Western Applied Research Corporation

2013 Annual Report

Summary of Research Results and Events

Compiled by: Laryssa Grenkow, Research Manager (WARC) April 2014

Western Applied Research Corporation

The Western Applied Research Corporation (WARC) was incorporated in 2003 and is directed by a seven member Board of Directors. The seven directors are local producers that represent both livestock and grain producers from each of the seven Agriculture Development and Diversification (ADD) districts in NW Saskatchewan.

WARC is a producer based organization that facilitates practical field research and demonstration. It also ensures the transfer of technology from research to farm level for the benefit of producers in NW Saskatchewan and the province. In addition to the field trial analysis the economic implication for the technology is evaluated.

WARC is affiliated with Agriculture and Agri-Food Canada (AAFC) at Scott. The Scott Research Farm acts as the main site for research and demonstration as well as coordination of the projects. Another location accessible to WARC through AAFC at Scott is Glaslyn. In addition to Glaslyn, there are seven other sites that are accessible through the AgriARM program: Indian Head, Redvers, Canora, Rosthern, Swift Current, Prince Albert, and Melfort.

Board of Directors

Don Karstens	Wilkie, SK
Laura Reiter	Radisson, SK
Rob Florence	Battleford, SK
Tim Nerbas	Maidstone, SK
Carol Baillargeon	Edam, SK
Ian Sonntag	Goodsoil, SK
Darin Egert	Cando, SK

WARC Contact Information

Box 89
Scott SK S0K 4A0
Office: (306) 247-2001
Fax: (306) 247-2022

Ashton Keller, Manager of Operations
ashton.keller@warc.ca

Laryssa Grenkow, Research Manager
laryssa.grenkow@warc.ca

Mike Sittler, Technician
mike.sittler@warc.ca

Associate Personnel

Sherrilyn Phelps	Regional Crop Specialist, Saskatchewan Ministry of Agriculture (SMA)
Eric Johnson	Weed Biologist, AAFC Scott
Larry Sproule	Technician, WARC (summer)
Herb Schell	Technician, WARC (summer)
Dan Ulrich	Minor Use Program, AAFC Scott
Arlen Kapiniak	Technician, AAFC Scott
Lorne Nielsen	Technician, AAFC Scott
Cindy Gampe	Technician, AAFC Scott

Scott Research Farm

The Scott Research Farm was established in 1910 by the Federal Department of Agriculture's Experimental Farm Service. In the 1970's organizational restructuring within Agriculture and Agri-Food Canada Research Branch resulted in Scott Research Farm becoming a sub-station of Saskatoon Research Centre.

The farm consists of approximately 340 hectares (840 acres) of dark brown loam soil (pH ranging from 5.0-6.5). In addition to this land base there were two Project Farms operated on leased land in North Western Saskatchewan. One located near Lashburn (Black climatic zone) and the other near Loon Lake (Grey climatic zone). These project farms were closed at the end of 2006. In 2007, a new Project Farm near Glaslyn (Grey climatic zone) was started.

In the early years, there were research programs in livestock, horticulture and field crop production. Along with specialization in the agriculture industry, Research Centres also specialized. As a result, the livestock and horticulture programs have been transferred to other AAFC Research Centres. Scott Research Farm now specializes in crop production systems**.**

Contact Information

Eric Johnson	Weed Biologist (Farm Manager)
Terri Sittler	Office Administrator
Mailing Address:	Box 10, Hwy 374 Scott, SK S0K 4A0
Phone:	(306) 247-2011
Fax:	(306) 247-2022

Weather Report for Scott, SK 2013

Soil Information:
Dark Brown Chernozemic (Typic Boroll)
Association: Scott, Elstow, Weyburn
Texture: Loam

- sand: 31%
- silt: 42%
- clay: 27%

Organic Matter: 3%
Soil pH: 6.0

Table 1. Mean monthly temperature, precipitation and growing degree day accumulated from April to September at Scott, SK

Year	April	May	June	July	August	Sept.	Average /Total
			Temperature (°C)				
2013	2.6	12.6	14.8	16.5	17.4	14.0	13.0
Long-term[z]	3.8	10.8	15.3	17.1	16.5	10.4	12.3
			Precipitation (cm)				
2013	7.8	38.9	113.5	26.1	63.3	0.0	249.6
Long-term[z]	21.6	36.3	61.8	72.1	45.7	36.0	273.5
			Growing Degree Days				
2013	7.7	241.6	292.6	354.9	383.1	269.9	1542.0
Long-term[z]	0.0	178.3	307.5	375.1	356.5	162.0	1379.4

[z]Long-term average (1981-2010)

Last spring frost: May 2, 2013 (-3.0°C)
First fall frost: September 20, 2013 (-0.2°C)

Extension Events

Field Days:

- Scott Field Day, July 17?, 2013, ~250 people in attendance

Winter Meetings:

- Humbolt Canola Day, November 27, 2013
- Stoughton Canola Day, November 28, 2013
- Agronomy Research Update (Saskatoon), December 11 & 12, 2013
- Crop Production Show Booth (Saskatoon), January 13-14, 2014
- Agri-ARM Research Update (Saskatoon), January 17, 2014, ~80 people in attendance
- Regional Pulse Update (North Battleford), February 3, 2014
- Agri-Visions (Lloydminster), February 12, 2014
- Crop Opportunity and Scott Research Update (North Battleford), March 6, 2014, ~100 people in attendance
- Kindersley Canola Day, March 7, 2014
- Soils and Crops Workshop (Saskatoon), March 11, 2014
- CanoLAB (Brandon), March 12 & 13, 2014
- Agriculture Information Day (Meadow Lake), March 19, 2014
- Master Seeders Knowledge Event (Regina), March 21, 2014
- Crop Talk (Prince Albert), March 25, 2014
- TopNotch Farming (Melfort), March 27, 2014

Optimal Seeding Rate for Spring Wheat

Authors & Affiliations: Laryssa Grenkow – Western Applied Research Corporation, Bryan Nybo – Wheatland Conservation Area, Stu Brandt – Northeast Agriculture Research Foundation, Chris Holzapfel – Indian Head Agricultural Research Foundation, Larry White – Conservation Learning Centre

Background & Objectives: Producers may see a benefit of increasing spring wheat seeding rates above the recommended rates when targeting higher wheat yields. In addition, a denser plant stand can also allow the crop to compete better with weeds. Previous research has shown that wheat yields can be increased by increasing seeding rates; however, there is a point when the benefits of an increased plant population do not outweigh the costs of additional seed. The objective of this trial was to demonstrate the yield and economic benefits with increasing seeding rates in spring wheat.

Methodology: Field trials were conducted at Scott, Prince Albert and Indian Head in 2012 and 2013 and at Melfort in 2013 only. The experimental design was a randomized complete block design with four replicates, with the exception of the Prince Albert site which was not replicated. The variety Unity VB (rated poor for lodging) was seeded in early to mid-May at rates of 60, 120, 180, 240, 420 and 480 viable seeds m^{-2}, which corresponds to seeding rates of 0.3-2.5 bu/ac. Fertilizer was applied according to soil test recommendations and herbicides were applied as required by each site. Seeding equipment at individual sites varied: row spacing was 10" at Scott, 12" at Indian Head and 9" at Swift Curren and Melfort.

Results:

Plant Density

The effect of seeding rate on plant density was significant at all site years except for Swift Current in 2013 (Table 1). As expected, as seeding rate increased, plant population also increased linearly at all site years. In this trial emergence rates varied by site (data not shown) and on average were much below the typical range of 80 to 90 percent, except at Indian Head. Due to poor emergence, none of the seeding rates produced plant densities within the optimum target range (215-270 plants m^{-2}) at Scott in 2013 (Table 1). In contrast, the recommended target density was achieved with as little as 300 and 240 seeds m^{-2} and Indian Head in 2012 and 2013, respectively; it took 420 seeds m^{-2} to reach the target density at Scott and Swift Current in 2012 and Melfort in 2013; and it took 480 seeds m^{-2} to reach the target density at Swift Current in 2013 (Table 1).

Grain Yield

At Scott in 2013, the yield response to seeding rate increased in a linear fashion; as expected, the two highest seeding rates resulted in significantly higher yields than the two lowest seeding rates (Table 2). This also reflected the positive linear response to seeding rate in plant density (Table 1), tiller density and crop biomass and negative linear response weed biomass (data not shown) at Scott in 2013. Although the crop was not harvested at Scott in 2012, the crop and weed biomass response was also linear, similar to 2013 (data not shown).

There was little response to high seeding rates at Swift Current. In 2012, all treatments, except the lowest seeding rate, had statistically similar grain yields; the lack of statistical difference between treatments was likely due to the lack of precipitation during grain filling period in July. There was, however, a positive linear response to seeding rate at this site year (Table 2), which may reflect the linear increase in plant

Table 1. Analysis of variance, least square means and orthogonal contrasts for effect on seeding rate on plant density by site year. Means within a column followed by the same letter do not significantly differ.

	Indian Head		Scott		Swift Current		Melfort
Effect	2012	2013	2012	2013	2012	2013	2013
Analysis of Variance							
P value							
Seeding Rate	<.0001	<.0001	<.0001	<.0001	0.0551	<.0001	<.0001
Least Square Means							
Plants m^{-2}							
60 seeds m^{-2}	61^{g}	79^{g}	41^{e}	30^{f}	31	48^{h}	53^{f}
120 seeds m^{-2}	138^{f}	138^{f}	73^{e}	46^{ef}	60	73^{g}	94^{e}
180 seeds m^{-2}	153^{f}	214^{e}	113^{d}	68^{de}	97	114^{f}	124^{d}
240 seeds m^{-2}	205^{e}	272^{d}	149^{c}	79^{cd}	90	127^{e}	178^{c}
300 seeds m^{-2}	258^{d}	320^{c}	163^{bc}	99^{bc}	115	162^{d}	195^{c}
360 seeds m^{-2}	336^{c}	391^{b}	195^{b}	133^{ab}	121	177^{c}	207^{bc}
420 seeds m^{-2}	397^{b}	405^{b}	233^{a}	123^{ab}	237	206^{b}	227^{b}
480 seeds m^{-2}	445^{a}	508^{a}	236^{a}	119^{ab}	138	235^{a}	275^{a}
Orthogonal Contrasts							
P value							
Linear	<.0001	<.0001	<.0001	<.0001	0.0028	<.0001	<.0001
Quadratic	0.0413	0.3442	0.1308	0.0229	0.7059	0.0990	0.0868
Cubic	0.7733	0.1119	0.7656	0.0671	0.5584	0.0293	0.1371

Table 2. Analysis of variance, least square means and orthogonal contrasts for effect on seeding rate on grain yield by site year. Means within a column followed by the same letter do not significantly differ.

	Indian Head		Scott	Swift Current		Melfort	Prince Albert	
	2012	2013	2013	2012	2013	2013	2012	2013
Analysis of Variance								
P value								
Seeding Rate	0.0205	<.0001	0.0050	0.0008	0.2144	0.0007	-	-
Least Square Means								
60 seeds m^{-2}	2800^{bc}	5030^{de}	3878^{d}	2500^{b}	3333	3620^{d}	1030	4462
120 seeds m^{-2}	2855^{bc}	5441^{a}	4102^{cd}	3443^{a}	3460	4652^{c}	1168	4929
180 seeds m^{-2}	3352^{a}	5326^{ab}	4309^{abc}	3572^{a}	3899	5549^{ab}	1036	4895
240 seeds m^{-2}	3152^{ab}	5286^{abc}	4293^{abc}	3613^{a}	3604	5810^{a}	1943	4391
300 seeds m^{-2}	2862^{bc}	5261^{bc}	4398^{abc}	3712^{a}	3854	5657^{ab}	1779	4334
360 seeds m^{-2}	2712^{bc}	5126^{cd}	4288^{bc}	3653^{a}	3852	5521^{abc}	2738	4275
420 seeds m^{-2}	2529^{c}	4928^{e}	4612^{ab}	3642^{a}	3845	5404^{abc}	1779	3831
480 seeds m^{-2}	2561^{c}	4947^{de}	4654^{a}	3762^{a}	3596	4802^{bc}	2200	4149
Orthogonal Contrasts								
P value								
Linear	0.0148	<.0001	<.0001	0.0001	0.0975	0.0066	-	-
Quadratic	0.0175	<.0001	0.6207	0.0030	0.0464	<.0001	-	-
Cubic	0.0550	0.0017	0.1920	0.0196	0.8592	0.3037	-	-

population with increasing seeding rates (Table 1). Seeding rate did not have a significant effect on grain yield at Swift Current in 2013 (Table 2). The quadratic response was, however, significant; the highest numerical yield was with the 180 seeds m^{-2} treatment, after which yield began to decline. The response at Prince Albert also appeared to behave similarly to the Swift Current site. Grain yields reached a maximum at 360 and 120 seeds m-2 in 2012 and 2013, respectively and then began to decline as seeding rate continued to increase (Table 2).

The yield response at Indian Head 2012 and 2013 and Melfort 2013 sites was also quadratic. Highest yields were from lower seeding rates (180, 120 and 240 seeds m^{-2} at Indian Head 2012, 2013 and Melfort 2013, respectively) and yields declined as seeding rate continued to increase. The reason for lower yields with higher plant densities at Indian Head was due to significant lodging at seeding rates exceeding 300 or 180 seeds m^{-2} in 2012 and 2013, respectively. Due to the high rate of seedling survival at Indian Head, there were relatively high overall plant populations which likely contributed to low optimal seeding rates and excessive lodging in treatments with higher seeding rates.

When all site years are combined, the response to seeding rate and plant density was also quadratic; the optimal seeding rate 306 seeds m^{-2} (Figure 1) and the optimum plant density was 191 plants m^{-2} (Figure 2). Under good growing conditions and low pest pressure combined with other best management practices, high seeding rates may not be necessary to reach maximum yield potential.

Grain Quality

There was no effect of seeding rate on thousand kernel weight at any of the site years, except Melfort in 2013 (data not shown); however there was little difference between treatments above the lowest seeding rate. In contrast, seeding rate had a significant effect on test weight and the test weight increased linearly as seeding rate increased at all site years (data not shown).

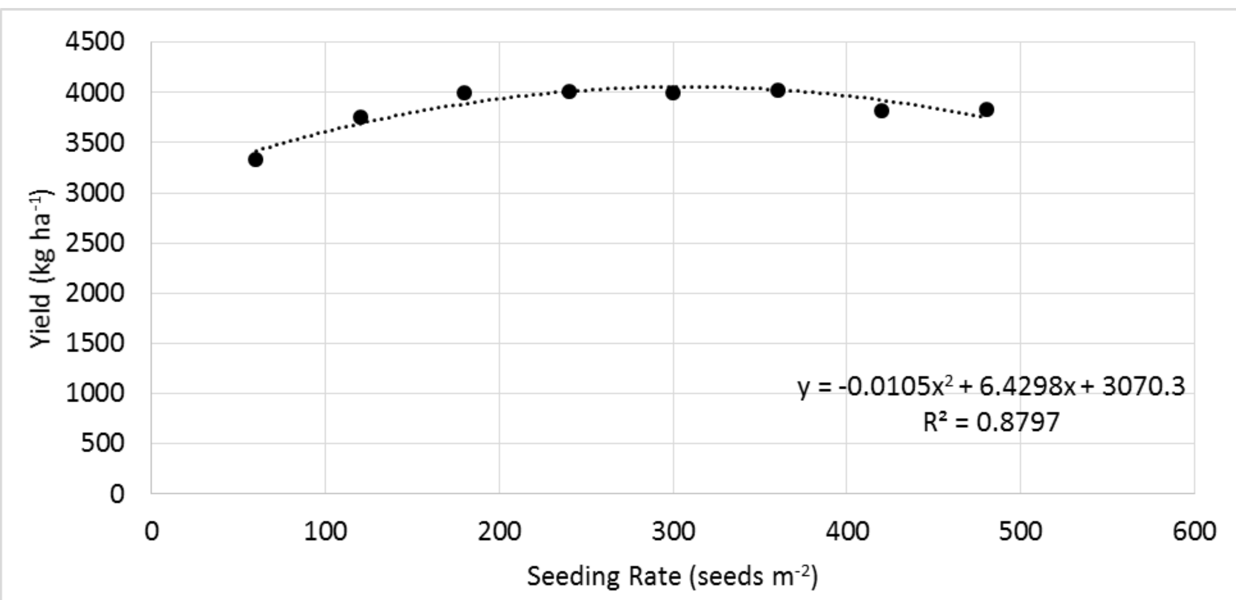

Figure 1: The relationship between seeding rate and grain yield (combined means of eight site years). Maximum grain yield achieved at 306 seeds m^{-2}.

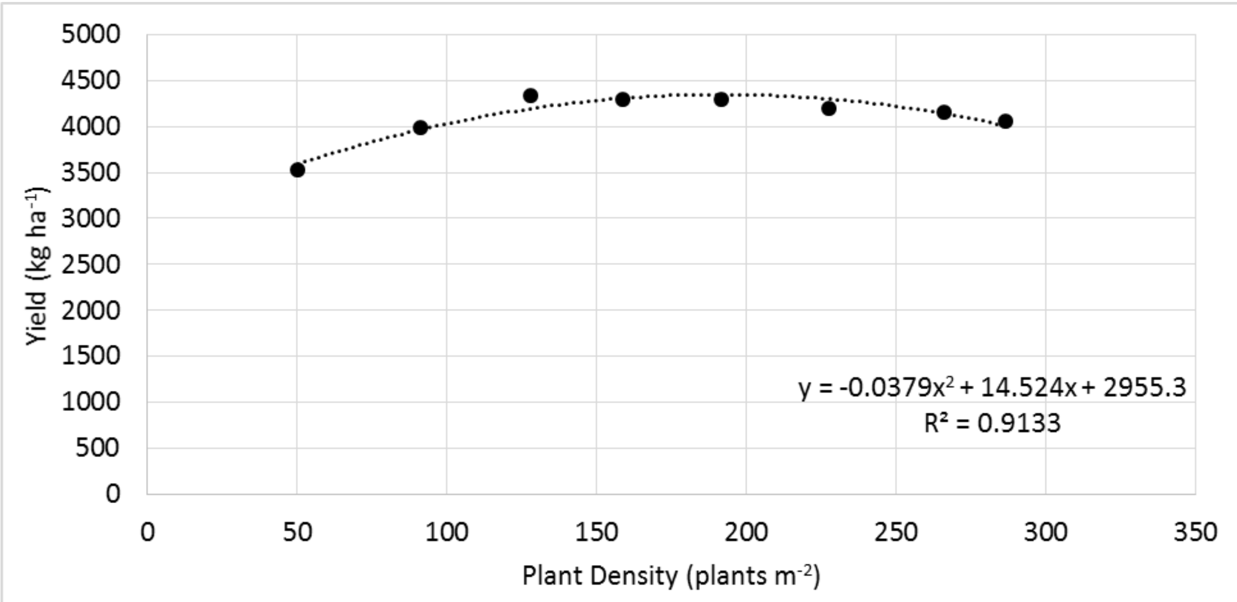

Figure 2: The relationship between plant density and grain yield (combined means of six site years). Maximum grain yield achieved at 191.6 plants m^{-2}.

<u>Economic Analysis</u>

The maximum economic return was reached at a seeding rates between 263-292 seeds m^{-2}, 250-288 seeds m^{-2} and 238-284 seeds m^{-2} when seed costs were \$9, \$11 and \$13 bu^{-1} depending on grain prices. The difference in optimum seeding rates were greater between grain prices than between seed prices used.

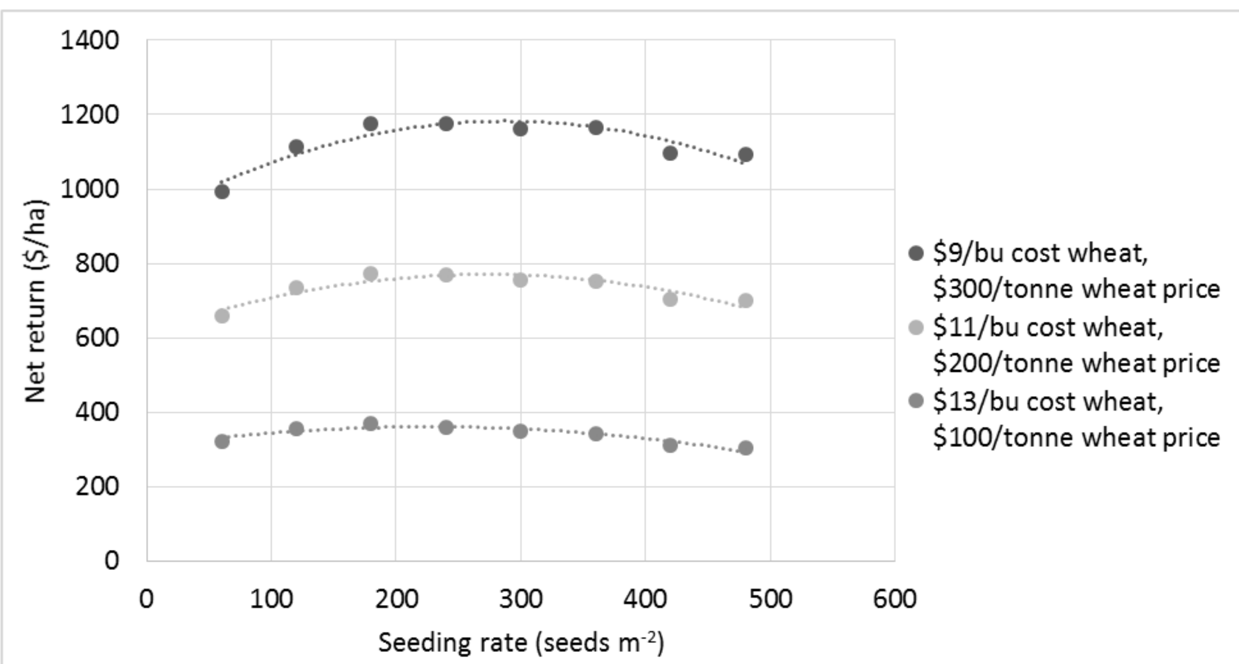

Figure 3. Net return of spring wheat at various seeding rates and grain prices Maximum economic return at 238, 273 and 292 seeds m^{-2} when seed cost to grain price ratios are \$9:\$100, \$11:\$200 or \$13:\$300 $tonne^{-1}$, respectively.

Conclusions: As seeding rate increased, plant populations increased linearly and plant emergence decreased. Grain yields responded to seeding rate in a quadratic fashion at 7 of 8 site years and the optimum seeding rate was, on average, 306 seed m^{-2}. Plant emergence, however, varied by site year and ranged from 33 to 107% at a seeding rate of 300 seeds m^{-2}. Maximum grain yields were achieved with 191 plants m^{-2} on average which is lower than the current recommendation of 215 – 270 plants m^{-2}. Sites in the drier part of the province are more limited by moisture and plant density increases provide no increase in yield. Locations where moisture is more abundant (Indian Head and Melfort) did not respond more to higher plant densities because lodging became an issue. It is likely that when best management practices and good growing conditions are combined, fewer plants are required to reach yield potential and prevent lodging. It is possible that the optimal plant populations for spring wheat would be higher optimal moisture conditions or if a variety with excellent lodging resistance were used or if lodging could be eliminated with the use of plant growth regulators. Net returns were maximized at seeding rates between 238-292 seeds m^{-2}.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Demonstrating the Effect of Fungicide Application and Seeding Rate on Disease Levels in Field Peas and Lentils

Authors & Affiliations: Laryssa Grenkow – Western Applied Research Corporation, Bryan Nybo – Wheatland Conservation Area, Chris Holzapfel – Indian Head Agricultural Research Foundation, Larry White – Conservation Learning Centre

Background & Objectives: Increasing seeding rates in peas and lentils has been promoted as a way to increase seed yield and reduce weed competition; however, a denser crop canopy may increase the incidence and severity of disease. Although diseases such as white mold in lentil and mycorsphaerella blight in pea may reduce yield and quality of seed in Saskatchewan, producers may not always see a benefit in applying fungicides. The project will help farmers determine the benefit, if any, of applying a foliar fungicide in peas and lentils at a low, medium and high seeding rates.

Methodology: The trial was conducted at Scott, Indian Head, Swift Current and Prince Albert in 2013. The experiment design was a complete 2x2x3 factorial arranged as a randomized complete block design with four replicates. The treatment consisted of a combination of crop (lentil or pea), fungicide application (yes or no) and seeding rate (low, medium or high). Seeding rates were adjusted to 130, 260 and 520 seeds m^{-2} for lentil and 50, 100 and 200 seeds m^{-2} for peas. Seeding occurred in mid- to late May at all sites. CDC Maxim lentil and Centennial pea varieties were used. Fertilizer was applied according to soil test recommendations for both peas and lentil and herbicides were applied as required. Only yield data was collected at Prince Albert. Disease was rated prior to and three weeks after fungicide application.

Results:

<u>Plant Density</u>

Plant density differed by crop and seeding rate at all three sites; lentils had a higher plant population, on average, compared to peas and plant density increased with each successive level of seeding rate (data not shown). Plant density at the medium and high seeding rates for were above the recommended target plant populations (75-85 and 130 plants m^{-2} for peas and lentil, respectively) at Swift Current and Indian Head. Plant density of pea and lentil were below the optimum at the low and medium seeding rates at Scott, but satisfactory weed control was achieved, and therefore weeds would not have limited yield.

