Project Identification

1. **Project Title:** The Effect of Shelterbelts on Crop Yield in North Central Saskatchewan
2. **Project Number:** 20200431
3. **Producer Group Sponsoring the Project: Saskatchewan Conservation Learning Centre**
4. **Project Location(s):** The Project was located at the Conservation Learning Centre located 18 km south of Prince Albert (SW 20 46 26 W2, RM 461) and on land near the CLC owned by cooperating producer Curtis Tetarenko.
5. **Project start and end dates (month & year):** Spring of 2021 to February 2022
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

This project was intended to showcase the potential benefits of shelterbelts on crop yield in north-central Saskatchewan. The objectives of this project were to evaluate how shelterbelts influence crops and soil nutrients, moisture, and temperature under conservation tillage practices.

8. **Project Rationale:**

Numerous studies have been conducted around the world examining the effect of shelterbelts on crop yield. In Saskatchewan, these studies have mainly been completed in the south, around Indian Head and Swift Current. A literature review by Kort (1998), reviewing shelterbelt studies across the world, found that shelterbelts generally increase field and forage crop yields across most regions. Improved yields are attributed to increased soil moisture due to snow trapping, reduced wind damage, and an improved microclimate. The degree of increases in yield varies with the crop, soil type, shelterbelt design, tree species, weather conditions, and geographic location.

A study completed close to Swift Current by Kowalchuck and Jong (1995), found that crop yields were lower than average about 10 meters into the field (from the edge of the field perpendicular to the shelterbelt), and crop yields were slightly above average 10-20 meters into the field, indicating that shelterbelts have a positive influence on crop yield about 10 meters from the shelterbelt. The reason for the decrease in crop yield directly next to the shelterbelt is likely because trees compete with the crop for moisture and nutrients. A few other potential explanations for decreases in yield next to a shelterbelt include; nutrient leaching due to snowmelt (caused by snow trapping), allelopathy by tree roots, shading by the shelterbelt, and in wet climates the added moisture from snow trapping may increase the incidence of disease. Shelterbelts are home to a number of both beneficial and harmful insects, which could be either detrimental or beneficial to the neighbouring crop.

Many of the studies on shelterbelts' effect on crop yield were completed from the 1960s to the 1990s. No recent studies have examined the effect of shelterbelts on crop yields under no-till management. Most provincial shelterbelt studies have been conducted in southern Saskatchewan; with few studies being completed in the north-central region.

Shelterbelts were first studied and planted on the Canadian Prairies to reduce soil erosion. With the shift to conservation tillage practices, there has been a reduced need for shelterbelts. In response to the reduced need for shelterbelts as protection from erosion, many producers no longer see a need for shelterbelts. The consequence of this misguided thought is that producers are removing shelterbelts at an alarming rate in order to make room for their larger equipment and to clear space for creating more growable acres. However, in dry years conservation tillage is often not enough to slow soil erosion. The studies that were done in southern Saskatchewan typically saw more of an increase in mean crop yield when conditions were dry (Kort, 1988; Kowalchuk and Jong, 1995). Additionally, shelterbelts provide many more benefits than simply reducing soil erosion. Shelterbelts have the potential to improve crop yields, reduce pesticide drift, and improve the health of livestock by protecting them from the elements. Some studies have found that the microclimate modifications that shelterbelts provide, help to hasten crop maturity and improve crop quality (Kort, 1988). Shelterbelts provide many essential services to the public; they filter pollutants in water, which improves water quality, reduce odours, improve mental health, provide habitat for wildlife, and increase biodiversity (Alcock et al., 2014; Rempel, 2014).

Recently, there has been more severe weather in Saskatchewan, likely due to climate change. Winds have been stronger, there have been more hailstorms, and the occurrence of drought and flooding has increased dramatically over the past few decades (Wittrock et al., 2019). From 2006 to 2019, the federal natural disaster bills in Canada increased from 120 million to more than 430 million, indicating that natural disasters like flooding, drought, wildfires, storms etc. are increasing; and are having a substantial and detrimental impact on Canada's economy (Rabson, 2020). Shelterbelts have been named as a mitigation strategy to protect crops against severe weather events associated with climate change (Wall and Smit, 2005). This study sought to demonstrate the effectiveness of shelterbelts in protecting crops against the elements.

