2013 Annual Project Report

for the

SASKATCHEWAN CANOLA DEVELOPMENT COMMISSION (SASKCANOLA)

PROJECT TITLE: QUANTIFYING GENETIC DIFFERENCES IN SEED LOSSES DUE TO POD DROP AND POD SHATTERING IN CANOLA

(CARP-SCDC 2011-20)

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Abstract / Executive Summary:
A study was initiated in 2011 to quantify the relative resistance to pod shattering and pod drop amongst high-yielding *Brassica napus* hybrids and to identify cultivars which may be well suited for straight-combining. Field trials were conducted at Indian Head, Scott and Swift Current in 2011 and 2012, and the 12 canola hybrids evaluated were: 1) 5440, 2) L130, 3) L150, 4) 45H29, 5) 45H31, 6) 73-75, 7) 73-45, 8) 6060, 9) 9553, 10) 46H75, 11) 2012 and 12) 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. 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. 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 for one more growing season at all four locations.

Background / Introduction:
Past research on canola harvest management issues has largely overlooked genetic variability in resistance to shattering, but focussed instead on other aspects including harvest (ie: Irvine and Lafond 2010), equipment considerations / header types (i.e. Hobson and Bruce 2002; Pari et al. 2012), timing of harvest operations (ie: Thomas et al. 1991, Vera et al. 2007), or general crop management (ie: Watson et al. 2008). Previous studies have made broader comparisons of oilseed crops (ie: Gan et al. 2008), but these were not focussed specifically on *B. napus* which comprises the vast majority of oilseed acres in Saskatchewan. Wang et al. (2007) provides one of the more comprehensive comparisons of pod shatter resistance amongst canola genotypes. While they did show yellow seeded *B. napus* canola and *B. juncea* to have greater shattering resistance than black seeded *B. napus* varieties as a whole; they also reported wide variability in environmental seed losses amongst the twenty-two *B. napus* genotypes that were evaluated. Another recent study in Saskatchewan evaluated pod sealant effects on canola seed yield and quantified losses amongst four *B. napus* hybrids and one open pollinated canola quality *B. juncea* cultivar (Holzapfel et al. 2010). While this research did not show a consistent benefit to *B. juncea* over *B. napus* (possibly due to disease at the wetter locations), the Argentine hybrid 5440 exhibited

consistently lower losses than the other cultivars evaluated. This was especially evident when canola was left standing several weeks past the optimal harvest stage (6% versus 20% yield losses) but also at the time of harvest (2% versus 7%). Varietal differences in resistance to pod shattering and drop such as these are import to growers who are interested in straight-combining and would like to minimize the risks associated with doing so. In addition to potential varietal differences, growers interested in straight-combining canola would also benefit from an improved understanding of the frequency and magnitude of environmental seed losses that can occur when Argentine canola hybrids are left to mature while standing.

Objectives:

A four-year study was initiated at multiple locations in 2011 with the specific objectives of:

1) Quantifying the frequency and magnitude of environmental seed losses in straight-combined *B. napus* canola under a wide range of environmental conditions.

2) Evaluating the relative resistance to pod shatter / pod drop amongst twelve modern *B. napus* hybrids to identify cultivars that may be particularly well suited for straight-combining.

3) Quantifying environmental seed loss contributions from pods breaking off at the pedicle and dropping versus pods shattering in *B. napus* canola.

Materials & Methods:

Field trials in 2011 and 2012 were located near Indian Head (50˚33'N 103˚39'W), Scott (52˚21'N 108˚50'W) and Swift Current (50˚16'N 107˚44'W), Saskatchewan. The treatments were twelve *Brassica napus* hybrid cultivars arranged in a modified Randomized Complete Block Design (RCBD) with four replications. In 2013, and additional site was initiated at Melfort (52˚49'N 104˚36'W) and the canola hybrids were updated in 2013 to stay current and to accommodate two new cultivars with potentially improved tolerance to shattering (L140P and 45H32). The RCBD was modified to keep varieties within common herbicide resistance groups adjacent to one another and the 16 hybrids that have been evaluated over the study period are provided in Table 1. A seeding rate of 115 viable seeds m^{-2} was used in all cases and the plots were direct seeded into standing cereal stubble. The specific seeding equipment used varied depending on the site with row spacings were 31 cm at Indian Head, 25 cm at Scott and 22 cm at Swift Current. The plots at each site were large enough to ensure that there was enough for two separate harvest passes to be completed at two distinct dates. Fertilizer formulations and rates varied depending on the location; however, all fertilizer was soil-placed either prior to or during seeding. Weeds were controlled using registered herbicides at the recommended rates and stages with at least one application of the partner herbicide (ie: Liberty, Roundup or Odyssey) applied in-crop. The plots were straight-combined using small plot combines at two separate dates. The first harvest date was targeted for at, or slightly before, the optimal harvest stage (seed dried to 10-12% moisture content with 2% or less green seed). The second harvest date 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. Dates of pertinent field operations and other agronomic information for individual sites are provided in Table 2.

Table 1. *Brassica napus* hybrids evaluated in 2011-12 canola shattering trials.

Hybrid Canola Cultivar Treatments			
InVigor 5440 (LL)	Pioneer 45H29 (RR)	BY 6060[Z] (RR)	BY 6050[Y] (RR)
InVigor L130 (LL)	Pioneer 45H31 (RR)	Proven 9553[Z] (RR)	Pioneer 46H75 (RR)
InVigor L150[Z] (LL)	Dekalb 73-75 (RR)	Pioneer 45H32[Y] (RR)	Nexera 2012 (RR)
InVigor L140P[X] (LL)	Dekalb 73-45[Z] (RR)	Dekalb 74-44BL[Y] (RR)	BY 5525 (CL)

[Z] 2011 and 2012 only; [Y] 2013 only

Several crop response variables were measured over the course of the growing season. Plant densities were determined by counting the number of plants in two separate one meter rows per plot and converting the averaged values to plants m^{-2}. The number of days from planting to maturity was recorded for each plot with the plants being considered mature when 60% of the seeds along the main raceme showed signs of colour change. Environmental seed losses due to pod shatter and/or pods breaking off at the pedicle and dropping (pod drop) were measured prior to each of the two harvest dates. These measurements were completed using shatter trays placed beneath the crop canopy well in advance of any potential seed losses with two trays per plot used at all locations except Swift Current where one tray per plot was used. All seed losses were estimated on a kg ha^{-1} basis and losses due to pod shattering and pods dropping were recorded separately (at all locations except Scott and Melfort at 2013) to distinguish between the two mechanisms of seed loss. Harvested seed yields at the two separate dates can also be used to assess shattering losses with any lower yields observed at the second harvest date presumably due to environmental seed losses (assuming equal header / combine losses for both dates). Grain yields were reported on a clean seed basis to a uniform moisture content of 10%. For the first harvest date, any yield losses measured in the trays were added back on to the harvested yield to estimate the total yield if no shattering / pod drop losses had occurred. Percent green seed data are presented to quantify differences in maturity and green was determined by crushing 500 seeds from each plot and counting the number of distinctly green seeds. Growing season weather conditions were estimated using data from the nearest Environment Canada weather station for each location.

Table 2. Dates of field operations and selected agronomic information for SaskCanola shattering trials at various locations (2011-2013).

Field Operation / Measurement	Indian Head 2011	Indian Head 2012	Indian Head 2013	Scott 2011	Scott 2013	Swift Current 2011	Swift Current 2012	Swift Current 2013	Melfort 2013
Seeding Date	17-05[Z]	18-05	25-05	17-05	15-05	13-05	12-05	17-05	22-05
Fertilizer Applied (kg N-P_2O_5-K_2O-S ha^{-1})	128-30-15-15	129-30-15-15	122-30-15-15	108-23-59-20	108-26-13-17	56-0-0-0	78-39-0-16	128-64-0-26	148-39-20-20
In-crop Herbicide 1	10-06	18-06	27-06 to 28-06[W]	09-06	11-06	09-06	12-06	17-Jun	19-06 to 24-06[W]
In-crop Herbicide 2	03-07[Y]	n/a	29-06[Y]	n/a	n/a	22-06[X]	n/a	n/a	n/a
Plant Density	09-06	18-06	13-06	02-06	05-06	22-06	04-06	13-06	13-06
Seed Losses Date 1	08-09	29-08 to 10-09[w]	20-09 to 21-09[W]	14-09	03-09	23-08	23-08	26-08	20-09
Harvest Date 1	09-09	29-08 to 10-09[w]	20-09 to 21-09[W]	14-09	03-09	23-08	23-08	28-08	13-09 to 16-09[W]
Seed Losses Date 2	03-10	28-09	15-10	3-10	27-09	08-09	18-09	20-09	18-10
Harvest Date 2	04-10	28-09	15-10	04-10	27-09	08-09	18-09	20-09	18-10

[Z]All dates are formatted dd-mm; [Y]Grassy weed herbicide only - applied across all treatments
[X]Liberty treatments only (first application was not effective); [w]T1 harvest and seed losses completed on separate days to account for maturity differences

Results and Discussion:

Growing Season Weather Conditions

Mean monthly temperatures (May-September) and total precipitation levels are presented with the long-term normals (1981-2010) for each site in Tables 3 and 4. In addition, daily weather parameters, including wind speed, for the last thirty days leading up to the final harvest date are provided for all sites in the Appendices (Tables A-1 through A-9). Overall, the range of locations over the three year period provided a wide variety of environmental conditions to evaluate varietal differences in canola's resistance to shattering and pod drop losses.

