Project Identification

1. **Project Title:** Alternative cropping options for north-central Saskatchewan
2. **Project Number:** 20190426
3. **Producer Group Sponsoring the Project:** Conservation Learning Centre
4. **Project Location(s):** SW 20-46-26 W2 RM #461 (Prince Albert)
5. **Project Start and End Dates (Month & Year):** Spring 2020 to February 2021
6. **Project Contact Person & Contact Details:**

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Objectives and Rationale

7. Project objectives:
To showcase potential crop options and examine their suitability for the region.

8. Project Rationale:
All proposed crops in the project are being grown in Saskatchewan. The acres of insured minor crops in the province from 70 739 to 135 854 since 2010. Minor crops include hemp, camelina, dry beans, faba beans, sunflowers and more. Incorporating minor crops into the crop rotation can provide a number of benefits, including optimizing soil nutrient use, helping to break disease and weed cycles, and spreading out risk (Gebremedhin and Swhab, 1998).

Dry beans (*Phaseolus vulgaris)* are well suited to the Thin Black soil zone in Saskatchewan, where there is less chance of spring and fall frost and moderate rainfall. Dry beans are not well suited to southern Saskatchewan, as they are highly susceptible to changes in temperature and moisture and do not tolerate flooding. A minimum of 12°C soil is required to germinate and grow quickly, which may be achieved earlier in the season by tilling, making growing them in more northern regions a possibility (Saskatchewan Pulse Growers, 2019).

Quinoa (*Chenopodium quinoa*) acres are on the rise in Saskatchewan and in Canada as a whole. In Canada, acres of quinoa increased from 312 to 11 868 between 2011 and 2016 and the majority are grown in Saskatchewan (Barrera, 2018). Quinoa is highly susceptible to weather events and insects, but grows well in more northern agricultural regions of the province because production can be lost due to heat sterilization.

Lentils (*Lens culinaris L.*) are typically grown in the Brown and Dark Brown soil zones, but they are beginning to be grown in the Thin Black and Black soil zones of Saskatchewan. Lentils like fields with good drainage and lighter textured soils (Fleury 2016). More determinate and disease resistant varieties are more well suited to fringe areas (Fleury 2016).

Chickpeas (*Cicer arietinum L.*) are a drought and heat tolerant, relatively long season crop with an indeterminate growth habit. Brown and Dark Brown soil zones are ideal for chickpeas as they do not tolerate wet conditions. Chickpeas were grown as an intercrop with flax in the Prince Albert area in 2019. Little to no disease was found, which is significant as disease is a major problem with chickpeas.

Soybeans (*Glycine max)* are one of the few legumes that can be used for cattle feed. Forage soybeans can be grown as an annual forage or pasture crops and are relatively equal in quality with alfalfa because of their similar nutrient and crude protein values.

Flax (*Linum usitatissimum*) is grown for either its oil or its fiber. In Canada, it is mainly grown for its oil. The acres of flax grown in Saskatchewan may increase with growing demand for natural materials to reduce waste (Flax Council of Canada, 2019).

Coriander (*Coriander sativum)* is a popular spice crop and a member of the Umbilliferae/carrot family. The most commonly grown type in Saskatchewan is large-seeded and has a shorter growing season (100 to 110 days) (Slinkard et al., 2000; Government of Saskatchewan, 2019).

Sunflower (*Helianthus annuus)* is a long season crop that takes from 120-150 days to mature and is the last crop to be harvested in the fall and combined around late October and November (National Sunflower Association, n.d.). Sunflowers require lots of heat and prefer loam, silty loam, and clay loam soils. Sunflowers have 5-6 foot long tap roots that can scavenge nitrogen that have leached below the rooting depths of other crops as well as access deep soil moisture. This makes them drought-resistant and reduces the amount of fertilizer needed. Oilseed sunflowers, used for birdseed and sunflower oil, mature more quickly than confection sunflowers and are more commonly grown in Saskatchewan.