In recent years, there has been a focus on the ability of shelterbelts to mitigate climate change by sequestering carbon. As a result, most of the recent shelterbelt studies have been concentrated on carbon storage. There is not yet any financial incentive for farmers to keep their shelterbelts and/or plant more shelterbelts based on their carbon storage potential; so, many producers believe that it is economically unviable to keep field shelterbelts. It is difficult to put a monetary value on the numerous producer benefits and social goods and services that shelterbelts provide (listed above), as many of these benefits can be difficult to recognize. The CLC is well suited to carry out this project because the site already has a wide variety of shelterbelts. The CLC is currently collaborating with the University of Saskatchewan's AGGP2 project that aims to produce a management toolbox. This toolbox will be in the form of a computer application to help producers and landowners manage their shelterbelts. The AGGP2 toolbox emphasizes carbon sequestration and so far, includes estimates of carbon storage and forecasts of carbon storage potential, recommendations of shelterbelt species to plant, forecasts of the future growth of different shelterbelt species, a carbon life cycle analysis of shelterbelts, a shelterbelt economic analysis, and much more. This demonstration could help to add to the valuable toolbox. Shelterbelts have been a topic of great interest by the producers who have attended our Field Days and winter meetings. This project's goal is to inform local producers of the effects shelterbelts have on crops in the area under conservation tillage practices.

References:

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<u>Methodology and Results</u>

9. **Methodology:**

The trial was set up with two sites in separate fields. Each site had three, 260-meter transects that ran perpendicular to established shelterbelts; there were seven sampling points along each of the transects. Transects were 10 m apart. The first shelterbelt field was seeded to canola, and the second field was seeded to oats. Both sites had their transects flagged out on May 19th. For a more detailed description of the transects see Table 1 below.

Table 1. Data points along each of the transects and their distance from the shelterbelts

TRT #	Transect #1 (m)	Transect #2 (m)	Transect #3 (m)
1	0	0	0
2	15	15	15
3	30	30	30
4	50	50	50
5	100	100	100
6	200	200	200
7	260	260	260

A summary of agronomic information for the oats and canola can be found in Table 2. In early summer, one of the cooperating producers decided to plow under their oats due to severe weed pressure and poor crop emergence as a result of hot and dry spring conditions. After discussing this change to the trial with Ministry of Agriculture staff, it was decided that the project would continue with the canola field only. Intense flea beetle pressure and evidence of sclerotinia was observed in the canola. Pest control products that were applied can be found in Table 2.

Composite soil samples from 0-15 cm and 15-30 cm depths were taken from four locations along the shelterbelts prior to seeding and sent to Agvise Laboratories for N-P-K-S, pH and organic matter analysis. Additional soil samples were also sent to Agvise Laboratories in the spring to determine soil moisture. Fall soil samples were also supposed to be taken to assess soil moisture but were forgotten. On October 4, 2021, a Wintersteiger plot combine was used to thresh biomass samples to estimate harvest yield. Due to poor yields, sample sizes were very small, and thousand kernel weight (TKW) and test weight were not recorded. A summary of data collection methods and shelterbelt characteristics can be found below in Table 2.