Table 3. Mean monthly temperatures at Indian Head, Scott and Swift Current (2011-2013) along with the long-term normal temperatures (1971-2000; Environment Canada 2013).

Location	Year	May	June	July	August	September
		---------- temperature (ºC) ----------				
Indian Head	2011	9.5	15.1	18.8	17.8	13.9
	2012	9.9	16.5	19.2	17.1	12.6
	2013	11.9	15.3	16.3	17.1	14.3
	LT	**10.8**	**15.8**	**18.2**	**17.4**	**11.5**
Scott	2011	10.1	14.4	17.0	16.3	13.7
	2012	9.7	15.1	18.6	17.0	12.2
	2013	12.6	14.8	16.5	17.4	14.0
	LT	**10.8**	**15.3**	**17.1**	**16.5**	**10.4**
Swift Current	2011	9.5	14.3	18.2	18.2	15.1
	2012	9.4	15.5	20.0	19	13.8
	2013	12.6	15.5	16.8	19.2	15.2
	LT	**10.9**	**15.4**	**18.5**	**18.2**	**12.0**
Melfort	2013	12.0	15.4	16.4	17.7	14.4
	LT	**10.7**	**15.9**	**17.5**	**16.8**	**10.8**

Table 4. Total monthly precipitation levels at Indian Head, Scott and Swift Current in 2011 along with the long-term normal amounts (1971-2000; Environment Canada 2013).

Location	Year	May	June	July	August	September
		---------- precipitation (mm) ----------				
Indian Head	2011	71.3	133.2	42.3	44.2	15.7
	2012	79.4	51.0	124.6	30.4	0.0
	2013	17.1	103.8	50.4	6.1	14.8
	LT	**51.8**	**77.4**	**63.8**	**51.2**	**34.1**
Scott	2011	30.8	190.2	76.2	51.8	3.8
	2012	50.6	164.6	56.4	51.4	24.4
	2013	38.9	113.5	26.1	63.3	0.0
	LT	**36.3**	**61.8**	**72.1**	**45.7**	**32.0**
Swift Current	2011	56.9	117.3	68.0	30.4	10.6
	2012	98.3	107.0	17.2	8.2	4.9
	2013	11.2	103.0	50.4	13.5	42.8
	LT	**48.5**	**72.8**	**52.6**	**41.5**	**31.5**
Melfort	2013	18.0	96.9	100.0	10.6	17.0
	LT	**42.9**	**54.3**	**76.7**	**52.4**	**34.3**

In 2011, mean monthly temperatures at all sites were slightly below normal in May and June, approximately normal July through August and warmer than normal in September when the harvest operations were primarily being completed. All sites received well above the normal amounts of rainfall in May and June combined while conditions were generally drier for the latter half of the growing season. In 2012, temperatures in May were cooler than normal, June was approximately normal while July, August and September were generally warmer than normal. Precipitation levels in 2012 precipitation were above average in May and June at all locations except at Indian Head where June was relatively dry. However, July of 2012 was wetter than normal at Indian Head but drier than normal at Scott and Swift Current. August and September were general drier than normal in 2012 with the exception of Scott where August was slightly wetter than normal. The site at Scott in 2012 was abandoned after hail and 90 km hr^{-1} winds on September 10 caused severe and irreversible damage to the mature canola plots. In 2013, May was warmer and drier than normal at all locations while precipitation levels were normal or above normal in June and July; however these months were generally cooler than average which was ideal for the flowering canola. September 2013 was warmer than normal at all locations and drier than normal at all locations except Swift Current where it was relatively wet.

Results – Indian Head 2011

Overall at Indian Head in 2011, canola yields were high and all of the cultivars evaluated yielded similarly with no significant yield differences amongst hybrids detected at either harvest date. Furthermore, yields appeared to be largely unchanged between the two harvest dates suggesting that environmental seed losses between the two dates were negligible and had little or no impact on yield. Percent green seed ranged from 0.1-0.4% for all varieties except 6060 which was significantly higher (2.2%), presumably due to slightly later maturity with this cultivar under these conditions. Overall, the first harvest date (September 9), and initiation of shattering measurements were timed reasonably well for all hybrids at Indian Head in 2011.

At the T1 harvest date, while total losses averaged only 0.25%, there were significant differences in shattering and total losses but not in losses dropped pods (Table 5). At this time, losses due to pod drop averaged less than 0.1%. Losses due to shattering were slightly more than double those due to pod drop at just under 0.2% on average; however they ranged from 0.1% for several varieties to 0.4% for 73-45, which was also one of the earliest maturing hybrids. Total losses followed similar patterns to the shatter losses and ranged from 0.2-0.5%.

With very little disease, relatively dry weather late in the season and no major wind events following the T1 harvest date, seed losses were surprisingly low when harvest was delayed to October 4. At this time, total losses at Indian Head in 2011 were only 0.8% and agronomically insignificant. This result was consistent with the observed lack of differences in yields for the two dates. While losses due to dropped pods, shattered pods and total losses significantly differed amongst hybrids, they were all relatively low. At the second harvest date, losses due to dropped pods ranged from 0.1-0.3% for most varieties, but tended to be higher for 9553 and 45H29 (0.6-0.7%) and were highest for 6060 (1.0%). Yield losses due to pod shatter were also highest for 6060 (0.8%) while shattering losses were only 0.4% or lower for 8 of 12 hybrids. Shattering losses were intermediate (0.6-0.7%) for 2012 and 73-45. Total yield losses (dropped plus shattered pods) were lowest for 5440, L130 and 45H31 (0.4-0.5%) and highest for 6060 at 1.7%. Again, while significant differences amongst hybrids were detected, all of these losses were considered quite low in the greater context and would not be expected to have a measurable on seed yield. When expressed as a percentage of 5440, a common industry check, total yield losses ranged from 88% (of the total losses observed 5440) for L130 up to 369% for 6060.

Table 5. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Indian Head 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 -------	
	---------- *kg ha*$^{-1}$ ----------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
5440	3183 a	3099 a	0.4 b	0.0 a	0.2 bc	0.2 bc	0.1 d	0.4 cde	0.5 cd	100 cd
L130	3095 a	2952 a	0.3 b	0.1 a	0.1 c	0.2 c	0.2 cd	0.2 e	0.4 d	88 d
L150	3123 a	3048 a	0.4 b	0.1 a	0.2 bc	0.3 bc	0.2 cd	0.4 cde	0.7 cd	132 cd
45H29	2985 a	3087 a	0.5 b	0.1 a	0.2 bc	0.3 bc	0.7 ab	0.5 bcd	1.2 b	240 b
45H31	3021 a	3094 a	0.1 b	0.1 a	0.2 bc	0.2 bc	0.2 cd	0.3 de	0.5 cd	111 cd
73-75	3415 a	3167 a	0.2 b	0.1 a	0.1 bc	0.2 bc	0.2 cd	0.3 de	0.6 cd	118 cd
73-45	3271 a	3083 a	0.2 b	0.1 a	0.4 a	0.5 a	0.2 cd	0.7 ab	0.9 bc	192 bc
6060	3080 a	3022 a	2.2 a	0.1 a	0.3 ab	0.4 ab	1.0 a	0.8 a	1.7 a	369 a
9553	3132 a	3085 a	0.3 b	0.1 a	0.1 c	0.2 bc	0.6 abc	0.3 de	0.9 bcd	181 bcd
46H75	2960 a	3041 a	0.2 b	0.0 a	0.1 bc	0.2 bc	0.3 bcd	0.3 de	0.6 cd	143 bcd
2012	2687 a	2722 a	0.2 b	0.0 a	0.2 bc	0.2 bc	0.2 cd	0.6 abc	0.8 bcd	180 bcd
5525	3153 a	3134 a	0.4 b	0.1 a	0.1 c	0.1 c	0.3 bcd	0.4 cde	0.7 cd	155 bcd
St. Error	136.4	115.0	0.28	0.04	0.07	0.07	0.16	0.09	0.16	41.6
Pr. > *F*	0.081	0.307	0.001	0.766	0.037	0.014	0.013	< 0.001	< 0.001	< 0.001
AICC	525.9	511.4	81.5	-386.9	-356.8	-354.9	-293.1	-336.1	-290.7	104.4

Results – Scott 2011

At Scott in 2011, canola yields were also 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 6). 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 ($P = 0.889$; Table 6). Losses due to pod drop averaged 0.7% and, without a significant overall F-test ($P = 0.150$), no cultivar differences were considered significant. Losses due to shattering were slightly higher averaging 0.9%, but again with no significant differences between hybrids ($P = 279$).

Total yield losses at Scott in 2011 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 ($P < 0.001$), 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 ($P = 0.081$). The combined total losses varied with hybrid ($P < 0.001$) 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.