Maturity Ratings

Days to flower was assessed at Indian Head, while days to maturity was assessed at Scott and Swift Current. Fungicide and seeding rate did not affect maturity at Scott and Indian Head, however, peas, on average, flowered 3.1 days longer than lentil at Indian Head and matured 2.8 days later than lentils at Scott (data not shown). At Swift Current, lentils took 1.8 days longer to mature than peas and the low seeding rate treatments matured 1.5 days later than the medium and high seeding rates (data not shown).

Disease Ratings

Disease levels were generally higher at Scott and Indian Head compared to Swift Current. At disease ratings taken just prior to fungicide application, seeding rate had an effect on disease levels at Swift Current and Indian Head (data not shown). Disease increased as seeding rate decreased at Indian Head and conversely, disease levels increased with increasing seeding rate at Swift Current. When disease was assessed three weeks after fungicide application there were no consistent effects of seeding rate on disease levels among sites (Table 1). Fungicide applications decreased disease in pea and lentil at Indian Head and Swift Current (Table 1). At Indian Head, there was significant interaction for lentil; disease levels decreased as seeding rate decreased without fungicide, while there were no differences in disease levels between seeding rates when a fungicide was applied (Table 1). Seeding rate and foliar fungicide had no effect on either of the disease ratings collected at Scott (Table 1).

Table 1: Effect of seeding rate and fungicide on disease rating for lentil (0-100%) and pea (0-9) three weeks after fungicide application. Means within a column followed by the same letter do not significantly differ.

			Site					
	Factor		Scott		Swift Current		Indian Head	
Effect	Seeding Rate	Fungicide	Lentil	Pea	Lentil	Pea	Lentil	Pea
Seeding Rate	Low		1.91	2.68	0.38	1.13[a]	1.00[b]	4.06
	Medium		2.79	2.69	0.38	0.88[a]	2.13[b]	4.38
	High		2.54	2.84	0.88	0.38[b]	4.75[a]	4.50
		P value	0.6310	0.9920	0.1304	0.0019	<.0001	0.8163
Fungicide		No	2.48	2.68	0.83[a]	1.00[a]	4.33[a]	5.67[a]
		Yes	2.34	2.78	0.25[b]	0.58[b]	0.92[b]	2.96[b]
		P value	0.8537	0.9324	0.0164	0.0099	<.0001	0.0003
Seeding Rate*Fungicide	Low	No	1.38	1.50	0.25	1.25	1.75[c]	4.88
	Medium	No	3.38	2.53	0.25	1.00	3.75[b]	6.13
	High	No	2.70	4.03	1.50	0.75	7.50[a]	6.00
	Low	Yes	2.45	3.85	0.50	1.00	0.25[c]	3.25
	Medium	Yes	2.20	2.85	0.25	0.75	0.50[c]	2.63
	High	Yes	2.38	1.65	0.25	0.00	2.00[bc]	3.00
		P value	0.4873	0.2752	0.1304	0.2781	0.0262	0.4070

Yield

Yields were higher with pea than lentils at Prince Albert (Table 2). Although yields at the medium and high seeding rates were numerically higher than the low seeding rates, these differences were not significant (Table 2). Applying a foliar fungicide significantly increase yields by 18%, on average (Table 2).

Yield was affected by main effects of crop, seeding rate and fungicide at Scott (Table 2). On average, peas yields were again higher than lentils yields (Table 2). Yields at the medium and high seeding rates were statistically similar and both higher than the low seeding rate (Table 2). The poor yields at the low seeding rate likely reflected the very low plant populations in both peas (26 plants m^{-2}) and lentils (91 plants m^{-2}) at Scott. Applying a fungicide also increased yields by 9% on average at Scott (Table 2).

The yield response to seeding rate at Indian Head was similar to the response at Scott; there was no yield improvements, on average, beyond the medium seeding rate (Table 2). Again the plant density was below the optimum for both pea (37 plants m^{-2}) and lentil (97 plants m^{-2}) at the low seeding rate, which likely limited yield potential. Although fungicide increased yields by 15%, on average, the crop by fungicide application interaction revealed that peas were more responsive to fungicide than lentils (Table 2).

At Swift Current, there was a significant three-way interaction between crop, seeding rate and fungicide application (Table 2). For pea, the high seeding rate treatments yielded higher than both the low and medium seeding rates, regardless of fungicide treatment (Table 2). Conversely, lentil yields were highest when high seeding rates and fungicide were combined and lowest when high seeding rates did not receive fungicide; lentils were generally not responsive to fungicide at low and medium seeding rates (Table 2).

Pea and lentil yields were generally higher at Scott and Indian Head than Prince Albert and Swift Current. The lack of interaction between seeding rate and fungicide application at either of the two high yielding sites is likely due to the relatively high yield potential, due to optimal growing conditions. And high disease incidence resulting in fungicide being beneficial in all situations. In contrast, at Swift Current, the interaction between seeding rate and fungicide revealed a benefit to fungicide at high seeding rates.

Thousand Kernel Weight

Thousand kernel weight was not affected by seeding rate or fungicide application at Scott, Swift Current or Prince Albert (data not shown). At Indian Head, fungicide application increased tkw of peas from 212.0g (no fungicide) to 232.2g (with fungicide), while fungicide did not affect tkw of lentil (data not shown).

Economic Analysis

A simple economic analysis was conducted using the variable costs of seeding rate and fungicide application and the gross income of each treatment from the combined analysis. The price of peas and lentils were $5.53/bu and $19.61/bu, respectively. Fungicide costs were assumed to be $44/ha and pea and lentil seed costs were assumed to be $14/bu and $0.65/lb, respectively. Applying a fungicide increased net return for both pea and lentil, regardless of seeding rate (Table 3). Increasing seeding rate, from low to medium rates, increased yields (combined analysis not shown) and net return (Table 3) for both pea and lentil whether a fungicide was applied or not. Increasing seeding rates from medium to high rates, however, reduced net return in both pea and lentil because the additional yield gains were not enough recover the cost of the additional seed (Table 3). It appears that the highest net return for both pea and lentil, on average, was a combination of the medium seeding rate and foliar fungicide application (Table 3).

Table 2: Seed yield (kg ha^{-1}) of crop, seeding rate and fungicide effect at each site. Means within a column followed by the same letter do not significantly differ.

Effect	Factor			Site			
	Crop	Seeding Rate	Fungicide	Scott	Swift Current	Indian Head	Prince Albert
Crop	Lentil			3416[b]	2603[a]	4148	1702[b]
	Pea			4765[a]	1311[b]	3887	2519[a]
			P value	<.0001	<.0001	0.0829	<.0001
Seeding Rate		Low		3510[b]	1759[b]	3733[b]	1854
		Medium		4287[a]	1863[b]	4134[a]	2284
		High		4475[a]	2248[a]	4185[a]	2193
			P value	<.0001	<.0001	0.0348	0.0607
Fungicide			No	3917[b]	1771[b]	3734[b]	1934[b]
			Yes	4264[a]	2143[a]	4300[a]	2287[a]
			P value	0.0144	<.0001	0.0005	0.0266
Crop*Seeding Rate	Lentil	Low		3067	2657[a]	3877	1519
	Lentil	Medium		3497	2632[a]	4297	1792
	Lentil	High		3685	2518[a]	4269	1795
	Pea	Low		3952	861[d]	3589	2189
	Pea	Medium		5078	1094[c]	3971	2777
	Pea	High		5265	1978[b]	4100	2590
			P value	0.0648	<.0001	0.8991	0.6892
Crop*Fungicide	Lentil		No	3229	2370	4066[a]	1471
	Lentil		Yes	3603	2835	4229[a]	1933
	Pea		No	4605	1171	3403[b]	2397
	Pea		Yes	4925	1451	4371[a]	2640
			P value	0.8422	0.0801	0.0095	0.4748
Seeding Rate*Fungicide		Low	No	3403	1601[c]	3575	1547
		Medium	No	4103	1808[b]	3792	2195
		High	No	4244	1903[b]	3837	2059
		Low	Yes	3616	1917[b]	3892	2160
		Medium	Yes	4471	1918[b]	4477	2374
		High	Yes	4705	2593[a]	4532	2326
			P value	0.7507	0.0003	0.5008	0.4609
Crop*Seeding Rate*Fungicide	Lentil	Low	No	2973	2519[b]	3908	1121
	Lentil	Medium	No	3272	2573[b]	4190	1759
	Lentil	High	No	3442	2018[c]	4100	1533
	Lentil	Low	Yes	3161	2795[ab]	3846	1918
	Lentil	Medium	Yes	3722	2692[b]	4404	1825
	Lentil	High	Yes	3927	3018[a]	4438	2057
	Pea	Low	No	3834	682[e]	3241	1974
	Pea	Medium	No	4935	1044[d]	3393	2631
	Pea	High	No	5047	1789[c]	3574	2586
	Pea	Low	Yes	4071	1040[d]	3937	2403
	Pea	Medium	Yes	5221	1145[d]	4549	2923
	Pea	High	Yes	5482	2168[c]	4626	2594
			P value	0.9488	0.0183	0.9423	0.5786

Conclusions: Applying a fungicide increased yields by 9-21% at all sites, which, on average, was enough to re-cover the additional cost of the fungicide. Targeting an optimum plant density by using seeding rates of 100 seeds m^{-2} for peas and 260 seeds m^{-2} for lentil resulted in higher yields compared to the lower seeding rates. Improvements in seed yield beyond these "medium" seeding rates were not consistent, and highest net return was achieved with the medium seeding rate, regardless of whether or not a fungicide was applied. The lack of interaction between seeding rate and fungicide 3 of 4 sites in 2013 shows the benefit of fungicide application in protecting high yield potential under optimal growing conditions. Thus, we recommend targeting plant populations from provincial guidelines (75-85 and 130 plants m^{-2} for peas and lentil, respectively) and protecting a crop with high yield potential using a fungicide to maintain yield and improve net return.

Table 3: Economic analysis.

Crop	Seeding Rate	Fungicide	Yield (kg/ha)	Gross Income ($/ha)	Seed Cost ($/ha)	Fungicide Cost ($/ha)	Net Revenue ($/ha)
Lentil	Low	No	2625	1892	75	0	1817
Lentil	Low	Yes	2930	2111	75	44	1993
Lentil	Med	No	2948	2125	149	0	1976
Lentil	Med	Yes	3161	2278	149	44	2085
Lentil	High	No	2773	1999	298	0	1701
Lentil	High	Yes	3354	2417	298	44	2075
Pea	Low	No	2433	494	51	0	443
Pea	Low	Yes	2863	582	51	44	486
Pea	Med	No	2987	607	103	0	504
Pea	Med	Yes	3459	703	103	44	556
Pea	High	No	3249	660	206	0	454
Pea	High	Yes	3717	755	206	44	506

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Optimal Timing of Weed Control in Field Pea and Lentil

Authors & Affiliations: Laryssa Grenkow – Western Applied Research Corporation, Larry White – Conservation Learning Centre

Background & Objectives: Weed control in pulse production is important since peas and lentils are poor competitors with weeds and canopy closure occurs later in the season. Producers may be applying herbicides and the end of the application window with the goal of controlling later emerging weeds, when early applications are generally considered to provide better weed control. The objective of this trial is to demonstrate the effect of herbicide application timing on weed control and crop yield of field pea and lentil.

Methodology: Field trials were located at Scott and Price Albert in 2013. The treatment s were arranged as a randomized complete block design with four replicates. There were a total of 14 treatments at each site; an untreated check for both crops along with early and late applications of three commonly used herbicides for both lentil (Odyssey, Solo, Sencor) and field pea (Odyssey, Viper, Sencor) applied at recommended rates. Early applications were made at the three above ground node growth stage, and late applications were made at the six above ground node growth stage, except for the late Sencor application which was applied at six inches of vine length stage. Centennial peas were seeded at 100 seeds m^{-2} and CDC Maxim lentils were seeded at 130 seeds m^{-2}. Cutlass mustard was cross-seeded into the entire trial area at a rate of 2.25kg ha^{-1} to ensure adequate weed pressure. Tame oats were also cross-seeded at Prince Albert. Fertilizer was applied at seeding according to soil test recommendations. All plots received a pre-seed glyphosate application on May 20th and 17th at Scott and Prince Albert, respectively. Trials were seeded May 22nd at Scott and May 21st at Prince Albert.

Results:

<u>Scott</u>

All herbicide options resulted in significantly higher lentil and pea seed yields (Figure 1 and 2) and crop biomass compared to the no herbicide control. Similarly, weed biomass was also significantly lower in all herbicide treatments compared to the no herbicide control in both lentil and pea. Mustard, in particular, was well controlled with all herbicide options. The only difference in seed yields between herbicide options at Scott was in lentils: Solo applied late had significantly higher yields than Sencor applied late (Figure 1). Sencor applied late also had significantly higher weed biomass in lentils than all other herbicide options (Figure 3). Wild oats, in particular, were not controlled by late applied Sencor, likely because the grassy weeds were larger than the recommended size at the time of application. The reason for the low lentil yields with Sencor applied late may have also been due to crop injury; although crop biomass when sprayed with a late was not significantly lower than an early application of Sencor, it was lower than lentils sprayed with Solo or Odyssey at the late application timing (Figure 4). There were no differences in weed or crop biomass between any herbicide treatments in peas at Scott (data not shown).

<u>Prince Albert</u>

Lentil and pea seed yields were much lower at Prince Albert than at Scott and none of the herbicide options resulted in significantly higher seed yields than the control plots receiving no herbicide (Figure 1 and 2). Visually, it appeared some herbicide options caused crop injury. Peas and lentils sprayed with Odyssey were very stunted, which may have resulted in lower yields when sprayed late in peas. Despite crop injury, Odyssey provided good weed control when applied late to peas and early in lentils. Oats were poorly controlled with Odyssey when applied early to peas and late to lentil. Sencor provided good control of early emerging weeds in peas at Prince Albert, however, this resulted in significantly lower seed yields when applied late compared to the control (Figure 2). Conversely, when Sencor was applied to lentil, weed control was very poor, especially when applied early. In addition, lentil yields were also lowest with both Sencor applications compared to other treatments, with early application being lowest (Figure 1). Solo applied to lentils at Prince Albert provided good weed control when applied late, with barnyard grass and sow thistle emerging later with the early application. The effective weed control with the late application of Solo also resulted in higher lentil yields than the early application (Figure 1). Solo treatments also showed some crop injury, slowing lentil growth. Viper applied to field peas at Prince Albert provided good control when applied early, as compared to the late application which resulted in poorer pea yields (Figure 2).

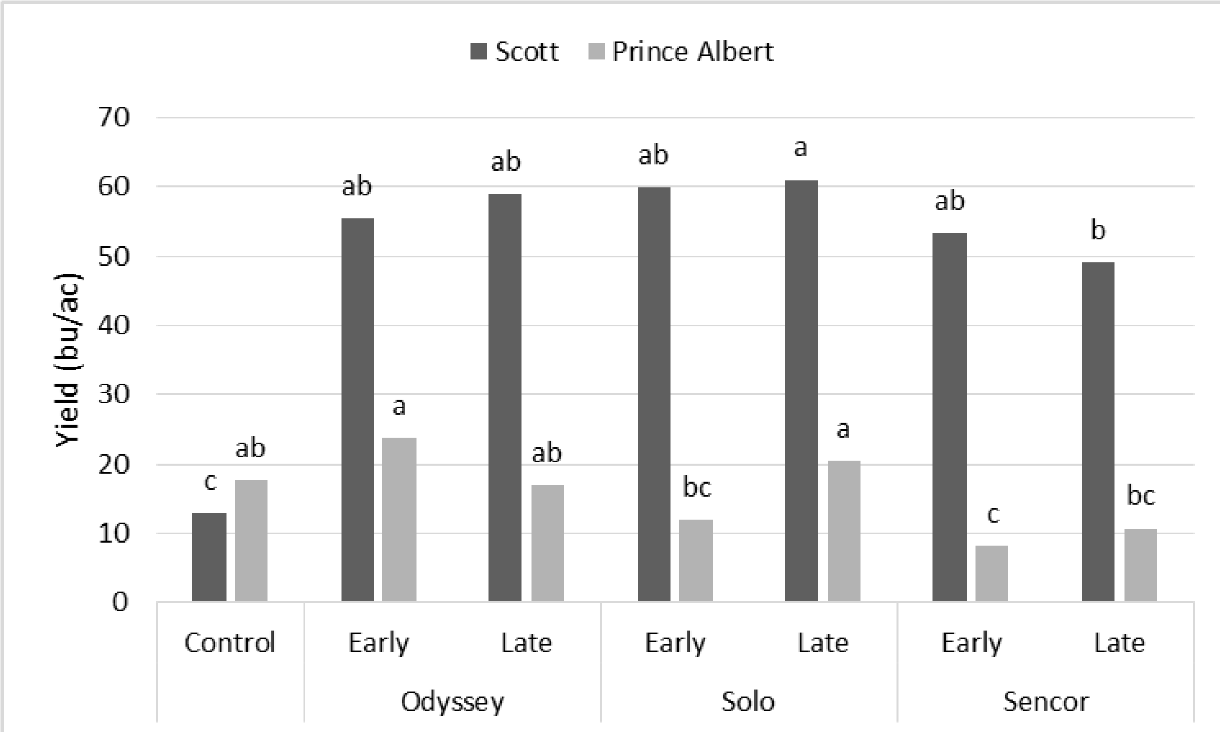

Figure 1. Lentil seed yields with various herbicide options at Scott and Prince Albert, SK in 2013.

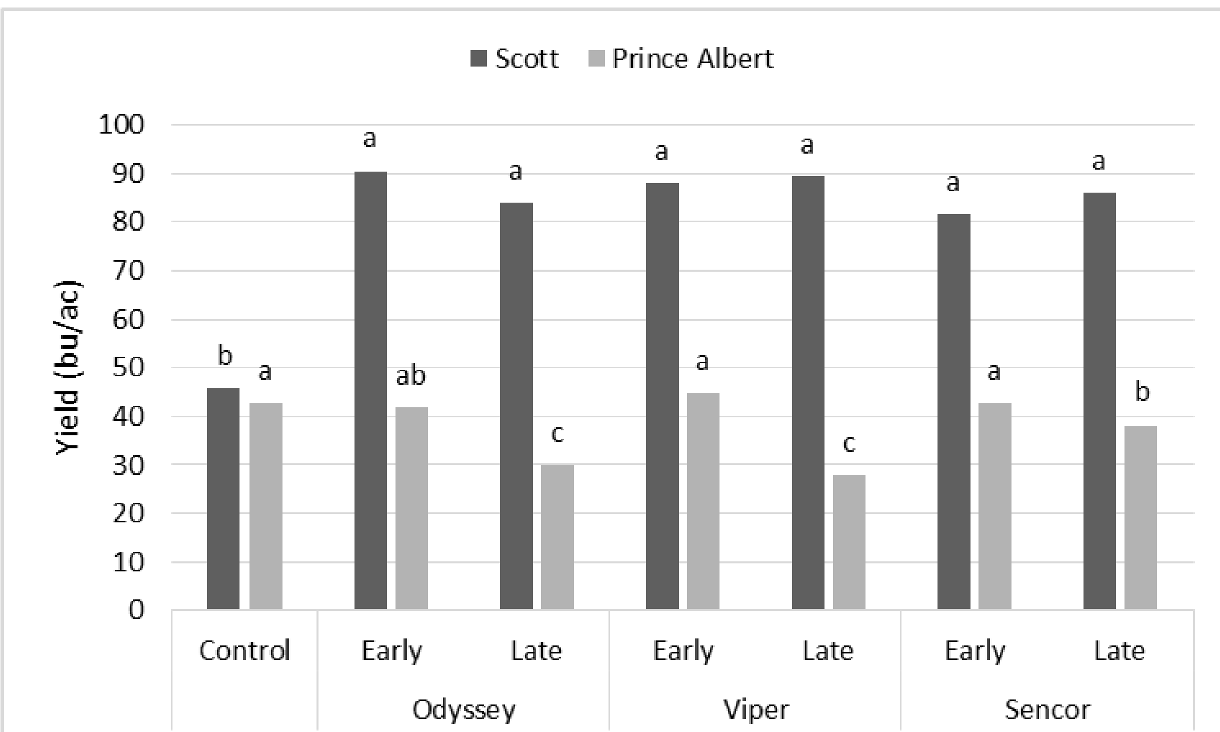

Figure 2. Field pea seed yields with various herbicide options at Scott and Prince Albert, SK in 2013.

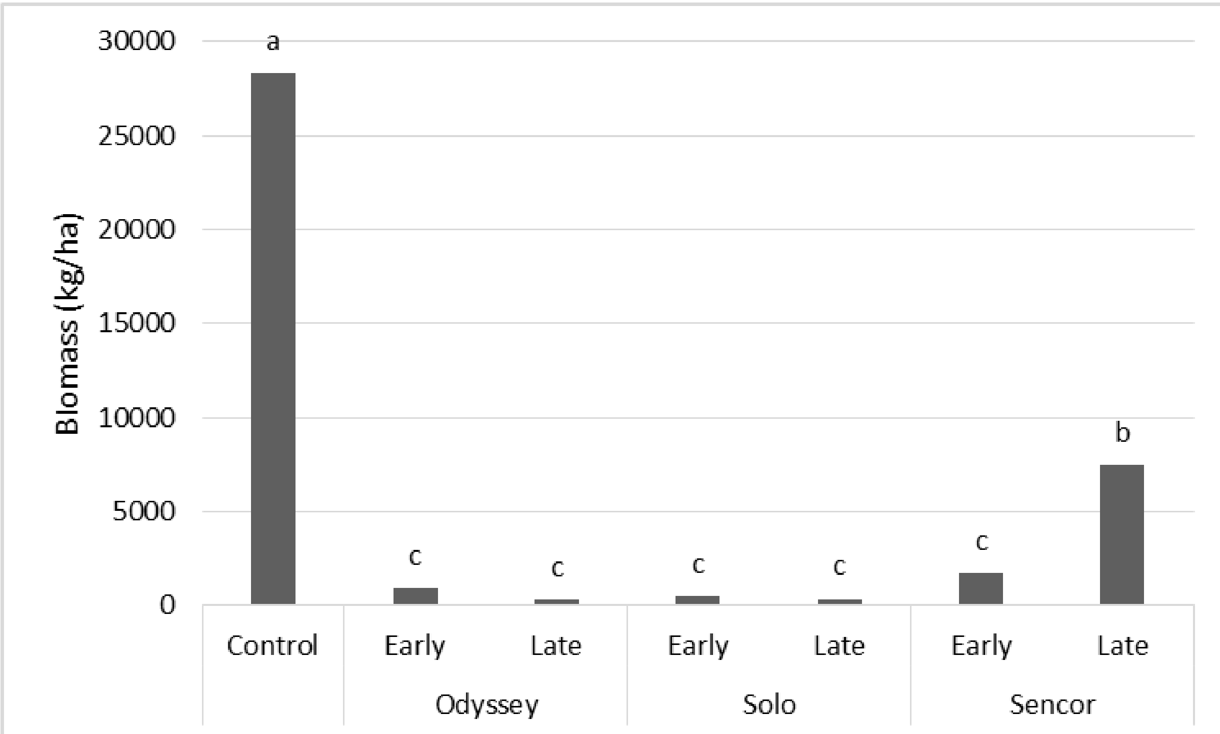

Figure 3. Weed biomass in lentils sprayed with various herbicide options at Scott.

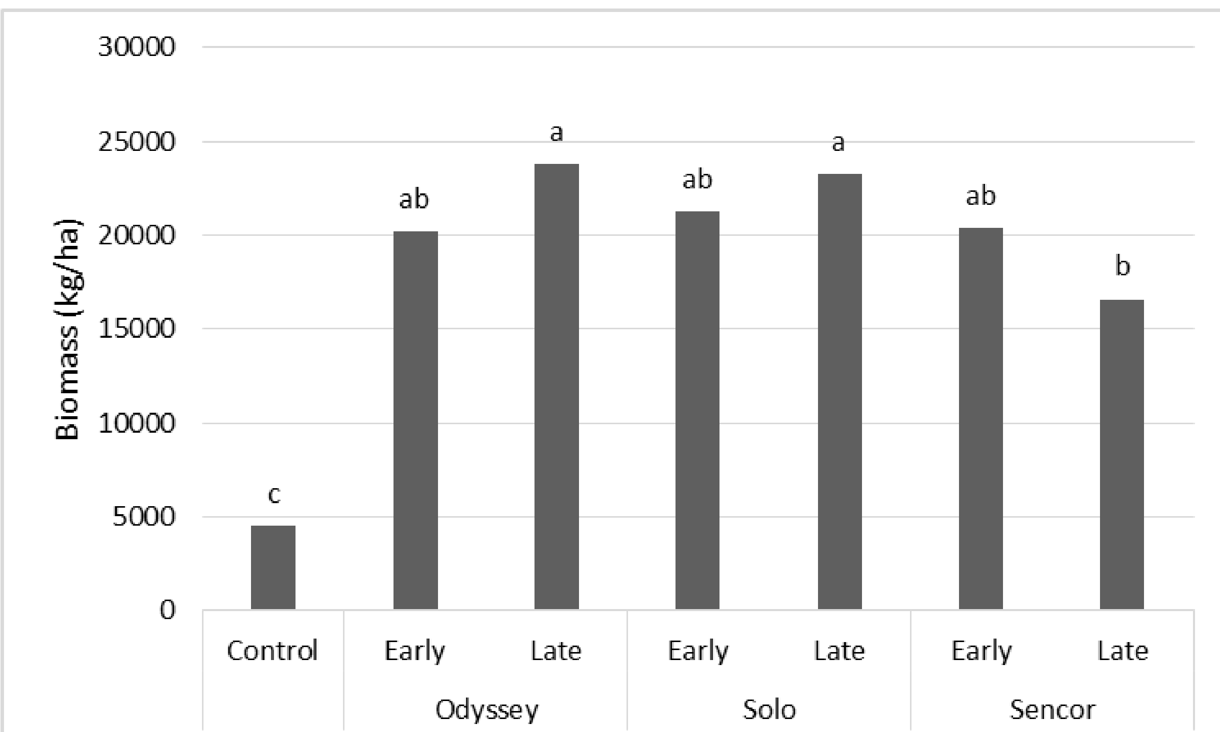

Figure 4. Crop biomass of lentils sprayed with various herbicide options at Scott.