Table 2. Summary of shelterbelt trial

	Canola	Oats
Direction of Tree Rows:	North/South	East/West
Number of Tree Rows:	20 planted rows	Natural Shelterbelt
Tree Species:	Hybrid Poplar	Trembling Aspen
Height of Shelterbelt:	14 meters	11.8 meters
Seeding Rate:	1028 RR Nexera @ 5 lb/ac	CS Camden Oats at 102 lb/ac
Fertilizer Rates:	N at 110 lb/ac P at 25 lb/ac S at 20 lb/ac	None (organic)
Crop Protection:	Insecticide: Matador + Glyphosate (½ rate) at 2 leaf stage Herbicide: Eclipse at 5 leaf stage Fungicide: Lance at 30% bloom	None (organic)
Soil Temperature:	Temperatures were taken at each data point along each transect (recorded in °C) on May 22nd and July 23rd Fall temperatures were omitted	
Plant Counts:	1 m from each data point along each transect were counted on June 18th	
Crop Staging:	July 23rd and August 20th	N/A
Lodging:	Rated on a scale of 1-9 August 20th	N/A
Biomass:	1 m^2 quadrats from each data point and along each transect were collected on August 20th	N/A
Threshing:	October 4th	N/A

10. Results

Weather

The 2021 growing season at the CLC was very hot and dry compared to past years (Table 3). The average temperature for the entire growing season was nearly 1˚C warmer than the long-term average. Total precipitation was 97.1 mm lower than the long-term average. Precipitation was very low in May, which contributed to poor emergence in the oats and canola. July was also exceptionally dry (9.6 mm) when compared to the long-term average of 84.6 mm, and hot with 10 days above 30°C. Canola yields likely suffered from extreme heat and drought between flowering-pod fill. The first fall frost occurred on October 2 (-0.9˚C). The complete monthly weather summaries can be downloaded from src.sk.ca/download-weather-summaries.

Table 3. Weather conditions in the 2021 growing season at the Conservation Learning Centre from the onsite SRC weather station.

	May	June	July	August	September	October	Average/Total
				--- Mean Temperature (°C) ---			
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) ---			
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 Samples - Canola

Composite soil samples were collected from the canola field along each transect and at each data point using a Dutch soil auger on May 17, 2021 and sent to Agvise Laboratories for analysis (Table 4). Nitrogen and sulfur were low close to the shelterbelt and peaked 100 m away. Phosphorus, potassium and zinc were highest 50 m from the shelterbelt. Organic matter content and soil moisture peaked 50 m from the shelterbelt.

Table 4. Spring 2021 composite soil test results from canola field.

Area	Depth	N	P	K	S	Zn	OM	pH	Salts	Moisture
	(cm)	(lb/ac)	(ppm)	(ppm)	(lb/ac)	(ppm)	(%)		(mmho/cm)	(%)
15 m	***0 – 15***	8	5	178	8	1.94	5.1	6.6	0.14	17.3
	15 – 30	5			6			6.8	0.13	
50 m	***0 – 15***	29	6	289	14	2.12	6.2	6.2	0.32	21.8
	15 – 30	16			24			7.0	0.13	
100 m	***0 – 15***	36	4	195	42	0.78	4.6	6.7	0.4	18.3
	15 – 30	13			72			7.5	0.52	
260 m	***0 – 15***	16	3	186	20	0.88	5.7	6.1	0.22	20.7
	15 – 30	13			28			6.9	0.46	

Soil Samples - Oats

In the oat field, composite soil samples were also collected along each transect and at each data point using a Dutch soil auger on May 17, 2021 and sent to Agvise Laboratories for analysis (Table 5). Nitrogen and soil organic matter were fairly consistent at every sample point along the transect. Phosphorus and zinc were highest close to the shelterbelt and decreased with increasing distance from the shelterbelt. Potassium levels increased with increasing distance from the shelterbelt. Sulfur content and soil moisture both peaked at 100 m from the shelterbelt.

Table 5. Spring 2021 composite soil test results from oat field.

