.4	0.41

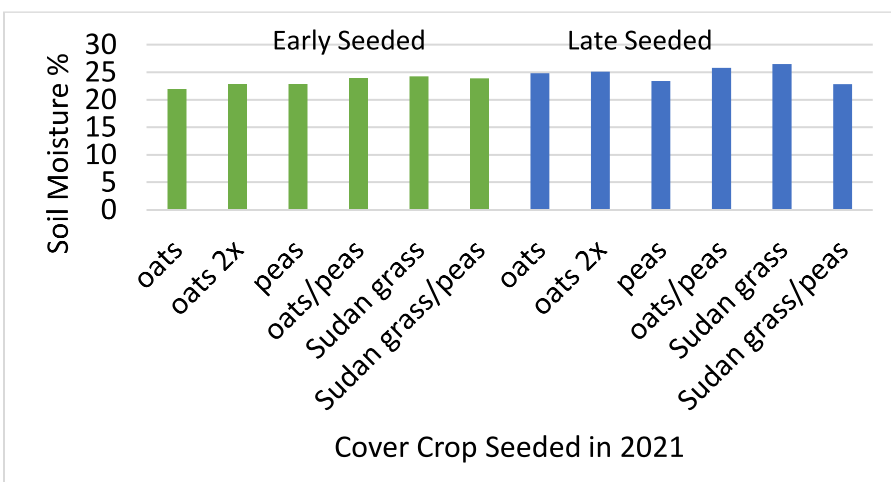

Figure 1. Soil moisture at time of 2022 seeding for each of the 2021 seeded cover crops.

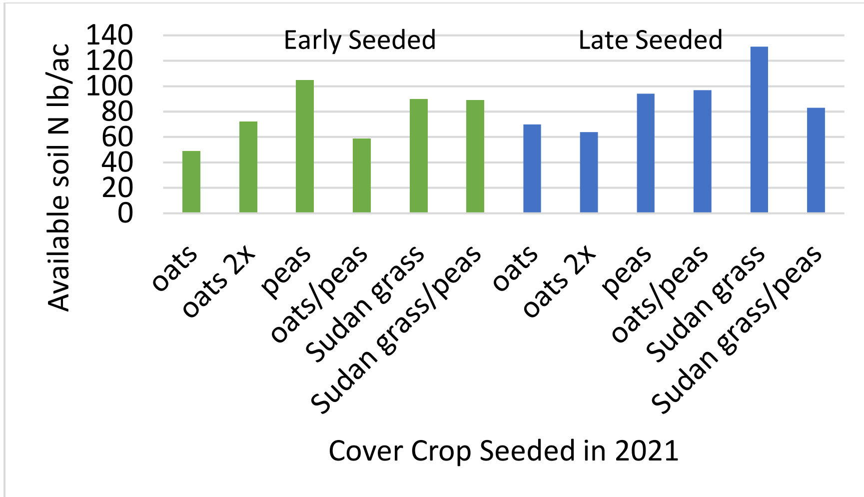

Figure 2. Available soil N at 0-30 cm at time of 2022 seeding for each of the 2021 seeded cover crops.

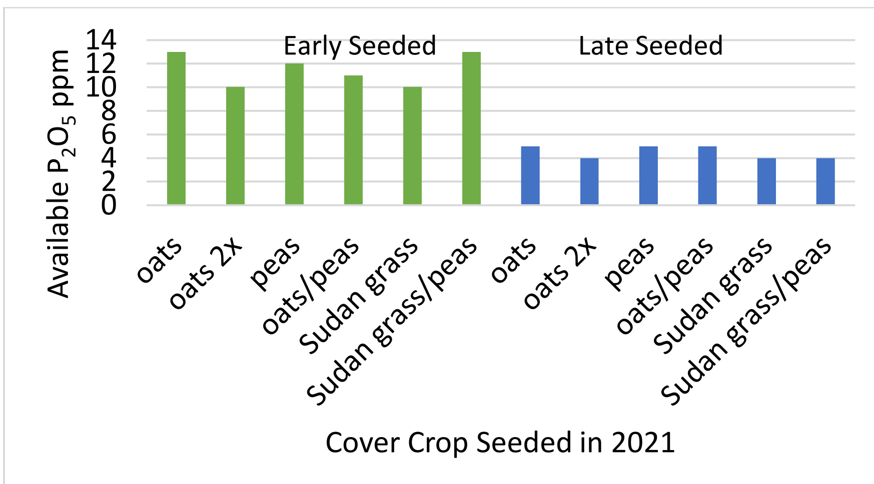

Figure 3. Soil available phosphorus at 0-15 cm at time of 2022 seeding for each of the 2021 seeded cover crops.

