Project Identification

1. **Project Title:** Demonstration of Soybean Varieties and Seeding Date for Observation in the Region
2. **Project Number:** 20190376
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):** August 2019 to February 2021

6. Project Contact Person & Contact Details:

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Objectives and Rationale

7. Project objectives:

To provide a demonstration for local producers of different soybean varieties. To explore the potential benefit of using tillage prior to seeding in early spring to warm the soil and the effect a spring frost could have on the crop.

8. Project Rationale:

Research sites in Saskatchewan and Manitoba have tested many new shorter season soybean varieties. These include Dauphin, Roblin, Outlook, Saskatoon, Floral, Kamsack, Rosthern, Melfort, and Scott. The published results indicated that yields of the check variety, NSC Reston R2Y, were 47 bu/ac in 2016. According to the Saskatchewan Pulse Growers, in Saskatchewan, typical yields are around 25-30 bu/ac. Farmers in the province's northeast grain belt report average yields near 40-50 bu/ac.

In 2017, a few varieties of soybeans were grown at the Conservation Learning Centre (CLC). Yields of these crops averaged 31 bu/ac, despite having been seeded late (June 7). In 2018, soybeans seeded at the CLC on May 23 yielded around 10-40 bu/ac, due to a difficult end to the growing season. These yields indicate that newer varieties of soybeans could be grown successfully in the region. Incorporating soybeans into crop rotations could benefit local producers by providing opportunities for good control of grassy weeds for a subsequent cereal crop, less fertilizer inputs and low disease levels.

Due to local climatic conditions, the shorter season varieties' will likely still experience yield losses due to frost in the late summer/early fall. The magnitude of the effects of fall frost on soybean crops decreases with the crop's increasing maturity. A previous study predicted yield losses of 65% due to frost when soybeans are at the beginning seed (R5) growth stage, 37% at full seed (R6), 11% at beginning maturity (R7), and 0% if at full maturity (Saliba, et al., 1996).

The CLC's 2017 and 2018 soybean demonstrations both experienced a fall frost at the R6 stage. Saliba et al.'s (1996) findings indicate that yields could have been reduced by around 37%. Yield losses due to late summer or fall frosts can be prevented by seeding soybean crops early, although the risk of the crops experiencing a spring frost increases. Seeding soybeans earlier can be achieved by tillage prior to seeding, which blackens the soil and thus increases soil temperature in the spring.

Soybean crops are most susceptible to spring frost injury between the cotyledon and unifoliate leaf stage. When seeded into fields with heavy residue, the residue may impede the transfer of heat from soil to plant. After emergence and prior to the cotyledon stage, soybeans are more tolerant to frost and temperatures as low as 2.8°C for up to a few hours. If at the cotyledon stage, soybeans that have experienced frost damage can leaf out again in 3-5 days. Soybeans also have the ability to compensate for gaps in the plant stand, meaning reseeding may not be necessary if scattered plants are lost (Manitoba Agriculture, 2019). This high phenotypic plasticity indicates that earlier seeding dates may not be as detrimental as previously thought.

References :

Saliba, et al. Crop Sci. 22 :73-78
Manitoba Agriculture. Agriculture Spring Frost Damage. Retrieved June 6, 2019 from https://www.gov.mb.ca/agriculture/crops/production/print,spring-frost-damagebulletin.html

Methodology and Results

9. Methodology:

This trial was set up as a randomized complete block design with 4 replicates. The seeding date treatments were in blocks to facilitate seeding, but varieties were randomized within those blocks. Five different soybean varieties were chosen with a varying range of maturity and other characteristics. Replicates 2 and 4 were tilled and replicates 1 and 3 were direct seeded into canola stubble. The treatment list can be found in Table 2. The three seeding dates were spread over three weeks with the first being May 13, 2020 and the final date of June 3, 2020. Spring seeding was slightly delayed by the presence of snow on the ground in early May.

Table 1. Location of soybean seeding date and variety trial and additional information.