Area	Depth (cm)	N (lb/ac)	P (ppm)	K (ppm)	S (lb/ac)	Zn (ppm)	OM (%)	pH	Salts (mmho/cm)	Moisture (%)
15 m	***0 – 15***	14	12	144	6	1.2	3.2	7.2	0.18	14.2
	15 – 30	10			4			7.4	0.22	
30 m	***0 – 15***	14	11	159	10	0.92	3.5	7.2	0.17	15.6
	15 – 30	14			8			7.4	0.19	
100 m	***0 – 15***	14	4	196	12	0.78	3.1	7.6	0.22	17.6
	15 – 30	10			10			7.9	0.22	
260 m	***0 – 15***	15	4	232	6	0.7	3.6	6.6	0.18	15.1
	15 – 30	15			6			6.6	0.15	

Data Analysis – Oats

Oat plant density was low due to hot and dry spring conditions and intense early spring weed competition (Table 6). Target plant density for conventional oats in the region is typically around 300 plants/m^2 and should be slightly higher for organic oats. Oat plant densities ranged between 92-251 plants/m^2 ($p>0.05$). Observably higher plant densities 30 m from the shelterbelt are a result of overlapping rows due to the logistics of seeding near headlands. Soil moisture was lower at the oat site compared to the canola site. The oat field was located on a sandier textured soil, which has less capacity to hold moisture. The position of the shelterbelt on the oat field of east-west may have lower soil moisture due to less snow trapping abilities.

Table 6. Summary of means of oat crop in shelterbelt study. Distance refers to each sampling point's distance from the shelterbelt.

TRT #	Distance (m)	Plant Density (plants/m^2)
1	0	123
2	15	133
3	30	251
4	50	92
5	100	95
6	200	133
7	260	107
p value		0.0754

Data Analysis – Canola

Average May soil temperature was 10.7°C overall (Table 7, $p>0.05$). In July, soil temperature was highest 15 m from the shelterbelt at 25.7°C, and lowest at 30 m and 260 m from the shelterbelt at 20.4°C ($p=0.0237$). Variability in July soil temperature may be explained by natural variations in topography.

Plant density was very low in the canola, likely due to hot and dry conditions and intense flea beetle pressure (Table 7, $p>0.05$). Plant density ranged between 19-68 plants/m^2, well below the typical target for the region of 80 plants/m^2.

Canola at all sampling points was at similar growth stages when assessed in July and August (Table 7, $p>0.05$). Lodging was more severe at 260 m from the shelterbelt than at 30 m, though lodging was minimal overall (Table 7, $p=0.0123$).

Wet biomass was highest 30 m from the shelterbelt at 15 597 kg/ha (Table 7, $p=0.0396$). Biomass was much lower 15 m and 100 m from the shelterbelt at 2 948 and 4 034 kg/ha, respectively ($p=0.0396$). Low biomass 15 m from the shelterbelt may be due to competition for moisture between the crop and tree roots.

Canola harvest yield ranged between 6.4-44.5 bu/ac and averaged around 21.1 bu/ac (Table 7, $p>0.05$). Yields were observably higher between 30-50 m from the shelterbelt. Yields were low due to hot and dry conditions but were comparable to the regional average. In 2021, canola yielded on average 24 bu/ac in the region (Government of Saskatchewan, 2021).

Table 7. Summary of means of canola crop in shelterbelt study. Distance refers to each sampling point's distance from the shelterbelt. There was a strip of grass between the shelterbelt and the field so there was no crop at 0 m from the shelterbelt, resulting in the missing data at sampling point 1.

#	Distance (m)	Soil Temp (°C)		Plant Density (# plants/m²)	Growth Stage		Lodging (1-9)[3]	Wet Biomass (kg/ha)	Yield (bu/ac)
		May	**July**		**July** (BBCH)[1]	**August** (% SCC)[2]			
1	0	10.4	24.5 AB	-	-	-	-	-	-
2	15	11.3	25.7 A	23	73	85	1.0 AB	2948 C	6.4
3	30	11.0	20.4 C	27	69	13	1.0 B	15597 A	44.5
4	50	10.9	23.0 ABC	27	71	63	1.7 AB	12859 AB	38.5
5	100	11.3	23.2 ABC	21	71	53	1.3 AB	4034 C	13.5
6	200	10.1	21.4 BC	68	76	77	2.0 AB	7131 BC	26.3
7	260	9.5	20.4 C	19	73	57	2.7 A	7189 BC	18.5
	p value	0.4079	0.0237	0.3239	0.1328	0.0795	0.0123	0.0396	0.0989

[1] Staged according to BBCH growth stages.