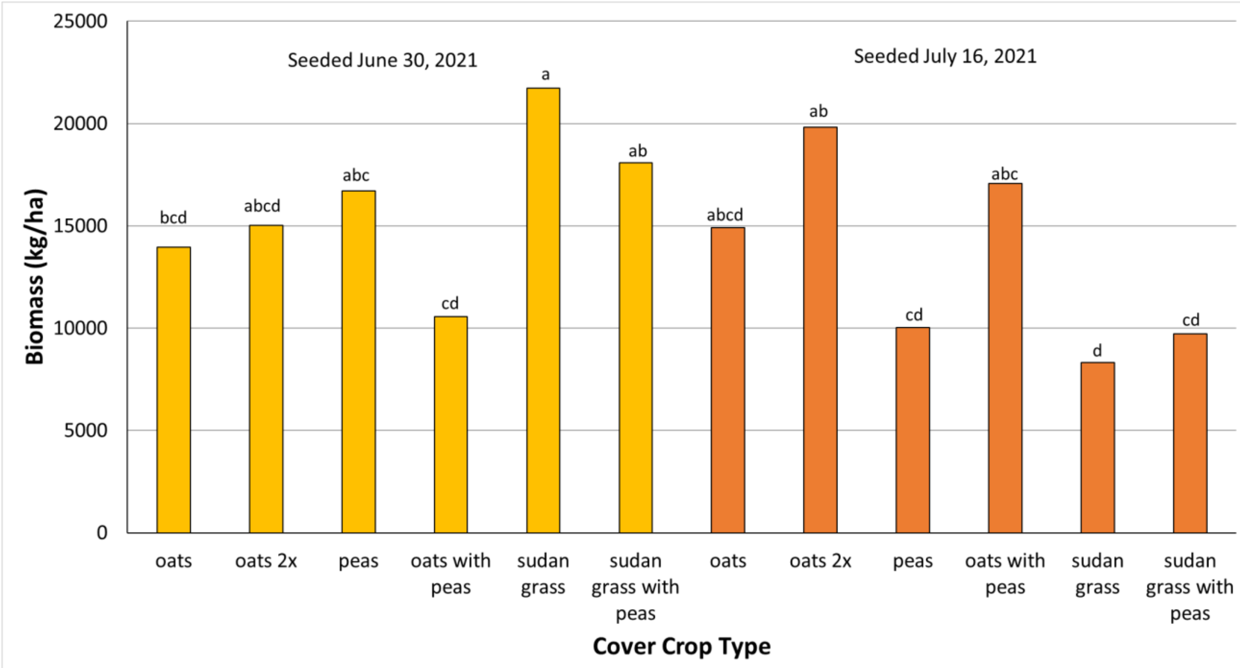

Figure 4. Mean biomass of various organically managed cover crops seeded at two different dates in 2021 near Prince Albert, SK. Means with the same letter are not significant (P>0.05). Yellow bars indicate earlier seeding date (June 30), orange bars are later seeded cover crops (July 16). Figure is from ADOPT20190427.

<u>2022 Results</u>

The earlier seeded cover crop treatments in rep 4 were overrun by Canada thistle and lamb's quarters. Two plots were not completely harvested and due to the variability, rep 4 data was omitted from all data analysis. None of the previous seeded cover crops influenced barley emergence (p=0.6877) or yield (p=0.2003). Mean plant stand across the trial was 157 plants/m2. The Haybuster drill performed well (Fig. 5). Barley yields were good and ranged between 69-95 bu/ac (Table 7).

Figure 5. Emerging organic barley that was direct seeded into 6 different cover crop combination mulches.

Table 7. 2022 mean results of barley cash crop direct seeded into various cover crop combinations.

