ANNUAL REPORT
Canola Agronomic Research Program (CARP)

The Annual Final Report should fully describe the work completed for the year and note the personnel involved. It should also note any deviations from the original plan and next and/or corrective steps as may be required if deviations are noted. The report should also provide an update on the status of the Project including forecasted date of completion. A complete statement of expenses should be included. In the event major changes are anticipated within the budget supporting notes along with a proposed budget should also be included. The report should also capture a complete summary of activity for the year.

Title: Pre-harvest herbicide and desiccation options for straight-combining canola: Effects on plant and seed dry-drown, yield and seed quality

Research Team Information

Lead Researchers:		
Name	**Institution**	**Expertise Added**
Chris Holzapfel	IHARF	Responsible for project development, reporting and field trials at the Indian Head (SK) site.
Research Team Members		
Name	**Institution**	**Expertise Added**
Jessica Pratchler	NARF	Responsible for site management at Melfort (SK) site
Jessica Weber	WARC	Responsible for site management at Scott (SK) site
Scott Chalmers	WADO	Responsible for site management at Melita (MB) site
Danny Petty	IHARF	Responsible for project administration and sub-contracts with collaborating organizations

Project Start Date: April 2017 **Project Completion Date: March 2020**

Reporting Period: April 1, 2017 to March 31, 2018

CARP Project Number: 2017.9

Instructions: This Annual Report shall be completed and submitted on or about March 31st of each fiscal year that the agreement is in effect. The Lead Researcher of the project in question shall complete and submit the report on behalf of his/her complete research team.

This Report is a means by which to provide a detailed update on the status of the project and summarize project activities. Details may be general in nature unless major issues or changes arise (e.g., change of scientists, significant change or delay of activities) including impacts on budgets. Please note that financial reports of major impact on budgets.

The following template is provided to assist you in completing this task. Please forward the completed document electronically to your appropriate CCC contact.

1. Forecasted Date of Completion:

March 31, 2020

2. Status of Activity: (please check one)

_____ **Ahead of Schedule** __**X**___ **On Schedule** _____**Behind Schedule** _____ **Completed**

Comment: The first year of field trials and preliminary analyses and summarization of results have been completed on schedule. Preparations for the 2nd year of field trials are underway.

3. Completed actions, deliverables and results; any major issues or variance between planned and actual activities.

Completed Actions / Methodology

Field trials were completed at four locations: Indian Head (SK), Melfort (SK), Scott (SK) and Melita (MB). The varieties 233P (Liberty Link® - LL - glufosinate ammonium tolerant) and 45M35 (Roundup Ready® - RR - glyphosate tolerant) were seeded into cereal stubble in mid-May at a rate of 120 seeds/m^2. With the exception of Melfort where no herbicides were applied, weeds were controlled using registered pre-emergent and in-crop herbicides. At Indian Head and Melita, conventional canola products (i.e. Edge, Lontrel, Muster, Assure 2) were utilized while, at Scott, each variety was sprayed with its partner in-crop herbicide (i.e. glyphosate or glufosinate ammonium). The pre-harvest herbicide / desiccant treatments were targeted for 60-70% seed colour change (glyphosate and saflufenacil) or 80-90% seed colour change (glufosinate ammonium and diquat); however, the RR hybrid tended to mature slightly later than the LL hybrid, therefore compromises were sometimes made with regard to application timing for logistic reasons. The overall project objectives were to evaluate differences in stem and seed dry-down associated with various pre-harvest herbicide / desiccant options for the two dominant herbicide systems (Liberty Link® and Roundup®). It was assumed that options and results for Clearfield® canola would be similar to those for the Liberty Link® system. A total of 10 treatments were arranged in a RCBD with four replicates (Table 1). Treatment 7 (RR – glufosinate ammonium) was not included at the Melfort site due to a protocol misinterpretation at the time of the pre-harvest applications.

Table 1. Treatment list for Canola Pre-harvest Herbicide / Desiccation Study (CARP 2017.9).

1) LL – untreated	**6)** RR – untreated
2) LL – glyphosate (890 g ai/ha)	**7)** RR – glufosinate ammonium (408 g ai/ha)
3) LL – saflufenacil (50 g ai/ha)	**8)** RR – saflufenacil (50 g ai/ha)
4) LL – glyphosate (890 g ai/ha) + saflufenacil (50 g ai/ha)	**9)** RR - glyphosate (890 g ai/ha) + saflufenacil (50 g ai/ha)
5) LL – diquat (40 g ai/ha)	**10)** RR – diquat (40 g ai/ha)

Various data were collected during the growing season, at the time of harvest and during the winter months. For explanatory purposes and to help assess overall data quality/trial uniformity, emergence was assessed approximately 3-4 weeks after seeding by counting plants in 2 x 1 m sections of crop row in each plot. Once the treatments were applied, visual assessments of stem / overall plant dry-down (rating scale of 0-100) were completed on weekly intervals starting on the day of application with a final set of ratings on all plots immediately prior to harvest. These ratings were subjective and, as such, differed somewhat across locations