Table 6. 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 -------	
	--------- *kg ha*$^{-1}$ ---------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
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
AICC	492.2	485.5	109.1	261.0	260.9	-219.6	-196.6	-158.6	-136.1	97.7

Results – Swift Current 2011

Yields at Swift Current in 2011 were well above average for the region with no significant differences amongst hybrids (P = 0.183; Table 7). For all treatments, the observed yields were similar for both harvest dates indicating that any environmental seed losses during this period were minimal. Similar to the T1 date (August 23), there were no significant yield differences amongst hybrids at the T2 harvest date (September 8; P = 0.110). Percent green seed ranged from 1.0% for 5525 to 8.2% for 6060. Percent green seed was higher than the desired level of 2% for 8 of 12 varieties, suggesting that the first harvest date was somewhat earlier than desirable, but this did not appear to have a negative impact on yields. The hybrids where percent green seed was below 2% were 5440, L130, 45H31 and 5525.

At the T1 harvest date for Swift Current (2011), total combined yield losses averaged less than 0.3%. Losses due to pod drops averaged 0.1% but varied with hybrid (P = 0.031). The only significant difference amongst cultivars was that, at 0.4%, pod drop losses were significantly higher for 73-75 than for any other hybrids (0.0-0.2%). Losses due to pod shatter averaged 0.2% and, without a significant overall F-test (P = 0.859), no cultivar differences were considered significant. When yield losses due to pod drop and pod shatter were added together, there were no significant differences amongst hybrids at the T1 stage at Swift Current (P = 0.335).

When harvest was delayed to September 8, total combined yield losses at Swift Current in 2011 were still very low, averaging only 2.4%. Yield losses due to pod drop averaged 0.9% and, while treatment means ranged from 0.2-1.9%, none were considered statistically significant (P = 0.694). Yield losses due to pod shatter averaged 1.5% and ranged from 0.8-2.4% but, again, no treatment differences were significant (P = 0.760). When expressed as a percentage of 5440, total yield losses ranged from 100-650% but, due to high variability and the low overall losses, no treatment differences were significant when expressed in this manner either.

Table 7. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Swift Current 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 -------	
	--------- *kg ha*$^{-1}$ ---------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
5440	2931 a	2909 a	1.4 de	0.1 b	0.3 a	0.4 a	0.3 a	0.8 a	1.1 a	100 a
L130	2983 a	2970 a	1.2 de	0.0 b	0.3 a	0.3 a	0.5 a	0.8 a	1.2 a	145 a
L150	2847 a	2860 a	3.7 bcde	0.0 b	0.1 a	0.1 a	0.2 a	0.9 a	1.1 a	140 a
45H29	2791 a	2818 a	3.8 bcd	0.0 b	0.1 a	0.2 a	2.8 a	2.0 a	4.8 a	652 a
45H31	2757 a	2739 a	1.3 de	0.1 b	0.1 a	0.6 a	0.9 a	1.7 a	2.6 a	323 a
73-75	3088 a	3035 a	4.3 bc	0.4 a	0.2 a	0.2 a	0.7 a	1.7 a	2.3 a	257 a
73-45	2936 a	3051 a	3.8 bcd	0.1 b	0.1 a	0.2 a	1.9 a	2.4 a	4.4 a	425 a
6060	2731 a	2570 a	8.2 a	0.0 b	0.2 a	0.2 a	0.7 a	2.1 a	2.8 a	213 a
9553	2653 a	2824 a	2.3 cde	0.1 b	0.1 a	0.1 a	0.8 a	0.8 a	1.6 a	208 a
46H75	2748 a	2729 a	5.3 b	0.0 b	0.1 a	0.5 a	0.6 a	2.0 a	2.5 a	313 a
2012	2680 a	2632 a	2.3 cde	0.2 b	0.4 a	0.3 a	0.5 a	1.9 a	2.4 a	312 a
5525	2810 a	3000 a	1.0 e	0.1 b	0.2 a	0.1 a	1.0 a	0.6 a	1.6 a	162 a
St. Error	137.1	148.6	1.12	0.07	0.13	0.14	0.87	0.82	1.41	179
Pr. > *F*	0.183	0.110	< 0.001	0.031	0.859	0.335	0.694	0.760	0.634	0.642
AICC	516.2	523.3	175.1	-120.5	-106.0	-104.3	-168.6	173.3	-134.9	214

Results – Indian Head 2012

Overall canola yields were below average in 2012 at Indian Head and heavy disease pressure combined with high winds late in the season created challenges for straight-combining. At the T1 harvest dates (August 29-September 10), yields ranged from 1767 kg ha^{-1} for 9553 up to 2723 kg ha^{-1} for 73-45. Canola seed yields at the second harvest date (September 28) for all hybrids tended to be much lower and, in most cases, were less than half of the estimated yields at the T1 date (Table 8). This was an indication that substantial yield loss due to due environmental seed losses (pod shatter and pod drop) had occurred for all hybrids during the harvest window for straight-combining. When harvest was delayed, the highest yields were observed with 46H75 followed by 2012 while L150 was the lowest yielding hybrid. Percent green seed ranged from 0.7% for 2012 to 2.7% for 73-45. It should be acknowledged that three separate T1 harvest dates were used at this site which may have impacted relative green seed levels. For the T1 date, the hybrids L130, 5440 and 73-45 were harvested August 29, 2012, 5525, 9553, 73075 and 45H31 were harvested on September 4 and the remaining hybrids (L150, 45H29, 6060 and 46H75) were harvested on September 10. Other than 73-75, 73-45 and 6060, percent green seed for all hybrids was below the desired level of 2.0%. Timing of harvest operations at Indian Head in 2012 was more challenging than normal due to the heavy sclerotinia stem rot infection levels, which exceeded 50% incidence in the check plots of separate fungicide trials completed on site.

At the T1 harvest date for Indian Head 2012, total yield losses were unusually high averaging 15% across the twelve hybrids. Losses due to pod drop at this time averaged 4.7% and did not differ amongst hybrids ($P = 0.525$). Yield losses due to shattering averaged 10.6% but significant variation amongst the hybrids was detected ($P = 0.010$). At the first harvest date, the highest shattering losses were observed with 73-45 (24%) and L130 (18%); however, these were the earliest maturing varieties and extreme winds shortly before they could be harvested likely biased the results against these particular hybrids to some extent. The lowest shattering losses at the T1 date were observed for 45H29, 45H31, 6060, 46H75 and 2012 (3-8%) and losses were intermediate for the remaining hybrids. Total yield losses at the first harvest date ranged from 5-29% but, due to high variability and a non-significant *F*-test ($P = 0.058$), none of the varietal differences in total seed losses were considered statistically significant at the T1 harvest date.

When harvest was delayed to September 28, mean total yield losses at Indian Head in 2012 had increased to 30%. Estimated yield losses due to pod drop increased to 15%, ranging from 11-21% but with no varietal differences considered significant ($P = 0.985$).Yield losses due to pod shatter also averaged 15%, again with no significant differences amongst the hybrids evaluated ($P = 0.796$). Finally, while the estimated total losses with a delayed harvest ranged from 20-36% for individual hybrids, these losses were highly variable from plot to plot and the effect of hybrid was not significant ($P = 0.998$) – losses were very high for all of the cultivars evaluated. When expressed as a percentage of 5440, total yield losses ranged from 70% for 46H75 up to 129% for 73-45 with the remaining values falling somewhere between these two levels.

Table 8. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Indian Head in 2012. 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 -------	
	--------- *kg ha*$^{-1}$ ---------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
5440	2301 bc	797 bc	1.7 bc	2.7 a	12.4 bc	15.1 a	11.7 a	16.1 a	27.8 a	100 bc
L130	2579 ab	679 bc	0.7 e	7.2 a	18.1 ab	25.4 a	14.9 a	18.9 a	33.8 a	123 ab
L150	1911 ef	513 c	1.2 cde	6.1 a	12.0 bc	18.2 a	15.7 a	16.6 a	32.3 a	119 abc
45H29	1961 def	796 bc	1.1 cde	4.7 a	7.8 c	12.6 a	17.0 a	13.8 a	30.8 a	107 abc
45H31	1907 ef	787 bc	1.4 cde	2.7 a	5.9 c	8.7 a	17.1 a	13.2 a	30.4 a	109 abc
73-75	1932 def	759 bc	2.5 a	6.3 a	9.6 bc	16.0 a	16.2 a	12.3 a	28.5 a	103 abc
73-45	2723 a	673 bc	2.7 a	5.6 a	23.6 a	29.2 a	10.7 a	26.1 a	36.7 a	129 a
6060	2074 cde	645 bc	2.1 ab	6.2 a	6.2 c	12.4 a	21.1 a	14.6 a	35.7 a	127 ab
9553	1767 f	773 bc	1.6 bcd	5.7 a	12.3 bc	18.1 a	12.7 a	15.5 a	28.1 a	105 abc
46H75	2217 cd	1160 a	0.8 e	1.5 a	3.3 c	4.9 a	11.1 a	6.9 a	19.6 a	70 d
2012	1907 ef	907 ab	0.7 e	2.2 a	7.2 c	9.4 a	16.5 a	15.5 a	26.6 a	95 cd
5525	1919 ef	788 bc	1.0 de	5.9 a	9.3 bc	15.3 a	12.6 a	12.3 a	28.8 a	106 abc
St. Error	100.0	103.8	0.25	2.31	4.08	5.94	5.72	5.70	10.85	13.1
Pr. > *F*	< 0.001	0.032	<0.001	0.525	0.010	0.058	0.985	0.796	0.998	0.010
AICC	502.4	505.1	71.7	-161.0	-94.3	-51.7	-40.7	-41.3	66.9	11.7

