AWC-DUC Winter Wheat Agri-Science Project 2016 Activity 2 Update

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Despite the challenges of getting this project initiated, we have now completed our second field season of the winter wheat project. Although, preliminary, activities are starting to report some interesting results. The following is a brief update of the project.

Human Resources.

The retirements of Dr. Byron Irvine from AAFC-Brandon and Mr. Eric Johnson from AAFC-Scott have created some variances. Dr. Ramona Mohr has stepped in to assume all of the Brandon activities and the transition has been seamless. Projects and manuscripts that Mr. Johnson oversaw have been delayed as a replacement has not been hired. We anticipate that the manuscripts will be completed by the end of 2017.

Update on Sub-Activities.

Sub-activity 2.1

Winter annual control through alternative pre and post-seed weed management Sub-Sub activity 2.1.1 using pre-seed herbicide applications.

Principal Investigator: Linda Hall, University of Alberta

Collaborators: Lethbridge - Brian Beres and Steven Simmill, Agriculture and AgriFood Canada

Melita – Scott Chalmers, Manitoba Agriculture

St. Albert and Edmonton –Keith Topinka, University of Alberta.

Winter wheat field trials examining herbicide options for winter annual weed control were conducted at 4 to 5 locations during the 2015 and 2016 field seasons. Weeds were at low levels during the fall at all locations, but were more prevalent the following spring. Adequate winter wheat survival at all locations allowed the research to continue through to harvest. Testing is continuing in 2016/17.

This trial was conducted at Edmonton, St Albert, Lethbridge and Melita in 2015/16. Five herbicide combinations were applied in-crop in winter wheat and compared to unsprayed checks (Table 1). Each herbicide combination was tested with a 100 g ai ha^{-1} and a 150 g ai ha^{-1} pyroxasulfone rate, thus totaling 10 herbicide combinations/rate treatments in a 5 x 2 factorial design. All treatments were applied in September 2015 just prior to seeding the winter wheat.

Data including fall and spring crop counts, herbicide efficacy and crop tolerance, crop and weed biomass, and seed yield were collected. More detailed statistical analyses will be conducted on this data.

Fall crop density was similar for almost all treatments at all locations. The exception was a 14% reduction of treatment 3, recorded 2 WAE.

Spring plant density trends differed by location. Herbicide treatments did not decrease density lower than the checks at Edmonton, Melita and Lethbridge. At St. Albert, treatments 8 and 12 were 34 and 31% lower in plant stand than the unsprayed check in the spring.

Crop tolerance to all herbicides was excellent in the fall and spring ratings of both tested locations Edmonton and St. Albert.

Herbicide efficacy 2 weeks after application (2WAA) was rated only at Edmonton due to lack of weeds at St. Albert. Treatments 5 and 11 provided weed control over 80%, while treatments 7, 9, 10 and 12 provided suppression between 63 and 75%.

Table 1. Herbicide treatments for pre-seed annual weed control trial.

Treatment number	Herbicide	Trade name	Formulation concentration	Rate (g ai/ha)
1	Untreated control			
2	Untreated control			
3	pyroxasulfone	Pyroxasulfone	85% WG	100
4	pyroxasulfone	Pyroxasulfone	85% WG	150
5	pyroxasulfone + carfentrazone + glyphosate	Pyroxasulfone/ Aim/ glyphosate	85% WG + 240 g/L + 356 g/L	100 + 9 + 440
6	pyroxasulfone + carfentrazone+ glyphosate	Pyroxasulfone/ Aim/ glyphosate	85% WG + 240 g/L + 356 g/L	150 + 9 + 440
7	pyroxasulfone + glyphosate	Pyroxasulfone/ glyphosate	85% WG + 540 g/L	100 + 440
8	pyroxasulfone + glyphosate	Pyroxasulfone / glyphosate	85% WG + 540 g/L	150 + 440
9	pyroxasulfone + flumioxazin	Pyroxasulfone/ Valterra	85% WG + 51% WG	100 + 107
10	pyroxasulfone + flumioxazin	Pyroxasulfone / Valterra	85% WG + 51% WG	150 + 107
11	pyroxasulfone + saflufenacil + glyphosate	Pyroxasulfone/ Heat/ glyphosate	85% WG + 70% WG + 540 g/L	100 + 50 + 440
12	pyroxasulfone + saflufenacil + glyphosate	Pyroxasulfone / Heat/ glyphosate	85% WG + 70% WG + 540 g/L	150 + 50 + 440

In the following spring, all treatments at St. Albert provided efficacy of 60% or better, and treatments 11 and 12 (Pyroxasulfone / Heat/ glyphosate) had control over 90%. Similarly, at Edmonton all treatments except 3 had efficacy of 60% or better, and treatments 10, 11 and 12 had control over 90%. A higher rate of Pyroxasulfone did not significantly increase control in any of the five low vs high rate comparisons at St. Albert, but it did improve control of 2 treatments (4 and 10) at Edmonton.

Crop biomass in herbicide treatments was similar to the unsprayed checks at all locations. Exceptions were a reduction for treatment 8 at St. Albert, and an increase in crop biomass in treatment 5 at Lethbridge.

Weed biomass at winter wheat anthesis was much smaller than the crop biomass, ranging from 5% (Lethbridge) to 0.3% (Melita). Hence, the weeds were not too competitive with the crop, and thus weed biomass did not correlate closely with crop biomass. There were no differences between the herbicide and unsprayed treatments at Lethbridge. At the other three locations, treatments 7, 9 and 12 always had a lower weed biomass than the checks, while 4, 5, 6, 8, 10 and 11 had a lower weed biomass two of three times. In summary, the herbicides were beneficial at decreasing the weedy biomass in 22 of the 40 herbicide treatments across all locations, and no treatments decreased the weedy biomass at all locations. Greater weed competition may have increased the differences between effective and non-effective herbicides in crop and weed biomass, and seed yield.