and therefore should be interpreted with some caution. The visual assessments of crop dry-down were not completed at Melfort. The intended harvest timing was before the crop dried down to the extent that treatment effects would no longer be evident but late enough that the canola could still be properly threshed and put through the combines; however, it was required that all plots of a given hybrid be harvested on the same date. At Indian Head, Melfort and Melita both hybrids were combined on the same date while, at Scott, the RR variety was harvested a few days later than the LL variety. Immediately after harvest, seed moisture content was assessed by weighing sub-samples both wet and again after being dried for a minimum of 24 hours at 70 °C or higher. This methodology appeared to work well at Indian Head and Melita; however, the values at Melfort and, to a lesser extent, Scott appeared too low (0.5-6.8% at Melfort and 2.7-5.5% at Scott) therefore methods at these locations may require refinement going forward. Whole plant (including seed) moisture was determined either immediately before or after harvest (depending on plot size / harvest area) by harvesting representative plants from each plot at ground level, weighing them wet, drying (with heat and air), weighing them again and calculating percent gravimetric moisture content. Seed weight, an important yield parameter with potential quality implications, was determined by counting a minimum of 300 seeds for each plot using an automated seed counting machine, weighing the counted seeds to the nearest 0.00 g and calculating g/1000 seeds. Percent green seed was determined for each plot by counting the number of distinctly green seeds in a minimum of one 500 seed crush. Selected agronomic information is provided in Table 2.

Table 2. Selected agronomic information for canola desiccation trials at four Western Canadian locations in 2017.

	Location (2017)			
Factor / Operation	**Indian Head, SK**	**Melfort, SK**	**Scott, SK**	**Melita, MB**
Previous Crop	Wheat	Wheat	Wheat	Rye
Variety	L233P (LL) / 45M35 (RR)	L233P (LL) / 45M35 (RR)	L233P (LL) / 45M35 (RR)	L233P (LL) / 45M35 (RR)
Pre-emergent Herbicide	890 g glyphosate/ha (May-10) 24 kg Edge/ha (May-14)	none	980 g glyphosate/ha + 280 g bromoxynil/ha (May-6)	890 g glyphosate/ha + 185 ml Centurion/ha (Apr-20)
Seeding Date	May-17	May-19	May-15	May-12
Seeding Rate	120 seeds/m^2	120 seeds/m^2	120 seeds/m^2	120 seeds/m^2
Row spacing	30 cm	30 cm	25 cm	24 cm
Fertility (kg N-P_2O_5-K_2O-S/ha)	140-35-18-18	134-56-0-28	81-22-0-25	126-35-25-10
Emergence Counts	Jun-12	Jun-9	Jun-12	mid-June
In-crop Herbicide	561 ml Lontrel 360/ha (Jun-10) 30 g Muster/ha + 741 ml Assure 2/ha (Jun-18)	none	2 l Liberty 150 SN/ha (Jun-7) + 1.5 l Liberty/ha + 185 ml Centrurion/ha (Jun-20) 300 g glyphosate/ha (Jun-7) + 445 g glyphosate/ha (Jun-21)	20 g Muster/ha + 741 ml Assure 2/ha (Jun-7)
Fungicide	350 g Lance WDG/ha + 395 ml Headline E.C. (Jul-12)	865 ml Acapela/ha (Jul-18)	445 ml Priaxor/ha (Jul-8)	none
Insecticide	none	none	none	none
Pre-harvest Applications	Trt 2, 3, 4, 8, 9 (Aug-23) Trt 5, 7, 10 (Aug-28)	Trt 2, 3, 4, 8, 9 (Aug-29) Trt 5, 7, 10 (Sep-5)	Trt 2, 3, 4 (Aug-22) Trt 5, 7, 8, 9 (Aug-25) Trt 10 (Aug-28)	Trt 2, 3, 4, 8, 9 (Aug-16) Trt 5, 7, 10 (Aug-22)
Harvest date	Sep-8 (all treatments)	Sep-12 (all treatments	Sep-8 (LL) Sep-11 (RR)	Sep-1 (all treatments)

Response data were analyzed and summarized on an individual site basis in order to assess data quality prior to any final combined analyses and facilitate preliminary extension activities going into the 2nd year of the project. A mixed model analyses with treatment effects considered fixed and replicate effects considered random was used along with contrasts to compare pre-determined groups of treatments. Individual treatment means were separated using Fisher's protected LSD test (which requires a significant F-test before any treatment differences are considered real); however, the $LSD^{0.05}$ values were also provided which can be utilized to compare specific individual treatments. The specific contrast comparisons were: 1) untreated (1,6) vs treated (2,3,4,5,7,8,9,10); 2) untreated (1,6) vs saflufenacil (3,8); 3) untreated (1,6) vs glyphosate + saflufenacil (4,9); 4) untreated (1,6) vs diquat (5,10); 5) saflufenacil (3,8) vs glyphosate + saflufenacil (4,9); 6)

saflufenacil (3,8) vs diquat (5,10); and saflufenacil + glyphosate (4,9) vs diquat (5,10). Glyphosate alone and glufosinate ammonium were excluded from the contrast comparisons since these products were not utilized in both herbicide systems.

Preliminary Results

Growing season weather information for the four locations is presented along with the long-term (1981-2010) averages in provided in Tables 3-4. Overall, the weather tended to be both warmer and drier than average; however, with good initial moisture and timely precipitation in June at most locations, yield potential was reasonably high at all locations. In general, harvest aids for canola tend to be less important under warm and dry conditions during the late summer / early fall.

Table 3. Mean monthly temperatures for the 2017 growing season relative to the long-term averages (1981-2010) at 4 locations in western Canada.