Legal Land Location	SE-20-46-26-W2 RM 461
Coordinates of Corners	N53°01.521' W105°45.790' N53°01.542' W105°45.784' N53°01.524' W105°45.813' N53°01.542' W105°45.811'
Soil Type	Clay loam
Soil Zone	Black

Table 2. Treatments applied in the "Demonstration of Soybean Varieties and Seeding Date for Observation in the Region"

Trt #	Seeding Date	Soybean Varieties	Soybean Varieties
1	May 13, 2020	1	NSC Newton
2	May 13, 2020	2	NSC Leroy
3	May 13, 2020	3	NSC Watson
4	May 13, 2020	4	NSC Redvers
5	May 13, 2020	5	NSC Wynyard
6	May 23, 2020	1	NSC Newton
7	May 23, 2020	2	NSC Leroy
8	May 23, 2020	3	NSC Watson
9	May 23, 2020	4	NSC Redvers
10	May 23, 2020	5	NSC Wynyard
11	June 3, 2020	1	NSC Newton
12	June 3, 2020	2	NSC Leroy
13	June 3, 2020	3	NSC Watson
14	June 3, 2020	4	NSC Redvers
15	June 3, 2020	5	NSC Wynyard

Each plot was 2 m by 7 m with the exception of the first replicate, which was 2 m by 5 m due to a mistake when trimming the plots. The soybeans were seeded into canola stubble around 2 inches deep using a Fabro Plot seeder with 10-inch row spacing. Prior to seeding, the soybeans were inoculated with Cell Tech West Granular. Based on spring soil test results, phosphorous was mid row banded at 48 lbs/ac. Due to an error in seeding, phosphorus was seed placed in the mid-May treatments (treatments 6-10), which may have resulted in seed damage. Soil temperatures for each replicate were measured at each seeding date and for a few weeks post-seeding. No pre-emergent herbicide was applied, but Basagran and Centurion were used as post-emergent herbicides in mid-June. Plots were staged and scouted for pests and diseases weekly. Spring plant densities were completed by counting two 1-meter sections from each plot on July 9, 2020. Plant heights were also collected prior to harvest. No harvest aids were used and entire plots were harvested on September 29, 2020 using a Wintersteiger plot combine. Yields were measured based on the weights collected by the Wintersteiger plot combine. The Manitoba Pulse Soybean Growers Soybean staging guide was used to determine the growth stage of each plot. Each plot's mean growth stage was recorded on September 8, 2020, prior to the first fall frost.

Data was analyzed by ANOVA using IBM SPSS software. Any non-parametric data was analyzed using the Kruskal-Wallis test.

10. Results

Weather

The spring and summer at the CLC saw good precipitation compared to past years (Table 3). 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 soybean growth. The coldest spring frost occurred on May 15th (-4.5°C), and the latest spring frost occurred on May 16th (-0.3°C). Spring frost likely did not impact soybeans in this trial, as the latest frost occurred only 3 days after the first seeding date, before seedlings had emerged. The first fall frost occurred earlier than normal on September 8 (-3.6°C), which was cold enough to cause considerable damage to soybean plants. Another hard frost occurred on September 16 (-5.3˚C), likely causing further damage to the soybeans and impacting yield. Precipitation was lower in the fall months relative to the 2019 growing season.

Table 3. 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 levels were medium, and P levels were very low (Table 4). Sulfur levels were high with 78 lb/ac available in the top 15 cm.

Table 4. 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	19	4	310	78	1.34	4.9	6.5	0.42
15 – 45	22			77			6.7	0.29
0 – 45	41							

Soil temperatures were consistently higher in the rototilled replicates (2 and 4) than in the non-rototilled replicates (1 and 3) (Table 5). However, temperature in the different replicates on the same day seldom varied by more than a few degrees. Soil temperatures in all replicates were highest post mid-May seeding date and at the late seeding date and then were slightly cooler post late-May seeding.

Table 5. Mean soil temperature of each replicate on and after each seeding date.