Herbicide treatments never reduced crop seed yields compared to the unsprayed check (Figure 1). The effect of pre-seed treatments on crop yield varied by location. The following treatments had yields higher than the unsprayed checks at two of four locations: 5, 6, 7, and 9, while treatments 3, 4, and 12 had higher yields at one location. Thus the Pyroxasulfone / Aim/ glyphosate mixture most consistently increased yield. Treatments with a low rate of Pyroxasulfone were more prevalent in the higher yield treatments than the high Pyroxasulfone rate. Of those 11 higher yielding treatments, 7 contained the low pyroxasulfone rate, compared with only 4 of the 11 instances which had a high Pyroxasulfone rate.

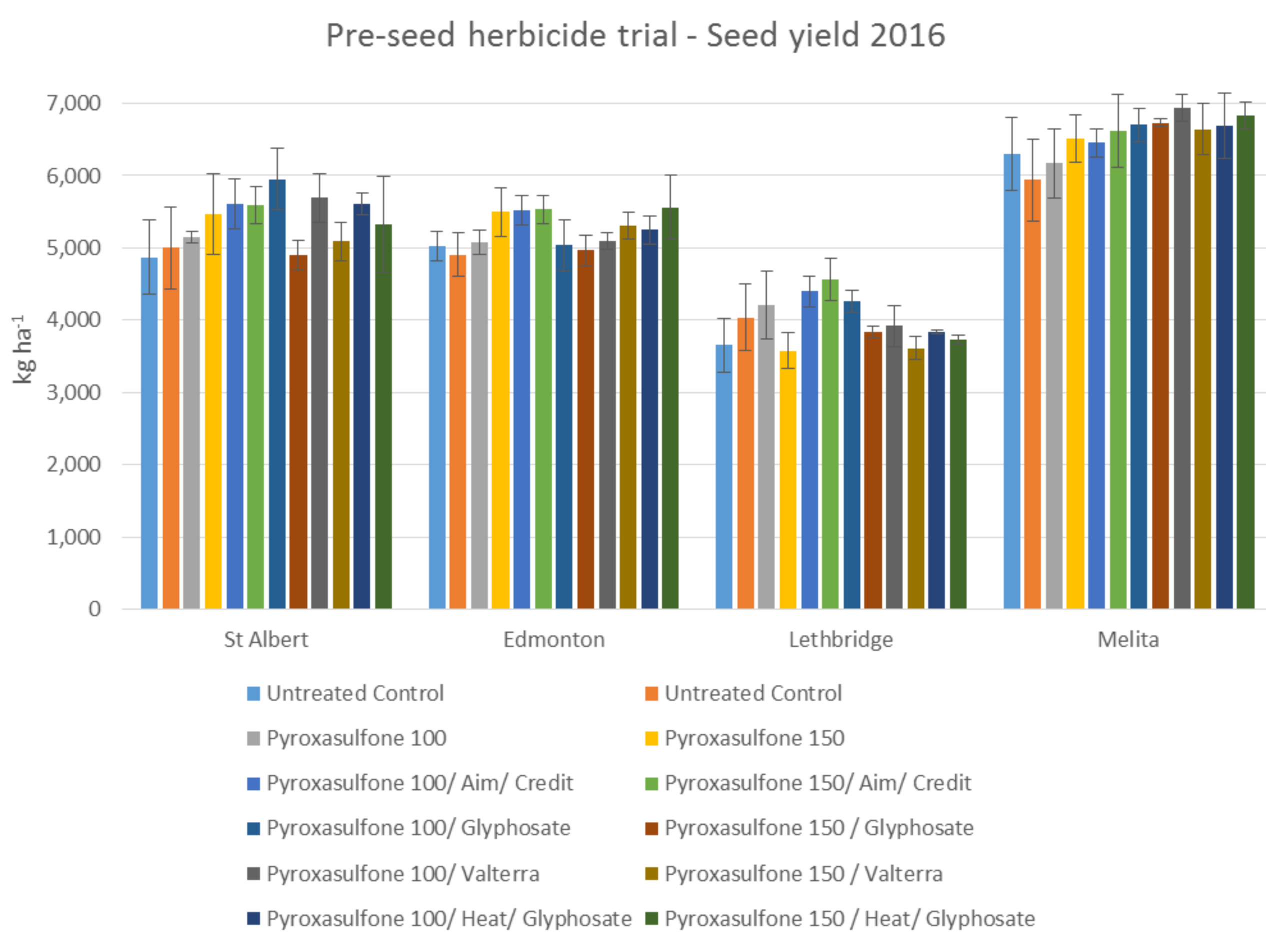

Figure 1. Seed yield of pre-seed herbicide trial in winter wheat at 4 locations in Western Canada 2015-16. Means and standard errors are shown.

Sub-activity 2.1 Winter annual control through alternative pre and post-seed weed management
Sub-Sub activity 2.1.2 using in-crop herbicide applications

This trial was conducted at Edmonton, St Albert, Lethbridge and Melita in 2015/16. Five herbicide combinations were applied in-crop in winter wheat and compared to an unsprayed check (Table 2). One treatment, Frontline XL was applied in the fall, and the others were applied in the spring.

Data including fall and spring crop counts, herbicide efficacy and crop tolerance, crop and weed biomass, and seed yield were collected. More detailed statistical analyses will be conducted on this data.