		Mean Monthly Temperature				
Location	**Year**	**May**	**June**	**July**	**August**	**Average**
		ºC				
Indian Head	2017	11.6	15.5	18.4	16.7	15.6
	LT	10.8	15.8	18.2	17.4	15.6
Melfort	2017	10.8	15.2	18.7	17.2	15.5
	LT	10.7	15.9	17.5	16.8	15.2
Scott	2017	11.5	15.1	18.3	16.6	15.4
	LT	10.8	15.3	17.1	16.5	14.9
Melita	2017	12.2	16.7	20.1	17.4	16.6
	LT	10.7	16.1	19.3	18.4	16.1

Table 4. Mean monthly precipitation amounts for the 2017 growing season relative to the long-term averages (1981-2010) at 4 locations in western Canada.

		Total Monthly Precipitation				
Location	**Year**	**May**	**June**	**July**	**August**	**Average**
		mm				
Indian Head	2017	10.4	65.6	15.4	25.2	117
	LT	51.8	77.4	63.8	51.2	244
Melfort	2017	46.4	44.1	33.3	3.1	127
	LT	42.9	54.3	76.7	52.4	226
Scott	2017	69.0	34.3	22.4	53.0	179
	LT	36.3	61.8	72.1	45.7	216
Melita	2017	6.1	64.2	44.8	39.5	155
	LT	61.9	76.4	56.9	43.2	238

Indian Head 2017

Results from the Indian Head (2017) site are presented in Tables 5-6. Seedling mortality was high overall; however, many ungerminated seeds eventually came with rains after the counts were completed. While the F-test was significant (P = 0.035) the only differences amongst individual treatments were between that with the highest counts and several other treatments where plant densities were more typical. Other than the two varieties, there were no treatments imposed at this time that could affect emergence.

Only the final visual stem dry-down ratings (completed just prior to harvest) were statistically analyzed; however, the ratings over time are presented graphically for the LL and RR canola at Indian Head in Figs. 1 and 2, respectively. At the time of harvest, visual dry-down values for untreated canola were statistically similar for both varieties (37-41%) and consistently higher in the treated plots. For LL canola, visual stem dry-down was statistically similar for glyphosate, glyphosate + saflufenacil and diquat (62-67%) but lower for saflufenacil applied alone (46%). With RR canola, values were statistically similar for glufosinate ammonium and both

treatments containing saflufenacil (44-48%) but higher for diquat (58%). The contrast comparisons detected an overall benefit to harvest aids both combined ($P < 0.001$) across hybrids and products and for individual products ($P < 0.001$-0.004). They also showed an advantage to the saflufenacil + glyphosate tank-mix over saflufenacil alone ($P = 0.008$) and to diquat over saflufenacil, with and without added glyphosate ($P \leq 0.001$) for this variable (Table 6).

Due to slight differences in maturity, seed moisture content at harvest was generally lower for the LL compared the RR hybrid. Looking at individual treatments in LL canola, seed moisture contents were mostly statistically similar across most treatments. Numerically, however, values were similar for the control and glyphosate alone (7.1-7.2%), intermediate for both saflufenacil treatments (6.5-6.7%) and lowest with diquat (5.8%). For the RR canola, seed moisture did not significantly differ between the control (11.9%) and the saflufenacil treatments (11.1-11.4%) but was lower with glufosinate ammonium (8.5%) and lowest with diquat (5.3%). The contrasts showed an overall benefit to harvest aids ($P < 0.001$) and to diquat ($P < 0.001$) but no difference between the control versus saflufenacil alone ($P = 0.371$) or with glyphosate ($P = 0.160$). When individual products were compared, there was no difference between saflufenacil and saflufenacil + glyphosate ($P = 0.186$) but the observed seed moisture was lower with diquat than both of those options ($P < 0.001$-0.002).

Total above-ground plant moisture at harvest was 31% and 39% in the LL and RR control treatments, respectively. No significant differences were detected amongst pre-harvest treatments were observed in the LL hybrid while in the RR hybrid the only product that significantly reduced whole plant moisture was diquat. Averaged across varieties and products, the contrasts did not show a significant benefit to the pre-harvest treatments for this variable ($P = 0.252$) or between the control and either of the treatments containing saflufenacil ($P = 0.261$-0.835) but did show a plant dry-down benefit to diquat ($P < 0.001$).

Provided that product applications and harvest were timed appropriately we did not expect to see any effect of pre-harvest applications on yield and this was the case at Indian Head in 2017 with no significant overall F-test ($P = 0.691$) or contrast comparisons ($P = 0.153$-0.977). While comparing hybrid performance was not an objective of this study, yields for both appeared to be similar at this site-year.

Table 5. Treatment means and tests of fixed effects for selected response variables at Indian Head, Saskatchewan in 2017. The treatments are various pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola hybrids. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; $P \leq 0.05$).

Treatment	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	- plants/m^2 -	------ % ------	------ % ------	------ % ------	--- kg/ha ---	g/1000 seeds	------ % ------
1) LL – Control	33.2 ab	41.3 cd	7.1 cd	30.8 c	3226 a	3.28 bcd	0.1 b
2) LL – Glyphosate	30.4 b	65.0 a	7.2 bc	26.8 c	3222 a	3.19 d	0.1 b
3) LL – Saflufenacil	41.8 a	45.6 c	6.7 cde	30.3 c	3275 a	3.26 bcd	0.0 b
4) LL – Safl + Glyph	32.0 b	61.9 ab	6.5 cde	30.0 c	3217 a	3.24 bcd	0.1 b
5) LL – Diquat	33.2 ab	66.9 a	5.8 de	28.2 c	3204 a	3.22 cd	0.5 b
6) RR – Control	25.0 b	36.9 d	11.9 a	38.6 ab	3098 a	3.36 ab	1.7 b
7) RR – Gluf. Amm.	31.6 b	43.8 cd	8.5 b	39.5 ab	3306 a	3.33 abc	0.7 b
8) RR – Saflufenacil	26.3 b	48.1 c	11.4 a	38.5 b	3196 a	3.35 ab	1.8 b
9) RR – Safl + Glyph	29.1 b	44.4 c	11.1 a	42.8 a	3225 a	3.42 a	2.1 b
10) RR – Diquat	27.9 b	57.5 b	5.3 e	30.7 c	3263 a	3.32 a-d	13.2
SE	3.49	3.01	0.47	1.47	72.0	0.048	0.97
LSD [X]	8.76	7.20	1.35	4.24	191.3	0.134	2.78
Pr > *F* (p-value)	**0.035**	**< 0.001**	**< 0.001**	**< 0.001**	0.691	**0.038**	**< 0.001**
AICC [W]	215.7	204.8	-179.3	-108.4	399.6	-38.1	143.3