Results – Swift Current 2012

Canola seed yields were also relatively low in 2012 at Swift Current. At the T1 harvest dates (August 23), yields differed amongst hybrids (P = 0.010) ranging from as low as 914 kg ha^{-1} for 2012 up to 1344 kg ha^{-1} for 45H29. When harvest was delayed to September 18, yields for all canola hybrids again tended to be lower, which was similar to the results observed at Indian Head in this year but not quite to the same extent (Table 9). Again, this implied that substantial yield loss due to due environmental seed losses had occurred between the two dates. With the delayed harvest, the highest yields were observed with 73-45 and L130 (860-862 kg ha^{-1}) while yields for 6060 and 2012 were the lowest (510-562 kg ha^{-1}). Percent green seed (at the T1 harvest date) ranged from 0.0-0.3% for all hybrids except for 5525 which, at 1.2%, was significantly higher. At this site, percent green seed for all hybrids was well below the desired level of 2.0% suggesting that the yield and seed loss measurements were initiated at an appropriate time for all of cultivars.

At the T1 harvest date for Swift Current 2012, total yield losses were reasonably low, averaging 1.5% and with no significant differences amongst hybrids (P = 0.691). Losses due to pod drop at this time averaged 0.8% and did not differ amongst hybrids (P = 0.380) while losses due to pod shattering averaged 0.6% and, again, did not differ amongst hybrids (P = 0.368).

When harvest was delayed to September 18, mean total yield losses at Swift Current in 2012 had increased to 10.6%, but none of the differences between individual varieties were considered significant (P = 0.736). Estimated yield losses due to pod drop increased to 5.8%, ranging from 3.5-9% but again with no differences between treatments being considered significant (P = 0.558).Yield losses due to pod shatter with delayed harvest at Swift Current (2012) averaged 4.8%, slightly less than the losses due to pod drop and again with no significant differences amongst hybrids (P = 0.228). Expressed as a percentage of 5440, total yield losses ranged from 62% for 2012 up to 214% for 6060, but once again, none of these differences were considered statistically significant (P =0.246).

Table 9. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Swift Current in 2012. 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 -------	
	--------- *kg ha*$^{-1}$ ---------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
5440	1316 ab	746 ab	0.0 b	0.6 a	1.1 a	1.7 a	3.5 a	6.4 a	10.0 a	100 a
L130	1293 ab	860 a	0.0 b	0.3 a	0.8 a	1.2 a	3.7 a	3.5 a	7.2 a	108 a
L150	1241 abc	723 b	0.3 b	0.7 a	0.3 a	1.0 a	2.4 a	3.7 a	6.1 a	85 a
45H29	1344 a	822 ab	0.0 b	1.4 a	0.4 a	1.9 a	7.5 a	3.2 a	10.7 a	119 a
45H31	1301 ab	824 ab	0.1 b	1.0 a	0.9 a	1.9 a	5.9 a	6.1 a	12.0 a	171 a
73-75	1273 ab	824 ab	0.1 b	0.7 a	0.4 a	1.1 a	9.0 a	4.0 a	13.0 a	163 a
73-45	1218 abc	862 a	0.0 b	1.0 a	0.5 a	1.6 a	6.0 a	3.6 a	9.6 a	106 a
6060	1033 cd	510 c	0.1 b	0.9 a	1.1 a	2.0 a	8.0 a	11.1 a	19.2 a	214 a
9553	1107 bcd	796 ab	0.1 b	1.6 a	0.5 a	2.2 a	8.9 a	3.5 a	12.4 a	205 a
46H75	1269 ab	846 ab	0.1 b	0.7 a	0.5 a	1.2 a	4.8 a	3.6 a	8.4 a	130 a
2012	914 d	562 c	0.0 b	0.1 a	0.6 a	0.7 a	2.7 a	5.1 a	7.8 a	62 a
5525	1091 bcd	741 ab	1.2 a	0.9 a	0.3 a	1.2 a	7.1 a	3.3 a	10.4 a	148 a
St. Error	93.7	52.5	0.15	0.50	0.27	0.56	2.51	2.01	4.12	55.4
Pr. > *F*	0.010	< 0.001	< 0.001	0.380	0.368	0.691	0.558	0.228	0.736	0.246
AICC	493.1	453.8	36.3	-358.1	-408.6	-321.7	-179.1	-215.5	-95.7	115.5

Results – Indian Head 2013

Recall that in 2013, the canola hybrids evaluated were updated and L150, 45H31, 73-45, 6060 and 9553 were replaced with L140P, 45H32, 74-44BL, 6050 and 1012. For the T1 harvest date in 2013 at Indian Head (September 20-21), canola yields were quite high overall, averaging over 2400 kg ha^{-1} but with some variation amongst hybrids ($P = 0.001$; Table 10). At this time, the highest yields were achieved with 74-44BL and L140P (2599-2624 kg ha^{-1}) while 1012 yielded significantly lower than any other individual hybrids (1982 kg ha^{-1}). With harvest delayed until October 15, yields averaged 2133 kg ha^{-1} which appeared to be lower than the first date; however, again, significant yield differences amongst the hybrids were detected ($P < 0.001$). Consistent with the first date, the highest yields were observed 74-44BL and L140P (2479-2562 kg ha^{-1}) and lowest with 1012 (1077 kg ha^{-1}). From one date to the next, yields for individual cultivars ranged from quite similar for the two dates (i.e. L140P) to considerably lower when harvest was delayed (i.e. 1012). Percent green seed (at the T1 harvest date) ranged from 0.2-0.7% for all hybrids except for 1012 which, at 1.9%, had a significantly higher percentage of green seeds than all of the other hybrids. At Indian Head in 2013, percent green seed for all hybrids were below the desired level of 2.0%.

At the time of the T1 harvest date for Indian Head 2013, total yield losses were low, averaging only 0.9%. Losses due to specifically to pod drop at this time averaged under 0.5% with some variation amongst hybrids detected ($P = 0.019$). While yield losses due to pod drop were quite low for all hybrids, at 0.1% they were lowest for L140P and, at 0.9%, highest for 1012. Yield losses due to pod drop for the remaining treatments fell within this range. Overall average yield losses due to pod shattering also fell below 0.5% but with significant variation amongst the hybrids ($P < 0.001$). These losses were highest for 1012 (1.9%) but significantly lower with no significant differences amongst the remaining 11 hybrids (0.1-0.5%). Total losses also varied amongst canola hybrids ($P = 0.005$) in that they were lowest for L140P (0.1%), highest for 1012 (2.8%) and intermediate for the remaining hybrids ($P = 0.5$-1.2%).

With harvest delayed until October 15, average total yield reductions due to environmental seed loss (dropped plus shattered pods) increased from 0.9% to 7.8%; however, the total losses incurred up to this stage varied with canola hybrid ($P < 0.001$). Overall, total yield losses were very low for L140P and 74-44BL (1.2-1.6%) and were much higher for 1012 (41%). Total losses for the remaining varieties were considered intermediate and ranged from 3.4-9.3%. Estimated yield losses due to pod drop increased to 2.9%, but again varied with hybrid ($P < 0.001$) and ranged from 0.5-0.8% for L140P and 74-44BL up to 5.7-6.6% for 5525 and 1012. Yield losses due to pod shatter with delayed harvest at this site averaged 4.9%, higher than the losses due to pod drop; however, again these losses varied amongst hybrids ($P < 0.001$). By far, the highest shattering losses were observed with 1012 where the estimated losses due specifically to pod shatter were 34%. While no differences amongst the remaining 11 hybrids were significant, the observed values ranged from 0.4-4.8% with the lowest shattering losses observed with L140P, 45H32 and 74-44BL (0.4-1.0%). Varietal effects on total losses followed similar patterns to those observed for the shattering and pod drop losses and, when expressed as a percentage of 5440, ranged from as low as 40-41% for L140 and 74-44BL up to 1177% (11.7 X as high as 5440) for 1012. That being said, the only significant differences in total losses (relative to 5440) were between 1012 and the remaining 11 hybrids.

