

Project Identification

Project Title: Alternative cover crop options for establishing Forage Legumes for seed production

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Producer Group Sponsoring the Project: Northeast Agriculture Research Foundation

Project Location(s): RM of Star City no. 428 SE 31-44-18 W2

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Objectives and Rationale:

Project Objectives: To demonstrate the differences in using a cover crop versus no cover in order to establish forage legumes for seed production; Secondly, to illustrate the differences in using a cover crop with a closed canopy versus an open canopy.

Project Rationale: Forage legumes are an alternative cropping option that may be used to extend cropping rotations. However, forage legumes take two growing seasons to produce harvestable seed and thus most producers do not consider growing forages for seed, as they do not want to forgo a year without harvestable income. Therefore, growing forage legumes with a cash crop, such as canola or wheat allows producers to establish the forage crop, while producing a harvestable income in year 1. Canola is a common option as a cash crop as it provides good weed control, however it has a closed crop canopy and thus limits sun exposure to the growing forage crop beneath. Additionally, genetic modifications of canola have caused EU export concerns, where the majority of clover seed is sold. Therefore, other cash crop options are needed as canola is no longer sustainable.

There are many alternative options to canola as potential cash crop options for cover cropping with forage legumes in the year of establishment, such as legumes and cereals. Like canola, legume crops are very competitive for space with the developing forage legume, however it provides a more open canopy for better light penetration than canola. Commonly grown pulse crop options in the northeast growing region are faba bean and field peas. Faba beans provide a more open canopy whereas peas have a more closed canopy, which is more likely to block light from the establishing forage crop. Furthermore, faba beans are more suited to wet conditions and peas develop better under less moisture than faba beans, which provides diverse cover crop options depending on the year and anticipated growing conditions. Cereals can also be competitive for space, but their plant architecture provides an inevitably more open canopy. Oats can be a great cover crop option, as they are a commonly grown cereal crop in the northeast and are well adapted into cropping rotations in this region. Additionally, weed control options are limited when growing a cover crop; Therefore, differences in the competitiveness of the various cover crops may be a very important aspect for weed control. Of these different cover cropping options little investigation has been completed to compare how these different options can be grown with a forage legume, and which option is the best for overall profitability. This demonstration was set-up to evaluate which cover cropping option was the best suited for establishing a forage legume crop by comparing oats, faba bean, and field peas as cover crop options with alsike clover and red clover.

Methodology and Results

Methodology: This small plot demonstration was located at SE 31-44-18 W2 in the RM of Star City, near Melfort, SK. The demonstration was set up as a randomized complete block design with 4 replicates. Treatments varied based on red clover or alsike clover as the forage legume and oats, faba bean or green peas as the cover crop. These factors were combined to generate 8 treatments (**Table 1**).

Table 1: Treatments used in Alternative cover crop options for establishing forage legumes for seed productions in Melfort, SK 2020 & 2021.

Treatment #	Legume crop	Cover Crop
1	Red Clover	Oats
2	Alsike Clover	Oats
3	Red Clover	Faba bean
4	Alsike Clover	Faba bean
5	Red Clover	Green Peas
6	Alsike Clover	Green Peas
7	Red Clover (monocrop)	None
8	Alsike Clover (monocrop)	None

Prior to seeding in 2020 the test was soil sampled for residual nutrient levels (***Table 2***). Results of the soil test were used for fertilizer recommendations. On May 29th, 2020 all plots were seeded at a 0.5-inch depth into canola stubble. Red and alsike clover were seeded in the seed row, and the cover crop was seeded in the side-band. Seeding was completed using a 6-row Fabro plot seeder on 12-inch row spacing. At Melfort plots were 2-meters wide by 7-meters long. Both the red and alsike clover were applied with a Nitragin Gold inoculant. Red clover received 189-grams/50 lbs of seed and Alsike clover received 378-grams/50 lbs of seed. Green peas and faba beans were treated with Apron Maxx at 325mL/100 kg of seed and Vibrance 500FS at 10mL/100 Kg of seed. Faba beans were inoculated with TagTeam granular at 3.7 kg/ha and green peas were inoculated with Nodulator granular at 7.3 kg/ha. Red clover was seeded at 8 lbs/ac and Alsike clover was seeded at 4 lbs/ac. All cover crops were seeded at 75% of their respective recommended seeding rates to ensure they would not out compete the clover crop. CS Camden oats were seeded at 263 viable seed/m^2, CDC Snowdrop faba beans were seeded at 34 viable seeds/m^2, and CDC Greenwater green peas were seeded at 64 viable seeds/m^2. The only fertilizer required was phosphorus applied at 17 kg/ha as 11-52-0 in the seed-row.