[Z] Gravimetric water content of seed at harvest
[Y] Gravimetric water content of above-ground plant material at harvest
[X] Least Significant Difference values presented can be used to compare individual treatments but do not control experiment-wise error
[W] Akaike Information Criterion (corrected) - A measure of overall model-fit (smaller is better)

While the overall F-test was not significant ($P = 0.035$), seed weight was not affected by pre-harvest

treatments. There was an overall tendency for larger seeds with the RR variety; however, significant differences amongst individual treatments were rare. No contrast comparisons for seed weight were significant (*P* = 0.199-0.836).

Table 6. Contrast results for selected response variables in canola desiccation study at Indian Head, Saskatchewan in 2017.

Group Comparison	Plant Density	Visual Dry-down	Seed Moisture [z]	Plant Moisture [y]	Seed Yield	Seed Weight	Green Seed
	p-value						
Untreated vs treated	0.322	**< 0.001**	**< 0.001**	0.252	0.153	0.444	0.068
Untreated vs Saflufenacil	0.115	**0.004**	0.371	0.835	0.274	0.799	0.979
Untreated vs Saflufenacil + Glyphosate	0.638	**< 0.001**	0.160	0.261	0.381	0.836	0.856
Untreated vs diquat	0.641	**< 0.001**	**< 0.001**	**0.001**	0.287	0.278	**< 0.001**
Saflufenacil vs Saflufenacil + Glyphosate	0.258	**0.018**	0.597	0.186	0.824	0.645	0.877
Saflufenacil vs Diquat	0.257	**< 0.001**	**< 0.001**	**0.002**	0.977	0.403	**< 0.001**
Saflufenacil + Glyphosate vs Diquat	0.997	**0.001**	**< 0.001**	**< 0.001**	0.846	0.199	**< 0.001**

[z] Gravimetric water content of seed at harvest
[y] Gravimetric water content of above-ground plant material at harvest

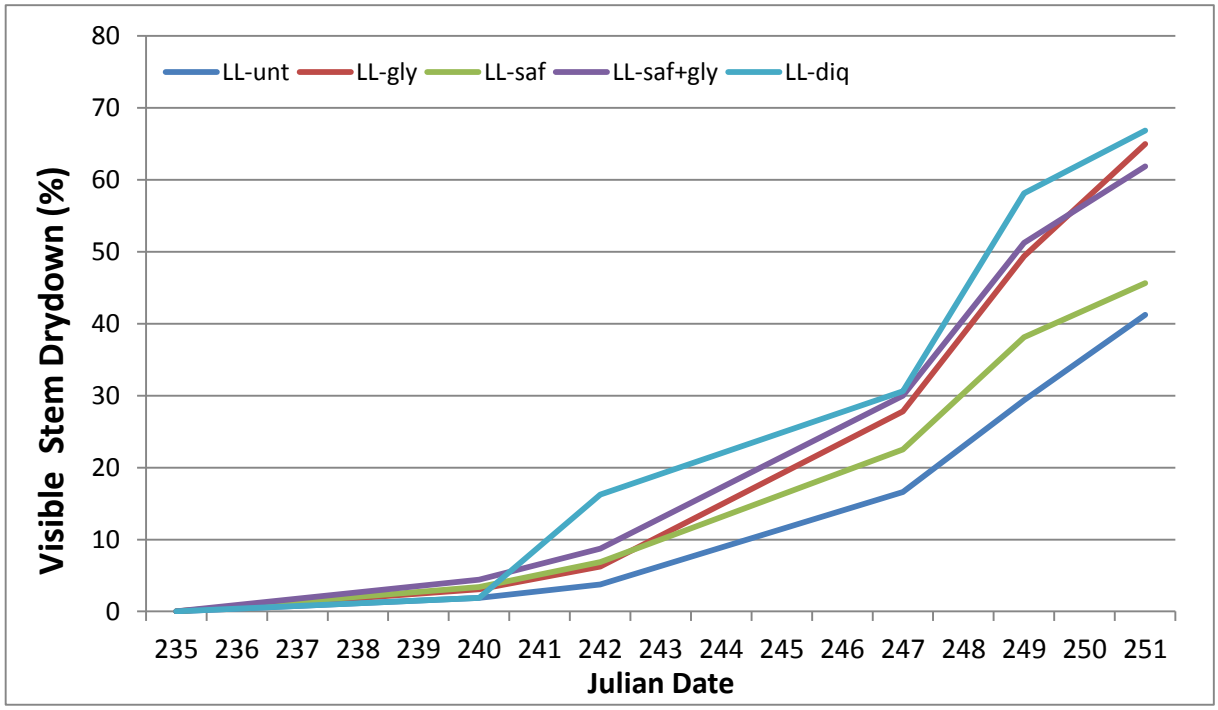

Figure 1. Rate of visible stem down for various pre-harvest treatments in glufosinate ammonium tolerant canola (Indian Head 2017).