Conclusions: For field pea, late applications of all three herbicides may reduce weed control and seed yields, as seen at Prince Albert. A late application of Sencor may cause crop injury in lentil and reduced weed control, reducing lentil yields, as seen at Scott. We recommend applying these herbicides early in the application window to control broadleaf and grassy weeds and reduce crop injury.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Managing Herbicide Resistance in Kochia

Authors & Affiliations: Tristan Coelho, Laryssa Grenkow - Western Applied Research Corporation

Background & Objectives: Group 2 herbicide resistant kochia has spread rapidly across the prairies and glyphosate (Group 9) resistant kochia also identified in Alberta. The biology of kochia allows for the rapid development and spread of herbicide resistance biotypes. To delay the onset of herbicide resistance it is recommended to tank-mix and rotate broadleaf herbicide groups. Several in-crop tank-mix options with Groups 4 and 6 herbicides are available for wheat growers. Current options to control resistant kochia in canola are primarily limited to pre-seed products. The objective of this trial is to demonstrate the wide range of herbicide control options for kochia.

Methodology: The demonstration was conducted at Scott in 2013. Soil at the Scott research farm is characterised as a Scott loam in the Dark Brown Soil Zone, with an organic matter content of 2.4% in the top 30 cm and pH of 6.0. Plots were established on no-till wheat stubble. Twenty-nine herbicide treatments were applied, including some fall and spring pre-plant products as well as in-crop products (Table 1). The treatments were arranged as a split-plot design with two replicates. The main factor in each plot was the herbicide treatment (Table 1) and the sub-factor was kochia type; Group 2 resistant and Group 2 susceptible kochia were each broadcast (600 seeds m^{-2}) within half of every plot. Fall herbicide treatments and kochia were applied October 18th, 2012. The nine spring pre-plant treatments were applied May 22nd, 2013. Shaw VB hard red spring wheat was seeded (at 112 kg ha^{-1}) to all plots on May 23rd, 2013. The remaining in-crop herbicide applications were applied June 27th, 2013 when the wheat crop reached the four-leaf stage. Kochia control was determined by a visual rating of the presence of kochia in both the susceptible and resistant portions of the plot separately. Plots were rated as G for good, F for fair or P for poor control of kochia. There were two ratings for each plot and the alphabetical rating was converted into a numerical rating as follows: GG=10, GF=8, FF=6, FP=4 and PP=2.

Results: Kochia control differed between herbicide treatments and type of kochia seeded. The best control of both resistant and susceptible biotypes was obtained with 11 herbicides including; fall application of Edge (with incorporation) (Figure 1), pre-plant application of glyphosate tank mixed with either bromoxynil or Distinct (Figure 1), and in-crop herbicides such as Retain, Pulsar, Trophy, Prestige, Optica Trio, Dvyel SP, Target and Benchmark (Figure 2). Seventeen remaining treatments provided better control of the susceptible biotype compared to the resistant biotype. In this project the susceptible kochia did not establish as well as the resistant which could have been related to the vigour of the seed. Therefore, the susceptible may have had lower stands to start with and reduced vigor which makes it appear to be more easily controlled.

Table 1: Treatment number, herbicide name, herbicide group(s), application timing and application date of the twenty-nine treatments included in this demonstration.

Treatment	Herbicide	Group	Timing
1	Edge granular + incorporation	3	fall
2	Fortress	3,8	fall
3	Glyphosate + 2,4-D amine	4,9	Pre-plant
4	Glyphosate + Bromoxynil	6,9	Pre-plant
5	Glyphosate + Dicamba	4,9	Pre-plant
6	Glyphosate + Distinct	4,9,19	Pre-plant
7	Glyphosate + Heat	9,14	Pre-plant
8	Glyphosate + Aim	9,14	Pre-plant
9	Glyphosate + Target	4,9	Pre-plant
10	Prepass	2,9	Pre-plant
11	Amitrole	13	Pre-plant
12	2,4-D	4	in-crop
13	Bromoxynil	6	in-crop
14	Retain	2,4	in-crop
15	Refine SG	2	in-crop
16	Pulsar	4	in-crop
17	Infinity	6,27	in-crop
18	Trophy	4	in-crop
19	Prestige	4	in-crop
20	Optica Trio	4	in-crop
21	Frontline XL	2,4	in-crop
22	Frontline 2,4-D	2,4	in-crop
23	Attain XC	4	in-crop
24	Dyvel SP	4	in-crop
25	Bromoxynil-MCPA	4,6	in-crop
26	Bromoxynil-2,4-D	4,6	in-crop
27	Benchmark	2,6	in-crop
28	Triton K	2,4	in-crop
29	Target	4	in-crop

Conclusions: Eleven herbicide options registered for spring wheat provided excellent control of both Gr. 2 resistant and susceptible biotypes: fall-applied Edge (Gr. 3), pre-plant-applied glyphosate (Gr. 9) tank-mixed with either bromoxynil (Gr. 6) or Distinct (Gr. 6, 19) and in-crop herbicides such as, Pulsar, Trophy, Prestige, Optica Trio, Dvyel SP, Target (all Gr. 4), Benchmark (Gr. 2, 6) and Retain (Gr. 2, 4). The diverse selection of effective herbicides in this demo shows that switching herbicide groups can provide excellent weed control equipping producers with various options to manage kochia, including rotating herbicide groups and/or tank-mixing and thus reducing selection pressure.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

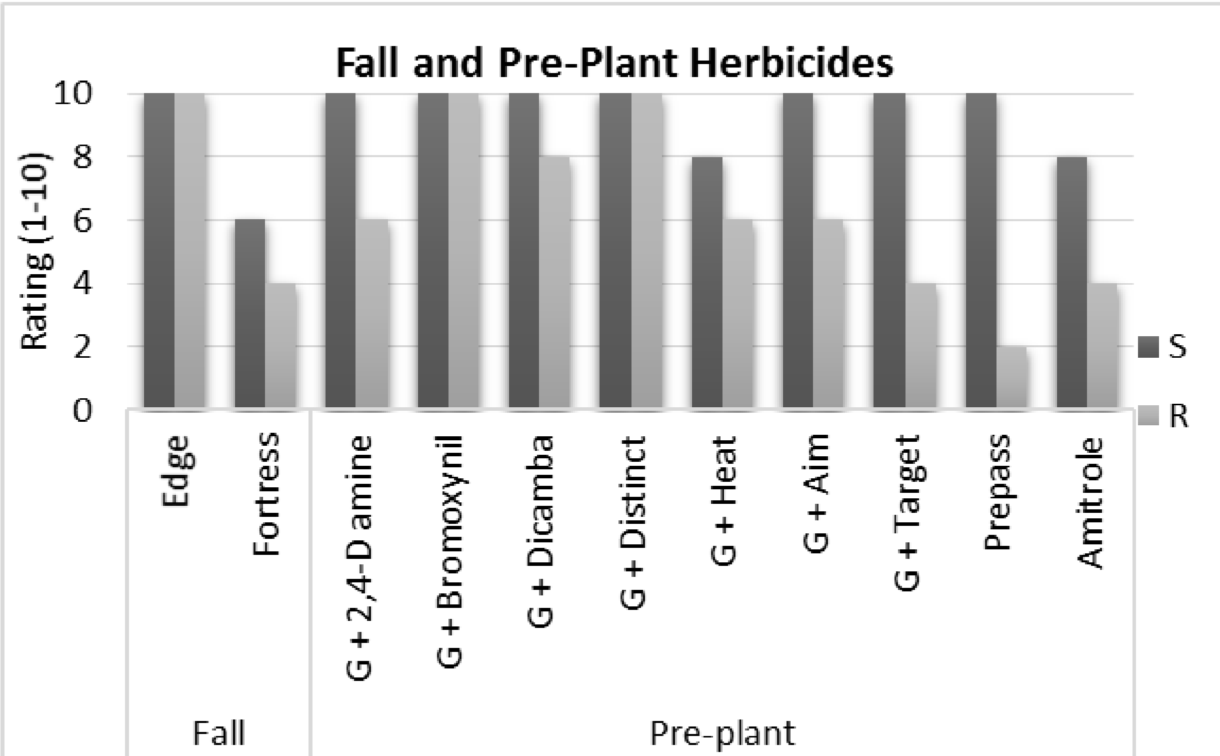

Figure 1. Control ratings of Group 2 susceptible (S) and resistant (R) Kochia with pre-plant or fall applied herbicides. Control rating from 2 to 10 = very poor to very good.

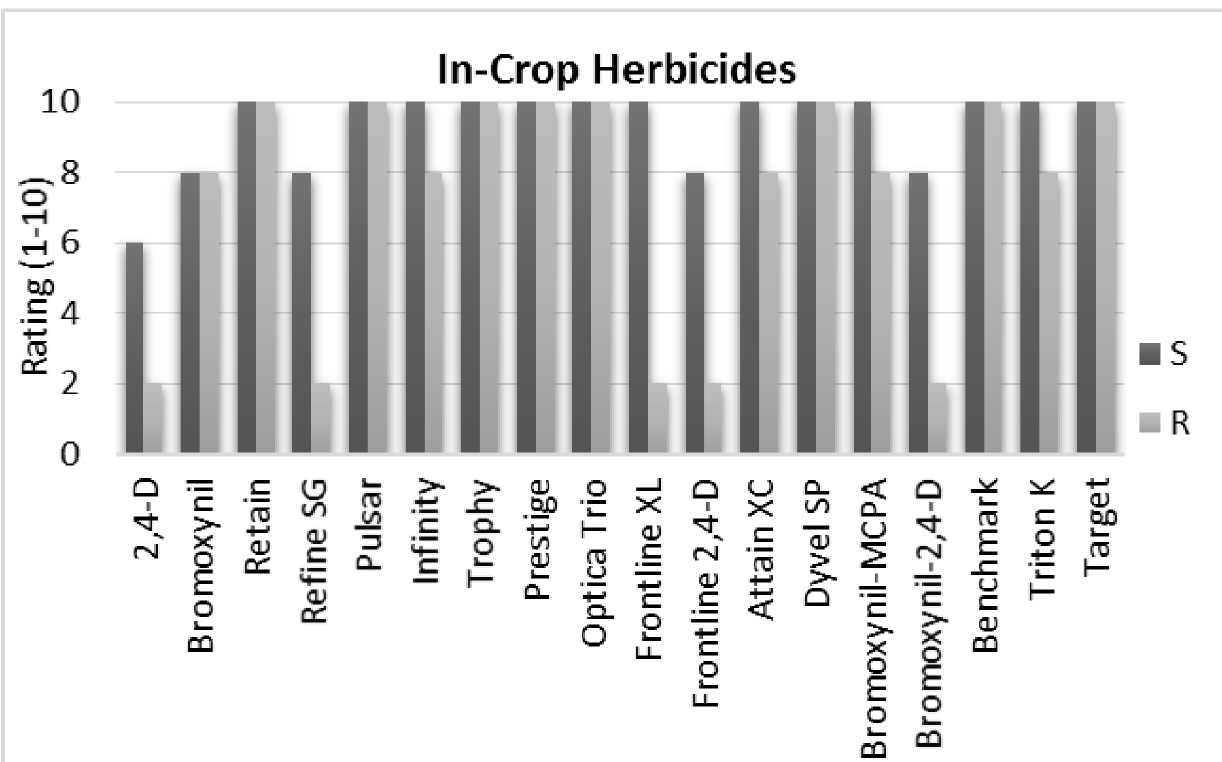

Figure 2. Control ratings of Group 2 susceptible (S) and resistant (R) Kochia with in-crop herbicides. Control rating from 2 to 10 = very poor to very good.

Demonstrating the Effects of Fungicide Application Timing on Leaf Disease and Fusarium Head Blight Infection Levels in Wheat

Authors & Affiliations: Chris Holzapfel – Indian Head Agricultural Research Foundation, Stuart Brandt, Northeast Agricultural Research Foundation, Laryssa Grenkow – Western Applied Research Corporation, Bryan Nybo – Wheatland Conservation Area, Larry White – Conservation Learning Centre

Background & Objectives: The increase in leaf disease and fusarium head blight (FHB) in spring wheat due to wet weather in recent years combined with strong grain prices has resulted in increased fungicide use for the majority of growers in Saskatchewan. The optimum timing of fungicide application for control of leaf spotting diseases is flag leaf stage, while the optimum timing for suppression of FHB is at early flowering. Even though optimum fungicide timing differs, producers are interested in the effects of a single fungicide application to control both leaf spotting diseases and FHB. Spring wheat cultivars differ in their genetic resistance to fungal pathogens and, consequently, the benefits of fungicide application may differ between cultivars. This objective of this trial is to demonstrate the effects of fungicide timing on leaf spot disease and FHB on two wheat cultivars that differ in their genetic resistance to fungal pathogens.

Methodology: Field demonstrations were conducted in 2013 near Indian Head, Melfort, Scott, Swift Current and Prince Albert. The varieties Unity VB or Shaw VB were treated with one of seven fungicide treatments. Unity VB is rated as fair for both FHB and leaf spot disease resistance while Shaw VB has poor resistance to both. The specific timings of fungicide application were based on the growth stage of the crop where T1 denotes flag-leaf stage, T2 denotes 75% head emergence and T3 was at the early flowering stage. Twinline was used for T1 and Prosaro used for T2/T3 applications at Swift current and Melfort. Acapela was used for T1 and Caramba used for T2/T3 applications at Scott and Indian Head. Treatments were arranged in as a randomized complete block design with four replicates. Spring wheat was direct-seeded at 375 seeds m^{-2}. Fertilizer was applied according to soil test recommendations and herbicides were applied as required by each site.

Results:

<u>Indian Head</u>

Overall at Indian Head, leaf disease levels were low at the time of flag-leaf fungicide application likely due to the drier than normal May, July and August. Disease levels were slightly higher for Shaw VB than for Unity VB (data not show) but leaf spot disease was not observed in the upper canopy (i.e. flag leaf) for either variety at the flag leaf stage. By the time the crop had finished flowering, leaf disease levels were higher with some spotting on the flag leaf, but were still relatively low overall. There appeared to be only a small reduction in leaf disease associated with the fungicide applications (data not shown). While FHB was detected, levels were low. There was an overall tendency for higher FHB severity and incidence with Shaw VB and, according to the ratings, the T3 fungicide application (early flower) appeared to be more effective at reducing FHB than the T2 application time (data not shown).

Grain yields at Indian Head differed between the two varieties and also amongst the fungicide treatments but the effect of fungicide on yield was similar for the two varieties with no V x F interaction detected. Spring wheat yields were well above average at Indian Head and, on average, Shaw VB yielded 501 kg ha^{-1}, or 10% higher than Unity VB. Similar yields were observed for the untreated check and T1 treatment (Table 1). While yields associated with the T2 treatment tended to be higher than the check or T1 treatment, only the T3 treatment significantly increased yields when averaged across both varieties (Table

1). Combining multiple application of fungicide did not provided statistically higher yields compared to the single application made at T3 (Table 1).

Table 1. Grain yield, thousand kernel weight, test weight, fusarium and blackpoint damage by variety and fungicide treatment at Indian Head in 2013. Means within a column followed by the same letter do not significantly differ.

Source	Grain Yield	1000 Seed Weight	Test Weight	Fusarium Damage	Blackpoint Damage
Variety	*kg ha^{-1}*	*g*	*kg ha^{-1}*	*%*	*%*
Unity	5204 b	34.6 b	82.3 a	0.02 a	0.10 b
Shaw	5705 a	35.2 a	82.2 a	0.02 a	0.79 a
SE	27.4	0.12	0.06	0.17	0.15
Fungicide					
Nil	5328 c	34.9 a	82.2 a	0.09 a	0.71 ab
T1	5243 c	34.7 a	82.2 a	0.03 a	1.28 a
T2	5383 bc	35.0 a	82.3 a	0.00 a	0.30 ab
T3	5576 ab	34.7 a	82.3 a	0.00 a	0.10 ab
T1 + T2	5410 abc	35.0 a	82.1 a	0.01 a	0.56 ab
T1 + T3	5617 a	35.0 a	82.3 a	0.01 a	0.17 ab
T1 + T2 + T3	5624 a	35.3 a	82.3 a	0.00 a	0.01 b
SE	51.3	0.23	0.10	0.02	0.28

The mean thousand kernel weight (TKW) was significantly higher for Shaw VB than it was for Unity VB (Table 1). Test weight and percent fusarium damaged kernels were not affected by variety or fungicide treatment but the effects on percent blackpoint infection were significant for both factors. Percent blackpoint was significantly higher for Shaw VB (0.8%) than for Unity VB (0.1%) and, with a significant fungicide effect, the tendency was for the highest blackpoint infection levels when only the flag-leaf application (T1) of fungicide was received (Table 1).

Melfort

May and August were drier than normal while June and July were wetter than normal, resulting in relatively low leaf spot diseases. In most cases and whenever fungicide was applied, the flag leaves were relatively free of disease at the time of the final ratings (data not shown). Similar to Indian Head, disease levels tended to higher with Shaw VB, particularly in the absence of foliar fungicides (data not shown). Fusarium head blight incidence and severity were higher at this location than any of the other sites. There were no consistent differences between the two varieties and no clear evidence of fungicide applications reducing the observed FHB infection based on the averaged ratings. Fusarium head blight incidence, always exceeded 50% at Melfort and the severity ranged from 10-19%.

Spring wheat yields were affected by variety and fungicide treatment with no V x F interaction detected. Similar to Indian Head, Shaw VB yielded 13.5%, or 595 kg ha^{-1} higher than Unity VB (Table 2). While all three individual fungicide applications tended to produce higher spring wheat yields than observed in the check, the greatest benefits were realized with the T2 and T3 applications. The only fungicide treatments that yielded significantly higher than the check received both the T1 and T3 applications. The lack of a significant V x F interaction suggests that the response to the various fungicide treatments was similar for the two varieties.

Table 2. Grain yield, thousand kernel weight, test weight, fusarium and blackpoint damage by variety and fungicide treatment at Melfort in 2013. Means within a column followed by the same letter do not significantly differ.

Source	Grain Yield	1000 Seed Weight	Test Weight	Fusarium Damage	Blackpoint Damage
Variety	*kg ha^{-1}*	*g*	*kg ha^{-1}*	*%*	*%*
Unity	4402 a	36.1 a	85.8 a	0.10 a	0.20 b
Shaw	4997 b	36.4 a	85.5 b	0.08 a	0.96 a
SE	60.0	0.17	0.06	0.013	0.11
Fungicide					
Nil	4340 b	35.3 b	85.5 a	0.11 ab	0.36 a
T1	4521 ab	35.8 ab	85.6 a	0.16 a	0.56 a
T2	4736 ab	36.5 ab	85.5 a	0.07 ab	0.73 a
T3	4829 ab	36.4 ab	85.7 a	0.07 ab	0.46 a
T1+ T2	4549 ab	36.8 a	85.5 a	0.08 ab	1.04 a
T1+ T3	4954 a	36. 5 ab	85.9 a	0.10 ab	0.54 a
T1+T2+T3	4965 a	36.4 ab	85.7 a	0.04 b	0.35 a
SE	112.2	0.31	0.11	0.024	0.20

Thousand seed weights tended to be higher with fungicide applications, particularly with the T2 and T3 application times (Table 2). Test weight was significantly higher for Unity VB than for Shaw VB (Table 2). Although highest of all the locations, the levels of fusarium damaged kernels detected in the cleaned grain sample were still relatively low at Melfort (0.09% on average) and there were relatively few significant differences amongst individual fungicide treatments (Table 2). Percent fusarium damaged kernels tended to be highest when fungicide was solely applied at the flag-leaf stage and lowest in the treatments that received either the T2 or T3 applications or no fungicidel (Table 2). Overall blackpoint infection levels were significantly higher for Shaw VB than for Unity VB but were not affected by fungicide (Table 2).

Scott

Precipitation amounts were nearly two times the long-term average in June but well below average in July while the crop was heading and flowering. Adequate moisture in August allowed for yields that were well above average. Estimated leaf disease levels were lower than those observed at Indian Head and Melfort but, as expected, were slightly lower with Unity VB than for Shaw VB (data not shown). All fungicides tended to reduce leaf spot disease ratings regardless of the application timing. Overall FHB severity and incidence levels were very low with no consistent differences amongst varieties or fungicide treatments (data not shown); however, stagonospora nodorum blotch infection levels were substantial. Overall, stagonospora nodorum blotch was more severe in Shaw VB than it was in Unity VB and fungicides did appear to reduce infection levels, particularly with T3 applications (data not shown).

Consistent with the previous two locations, spring wheat yields were affected by both variety and fungicide but no interaction between these two factors was detected. In contrast to Indian Head and Melfort, Unity VB out yielded Shaw VB by 7% at Scott, with an observed difference of 381 kg ha^{-1} (Table 3). All treatments that received a fungicide application tended yield higher than the check; however, the best results were observed when fungicide was applied at T2 or T3 timings. There appeared to be some benefit to the dual application (T1 + T2) but the yields were not statistically different from a single T3 application (Table 3).

Table 3. Grain yield, thousand kernel weight, test weight, fusarium and blackpoint damage by variety and fungicide treatment at Scott in 2013. Means within a column followed by the same letter do not significantly differ.

Source	Grain Yield	1000 Seed Weight	Test Weight	Fusarium Damage	Blackpoint Damage
Variety	*kg ha^{-1}*	*g*	*kg ha^{-1}*	*%*	*%*
Unity	5508 a	36.8 a	82.5 a	0.00	0.04 b
Shaw	5127 b	36.3 a	82.5 a	0.00	0.38 a
SE	88.1	0.24	0.16	—	0.082
Fungicide					
Nil	4511 c	33.6 b	81.9 a	0.00	0.14 a
T1	5030 bc	37.0 a	82.5 a	0.00	0.22 a
T2	5178 abc	36.7 a	82.4 a	0.00	0.21 a
T3	5644 ab	36.7 a	82.9 a	0.00	0.11 a
T1 + T2	5772 a	37.4 a	82.7 a	0.00	0.46 a
T1 + T3	5613 ab	37.4 a	82.5 a	0.00	0.04 a
T1 + T2 + T3	5475 ab	37.0 a	82.4 a	0.00	0.30 a
SE	164.8	0.45	0.30	—	0.153

Thousand seed weights were similar for the two varieties but were increased by an average of 10% with fungicide applications. Test weights were not affected by either variety or fungicide treatment. No fusarium damaged kernels were detected at Scott while percent blackpoint infection differed between varieties (0.04% for Unity VB and 0.38% for Shaw VB) but not by fungicide.

<u>Swift Current</u>

As a result of the drier overall conditions that at this location, leaf disease levels were low both prior to the flag-leaf fungicide application and at the soft dough stage, but were noticeably higher in Shaw VB than for Unity VB (data not shown). There was no obvious reduction in leaf disease associated with the application of foliar fungicides. Individual heads were not rated for FHB infection because close the untreated check plots did not show any signs of this disease.

Spring wheat yields at Swift Current were affected by variety but not fungicide treatment and, again, there was no V x F interaction detected. Similar to at Indian Head and Melfort, Shaw VB was the higher yielding of the two varieties (242 kg ha^{-1} or 6.5% higher than Unity VB).

No differences inTKW amongst either the varieties or fungicide treatments were detected (Table 4). Fungicide effects on test weight were somewhat inconsistent and there were relatively few significant differences between individual treatments. Percent blackpoint infection was extremely low for Unity VB (0.01%) but significantly higher for Shaw VB (0.16%).

<u>Prince Albert</u>

May was drier than normal but June and July were much wetter than normal. Data from several plots were discarded due to flooding and overall yields were limited by excess moisture. While disease ratings of individual plots were not completed, visual assessments of the plots on July 31 and August 8 did not detect any leaf spot disease or FHB at this location. Grain yield was affected by fungicide but not variety. Similar to Scott and in contrast to the other sites, Unity VB at Prince Albert tended to yield higher than Shaw VB with average yields of 2507 and 2270 kg ha^{-1}; however, the difference was not statistically

Table 4. Grain yield, thousand kernel weight, test weight, fusarium and blackpoint damage by variety and fungicide treatment at Swift Current in 2013. Means within a column followed by the same letter do not significantly differ.