Fall crop density was generally similar to the check or within variation typical for emergence. Spring crop densities were generally equivalent to the unsprayed, check, and mirrored the fall densities. The fall applied Frontline XL treatment did not have a reduced spring density compared to the unsprayed check.

Crop damage was not observed in any of the fall or spring applied treatments 1 and 2 weeks after application, or in the spring for the fall applied Frontline XL.

Herbicide efficacy data collection at St. Albert and Edmonton started 1 week after fall application (1WAA) of Frontline XL. At that time it provided only 15% control of weeds, however, the following spring it controlled 96% of weeds.

Spring applications of Paradigm/Simplicity and Infinity gave 80% or greater weed control 2 WAA at both St. Albert and Edmonton. Pixxaro A/B also gave 80% control at Edmonton. All other herbicides at both locations suppressed weed growth 60-79%.

Herbicide treated plots generally had similar biomass weights as the unsprayed checks. Only Edmonton had increases of 22, 16 and 21% following Frontline XL, Pixxaro A/B and Refine SG/MCPA applications.

Weed biomass was relatively low at all locations, ranging from 0.2 to 2.7% of crop biomass. Thus, though treatment responses varied by location, they would not have a major effect on the crop. At St. Albert, all herbicide treatments removed over 90% of the weed biomass, compared with the unsprayed check. Edmonton herbicide treatments had only 1% of the unsprayed check's biomass, except for the Infinity treatment (58%). At Lethbridge, only Paradigm/Simplicity reduced weed biomass (42% of unsprayed). Melita's weed biomass was low, averaging only 0.2% of the crop biomass, and thus an increase in the Frontline XL treatment weights is not a concern.

Seed yields were good at all locations, averaging from 3.8 to 6.8 t ha^{-1} (Figure 2). In crop herbicide treatments resulted in wheat seed yields equal to, and occasionally greater than the unsprayed checks at the 4 trial locations. No herbicide treatment was consistently better.

Table 2. Herbicide treatments for in-crop annual weed control trial.

Herbicide	Trade name	Formulation concentration	Application timing	Rate (g ai/ha)
Untreated control				
Florasulam + MCPA ester	Frontline XL	4 g/L + 280 g/L	3-4L in fall	355
Halauxifen-methyl /florasulam + pyroxsulam + MCPA ester	Paradigm + Simplicity + MPCA ester	400 g/kg + 30 g/L + 500 g/L	Spring; tillering	10 + 15 + 280
Halauxifen-methyl/fluroxypyr + MCPA ester	Pixxaro A + Pixxarro B	266.25 g/L + 600 g/L	Spring; tillering	82 + 350
Pyrasulfatole + bromoxynil	Infinity	247.5 g/L	Spring; tillering	202
Thifensulfuron/ tribenuron + MCPA ester	Refine + MCPA ester	50% SG + 600 g/L	Spring; tillering	15 + 280

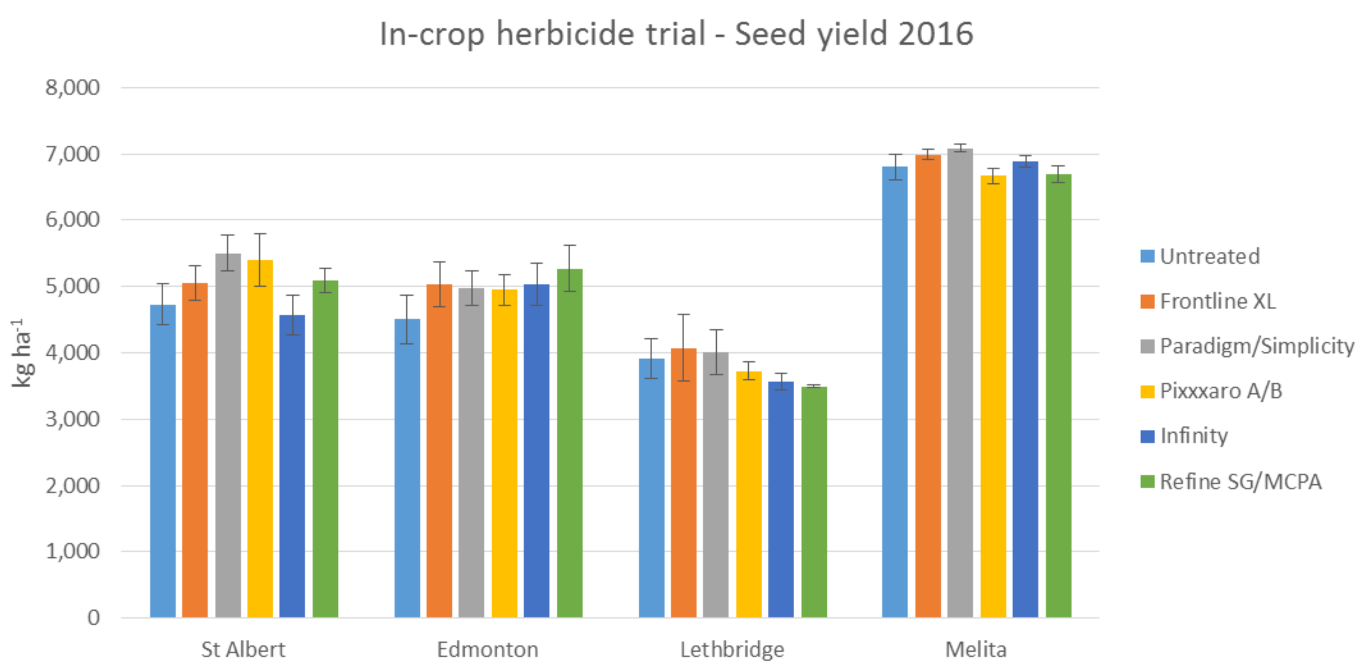

Figure 2. Seed yield of in-crop herbicide trial in winter wheat at 4 locations in Western Canada 2015-16. Means and standard errors are shown.