The overall F-test for percent green seed was highly significant at Indian Head in 2017 (*P* < 0.001). Due to later maturity and the fact that all treatments were harvested on the same date, there tended to be higher green counts with the RR hybrid; however, in most cases, individual treatment differences were not significant. Treatments containing glyphosate, saflufenacil or glufosinate ammonium had no effect on percent green seed; however, results with diquat varied. With the LL variety, which was more advanced at the time of the treatment applications, percent green seed was 0.5% compared to 0.0-0.1%. On the other hand, in the RR variety percent green seed was 13.2% with diquat compared to 0.7-2.1% for the other treatments. With post-application precipitation and rehydrating of the affected seed it is possible that some of this would have cured out with time; however, these results illustrate the dangers of applying a fast-acting (albeit effective) product

like diquat too early. The contrasts comparing the control to all treated plots was not significant at the desired probability level (*P* = 0.068); however, for the saflufenacil (with and without glyphosate) there was no impact (*P* = 0.856-0.979) while the effect of diquat was highly significant (*P* < 0.001).

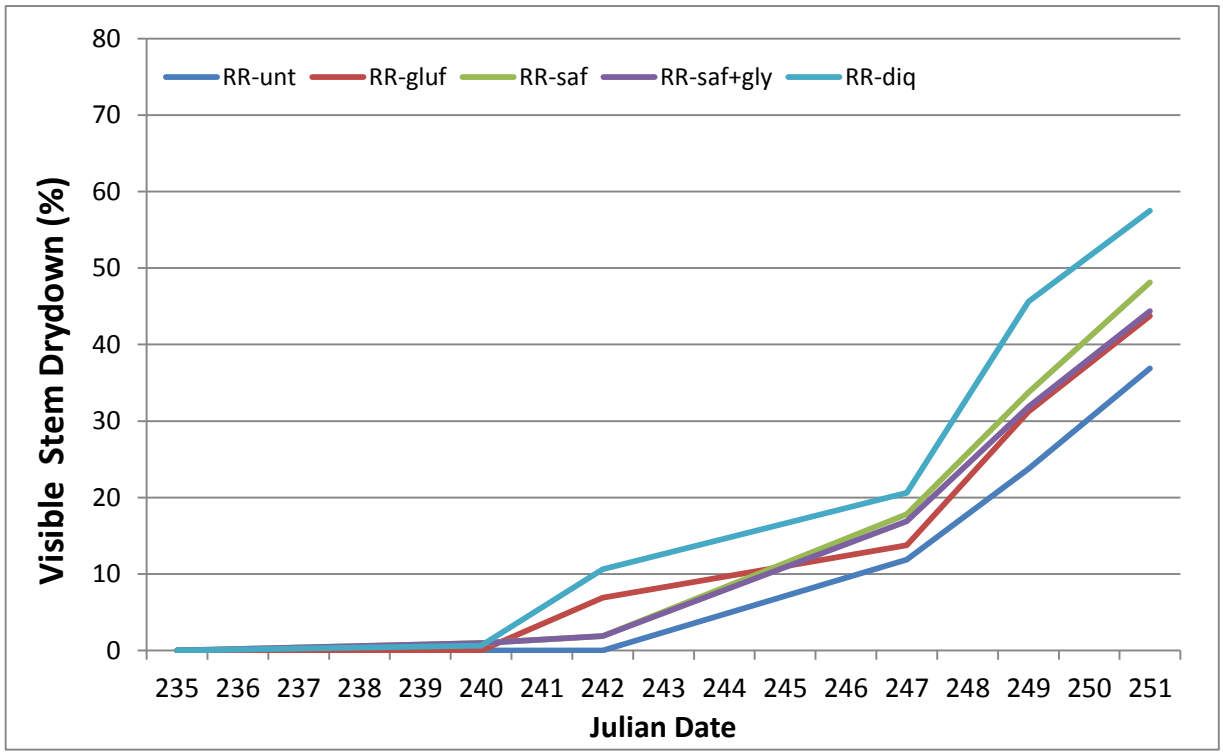

Figure 2. Rate of visible stem down for various pre-harvest treatments in glyphosate tolerant canola (Indian Head 2017).

Melfort 2017

Results from the Melfort site in 2017 are presented in Tables 7-8. Emergence at this site was variable but good overall with mean populations ranging from 58-89 plants/m^2. While the overall F-test was not significant (*P* = 0.335) at this site-year, some of the contrast comparisons were; however, this was solely attributed to random variability.

Visual dry-down ratings were not completed at Melfort in 2017.

The observed seed moisture values at this location were extremely low and are therefore somewhat suspect; however, the overall F-test for this variable was significant (*P* < 0.001) and there was evidence of benefits to the pre-harvest treatments. For the LL hybrid, the calculated seed moisture content in the control was 3.5% and the values ranged from 0.5-1.3% with no significant differences amongst the individual pre-harvest treatments. For the RR canola, the calculated seed-moisture content in the control was higher at 6.8% and ranged from 2.8-5.5% for the remaining treatments with the lowest values observed with saflufenacil + glyphosate and diquat. The contrast comparisons showed a benefit to using harvest aids over the controls when averaged across products (*P* = 0.002) and for individual products (*P* = 0.002-0.027) but no significant differences amongst individual treatments (*P* = 0309-0.898).