Source	Grain Yield	1000 Seed Weight	Test Weight	Fusarium Damage	Blackpoint Damage
Variety	*kg ha^{-1}*	*g*	*kg hl^{-1}*	*%*	*%*
Unity	3712 b	32.4 a	81.0 a	0.00	0.01 b
Shaw	3954 a	32.5 a	80.8 a	0.00	0.16 a
SE	71.5	0.27	0.10	–	0.031
Fungicide					
Nil	3777 a	32.7 a	81.2 a	0.00	0.06 a
T1	3901 a	32.9 a	81.3 a	0.00	0.05 a
T2	3797 a	32.2 a	81.2 ab	0.00	0.05 a
T3	3841 a	32.3 a	80.3 b	0.00	0.08 a
T1 + T2	3902 a	32.7 a	80.7 ab	0.00	0.13 a
T1 + T3	3670 a	31.8 a	80.9 ab	0.00	0.01 a
T1 + T2 + T3	3941 a	32.4 a	80.8 ab	0.00	0.21 a
SE	133.7	0.51	0.20	–	0.059

significant (Table 5). While the overall effect of fungicide was significant, the estimated means were variable and there were no significant differences between individual treatments. The high variability and loss of data points that resulted from flooding made it difficult to detect significant effects at this site. No FHB was detected (Table 5). Although not statistically significant, the results suggested that blackpoint was lower for Unity VB than for Shaw VB and infection levels appeared to be the highest when no fungicide was applied (Table 5).

Table 5. Grain yield, thousand kernel weight, test weight, fusarium and blackpoint damage by variety and fungicide treatment at Prince Albert in 2013. Means within a column followed by the same letter do not significantly differ.

Source	Grain Yield	1000 Seed Weight	Test Weight	Fusarium Damage	Blackpoint Damage
Variety	*kg ha^{-1}*	*g*	*kg hl^{-1}*	*%*	*%*
Unity	2507 a	37.5 a	82.7 a	0.00	0.04
Shaw	2270 a	37.9 a	81.3 a	0.00	0.20
SE	99.2	0.41	2.90	—	—
Fungicide					
Nil	2449 a	37.5 a	81.4 a	0.00	0.45
T1	2736 a	37.5 a	82.2 a	0.00	0.00
T2	2575 a	38.3 a	83.4 a	0.00	0.00
T3	1963 a	38.4 a	80.5 a	0.00	0.05
T1+ T2	2510 a	37.3 a	82.0 a	0.00	0.10
T1+ T3	2046 a	37.4 a	81.8 a	0.00	0.10
T1+T2+T3	2441 a	37.7 a	82.9 a	0.00	0.15
SE	183.3	0.75	1.10	—	—

Conclusions: While weather conditions during the 2013 growing season in Saskatchewan were less conducive to the development of cereal diseases than those encountered the previous season, reasonably strong fungicide responses were detected at three of the five sites (Indian Head, Melfort and Scott). There were no responses to fungicide at Swift Current, where the climate is drier and observed disease levels were extremely low, or at Prince Albert where overall yields were limited by excess moisture. Averaged across varieties, yield increases associated with foliar fungicide application were 6%, 14% and 25% at Indian Head, Melfort and Scott, respectively. The early flower stage (T3) provided the highest and most consistent yield response at all three of these locations. There were no cases where a dual fungicide application resulted in higher yields than a single T3 application. The flag-leaf application (T1) provided no yield benefit over the untreated check. At the three locations where FHB infection was observed in the plots, the severity was never high enough to result in grade reductions. While, numerically, percent fusarium damaged kernels tended to be lower in treatments that received either the T2 or T3 applications, treatment differences were rarely significant due to the high variability and low overall levels. The exception to this was Melfort where percent fusarium damaged kernels were generally lower with the T2 and T3 applications. Percent blackpoint infected kernels were typically higher with Shaw VB as opposed to Unity VB but were rarely affected by fungicide application. Despite the contrasting disease packages of the two varieties chosen for this demonstration, variety by fungicide (V x F) interactions were never detected for grain yield. This result would suggest that at sites where disease pressure is moderate to high, fungicides were beneficial regardless of the genetic disease resistance and in environments where disease pressure was low or other factors were limiting yield, the fungicides did not provide any benefits, regardless of the variety. Based on the results of this demonstration, the probability of dual fungicide applications being economically viable for spring wheat in Saskatchewan is relatively low. Fungicide applications targeting FHB will also provide protection against leaf spot disease and gave the most consistent yield benefits. A good option might be to select varieties with good resistance to leaf disease but to plan on applying a fungicide to control FHB sometime between 75% head emergence and early flowering, especially when warm and humid conditions are encountered. This trial will be conducted again in 2014 without the T2 (75% head emergence) treatments.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Straight Combining Canola Small Plot Demonstration

Authors & Affiliations: Stuart Brandt, Northeast Agricultural Research Foundation, Chris Holzapfel – Indian Head Agricultural Research Foundation, Laryssa Grenkow – Western Applied Research Corporation, Larry White – Conservation Learning Centre

Background & Objectives: Canola swaths are subject to being blown about by winds, resulting in losses that usually exceed 50% in the blown swaths. The fall of 2012 was one of the worst years for such losses in recent memory. Canola can be left standing and straight combined, but here the risk is that pods will shatter or whole pods will fall off the plant. Canola cultivars with improved shatter resistance have been identified in recent years but many growers are still reluctant to straight combine these cultivars in part because they lack good information about the risk relative to swathing. The objective of this trial is to demonstrate the risks and benefits of the two combining options and management considerations with both, allowing growers to make better informed decisions about when and where to utilize each harvesting option.

Methodology: The trial was conducted at Melfort, Indian Head, Scott and Prince Albert in 2013. There were five harvesting treatments applied to the canola: swathing at 20-30% seed colour change (SCC), swathing at 50-60% SCC, straight cutting at 12% seed moisture content (SMC), straight cutting one and two weeks after the first straight cutting date (Table 1). Treatment were arranged as a randomized complete block design with eight replicates. The entire trial was applied to canola seeded both at early and late May to capture differing environmental conditions during growth, maturity and harvest at each location. The variety used was InVigor 5440 and was seeded at 125 seeds m^{-2}. Fertilizer was applied according to soil test recommendations and herbicides were applied as required by each site.

Table 1. Dates of swathing and straight cutting treatments at Melfort, Indian Head, Prince Albert and Scott in 2013.

	Sites						
Treatment	Melfort (early)	Melfort (late)	Indian Head (early)	Prince Albert (early)	Prince Albert (late)	Scott (early)	Scott (late)
Swath @ 20-30% SCC	Aug 26	Sept 13	Aug 21	Sept 4	Sept 4	Aug 21	Sept 9
Swath @ 50-60% SCC	Aug 30	Sept 18	Aug 27	Sept 9	Sept 9	Aug 27	Sept 16
Straight @ 12% SMC	Sept 13	Sept 30	Sep 12	Oct 15	Oct 15	Sept 12	Sept 27
Straight @ 12% SMC + 7 days	Sept 20	Oct 8	Sep 21	Oct 21	Oct 21	Sept 19	Oct 4
Straight @ 12% SMC + 14 days	Sept 30	Oct 18	Sep 28	Oct 28	Oct 28	Sept 27	Oct 19

Results:

Melfort

Canola yield was generally higher with straight cutting compared with swathing (Table 2). However swathing at 50-60% SCC was statistically similar to straight cutting at 12% SMC or at 14 days later when canola was seeded early. Lower yield where canola was swathed at 20-30% SCC when seeded early was likely due to incomplete seed filling as evidenced by lower seed weight (data not shown). When seeded late, swathing at 50-60% SCC was statistically similar to all straight cutting stages. Reduced yield with the late seeded canola swathed at 50-60% SCC was likely due to shatter losses during swathing as the crop was very dry at this stage. Low yield with straight cutting at 14 days after the crop dried to 12% SMC in the late seeded canola could be attributed to pod shatter during or before combining. Wind speed reached ≥ 50 km hr^{-1} on August 30th, September 16, 21, 29, 30, October 7 and 15.

Indian Head

Seed yield was highest where straight cutting was done 14 days after 12% SMC or where swathing was done at 50-60% SCC. Swathing at 20-30% SCC resulted in statistically lower yield than any other treatment due to incomplete seed filling where swathing was done early at the 20-30% SCC stage as suggested by reduced seed weight (data not shown). Wind speed reached ≥ 50 km hr^{-1} five days between August 21 and September 28.

Prince Albert

Straight cutting at 14 days after 12% SMC resulted in a dramatic reduction in yield compared with other treatments where the crop was sown early. There were not statistical differences between any of the other treatments at the early seeding date. Shatter losses appeared to increase as combining was delayed beyond the point where the crop had dried to 12% SMC, likely due to the very long period of time that elapsed between harvest dates at this site. Where seeding was delayed, yield was highest with straight cutting at 12% SMC followed by straight cutting 7 days later. Yields were lower where the crop was straight cut at 14 days after 12% SMC or where swathing was done at 50-60% SCC. Lowest yield was where swathing was done at 20-30% SCC. Yields were likely reduced due to incomplete seed filling where swathing was done, while delaying straight cutting past 12% SMC increased seed shatter losses.

Scott

With early seeding, yield was highest with straight cutting at 7 days after 12% SMC followed by straight cutting at 14 days after 12% SMC. Lowest yield occurred where the crop was swathed at 20-30% SCC, due to incomplete seed filling, as seen with lower seed weights (data not shown).

Where seeding was delayed, yield was highest where swathing was done at 50-60% SCC or straight cut at 12% SMC. During the time period where the early seeding date canola was swathed and straight-combined wind reached ≥ 50 km hr^{-1} on September 23 and 26 only. During the swathing and harvesting of the late seeded canola there were 5 days with ≥ 50 km hr^{-1} wind speeds.

Table 2. Canola yield (kg/ha) with swathing or straight cutting at various timings at Melfort, Indian Head, Prince Albert and Scott in 2013.

	Sites							
Treatment	Melfort (early)	Melfort (late)	Indian Head (early)	Prince Albert (early)	Prince Albert (late)	Scott (early)	Scott (late)	All Sites Mean
Swath @ 20-30% SCC	3494	2209	3355	3975	2585	3173	3351	3163
Swath @ 50-60% SCC	3677	1885	3644	3707	2811	3558	3604	3269
Straight @ 12% SMC	3721	2447	3558	3925	3608	3444	3583	3469
Straight @ 12% SMC+7D	3850	2436	3442	3551	3074	3958	3365	3382
Straight @ 12% SMC+14D	3716	2154	3758	2934	2723	3792	3433	3216
LSD P=0.05	173	252	123	470	238	194	168	
Probability of F	0.0008	0.0005	0.0001	0.0028	0.0001	0.0001	0.0083	

Although the effect of harvest timing had significant effects on seed weight at Scott and Indian Head only, most other sites followed similar trends (data not shown). Swathing generally resulted in low seed weight; seed weight was lowest with swathing at 20-30% SCC, and highest at the point where the crop was straight cut at 12% SMC. Tendencies for seed weight to decline when straight cutting was delayed past 12% SMC may have reflected shattering of larger pods containing larger seeds. Green seed was quite variable between treatments with little evidence of any real trends (data not shown).

Conclusions: During the harvest period from late August through October of 2013, conditions were much drier and wind events were not nearly as severe as during 2012. Under these conditions, overall, straight cutting when the crop reached 12% SMC provided the greatest yield. Sometimes either straight cutting at 7 days after the 12% SMC or swathing at 50-60% SCC resulted in yield equal to straight cutting at 12% SMC. In five of seven cases, swathing earlier at 20-30% SCC resulted in reduced yield compared with swathing at 50-60% SCC. Delaying straight cutting for 2 or more weeks after the crop first dried to 12% SMC resulted in increased yield at 3 sites and decreased yield at another two sites. Overall cutting too early risks reduced yield due to incomplete seed filling, while delaying swathing beyond the 12% seed moisture stage risks increased seed shatter losses.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Nitrogen Fertilizer Management Options for Winter Wheat

Authors & Affiliations: Chris Holzapfel – Indian Head Agricultural Research Foundation, Laryssa Grenkow – Western Applied Research Corporation

Background & Objectives:
In order to minimize N fertilizer losses due to leaching and denitrification in the fall and early spring, the traditional recommendation for winter wheat in southeast Saskatchewan has been to broadcast N fertilizer early in the spring. The N fertilizer alternatives include applying urea or anhydrous ammonia at seeding (side- or mid-row band) or surface applications of liquid urea ammonium nitrate (UAN) or urea early in the spring. Due to the long growing season of winter wheat and high potential for environmental losses with fall or surface applications of N, slow release products such as Super Urea (SU), Nutrisphere-N (NSN) or ESN may also have merit for use with this crop. Urea ammonium nitrate has been a popular alternative to ammonium nitrate for spring broadcasting because it can be applied with a sprayer and has reduced the potential for NH_3 loss relative to urea; however, fall applications of UAN are not recommended because the NO_3^-, which comprises 25% of the total N in UAN, is susceptible to leaching and denitrification. The objective of this trial is to demonstrate various options available to producers for managing N fertility in winter wheat and enable them to choose methods that fit their farming operations while minimizing risks at the same time.

Methodology: A winter wheat field trial was initiated in the fall of 2012 at Indian Head and Scott. Twenty-three N fertilizer treatments were evaluated where the rates, placement methods, timings and forms of N fertilizer were varied. The applied N rate was 0, 75 or 115 kg N ha^{-1} and the forms were untreated urea (46-0-0), ESN (44-0-0), NSN (46-0-0), UAN (28-0-0) or AN (34-0-0). For fall applications, granular fertilizers were placed in a side-band while, for spring applications, granular fertilizer was broadcast on the soil surface. Liquid UAN was applied in surface dribble-band. Split-applications received 40% of fertilizer in fall and the remainder in spring. Treatment were arranged as a randomized complete block design with four replicates. The winter wheat variety CDC Buteo was directed seeded at 300 seeds m^{-2} into canola stubble on September 14, 2012 at Indian Head. Fertilizer was applied according to soil test recommendations and herbicides were applied as required by each site. Plots at Scott were terminated before harvest due to poor over-wintering conditions, reducing plant populations below sufficient levels.

Results: Results presented are those from the Indian Head site only. Mean plant densities for all treatments were extremely low, ranging from only 29-80 plants m^{-2} (Table 1). Winter Cereals Canada recommends that stands below 45 plants m^{-2} may require re-seeding. The overall effect of N fertilizer treatment on plant densities was significant. While relatively few individual treatment differences were significant, averaged across all forms, fall N application resulted in densities of 65 plants m^{-2} while the average population for spring application was on 43 plants m^{-2} (data not shown). Split application resulted in similar plant populations as the fall application and higher populations than spring application, indicating that applying 40% of the fertilizer in the fall was sufficient to achieve the improved plant stands. When fall versus spring applications were compared for individual N forms, fall was better for all granular formulations (24-26 plants m^{-2} higher plant densities) but no difference was observed between fall and spring dribble banded UAN (data not shown). All the N formulations performed similarly to untreated urea, with the exception of UAN applied in the fall, which was inferior to untreated urea.

Table 1. Effect of N fertilizer treatment on winter wheat plant density, height, grain yield and protein.

Treatment	Plant Density	Plant Height	Grain Yield	Protein
	---- *plants* m^{-2} ----	-------- *cm* --------	------- *kg* ha^{-1} ------	--------- % --------
Check (0 N)	43.5 ^{ab}	72 ^{b}	2834 ^{c}	12.2 ^{ab}
Fall – Urea – 75 N	80.1 ^{a}	82 ^{a}	3962 ^{abc}	12.6 ^{ab}
Fall – ESN – 75 N	70.0 ^{ab}	83 ^{a}	4259 ^{a}	12.2 ^{ab}
Fall – NSN – 75 N	72.2 ^{ab}	83 ^{a}	4257 ^{a}	12.1 ^{ab}
Fall – UAN – 75 N	45.7 ^{ab}	83 ^{a}	3903 ^{abc}	12.5 ^{ab}
Fall – Urea –115 N	66.4 ^{ab}	80 ^{ab}	4389 ^{a}	12.5 ^{ab}
Fall – ESN – 115 N	58.2 ^{ab}	84 ^{a}	4218 ^{ab}	12.4 ^{ab}
Fall – NSN – 115 N	67.8 ^{ab}	81 ^{ab}	4355 ^{a}	12.4 ^{ab}
Fall – UAN – 115 N	59.3 ^{ab}	83 ^{a}	4222 ^{ab}	12.6 ^{ab}
Spring – AN – 75 N	35.5 ^{ab}	79 ^{ab}	3623 ^{abc}	12.2 ^{ab}
Spring – Urea – 75 N	47.3 ^{ab}	83 ^{a}	3717 ^{abc}	12.4 ^{ab}
Spring – ESN – 75 N	31.7 ^{b}	80 ^{ab}	3311 ^{abc}	12.5 ^{ab}
Spring – NSN – 75 N	29.3 ^{b}	80 ^{ab}	2923 ^{bc}	12.6 ^{ab}
Spring – UAN – 75 N	46.8 ^{ab}	82 ^{a}	3508 ^{abc}	11.7 ^{b}
Spring – AN –115 N	30.1 ^{b}	82 ^{a}	3391 ^{abc}	12.5 ^{ab}
Spring – Urea – 115 N	48.4 ^{ab}	82 ^{a}	3302 ^{abc}	12.6 ^{ab}
Spring – ESN – 115 N	47.8 ^{ab}	82 ^{a}	3401 ^{abc}	12.8 ^{a}
Spring – NSN – 115 N	58.2 ^{ab}	82 ^{a}	3402 ^{abc}	12.9 ^{a}
Spring – UAN – 115 N	39.4 ^{ab}	80 ^{ab}	3548 ^{abc}	12.7 ^{a}
Split – Urea – 115 N	72.2 ^{ab}	83 ^{a}	4312 ^{a}	12.6 ^{ab}
Split – ESN – 115 N	78.7 ^{a}	80 ^{ab}	4089 ^{abc}	12.5 ^{ab}
Split – NSN – 115 N	53.6 ^{ab}	86 ^{a}	4406 ^{a}	12.4 ^{ab}
Split – UAN – 115 N	56.9 ^{ab}	81^{a}	4046 ^{abc}	12.6 ^{ab}

$^{a-c}$ Means within a column followed by the same letter do not significantly differ according to Tukey's studentized range test ($P \leq 0.05$).

Despite the poor overall establishment, winter wheat grain yields at Indian Head were just slightly lower than average: individual treatment yields ranged from 2834-4389 kg ha^{-1} and were affected by N fertilizer treatment (Table 1). Yields were similar between the two N fertilizer rates used indicating that the lower rate was sufficient to optimize yields. Similar to the results for plant density, grain yields for both fall application and split application were significantly higher than when the entire N requirements were applied in the spring (data not shown). Significantly higher yields were achieved with fall application for all forms (Table 1). Compared to spring broadcast AN, grain yields were significantly higher when N was applied in the fall but were similar with spring broadcast N, regardless of formulation (Table 1). When compared to untreated urea for either fall or spring application timing, no advantages (or disadvantages) to any of the controlled release N forms evaluated were observed (Table 1).

Within any given application times and rates, percent protein tended to be inversely related to grain yield. Increasing the N fertilizer rate (averaged across all forms and application times) from 75 to 115 kg N ha^{-1} increased protein concentrations from 12.3 to 12.6% (data not shown). Similar protein levels were achieved with fall and spring application which suggests higher overall N uptake and availability with fall application where grain yields were 24% higher.

Conclusions: With extremely dry conditions at planting followed by a late and relatively dry spring, 2012/13 was a challenging year for establishing winter wheat. In general, all treatments where N fertilizer was applied in the fall, regardless of rate, resulted in improved plant stands, higher grain yields, with the best results achieved with side-band placement. It appears that under the extremely dry fall soil conditions that were encountered, this was the most viable and effective option. Split-N treatments performed similarly to where N was applied in the fall. When all N was surface broadcast in the spring, both plant densities and grain yields were reduced. There was no observed advantage to the slow release N forms evaluated; however, in years where fall moisture levels are high, such products may be a good fit for winter wheat when applying N fertilizer in the fall. While ESN is generally better suited to in-soil placement, NSN may be good choices for broadcast applications. There was no yield difference between the two nitrogen rates (75 and 115 kg N ha^{-1}), but grain protein concentrations were increased significantly at the higher rate. Similar protein levels were observed (in most cases) with fall and spring N application. Based on these results, it is recommended that at least a portion of winter wheat N requirements be applied at time of seeding, particularly under dry conditions. The observed advantage to fall N application for winter wheat would not necessarily be achieved when soil moisture is high at the time of planting and applying N in a split application gives growers the opportunity to fine tune total N rates in the spring according to crop establishment, soil test results and economic considerations. This trial will be conducted again in 2014 at Scott and Indian Head with SuperU replacing NSN treatments.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Improving Phosphorus Efficiency

Authors & Affiliations: Tristan Coelho, Laryssa Grenkow - Western Applied Research Corporation

Background & Objectives: Phosphorus is a major crop nutrient that is required in relatively large amounts by plants; however, many prairie soils lack sufficient P. Seed-row placement of P fertilizer is often the most efficient placement because P is immobile in the soil and is important during the early stages of crop growth. There are many products on the market that promise to improve P use efficiency. One of the proposed benefits of Alpine liquid fertilizer is the higher concentration of orthophosphates compared to 10-34-0 fertilizer, which is primarily comprised of polyphosphates. Plant roots primarily take up P in the form of orthophosphates; however, ortho- and poly-phosphates are generally regarded to be equally available because polyphosphates are quickly hydrolyzed in the soil naturally before plants take up P in large quantities. Polyphosphates, in fact, can form chelates with Ca, Mg, Fe and Al (especially in alkaline or calcareous soils), reducing hydrolysis, improving P mobility in soil, increasing root interception and plant uptake of P. Additional proposed benefits of Alpine fertilizer include: a low salt index, a low impurity level, good product storability and a low viscosity. The objective of this trial is to demonstrate the benefits, if any, associated with liquid orthophosphates compared to liquid polyphosphates, and if there is any benefit of applying “starter P” on P-deficient soils.

Methodology: A non-replicated field scale demonstration was established in 2012, on a farm near Waseca, Saskatchewan. Plot size was approximately 32m x 800m. Treatments applied included a no P fertilizer check, Alpine (6-22-4) at 11 lbs P_2O_5/ac, Alpine at 15 lbs P_2O_5/ac, ammonium polyphosphate (APP) (10-34-0) at 15 lbs P_2O_5/ac, and a 50:50 blend of Alpine and APP applied at 30 lbs P_2O_5/ac. All fertilizer treatments were applied in the seed-row with canola. Soil samples were collected in the spring and fall of 2012.

The collaborating producer was unable to proceed with the application all of the treatments for the 2013 season due to limitations of equipment and products available. The demonstration was reduced to two treatments, the no P fertilizer check and APP at 25 lbs P_2O_5/ac was placed in the seed-row with wheat. Plant tissue samples for both treatments were collected at 75% head emergence, (60 days after sowing). Yield data for both 2012 and 2013 were collected using a yield monitor.

Results: Soil samples collected in the spring of 2012 revealed only 11 lbs P_2O_5/ac in the 0-6" depth, which is considered deficient for canola. In 2012, all fertilizer treatments appeared to improve canola seed yield over the no P fertilizer check; however, there was little difference in seed yield between fertilizer treatments (data not shown). Fall soil samples taken post-harvest revealed similar concentrations of all macronutrients in the 0-6" soil depth for all treatments.

In 2013, wheat tissue samples collected revealed that P was deficient in both treatments: 0.18% in the no P fertilizer check and 0.20% in the 25 lbs P_2O_5/ac. According to the Saskatchewan Ministry of Agriculture, the optimal level of above ground spring wheat plant P should be in the range of 0.25-0.5%. An increase of 0.02% P in the 25 lbs P_2O_5/ac treatment positively affected the concentration of other plant nutrients: increase of 0.16% Nitrogen, 0.34% Potassium and 0.04% Sulfur resulted. The fertilized treatment produced 61% more above ground biomass than the check in 2013 (data not shown). A visual assessment revealed taller plants, thicker stems and darker green leaves in the fertilized treatment. The 2013 yield monitor data showed a higher yield with the 25 lbs P_2O_5/ac treatment than the check.

Conclusions: Results from this demonstration should be taken cautiously, as the treatments were not replicated in space or time. It appeared that although starter P fertilizer can improve the yield of wheat and canola, P fertilizer applied below the rate required to satisfy crop demand may limit seed yield on P-deficient soils. There did not appear to be any advantage of using the Alpine fertilizer compare to APP. Adhering to the IPNI's 4R Nutrient Stewardship principles (applying the right fertilizer source, at the right rate, at the right time in the right place) will allow farmers to build a framework to maximize fertilizer use efficiency and crop yield potential.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Precision Inter-Row Seeding

Authors & Affiliations: Sherrilyn Phelps – Saskatchewan Ministry of Agriculture, Tristan Coelho - Western Applied Research Corporation

Background & Objectives: Seeding between stubble rows provides protection to the emerging crop and results in less drag on the tractor pulling the seeding equipment. Seeding into the soil between stubble rows should give better seed placement and allow for better packing, which is especially important for small seeded crops such as canola. The objective of this trial is to demonstrate the effect of precision seeding between the rows of last year's stubble compared to seeding with no consideration of stubble row on crop establishment and yield.