Sub-activity 2.2

Nitrogen management for establishment of winter wheat on barley stubble.

Nitrogen (N) fertilizer management is key to optimizing the yield and protein content of winter wheat. A series of field studies were conducted at Brandon and Lethbridge to assess the impact of nitrogen fertilizer source and rate on the growth, yield and quality of winter wheat established on barley stubble over five site-years. Two additional site-years had been established at Brandon but were affected by flooding and by reduced plant populations that reduced final yields. Nitrogen management practices consisted of a factorial combination of four rates of N fertilizer (0, 40, 80, 120 kg N ha^{-1}) and six N application/straw treatments (urea banded at seeding with surface straw; urea banded at seeding with straw removed; ESN banded at seeding with surface straw; SuperU banded at seeding with surface straw; UAN dribble banded in spring with surface straw; SuperU broadcast in spring with surface straw).

A mixed model analysis by site-year demonstrated no effects of N management on spring plant stands for winter wheat. Grain yield increased linearly with increasing N rate in 3 of 5 site-years, with linear increases in % grain protein at the Brandon 2012 and 2014 sites resulting in increased N uptake in grain (Figure 1). Effects of N/straw management were not consistent at the N-responsive sites (Figure 2). At Brandon in 2014, urea banded at seeding, with barley straw removed, produced a higher grain yield than all other treatments, which contributed to higher N uptake in grain. In part, reduced N immobilization may have contributed to increased N availability where surface straw had been removed. In contrast, at Brandon in 2012, grain yields were similar whether straw had been removed or retained. No effect of N/straw management was evident at Lethbridge in 2012. Neither N rate nor N/straw management had an overall effect on yield at the remaining two site-years.

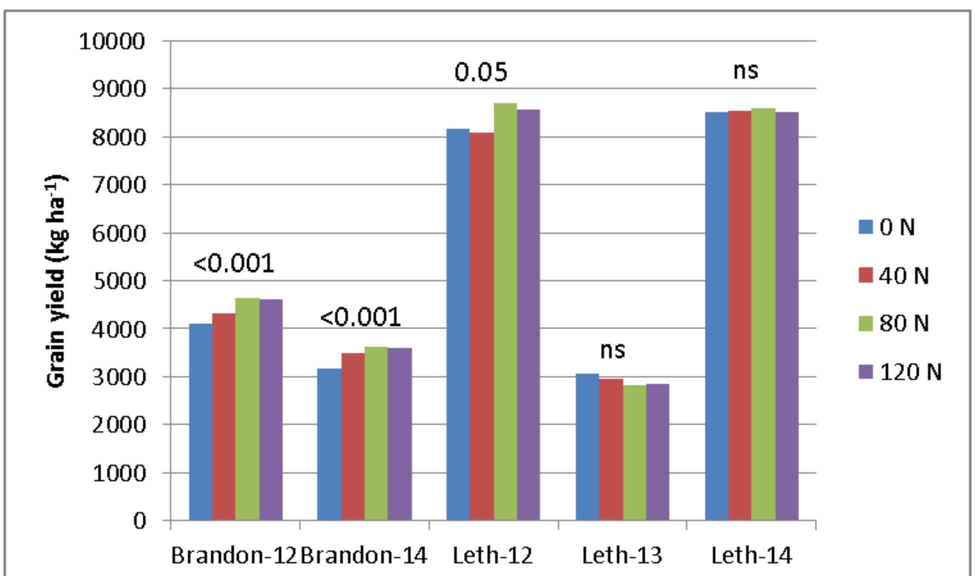

Figure 1. Effect of N fertilizer rate (in kg N ha^{-1}) on winter wheat yield over five site-years.

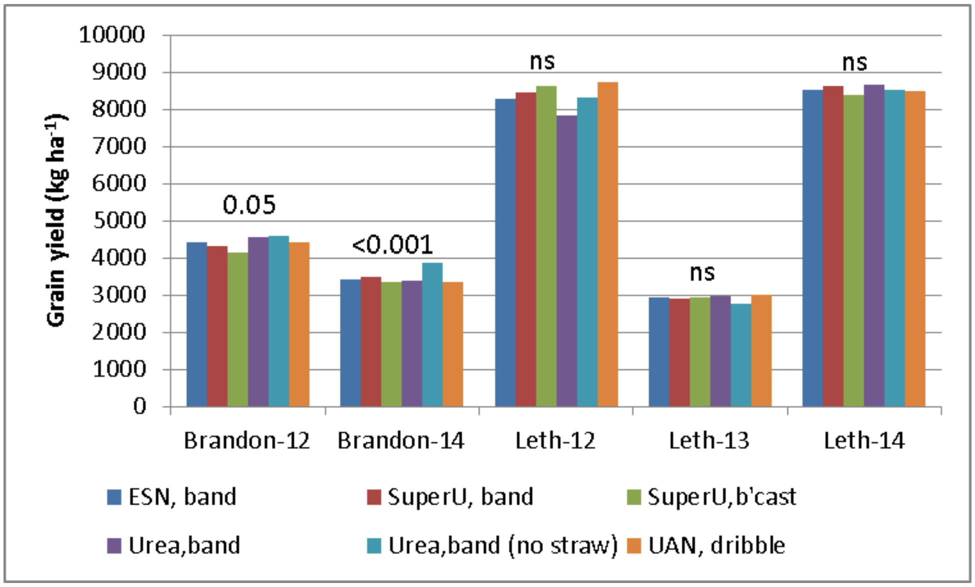

Figure 2. Effect of N fertilizer and straw management on grain yield for winter wheat over five site-years. Unless otherwise indicated, barley straw was retained on the soil surface. All N fertilizer was banded at seeding, with the exception of broadcast SuperU and dribble-banded UAN which was applied in the spring.