Table 2: Residual soil nutrient levels (0-12”) found in Alternative cover crop options for establishing forage legumes for seed production in Melfort, SK 2020.

Residual Soil Levels			
Nitrogen (lb/ac)	*Phosphorus (ppm)*	*Potassium (ppm)*	*Sulphur (lb/ac)*
54	19	477	48

The trial received crop protection products as required. The plot area was sprayed with a pre-emergent herbicide of Glyphosate 540 at 1L/ac on May 24th, 2020. No fungicide, insecticides, or desiccants were used. Lastly, all oat plots were harvested on September 16th, peas on September 14th, and faba beans on September 24th where 5 full crop rows were collected using a plot combine. In year 2, no herbicide, fungicide, or insecticide were applied. All plots were desiccated with Reglone at 1.09 L/acre in 200 L H_2O/acre on August 9, 2021. All plots were then harvested for forage seed on August 31, 2021.

To assess treatment differences data collection consisted of plant density and yield in year 1. In year 2 plant density, weed density, seed yield, and economics were analyzed. Methodology for the first and second year of data collection are described below. Both site years were analyzed individually, using Randomized Complete Block in Statistix 10.

Results:

Environmental Conditions:

In 2020, average growing season temperature was comparable to the long-term average, whereas total precipitation was 42.5mm less than the long-term average (
Table ***3***). May and June were 0.6°C and 1.6°C cooler than the long-term average whereas July and August were 1.3°C and 0.8°C warmer than the long-term average. The slightly cooler temperatures in May and June coincided with adequate to greater incidence of rainfall, particularly in June where precipitation was much greater than the long-term average. This resulted in good plant emergence following seeding as the majority of plots were seeded in late May and received the June moisture. Warmer temperatures in July followed by slightly decreased average precipitation supported good plant growth. Reduced precipitation in both August and September resulted in great harvesting conditions of the cover crops.

The environmental conditions of 2021 were marked by being warmer and dryer than the long-term average for several months of the growing season. The mean temperature was greater than the long-term average from June-September (
Table ***3***). The deviation from the long-term mean temperature was most pronounced in September and July when the temperature was 3.2°C and 2.6°C greater than the mean, respectively. May was the only month that was cooler than average with a monthly mean of 9.6°C relative to the long-term mean of 10.7°C (
Table ***3***). Across the growing season, Melfort received 55% of the long-term average for precipitation. From May-September, all months except August (16.9mm above normal) received below average precipitation. This deficit was most pronounced in July and September which received 76.5mm and 31.2mm less precipitation than the long-term average.

Table 3. Mean temperatures and precipitation collect from the Environment Canada Weather Station at Melfort SK., from May to September in 2020 & 2021.

	May	June	July	August	September	Average/Total
			--- Mean Temperature (°C) ---			
2020	10.1	14.3	18.8	17.6	10.8	14.3
2021	9.6	18.2	20.1	16.9	14.0	15.8
Long-Term[x]	10.7	15.9	17.5	16.8	10.8	14.3
			--- Total Precipitation (mm) ---			
2020	26.7	103.7	52.4	18.5	21.2	222.5
2021	31.4	37.6	0.2	69.3	7.5	146.0
Long-Term[x]	42.9	54.3	76.7	52.4	38.7	265.0

[x] Long-term climate normal from Environment Canada Weather Station located at Melfort SK., from 1981-2010