Methodology: The field-scale demonstration took place at three locations in 2013. The cooperating producers used equipment with capabilities to seed between the rows: a Seed Hawk was used at one location in Wilkie and at Waseca and a Bourgault Paralink was used at the other Wilkie location. Plot size was one seeder-width and treatments were only replicated at one of the Wilkie locations (were canola was seeded). Treatments evaluated included seeding the crop between stubble rows and seeding with no consideration of stubble row (seeding within the row). The producers' ability to seed between the rows was very consistent; however, seeding within/into the stubble rows was very inconsistent as the seeders would not frequently seed into the previous years' stubble row. Crop density was estimated by counting seedlings in two paired rows 0.5m in length at 20 sites in each treatment. Yield results not were obtained.

Results: Plant counts for lentil and canola did not indicate improved emergence with seeding between the rows in comparison to seeding within rows (data not shown). In fact, in the lentil field the emergence numbers were higher and standard deviation lower with the strip seeded within the stubble rows (data not shown). Although the data appears to suggest that there is more variability in the strips seeded between the rows than the strips seeded within the rows, this may be partially explained by the sampling methods used. The plant counts were done randomly but we did try to find spots in the field where the within row treatment had plants that were actually within the row and not between the row; therefore, we may have inadvertently chosen locations where there were consistently more plants, skewing the results.

Conclusions: It was difficult to evaluate the differences in plant density using the protocol outlined. No conclusions can be drawn as to whether or not inter-row seeding improves crop establishment.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Application of Fall 2,4-D Preceding Canola, Peas and Flax/Lentil

Authors & Affiliations: Stewart Brandt - Northeast Agriculture Research Foundation, Larry White - Conservation Learning Centre Inc., Chris Holzapfel - Indian Head Agricultural Research Foundation, Laryssa Grenkow - Western Applied Research Corporation, Lana Shaw - South East Research Farm

Background & Objectives: Wet weather has favoured greater infestations of perennial broadleaf weeds in grain crops. One control strategy is to use fall applied 2, 4-D, however, delayed or high application rates of 2, 4-D required for perennial weed control increases risk that residues remain in the soil the following spring. Such residues can be damaging to sensitive crops like canola, peas, lentil and flax. The objective of this trial is to demonstrate the frequency and extent of subsequent crop damage to pea, lentil/flax and canola from fall applied 2, 4-D at high rates as used for the control of dandelion or other perennial weeds.

Methodology: Treatments included five rates of 2, 4-D (0, 3, 6, 12 and 24 ounces 2, 4-D amine ac^{-1}) applied before direct seeding canola, peas or flax (lentil at Scott). Treatments were arranged as a split-plot design with crop as the main plot and 2,4-D rate as the sub-plot. Actual 2,4-D application dates in 2012 were September 28th at Redvers, October 5th at Melfort, 12th at Scott, and 15th at Prince Albert and Indian Head. Soil samples were collected at 4-5 locations per replicate at 0-12" depth in fall 2012 (Table 1).

In spring 2013, plots were treated with glyphosate for pre-seeding weed control at all sites. Seeding occurred between May 16 and 25 depending on location. The varieties used were Bethune flax, L-130 canola (5525 CL at Indian Head), Meadow peas and Maxim lentil. Fertilizer was applied according to soil test recommendations and herbicides were applied as required by each site.

Table 1. Soil characteristics of Agri-ARM sites

Soil Factors	Site				
	Melfort	Prince Albert	Indian Head	Scott	Redvers
Soil Texture	Clay	Loam	Clay-Loam	Loam	Clay loam
Soil OM (%)	8.1	6.1	2.8	2.4	4.1
Available N (kg ha^{-1})	95	14	31	21	3
Available P_2O_5	50	15	14	97	>108
Available K_2O	>1200	600	>1080	754	965
Available S	56	7	15	15	>86

Results: Snow came abnormally early at all sites in fall of 2012, with permanent snow cover present by the end of October. This likely meant that soil temperatures remained higher than normal because of the insulating effect of the snow. Snow also left later than normal in spring 2013 due to heavier than normal snow cover across all sites and cooler than normal temperatures. The late spring meant that most crops were sown later than normal and emergence was delayed as well. At the time of seeding, seedbed conditions at Melfort were barely dry enough to facilitate good seed placement, the seedbed was moist but somewhat cool at Prince Albert and near ideal with adequate moisture at Scott and Indian Head.

Seeding rates were selected near the low end of what was recommended for these crops to increase the probability that yield effects would be evident if treatments reduced plant density; however treatments did not reduce plant densities and there were no statistical differences in 2, 4-D rate on plant density for any crop at ten or 21 days after emergence (Table 2). The only location where densities of canola plants were below 50 per m^{-2}, the lower critical threshold for canola, was at Redvers. Pea densities were at or above the threshold considered adequate to achieve full yield potential (80 plants m^{-2}) at Indian Head and Melfort. At Scott, pea densities were 59-67 plants m^{-2}. Flax plant densities were very high at Indian Head, lower at Melfort and quite low at Redvers, likely limiting yield potential. Lentil plant were somewhat below what would be consider ideal for a lentil crop. Plant density was not assessed at Prince Albert because emergence was variable (not treatment related) and because subsequent of subsequent weed completions, crops were terminated in mid-August. Abnormal appearing plants were assessed to provide insight into sub-lethal damage from 2,4-D residues. There were no indications that increasing rates of 2,4-D increased abnormal appearing plants and differences between treatments were not statistically significant for any crop at any site. Numbers of abnormal plants at Indian Head tended to be higher than at Scott or Melfort. Some of this difference could be accounted for by higher overall plant densities at Indian Head. Due to disease, many of the plots were terminated early at Prince Albert, Melfort, Redvers and Indian Head. The yield results that were obtained did not appear to be affected by treatment.

Conclusions: There were no significant reductions in emergence, seedling injury or negative impacts on seed yield observed for canola, flax, lentil or field pea at any site in 2013, which was unexpected. However, these results should not mislead us to conclude that such applications are always safe. Previous research has shown that fall applications of 2,4-D preceding these crops can cause significant injury and yield reduction, particularly at high rates required for effective perennial weed control. Damage can also be higher on clay soils than on coarser textured soils, and on low compared with high organic matter soils. The early snow cover in fall of 2012 may have provided sufficient insulation to allow microbial activity to persist longer, thereby breaking down residues. In addition, later seeding in spring 2013 due to wet conditions may also have allowed greater 2,4-D breakdown. This demonstration will be continued in 2014.

Table 2. Plant densities at 10 and 21 days after emergence.

2,4-D Rate (oz/ac)	Site				
	Melfort	Indian Head	Scott	Redvers	Mean
			Canola at 10 Days		
0	68	74	59	35	59
3	72	75	62	37	62
6	77	75	53	35	60
12	82	72	57	34	61
24	74	76	59	33	61
			Canola at 21 Days		
0	60	70	54	-	61
3	64	68	57	-	63
6	60	70	50	-	60
12	70	69	56	-	65
24	56	71	54	-	60
			Pea at 10 Days		
0	91	104	67	-	87
3	84	100	62	-	82
6	61	99	62	-	74
12	71	110	62	-	81
24	97	106	59	-	87
			Pea at 21 Days		
0	88	114	61	-	88
3	92	108	65	-	88
6	60	114	61	-	78
12	64	122	65	-	84
24	79	116	66	-	87
			Flax/Lentil at 10 Days		
0	240	401	92	133	258
3	238	381	89	124	248
6	240	396	82	123	253
12	230	399	79	116	248
24	261	434	84	117	271
			Flax/Lentil at 21 Days		
0	239	406	86	-	323
3	239	366	86	-	303
6	214	338	83	-	276
12	212	395	83	-	308
24	233	429	82	-	331

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Demonstrating Canaryseed's Weak Response to Nitrogen and Strong Response to Fungicide

Authors & Affiliations: Bill May – Agriculture and Agri-Food Canada, Lana Shaw – Southeast Agricultural Research Foundation, Bryan Nybo – Wheatlands Conservation Area, Inc., Stewart Brandt – Northeast Agricultural Research Foundation, Laryssa Grenkow – Western Applied Research Corporation

Background & Objectives: Although research has been done on the effects of nitrogen (N) and fungicides on canaryseed, farmers often are not familiar with the response of canaryseed to various inputs. Although most grain crops are generally responsive to large amounts of fertilizer N, canaryseed is often unresponsive to N. In addition, canaryseed's response to fungicide may not be consistent each year. The objective of this trial is to demonstrate the relatively weak response of canaryseed to N fertilizer and stronger response of canaryseed to control septoria leaf mottle (especially in eastern Saskatchewan).

Methodology: The trial was conducted at Melfort, Indian Head and Swift Current in 2012 and 2013, with additional sites at Scott and Redvers in 2013. The treatments were set up as a split-plot design with four replicates. Fungicide was the main plot and N rate was the sub-plot. Six nitrogen rates were applied (10, 20, 30, 50, 70 and 90 kg ha^{-1}) and two fungicide treatments were applied (no fungicide or Stratego). Nitrogen was applied as urea in the side-band or mid-row band. CDC Batista was seeded at 35 kg ha^{-1}. All other nutrients were applied according to soil test recommendations and herbicides were applied as required.

Results: In both 2012and 2013 there was no significant interaction between fungicide and nitrogen rate (data not shown). In 2012 the application of a fungicide increased grain yield at 2 out of 3 locations (Table 1). Although there were some numerical increases in grain yield from a fungicide in 2013, none were statistically significant (Table 1). The yield component that seems to be responding to the fungicide is kernel size; thousand kernel weight increased at all three sites in 2012 and just small numerical increase at some of the sites in 2013 (data not shown).

Table 1. Effect of level of fungicide and N rate on grain yield (kg ha^{-1}) of canaryseed at each site year

	Site year							
Factor	Melfort		Indian Head		Swift Current		Scott	Redvers
	2012	2013	2012	2013	2012	2013	2013	2013
Fungicide								
No Fungicide	1114^{b}	1650^{a}	798^{b}	1980^{a}	796^{a}	643^{a}	562^{a}	1552^{a}
Fungicide	1297^{a}	1671^{a}	1037^{a}	1936^{a}	837^{a}	682^{a}	672^{a}	1731^{a}
N rate (kg N ha^{-1})								
10	1394^{a}	1389^{b}	799^{a}	1687^{d}	667^{d}	554^{d}	489^{c}	1705^{a}
20	1285^{ab}	1353^{b}	911^{a}	1832^{cd}	737^{cd}	636^{bcd}	529^{c}	1687^{a}
30	1284^{ab}	1552^{b}	1018^{a}	1885^{bcd}	820^{bc}	604^{cd}	565^{bc}	1688^{a}
50	1221^{b}	1789^{a}	949^{a}	2046^{abc}	797^{c}	700^{abc}	628^{b}	1761^{a}
70	1018^{c}	1968^{a}	901^{a}	2198^{a}	928^{ab}	763^{a}	735^{a}	1439^{b}
90	1029^{c}	1911^{a}	896^{a}	2098^{ab}	949^{a}	721^{ab}	758^{a}	1568^{ab}

The effect of fertilizer N on grain yield was inconsistent among site years. Grain yield declined as the N rate increased at Melfort in 2012 and Redvers in 2013 (Table 1). There was no response to applied N at

Indian Head in 2012 and there were yield increases as N rate increased at the other five sites. It appeared that at sites with a positive response to N, yield was optimized at 70 kg ha^{-1} (62 lbs N ac^{-1}) which is higher than the normal recommended range of 30 to 50 lbs N ac^{-1} (Figure 1). The reason for the larger than normal response of grain yield to N in 2013 is not known. Panicle density increased as the N rate increased at 3 out of the 5 sites where grain yield responded positively to N rate (data not shown). The other yield components did not seem to be consistently affected by N rate. It is interesting to note that the test weight decreased as the N rate increased at all locations in 2012 and none in 2013 (data not shown).

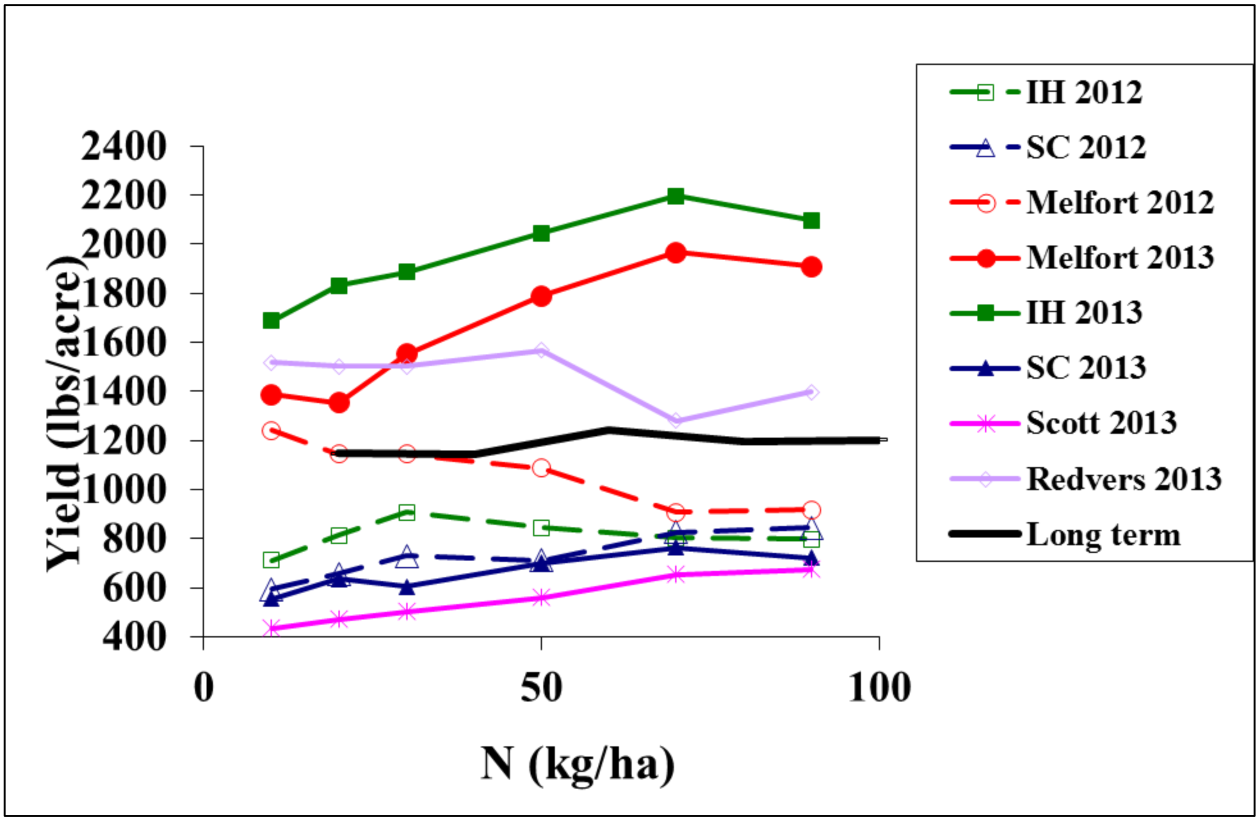

Figure 1. The effect of nitrogen on the grain yield of canaryseed

Conclusions: In conclusion, there was no synergistic effect of fungicide and high N rates on grain yield of canaryseed. Fungicides did not have as large effect or consistent effect on canaryseed as expected while fertilizer N applications had a larger, more consistent effect. From these results and previous results the N fertilizer recommendation for canaryseed is 30 to 50 lbs N ac^{-1} and it is still recommended that growers apply a fungicide on canaryseed when grown on the eastern half of Saskatchewan.

Acknowledgements: Funding provided through the ADOPT program from the Saskatchewan Ministry of Agriculture.

Short Season Corn and Soybean Demonstration

Authors & Affiliations: Tristan Coelho, Laryssa Grenkow – Western Applied Research Corporation

Background & Objectives: Corn and soybean acreage is pushing west past the Manitoba border with the release of new short season genetics. The objective of this trial is to demonstrate the current corn and soybean varieties available and suitable for northwest Saskathewan.

Methodology: The three short season corn varieties, DKC26-25, P7443R and 2D093, had a corn heat unit (CHU) ratings between 2000-2100. The short-season soybean varieties, Reston RRY2, Anola RR2Y and P001T34R, had CHU ratings between 2325-2350. Between April 1 and October 14th of 2013, Scott received 2592-2811 CHUs. Corn and soybean were seeded May 30th and 31st, respectively into tilled soil with good moisture. The six treatments were arranged as a randomized complete block design with four replicates. Fertilizer was applied according to soil test recommendations and herbicides were applied as required. Corn was seeded on 20" row spacing and soybeans seeded on 10" row spacing. Corn was harvested by plucking cobs from stalks on October 2nd, drying for 10 days and then threshing using a stationary thresher and weighting kernels. Soybeans were straight-combined at maturity on October 2nd.

Results: Prolonged cool wet weather delayed corn and soybean emergence until June 17th, resulting in low emergence for soybeans of 80% (40 plants m^{-2}). Root rot likely reduced soybean emergence, early season vigor and nodulation. A minor hail storm in mid-July caused defoliation, resulting in an estimated 10% yield loss in soybeans. Late season moisture is critical for soybean pod fill and development, Scott received only 28 mm during this period, which may have caused the pod abortion and small seed size in most plots. Soybean seed yield ranged from 17-24 bu ac^{-1}, however due to low pod height and improper harvesting equipment, harvest losses were likely greater than what would have been achieved on field scale. Cool wet weather also delayed emergence with the three corn hybrids tested and fall frost on September 27th resulted in immature kernels in corn. Corn grain yields ranged from 40-65 bu ac^{-1}.

Conclusions: Although northwest Saskatchewan may not have the heat units required to consistently produce high yields, our experience with short season corn and soybean varieties at the Scott research farm in 2013 has shown some promising results. We encourage farmers looking to experiment with the new crops to select the varieties with the lowest CHU rating and start with a small acreage.

Acknowledgements: In-kind contributions provided by Quarry Seeds, DuPont Pioneer, Monsanto, and North Star Genetics.

Evaluation of Low Heat Unit Corn Hybrids Compared to Barley for Grazing

Authors & Affiliations: Laryssa Grenkow - Western Applied Research Corporation, Bart Lardner, Leah Pearce, Stacy Pritchard - Prairie Agricultural Machinery Institute

Background & Objectives: The objective of this trial is to evaluate the forage yield and quality of three corn varieties compared to a forage barley.

Methodology: Corn was planted on using a Versatile with 1" hoe-type openers on 30" row spacing. Three corn varieties (DKC26-25, P7443R and 2D093) were seeded at 30,000 seeds $acre^{-1}$. Fertilizer applied to corn was 107-25-12.5-12.5 lbs N-P_2O_5-K_2O-S $acre^{-1}$. Glyphosate was applied pre-plant and in-crop at the 4 leaf stage. Ranger barley was seeded using the same Versatile with 10" row spacing at 100 lbs $acre^{-1}$. Fertilizer applied to barley was 64-21-0-0 lbs N-P_2O_5-K_2O-S $acre^{-1}$. Glyphosate was applied-pre-plant and 2,4-D was applied in-crop at the 3 leaf stage.

Results: Though the data from 2013 has yet to be analyzed, it appears to follow a similar trend as 2012. Barley differs from corn, on average, in terms of yield and quality (Table 1). Although corn has a higher moisture content compared to the barley, all varieties had significantly higher dry matter yield than barley (Table 1). These trend were similar at the other three sites in 2012 (Evansburg, Fairview, AB and Melfort, SK).

Table 1: Forage yield and quality of corn and barley from Scott in 2012

	Corn			Barley	Contrast
	DKC26-25	2D093	P7443R	Ranger	Corn vs. Barley
Cobs/plant	1.45	1.59	1.64	-	-
Moisture, %	74.48[a]	72.62[a]	73.67[a]	67.68[b]	<0.001
DM, %	25.52[b]	27.39[b]	26.33[b]	32.32[a]	<0.001
ton/acre, DM	4.47[ab]	6.06[a]	5.02[a]	3.04[b]	<0.01
tonne/ha, DM	10.02[ab]	13.56[a]	11.25[a]	6.83[b]	<0.01

[a-c] Means within a row with different superscript differ ($P < 0.05$). Mean separation was done by using Tukey-Kramer Test.

Conclusions: A complete analysis of data from all sites will be completed in 2015, providing us with improved insight on the yield and quality of corn versus barley for forage. However, it appears that corn does provide higher dry matter accumulation, despite the short growing season at Scott. This trial will continue in 2014 at the Scott Research Farm.

Acknowledgements: Funding provided by the Prairie Agricultural Machinery Institute and in-kind contributions provided by Monsanto, Pioneer and Hyland.

Response of Canola to Low Plant Populations and Evaluation of Reseeding Options

Authors & Affiliations: Anne Kirk, Blaine Davey - Western Applied Research Corporation, Sherrilyn Phelps - Saskatchewan Ministry of Agriculture, Eric Johnson - Agriculture and Agri-Food Canada, Steve Shirtliffe - Department of Plant Sciences, Cecil Vera - Agriculture and Agri-Food Canada, Chris Holzapfel - Indian Head Agricultural Research Foundation and Bryan Nybo - Wheatland Conservation Area, Inc.

Background & Objectives: Current canola seeding rate recommendations are to achieve a target plant population of 70-140 plants m^{-2}, which, based on a typical 50% seed survival rate translates to a seeding rate of 140-280 seeds m^{-2} (Canola Council of Canada 2013). There have been numerous studies looking at canola seeding rates; however, there is limited data on the response of canola, particularly hybrids, to extremely low plant populations. Studies by Angadi et al. (2003) Shirtliffe (2009) and McGregor (1987) found minimal reductions in seed yield when plant populations were reduced to 40-45 plants m^{-2}. Newer hybrid canola cultivars may have a higher degree of phenotypic plasticity than open pollinated cultivars, and may be able to compensate at reduced densities with increased plant size. The potential drawbacks to low plant populations include reduced weed competition, extended maturity and difficult swathing. The objective of this trial is to determine the minimum plant population required to reach maximum yield and quality risks with each reseeding option in terms of maturity, yield and quality.

Methodology: Field experiments were conducted at Indian Head, Melfort, Saskatoon, Scott and Swift Current 2010-2012. Both experiment 1 and 2 were set up as a randomized complete block design with four replicates. Experiment 1 consisted of seven seeding rates varying: canola (5440LL) was seeded at 5, 10, 20, 40, 80, 150 and 300 seeds m^{-2}. At Scott and Melfort 5770LL was also seeded to all seven seeding rates. Experiment 2 consisted of re-seeding option: three varieties seeded in early or mid-June compared to two control plots (low and high plant population) seeded in early May. The variety 5440 LL was seeded at a rate of 150 seeds m^{-2} in one treatment, and at a rate of 40 seeds m^{-2} to the remaining seven treatments in early May. The 40 seed m^{-2} treatments were used to simulate poor emergence conditions. All but one of the treatments planted at 40 seeds m^{-2} was later killed with glyphosate. After glyphosate application, two hybrid canola cultivars, 5440LL and 9350RR, and a synthetic Polish canola variety were planted in early and mid-June. Plots in both experiments were fertilized to soil test recommendations and herbicides, insecticides and fungicides were applied as required. Plots were straight combined.

Results:

Experiment 1

Plant density increased with increasing seeding rates at all locations (data not shown). Reduced emergence at the highest seeding rates is likely the result of increased plant competition and self-thinning. At most site years, percent emergence was near or above 100% at the lowest seeding rates, due to the presence of volunteer canola.

Seed yield increased with increasing plant density at ten of the eleven locations (Table 1). There was no significant yield difference between seeding rates of 20, 40 and 80 seeds m^{-2} (corresponding to plant densities of 12-39 plants m^{-2}, on average) at six of eleven site years, and no significant yield difference between seeding rates ranging from 20 to 300 seeds m^{-2} at four site years (Table 1). As plant density increased yield reached a plateau; however, plant density was not high enough to result in a yield decrease, as seen in other studies.