Date	Timing	Rep 1 (°C)	Rep 2 (°C)	Rep 3 (°C)	Rep 4 (°C)
		Stubble	Rototilled	Stubble	Rototilled
May 13	At Early Seeding	12.4	14.1	11.7	17.4
May 14	Post Early Seeding	13.3	13.76	13.36	14.92
May 19	Post Early Seeding	13.26	14.28	13.12	15.14
May 22	Post Early Seeding	13.04	13.82	13.02	14.2
May 23	At Mid Seeding	13.7	14.8	14.6	16.3
May 27	Post Mid Seeding	12.36	12.56	12.28	12.58
June 1	Post Mid Seeding	17.96	21.02	18.34	20.84
June 3	At Late Seeding	15.6	17.9	16	17.4
June 5	Post Late Seeding	13.68	13.72	13.58	14.48
June 8	Post Late Seeding	12.44	12.7	12.46	13.28
June 10	Post Late Seeding	14.44	16.06	14.98	16.56
June 12	Post Late Seeding	15.68	16.7	15.74	18.08
June 15	Post Late Seeding	15.58	16.44	15.78	16.52
June 18	Post Late Seeding	13.14	13.66	13.36	13.52

The late-May seeding date of NSC Newton had a significantly higher plant density than several other treatments according to a multivariate ANOVA ($F(14,39)=2.711$, $p=0.007$) (Table 6). The mid-May seeding dates of NSC Leroy and NSC Wynyard, and the late-May seeding date of NSC Wynyard all had significantly lower plant density than the late-May NSC Newton treatment.

The mid-May seeding date of NSC Newton had the tallest mean plant height (Table 6). Plants in this treatment were significantly taller than in treatments 2, 4, 9, 12, 14, and 15, according to multivariate ANOVA ($F(14,39)=5.045$, $p<0.005$) (Table 6). Treatments in the late-May seeding date tended to be shorter than in the other seeding dates. Plants in all treatments were much shorter than expected, likely due to cool spring temperatures slowing growth and deer grazing pressure.

Overall, yield was below the average 25-30 bu/ac typical for the province. Yield was highest in the early-May NSC Watson treatment at 25.73 bu/ac, significantly higher than the mid-May and late-May NSC Newton treatments, and mid-May and late-May Redvers treatments (Table 6). All other treatments were not statistically different from each other. Yield may have been impacted by an early fall frost on September 8.

There were significant differences in mean growth stages recorded on September 8 across treatments (Table 6). The mid-May treatment of NSC Wynyard was the furthest along with a mean growth stage of R6.75, meaning it was almost beginning maturity. According to research by Saliba, et al. (1996), this puts yield losses of mid-May NSC Wynyard somewhere between 11-37%. The lowest mean growth stage occurred in the late-May NSC Newton treatment which was at R5.25 and was significantly lower than mid-May NSC Wynyard. Yield losses for this treatment were likely around 65%, since the treatment was just beginning to mature (Saliba, et al., 1996). The majority of plots were around R6 at the first fall frost, meaning yield losses overall were likely around 37% (Saliba, et al., 1996).

In both the mid- and late-May treatments, NSC Leroy observably had the highest yield of all the tested varieties (Table 6). In the early-May treatment, NSC Watson was the highest-yielding variety. NSC Redvers was the lowest-yielding variety in both early- and mid-May seeded treatments, and the second lowest-yielding in the late-May seeded treatments. On the day of the first fall frost, the late-May treatments of NSC Newton and NSC Redvers had the lowest mean growth stages of all treatments, which resulted in the lowest yields of all treatments.

Table 6. Summary of statistical analysis and means of main effects investigating soybean variety and seeding date.

	Treatment		**Mean Plant Density**	**Mean Height**	**Mean Yield at 14.5% moisture**	**Mean Growth Stage on Sep 8**
	Seeding Date	Variety	plants/m^2	m	bu/ac	
1	Early-May	NSC Newton	37.50 AB	73.00 AB	18.30 ABC	5.75 ABC
2	Early-May	NSC Leroy	38.00 AB	60.25 BC	19.47 ABC	6.63 A
3	Early-May	NSC Watson	44.00 AB	63.25 ABC	25.73 A	6.38 AB
4	Early-May	NSC Redvers	35.50 AB	58.25 C	18.15 ABC	6.00 ABC
5	Early-May	NSC Wynyard	36.00 AB	61.13 ABC	24.03 AB	6.63 A
6	Mid-May	NSC Newton	38.00 AB	74.38 A	13.22 C	5.75 ABC
7	Mid-May	NSC Leroy	26.00 B	66.13 ABC	18.09 ABC	6.63 A
8	Mid-May	NSC Watson	31.50 AB	64.13 ABC	16.94 ABC	6.50 A
9	Mid-May	NSC Redvers	32.00 AB	58.13 C	12.14 C	5.75 ABC
10	Mid-May	NSC Wynyard	24.00 B	63.50 ABC	16.88 ABC	6.75 A
11	Late-May	NSC Newton	55.50 A	65.50 ABC	9.25 C	5.25 C
12	Late-May	NSC Leroy	40.50 AB	55.50 C	16.70 ABC	5.75 ABC
13	Late-May	NSC Watson	40.67 AB	67.00 ABC	13.55 BC	5.67 ABC
14	Late-May	NSC Redvers	36.67 AB	57.33 C	8.55 C	5.33 BC
15	Late-May	NSC Wynyard	30.67 B	55.83 C	14.58 ABC	5.67 ABC
		p-value	0.007	<0.001	<0.001	<0.001