Sub-activity 2.3

Enhancing winter wheat production through residue management.

Field studies to assess a wide array of potential stubble management practices were conducted at Beaverlodge, Brandon, Lacombe and Lethbridge over a total of 10 site-years. Stubble management practices included barley (swath removed; swath removed+barley seed broadcast; combined); canola (swathed and combined); dry pea (combined; plants pulled or cut low with swath removed, in both cases seeded between the rows of the preceding cereal crop), and camelina (combined; swath removed). Data for spring-seeded camelina were collected in 8 of 10 site-years. Data for fall-seeded camelina were collected at two sites in the initial year of the study, then discontinued.
Soil temperatures were recorded over the winter period at one to two hour intervals in all site-years except Lethbridge in 2012 and 2013. The average minimum temperature recorded in a given year ranged, among the site-years monitored, from -1.1 to -10.0 C in treatment 1 (barley with swath removed), -1.2 to -13.0 C in treatment 4 (canola swathed and combined), and -2.5 to -12.5 C in treatment 5 (dry pea combined).
A combined mixed model analysis across all sites demonstrated higher snow trapping potential (STP) for barley systems than other management systems, but this effect varied among sites. Snow trapping potential was more strongly influenced by preceding crop species than by differing management practices within a given preceding crop species. Barley consistently met or exceeded the STP considered adequate for winter wheat production of >20 after fall operations, and consistently exceeded that associated with canola or pea. In the majority of

site-years in this study, neither pea nor canola produced an STP >20. In previous studies in western Canada, Irvine et al. (2013) similarly found that cereals resulted in a higher STP than canola and field pea; however, canola produced an STP >20 in their study.

Despite differences in STP, a combined mixed model analysis across all sites showed similar spring plant densities for barley, canola, spring-seeded camelina, and pea (swath removed) (Figure 1). No difference was evident between pea treatments. Similar trends were evident for head counts, which were similar for barley, canola, pea (swath removed), and spring-seeded camelina (combined) (Figure 2). No difference was evident between pea treatments or between camelina treatments.

A combined mixed model analysis across all sites demonstrated similar yields for canola, pea, spring-seeded camelina, and barley treatments where the swath had been removed (Figure 3). No difference was evident among barley treatments. Previous studies by Irvine et al. (2013) suggested pea stubble as an alternative to canola for winter wheat production, noting increased protein and more stable crop responses under environmental variability, whereas barley grown for grain was considered as an intermediate stubble option. No differences in test weight were observed.

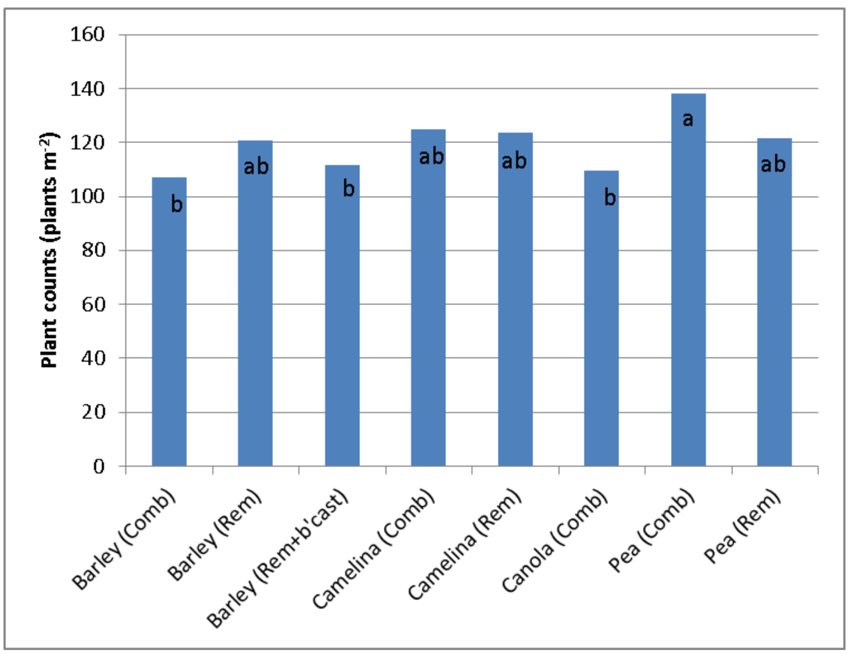

Figure 1. Effect of preceding residue management on spring plant stand of winter wheat.