With a significant F-test (*P* = 0.003), whole plant moisture content at Melfort ranged from 24-31% and 26-28% for the LL and RR hybrids, respectively. For the LL canola, whole plant moisture was highest for the control (31%) and ranged from 24-27% in the treated plots but with no significant differences between products. For the RR variety, observed whole plant moisture was similar for across treatments. The contrast comparisons showed an overall reduction in plant moisture content when averaged across (*P* = 0.003) products and also with both treatments containing saflufenacil (*P* = 0.003-0.017). While the contrast comparing diquat to the untreated controls was not significant at the desired probability level (*P* = 0.063), whole moisture still tended to be lower with diquat and did not significantly differ from that observed with saflufenacil (with and without added glyphosate; *P* = 0.2030.552).

Yields were highly variable ranging from 3596-4233 kg/ha amongst individual treatments but with no significant

F-test (P = 0.207) and a relatively high $LSD^{0.05}$ value of 618 kg/ha (11 bu/ac). According to the orthogonal contrasts, yields were higher for canola treated with diquat than for the untreated control plots (P = 0.008); however, it is probable that this result was due to random variability as opposed to a genuine treatment effect. The high yield variability at this site was primarily attributed to plugged runs and late trips when metering canola through the cone during seeding.

Table 7. Treatment means and tests of fixed effects for selected response variables at Melfort, Saskatchewan in 2017. The treatments are various pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola hybrids. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; $P \leq 0.05$).

Treatment	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	-- plants/m^2 --	------- % -------	------- % -------	------- % -------	----- kg/ha -----	g/1000 seeds	------- % -------
1) LL – Control	88.6 a	–	3.5 bc	30.7 a	3596 a	3.55 a	0.4 cd
2) LL – Glyphosate	73.9 a	–	0.5 d	25.9 b	3715 a	3.55 a	0.4 d
3) LL – Saflufenacil	84.1 a	–	1.3 cd	24.7 b	3849 a	3.50 a	0.3 d
4) LL – Safl + Glyph	62.3 a	–	1.0 cd	23.7 b	3805 a	3.61 a	0.4 cd
5) LL – Diquat	79.6 a	–	1.3 cd	26.8 ab	4059 a	3.56 a	0.4 cd
6) RR – Control	71.0 a	–	6.8 a	27.9 ab	3517 a	3.66 a	1.1 a-c
7) RR – Gluf. Amm.	–	–	–	–	–	–	–
8) RR – Saflufenacil	78.3 a	–	4.5 ab	26.5 bc	3673 a	3.66 a	0.7 bcd
9) RR – Safl + Glyph	58.3 a	–	2.8 bcd	25.5 b	3705 a	3.67 a	0.8 bcd
10) RR – Diquat	67.7 a	–	2.8 bcd	26.2 b	4233 a	3.69 a	1.5 a
SE	9.43	–	1.16	1.94	271.1	0.051	0.23
LSD [X]	25.5	–	2.80	4.22	617.6	0.145	0.66
Pr > F (p-value)	0.335	–	**< 0.001**	**0.003**	0.207	0.159	**0.003**
AICC [W]	278.2	–	-128.3	-102.3	440.1	-33.5	53.5

[Z] Gravimetric water content of seed at harvest
[Y] Gravimetric water content of above-ground plant material at harvest
[X] Least Significant Difference values presented can be used to compare individual treatments but do not control experiment-wise error
[W] Akaike Information Criterion (corrected) - A measure of overall model-fit (smaller is better)

Table 8. Contrast results for selected response variables in canola desiccation study at Melfort, Saskatchewan in 2017.

Group Comparison	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	---------- p-value ----------						
Untreated vs treated	0.239	–	**0.002**	**0.024**	0.145	0.944	0.972
Untreated vs Saflufenacil	0.875	–	**0.027**	**0.017**	0.329	0.657	0.278
Untreated vs Saflufenacil + Glyphosate	0.035	–	**0.002**	**0.003**	0.362	0.490	0.585
Untreated vs diquat	0.488	–	**0.003**	0.063	**0.008**	0.693	0.328
Saflufenacil vs Saflufenacil + Glyphosate	**0.025**	–	0.309	0.488	0.980	0.261	0.585
Saflufenacil vs Diquat	0.397	–	0.372	0.552	0.072	0.403	**0.045**
Saflufenacil + Glyphosate vs Diquat	0.141	–	0.898	0.203	0.080	0.767	0.133

[Z] Gravimetric water content of seed at harvest
[Y] Gravimetric water content of above-ground plant material at harvest

Seed weight was not affected at Melfort in 2017 (P = 0.159) with similar values across pre-harvest treatments and hybrids (3.5-3.7 g/1000 seeds). None of the predetermined contrast comparisons were significant for seed size at this location (P = 0.261-0.944), thereby providing further evidence that the pre-harvest applications did

not affect this response variable.

The overall F-test for percent green seed was significant (P = 0.003) with lower values in general and no differences amongst the pre-harvest treatments for the LL hybrid. For the RR hybrid, the values were highest with diquat, intermediate in the untreated control and lowest with saflufenacil and glyphosate plus saflufenacil. When averaged across the hybrids, the only significant comparison was between saflufenacil and diquat (P 0.045) with a higher percentage of green seed when diquat was applied.

Scott 2017

Treatment means and contrast results for the Scott location are presented in Tables 9 and 10, respectively. While there was considerable variability in individual measurements, emergence was good overall and mean plant densities were consistent across treatments (64-76 plants/m2; P = 0.927). As expected, none of the contrast comparisons were significant (P = 0.28-0.93).