Table 10. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Indian Head in 2013. 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 -------	
	--------- *kg ha*$^{-1}$ ---------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
5440	2505 abc	2203 cde	0.2 b	0.3 cde	0.5 b	0.8 bc	1.3 def	2.4 b	3.7 bc	100 b
L130	2485 abc	2208 cde	0.3 b	0.3 cde	0.3 b	0.6 bc	3.2 cd	1.4 b	4.6 bc	157 b
L140P	2599 ab	2562 a	0.3 b	0.1 e	0.1 b	0.1 c	0.8 ef	0.4 b	1.2 c	40 b
45H29	2371 bc	2234 bcd	0.5 b	0.9 ab	0.3 b	1.2 b	2.6 cdef	2.0 b	4.6 bc	119 b
45H32	2435 abc	2245 bcd	0.5 b	0.7 abc	0.1 b	0.9 bc	2.9 cde	0.7 b	3.6 bc	93 b
73-75	2458 abc	2263 bcd	0.3 b	0.4 bcde	0.4 b	0.8 bc	3.1 cd	1.9 b	5.0 bc	143 b
74-44 BL	2624 a	2479 ab	0.3 b	0.2 de	0.4 b	0.5 bc	0.5 f	1.0 b	1.6 bc	41 b
6050	2384 abc	2379 abc	0.4 b	0.5 abcde	0.4 b	0.9 bc	1.3 def	2.1 b	3.4 bc	93 b
1012	1982 d	1077 f	1.8 a	0.9 a	1.9 a	2.8 a	6.6 a	34.2 a	40.8 a	1177 a
46H75	2367 bc	1967 e	0.3 b	0.5 abcde	0.3 b	0.8 bc	4.2 bc	4.8 b	9.0 bc	273 b
2012	2266 c	2017 de	0.5 b	0.1 de	0.5 b	0.6 bc	2.7 cdef	4.6 b	7.3 bc	259 b
5525	2411 abc	1957 e	0.7	0.6 abcd	0.4 b	1.1 bc	5.7 ab	3.7 b	9.3 b	286 b
St. Error	97.5	110.0	0.17	0.20	0.24	0.40	0.88	2.23	2.85	0.941
Pr. > *F*	0.001	< 0.001	< 0.001	0.019	< 0.001	0.005	< 0.001	< 0.001	< 0.001	< 0.001
AICC	497.3	503.9	42.8	-276.8	-263.1	-227	-171	-100.9	-83.8	164.3

Results – Scott 2013

At the T1 harvest date in 2013 at Scott (September 3), canola yields varied amongst hybrids ($P < 0.001$; Table 11) 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 ha^{-1}). With harvest delayed until September 27, seed yields still varied amongst hybrids ($P < 0.001$) 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 11).

At Scott in 2013, yield losses due to pod drop were not differentiated from those due to pod shatter and only the total loss estimates are available. At the first harvest date, total losses were low (0.6% on average) and not affected by canola hybrid ($P = 0.440$). 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.

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 ($P = 0.006$). 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.

Table 11. 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; $P \leq 0.05$).

	Yield T1	Yield T2	Green Seed T1	Drop T1	Shatter T1	Total T1	Drop T2	Shatter T2	------- Total T2 -------	
	--------- *kg ha*$^{-1}$ ---------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
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
AICC	511.6	558.5	244.4	—	—	-300.0	—	—	-193.1	65.6

Results – Swift Current 2013

In 2013 for the T1 harvest stage at Swift Current (August 26), average yields were 2337 kg ha^{-1} and, due to a non-significant *F*-test ($P = 0.136$; Table 12), no differences amongst hybrids were declared significant. When straight-combining was delayed until September 20, yields averaged 2029 kg ha^{-1}; however, unlike the first date, significant variety differences were detected at this time ($P < 0.001$). With harvest delayed, the highest yielding hybrids were 5440, L130, L140P, 74-44BL, 46H75 and 2012 (2070-2262 kg ha^{-1}) while the lowest yields were recorded for 1012 (1546 kg ha^{-1}) and then 45H29 (1846 kg ha^{-1}). Yields for all hybrids tended to be lower at the second harvest date, presumably due to yield loss due to shattering and/or pod drop. Percent green seed at the first (T1) harvest date ranged from 0.8% for L130 up to 8.0% for 46H75. These differences were presumably a function of differences in maturity amongst the hybrids but, for the most part, suggest that the yield and seed loss measurements were initiated close to the optimal stage for most varieties.

At the T1 harvest date for Swift Current in 2013, total yield losses were low, averaging only 0.3% with a range of 0.0-0.6%. Losses due to specifically to pod drop at this stage averaged under 0.1% while losses due to pod shatter were slightly over 0.2%. At the T1 harvest date, no differences amongst canola hybrids were significant for losses due to pod drop ($P = 0.385$), pod shatter ($P = 0.187$) or for total losses ($P = 0.304$).

With harvest delayed to September 20, overall mean yield reductions due to environmental seed loss (dropped plus shattered pods) increased from 0.3% to 2.9% and varied with canola hybrid ($P = 0.012$). Overall, total yield losses were lowest for L130 (1.0%) and highest for 45H29 (5.5%) while those for the remaining hybrids fell between these values. When total yield losses at the T2 harvest date were expressed as a percentage of 5440, they ranged from 93% for L140 up to 880% for 45H29; however, none of these differences were considered significant ($P =0.183$).

Table 12. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Swift Current in 2013. 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 -------	
	--------- *kg ha*$^{-1}$ ---------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
5440	2505 a	2262 a	1.5 de	0.0 a	0.6 a	0.6 a	0.2 d	1.2 cde	1.4 cd	100 a
L130	2298 a	2070 abcd	0.8 e	0.0 a	0.0 a	0.0 a	0.4 cd	0.6 e	1.0 d	93 a
L140P	2401 a	2193 abc	2.0 cde	0.1 a	0.5 a	0.6 a	0.6 bcd	1.1 cde	1.7 cd	109 a
45H29	2314 a	1846 e	3.8 bcd	0.2 a	0.2 a	0.4 a	2.7 a	2.8 ab	5.5 a	880 a
45H32	2184 a	1943 de	4.5 b	0.2 a	0.2 a	0.4 a	2.8 a	2.3 abc	5.0 ab	853 a
73-75	2371 a	1975 cde	3.5 bcd	0.0 a	0.1 a	0.1 a	1.9 ab	0.9 de	2.9 bcd	316 a
74-44 BL	2408 a	2212 ab	2.0 cde	0.1 a	0.4 a	0.5 a	0.7 bcd	1.8 bcde	2.6 bcd	255 a
6050	2349 a	2017 bcde	2.0 cde	0.2 a	0.2 a	0.4 a	0.8 bcd	1.2 cde	2.0 c	146 a
1012	2056 a	1546 f	3.5 bcd	0.1 a	0.1 a	0.2 a	1.5 abcd	3.3 a	4.8 ab	543 a
46H75	2358 a	2169 abc	8.0 a	0.0 a	0.2 a	0.2 a	1.4 abcd	1.2 cde	2.5 bcd	523 a
2012	2458 a	2135 abcd	1.0 e	0.0 a	0.2 a	0.2 a	0.6 bcd	1.5 bcde	2.1 cd	380 a
5525	2341 a	1976 cde	4.3 bc	0.1 a	0.2 a	0.3 a	1.8 abc	2.0 abcd	3.8 abc	551 a
St. Error	96.4	79.2	0.81	0.07	0.18	0.21	0.54	0.46	0.92	30.7
Pr. > *F*	0.136	< 0.001	< 0.001	0.385	0.187	0.304	0.011	0.007	0.012	0.183
AICC	501.6	486.9	155.6	-352.7	-290.6	-278.3	-203.2	-215.8	-164.3	-239.7

Results – Melfort 2013

2013 was the first year that this trial was conducted at Melfort. At the T1 harvest stage, completed on two separate dates ranging from September 13-16, yields averaged 3766 kg ha^{-1} but varied depending on the specific hybrid ($P < 0.001$; Table 13). The highest yields at the T1 stage were observed for L130, L140P, 45H29, 45H32, 73-75 and 74-44BL (3878-4091 kg ha^{-1}) while the lowest yields were with 1012, 2012 and 5525 (3271-3382 kg ha^{-1}). At the T2 harvest date (October 18), overall average yields were 3803 kg ha^{-1} suggesting that any environmental seed losses that occurred were minimal and did not have an impact on yield. The overall effect of hybrid on seed yield was significant at the T2 date ($P < 0.001$) and, with some exceptions, the effects were similar to those observed at the first date. The highest yielding hybrids at the T2 date were 5440, L140P, 45H32, 74-44BL and 46H75 (4048-4204 kg ha^{-1}) while the lowest yields were with 1012, 2012 and 5525 (3133-3338 kg ha^{-1}). Again, yields for all hybrids were generally similar between the two dates and, in some cases, tended to be higher at the second harvest date. Percent green seed at the T1 harvest date was affected by hybrid ($P < 0.001$) and ranged from 3.3-4.5% for L130, 5440, L140P and 2012 up to 33-34% for 43H32 and 46H75. These differences were assumed to be a function of differences in maturity amongst the hybrids; however, the fact that all hybrids had green seed levels above the desired maximum of 2% indicate that the yield and shattering measurements were initiated considerably ahead of the optimal harvest stage.

Yield losses due to pod drop versus pod shatter were not recorded separately at Melfort in 2013 therefore, only the total losses are reported and discussed. At the T1 harvest date, total yield losses were quite low, averaging only 0.5%; however, they were affected by hybrid ($P = 0.048$) with a range of 0.1-1.0%. The lowest total losses were observed for L140P and 45H32 while the highest were measured for 6050 and 1012. For the remaining hybrids, losses were intermediate at the T1 stage; however, all were relatively low and unlikely to have any impacts on seed yield.