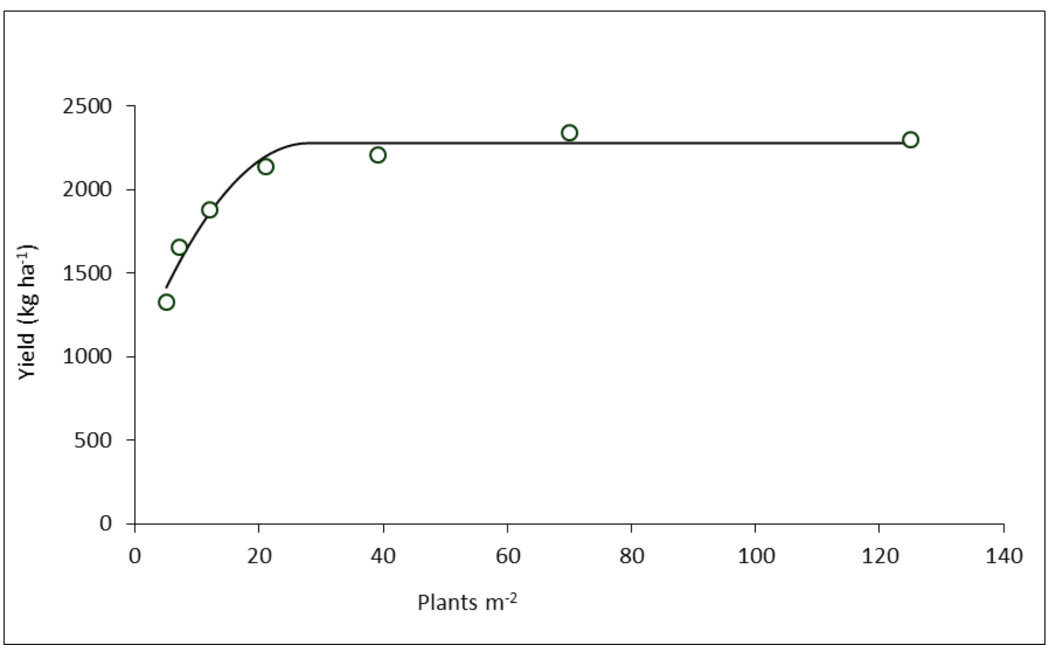

Figure 1. Mean quadratic response of seed yield to plant density. 100%, 90% and 80% of maximum yield achieved at 28, 18 and 12 plants m^{-2}, respectively.

Table 1. Seed yield (kg ha^{-1}) response to various seeding rates at individual site years and mean plant density and seed yield across all site years.

Seeds m^{-2}	Mean plants m^{-2}	Indian Head			Melfort	Saskatoon			Scott	Swift Current			Mean seed yield
		2010	2011	2012	2011	2010	2011	2012	2011	2010	2011	2012	
5	5	2122^{c}	2245^{d}	1370	1702^{de}	1404^{b}	1305^{c}	1337^{c}	1075^{d}	1327^{c}	574^{d}	818^{e}	1328^{f}
10	7	2010^{bc}	2934^{c}	1853	1627^{e}	1490^{b}	1657^{b}	1594^{c}	1637^{c}	1381^{bc}	1043^{c}	1063^{d}	1660^{e}
20	12	2254^{abc}	3080^{bc}	2056	1757^{cde}	1813^{ab}	1919^{ab}	1641^{c}	1778^{bc}	1619^{abc}	1279^{c}	1209^{cd}	1882^{d}
40	21	2631^{ab}	3437^{ab}	2075	2070^{bc}	1922^{a}	2337^{a}	2039^{b}	2359^{a}	1852^{ab}	1903^{b}	1314^{c}	2142^{c}
80	39	2512^{ab}	3509^{a}	1865	2010^{bcd}	2011^{a}	2326^{a}	2394^{ab}	2422^{a}	1844^{ab}	2140^{ab}	1483^{b}	2214^{bc}
150	70	2825^{a}	3511^{a}	2018	2403^{a}	2091^{a}	2389^{a}	2491^{a}	2282^{ab}	1930^{a}	2333^{a}	1590^{b}	2347^{a}
300	125	2710^{a}	3658^{a}	1873	2280^{ab}	1976^{a}	2429^{a}	2353^{ab}	2512^{a}	1842^{ab}	2344^{a}	1678^{a}	2304^{ab}

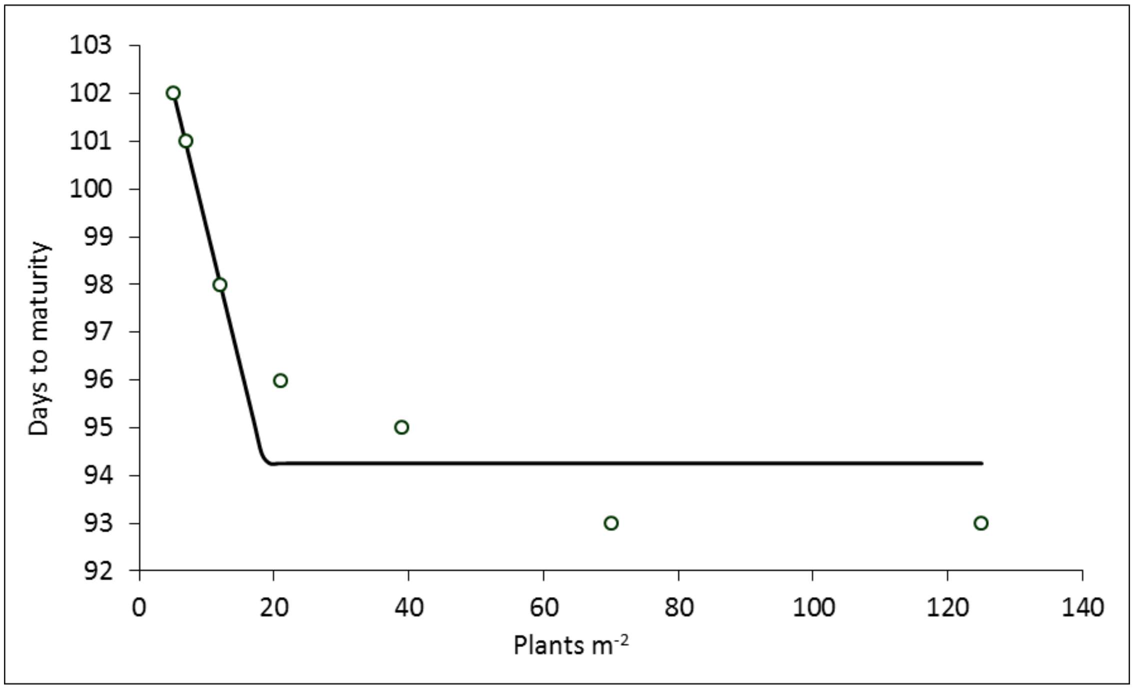

Figure 2. Mean quadratic response of days to maturity to plant density. The breakpoint, plant density above which there is no significant change in days to maturity, is 19 plants m^{-2}.

There was a strong quadratic relationship at six of the ten site years (data not shown) and in the combined analysis of all site years (Figure 1). At the sites where there was a strong relationship between yield and plant density seed yield plateaued at plant densities ranging from 11 to 30 plants m^{-2} (data not shown). Ninety and 80% of maximum yield was achieved at plant densities ranging from 8 to 20 and 6 to 12 plants m^{-2}, respectively at the individual sites (data not shown). When site years were combined yield plateaued at 28 plants m^{-2} and 90 and 80% of maximum yield was achieved at plant densities of 18 and 12 plants m^{-2}, respectively (Figure 1). The results of this study found that plant density can be reduced to lower levels without significant yield reductions than those previously reported. However, these numbers should not be used as target seeding rates; the plant densities and associated yields reported in the present study can be used as a guideline for when reseeding is being considered. It is also important to consider environmental conditions when interpreting these results. With the exception of Melfort 2011, which experienced less than normal precipitation, precipitation was not limiting in any site year.

The number of pods per plant, branches per plant and seeds per pod were measured at the Saskatoon and Scott locations. As plant density decreased the number of branches per plant increased and pods per plant increased (data not shown). Averaged across years and locations, the number of pods per plant increased from 150 at 150 and 300 seeds m^{-2} to 851 at 5 seeds m^{-2}. In general, the increase in pods per plant was due to increased podding on primary and secondary branches, not the main raceme (data not shown). The number of seeds per pod was fairly stable across the range of plant populations and ranged from 25 to 27 seeds per pod.

Although seed yield was maintained at low plant populations, other agronomic factors can be affected. The length of flowering period generally increased with decreasing plant density, on average by 6 days as plant density decreased from 70 to 21 plants m^{-2}. At some sites, this period was prolonged; for example, at Scott and Indian Head, length of flowering at 70 plants m^{-2} was 9-24 days shorter than at 5 plants m^{-2}. Increasing plant density also significantly reduced days to maturity (data not shown). The combined analysis found that when the plant population was reduced from 70 to 5 plants m^{-2} there was a 9 day increase in days to maturity, however, reductions from 70 plants m^{-2} to 21 plants m^{-2} (approximate value where 90% maximum yield achieved) resulted in a 3 day increase in days to maturity. The increase in flowering time and days to maturity at lower plant densities was likely a result of increased branching. Averaged across all site years, the plant density at which days to maturity plateau's is 19 plants m-2 (Figure 2). Across the nine site years the breakpoint ranged from 8 to 67 plants m^{-2} (data not shown). A greater percentage of green seed at lower seeding rates reflects the increase in days to maturity when plant density decreases. Percent distinctly green seed decreased with increasing plant density, with significant differences between plant densities at seven of ten sites where green seed was measured. Averaged across site years there were significant differences in percent green seed, 5 plants m^{-2} resulted in 0.76% greater green seed than a density of 70 plants m^{-2}.

Plant density had a significant effect on lodging at four of seven sites where lodging was measured (data not shown). Results were inconsistent however: at Indian Head in 2011 and 2012 lodging was observed at the higher plant densities, while at Scott in 2011 and 2012 there was more lodging at the lower plant densities. Increased lodging at lower plant densities occurred due to the canola plants becoming so large that the stem was unable to support the pant at maturity. In some cases the stems were susceptible to breaking.

In general, seed weight was not strongly influenced by plant density and inconsistent effects among site years occurred: seed weight decreased with increasing plant density at two sites and increased with increasing plant density at two sites (data not shown).

At Scott and Melfort, where 5770LL was compared to 5440LL, there were no significant yield difference between the two cultivars at any seeding rate (data not shown). On average, 5770LL reached maturity three days later than 5440LL, which resulted in 5770LL having a greater percentage of distinctly green seed (data not shown).

Experiment 2

The low plant population control had, on average 21 plants m^{-2} compared to 79 plants m^{-2} in the high plant population control. All re-seeding options provided plant populations significantly higher than the low plant population control seeded in early May, however, reseeding in mid-June resulted in a reduced plant stand compared to early June seeding (Table 2).

The high plant population control seeded in early May had significantly higher yields at eight of 12 sites years compared to the low plant population control (Table 3), which illustrates the importance of targeting adequate plant populations to begin. Reseeding a low plant stand of canola to 5440 LL in early June resulted in a significant yield increase in six of 12 site years and in the combined analysis (Table 3). Reseeding to 9350RR resulted in a significant yield increase in only three site years (Table 3). At both Swift Current site years reseeding resulted in a significant yield decrease (data not shown), likely to hot and dry conditions in August. Generally, reseeding in mid-June resulted in a lower yield. Although the polish canola requires a shorter growing season, it did not provide a yield benefit over the low plant population control seeded in early May treatment when reseeded in both early or mid-June (Table 3). The B. napus varieties yielded significantly higher than the B. rapa when seeded in early June; however, there was no significant yield difference between B. napus and B. rapa at the mid-June seeding date (Table 3).

Percent green seed increased as seeding dates were delayed. Averaged across site years, green seed increased from approximately 1% with early May seeded canola to over 5% with mid-June seeded canola (data not shown). There was generally no significant difference in percent green seed between cultivars at either reseeding date or between the low and normal seeding rate treatments planted in early May.

The economic analysis only includes variable costs that differ between treatments, i.e. seed and herbicide costs (Table 4). Canola seeded in early May at a rate of 150 seeds m^{-2} provided the greatest economic return (Table 4). On average, reseeding to 5440LL resulted in positive net returns compared to the low plant population control seeded in early May (Table 4). When including the SCIC establishment benefit of \$148 ha^{-1} there is a positive net return for 9350RR seeded in early June as well (Table 4). Although the seed costs for the polish variety are lower than that of a hybrid, it did not make economic sense to reseed to polish canola at either reseeding date (Table 4).

Conclusions: Canola plants exhibited a high level of plasticity and were able to maintain seed yield across a range of plant populations. When results from all site years were combined a plant population of 18 plants m^{-2} was required to achieve 90% of maximum yield, compensating by increasing the number of branches and pods per plant. A potential drawback of reduced plant populations is increased days to maturity and green seed. There was no significant difference between the low and high plant populations seeded in early May but as seeding date was delayed to mid-June there was a significant increase in green seed content. Distribution of the canola plants in the field is another consideration: non-uniform distribution of seedlings may yield lower than uniformly distributed plants at very low plant populations.

Table 2. Influence of seeding date, variety and seeding rate on spring plant density.

	Indian Head		Melfort		Swift Current		Scott	Saskatoon		
Treatment[1]	2010	2011	2010	2012	2011	2012	2011	2010	2012	Mean
	------------------ (plants m^{-2}) ------------------									
EM - 5440 LL - 20	19^{d}	12^{b}	45c^{d}	28^{e}	18^{c}	16^{c}	4^{b}	29^{d}	17^{d}	21^{e}
EM - 5440 LL -150	90^{ab}	85^{a}	84^{a}	88^{c}	79^{a}	84^{a}	27^{b}	78^{c}	94^{ab}	79^{abc}
EJ - Polish - 150	79^{bc}	87^{a}	46^{d}	87^{c}	44^{b}	58^{b}	59^{a}	92^{bc}	79^{bc}	70^{b}c
EJ - 5440 LL - 150	96^{ab}	97^{a}	81^{ab}	114^{a}	83^{a}	80^{a}	69^{a}	128^{a}	111^{ab}	95^{a}
EJ - 9350 RR - 150	103^{a}	95^{a}	58^{abc}	60^{d}	74^{a}	78^{a}	74^{a}	109^{ab}	120^{a}	86^{ab}
MJ - Polish - 150	63^{c}	8^{b}	15^{d}	88^{c}	52^{b}	11^{c}	65^{a}	-	52^{cd}	45^{d}
MJ - 5440 LL - 150	98^{ab}	6^{b}	24^{cd}	108^{ab}	80^{a}	20^{c}	59^{a}	-	85^{abc}	61^{cd}
MJ - 9350 RR - 150	93^{ab}	5^{b}	26^{cd}	93^{bc}	81^{a}	16^{c}	72^{a}	-	90^{ab}	61^{cd}
LSD	21.46	13.40	35.07	19.56	12.87	10.62	23.01	28.38	38.35	21.98
CV	37.31	88.01	71.37	35.03	37.00	69.89	51.56	46.47	47.30	56.47

[1]Seeding date – variety – seeding rate (seeds m^{-2})

Table 3. Influence of seeding date, variety and seeding rate on yield.

	Indian Head		Melfort			Swift Current		Scott		Saskatoon			
Treatment[1]	2010	2011	2010	2011	2012	2011	2012	2010	2011	2010	2011	2012	Mean
	------------------ yield (kg ha^{-1}) ------------------												
EM - 5440 LL - 20	1737^{c}	1841^{c}	1116	2502	2623^{cd}	714^{b}	1023^{b}	1010^{b}	1752^{d}	1051^{b}	1607^{b}	1606	1549^{bc}
EM - 5440 LL -150	2403^{a}	2951^{a}	1310	2239	3001^{ab}	1050^{a}	1634^{a}	2724^{a}	2385^{bc}	1530^{b}	2277^{a}	1916	2121^{a}
EJ - Polish - 150	993^{e}	810^{d}	1147	2559	1594^{f}	266^{e}	380^{d}	635^{b}	1548de	1039^{b}	1162^{b}	1521	1139^{d}
EJ - 5440 LL - 150	2194^{ab}	2374^{b}	1746	3007	3216^{a}	456^{d}	648^{c}	2492^{a}	2664^{a}	2631^{a}	1782^{ab}	1878	2092^{a}
EJ - 9350 RR - 150	2002^{bc}	2109^{bc}	1496	1579	2794^{bc}	590^{c}	700^{c}	2181^{a}	2186^{c}	2259^{a}	1765^{ab}	1985	1808^{ab}
MJ - Polish - 150	1036^{e}	250^{e}	1264	1986	1362^{f}	110^{f}	-	220^{b}	1329^{e}	-	1290^{b}	1103	935^{d}
MJ - 5440 LL - 150	1313^{d}	86^{e}	1379	2790	2475^{d}	173^{f}	-	-	866^{f}	-	1538^{b}	1714	1270^{cd}
MJ - 9350 RR - 150	1342^{d}	198^{e}	1536	2222	1998^{e}	269^{e}	-	571^{b}	1389^{e}	-	1702^{ab}	1859	1246^{cd}
LSD	287.73	396.39	ns	ns	266.78	69.36	256.60	886.03	212.34	516.30	604.65	ns	392.68
CV	35.67	84.12	30.41	29.17	27.82	67.29	53.37	55.26	33.34	42.73	29.84	27.14	52.30

[1]Seeding date – variety – seeding rate (seeds m^{-2})

Table 4. Influence of reseeding canola on economic return at Indian Head, Melfort, Saskatoon, Scott and Swift Current in 2010, 2011 and 2012.

	Early May		Early June			Mid June		
	5440LL	5440LL (Low)	5440LL	9350RR	Polish	5440LL	9350RR	Polish
Expenses								
Seed cost ($ kg^{-1})[1]	27.56	27.56	27.56	27.56	10.56	27.56	27.56	10.56
Seeding rate (kg ha^{-1})[2]	8.88	8.88	8.88	5.97	3.83	8.88	5.97	3.83
Initial seed cost ($ ha^{-1})	244.73	244.73	244.73	244.73	244.73	244.73	244.73	244.73
Reseeding seed cost ($ ha^{-1})	0	0	244.73	164.53	40.44	244.73	164.53	40.44
Cost of seeding ($ ha^{-1})[3]	38.14	38.14	76.27	76.27	76.27	76.27	76.27	76.27
In crop herbicide[1]	59.28	59.28	33.35	5.56	64.22	33.35	5.56	64.22
Burn off[1]	0	0	5.56	5.56	5.56	5.56	5.56	5.56
Cost of spraying ($ ha^{-1})[3]	24.70	24.70	24.70	24.70	24.70	24.70	24.70	24.70
Total ($ ha^{-1})	366.85	366.85	629.35	521.36	455.93	629.35	521.36	455.93
Income								
Yield (kg ha^{-1})	2121.00	1549.00	2092.00	1808.00	1139.00	1270.00	1246.00	935.00
Crop Value ($ ha^{-1})[4]	1230.18	898.42	1213.36	1048.64	660.62	736.60	722.68	542.30
Income - Expenses ($ ha^{-1})	863.33	531.57	584.01	527.28	204.69	107.25	201.32	86.37
Gain or loss from low ($ ha^{-1})	331.76		52.45	-4.28	-326.87	-424.31	-330.24	-445.19
Gain or loss including reseeding benefit[5]	331.76		200.65	143.92	-178.67	-276.11	-182.04	-296.99

[1]Costs obtained in spring 2013 from industry

[2]Based on a seeding rate of 150 live seeds m^{-2} for all treatments. Treatment 2 was seeded at 20 seeds m^{-2}; however, this was to mimic a situation where canola was seeded at a typical seeding rate and environmental conditions resulted in a low plant stand.

[3]Based on costs from custom rate guide (Saskatchewan Ministry of Agriculture 2012).

[4]Based on a price of $0.58 kg^{-1}

[5]Includes Saskatchewan Crop Insurance Corporation (SCIC) establishment benefit of $148.20 ha^{-1} to help cover reseeding costs

If faced with a canola stand with lower than the optimum plant density the decision to reseed will be based on plant density, date and uniformity of the plant stand. The results of the reseeding study show that when faced with a plant stand of 20 plants m^{-2} or less, reseeding in early June to hybrid canola provides a yield and economic benefit compared to leaving the stand of low density canola. Although B. rapa will mature earlier than B. napus it is lower yielding. This study found no advantage to reseeding with B. rapa, even when reseeding was postponed to mid-June. When reseeding is required, it is recommended that producers reseed as early as possible to reduce the risk of yield and quality reductions due to fall frost. If conditions do not allow for reseeding to occur in late May or early June it is not recommended that producers reseed to canola.

Acknowledgements: Funding provided by the Saskatchewan Canola Development Commission and the Saskatchewan Crop Insurance Corporation.

Seeding Rates for Precision Seeded Canola

Authors & Affiliations: Laryssa Grenkow - Western Applied Research Corporation, Eric Johnson - Agriculture and Agri-Food Canada, Stewart Brandt - Northeast Agricultural Research Foundation, Chris Holzapfel - Indian Head Agricultural Research Foundation, Lana Shaw - South East Research Farm and Anne Kirk – University of Manitoba

Background & Objectives: The establishment of an adequate and even canola (Brassica napus L.) stand is essential to reaching yield potential. Non-uniform plant distribution within the row can result in greater intraspecific competition, reducing yield potential. With less intraspecific competition of crop plants within a row, evenly distributed populations may allow producers to target lower plant populations and hence use lower seeding rates without reductions in yield. Recent field studies have shown that modern hybrid canola can reach maximum yield potential with as little as 28 plants m^{-2}, on average, which is lower than the current guidelines which suggest that yield begins to decline at plant populations below 40-50 plants m^{-2}. SeedMaster proposes that its UltraPro canola meter can seed canola more uniformly allowing producers to significantly reduce seeding rates and maintain maximum yield potential. If this “precision” seeding equipment can produce a uniform plant stand using low seeding rates, it has the potential to reduce seed input costs, reducing the cost of production. While studies have been performed looking at the effect of seeding rate and plant uniformity, third party independent research needs to be performed on the UltraPro canola meter to test its claims. The objective of this trial is to determine if the UltraPro canola roller produces more uniform canola seed placement than conventional rollers and if more uniform seed placement has the potential for allowing lower canola seeding rates.

Methodology: Field trials were conducted near Scott, Melfort, Redvers and Indian Head, Saskatchewan in 2012 and 2013. The treatments applied were a factorial combination of six seeding rates (10, 20, 40, 80, 160 and 320 seeds m^{-2}) and two metering types (traditional Valmar versus UltraPro roller). The experimental design was a randomized complete block design with four replicates. The hybrid canola variety L-150 (in 2012) or L-130 (in 2013) was direct seeded at all locations. Seeding equipment varied between sites and row spacing ranged from 20 to 30 cm. Plot size ranged from 25 to 40 m^{-2}. Fertilizer was applied according to soil test recommendations and herbicides and fungicides were applied as required. The plots were straight combined at Indian Head and Scott and swathed at Melfort.

Data collection included spring and fall seedling density and uniformity, days to maturity and seed yield. Plant uniformity was evaluated by measuring the distance between 10 plants in four rows per plot at the

2-3 leaf stage in spring and after harvesting plot plots in fall. Variability of within-row plant spacing was determined by standardizing each measured spacing and calculating the mean distance between plants for each treatment as well as the standard deviation of those observed distances. Spring plant density was calculated from the spring seedling uniformity measurements. The number of days from planting to maturity was recorded with plants declared mature when 60% of seeds along the main raceme showed colour change. Seed yield was calculated from clean seed weight per plot and adjusted for moisture content.

Results: Results presented are from a preliminary analysis. Spring plant density was affected only by seeding rate (Table 1). Plant density response was similar for both metering systems used; there were no differences in plant density between rollers at any level of seeding rate (Table 1). Mean spring plant density was above the lower critical threshold of 50 plants m^{-2} with seeding rates ≥ 80 seeds m^{-2}. On average, plant populations were significantly higher at 160 and 320 seeds m^{-2} compared to all other seeding rates using either rollers (Table 1). At individual site years, there were generally no significant differences in spring plant density between the two rollers at each level of seeding rate, except at the 320 seeds m^{-2} rate at Scott (2013), Redvers (2012, 2013) and Melfort (2012) (data not shown). Mean distance between seedlings was also similar for both rollers at each level of seeding rate (Table 2). There was, however, some evidence that the UltraPro roller produced a more uniform plant distribution at lower seeding rates than the Valmar; the standard deviation of distance between seedlings was higher for the Valmar roller than for the UltraPro roller at 10-40 seeds m^{-2} (Table 2).

Table 1. Least squared means and analysis of variance of measured variables (7 site years combined)

Roller	Seeding Rate (seeds m^{-2})	Spring Plant Density (plants m^{-2})^z	Days to Maturity^z	Seed Yield (kg ha^{-1})^z	Fall Plant Density (plants m^{-2})^z
		Least Squared Means			
Valmar	10	13^{c}	95.8^{ab}	1934^{c}	12^{d}
Valmar	20	20^{c}	96.3^{a}	2253^{abc}	17^{cd}
Valmar	40	36^{c}	95.0^{abc}	2290^{abc}	28^{bcd}
Valmar	80	80^{bc}	94.2^{abc}	2488^{abc}	56^{bcd}
Valmar	160	131^{b}	91.9^{bc}	2472^{abc}	96^{ab}
Valmar	320	216^{a}	91.6^{c}	2593^{a}	140^{a}
Ultra	10	11^{c}	96.2^{a}	1949^{bc}	12^{d}
Ultra	20	21^{c}	96.0^{ab}	2284^{abc}	16^{cd}
Ultra	40	37^{c}	94.3^{abc}	2524^{abc}	31^{bcd}
Ultra	80	60^{bc}	93.8^{abc}	2529^{abc}	50^{bcd}
Ultra	160	121^{b}	91.1^{c}	2637^{a}	84^{abc}
Ultra	320	219^{a}	91.4^{c}	2562^{ab}	132^{a}
		Analysis of Variance (P Value)			
Seeding Rate		<.0001	<.0001	<.0001	<.0001
Roller		0.6367	0.5192	0.3134	0.6387
Seeding Rate*Roller		0.9711	0.9847	0.9051	0.9957

^{z} Treatments means separated using the Tukey Method. Means within a column followed by the same letter are not significantly different at P ≤ 0.05.