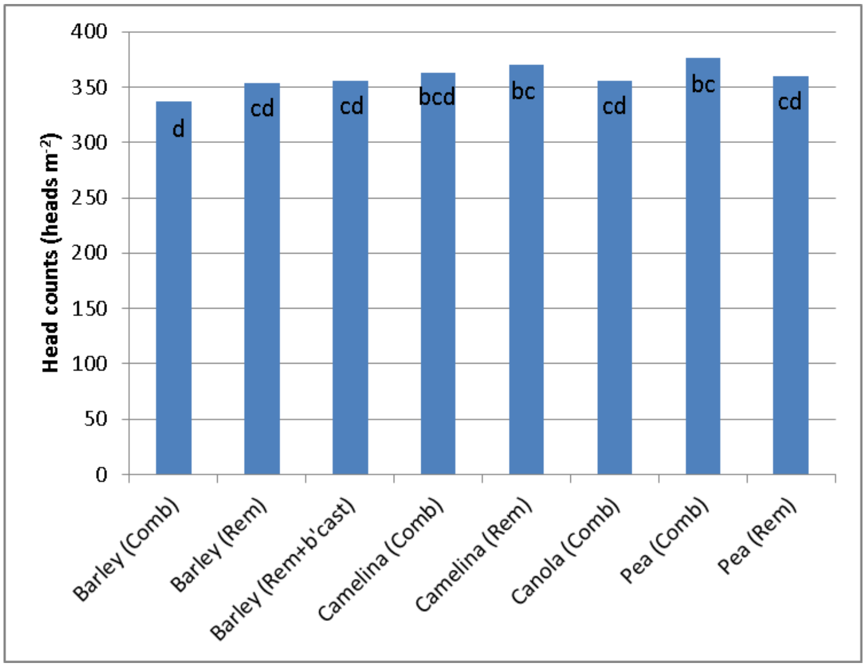

Figure 2. Effect of preceding residue management on head counts of winter wheat.

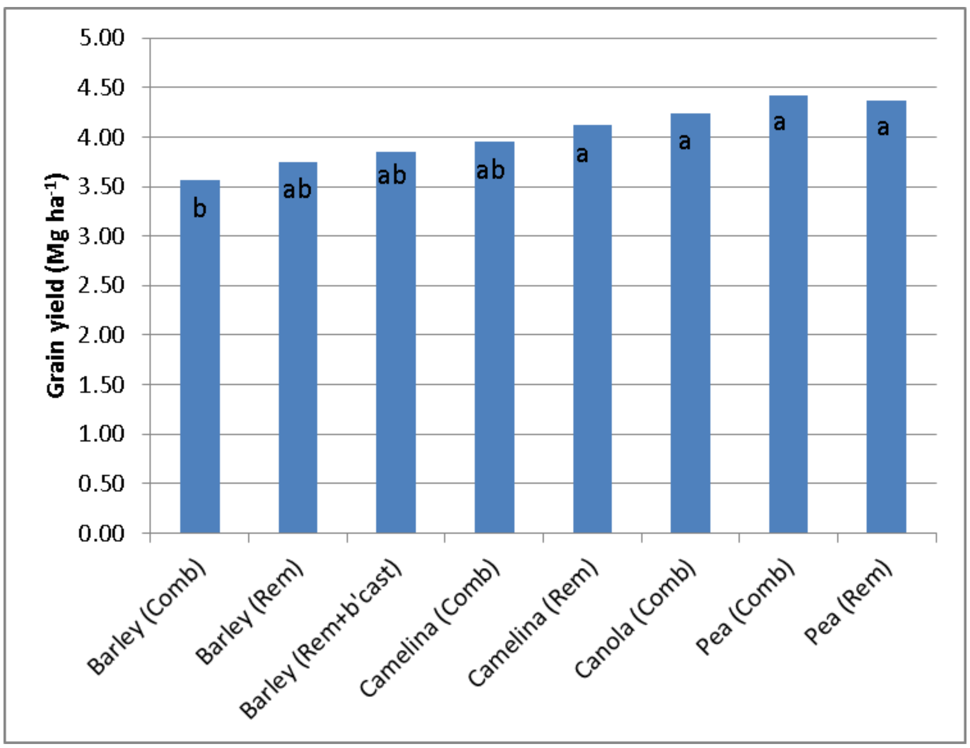

Figure 3. Effect of preceding residue management on grain yield of winter wheat.

Sub-activity 2.4

Expanding the seeding window for winter wheat

Factors limiting the inclusion of winter wheat (Triticum aestivum) in western Canadian crop rotations often relate to seeding window. Several constraints make it harder to seed winter wheat during the optimal seeding period of early to mid September including: 1)reduced fallow/continuous cropping, 2)increased use of longer season varieties, 3)introduction of new later maturing crops, 4)increasing variability of weather. Although late planting of winter wheat is known to reduce winter wheat yield and increase winterkill, farmers in Western Canada are planting winter wheat later. The objective of this study is to evaluate the impact of later seeding dates on the stand establishment and yield of winter wheat.

This study has been conducted at 10 sites across three Canadian Prairie Provinces in 2013-14, 2014-15 and 2015-16 (Figure 1). Experiments were not conducted at four locations in 2013-14 and these sites have the final experiment in the ground for 2016-17. The experiment design is RCBD with four replicates at each location. There are six planning date treatments: Aug 15, Sept 1, Sept 15, Oct 1, Oct 15, and Nov 1 (not all dates were possible at all sites in all years, see Table 3). At each seeding date winter wheat is planted with and withougt a fungicide seed treatment (Tebuconazole with Prothioconazole, trade name Raxil Pro). The winter wheat variety is Flourish and the seeding rate is 450 seeds m^{-2}. Measurements include: days to emergence, fall plant population density, spring plant population density, crop yield and moisture content. Results presented in this report are from 2013-14 and 2014-15. Data from the irrigated site in Lethbridge was not included in the analysis. Analysis is still on-going for the 2015-16 experiments.