Values with the same letter are not statistically different (P<0.05).

As was expected, the earlier seeded treatments matured more quickly than the late-seeded treatments. The early-May and mid-May seeding dates had a lower proportion of green plots when surveyed in the fall compared to the late-May seeding date (Table 7).

Across all seeding dates, certain varieties matured more quickly than others (Table 7). NSC Wynyard matured more quickly than other treatments. When scouted on September 8, 75% of NSC Wynyard plots were yellow. In contrast, only 17% of NSC Newton plots were yellow on September 8.

Table 7. Maturity of soybean plots by seeding date and variety observed on September 8th (prior to first frost).

Seeding Date / Variety	% Plots Green on Sep 8
Early-May	35
Mid-May	40
Late-May	90
NSC Leroy	42
NSC Newton	83
NSC Redvers	75
NSC Watson	50
NSC Wynyard	25

Mean plant density was highest in the late-May seeding date at around 42 plants/m^2, though not significantly different than in the early-May seeding date at around 38 plants/m^2 (Table 8). The higher plant density in the later seeding date may be because the soil was warmer, thus plants were able to emerge better and grow more quickly than the soybeans planted into colder soil in early and mid May. Plant density was significantly lower in the mid-May seeding date at 30 plants/m^2, according to a multivariate ANOVA ($F(3,54)=199.587$, $p<0.005$). This was likely due to seed damage caused by accidentally seed-row placing the phosphorus in the mid-May treatments.

Mean plant height was similar in the early- and mid-May seeding treatments, and lowest in the late-May treatment (Table 8). This difference was not statistically significant.

Mean yield was highest in the early-May treatment at 21.14 bu/ac, which is still lower than the average for the province of 25-30 bu/ac identified by the Saskatchewan Pulse Growers (Table

8). Mean yield in the early-May treatment was significantly higher than in the other seeding dates according to Kruskal-Wallis H-test (F(2)=14.259, p=0.001). Mean yield was similar across the mid- and late-May seeding dates. These results indicate that seeding soybeans early in the spring may be benefical.

Table 8. Summary of means for soybeans by seeding date.

Seeding Timing	Mean Plant Density	Mean Height	Mean Yield
	plants/m^2	m	bu/ac
Early	38.2 AB	63.18	21.14 A
Mid	30.3 B	65.25	15.45 B
Late	41.65 A	60.26	13.08 B
p-value	<0.005	0.230	0.001

Values with the same letter are not statistically different (P<0.05).

Plant density was lowest in the rototilled replicates (Table 9). Replicates 2 and 4 had significantly lower plant density than replicate 1 according to a multivariate ANOVA (F(3,39)=7.235, p=0.001), but this difference was not significant with replicate 3. Lower plant densities in rototilled treatments could be due to increased competition of seedlings with weeds due to the lack of stubble suppressing weed growth.

Mean plant height was significantly higher in the first two replicates, according to multivariate ANOVA (F(3,39)=25.897, p<0.005) (Table 9). Plants in the 4th replicate were significantly shorter than plants in any other replicate. In this case, the difference in plant height between replicates is likely related to factors other than rototilling, such as landscape effects or wildlife grazing.

Replicates 1 and 2 yielded significantly higher than replicate 4, according to a Kruskal-Wallis H-test (F(3)=8.749, p=0.033) (Table 9). Once again, this difference is likely not due to rototilling and may have been caused by wildlife grazing. It was noted that wildlife seemed to favor grazing the fourth replicate.