TRT	Cover Crop	Soil temp	Weed Density	Weed Biomass*	Yield
		°C	plants/0.25m^2	kg/ha	bu/ac
1	forage oats	22.3 a-d	11.0 b-d	2359 b-e	74.3
2	2x forage oats	21.3 cd	12.3 a-d	4233 ab	76.0
3	Silage peas	23.8 ab	15.7 ab	3403 abcd	69.4
4	forage oats, silage peas	24.1 a	11.0 b-d	3129 a-d	71.2
5	Sudan grass	20.8 d	6.0 d	951 e	87.7
6	Sudan grass, silage peas	21.8 b-d	7.0 cd	2238 b-e	85.3
7	forage oats	22.7 a-d	14.7 a-c	4691 a	75.3
8	2x forage oats	20.9 d	11.0 b-d	3819 abc	83.8
9	Silage peas	23.2 a-c	14.7 a-c	2023 cde	87.4
10	Sudan grass, silage peas	22.1 a-d	8.3 b-d	1600 de	90.2
11	Sudan grass	24.1 a	9.7 b-d	3335 a-d	95.4
12	Sudan grass, silage peas	24.2 a	20.0 a	4955 a	74.9
	p value	0.0151	0.0517	0.0707	0.2003

*Weed biomass post hoc comparisons @ 0.1

The cover crops had self terminated due to frost the fall prior to seeding the cash crop. The presentation of cover crop mats in the spring of 2022 were very different. Examples of some cover crop combinations are included in Figure 6. Peas and Sudan grass were very flat to the ground, whereas the oat cover crops were still upright. Cover crops that produced higher amounts of biomass in 2021 had better ground cover with less visible bare soil. These features likely influenced the measured soil temperatures. Soil temperature (Table 7 and Fig. 7) was greatest with cover crop treatments that had the lowest biomass in 2021 (Fig. 4), including early seeded oats/peas, and late seeded Sudan grass and Sudan grass/peas ($p<0.05$; $p=0.0151$). The coolest soil temperatures corresponded with the greatest biomass producing cover crops, early seeded Sudan grass and late seeded 2x forage oats. This suggests enough biomass was created to reduce light penetration and warming of the soil.

Early Pea **Early Sudan Grass** **Late oats**

Figure 6. There were visual differences spring 2022 between the cover crop's ability to cover the soil. The cover crops were allowed to self-terminate in fall of 2021. Pea and sudan grass cover crops were flattened to the ground, while oats were still upright.

Weed density was lowest in both early seeded Sudan grass treatments ($p<0.1$; $p=0.0517$), and weed biomass was lowest in the early seeded Sudan grass ($P<0.1$; $p=0.0707$). Silage peas did not suppress weeds as both treatments (3 and 9) had some of the highest weed densities (>14.5 plants/$0.25m^2$). Peas are typically included as a pulse to increase N for the subsequent crop. It is not surprising that peas do not suppress weeds well due to their quick rate of decomposition. Late seeded spring forage oats also did not suppress weeds well. Perhaps this is due to the stubble remaining upright allowing for light to infiltrate the canopy.