Figure 1. Trial locations across the Canadian Prairie Provinces (map source: Google 2016)

Major findings from the first two years of experiments included that winter wheat could be planted in October and even into early November at most sites in most years (Table 1). Both early and late planting reduced winter wheat yield

(Figure 2). However, yield reductions for planting in October where not as large as expected. These trends will be confirmed by data from the 2015-16 and 2016-17 site years. Late planting reduced winter wheat spring plant stands (Figure 3). Winter wheat yields were higher when planted with the seed treatment (Table2). Seed treatment increased yield at three out of five sites in 2013-2014, and four out of eight sites in 2014-2015. Spring plant stands were significantly greater when planted with the seed treatment (Table 2). Seed treatment had a significant effect on spring plant stands at one out of five sites in 2013-2014, and four out of nine sites in 2014-2015.

Sub-activity 2.5

Mitigating herbicide residual activity on fall stand establishment

This trial was conducted at Edmonton, St Albert, Lethbridge, Melita Newstead soil zone and Melita Stanton soil zone in 2015/16. The trial commenced in the spring of 2015, with 3 herbicide combinations applied pre-seed to peas, and 3 herbicide combinations applied in-crop in peas (Table 3). The peas were grown with good management practices and combined. Winter wheat was sown into the pea stubble; all measurements were recorded in the winter wheat crop during the fall of 2015 and the following year. All treatments were compared to an unsprayed check.

Data including fall and spring crop counts, herbicide efficacy and crop tolerance, crop and weed biomass, and seed yield were collected. More detailed statistical analyses will be conducted on this data.

Table 3. Herbicide treatments for residual weed control trial.

Herbicide	Trade name	Formulation concentration	Application timing	Rate (g ai/ha)
Untreated control				
pyroxasulfone	Pyroxasulfone	85%	Pre-seed to peas 2015	150
sulfentrazone	Authority	480 g/L	Pre-seed to peas 2015	140
pyroxasulfone/ sulfentrazone	Pyroxasulfone/ Authority	85% + 480 g/L	Pre-seed to peas 2015	150, 140
imazethapyr/AgSurf	Pursuit/AgSurf	240 g/L + 100%	In-crop in peas 2015	50.4, 0.25%
imazethapyr/imazamox /Merge	Odyssey/Merge	70% + 100%	In-crop in peas 2015	29.7, 0.5%
imazamox/bentazon /UAN	Viper ADV/UAN	449 g/L + 28%	In-crop in peas 2015	444, 560

Relative crop density between treatments varied by location when measured four weeks after fall emergence. No treatment consistently improved or reduced fall crop emergence. Most treatments were similar to the unsprayed check.

The residual nature of the 2015 applied herbicides did not appear to reduce spring crop density, with the exception of an 11% decrease at Melita's Stanton site in the Pursuit treatment. Spring crop densities followed the same trends as fall crop densities, thus percent survival did not seem affected by herbicide treatments.

A year after herbicide application at St. Albert, the May applied pre-seed treatments Authority suppressed weeds (66%), while the other pre-seed herbicide plots had less than 50% efficacy. Pursuit, applied in-crop to the earlier pea crop in June 2015 provided 99% control in the spring of 2016, while the two other 2015 in-crop treatments Odyssey and Viper ADV suppressed weeds with 69-73% efficacy.

At Edmonton, May 2015 pre-seed applications did not provide any weed control in spring 2016. However, Pursuit again controlled the weeds (87%) and Odyssey provided weed suppression (70%) while Viper ADV treatments gave 24% efficacy.

A year after herbicide application, barely perceptible herbicide crop injury rated 0.5 to 2.2% was noted in the spring of 2016 at Edmonton with Pursuit, Odyssey and Viper ADV treatments. No injury was noted at St. Albert.

Crop biomass varied by location, but herbicide treated plots generally had similar or greater biomass than unsprayed plots. No treatment consistently improved or reduced crop biomass.

Weeds were removed in this trial so they would not affect yield and crop growth. Weed biomass data was collected which verified they were at low levels. Compared to crop biomass, weed biomass was 1% or less at 4 locations, and 4% at Lethbridge.

Relative seed yields varied by location (Figure 3). Seed yields in all herbicide treated plots at St. Albert and EDMONTON were increased an average of 14% compared with the unsprayed check. At Melita's Stanton site, only Odyssey treated plots had a higher seed yield, while at Lethbridge and Melita's Newstead site there were no treatment differences.