Replicate 3 had a significantly higher mean growth stage than replicates 1 and 2, according to a Kruskal-Wallis H-test (F(3)=10.838, p=0.013) (Table 9). Replicate 4 was not significantly different from the other replicates. There are likely factors other than rototilling influencing these results.

The trial was located on a slight slope and replicates 3 and 4 were at the highest point of the slope. This may have negatively impacted these replications and resulted in poor results for plant density, height, yield and growth stage for these treatments (Table 9). The more northern replicates (3 and 4) were also closer to a stubborn patch of field horsetail, which may have resulted in more weed pressure in those replicates.

Table 9. Summary of means for soybeans by replicate.

Replicate	Rototilled?	Mean Plant Density	Mean Height	Mean Yield at 14.5% moisture	Mean Growth Stage
		plants/m^2	m	bu/ac	
1	No	44.13 A	66.87 A	18.69 A	5.8 B
2	Yes	31.33 B	69.00 A	19.84 A	5.8 B
3	No	39.38 AB	53.73 B	14.04 AB	6.5 A
4	Yes	31.00 B	61.18 C	13.85 B	6.3 AB
	p-value	0.001	<0.005	0.033	0.013

Values with the same letter are not statistically different (P<0.05).

References :

Saliba, et al. Crop Sci. 22 :73-78

11. Conclusions and Recommendations

Overall, the early-May seeding date yielded significantly higher than the other seeding dates (Table 6). The mid-May seeding date may have been negatively impacted by accidentally seed-row banding the phosphorus fertilizer. Had the phosphorus been side-banded as intended, the mid-May treatments may have performed better. The late-May treatments were generally shorter and yielded lower than the other treatments, likely due to an early fall frost on September 8.

In two of the three seeding dates, NSC Leroy was the highest yielding variety (Table 6). NSC Watson produced the best yields in the early seeding date. NSC Wynyard produced relatively good yields in all seeding dates, despite having some of the lowest plant density in all treatments. This would indicate that NSC Wynyard is a variety that is able to compensate fairly well for spring stressors. NSC Redvers and NSC Newton were the lowest yielding varieties across all seeding dates.

Rototilling did not seem to have large impacts on soybean growth or production (Table 9). Rototilling the soil may have negatively impacted soybeans by providing more opportunities for weed competition. Reproducing the trial with the use of a pre-emergent herbicide may produce better results. Seedlings in the rototilled replicates may also have been damaged from strong spring and early summer winds, as they were more exposed to the elements than seedlings in the other replicates that were protected by stubble.

Differences between treatments may have been more pronounced if there had been more variation in temperature between the seeding dates. Spring growth was slow due to cool temperatures, which minimized the impact of seeding date on production. Additionally, yield in some plots was impacted by deer grazing. Installing deer fence around the trial early in the season may have prevented this.

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. The CLC also thanks a local producer for providing some of the inputs that were used.

13. Abstract:

This trial aimed to demonstrate soybean varieties to local producers, examine the benefits of using tillage to allow earlier spring seeding of soybeans, and explore the effects of spring frost on the crop. Five soybean varieties were seeded: NSC Newton, NSC Leroy, NSC Watson, NSC Redvers, and NSC Wynyard. Two replicates were rototilled prior to seeding and two were direct seeded into canola stubble. Three separate blocks were seeded on: May 13 (Early), May 23 (Mid), and June 3 (Late). Overall, yield was lower than expected. This was likely due to cool spring temperatures slowing growth, deer grazing and an early September frost. The latest spring frost occurred before soybeans of any seeding date had emerged, and likely had no effect on yield. NSC Watson was the highest yielding variety in the early seeding block, and NSC Leroy was the highest yielding variety in the mid- and late-seeded blocks. NSC Redvers and NSC Newton were the lowest yielding varieties overall. Rototilling replicates did increase soil temperature, but typically not by more than a few degrees compared to the no-till replicates. Tillage did not seem to benefit soybean production but did have a significant negative impact on plant density. This could be due to increased weed competition and/or exposure in rototilled replicates. The early-seeded soybeans had significantly higher yield than the later seeded blocks. Phosphorus was accidentally seed-row placed in the mid-seeding block, which likely contributed to low plant densities and poor yields for this seeding date. Soybeans in the late-seeded block were shorter and yielded lower than soybeans in the other seeding dates. 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.