In general, visual dry-down ratings were higher at Scott than the Indian Head site; however, this may have been due as much to the subjective nature of these measurements as to differences in environmental conditions and timing of operations. The F-test for this this variable was highly significant (P < 0.001) and, for both the LL and RR hybrids, there were clear benefits to all pre-harvest options with mean ratings of 70-71% in the controls and 86-96% in the treated plots. Focusing on LL canola, the most thorough dry-down occurred with glyphosate and saflufenacil + glyphosate with no difference between these two treatments (95-97%). Dry-down with diquat treatment was slightly but significantly lower (90%) and the lowest dry-down ratings were recorded with saflufenacil applied alone (86%). For visual dry-down ratings in the RR canola, the most effective treatment was diquat (96%) while glufosinate ammonium and saflufenacil (with and without glyphosate) were also quite effective and performed similarly (91-93%). Bear in mind that harvest was completed at separate dates for the LL and RR at Scott (3 days later for RR); therefore, these values do not reflect the differences in maturity between the two hybrids. Data illustrating the overall rate of dry-down at Scott is presented graphically for LL and RR canola in Figs. 3 and 4, respectively.

Table 9. Treatment means and tests of fixed effects for selected response variables at Scott, Saskatchewan in 2017. The treatments are various pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola hybrids. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; $P \leq 0.05$).

Treatment	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	-- plants/m^2 --	------- % -------	------- % -------	------- % -------	----- kg/ha -----	g/1000 seeds	------- % -------
1) LL – Control	76.0 a	70.0 f	3.6 bc	28.5 ab	3450 a	3.40 c	0.3 a
2) LL – Glyphosate	71.5 a	96.5 a	2.7 c	11.9 f	3440 a	3.40 c	0.4 a
3) LL – Saflufenacil	76.5 a	86.3 e	3.5 bc	29.5 a	3482 a	3.37 c	0.3 a
4) LL – Safl + Glyph	70.5 a	94.5 abc	2.9 bc	13.7 f	3385 a	3.40 c	0.3 a
5) LL – Diquat	73.3 a	90.3 d	2.8 c	25.2 a-d	3563 a	3.39 c	0.5 a
6) RR – Control	67.3 a	71.3 f	5.5 a	27.6 abc	3712 a	3.77 ab	0.2 a
7) RR – Gluf. Amm.	71.3 a	92.3 bcd	3.7 b	21.9 de	3743 a	3.65 b	0.2 a
8) RR – Saflufenacil	71.0 a	91.3 cd	5.2 a	22.9 cde	3992 a	3.77 ab	0.5 a
9) RR – Safl + Glyph	64.0 a	93.3 a-d	5.3 a	24.3 b-e	3908 a	3.83 a	0.3 a
10) RR – Diquat	71.8 a	96.0 ab	2.9 bc	20.0 e	3487 a	3.78 ab	1.9 a
SE	6.64	1.94	0.33	1.92	234.5	0.079	0.40
LSD [X]	17.10	3.95	0.92	4.88	530.8	0.166	1.10
Pr > F (p-value)	0.927	**< 0.001**	**< 0.001**	**< 0.001**	0.267	**< 0.001**	0.108
AICC [W]	255.4	170.8	-198.3	-95.9	463.6	-19.7	89.3

[Z] Gravimetric water content of seed at harvest
[Y] Gravimetric water content of above-ground plant material at harvest
[X] Least Significant Difference values presented can be used to compare individual treatments but do not control experiment-wise error
[W] Akaike Information Criterion (corrected) - A measure of overall model-fit (smaller is better)

While not to the same extent as Melfort, values for percent seed moisture were also unusually low at Scott; however, the overall F-test was highly significant (P < 0.001). For the LL canola, while no individual treatment

differences were significant, seed moisture tended to be highest in the control and with saflufenacil applied alone (3.5-3.6%) but lower with glyphosate, saflufenacil + glyphosate, and diquat (2.7-2.9%). In the untreated RR canola control, percent seed moisture was 5.5% which did not significantly differ from that achieved with saflufenacil, regardless of whether it was tank-mixed with glyphosate (5.2-5.3%). At 3.7% and 2.9%, seed moisture of the RR canola was lower with both glufosinate ammonium and diquat, respectively. While diquat appeared to be more slightly effective, the difference in seed moisture between these latter two treatments was not significant. The contrast comparisons showed an overall benefit to pre-harvest applications for reducing seed moisture ($P < 0.001$; across products and hybrids) and, more specifically, an advantage to diquat over saflufenacil with or without glyphosate ($P < 0.001$-0.003). Again, glyphosate (alone) and glufosinate ammonium were not included in the contrast comparisons.

Table 10. Contrast results for selected response variables in canola desiccation study at Scott, Saskatchewan in 2017.