Year 1

Plant Density:

Plant densities were assessed on June 22nd where 2 1-meter crop rows were counted per plot to determine the establishment of the oat, faba bean, and green pea cover crops. Plants per meter were averaged per plot and converted into plants/m^2. Based on the analysis of variance (ANOVA) all treatments were considered highly significant (***Table 4***), which was largely attributed to average plant densities varying drastically between the cover crop options. For each cover crop, average plant densities were slightly greater when grown with alsike clover as compared to red clover. Oats increased by 5 plants/m^2, faba beans by 3 plants/m^2 and green peas by 14 plants/m^2. Regardless of these differences within cover crop treatments, plant densities were considered comparable and were only significantly different between cover crop options. However, the slight average reduction in plant densities of each cover crop when grown with red clover as opposed to alsike clover are likely attributed to red clover being more competitive than alsike in the early stages of growth, and thus the inter-plant competition was greater between the forage crop and the cover crop when grown with red clover.

Table 4: Statistical analysis and average treatment means for year one of Alternative cover crop options for establishing forage legumes for seed production in Melfort, SK 2020.

		Plant Density (plants/m^2)[y,z]	Yield (Kg/ha)[y,z]	Yield (bu/ac)[y,z]
P-value		<0.0001***	<0.0001***	<0.0001***
Grand Mean		105.0	2511.0	49.8
CV		10.10	13.80	14.58
Forage	**Cover Crop**			
Red clover	Oat	233.4a	3148.3ab	82.5ab
Alsike Clover	Oat	238.7a	3469.2a	91.0a
Red Clover	Faba bean	18.9b	1407.8c	20.7c
Alsike Clover	Faba bean	21.7b	1498.7c	22.3c
Red Clover	Green Pea	51.7c	2793.5b	41.7b
Alsike Clover	Green pea	65.6c	2748.7b	40.8b

[y]*** highly significant; [z]Values with the same letter are statistically similar

Cover Crop Grain Yield:

Yield was measured by cleaning and weighing each harvested plot sample and converting to kg/ha and bu/ac equivalents while correcting for consistent moisture. Moistures varied by cover crop from 13.5% for oats to 16.0% for faba beans and green peas. When comparing yields amongst the different cover crops there was significance between cover crops, but not within cover crop options (Table 4). Therefore, yields were considered similar for each cover crop regardless of whether it was grown with alsike clover or red clover. When comparing treatment averages oats had a 321 kg/ha yield gain and faba beans had a 91 kg/ha average yield gain when grown with alsike clover as compared to red clover. The yield differences of oat and faba bean reflect the plant density differences described previously. Conversely, green pea yield increased by 45 kg/ha when grown with red clover as compared to alsike clover. The data suggests that the large differences found in plant density of the two pea treatments is likely due to sampling error.

Year 2

Forage Plant Density:

Plant density of the forage crop in year two was measured on May 31st, 2021 by counting the number of emerged plants along two 1-meter sections of crop row using the line intercept method to derive a percent plant cover estimate. The ANOVA demonstrated that there were no differences on percent establishment based on the effects of forage species (p=0.49), cover crop species (p=0.54), or the interaction between forage and cover crop species with p=0.82 (Table 5). All treatment combinations of forage and cover crop species were statistically similar. Alsike clover with a faba bean cover crop had the highest establishment at 97.5% while alsike clover with a green pea cover crop had the lowest numerical establishment at 83.8%.

Table 5: Statistical analysis and average treatment means for year two of Alternative cover crop options for establishing forage legumes for seed production in Melfort, SK 2021.