Grain corn (*Zea mays*) has been grown in pockets of western Canada (red River Valley of Manitoba and Southern Alberta) for many years, but producers have recently begun growing grain corn in southern Saskatchewan. Growing corn in Saskatchewan is limited by the corn heat units (CHU) in the area but has been made possible by new earlier maturing varieties (Gilmour, 2015). However, the number of CHU's may fall short in below average temperatures. Corn also relies on high levels of precipitation and may not be successful in drought prone areas.

Buckwheat (*Fagopyrum esculentum*) has been grown in Canada since the 1920's and was at its production peak in the 1970's. In the 2000's, buckwheat production dropped dramatically when Japan began buying Chinese buckwheat instead. China was able to provide a fresher, albeit lower quality, buckwheat that appealed to Japanese consumers. As demands for gluten free alternatives rise, Canadian buckwheat producers are hopeful that buckwheat markets will improve, though they are still presently able to fetch a fair price (Milligan, 2015). Loam and sandy loam soils are most suitable and buckwheat is typically seeded in early June due to frost sensitivities. Mature plants are 2-5 feet in height, have hollow stems and shallow roots, making buckwheat susceptible to lodging. Flowers may be aborted if conditions are too hot and dry (Government of Alberta, 2001). Buckwheat is highly competitive with weeds and only has one registered herbicide.

Canary grass (*Phalaris canariensis*) is well suited to Dark Brown and Black soil zones of the province, due to its sensitivity to heat and drought. Heavy clay soils that are moisture retentive are ideal. Excess soil moisture and nutrients contributes to lodging. Most canary seed is sold as birdseed, and Canada is its largest producer and exporter (Milligan, 2016). Hairless canary seed was approved for human consumption in Canada in 2016. There is hopes that rising consumption of gluten-free products will help propel the canary seed market.

Intercropping provides another opportunity for diversifying crop rotations. In 2019, there were 72 400 acres and 140 producers who insured their intercrops this year, according to SCIC. OF these, the top four highest seeded acres include peola, lentil/wheat, oat/pea, and chickpea/flax. When grown in combination with flax, chickpea becomes a viable option in the Black soil zone because the flax can introduce the late season moisture stress that chickpeas require to mature. This leads to less green seed and improved quality compared to when chickpeas are grown alone (Isaacs, 2019). Both intercropping and diversifying crop rotations are recognized to increase biodiversity and resiliency to climate change (Lakhran et al., 2017).

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Methodology and Results

9. Methodology:

This trial was arranged as 2 replicates of 16 different crop treatments. A treatment list can be found in table 1. They were not randomized to facilitate seeding. There was a border of fall rye between the coriander and canary seed, and two borders between the corn and quinoa. These were put in place to prevent accidental spray drift to sensitive crops.

Table 1. List of treatments and crops grown in the Alternative Cropping Options for North-central Saskatchewan" trial.

TRT	CROP
1	Sunflower
2	Fababean
3	Soybean
4	Canola/pea
5	Flax
6	Chickpea/flax
7	Kabuli chickpeas
8	Dry bean (Blackstrap)
9	Lentils (small red)
10	Buckwheat
11	Coriander (sm)
12	Coriander (lg)
13	Canary seed
14	Pea/oat
15	Corn
16	Quinoa

Each plot was 2m by 7m seeded into canola stubble by a Fabro plot seeder with 10-inch row spacing. The corn was seeded with a simple disk-type garden seeder (Earthway). Seeding depths, fertilizer rates, and seeding dates can be found in Table 2. Seeding rates can be found in Table 3. No seed treatments were applied and no pre-emergent herbicides were used.

Table 2. Seeding depths, soil temperatures at seeding, seeding dates, emergence dates and fertilizer rates for each treatment and crop of this study.