When harvest was delayed to October 18, the mean yield loss due to pod shatter and pod drop increased from 0.5% to 3.8% and again, varied amongst the hybrids ($P = 0.004$). At this time, total yield losses were lowest for L140P (0.8%) and highest for 1012 (4.5%) with total losses for the remaining hybrids ranging from 1.6-3.4%. When the total yield losses at the T2 harvest date were expressed as a percentage of 5440, they ranged from 39% for L140 up to 240% for 1012 and the overall effect of hybrid on losses expressed in this manner was significant ($P = 0.004$). Again, at such low levels, the observed seed losses were unlikely to have much impact on seed yield and therefore the similar yields observed at the two dates were not unexpected.

Table 13. Least squares means and tests of fixed effects for selected response variables in canola shattering trial at Melfort in 2013. 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 -------	
	--------- *kg ha*$^{-1}$ ---------		%	---------- % of seed yield ----------						% of 5440
Cultivar										
5440	3711 c	4060 ab	4.0 e	—	—	0.4 abcd	—	—	1.9 bcd	100 cd
L130	3941 ab	3921 bc	3.8 e	—	—	0.7 abc	—	—	2.0 bcd	111 bcd
L140P	4046 a	4262 a	4.3 de	—	—	0.1 d	—	—	0.8 d	39 d
45H29	4044 ab	3818 bc	14.3 bc	—	—	0.4 bcd	—	—	1.6 cd	94 cd
45H32	3878 abc	4048 ab	32.5 a	—	—	0.1 d	—	—	1.6 cd	88 cd
73-75	4091 a	3794 bc	10.0 bcde	—	—	0.6 abcd	—	—	1.7 bcd	95 cd
74-44 BL	4032 ab	4204 a	4.8 cde	—	—	0.6 abcd	—	—	2.0 bcd	111 cd
6050	3816 bc	3667 c	15.8 b	—	—	0.9 ab	—	—	2.6 bc	142 bc
1012	3382 d	3133 d	18.5 b	—	—	1.0 a	—	—	4.5 a	240 a
46H75	3658 c	4043 ab	33.8 a	—	—	0.2 cd	—	—	2.5 bc	140 bc
2012	3326 d	3350 d	4.5 cde	—	—	0.7 abcd	—	—	2.9 bc	169 abc
5525	3271 d	3338 d	14.0 bcd	—	—	0.2 cd	—	—	3.4 ab	195 ab
St. Error	79.2	124.7	3.41	—	—	0.21	—	—	0.53	30.7
Pr. > *F*	< 0.001	< 0.001	< 0.001	—	—	0.048	—	—	0.004	0.004
AICC	472.4	494.7	259.2	—	—	-266.9	—	—	-198.6	84.3

Summary and Conclusions:
Overall, the four locations and three year study period have provided a wide range of environmental conditions and variation in the potential for yield losses due to pod drop and pod shatter to occur when straight combining canola. Consequently, the data that has been collected to date is providing insights towards both potential varietal differences in canola's resistance to environmental seed losses and to the overall risks of yield losses associated with leaving standing canola to mature with the intent of straight-combining. Tables 14 and 15 provide a summary of the mean yield losses due to pod drop and pod shatter at either the optimal harvest date (or slightly earlier) and when harvest is delayed due to unfavourable weather or other challenges. Because the hybrids have changed over the study period and environmental seed losses varied dramatically depending on the specific conditions encountered, it is not possible to simultaneously compare average losses of all 17 of the hybrids tested. Consequently, means are presented for various periods including 2011-13, 2011-12 and 2013 and only the means within a specific period should be compared to one another.

Table 14. Overall summary of yield losses due to pod drop and pod shatter at the T1 harvest date (targeted optimal timing).

	T1 DROP			T1 SHATTER			T1 TOTAL		
	2011-13	2011-12	2013	2011-13	2011-12	2013	2011-13	2011-12	2013
Cultivar	---------- % of yield ----------								
5440	0.6	0.7	0.2	2.3	3.0	0.6	2.3	3.7	0.6
L130	1.2	1.7	0.2	2.9	4.0	0.2	3.4	5.7	0.5
L150	—	1.5	—	—	2.7	—	—	4.3	—
L140P	—	—	0.1	—	—	0.3	—	—	0.4
45H29	1.2	1.4	0.6	1.4	1.8	0.3	2.1	3.3	0.6
45H31	—	0.9	—	—	1.6	—	—	2.6	—
45H32	—	—	0.5	—	—	0.2	—	—	0.5
73-75	1.2	1.7	0.2	1.6	2.2	0.3	2.3	3.8	0.5
73-45	—	1.6	—	—	5.2	—	—	6.7	—
74-44BL	—	—	0.2	—	—	0.4	—	—	0.6
6060	—	1.5	—	—	1.7	—	—	3.3	—
6050	—	—	0.4	—	—	0.3	—	—	0.7
9553	—	1.7	—	—	2.7	—	—	4.5	—
1012	—	—	0.5	—	—	1.0	—	—	1.2
46H75	0.5	0.6	0.3	0.7	0.9	0.3	1.1	1.6	0.4
2012	0.4	0.5	0.1	1.5	1.9	0.4	1.6	2.4	0.5
5525	1.2	1.6	0.4	1.6	2.1	0.3	2.3	3.7	0.5

At the T1 harvest date, environmental seed losses were generally low for all hybrids and differences amongst them were small. Overall, the losses were highest in 2011-12, largely due to the extreme shattering and pod drop observed at Indian Head in 2012. At the T1 harvest date for this particular site (Indian Head 2012), the results were somewhat biased against L130 and 73-45 because these were the earliest maturing hybrids and they were affected by high winds on August 24 to a much greater extent than the less mature hybrids. These effects are evident in the results presented in Table 14 and, consequently, the overall means presented for these two hybrids, particularly in 2011-12, should be interpreted cautiously. When averaged across all sites over the three year period, the total seed losses encountered at the T1 harvest date ranged from 1.6-67%; however, when L130 and 73-45 were not considered, the losses were well under 5% for all hybrids. In 2013 with the updated hybrids, average total seed losses ranged from 0.4-1.2% at the T1 harvest date and were agronomically insignificant for all hybrids. At this time, losses due to pod drop always tended to be lower than the losses due to pod shatter.

Table 15. Overall summary of yield losses due to pod drop and pod shatter at the T2 harvest date (targeted 3-4 weeks past optimal timing).

	T2 DROP			T2 SHAT			T2 TOTAL		
	2011-13	2011-12	2013	2011-13	2011-12	2013	2011-13	2011-12	2013
Cultivar	---------- % of yield ----------								
5440	2.6	3.4	0.8	4.3	5.3	1.8	6.0	8.7	2.5
L130	3.6	4.4	1.8	4.0	5.2	1.0	6.6	9.5	2.9
L150	—	4.1	—	—	4.9	—	—	9.0	—
L140P	—	—	0.7	—	—	0.8	—	—	1.5
45H29	5.6	6.8	2.7	3.8	4.4	2.4	7.7	11.2	3.4
45H31	—	6.0	—	—	5.0	—	—	11.0	—
45H32	—	—	2.9	—	—	1.5	—	—	2.9
73-75	5.3	6.4	2.5	3.6	4.5	1.4	7.4	10.9	3.1
73-45	—	.9	—	—	7.6	—	—	12.4	—
74-44BL	—	—	0.6	—	—	1.4	—	—	2.0
6060	—	7.5	—	—	7.0	—	—	14.5	—
6050	—	—	1.1	—	—	1.7	—	—	2.8
9553	—	5.5	—	—	4.5	—	—	10.0	—
1012	—	—	4.1	—	—	18.8	—	—	13.8
46H75	3.8	4.1	2.8	2.9	2.9	3.0	5.9	7.3	4.1
2012	3.4	4.2	1.7	4.6	5.2	3.1	6.2	8.2	3.6
5525	4.8	5.2	3.8	3.7	4.0	2.9	7.7	10.0	4.9

As expected, average yield losses due to pod drop and pod shatter increased when harvest was postponed by 3-4 weeks past the optimal harvest date. This applied to losses due to pod drop, pod shatter and total losses and was true for of the hybrids evaluated in 2011-13, 2011-12 and in 2013. With delayed harvest, total losses for individual cultivars averaged 5.9-7.7% for the applicable hybrids when averaged over the three year period (2011-13). For 2011-12, with relatively high losses at both Indian Head and Swift Current in 2012, the total losses ranged from 7.3-14.5% and were lowest for 46H75 and highest for 6060. In 2013, with updated hybrids but low overall environmental seed losses, total yield losses ranged from 1.5% for L140P to 13.8% for 1012. While losses tended to be highest for 1012 at all locations, the difference between this and the other entries was much larger at Indian Head in 2013 (with delayed harvest) and this may have skewed the averages against 1012 to a certain extent. Not including 1012, mean total yield losses with delayed harvest in 2013 ranged from 1.5-4.9% and had minimal effects on the harvested grain yields. Another observation of considerable interest is that, with delayed harvest, estimated yield losses due to pod drop frequently exceeded those due to pod shatter. While observed yield losses due to pod drop were relatively inconsequential when canola was straight-combined in a timely manner, this appears to be a factor of increasing importance as things are delayed. Overall, the two new shatter tolerant hybrids (L140P and 45H32) performed well; however overall losses were low at all sites in 2013 and the conditions were not ideal to assess whether these 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.