[2] Staging based on % SCC = % seed colour change, as described in the Canola Council of Canada's "Guide to Managing Canola Harvest" available at https://www.canolacouncil.org/download/130/agronomy-guides/2564/canola_harvest_guide-2

[3] Lodging was rated on a scale of 1-9 where 1 = no lodging and 9 = plants were completely flat.

11. Conclusions and Recommendations

Hot and dry conditions throughout the growing season, early weed competition and intense spring flea beetle pressure resulted in poor plant densities in the canola and oat crops, and low canola yields. In the canola, lodging was lowest and biomass greatest at 30 m from the shelterbelt, suggesting that growing conditions were most suitable at this distance. This distance is further than was found in Kowalchuk and Jong's 1995 Swift Current study, where it was determined that crop performance improved 10-20 m from the shelterbelt (Kowalchuk and Jong, 1995). The shelterbelts in Swift Current study were only 6 m tall whereas the CLC's shelterbelts were over twice as tall at 14 m, which may explain why crop performance improved further from the shelterbelts in the CLC study. This difference may also be due to extremely hot and dry conditions, which exaggerated competition for soil moisture between the crop and the tree roots. This is supported by the spring soil tests that found the lowest soil moisture at 15 m and the highest soil moisture at 50 m from the shelterbelt. Greater soil moisture and protection from wind, as indicated by reduced lodging at 30 m, indicates that shelterbelts may offer a yield bump at a specific distance. This yield bump may help offset any reduction in yield due to close proximity to a shelterbelt. Non-crop areas can also serve as habitat for beneficial insects that provide pollination or are predators for other insect pests. This benefit can result in a "halo effect" of localized differences in crop yield (Galpern et. Al., 2020).

It would be beneficial to repeat this study in a cooler, wetter year and with more complete data collection in order to assess the impacts of shelterbelts on crop performance under more typical growing conditions. The additional measurement of snow pack along the transects would be a very achievable and low cost measurement to include.

References:

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Supporting Information

12. Acknowledgements

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 also thanks cooperating producers Ken Blocka and Curtis Tetarenko for their participation in the project.

Abstract

13. Abstract/Summary

This project intended to assess how shelterbelts influence crop performance, soil nutrients, moisture and temperature in north-central Saskatchewan. The trial was conducted near the Conservation Learning Centre, located 18 km south of Prince Albert, SK. Two sites were selected, one conventional canola field with a north/south 20 row planted hybrid poplar shelterbelt approximately 14 m in height, and one organic oat field with an east/south natural trembling aspen shelterbelt around 11.8 m tall. Three transects ran perpendicular to the shelterbelts, with seven sampling points along each transect at 0, 15, 30, 50, 100, 200 and 260 m into the field. The 2021 growing season was unusually hot and dry, which contributed to low plant densities in both the oats and canola. Due to difficult growing conditions and heavy weed pressure, the oat field was terminated in early summer by the cooperating producer. Canola lodging was the lowest and biomass was the highest at 30 m from the shelterbelt, suggesting that growing conditions may be the most suitable at this location. Improved growing conditions at 30 m could be due to greater soil moisture, protection from wind, and the proximity of beneficial insects that live in the shelterbelt. In comparison, a 1995 Swift Current study on shelterbelt effects on crop yield found that crop performance was maximized at 10-20 m from the shelterbelt, much closer than 30 m. Shelterbelts in the Swift Current study were less than half as tall as the shelterbelts at the CLC, which may explain why improved crop performance was observed further from the shelterbelts at the CLC. This difference may also be explained by drought conditions worsening competition between the crop and tree roots for moisture. Canola yields were low overall, ranging between 6.4-44.5 bu/ac, but were comparable to average yields for the region in 2021. It would be beneficial to repeat this study in a cooler, wetter year and with more complete data collection, and to include a measure of snow pack along the transects, in order to assess the impacts of shelterbelts on crop performance under more typical growing conditions.