The trends seen in spring plant density were consistent in the fall plant sampling results. All treatments ≥ 80 seeds m-2 resulted in plant populations above the lower critical threshold. Seeding rate again was the only factor which significantly affected fall plant density (Table 1). Plant density at 320 seeds m^{-2} was significantly higher than at seeding rates ≤ 80 seeds m^{-2}, and there was no differences in fall plant density between the two rollers at any level of seeding rate (Table 1). At individual site years, the only differences in fall plant density between rollers was at Redvers (2013) at 320 seeds m^{-2} and at Melfort (2012) at 160 seeds m^{-2} (data not shown). As seen in the spring, mean distance between seedlings was similar for both rollers at each level of seeding rate; however, the standard deviation did not vary among rollers to the same extent as it did in the spring evaluations (Table 3). Because self-thinning likely resulted in similar distance and distribution of plants within the row, regardless of earlier variability, the slight advantage of the UltraPro roller may have minimal effects on intraspecific competition in canola.

Like plant density, maturity was affected, on average, by seeding rate only (Table 1). As seeding rate increased, days to maturity decreased linearly with both metering systems. The two highest seeding rates had significantly shorter days to maturity (~4.9 days) compared to the lowest two seeding rates for the UltraPro roller. The two highest seeding rates using the Valmar roller also had significantly shorter maturity dates than the 20 seeds m^{-2} treatment and was numerically shorter than the 10 seeds m^{-2} treatment (Table 1). The Valmar had, on average, 4.3 days difference between the two highest and two lowest seeding rates.

Table 2. Mean and standard deviation of measured distance between plants in spring by seeding rate and roller type (7 site years combined)

	Valmar		Ultra	
Seeding rate	Mean Distance	Standard Deviation	Mean Distance	Standard Deviation
10 seeds m^{-2}	39.1	34.1	36.1	22.5
20 seeds m^{-2}	23.7	20.9	22.5	16.9
40 seeds m^{-2}	15.1	15.1	12.2	8.5
80 seeds m^{-2}	6.5	5.3	6.7	4.5
160 seeds m^{-2}	3.8	4.0	3.8	3.2
320 seeds m^{-2}	2.3	1.9	2.4	2.2

Table 3. Mean and standard deviation of measured distance between plants in fall by seeding rate and roller type (7 site years combined)

	Valmar		Ultra	
Seeding rate	Mean Distance	Standard Deviation	Mean Distance	Standard Deviation
10 seeds m^{-2}	36.1	23.2	37.7	22.8
20 seeds m^{-2}	26.6	20.8	26.0	17.6
40 seeds m^{-2}	16.8	15.7	16.4	14.3
80 seeds m^{-2}	9.3	8.3	9.0	6.5
160 seeds m^{-2}	4.8	3.3	5.5	3.8
320 seeds m^{-2}	4.5	4.4	4.2	3.4

Seeding rate, again, was the only factor that affected seed yield (Table 1). There was generally a lack of significant differences among treatments, on average. The exception was that both treatments seeded at 10 seeds m^{-2} were significantly lower than the Valmar seeded at 320 seeds m^{-2} or the UltraPro seeded at 160 seeds m^{-2} (Table 1). At individual site years, there were no differences in seed yield between rollers at each level of seeding rate, except at Scott in 2013 where the Valmar had higher yields than the UltraPro at 10 seeds m^{-2} (data not shown). There was generally no yield improvements passed the 20 seeds m^{-2} seeding rates on average and at individual site years, there were no statistical differences among treatments above 40 seeds m^{-2} at any of the sites (data not shown). It appears that canola reached maximum yield potential at lower than recommended plant populations, however, there was no advantage of using the UltraPro roller at those lower densities, despite there being an advantage of plant uniformity in those treatments. This is consistent with previous results, indicating that canola can compensate at very low plant populations, resulting in similar yield potential over a range of plant densities.

Conclusions: Seeding rate was the only factor to significantly affect plant density, maturity and seed yield. There were generally no differences in plant density in spring or fall, seed yield or maturity between the rollers at any level of seeding rate. Although there appeared to be more uniform distribution of seedlings, on average, with the UltraPro roller than the Valmar at 10-40 seeds m^{-2} seeding rates, this did not translate into improvements in seed yield. Differences in uniformity generally disappeared at fall plant population assessment, likely due to the self-thinning nature of canola. This experiment will be conducted again in 2014.

Acknowledgements: Funding provided by the Saskatchewan Canola Development Commission.

Field Pea Input Study

Authors & Affiliations: Laryssa Grenkow - Western Applied Research Corporation, Eric Johnson - Agriculture and Agri-Food Canada, Anne Kirk – University of Manitoba, Stewart Brandt – Northeast Agricultural Research Foundation, Sherrilyn Phelps – Saskatchewan Ministry of Agriculture, Chris Holzapfel – Indian Head Agricultural Research Foundation and Bryan Nybo – Wheatlands Conservation Area Inc.

Background & Objectives: Most of the previous research concentrated on field pea production inputs has concentrated on one input such as inoculant type or seeding rate. It is important for producers to know which agronomic factors have the largest effect on harvestable yield and which combination of inputs provide the best economic rate of return. Appropriate inoculation and good soil fertility management has the ability to increase yield and improve yield stability. Research conducted on field pea inoculants found granular inoculant to increase field pea biomass, yield and protein concentration compared to liquid and peat based inoculants. Generally, nitrogen (N) fertilizer application is not required in field pea production since inoculated pulse crops fix their own N; however, starter N fertilizer N may be beneficial when nodulation is restricted or delayed but can reduce nodule formation and N fixation. There have been conflicting and inconsistent effects of starter N on field pea yields. Several studies have investigated the optimum seeding rate and plant density of field pea. Past research suggests that field pea produced optimum yield at 80 plants m^{-2} (108 seeds m^{-2}) and yields dropped significantly at 50 plants m^{-2}. Research on fungicide seed treatments shows variable response of field pea to seed treatments. Fungicide seed treatments may be recommended when spring conditions favour disease development or when soil inoculum levels are high. Previous research in Saskatchewan saw few benefits from seed-applied fungicide on field pea, where seed treatment had an effect on seed yield in only one of thirteen site-years. Foliar fungicides are also recommended when conditions favour disease development. Disease levels are dependent on environmental conditions and fungicides are found to be more beneficial in years with higher levels of disease.

Research similar to this proposal was conducted with canola from 2005 to 2008. The canola input study showed that the combined effect of the recommended agronomic practices increased the canola yield in synergistic fashion. The full input package has a higher yield than the sum of the different agronomic practices alone. This means that producers who adopt new practices may not see the full benefit if they do not apply many of them together. In the present study, the objective is to identify which agronomic practices contribute most to field pea yield, and determine if combining some of the agronomic practices have negative, positive or no impact on yield. Results from this project may also provide insight into factors that are currently limiting the yield potential of field pea and which provide the best economic return for producers across Saskatchewan.

Methodology: Field trials were located at Scott, Swift Current, Melfort and Indian Head research farms in 2012 and 2013. Due to excess moisture in 2013, the trial at Melfort was terminated after assessing plant populations. Twenty-two treatments of field pea (cv. CDC Meadow) were seeded into cereal stubble in a randomized complete block design with four replications. The variables investigated include seeding rate, seed treatment, inoculant type, starter fertilizer and foliar fungicide. The inputs included in the empty and full input package treatments are listed in Table 1. The remaining twenty treatments start with the empty input package and add a component or multiple components of the full input package into the empty input package. Phosphorus fertilizer was applied to soil test recommendations and herbicides, insecticides and desiccants were used as required at all sites. Headline was applied at the start of flowering and Priaxor DS was applied 10 – 14 days later. The plots were straight-combined using plot combines.

Table 1. Inputs included in the empty and full treatments.

Variable	Empty Input Package	Full Input Package
Variety	CDC Meadow	CDC Meadow
Seeding rate (SR)	60 seeds m-2	120 seeds m-2
Seed treatment (ST)	None	Apron Maxx RTA
Inoculant type (GI)	Liquid (Boost N)	Granular (Optimize)
Starter fertilizer (Fz)	None	30 lb ac^{-1} 46-0-0
Fungicide (Fn)	None	Headline EC + Priaxor DS

Results: As expected the higher seeding rate increased plant density, on average, by 39 plants m^{-2} compared to the low seeding rate treatments (Table 2). Similar trends in plant density response to seeding rate were observed at all site years (data not shown). Adding a granular inoculant also consistently resulted in higher plant populations compared to the liquid inoculant treatments (Table 2). At Scott, Indian Head and Swift Current, applying granular inoculant increased plant density by 10-18 plants m^{-2} compared to applying a liquid inoculant. Conversely, adding starter N fertilizer consistently reduced plant density by 7 plants m^{-2} on average (Table 2). Applying a seed treatment had somewhat inconsistent effects on plant density: although the combined analysis showed it significantly increased plant density compared to no seed treatment treatments (Table 2), the modest improvement in plant density was only significant at two of the seven site years (Scott and Swift Current in 2012) (data not shown).

The overall treatment effect on disease ratings conducted at fungicide application were not, on average significant (Table 1). However, the contrasts revealed that treatments with the higher seeding rates had on average, greater disease incidence than the treatments with low seeding rates (Table 2). This trend occurred at Swift Current in 2013 and Scott (data not shown). We suspect that a denser canopy created in the high seeding rate treatments resulted in more suitable conditions for disease to occur. In contrast, treatments with starter N fertilizer had significantly less disease incidence than those without at Scott in 2012 and Indian Head in 2013 (data not shown); this may be due to the reduced plant populations caused by seed- placed N fertilizer. None of the other input affected disease prior to fungicide application.

Table 1**.** Treatment means of plant density, days to flower and maturity, seed yield, thousand kernel weight, test weight, seed protein and disease incidence averaged over all site years.

Treatment	Plant Density (plant m^{-2})	Days to Flower	Days to Maturity	Yield (kg ha^{-1})	TKW	TW^{y}	$Protein^{y}$	Disease 1^{y}	Disease 2
Empty (E)	47^{c}	50^{bcdef}	85^{abcdef}	2538.2^{g}	191.8^{bcd}	83.4	22.1	1.7	4.2^{abcdef}
Full (F)	89^{a}	49^{cdef}	$85^{bcdefgh}$	3439.0^{ab}	197.0^{ab}	83.4	21.9	1.6	$3.9^{cdefghi}$
E+ST^{z}	52^{bc}	49^{cdef}	85^{abcde}	2618.7^{fg}	191.2^{bcd}	83.6	22.1	1.7	4.3^{abcde}
E+SR^{z}	90^{a}	49^{cdef}	84^{gh}	3157.3^{abcd}	187.5^{cde}	83.4	22.3	1.7	4.8^{a}
E+GI^{z}	56^{bc}	50^{bcdef}	85^{bcdef}	2710.7^{efg}	187.4^{cde}	83.3	22.2	1.5	4.5^{abc}
E+Fz^{z}	49^{bc}	50^{a}	86^{ab}	2835.2^{cdefg}	189.0^{cde}	83.5	22.4	1.5	4.4^{abcde}
E+Fn^{z}	50^{bc}	49^{def}	86^{abc}	2887.3^{cdefg}	204.0^{a}	83.5	21.9	1.6	3.6^{fghi}
E+ST+SR	90^{a}	49^{f}	84^{h}	2758.4^{defg}	184.4^{de}	83.3	22.0	1.8	4.8^{a}
E+ST+GI	54^{bc}	50^{bcdef}	85^{abcdef}	2866.3^{cdefg}	192.2^{bc}	83.5	22.2	1.7	4.0^{cdefgh}
E+Fz+GI	54^{bc}	50^{abcde}	85^{abcd}	2715.2^{efg}	189.0^{cde}	83.4	22.5	1.5	4.2^{abcdef}
E+Fz+SR	88^{a}	49^{bcdef}	84^{efgh}	2888.0^{cdefg}	187.3^{cde}	83.4	22.3	1.8	4.7^{ab}
E+SR+Fn	89^{a}	49^{f}	84^{defgh}	3213.7^{abc}	200.2^{a}	83.6	21.7	1.7	$3.9^{cdefghi}$
E+Fz+Fn	52^{bc}	50^{abcd}	86^{a}	3023.7^{bcdef}	202.9^{a}	83.4	22.3	1.5	3.3^{i}
E+GI+Fn	52^{bc}	50^{abc}	86^{abc}	3115.1^{bcde}	202.7^{a}	83.6	21.9	1.6	3.4^{ghi}
E+ST+Fn	51^{bc}	50^{bcdef}	85^{abc}	3030.4^{bcdef}	200.0^{a}	83.7	21.8	1.7	3.7^{efghi}
E+ST+Fz	58^{b}	50^{ab}	85^{abcd}	2712.4^{efg}	186.6^{cde}	83.5	22.4	1.5	4.1^{bcdefg}
E+SR+GI	96^{a}	49^{f}	84^{fgh}	2931.0^{cdefg}	185.3^{cde}	83.3	22.1	1.6	4.8^{a}
E+ST+SR+GI+Fn	91^{a}	49^{f}	84^{cdefgh}	3425.7^{ab}	201.7^{a}	83.7	21.5	1.8	4.0^{cdefgh}
E+SR+GI+Fn	96^{a}	49^{f}	$85^{bcdefgh}$	3557.8^{a}	201.2^{a}	83.5	21.8	1.7	$3.9^{cdefghi}$
E+ST+GI+Fn	51^{bc}	50^{bcdef}	85^{abcd}	3224.4^{abc}	201.5^{a}	83.6	21.7	1.6	3.4^{hi}
E+ST+SR+GI	96^{a}	49^{ef}	84^{h}	3070.4^{bcde}	182.5^{de}	80.5	22.2	1.7	4.5^{abcd}
E+ST+SR+Fn	88^{a}	49^{f}	84^{cdefgh}	3418.9^{ab}	201.2^{a}	83.5	21.8	1.7	3.8^{defghi}

^{z} ST – Seed Treatment; SR – Seeding Rate; GI – Granular Inoculant; Fz – Starter N Fertilizer; Fn – Foliar Fungicide.

^{y} Means are not significantly different ($P > 0.05$) according to Fisher's Protected LSD.

$^{a\text{-}j}$ Means within a column followed by same letter grouping are not significantly different ($P > 0.05$) according to Fisher's Protected LSD.

Table 2: Single degree of freedom contrasts comparing mean response to inputs

	Contrast									
	Low SR[z] vs. High SR		No ST[z] vs. ST		Liquid vs. Granular Inoculant		No Fn[z] vs. Fn		No Fz[z] vs. Fz	
Variable	Estimate[y]	P > F	Estimate[y]	P > F	Estimate[y]	P > F	Estimate[y]	P > F	Estimate[y]	P > F
Plant density (plants m^{-2})	-39	<.0001	-4	0.0292	-13	<.0001	-2	0.2992	7	0.0006
Seed yield (kg ha^{-1})	-329.6	<.0001	-92.0	0.1661	-217.7	0.0013	-416.8	<.0001	97.2	0.1912
Days to flower	0.34	<.0001	0.09	0.1678	0.10	0.1275	0.09	0.1355	-0.31	<.0001
Days to maturity	1.31	<.0001	0.20	0.317	0.31	0.1157	-0.42	0.0335	-0.60	0.007
TKW (g 1000 $seeds^{-1}$)	2.01	0.0856	0.20	0.8671	-0.15	0.8951	-13.38	<.0001	2.71	0.0393
TW (kg hL^{-1})	0.33	0.2095	0.22	0.4133	0.32	0.2245	-0.39	0.1371	-0.13	0.6509
Protein (%)	0.18	0.0449	0.16	0.065	0.07	0.4026	0.40	<.0001	-0.31	0.002
Disease 1 (1-9)	-0.13	0.0026	-0.05	0.2168	0.01	0.7535	0.01	0.8282	0.10	0.0424
Disease 2 (1-9)	-0.40	0.0002	0.09	0.3996	-0.01	0.9421	0.74	<.0001	0.02	0.8814

[z] SR – Seeding Rate; ST – Seed Treatment; Fn – Foliar Fungicide; Fz – Starter N Fertilizer.

[y] Estimate is difference in treatment 1 minus treatment 2.

Differences in disease ratings at fungicide application among treatments at individual sites was relatively small compared to differences at the second disease rating (data not shown).

Three weeks after fungicide application, the treatment effect on disease ratings was significant (Table 1). The high seeding rate increased disease compared to the low seeding rate treatments and peas receiving a foliar fungicide had lower disease incidence compared to treatments that did not receive a foliar fungicide (Table 2). Applying a seed treatment, granular inoculant or starter N fertilizer did not affect disease incidence three weeks after fungicide application on average (Table 2).

Days to flower and DTM were both affected by treatment, however treatment differences were relatively minor when site years were combined (Table 1). Generally, the high seeding rate reduced both DTF and DTM compared to the low seeding rate treatments (Table 2). Conversely, applying a starter N fertilizer increased both DTF and DTM (Table 2). These observations were consistent among individual site years as well (data not shown). Applying a foliar fungicide also increased DTM on average (Table 2), however this was only observed at Indian Head in 2012 (data not shown). Seed treatment and granular inoculant also reduced DTF and DTM at Swift Current in 2012 (data not shown).

The overall treatment effect on seed yield was significant on average and at all site years except Indian Head in 2013 (Table 1). On average, the high seeding rate, foliar fungicide and granular inoculant treatments significantly increased seed yields by 329, 417 and 218 kg ha^{-1} compared to the low seeding rate, no fungicide and liquid inoculant treatments, respectively (Table 2). Increasing the seeding rate and applying a foliar fungicide resulted in consistent (5 of 7 site years) and relatively high increases in seed yield at individual site years (data not shown). Foliar fungicide improved yields at all site years except Indian Head and Swift Current in 2013 (data not shown). Granular inoculant improved yields compared to liquid inoculants by a relatively large margin at Scott in 2012 and improved yield modestly at Swift Current and Melfort in 2012 (data not shown). Seed treatments significantly increased yields at Scott and Swift Current in 2012 (data not shown). Starter N fertilizer had no beneficial effect on seed yield and significantly decreased seed yields at some site years (data not shown).

When applying individual inputs alone to the empty input package, the relative yield increase was 11.7, 13.8, 3.2, 24.4 and 6.8% when adding starter N fertilizer, foliar fungicide, seed treatment, higher seeding rate or granular inoculant, respectively, compared to the empty input package when all site years were combined (data not shown). On average, the high seeding rate was the only input which resulted in significant yield improvements compared to the empty input package (Table 1). Increasing seeding rate only resulted yield increases at Scott, Swift Current and Melfort in 2012 (data not shown). Although not significant in the overall analysis, applying a foliar fungicide to the empty input package increase seed yield compared to the empty input package at Scott in 2013 and Indian Head and Melfort in 2012 (data not shown). Granular inoculant only increased seed yield relative to the empty package at Scott in 2012 and applying a seed treatment or starter fertilizer alone never increased seed yields relative to the empty package (data not shown).

When combining inputs, on average, highest numerical yield came from the E+GI+SR+Fn treatment; however, this yield was not statistically different than E+SR, E+SR+Fn, E+SR+ST+GI+Fn, E+ST+GI+Fn, E+ST+SR+Fn treatments or the full input package (Table 1). This indicates that combining inputs, on average, did not increase seed yields in a synergistic fashion (data not shown). Although including fungicide to other combinations was not, on average, sequentially additive, the relative yield increase for fungicide was quite large compared to other inputs when combined with two or more inputs (data not shown). The foliar fungicide may have been required to protect yield by reducing disease incidence;

applying Fn combination with the SR, GI, Fz, and SR + GI significantly reduced disease incidence three weeks after application when as compared to these inputs applied without fungicide (Table 1). Although applying fungicide in combination with more than two other inputs resulted in larger relative yield increases, applying fungicide alone to the empty input package resulted in modest yield increases; conversely, seeding rate resulted in large relative increases when applied alone but had modest increases when combined with other inputs (data not shown). On average, all other combinations behaved antagonistically (data not shown); however, we suspect that the interactions would be better described as compensatory.

The treatment effect had a significant effect on TKW at all site years (data not shown). Contrasts showed that the treatments receiving foliar fungicide applications consistently increased TKW (6 of 7 site years) (data not shown) compare to treatments without by 13.4g, on average (Table 2). Seeding rate and granular inoculant have inconsistent effects on TKW (data not shown), but did not show any significant differences in the combined analysis (Table 2). Applying starter N fertilizer decreased TKW compared to no starter fertilizer treatments (Table 2). The overall treatment effect on seed protein concentration was significant at Indian Head in 2012 and at Scott and Swift Current (data not shown). Seed protein concentration was often inversely related to seed yield. In 2012, treatments receiving foliar fungicide had higher yields than treatments without at all sites (data not shown); consequently, protein significantly decreased with fungicide application at these sites (data not shown) due to a dilution effect of higher yield potential. Seed treatment also increased yields and decreased protein concentration at Scott and Swift Current in 2012 (data not shown). Starter N fertilizer treatments had significantly higher protein concentrations on average, which may reflect the consistently lower yields achieved with these treatments across site years (Table 2). Higher seeding rates and granular inoculants had inconsistent effects on seed protein concentrations at individual site years (data not shown). Overall, however, higher seeding rates were found to reduce protein concentration (Table 2), likely due to higher yields, and again diluting protein concentration of the seed.

An economic analysis was conducted using the combined treatment means and both 2012 and 2013 pea prices ($8.46/bu and $5.83/bu, respectively) to contrast net return under high (Table 3) and low price conditions (data not shown). The modest yield improvements made with each input applied alone to the empty input package was enough to cover the additional cost of the input in both price situations. Using 2012 prices, the E+SR+GI+Fn treatment had the highest net return because it had the highest yield on average and lower input costs compared to combinations containing four or all five inputs. All other treatments resulted in higher net returns than the empty input package except the E+ST+SR and E+Fz+GI. However, with 2013 prices, many of the treatments containing two or more inputs resulted in lower net returns compared to the empty input package because cost of additional inputs were not covered by improvements in yield. Applying only the high seeding rate to the empty package resulted in the highest return with 2013 price and the second highest return with 2012 prices, due to the large increase in yield and relatively low input costs.

Conclusions: Increasing seeding rate and applying a granular inoculant consistently increased plant density (on average 39 and 13 plants m^{-2}, respectively). Seed treatments did not consistently improve plant density and starter N fertilizer generally decreased plant density by 7 plants m^{-2}. Higher seeding rates resulted in significantly higher disease ratings both before and after fungicide application likely due to higher plant populations and thicker canopy; foliar fungicides treatments reduced leaf disease compared to those without. High seeding rates reduced DTF and DTM while starter N fertilizer had the opposite effect. The other inputs had somewhat inconsistent effect on maturity at individual site years. High seeding rates and application of a foliar fungicide consistently increased seed yields (5 of 7 site years)

Table 3. Basic economic analysis of the various combinations of inputs. Gross income based on a market price of $8.48/bu (2012 price). Input costs are based on spring 2012 retail prices.

Treatment	Yield (kg/ha)	Gross income ($/ha)	Seed cost ($/ha)	Seed treatment ($/ha)	Fertilizer ($/ha)	Inoculant ($/ha)	Fungicide ($/ha)	Total costs ($/ha)	NET Gain ($/ha)
Empty (E)	2538	789	59	0	0	5	0	64	725
Full (F)	3439	1069	119	30	34	35	82	299	770
E+ST[z]	2619	814	59	15	0	5	0	79	735
E+SR[z]	3157	982	119	0	0	9	0	128	854
E+GI[z]	2711	843	59	0	0	35	0	95	748
E+Fz[z]	2835	882	59	0	34	5	0	97	784
E+Fn[z]	2887	898	59	0	0	5	82	145	753
E+ST+SR	2758	858	119	30	0	9	0	159	699
E+ST+GI	2866	891	59	15	0	35	0	110	781
E+Fz+GI	2715	844	59	0	34	35	0	128	716
E+Fz+SR	2888	898	119	0	34	9	0	161	737
E+SR+Fn	3214	999	119	0	0	9	82	209	790
E+Fz+Fn	3024	940	59	0	34	5	82	179	761
E+GI+Fn	3115	969	59	0	0	35	82	176	793
E+ST+Fn	3030	942	59	15	0	5	82	161	782
E+ST+Fz	2712	843	59	15	34	5	0	113	731
E+SR+GI	2931	911	119	0	0	35	0	154	758
E+ST+SR+GI+Fn	3426	1065	119	30	0	35	82	266	799
E+SR+GI+Fn	3558	1106	119	0	0	35	82	235	871
E+ST+GI+Fn	3224	1003	59	15	0	35	82	191	811
E+ST+SR+GI	3070	955	119	30	0	35	0	184	770
E+ST+SR+Fn	3419	1063	119	30	0	9	82	240	823

[z] ST – Seed Treatment; SR – Seeding Rate; GI – Granular Inoculant; Fz – Starter N Fertilizer; Fn – Foliar Fungicide

by an average of 329 and 417 kg ha^{-1}, respectively, compared to the low seeding rate or no fungicide application. Increasing seeding rate had a larger effect on yield when applied alone as compared to when applied with other inputs; therefore, we suspect that an intermediate seeding rate may provide yield improvements and be more economical when combined with other inputs. In contrast, fungicide application had a greater effect on yield when combined with other inputs, essentially "protecting" higher yield potential. Granular inoculants and seed treatments had inconsistent effects on seed yield at individual site years while starter N fertilizer never had beneficial effects on seed yield. Combining inputs generally did not increase yields in a synergistic or sequentially additive fashion. Although the combination of granular inoculant, high seeding rate and foliar fungicide resulted, on average, in the highest yields and highest net returns, applying only the high seeding rate to the empty input package had significant yield increases on average compared to the empty input package and had the second highest net return. Growers should focus on seeding rate, granular inoculant and fungicide in order to maximize yield potential and economic return.