		% Establishment		Weed Density (m^2)		Yield (Kg/ha)[y,z]		Yield (lbs/ac)[y,z]	
Forage p-value		0.48		0.003*		<0.0001***		<0.0001***	
Cover Crop p-value		0.54		0.060		0.73		0.72	
Forage*Cover Crop p-value		0.82		0.52		0.79		0.79	
Grand Mean		91.56		1.03		523.38		465.81	
CV		31.58		107.18		22.33		22.33	
Forage Species									
Alsike Clover		90.0	a	1.7	a	366.47	b	326.15	b
Red Clover		93.1	a	0.4	b	680.30	a	605.46	a
Cover Crop									
None		93.8	a	0.8	a	564.21	a	502.15	a
Oat		89.4	a	0.5	a	505.97	a	450.31	a
Faba Bean		95.6	a	0.9	a	510.91	a	454.71	a
Green Pea		87.5	a	2.0	a	512.44	a	456.07	a
Forage*Cover Crop									
Red clover	Oat	91.3	a	0.0	b	693.65	a	617.35	a
Alsike Clover	Oat	87.5	a	1.0	ab	318.28	b	283.27	b
Red Clover	Faba bean	93.8	a	0.0	b	671.24	a	597.41	a
Alsike Clover	Faba bean	97.5	a	1.8	ab	350.58	b	312.02	b
Red Clover	Green Pea	91.3	a	1.0	ab	664.01	a	590.97	a
Alsike Clover	Green pea	83.8	a	3.0	a	360.86	b	321.17	b
Red Clover		96.3	a	0.5	ab	692.29	a	616.13	a
Alsike Clover		91.3	a	1.0	ab	436.14	ab	388.16	ab

Weed Control:

Weed control was determined by counting the weed species present in $1m^2$ per plot on June 28th. Weed density was only significantly different between forage crops, and was not significantly affected by cover crop (Table 5). Overall, alsike clover had a higher weed density at an average of 1.7 weeds/m^2 as compared to red clover which had an average weed density of 0.4 weeds/m^2. Overall, weed pressure was quite low at an overall average of 1 weed/m^2. Although, there were significant treatment differences between the two forage crops, the difference of 1.3 weeds/m^2 is very small from an agronomic perspective.

Forage Seed Yield:

Forage seed yield was measured after the harvested forage seed was cleaned and dried down to the appropriate storage moisture. The ANOVA indicated that there were highly significant differences in forage seed yield based on the forage species with $p<0.001$ (Table 5). Red clover had a forage yield (680.30 kg/ha & 605.46 lbs/ac) that was significantly higher than alsike clover (366.47 kg/ha & 326.15 lbs/ac). This is the opposite rank in seed yield for these two species that is described in some forage seed production manuals that describes alsike clover having a higher average seed yield than red clover (Brett Young, 2020). However, there were no significant differences in forage seed yield based on the cover crop species used in 2020 nor the interaction between forage and cover crop species. When

looking at the interaction between forage and cover crop species, two overlapping groups of treatments could be identified. Red clover treatments consistently had a higher forage seed yield than alsike clover regardless of the cover crop species used in 2020. The only exception was alsike clover seeded alone (436.14 kg/ha & 388.16 lbs/ac) which had a forage seed yield that was statistically similar to all of the red clover treatments. Red clover had the numerically highest seed yield in the oat cover crop treatment (693.12 kg/ha) while alsike clover had the highest yield with no cover crop (435.80 kg/ha). Based on the yield difference between forage seed crops grown with a cover or in a monoculture, the seed yield of red clover was less impacted by cover crop competition than alsike clover. Red clover under cover crop had an average seed yield that was 11.97 kg/ha less than the monoculture while alsike clover seed yield was on average 92.82 kg/ha less than the monoculture when grown with a cover crop.

Economics:

The economic analysis of each treatment was conducted using resources such as the Saskatchewan Crop Planning Guide (2020 and 2021), Brett Young Seed Guide, quotes from local ag-retailers and forage seed brokers. All treatments had a positive net profit at the end of the two-year demonstration that was primarily driven by the net profit of the second year with red clover treatments having the highest profitability. Net profit in year one of the study ranged from $145.37 per hectare for the oat and alsike clover treatment to -$619.30/ha for the red clover monocrop (**Table 6**). Among the treatments with a cover crop, the faba bean and red clover had the lowest net profit at -$438.28/ha. When comparing cover crops, green pea provided the highest net profit in year one ($126.04/ha for both forage treatments) followed by oat $102.24/ha, and then faba bean (-$419.60/ha). The lower profitability of the faba beans could have been attributed to their comparatively low stand density and yield relative to the oat and green pea treatments (**Table *4***). Faba beans are bested suited to an early seeding date and their yield can be compromised with a later seeding date like the May 29th date used in this study (Saskatchewan Pulse Growers, 2022). Faba beans may also have been more impacted by inter-plant competition with the forage legume as well as the reduced seeding rate used. The influence of forage legume species on profitability was opposite in year one than in year two. In year one, alsike clover treatments had a higher grain yield for oat and faba bean which resulted in higher profitability (**Table 6**). However, red clover treatments had a higher selling price and higher forage seed yield in year two which resulted in red clover treatments having the highest profitability in year two and across the entire study period.

Across the study period, red clover was most profitable when grown with an oat cover crop ($2997.44/ha) while alsike clover was most profitable when grown with a green pea cover crop ($1,063.42/ha). Our results indicate that using oat or green pea as a cover crop when establishing forage legumes enhances the system economics when growing alsike and red clover for seed in Northeastern Saskatchewan.

Table 6: Economic analysis of the eight treatments in Alternative cover crop options for establishing forage legumes for seed production in Melfort, SK 2020 & 2021

Forage Legume	Red	Alsike	Red	Alsike	Red	Alsike	Red	Alsike
Cover Crop	Oat	Oat	Faba Bean	Faba Bean	Green Pea	Green Pea	N/A	N/A
Fixed Costs Year 1 ($/ha)	$579.04	$579.04	$582.79	$582.79	$586.18	$586.18	$567.41	$567.41
Forage Legume Seed ($/ha)	$50.51	$41.90	$50.51	$41.90	$50.51	$41.90	$50.51	$41.90
Cover Crop Seed ($/ha)	$65.62	$65.62	$105.59	$105.59	$97.09	$97.09		
Seed Treat and Inoc. ($/ha)	$1.38	$0.74	$83.74	$83.11	$124.09	$105.44	$1.38	$0.74
Total Costs Year 1 ($/ha)	$696.55	$687.30	$822.64	$813.39	$857.86	$830.60	$619.30	$610.05
Cover Crop Yield (kg/ha)	3,150.78	3,471.92	1,397.66	1,499.85	2,808.39	2,750.86		
Cover crop price ($/kg)	$0.24	$0.24	$0.28	$0.28	$0.35	$0.35		
Revenue Year 1 ($/ha)	$755.65	$832.67	$384.36	$412.46	$980.32	$960.23	$0.00	$0.00
Net Profit Year 1 ($/ha)	$59.10	$145.37	-$438.28	-$400.93	$122.45	$129.63	-$619.30	-$610.05
Fixed Costs Year 2 ($/ha)	454.4677	454.4677	454.4677	454.4677	454.4677	454.4677	454.4677	454.4677
Forage Seed Yield Year 2 (kg/ha)	693.1157	318.035	670.7285	350.3134	663.4981	360.5863	691.746	435.7978
Forage Seed Price Year 2 ($/kg)	$4.90	$3.85	$4.90	$3.85	$4.90	$3.85	$4.90	$3.85
Revenue Year 2 ($/ha)	$3,392.80	$1,224.43	$3,283.22	$1,348.71	$3,247.82	$1,388.26	$3,386.10	$1,677.82
Net Profit Year 2 ($/ha)	$2,938.33	$769.97	$2,828.75	$894.24	$2,793.36	$933.79	$2,931.63	$1,223.35
Total Costs Both Years ($/ha)	$1,151.02	$1,141.77	$1,277.10	$1,267.85	$1,312.33	$1,285.07	$1,073.76	$1,064.51
Total Revenue Both Years ($/ha)	$4,148.45	$2,057.11	$3,667.57	$1,761.17	$4,228.14	$2,348.49	$3,386.10	$1,677.82
Net Profit Both Years ($/ha)	$2,997.44	$915.34	$2,390.47	$493.31	$2,915.81	$1,063.42	$2,312.33	$613.31