Trt	Crop	Seeding Date	Emergence Date	Soil Temp.	Depth	N	P
				°C	in	lb/ac	lb/ac
1	Sunflower	June 3	June 15	14.6	1.25	10	15
2	Fababean	May 23	June 2	15	2-3	0	26
3	Soybean	May 23	June 6	15	2	0	34
4	Canola/pea	June 3	June 15	14.6	Peas 2, canola 0.75*	0	0
5	Flax	June 3	June 15	14.6	1.25	15	15
6	Chickpea/flax	June 3	June 15	14.6	Chickpeas 2.5, flax 1.25*	0	0
7	Kabuli chickpeas	June 3	June 15	14.6	2	0	0
8	Dry bean (Blackstrap)	June 3	June 19	14.6	2	13	20
9	Lentils (small red)	May 23	June 2	15	1-2	0	22
10	Buckwheat	June 3	June 15	14.6	1.25	10	30
11	Coriander (sm)	June 3	June 19	14.6	1.25	30	20
12	Coriander (lg)	June 3	June 19	14.6	1.25	30	20
13	Canary seed	June 3	June 13	14.6	1.25	8	17
14	Oat/pea	June 3	June 15	14.6	Peas 2.5, oats 1.25*	0	0
15	Corn	May 23	June 6	15	2	118	63
16	Quinoa	June 3	June 15	14.6	0.75	60	23

*For intercrops, the first listed crop was seeded down the fertilizer row and the second crop was seeded down the seed row of the Fabro plot seeder.

Table 3. Seeding rate for crops in Alternative Cropping Options trial.

Trt	Seed Type	Seeding Rate	
		plants/m^2	lb/ac
1	Sunflower	10	
2	Fababean	45	
3	Soybeans	50	
4	Canola/pea		Canola-2, Pea-100
5	Flax		50
6	Chickpea/flax		Chickpea-120, Flax-15
7	Kabuli Chickpeas		120
8	Dry bean (blackstrap)	45	
9	Lentils (small red)	130	
10	Buckwheat		72
11	Coriander (sm)		20
12	Coriander (lg)		30
13	Canary Seed		30
14	Oat/pea		Oat-30, Pea-120
15	Corn	15	
16	Quinoa		10

Table 4. Additional information for Alternative Cropping Options trial.

Legal Land Location	SE 20-46-26-W2 RM 461
Coordinates of Corners	N53°01.554' W105°45.999' N53°01.565' W105°46.002' N53°01.553' W105°46.031' N53°01.565' W105°46.030'
Soil Zone	Black
Soil Type	Clay loam

Weed control was a challenge in this trial. To illustrate this to producers only replicate 2 was hand weeded, leaving replicate 1 weeds to be controlled only by herbicide. On June 16, 2020 treatments 1-9 were sprayed with Centurion and treatment 15 was sprayed with MCPA Amine 600. On July 3, 2020 treatments 10-12 were sprayed with Poast, treatments 2 and 3 were sprayed with Basagran, and treatment 16 was sprayed with Centurion. Spring plant densities were measured for treatments 2, 9, and 15 on June 15, 2020, and the remainder of treatments were measured on July 7, 2020. The crops were scouted weekly for disease and insect pressure. On July 17, 2020 the fungicide Priaxor was applied to treatments 2 and 9, and on Aug 26, 2020 the insecticide Coragen was applied to treatment 16. Reglone was applied as a pre-harvest desiccant to treatments 8 and 9 on Sept 4, 2020. Treatments 1-14 and 16 were harvested using a Wintersteiger plot combine. Harvest data for treatment 15 was taken by hand and included plant height, biomass of 1 m front and back, number of cobs in 1 m front and back, and length of those cobs. Treatments 8 and 10 were harvested Sept 22, 2020; treatments 2, 3, and 14 were harvested Sept 29, 2020. Yield was measured after samples had been dried, cleaned, and weighed.

10. Results

Weather

The spring and summer at the CLC saw good precipitation compared to past years (Table 5). Temperatures throughout the growing season were slightly cooler than in past years, but similar to 2019. May and June were colder than the historical average, which likely impacted growth. The coldest spring frost occurred on May 15th (-4.5°C), and the latest spring frost occurred on May 16th (-0.3°C), well before any of the crops in this trial were seeded. The first fall frost occurred earlier than normal on September 8th (-3.6°C) whereas the first hard frost did not occur until September 16th (-5.3°C). Precipitation was lower in the fall months relative to the 2019 growing season.