While foliar fungicide consistently increased TKW, increasing seeding rates and applying starter N fertilizer generally decreased TKW. Protein concentrations decreased in conjunction with increases in yield at individual site years with high seeding rates, foliar fungicide and seed treatment applications. This project will be continued in 2014.

Acknowledgements: Funding for this project provided by the Saskatchewan Pulse Grower

Quantifying Genetic Differences in Seed Losses Due to Pod Drop and Pod Shattering in Canola

Background & Objectives: Past research on canola harvest management issues has largely overlooked genetic variability in resistance to shattering, especially in currently available Brassica napus cultivars. In addition, harvest management and environmental conditions can affect shattering. Varietal differences in resistance to pod shattering and drop are import to growers who are interested in straight-combining and would like to minimize the associated risks. The objective of this trial is to quantify the relative resistance to pod shattering and pod drop amongst high-yielding Brassica napus hybrids under a range of environmental conditions and to identify cultivars which may be well suited for straight-combining.

Methodology: Field trials were conducted at Indian Head, Scott and Swift Current, SK in 2011 and 2012, and the 12 canola hybrids evaluated were: 5440, L130, L150, 45H29, 45H31, 73-75, 73-45, 6060, 9553, 46H75, 2012 and 5525. In 2013, the trials were expanded to include a location at Melfort and, while L150, 45H31, 73-45, 6060 and 9553 were removed, they were replaced by the newer hybrids L140P, 45H32, 74-44BL, 6050 and 1012. Cultivar treatments were arranged as a randomized complete block design with four replicates. All varieties were direct seeded into cereal stubble at 115 seeds m^{-2}. Fertilizer was applied according to soil test recommendations and all herbicides and fungicides were applied as required. The plots were straight-combined using small plot combines at two separate dates. The first harvest date (T1) was targeted for, or slightly before, the optimal harvest stage (seed at 10-12% moisture content with ≤2% green seed). The second harvest (T2) was targeted for 3-4 weeks past the optimal stage. Timing of the harvest operations and shatter measurements has proven challenging due to maturity differences amongst hybrids and at some sites, separate T1 harvest dates were required to accommodate these differences. In 2013, the layout of the plots was modified slightly to permit desiccation of the plot areas harvested at the T1 date. The canola harvested at the T2 date was not desiccated.

Results: As expected, the observed yield losses due to pod drop and pod shatter generally increased as harvest was postponed past the optimal crop stage; however, the extent to which these losses increased varied dramatically depending on the specific conditions encountered. Averaged sites, total losses observed with straight-combining were typically less than 5% for all hybrids and unlikely to have much impact on yield relative to swathing, provided that combining was not excessively delayed. With delayed harvest, the actual losses were extremely variable and, depending on hybrid and sites where evaluated, average total losses could exceed 10% and, for individual hybrids under extreme conditions, sometimes exceeded 30%. While yield losses due to pod drop were typically negligible with early harvest, these losses frequently exceeded those due to pod shatter when harvest was delayed by 3-4 weeks and pod drop appears to be a factor of increasing importance as straight-combining is delayed. Overall, the two new shatter tolerant hybrids (L140P and 45H32) performed well; however the losses were low at all sites in 2013 and these conditions were not ideal to assess whether the new cultivars were a substantial improvement over the others evaluated. For all of the hybrids evaluated in 2013 the lowest total losses were observed for L140P followed by 74-44BL, 6050, 5440 and then L130 and 45H32. All things considered, while varietal differences in resistance to pod drop and pod shatter were frequently detected within individual sites, the differences amongst hybrids were typically much smaller than the differences observed between harvest dates or from one site to the next. Furthermore, the observed differences were not always consistent from year to year or site to site.

Scott 2011

Canola yields were high but with some variation amongst hybrids. At the first harvest date (September 14), yields were highest for 73-75 (3237 kg ha^{-1}) and lowest for 2012 (2463 kg ha^{-1}) with yields of most hybrids falling between this range (Table 1). At this time, percent green seed ranged from 0.3% for L130 to 3.8% for 6060. However, all but two hybrids were at or below the desired minimum level of 2% green indicating that, overall, the yield and seed loss measurements were initiated at an appropriate time. When harvest was delayed until October 4, 5440 was the highest yielding hybrid (3085 kg ha^{-1}) and the lowest was still 2012 (2479 kg ha^{-1}). While yields for many hybrids were similar between the two dates, some tended to decline as harvest was delayed (i.e. 73-75, 6060, 5525), presumably a result of shattering and pod drop losses.

At the T1 harvest date, total losses averaged only 1.5% with no significant differences amongst hybrids (Table 1). Losses due to pod drop averaged 0.7% and no cultivar differences were considered significant. Losses due to shattering were slightly higher averaging 0.9%, but again with no significant differences between hybrids. Total yield losses were still relatively low after harvest had been delayed to October 4, averaging 7.5% when both shattering and pod drop losses were combined. Yield losses due to pod drop were significantly affected by hybrid, ranging from only 0.9% for 2012 to 6.6% with 6060. The overall average yield loss due to pod drop was 4.1%, over half of the total estimated losses; however, this was not necessarily true for all individual varieties (i.e. 5440, 2012). With the delay in harvest, yield losses due to pod shattering averaged 3.3% and there were no significant differences amongst the hybrids. The combined total losses varied with hybrid and were highest for 6060 (12.9%) and lowest for 5440, L150 and 2012 (3.6-4.7%). Expressed as a percentage of 5440, losses ranged from 87% for 2012 to as high as 322% for 6060. The trial at Scott was terminated early due to hail damage in 2012.

Scott 2013

At the T1 harvest date (September 3), canola yields varied amongst hybrids (Table 2) with the lowest yields observed for 1012 (1589 kg ha^{-1}) and the highest yields with 45H32, 73-75, 74-44 and 6060 (2768-2936 kg

Table 1. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Scott in 2011. Means within a column followed by the same letter do not statistically differ (Fisher's protected LSD test; $P \leq 0.05$).

	Yield T1	Yield T2	Green Seed T1	Drop T1	Shatter T1	Total T1	Drop T2	Shatter T2	------- Total T2 -------	
Cultivar	--------- *kg ha⁻¹* ---------		*%*	--------------------------------- % of seed yield ---------------------------------						% of 5440
5440	2976 abc	3085 a	0.7 d	0.3 a	0.8 a	1.1 a	1.4 ef	2.9 a	4.3 d	100 ef
L130	2901 bc	2961 abc	0.3 d	0.7 a	0.8 a	1.6 a	2.5 de	2.4 a	5.0 cd	118 def
L150	2899 bc	3021 ab	1.1 cd	0.6 a	1.1 a	1.7 a	1.8 ef	2.8 a	4.7 d	106 ef
45H29	3112 ab	2944 abc	1.3 cd	0.8 a	0.7 a	1.5 a	5.9 ab	2.5 a	8.4 bc	197 bcde
45H31	2889 bc	2823 bc	0.9 cd	0.7 a	0.7 a	1.5 a	5.7 ab	3.6 a	9.3 ab	227 abc
73-75	3237 a	2847 bc	1.1 cd	0.8 a	0.6 a	1.4 a	5.8 ab	4.3 a	10.1 ab	241 ab
73-45	2794 bc	2771 c	0.9 cd	1.0 a	1.3 a	2.2 a	5.5 abc	5.0 a	10.5 ab	257 ab
6060	2704 cd	2348 d	3.8 a	0.5 a	0.9 a	1.5 a	6.6 a	6.3 a	12.9 a	322 a
9553	2712 cd	2815 bc	2.7 ab	1.0 a	0.7 a	1.7 a	4.6 bc	2.5 a	7.1 bcd	176 bcdef
46H75	2955 abc	2884 abc	2.0 bc	0.6 a	0.5 a	1.1 a	3.9 cd	1.7 a	5.6 cd	137 cdef
2012	2463 d	2479 d	1.3 cd	0.0 a	1.3 a	1.4 a	0.9 f	2.7 a	3.6 d	87 f
5525	2996 abc	2756 d	1.4 cd	0.9 a	0.8 a	1.6 a	5.0 bc	3.4 a	8.4 bc	204 bcd
St. Error	105.1	78.9	0.41	0.22	0.22	0.39	0.55	0.94	1.30	39.5
Pr. > *F*	0.002	< 0.001	< 0.001	0.150	0.279	0.889	< 0.001	0.081	< 0.001	< 0.001

ha^{-1}). With harvest delayed until September 27, seed yields still varied amongst hybrids and were highest with 45H32, 73-75, and 74-44 (3902-3980 kg ha^{-1}) but, at this point, were lowest for the three Liberty Link® hybrids 5440, L130 and L140P (2547-2613 kg ha^{-1}). Unexpectedly, and difficult to explain, yields at the second harvest date were all higher than those measured at the T1 date, in many cases by a relatively large margin. With percent green seed averaging 9.7% and ranging from 1.0-16.8% ($P < 0.001$) we can speculate that the yield and shattering measurements were initiated earlier than optimal for most of the hybrids. Percent green seed (at the T1 harvest date) was lowest for L130 (1.0%) and highest for 45H29 (16.8%) while values for the remaining hybrids were intermediate, but mostly well above the desired minimum level of 2.0% (Table 2).

Yield losses due to pod drop were not differentiated from those due to pod shatter. At the first harvest date, total losses were low (0.6% on average) and not affected by canola hybrid. That being said, since these measurements appeared to have been initiated somewhat before the optimal harvest stage, it was not unexpected for losses due to pod drop and pod shatter to be quite low at the T1 harvest date.

Table 2. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Scott in 2013. Means within a column followed by the same letter do not statistically differ (Fisher's protected LSD test; P ≤ 0.05).

	Yield T1	Yield T2	Green Seed T1	Total T1	------- Total T2 -------	
Cultivar	------------ *kg ha^{-1}*	------------	*%*	-------- *% of seed yield*	-------	*% of 5440*
5440	1861 cd	2613 e	1.5 gh	0.4 a	2.9 bcd	100 bc
L130	1734 cd	2586 e	1.0 h	0.7 a	3.8 ab	145 ab
L140P	2116 bc	2547 e	5.3 efgh	0.6 a	2.1 cd	80 c
45H29	2560 ab	3748 ab	16.8 ab	0.4 a	1.9 cd	69 c
45H32	2936 a	3910 a	15.0 abcd	0.5 a	1.5 d	64 c
73-75	2768 a	3902 a	7.3 efgh	0.5 a	2.6 bcd	94 bc
74-44 BL	2917 a	3980 a	11.5 bcde	0.6 a	1.9 cd	66 c
6050	2908 a	3619 abc	19.8 a	0.7 a	3.3 bc	116 bc
1012	1589 d	3364 bcd	8.5 defg	0.9 a	5.2 a	187 a
46H75	2197 bc	3594 abc	16.5 abc	0.4 a	2.4 bcd	90 bc
2012	1760 cd	2983 de	3.3 fgh	0.6 a	1.9 cd	68 c
5525	1984 cd	3194 cd	9.3 cdef	0.5 a	3.1 bcd	103 bc
St. Error	169.7	341.5	2.8	0.14	0.63	24.8
Pr. > *F*	< 0.001	< 0.001	< 0.001	0.440	0.006	0.006

With harvest delayed until September 27, overall mean yield losses due to dropped plus shattered pods increased from 0.6% to 2.7%; however, the total losses incurred up to this stage varied with canola hybrid. Overall, the lowest losses were observed with 45H32 (1.5%) while the highest total losses were, again, observed with 1012 (5.2%). While losses for the remaining hybrids fell between these values, those observed for all except L130, 6050 and 1012 did not significantly differ from those observed with 45H32 and all were low enough that the effect on seed yield was most likely negligible.

Conclusions: The results to date would suggest that, while genetic differences in resistance to environmental seed losses do exist, all of the hybrids evaluated could be straight-combined successfully provided that harvest is completed in a reasonably timely manner, disease pressure is low and extreme weather is not encountered during the critical crop stages. Consequently, factors such as overall yield potential, days to maturity and herbicide system are likely at least, if not more, important to considered when choosing a canola hybrid with the intention of straight-combining. These trials are scheduled to continue in 2014.

Acknowledgements: Funding provided by the Saskatchewan Canola Development Commission and Manitoba Canola Growers Association. In-kind contributions provided by Bayer CropScience, Brett Young, Dow Agrosciences, Monsanto, Pioneer Hi-bred and Viterra.

Regional Testing of Cereal, Oilseed and Pulse Cultivars 2013

Authors & Affiliations: L.P. Nielsen and G.J. Moskal – Agriculture and Agri-Food Canada

Methodology: Cultivars are tested regionally to determine their adaptation to the wide range of soil and climatic conditions in Saskatchewan. These tests are conducted at approximately 12 locations each year including two by Scott Research Farm staff (Scott and Glaslyn) and one at the Melfort Research Farm. Results form the basis of cultivar recommendations – yield data can help producers assess the performance of varieties in their area. However, data from a single location can be limited, particularly for new varieties. More comprehensive information is contained in the Saskatchewan Ministry of Agriculture publication, *Varieties of Grain Crops 2014*. Seed quantities for new varieties listed herein may be limited for 2014.

Table 1. Average Yield of Crop Species on Fallow expressed as a % of hard red spring wheat (AC Barrie) at Scott, Glaslyn and Melfort and (kg/ha). For most crops, data presented is based on yields averaged over the past 5 years.

	Cultivar	Scott		Glaslyn		Melfort	
Bread Wheat	AC Barrie	100	(3587)	100	(4422)	100	(4063)
Soft White	Sadash	145	(5207)	137	(6062)	158	(6430)
Durum Wheat	Strongfield	113	(4039)	---	---	116	(4722)
Barley	AC Metcalfe	129	(4626)	127	(5604)	118	(4807)
Oat	CDC Dancer	149	(5346)	140	(6208)	125	(5090)
Field Pea (yellow)	Cutlass	65	(2348)	81	(3601)	110	(4465)
Field Pea (green)	CDC Striker	77	(2765)	81	(3590)	104	(4221)
Lentil	CDC Maxim	65	(2344)	---	---	70	(2721)
Canary	Cantate	48	(1716)	---	---	57	(2296)
Canola	5440	*117	(4216)	*55	(2432)	98	(3965)
Mustard (Juncea)	Cutlass	*65	(2328)	---	---	---	---
Flax	CDC Bethune	*74	(2661)	*49	(2172)	51	(2061)

* Less than 5 years of data

Table 2. Yield of Flax Cultivars at Scott, Glaslyn and Melfort 2013

	2013 Yield (kg/ha)			Long Term Average Yield (% of CDC Bethune)		
Cultivar	Scott	Glaslyn	Melfort	Scott	Glaslyn	Melfort
CDC Bethune	2726	1735	3806	100	100	100
CDC Glas	2679	1887	3882	101	91	115*
CDC Neela	2469	1877	3624	93	84	112*
CDC Sanctuary	2521	1765	3466	83	105	88
CDC Sorrel	2337	1999	3008	99	99	91
FP2308	2351	1590	3680	88	80	115*
Prairie Sapphire	1700	1468	3021	64	84	100
Westlin 70	1678	1641	3624	63	88	97*
Westlin 71	2077	1420	3246	78	65	85*

***** Less than 3 years of data

Table 3. Yield of Spring Wheat Cultivars at Scott, Glaslyn and Melfort 2013

Cultivar	2013 Yield (kg/ha)			Long Term Average Yield (% of AC Barrie)					
Hard Red	Scott	Glaslyn	Melfort	Scott		Glaslyn		Melfort	
AC Barrie	3410	4509	5160	100		100		100	
AC Bailey	4008	4798	5429	104	*	102		95	
AAC Brandon	4515	5123	5986	126	*	116	*	108	*
AAC Elie	4570	5206	6129	127	*	112	*	107	*
AC Redwater	3954	4607	5467	110	*	98	*	97	*
Carberry	3860	4972	5482	115		105		95	
Cardale	3878	4666	5822	108	*	101		102	
CDC Kernen	3882	4259	5521	106	*	101		104	
CDC Plentiful	3929	4802	5657	110	*	105	*	108	
CDC Stanley	4012	4755	6308	113		95		105	
CDC Thrive	3889	4383	5519	110		95		104	
CDC Utmost VB	4086	4413	6278	109		96		108	
CDC VR Morris	4135	5006	5907	112	*	109		108	
Glenn	3826	4577	5364	111		107		100	
Muchmore	4152	5071	5878	113		106		95	
Shaw VB	4055	4656	6289	116		107		112	
Stettler	4505	4783	5753	114		108		106	
SY 433	3661	4728	5574	95	*	102		101	
Vesper VB	3981	4235	6045	107	*	101		116	
WR859 CL	3705	4436	5039	110		104		95	
5604 HR-CL	3612	4541	5182	102		94		93	
5605 HR-CL	3646	5020	5797	102	*	114	*	112	*
Hard White									
AAC Iceberg	3874	4676	5258	108	*	93	*	96	*
AAC Whitefox	3763	4842	5241	105	*	106	*	102	*
AAC Whitehawk	3494	3938	4227	92	*	79		81	
CDC Whitewood	3813	4773	5314	106	*	100	*	99	*
Soft White									
Chiffon	5997	5721	8706	185	*	125	*	136	*
Sadash	5747	6238	7489	164	*	136	*	122	
CPS									
AAC Crusader	4705	4956	6840	139	*	120	*	124	*
AAC Ryley	4247	5173	6464	126	*	117	*	110	*
Conquer VB	4665	5281	7782	123	*	131	*	134	
Enchant	4123	4986	5671	122	*	119	*	103	
General Purpose									
AAC Innova	5600	6145	7499	138		172		124	
AAC Proclaim	4573	4615	6912	107	*	142	*	119	*
CDC NRG003	5014	5054	6760	120		125		115	
Pasteur	5211	5995	7802	143		138		127	
Minnedosa	4569	4873	6307	141		106		109	

***** Less than 3 years of data

Table 4. Yield of Durum Cultivars at Scott and Melfort 2013

	2013 Yield (kg/ha)		Long Term Average Yield (% of Strongfield)		
Cultivar	Scott	Melfort	Scott		Melfort
Strongfield	3873	5501	100		100
AAC Current	3540	5327	88	*	98
AAC Marchwell	3845	5245	95	*	95
AAC Raymore	3445	4721	85	*	92
CDC Desire	3831	4592	95	*	91
CDC Vivid	3651	4559	90	*	97
CDC Fortitude	3393	4766	84	*	87
DT 832	3671	5083	91	*	92
Enterprise	3782	5245	94		98
Transcend	3553	5506	88	*	100

* Less than 3 years of data

Table 5. Yield of Oat Cultivars at Scott, Glaslyn and Melfort 2013

	2013 Yield (kg/ha)			Long Term Average Yield (% of CDC Dancer)		
Cultivar	Scott	Glaslyn	Melfort	Scott	Glaslyn	Melfort
CDC Dancer	5327	6393	6867	100	100	100
AAC Justice	6226	5817	8259	116	94	120
AC Stride	6823	6122	9567	117	100	126
Bradley	5859	5735	8606	109	92	115
CDC Big Brown	5985	6354	7588	105	102	110
CDC Haymaker	4571	5036	7838	85	81	114
CDC Nasser	6278	5109	8055	109	94	115
CDC Ruffian	6908	6279	8734	129	101	127
CDC Seabiscuit	5564	6101	8270	109	102	115
Souris	6124	5274	8171	111	93	127
Summit	6665	6187	9034	116	100	113

* Less than 3 years of data

Table 6. Yield of Barley Cultivars at Scott, Glaslyn and Melfort 2013

Cultivar	2013 Yield (kg/ha)			Long Term Average Yield (% of AC Metcalfe)		
TWO ROW	Scott	Glaslyn	Melfort	Scott	Glaslyn	Melfort
AC Metcalfe	4626	6631	6308	100	100	100
AC Synergy	5781	6967	7264	112	110	109
ABI Voyager	5881	6329	7658	127	113	121
Brahma	6099	7107	7471	117	111	118
Busby	5187	6498	7119	111	111	108
Canmore	5498	7008	6639	119	125	105
CDC Carter	5494	5308	7210	108	95	105
CDC Clear	4627	5273	6814	96	94	105
CDC ExPlus	3711	4385	6880	89	75	103
CDC Kindersley	6064	6954	6813	112	100	107
CDC Maverick	4553	6034	6359	90	95	93
CDC PolarStar	5105	6224	6462	107	101	101
Cerveza	6030	6529	7355	139	107	120
Gadsby	6004	6694	6487	121	109	110
Major	6021	6801	7507	128	111	120
Taylor	2105	2471	5964	70	56	99
TR07728	6099	7107	7471	117	111	118
TR10214	6071	6847	7387	131	122	117
TR10694	5498	7008	6639	119	125	105
TR11698	5637	7037	7256	122	126	115
SIX ROW						
Amisk	5357	7569	8309	116	135	132
Breton	5199	7329	6466	100	114	110
CDC Anderson	4511	6620	6924	103	98	114
Celebration	4956	6428	7429	111	97	109

* Less than 3 years of data

Table 7. Yield of Pea Cultivars at Scott, Glaslyn and Melfort 2013

Cultivar	2013 Yield (kg/ha)			Long Term Average Yield (% of Cutlass)		
Yellow	Scott	Glaslyn	Melfort	Scott	Glaslyn	Melfort
Cutlass	3905	4732	5574	100	100	100
AAC Ardill	4137	4643	6525	110	129	117
Abarth	4253	4597	5383	118	128	97
AC Earlystar	3726	5127	6515	103	142	117
Agassiz	4113	4855	4485	130	129	106
CDC Amarillo	4289	4994	5002	125	110	117
CDC Golden	3861	4539	4606	114	103	102
CDC Hornet	4435	4712	5531	112	100	102
CDC Meadow	3840	4769	6432	110	111	114
CDC Saffron	3915	4413	6588	116	100	113
CDC Treasure	3239	4795	6019	109	114	107
CDC 2847-21	4002	4969	5862	111	138	105
CDC 2950-19	4882	4625	5101	136	128	92
LN4228	3950	4287	5158	115	119	93
Green						
CDC Limerick	4322	4451	4978	110	91	101
CDC Patrick	3548	4295	5069	113	112	96
CDC Pluto	3879	4391	4538	107	109	96
CDC Raezer	3104	4401	5730	104	90	101
CDC Striker	3300	4119	4791	118	100	92
CDC Tetris	3710	4461	5553	118	113	108
CDC 2472-4	4305	3881	5296	125	82	107
Cooper	4399	3771	5330	117	106	98
Red						
CDC 2710-1	4425	4446	4814	123	123	86
Dun						
CDC Dakota	4243	4332	6090	135	104	114
Forage						
CDC Horizon	3641	3609	4915	84	68	92
Maple						
CDC Mosaic	3683	3883	5092	80	75	90

* Less than 3 years of data

Table 8. Yield of Lentil Cultivars at Scott and Melfort 2013 (* Less than 3 years of data)

	2013 Yield (kg/ha)		Long Term Average Yield (% of CDC Maxim CL)	
Cultivar	Scott	Melfort	Scott	Melfort
CDC Maxim CL	1618	4021	100	100
Small Green				
CDC Imvincible	1074	4193	93	88
3592-13	1646	4542	70	106*
3674-30	2205	4334	94	108*
Medium Green				
CDC Imigreen CL	1070	1292	63	53
Large Green				
CDC Greenland	826	1932	64	67
CDC Greenstar	2059	1794	77	68
CDC Impower CL	1889	1169	74	46
3484-2	1687	2782	72	73*
Extra Small Green				
CDC Asterix	2192	3724	70	93
French Green				
CDC Marble	1960	4703	84	119*
CDC Peridot	1585	4257	82	72
Green Cotyledon				
CDC QG-1	1873	1594	52	50
CDC QG-2	1638	4145	70	97*
CDC QG-3	894	926	38	23*
Extra Small Red				
CDC Robin	1295	3555	80	73
CDC Rosie	1605	3819	99	96
CDC Ruby	1245	3276	77	88
IBC 507	1170	4446	72	111*
IBC 605	1065	4116	66	102*
3959-6	2046	4243	126	106*
Small Red				
CDC Dazil	1491	3948	92	100
CDC Imax CL	1184	3020	73	60
CDC Maxim CL	1618	4021	100	100
CDC Redcliff	1753	3232	108	103
CDC Scarlet	2352	3970	145	118
IBC 550	2209	3966	137	99*
3365-7	2437	4494	151	96*
3646-4	2724	3225	168	80*
3674-15	2224	4538	137	113*
Medium Red				
CDC KR-2	2114	3070	131	76*
IBC 479	2078	2061	128	51*
IBC 598	1614	625	100	16*
Large Red				
CDC KR-1	1971	1862	84	74
Spanish Brown				
CDC SB-2	640	2389	40	91
CDC SB-3	1031	3257	64	81*
3674-17	2648	3713	164	92*