Overall, while varietal differences in resistance to pod drop and pod shatter were frequently detected within individual site-years, the differences amongst hybrids were typically much smaller than the differences observed between harvest dates or from one site-year to the next. Furthermore, the observed differences were not always consistent from year to year or site to site. These results would suggest that, while varietal differences in environmental seed losses do exist, all of the hybrids 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 harvest period. 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 for one more growing season at all four locations.

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Appendices:

Table A-1. Daily, air temperature, precipitation and wind data for the 30 day period leading up to the final harvest date at Indian Head in 2011. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Sept-04	21.2	0.9	11.1	0	35	20
Sept-05	26.8	8.7	17.8	0	37	20
Sept-06	28.6	5.8	17.2	0	<31	–
Sept-07	30.2	7.1	18.7	0.7	<31	–
Sept-08	29.4	11.3	20.4	2.4	<31	–
Sept-09	30	6.9	18.5	0.5	<31	–
Sept-10	31.2	10.8	21	3	33	27
Sept-11	32	6.5	19.3	1.3	54	34
Sept-12	17.7	8.7	13.2	0	48	34
Sept-13	12.1	-3.1	4.5	0	52	35
Sept-14	12.7	-5.1	3.8	0	<31	–
Sept-15	18.1	-2.2	8	0	56	17
Sept-16	15.6	5.6	10.6	0	52	18
Sept-17	18.2	8.8	13.5	0	43	18
Sept-18	19.2	3.4	11.3	0	48	29
Sept-19	19.1	3.8	11.5	0	37	34
Sept-20	14.8	8.5	11.7	0	46	35
Sept-21	14.1	2.8	8.5	0	<31	–
Sept-22	20.9	2.5	11.7	0	54	19
Sept-23	28.8	6.3	17.6	0	37	20
Sept-24	31	11	21	3	32	19
Sept-25	31.5	7.6	19.6	1.6	39	18
Sept-26	26	7.5	16.8	0	50	20
Sept-27	28.2	6.9	17.6	0	35	20
Sept-28	20.9	8.1	14.5	0	56	32
Sept-29	15.6	1.8	8.7	0	33	31
Sept-30	21.2	0.9	11.1	0	57	18
Oct-01	23.4	9.9	16.7	0	52	20
Oct-02	18.3	9.1	13.7	0	39	9
Oct-03	18.4	0.8	9.6	0	<31	–

Table A-2. Daily, air temperature, precipitation and wind data for the 30 day period leading up to the final harvest date at Scott in 2011. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Sept-04	23.4	4	13.7	0	39	21
Sept-05	28.3	2.2	15.3	0	<31	–
Sept-06	29.7	4.5	17.1	0	<31	–
Sept-07	32.3	6.2	19.3	0	35	23
Sept-08	31.5	6.6	19.1	0	<31	–
Sept-09	32.1	7.7	19.9	0	<31	–
Sept-10	28.9	10.9	19.9	0	<31	–
Sept-11	26.7	9.1	17.9	0.2	61	34
Sept-12	18.1	4.5	11.3	0.2	37	30
Sept-13	9.9	-3.8	3.1	0	35	36
Sept-14	14.7	-6.8	4	0	41	15
Sept-15	20.9	0	10.5	0	39	15
Sept-16	21.6	8.2	14.9	0	44	28
Sept-17	19.3	0.8	10.1	2.6	48	27
Sept-18	18.5	3.9	11.2	0	37	25
Sept-19	14.5	3	8.8	0	32	29
Sept-20	17.1	3	10.1	0	<31	–
Sept-21	20.5	0.6	10.6	0	54	16
Sept-22	25.8	6.8	16.3	0	<31	–
Sept-23	29.7	6.8	18.3	0	37	20
Sept-24	31.7	6.7	19.2	0	<31	–
Sept-25	31.6	6.4	19	0	44	15
Sept-26	22.3	8.8	15.6	0	41	30
Sept-27	24.5	5.6	15.1	0	39	25
Sept-28	17.6	4.8	11.2	0	57	27
Sept-29	16.3	-1.7	7.3	0	35	16
Sept-30	27.3	5.3	16.3	0	35	14
Oct-01	14.4	5	9.7	2.3	44	36
Oct-02	13.1	4.3	8.7	1.7	37	10
Oct-03	19.3	0.9	10.1	0	46	10

Table A-3. Daily, air temperature, precipitation and wind data for the 30 day period leading up to the final harvest date at Swift Current in 2011. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Aug-11	22.3	11.1	16.7	6.6	46	29
Aug-12	22.4	11.8	17.1	1.2	<31	–
Aug-13	26.7	10.2	18.5	0	37	19
Aug-14	30.4	12.5	21.5	1.4	50	18
Aug-15	25	12.5	18.8	0.5	46	28
Aug-16	21.4	7.5	14.5	0	44	30
Aug-17	26.8	7.2	17	0	44	28
Aug-18	20.4	9.6	15	0	54	34
Aug-19	20.5	5.8	13.2	0	39	30
Aug-20	23	6	14.5	0	<31	–
Aug-21	30.7	9.9	20.3	0	<31	–
Aug-22	33.1	14.3	23.7	0	44	26
Aug-23	26.8	14.2	20.5	0	52	30
Aug-24	29.2	6.9	18.1	0	44	20
Aug-25	27	12.9	20	0	43	28
Aug-26	25.1	9	17.1	0	32	9
Aug-27	28.2	10.5	19.4	2.5	43	5
Aug-28	29.7	12.6	21.2	0.3	<31	–
Aug-29	31.5	12.1	21.8	0	39	19
Aug-30	26.9	13.7	20.3	0	43	28
Aug-31	16.6	9.4	13	15	41	7
Sep-01	15.9	7.6	11.8	0	<31	–
Sep-02	17.4	7.4	12.4	7.4	61	28
Sep-03	16.6	6.3	11.5	0	43	31
Sep-04	22.8	4.8	13.8	0	48	18
Sep-05	27.1	8.7	17.9	0	35	19
Sep-06	29.2	10.1	19.7	0	<31	–
Sep-07	30.5	11.1	20.8	0	39	25
Sep-08	30.9	13	22	0	<31	–
Sep-09	30.1	12.1	21.1	0	<31	–

Table A-4. Daily, air temperature, precipitation and wind data for the 35 day period leading up to the final harvest date at Indian Head in 2012. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Aug-24	25.8	10.7	18.3	2.8	52	18
Aug-25	20.9	9.4	15.2	0	78	26
Aug-26	22.2	8.7	15.5	0	50	28
Aug-27	27.5	4.9	16.2	0	<31	–
Aug-28	32.6	8.5	20.6	0	44	16
Aug-29	31.5	12.7	22.1	0	56	19
Aug-30	26.2	9.1	17.7	0	37	27
Aug-31	30.2	10.1	20.2	0	46	19
Sep-01	27.6	9.8	18.7	0	44	14
Sep-02	25.4	8.7	17.1	0	54	26
Sep-03	25.0	9.7	17.4	0	56	29
Sep-04	20.9	10.5	15.7	0	63	27
Sep-05	20.5	7.5	14.0	0	41	31
Sep-06	14.2	4.8	9.5	0	35	36
Sep-07	23.2	2.7	13.0	0	41	29
Sep-08	20.0	2.7	11.4	0	48	36
Sep-09	28.6	6.1	17.4	0	54	18
Sep-10	29.5	12.1	20.8	0	59	29
Sep-11	18.5	5.1	11.8	0	74	28
Sep-12	17.5	3.7	10.6	0	70	33
Sep-13	18.7	1.9	10.3	0	37	34
Sep-14	25.0	1.5	13.3	0	48	18
Sep-15	24.8	3.1	14.0	0	50	35
Sep-16	16.0	2.4	9.2	0	37	35
Sep-17	15.1	-3.4	5.9	0	41	19
Sep-18	25.7	5.8	15.8	0	63	31
Sep-19	15.9	5.1	10.5	0	59	33
Sep-20	18.0	5.0	11.5	0	43	32
Sep-21	17.2	-3.1	7.1	0	50	35
Sep-22	14.5	-5.8	4.4	0	<31	–
Sep-23	21.9	-1.1	10.4	0	32	20
Sep-24	22.7	0.6	11.7	0	35	35
Sep-25	18.7	-4.9	6.9	0	<31	–
Sep-26	-	-2.6	-	-	<31	–
Sep-27	22.8	0.5	11.7	0	<31	–