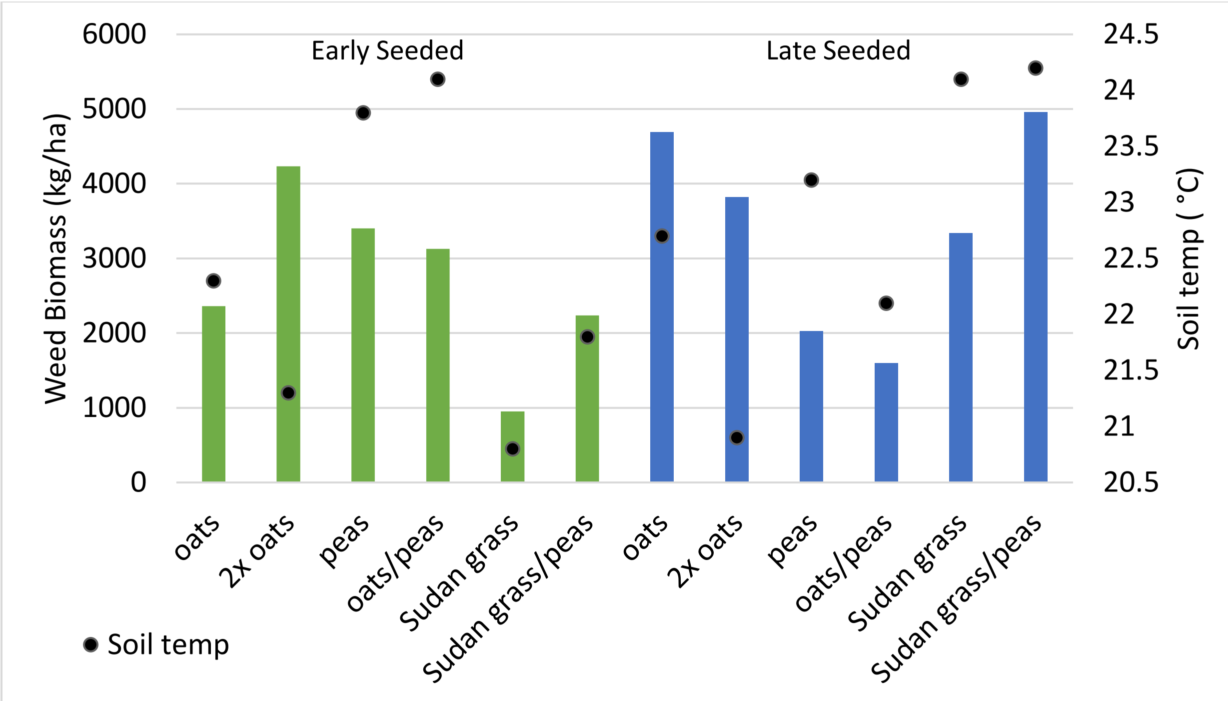

Figure 7. Comparison of various cover crop's ability to suppress weeds in the subsequent year when seeded to a barley cash crop.

11. Conclusions and Recommendations

This demonstration provides valuable information on a set of cover crop combinations for use in the Prince Albert region to help producers adopt cover cropping as a promoted best management practice to store carbon and reduce greenhouse gases. The year of cover crop establishment (2021), which was featured as a separate ADOPT project, demonstrated at least 5 different cover crop combinations that can be successfully established under dry conditions. It also identified that certain species perform better when seeded early, such as Sudan grass. When growing conditions are unfavorable, higher seeding rates and earlier seeding can aid in ensuring sufficient biomass is created.

In fall of 2021, the cover crops naturally terminated by frost and in 2022, a barley cash crop was successfully directly seeded into the remaining cover crop mulches. Barley yielded well (69-95 bu/ac) and the different cover crops established the year prior had no an effect on yield. In June 2022, there were no observable trends in soil moisture or N availability across treatments, but early seeded cover crops may have accessed more P during 2021 growth to be released to the barley crop. Cover crops continued to influence weed control in the barley cash crop. Early seeded Sudan grass, which had produced the greatest biomass in 2021, had the best weed control and cooler soil temperatures at time of seeding. Cover crop biomass did not always equate to best weed control. Peas alone and some oat cover crops had the poorest weed control. However, the inclusion of peas in a cover crop would be for N fixing ability to increase soil fertility for subsequent crops. Peas tend to decompose relatively quickly, while the oat cover crop remained upright and may have allow greater light penetration into the canopy. The

4th rep of the trial did need to be removed from data analysis due to extreme pressure from perennial weeds like Canada thistle.

Further cover crop research and demonstrations are required, as there are many other types of cover crops to investigate. Finding a way to incorporate cover crops into rotation where producers will not lose a year of income will likely increase adoption. There are also various techniques to seeding and terminating cover crops to be investigated.

A video sharing project results was filmed and will be posted to the CLC YouTube page. A TikTok video about the project has received 45.9K views, 885 likes, and 44 interactions (saves and comments). This project was shared at a local organic producer meeting in 2022 and 2023 with approximately 20 producers in attendance.

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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 Ministry was also acknowledged in a video shared to the CLC YouTube page and during winter presentations in 2022 and 2023. The CLC would also like to thank local organic producers for help developing and carrying out this demonstration.

Abstract

13. Abstract/Summary

This organically managed demonstration provides valuable information on a set of cover crop combinations for use in the Prince Albert region to help organic and conventional producers to adopt cover cropping as a promoted best management practice to store carbon and reduce greenhouse gases. In 2021, 6 combinations of cover crops (oats, 2X oats, peas, oats/peas, Sudan grass, and Sudan grass/peas) were established on 2 different seeding dates (June and July). All treatments were successfully established under dry conditions. When growing conditions are unfavorable, higher seeding rates and earlier seeding can aid in ensuring sufficient biomass is created. In fall of 2021, a barley cash crop was successfully directly seeded into the remaining cover crop mulches. Barley yielded well (69-95 bu/ac) and the different cover crops established the year prior had no an effect on yield. However, cover crops continued to influence weed control in the barley cash crop. Early seeded Sudan grass, which had produced the greatest biomass in 2021, had the best weed control. Cover crop biomass did not always equate to best weed control. Monocropped peas and some oat cover crops had the poorest weed control. However, the inclusion of peas in a cover crop would be for N fixing ability to increase soil fertility for subsequent crops as pea straw breaks down quickly. Further cover crop demonstrations are required, as there are many other types of cover crops to investigate and techniques. Videos of this project can be found on the Conservation Learning Centre’s YouTube and TikTok accounts.