Table 5. Weather conditions in the 2020 growing season at the Saskatchewan Conservation Learning Centre.

	May	June	July	August	September	October	Average/Total
				--- Temperature (°C) ---			
2020	9.2	13.4	17.6	16.1	10.9	1.0	11.4
2019	9.5	15.8	17.4	15.1	11.6	1.0	11.7
2012-2018	11.8	16.1	18.5	17.3	11.6	3.5	13.1
				--- Precipitation (mm) ---			
2020	68.4	91.4	32.2	33.2	31.6	10.1	266.9
2019	30.0	54.4	57.4	16.8	59.6	11.6	229.8
2012-2018	36.4	80.6	96.1	48.0	25.8	26.0	310.5

Soil Test Results

Soil tests indicated that N was high and P was low (Table 6). Sulfur levels were medium with 43 lb/ac available in the top 45 cm.

Table 6. May 6, 2020 soil test results.

Depth (cm)	N (lb/ac)	P (ppm)	K (ppm)	S (lb/ac)	Zn (ppm)	OM (%)	pH	Salts (mm ho/cm)
0 – 15	22	8	360	14	1.33	5.3	6.3	0.21
15 – 45	68			29			6.6	0.35
0 – 45	90							

Sunflower plants flowered 51 days after emergence but did not fully mature in time for harvest (Table 7). An early fall frost on September 8th prevented maturity in several of the alternative crops in this trial. Sunflower emergence was good with a mean plant density of 13 plants/m^2.

Faba beans flowered at 39 days and matured at 88 days (Table 7). Plant density was slightly higher than the target plant stand at 48 plants/m^2.

Soybeans flowered 49 days post-emergence and matured at 106 days (Table 7). Emergence was low in the soybeans, with a mean plant density of 33 plants/m^2. Target plant stand for soybeans was 50 plants/m^2.

In the canola/pea intercrop, the canola flowered at 25 days and matured at 77 days and the peas flowered at 36 days and matured at 93 days (Table 7). The 16-day difference in maturity might make harvest timing difficult. Emergence was very poor in the canola with only 11 plants/m^2 compared to a target of 75 plants/m^2. Pea emergence was also low.

Days to flower for both flax and chickpea were the same when seeded alone and when intercropped (Table 7). The flax flowered 36 days post-emergence and the chickpeas flowered 32 days post-emergence. The chickpeas and flax did not fully mature when seeded alone or when seeded together. Flax emergence was low when seeded alone and when planted in intercrop. Chickpea emergence was good in both cases.

Blackstrap dry beans flowered at 34 days and matured at 63 days post-emergence (Table 7). Emergence was good with a mean plant density of 90 plants/m^2.

Lentils began flowering at 39 days post-emergence and matured around 94 days post-emergence (Table 7). Plant density was on target at 127 plants/m^2.

Buckwheat flowered at 29 days and reached full maturity at 93 days (Table 7). Buckwheat plant density was 24 plants/m^2, much lower than the target 160 plants/m^2. However, buckwheat plants did branch out to fill in the gaps in the plant stand.

The small and large coriander flowered at 40 days and 37 days post-emergence, respectively (Table 7). Both sizes of coriander matured in 116 days. Plant density was low for both sizes of coriander but was observably lower for the large coriander.

Canary seed began flowering at 40 days and reached maturity at around 108.5 days (Table 7). Mean plant density was 159 plants/m^2.

In the oat/pea intercrop, oats flowered at 46 days and matured at 92.5 days and peas flowered at 40 days and matured at 97 days post-emergence (Table 7). Maturity was similarly timed in the oats and peas, which simplifies harvest of this intercrop. Plant density in the oats averaged around 93 plants/m^2, very close to the target 100 plants/m^2. Emergence was low in the peas, with a plant density of 63 plants/m^2 compared to the target 80 plants/m^2.