Conclusions and Recommendations:

All cover crop options established and yielded as expected in year 1 when grown with a forage legume. Oats, faba beans, and green peas all had greater average plant densities when grown with alsike clover as compared to red clover. This resulted in higher profitability in year 1 when cover crops were grown with alsike clover versus red clover. This was anticipated as red clover is known to be more competitive than alsike clover. Even though average plant densities were slightly reduced for all cover crops when grown with red clover, there was no significance between forage legume crops for plant establishment within each cover crop option. Additionally, faba beans and oats had slightly higher average yields when grown with alsike clover, which may be partially attributed to better plant stands as compared to when they were grown with red clover. Green peas also had reduced plant stands when grown with red clover, but had greater average yields than when grown with alsike clover. This different outcome with green pea final yields may suggest that a sampling error occurred. Faba beans had significantly lower yields in year 1, which resulted in reduced profitability as compared to pea and oat.

In year two, no differences were observed in the rate of forage establishment between treatments. Alsike clover treatments had a significantly higher weed density which could also be linked to the difference in its competitive ability compared to red clover that was described previously. The seed yield of alsike clover was more negatively affected by the presence of a cover crop in the previous year when compared to red clover. While all treatments had a positive net profit in year two, the higher seed yield and commodity price of red clover treatments resulted in a higher net profit when compared to alsike clover treatments. Our results indicate that growing a cover crop when establishing forage legumes for seed in Northeastern Saskatchewan improves system profitability with minimal loss in productivity. For the period of this study, red clover provided greater yield, profitability, and competitiveness to other plants when compared to alsike clover. Oat and green pea were suitable cover crops in year one, whereas faba beans were less suited due to lower seed yields. These two cover crops provided a positive net profit in year one and increased overall profit for the two-year period for both forage legume species.

Extension Activities

No extension activities have highlighted this project at this point in time. The final project report will be shared on neag.ca, and will also be passed on to the Saskatchewan Forage Seed Development Commission.

Supporting Information

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Works Cited:

Brett Young. 2020. Clover *in* 2020 Seed Production Guide. [Online]. Available: https://www.brettyoung.ca/sites/default/files/atoms/files/SEED%20PRODUCTION%20GUIDE%202020.pdf [February 1, 2022].

Saskatchewan Pulse Growers. 2022. Seeding: Growing Faba Beans. [Online]. Available: https://saskpulse.com/growing-pulses/faba-beans/seeding/#:~:text=Faba%20beans%20should%20be%20grown,drought%20stress%20in%20early%20summer. [February, 2022].

Abstract

Abstract/Summary:

Integrating forage legumes into crop rotations can allow producers to diversify crop rotations; however, their uptake in crop rotations in Northeastern Saskatchewan has been low because they require an establishment year before providing a marketable product. Cover crops provide an option to produce harvestable seed in the year of establishment and increase profitability in the 1st season. Cover crops, such as canola and wheat have been investigated previously, however other grain crops that are common to the Northeast region have not been, such as pea, oat, and faba bean. To demonstrate the effect of various cover crop options grown with forage legumes, a small plot demonstration was set-up near Melfort, SK to evaluate the plant establishment, weed control, cover crop yields, forage legume yields, and economics of this system. The cover crop options used were oats, faba beans, and green peas, with the forage legume crops being red clover and alsike clover. In the first year, cover crop plant establishment and seed yields were not significantly different between alsike and red clover. In year 2, forage legume establishment was greater for red clover as compared to alsike, but was not affected by the use of a cover crop. Weed control was also not affected by the use of a cover crop. Lastly, forage yields in year two were greater for red clover as compared to alsike, however there was no significant effect of the different cover crops used as compared to the red and alsike monocrops. Overall, all cover crop alternatives were more economical as compared to growing both forage crops as a monocrop, with the exception of faba beans as a cover crop with alsike clover.

Finances

Budget Report

See attached excel spreadsheet