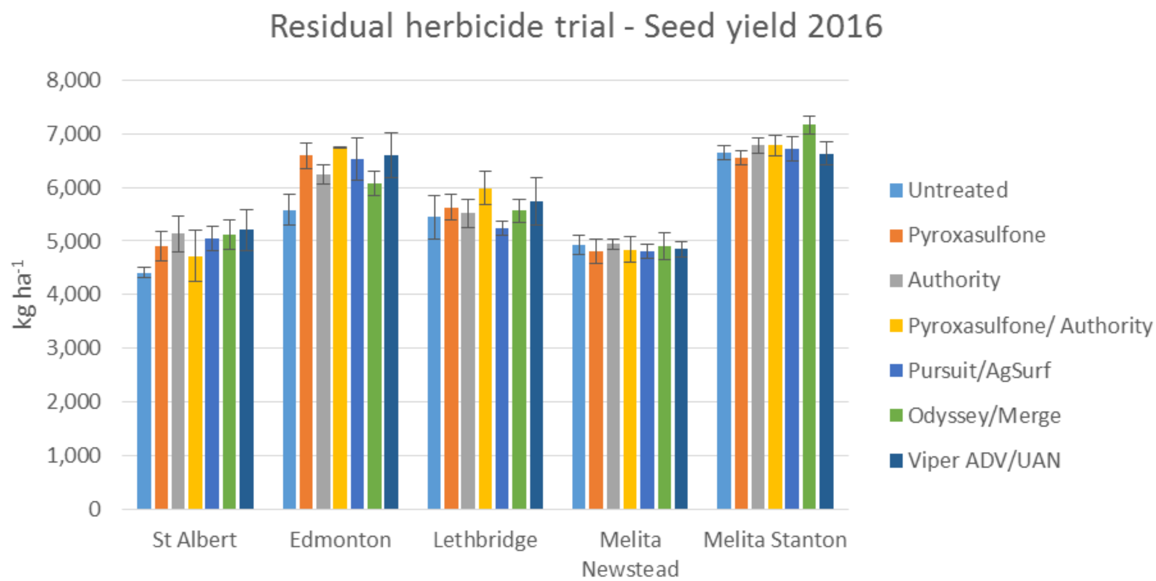

Figure 3. Seed yield of residual herbicide trial in winter wheat at 5 locations in Western Canada 2015-16. Means and standard errors are shown.

Sub-activity 2.6

Control of Japanese and downy brome, wild oat, and cleavers in winter wheat with novel herbicides.

The results of this Activity have been previously reported. Manuscript preparation is being discussed with Mr. Eric Johnson as he has since retired and moved to work for the University of Saskatchewan. We do expect to have manuscripts submitted and published before the end of the project.

Sub-activity 2.7 (Sub-activity 1 &2)

Effect of Neonicotinoid Insecticide Treatments on Winter Wheat Cold Tolerance and Winter Survival

Sub activity 1: Evaluation of a neonicotinoid seed treatment (Raxil Pro) with eight Canadian winter wheat varieties
Out of the four site years thus far, only the Vauxhall 2015 location demonstrated significant winter survival pressure. At this location a significant difference was noted for winter survival among varieties and for the seed treatment (Table 1). It is interesting to note that there was not a significant difference in yield, even though there was a significant positive effect from seed treatment effect on winter survival. In 2016, there was an almost complete lack of winter in Southern

Alberta, meaning the winter survival stress required to determine if there is a difference between winter wheat varieties or seed treatments was not present. Along with field experiments, we are working on evaluating the same winter wheat lines, with and without a seed treatment to determine if cold tolerance assessed via indoor freezing tests is affected by a seed treatment. We are currently optimizing the protocol and will have the results completed in the last year of this project (see images attached with this document).
We currently have this trial seeded for 2016-17 at two Alberta locations, Lethbridge and Vauxhall.

Sub activity 2: Evaluation of a seed treatment x seeding rate interaction
This trial grown over the last two years has not demonstrated any winter survival or grain yield differences between seed treatments. In 2015, an issue with seed lots caused an issue with the Raxil WW treatment. In 2016, a lack of winter conditions led to very high winter survival ratings for all treatments (Table 2). Seeding rate increased winter survival in both years, however it did not lead to a significant difference in yield. In 2015, increased seeding rate increased yield and in 2016 it decrease yield. The decrease in yield from the increased seeding rate in 2016 was surprising, but likely due to the very early spring and dry conditions. The sandy soil at Vauxhall and the late arrival of irrigation water, relative to the crop needs, likely caused the decrease in yield.

Table 1: Winter survival and Yield results from a two year, two locations test comparing winter wheat varieties with and without a seed treatment

		Visual Winter Survival (%)				Grain Yield (kg/ha)				
		Leth 2015	Vaux 2015	Leth 2016	Vaux 2016	Leth 2015	Vaux 2015	Leth 2016	Vaux 2016	Mean
Mean	no treatment	59.7	46.7	92.6	93.1	5929.4	3812.5	7241.5	4520.7	5376.0
	treatment	56.6	56.0	91.8	93.9	6117.9	4118.6	7412.4	4697.5	5586.6
Line		0.4	<.0001	0.2	0.8	0.0	<.0001	<.0001	0.3	<.0001
Treatment		0.3	0.0	0.4	0.6	0.5	0.1	0.3	0.5	0.07
Line*Treatment		0.3	0.1	0.1	0.2	0.0	0.3	0.2	0.5	0.36

Table 2: Winter survival yield results from a two year test comparing seeding rates of 150 and 450 seeds/m2 and three seed treatments (no seed treatment, Raxil Pro and Raxil WW)

		Visual Winter Survival (%)		Grain Yield (kg/ha)	
Rate	Seed treatment	2015	2016	2015	2016
150	Control	66.3	93.8	6442.9	5535.5
450	Control	88.8	96.3	6148.2	4579.0
150	Raxil Pro	31.3	95.0	5587.5	5622.4
450	Raxil Pro	56.3	100.0	6231.6	4705.3
150	Raxil WW	61.3	93.8	6196.4	6203.3
450	Raxil WW	87.5	97.5	6578.6	4606.6
150		52.9	94.2	6075.6	5787.1
450		77.5	97.9	6319.4	4630.3
	Control	77.5	95.0	6295.5	5057.2
	Raxil Pro	43.8	97.5	5909.5	5163.8
	Raxil WW	74.4	95.6	6387.5	5404.9

	Rate	<.0001	0.02	0.58	0.06
	Seed treatment	<.0001	0.35	0.64	0.87
	Rate x Seed Treatment	0.92	0.77	0.66	0.86

Freezing Temperature: -10°C -15°C -20°C

Figure 1: Images of plants resulting from LT50 tests completed at Lethbridge. Note Hazlet, fall rye which demonstrates higher levels of cold tolerance in comparison to winter and spring wheats.