Corn flowered at 68 days post-emergence and matured at 86 days post-emergence (Table 7). Mean plant density was 21 plants/m^2.

Quinoa flowered around 44 days post-emergence but did not fully mature before the first frost (Table 7). Emergence was low at 21 plants/m^2. Plant density may have been impacted by weed pressure, due to the lack of registered herbicides for quinoa.

Table 7. Mean days to flower, days to maturity and plant density for Alternative Cropping Options trial.

Trt	Seed Type	Mean Days to Flower	Mean Days to Flower (pea/flax)	Mean Days to Maturity	Mean Days to Maturity (pea/flax)	Mean Plant Density	Mean Plant Density (pea/flax)
		# of days		# of days		plants/m^2	
1	Sunflower	51		N/A*		13	
2	Fababean	39		88		48	
3	Soybeans	49		106		33	
4	Canola/pea	25	36	77	93	11	46
5	Flax	36		N/A*		196	
6	Chickpea/flax	32	36	N/A*	N/A*	36	65
7	Kabuli Chickpeas	32		N/A*		37	
8	Dry bean (blackstrap)	34		63		90	
9	Lentils (small red)	39		94		127	
10	Buckwheat	29		93		24	
11	Coriander (sm)	40		116		86	
12	Coriander (lg)	37		116		15	
13	Canary Seed	40		108.5		159	
14	Oat/pea	46	40	92.5	97	93	63
15	Corn	68		86		21	
16	Quinoa	44		N/A*		21	

*N/A: days to maturity not available, plants never fully matured.

Yields were low for many crops due to significant weed pressure, animal grazing and an early fall frost. Sunflower had to be harvested before it was fully matured, which led to it spoiling in storage. Sunflower yields were low, at around 34 bu/ac (Table 8). Sunflower seeds were also eaten by birds throughout the growing season, despite the installation of a scarecrow in late summer.

Faba beans had high yields at approximately 76 bu/ac (Table 8). This would indicate that faba beans are well-suited to the region.

Soybean yields were low at 20 bu/ac (Table 8). Soybean plots suffered heavy grazing from deer, despite the installation of a 3D deer fence. Additionally, the early fall frost likely contributed to poor yields. The installation of an electric fence around the soybeans and other pulse crops likely would have helped reduce yield losses. It is also important to note that grazing losses would not be as severe on a field scale.

The canola/pea intercrop yields were poor (Table 8). The plots were eaten and trampled by deer, resulting in low yields and severe lodging which made combining difficult. Once again, the impacts of grazing animals would not be as pronounced on a field scale.

Flax yields were low, largely due to intense weed competition and an early fall frost preventing the flax from maturing fully (Table 8). The weeds also made harvested samples very messy, and cleaning the flax was difficult due to how small and light the grain is.

Flax and chickpeas yielded higher in the chickpea/flax intercrop than when seeded alone, though yields were low in both cases due to an early fall frost (Table 8). The flax yield increase could be due to the chickpeas helping to reduce weed competition for the flax. Chickpea yield may have benefitted from the late season moisture stress induced by being planted with the flax.

Chickpea yielded very low when seeded alone (Table 8). Chickpeas never fully matured, due in part to early frost.

Dry bean yields were on target with the yield goal recommended in the Government of Saskatchewan's 2020 Crop Planning Guide (Table 8).

Lentils yielded higher than the target yield identified in the 2020 Crop Planning Guide (Table 8).

Buckwheat yields were much lower than the target 40 bu/ac (Table 8). This is likely due to poor emergence in the buckwheat.

The large coriander seed yielded higher than the small coriander seed (Table 8). This could be due to the fact that the recommended seeding rate for small coriander seed was lower than for large coriander seed. The larger seeds may also have produced more hardy seedlings. Yields for both sizes of coriander were high.

Canary seed yields were low (Table 8).