Table A-5. Daily, air temperature, precipitation and wind data for the 30 day period leading up to the final harvest date at Swift Current in 2012. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Aug-19	30.2	10.5	20.4	0	<31	–
Aug-20	33.0	12.7	22.9	0	32	9
Aug-21	33.2	11.7	22.5	0	43	21
Aug-22	28.1	14.7	21.4	0	57	27
Aug-23	30.2	10.3	20.3	0	32	17
Aug-24	20.7	9.1	14.9	0	63	25
Aug-25	21.1	7.1	14.1	0	69	29
Aug-26	23.3	6.8	15.1	0	<31	–
Aug-27	31.1	10.9	21.0	0	52	13
Aug-28	34.2	16.7	25.5	0	<31	–
Aug-29	25.6	10.3	18.0	0	67	29
Aug-30	26.7	7.1	16.9	0	43	23
Aug-31	31.5	9.9	20.7	0	44	13
Sep-01	24.1	8.6	16.4	1.9	48	32
Sep-02	23.7	6.0	14.9	0	63	28
Sep-03	22.7	8.0	15.4	0	44	29
Sep-04	17.1	8.5	12.8	-	<31	–
Sep-05	18.8	5.3	12.1	0	41	34
Sep-06	17.6	6.2	11.9	0	32	34
Sep-07	24.9	5.7	15.3	0	41	25
Sep-08	23.3	2.1	12.7	0	35	18
Sep-09	30.8	11.3	21.1	0	69	26
Sep-10	26.9	6.5	16.7	0	70	27
Sep-11	16.0	3.5	9.8	0	74	28
Sep-12	16.1	3.5	9.8	0	56	29
Sep-13	21.0	6.1	13.6	0	46	30
Sep-14	28.8	8.7	18.8	0	52	19
Sep-15	22.0	6.6	14.3	0	37	1
Sep-16	15.8	3.2	9.5	0	44	30
Sep-17	19.7	-0.1	9.8	0	33	26

Table A-6. Daily, air temperature, precipitation and wind data for the 30 day period leading up to the final harvest date at Indian Head in 2013. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Sep-15	19.2	-3	8.1	0	33	18
Sep-16	25.3	5.3	15.3	0	54	18
Sep-17	29.2	10.2	19.7	0	50	19
Sep-18	–	–	–	–	<31	–
Sep-19	11	1.9	6.5	11.6	44	31
Sep-20	17.1	-1.9	7.6	0	<31	–
Sep-21	21.1	1.3	11.2	0	50	15
Sep-22	21.5	6.1	13.8	0	<31	–
Sep-23	18.9	6	12.5	0	32	24
Sep-24	21.1	5.2	13.2	0	46	26
Sep-25	19.7	9.6	14.7	1.5	39	9
Sep-26	13.3	8.5	10.9	1.7	54	30
Sep-27	13.5	1.9	7.7	0	32	27
Sep-28	17.2	1.1	9.2	0	43	30
Sep-29	24.1	3.8	14	0	63	24
Sep-30	20.1	5.2	12.7	0	57	23
Oct-01	16.7	2	9.4	0	67	27
Oct-02	14.3	-1.9	6.2	0	43	29
Oct-03	6.5	-3.9	1.3	0	<31	–
Oct-04	9.8	-8.5	0.7	0	32	1
Oct-05	12.2	-8.9	1.7	0	<31	–
Oct-06	17.5	-1.1	8.2	0	43	32
Oct-07	22.6	0.6	11.6	0	48	18
Oct-08	17.6	1.4	9.5	0	43	25
Oct-09	12.4	-2.3	5.1	0	37	33
Oct-10	17.8	-0.2	8.8	0	46	16
Oct-11	10.2	2.1	6.2	0	56	35
Oct-12	10.8	-3.8	3.5	0	59	31
Oct-13	10.6	-6.3	2.2	0	<31	–
Oct-14	12.2	-8.5	1.9	0	<31	–

Table A-6. Daily, air temperature, precipitation and wind data for the 30 day period leading up to the final harvest date at Scott in 2013. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Aug-28	29.6	8.9	19.3	0	44	8
Aug-29	29.6	12	20.8	0	33	17
Aug-30	26.2	13	19.6	0	44	24
Aug-31	20.4	10.9	15.7	0	41	34
Sep-01	24.7	7.2	16	0	<31	–
Sep-02	30.1	7	18.6	0	<31	–
Sep-03	24.1	10.9	17.5	0	<31	–
Sep-04	30.6	12.1	21.4	0	41	17
Sep-05	32.6	10.2	21.4	0	33	1
Sep-06	22.1	13.6	17.9	0	<31	–
Sep-07	20.9	12.1	16.5	0	<31	–
Sep-08	23.9	12.2	18.1	0	<31	–
Sep-09	26	11	18.5	0	37	28
Sep-10	23.4	9.6	16.5	0	39	31
Sep-11	21.9	4.4	13.2	0	<31	–
Sep-12	26.7	4.4	15.6	0	32	18
Sep-13	30.2	7.9	19.1	0	35	2
Sep-14	20.4	6.3	13.4	0	<31	–
Sep-15	22.5	2.4	12.5	0	37	14
Sep-16	29.6	9	19.3	0	48	16
Sep-17	22	8.6	15.3	0	41	28
Sep-18	12.9	6.3	9.6	0	33	33
Sep-19	15.6	2	8.8	0	<31	–
Sep-20	21.8	-0.2	10.8	0	46	15
Sep-21	26.1	4.6	15.4	0	32	15
Sep-22	20.7	6	13.4	0	<31	–
Sep-23	20.6	4.9	12.8	0	50	25
Sep-24	18	2.5	10.3	0	<31	–
Sep-25	15.3	3.1	9.2	0	39	1
Sep-26	11.3	2.9	7.1	0	50	32

Table A-7. Daily, air temperature, precipitation and wind data for the 30 day period leading up to the final harvest date at Swift Current in 2013. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Aug-21	–	7.2	–	–	< 31	–
Aug-22	29.1	8.8	19	0	48	17
Aug-23	27.8	12.3	20.1	0.4	<31	–
Aug-24	29.4	14.1	21.8	0	46	25
Aug-25	32.4	12.1	22.3	0	39	16
Aug-26	32.1	15.4	23.8	0	44	24
Aug-27	31.5	12.8	22.2	0	44	18
Aug-28	35.6	15.5	25.6	0.6	43	26
Aug-29	31.9	15.2	23.6	0	44	26
Aug-30	29.9	14.8	22.4	0	59	28
Aug-31	18.6	9.7	14.2	0.7	54	31
Sep-01	26.2	7.6	16.9	0	32	15
Sep-02	35.1	11.4	23.3	0	33	17
Sep-03	25	16	20.5	0	41	8
Sep-04	30.5	13.4	22	0	37	13
Sep-05	33.3	15.7	24.5	0	<31	–
Sep-06	27.6	16.8	22.2	1.9	43	4
Sep-07	17.4	11.4	14.4	0.9	44	10
Sep-08	19.9	11	15.5	0	<31	–
Sep-09	23.7	13.3	18.5	3.3	52	29
Sep-10	24.7	10.5	17.6	0	39	29
Sep-11	23.1	7.6	15.4	0	33	32
Sep-12	25.8	7.2	16.5	0	35	16
Sep-13	30.2	11.1	20.7	0	43	20
Sep-14	21	6.1	13.6	0	44	5
Sep-15	23.4	3.4	13.4	0	44	16
Sep-16	28.9	10.5	19.7	0	56	17
Sep-17	–	11.2	–	–	<31	–
Sep-18	15.7	7.3	11.5	10.3	35	7
Sep-19	15.4	4.3	9.9	0	41	31

Table A-8. Daily, air temperature, precipitation and wind data for the 30 day period leading up to the final harvest date at Melfort in 2013. Data were logged at the nearest Environment Canada weather station (Environment Canada 2013).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	---------- (ºC) ----------			(mm)	(km/h)	(degrees)
Sep-18	14.1	5.8	10	0	<31	–
Sep-19	13.7	1.3	7.5	0	35	32
Sep-20	17.2	-0.1	8.6	0	<31	–
Sep-21	23.2	4.8	14	0	52	14
Sep-22	21.2	11	16.1	0	41	16
Sep-23	20.6	5	12.8	0	35	24
Sep-24	20.8	4.7	12.8	0	43	24
Sep-25	10.2	4.4	7.3	9.6	37	4
Sep-26	10.5	8	9.3	7.4	41	36
Sep-27	12.2	3.7	8	0	33	27
Sep-28	15.2	-0.4	7.4	0	<31	–
Sep-29	22.5	3.3	12.9	0	69	24
Sep-30	17.2	5.4	11.3	0	50	27
Oct-01	10.9	5.2	8.1	0	33	26
Oct-02	7.6	2.1	4.9	2	<31	–
Oct-03	7.3	0.2	3.8	0	<31	–
Oct-04	10.9	-2.3	4.3	0	<31	–
Oct-05	13.8	0.9	7.4	0	48	22
Oct-06	14.5	2.8	8.7	0	39	33
Oct-07	18.3	1.3	9.8	0	52	15
Oct-08	16.4	1.8	9.1	0	37	26
Oct-09	11.1	1.5	6.3	0	33	26
Oct-10	17	1.6	9.3	0	46	17
Oct-11	13.5	2.6	8.1	0	43	32
Oct-12	9.7	-1.1	4.3	0	41	29
Oct-13	11.7	-4	3.9	0	43	26
Oct-14	9.6	-3.1	3.3	0	<31	–
Oct-15	13.8	-2.6	5.6	0	50	26
Oct-16	8.9	-1.9	3.5	0	37	33
Oct-17	7	-2.9	2.1	0	35	32