In the oat/pea intercrop, the oats performed well but pea yields were low (Table 8).

Quinoa yields were good, despite not fully maturing before frost (Table 8). Weed management was difficult for quinoa due to the lack of registered herbicides.

Table 8. Yield of crops in Alternative Cropping trial.

TRT	Seed Type	**Mean Yield**	**Mean Yield** (pea/flax)
		bu/ac	bu/ac
1	Sunflower	37.92*	
2	Fababean	75.88	
3	Soybeans	19.70	
4	Canola/pea	2.66*	6.40
5	Flax	2.41*	
6	Chickpea/flax	5.10+	4.19*
7	Kabuli Chickpeas	2.04	
8	Dry bean (blackstrap)	27.21	
9	Lentils (small red)	49.33	
10	Buckwheat	15.59	
11	Coriander (small)	63.24*	
12	Coriander (large)	80.82*	
13	Canary Seed	18.77	
14	Oat/pea	110.99	11.60
16	Quinoa	28.80*	

*Yield is not corrected for moisture. Moisture could not be tested for these samples due to small sample size, sample spoiling in storage, or the sample being too dry for moisture reading.

+Yield represents a single replicate, not the mean. Yields in replicate 2 were too low to calculate corrected yield.

Corn plants were tall and produced lots of biomass (Table 9). The corn averaged at around 6 cobs per plant and cobs were fairly large, averaging at 24 cm in length. The majority of harvested cobs were fully ripe.

Table 9. Corn harvest data in Alternative Cropping trial.

Corn Harvest Data	
Mean Plant Height (m)	2.10
Mean Biomass (kg/m^2)	3.84
Mean Number of Cobs (cobs/plant)	6.25
Mean Cob Length (cm)	23.99

11. Conclusions and Recommendations

Faba beans, dry beans and lentils performed well in a north-central growing environment. Some of the other crops may have performed better if not for an unusually early frost at the beginning of September resulting in several crops not reaching full maturity, namely: sunflower, flax, chickpea/flax, chickpea, and quinoa. Further research should be conducted in the future to determine how these crops perform under different weather conditions.

While many of the crops in this trial performed well, there were a few challenges associated with growing these alternative crops. Despite hand weeding and the use of herbicides, weed management was an issue. Weed pressure was especially significant in the quinoa plots, due to the lack of registered herbicides. The pulse crops were also heavily grazed and trampled by deer resulting in very low yields and significant lodging, though this effect would not be as important on a field scale.

12. Acknowledgements:

The Conservation Learning Centre graciously acknowledged the Ministry's support through signage directly in field with the project, verbally during the walking tour and on the walking tour agenda handed out to all visitors.

13. Abstract:

This trial aimed to demonstrate some alternative cropping options available to local producers and to assess their suitability for the north-central Saskatchewan region. 13 crops were seeded, as well as 3 intercrops: sunflower, faba bean, soybeans, canola/pea, flax, chickpea/flax, Kabuli Chickpeas, dry bean (blackstrap), lentils (small red), buckwheat, coriander (small seed size), coriander (large seed size), canary seed, oat/pea, corn and quinoa. Faba beans, lentils and dry beans all performed well in a north-central growing environment. An early September frost meant several crops did not fully mature, namely: sunflower, flax, the chickpea and flax intercrop, chickpea and quinoa. The pulse crops suffered heavy grazing and trampling by deer, despite the installation of a 3D deer fence. Weed management was also an issue given the minimal options of registered herbicides for the crops in the trial. Repeating this trial under different weather conditions would provide further insights into the suitability of these crops for incorporation into local crop rotations. This trial was featured in a walking tour in lieu of the CLC's Annual Field Day in July of 2020. Approximately 10 people attended, including local

producers and commodity group representatives. Walking tour attendance was restricted due to COVID-19. The Alternative Cropping Options in North-Central Saskatchewan trial was also featured in a YouTube video as part of the CLC's Virtual Field Day, reaching 31 viewers at the time of writing this report.