Group Comparison	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	p-value						
Untreated vs treated	0.931	**< 0.001**	**0.001**	**< 0.001**	0.763	0.779	0.356
Untreated vs Saflufenacil	0.721	**< 0.001**	0.611	0.278	0.400	0.795	0.744
Untreated vs Saflufenacil + Glyphosate	0.464	**< 0.001**	0.203	**< 0.001**	0.724	0.635	0.948
Untreated vs diquat	0.883	**< 0.001**	**< 0.001**	**0.003**	0.762	0.983	**0.018**
Saflufenacil vs Saflufenacil + Glyphosate	0.280	**< 0.001**	0.436	**< 0.001**	0.622	0.465	0.794
Saflufenacil vs Diquat	0.834	**0.003**	**< 0.001**	**0.042**	0.256	0.812	**0.038**
Saflufenacil + Glyphosate vs Diquat	0.381	0.586	**< 0.001**	**0.041**	0.513	0.620	**0.021**

[Z] Gravimetric water content of seed at harvest
[Y] Gravimetric water content of above-ground plant material at harvest

Whole plant moisture content at harvest for this site-year was 29% for the untreated LL control and ranged from 12-25% in the treated plots. The only LL treatments that were a significant improvement over the control in this regard were those that contained glyphosate where the observed values were 12-13% compared to 25-30% for saflufenacil (alone) and diquat, neither of which significantly differed from the control. For RR canola, whole plant moisture in the control was 28% while that of the plots treated with glufosinate ammonium and diquat were significantly lower and did not differ from one another (20-22%). While the observed whole plant moisture values for saflufenacil and saflufenacil + glyphosate tended to be lower (23-24%) than the control, the difference was not significant according to the multiple comparisons test. The contrasts showed an overall benefit to pre-harvest applications across treatments ($P < 0.001$) and also for saflufenacil + glyphosate and diquat ($P < 0.001$-0.003) but not saflufenacil applied alone ($P = 0.278$). Furthermore, the contrasts also showed an advantage to the tank mix with glyphosate over saflufenacil alone ($P < 0.001$), to diquat over saflufenacil alone ($P = 0.042$) and to saflufenacil + glyphosate over diquat ($P = 0.041$). In the case of the latter comparison, the difference was primarily due to the strong performance of glyphosate in the LL canola as diquat performed better than the saflufenacil + glyphosate tank-mix in the RR canola.

While there was substantial variability with treatment means ranging from 3385-3992 kg/ha, the overall F-test for seed yield at Scott in 2017 was not significant ($P = 0.267$) and neither were any of the predetermined contrast comparisons ($P = 0.256$-0.763). Again, other than potential varietal differences (which were not a focus and therefore not specifically tested for), none of the pre-harvest treatments were expected to impact yield if applied at appropriate crop stages.

The overall F-test was highly significant for seed weight ($P < 0.001$) at Scott but appeared to be due entirely to larger seeds in the RR hybrid with no evidence to suggest pre-harvest application effects amongst either the individual treatment means or contrast comparisons ($P = 0.465$-0.812).

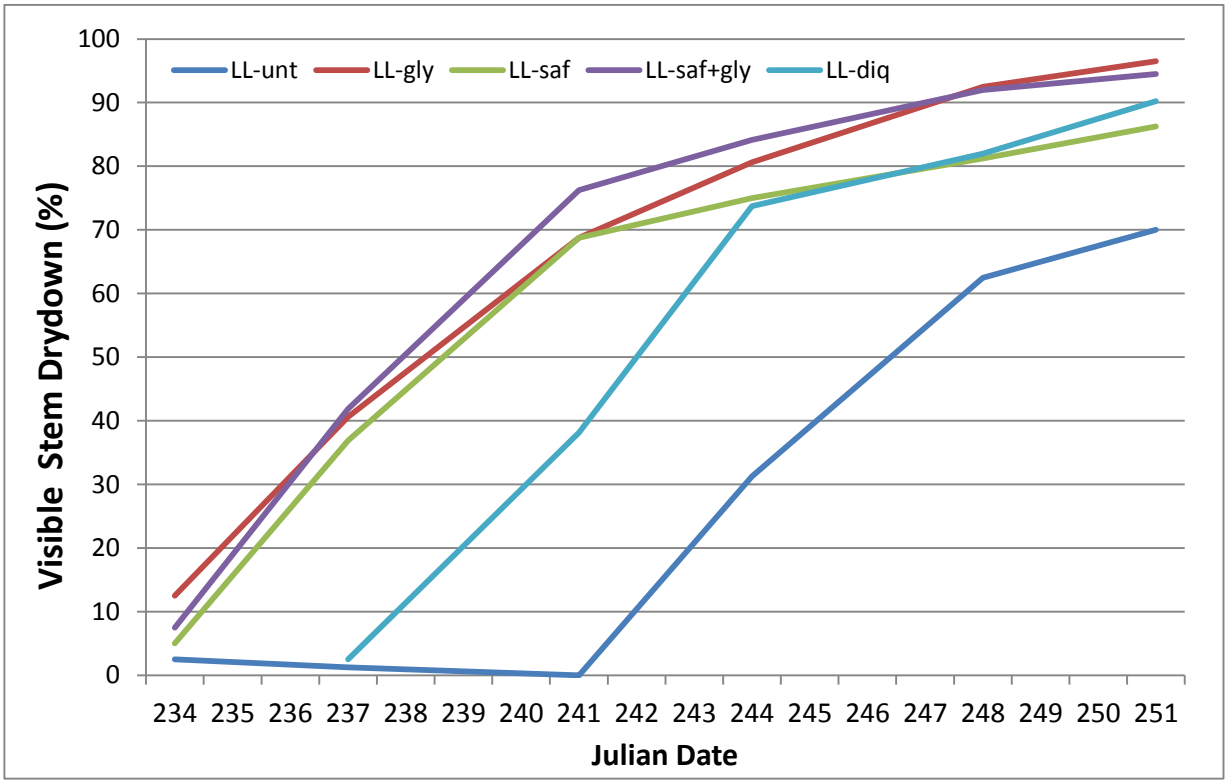

Figure 3. Rate of visible stem down for various pre-harvest treatments in glufosinate ammonium tolerant canola (Scott 2017).

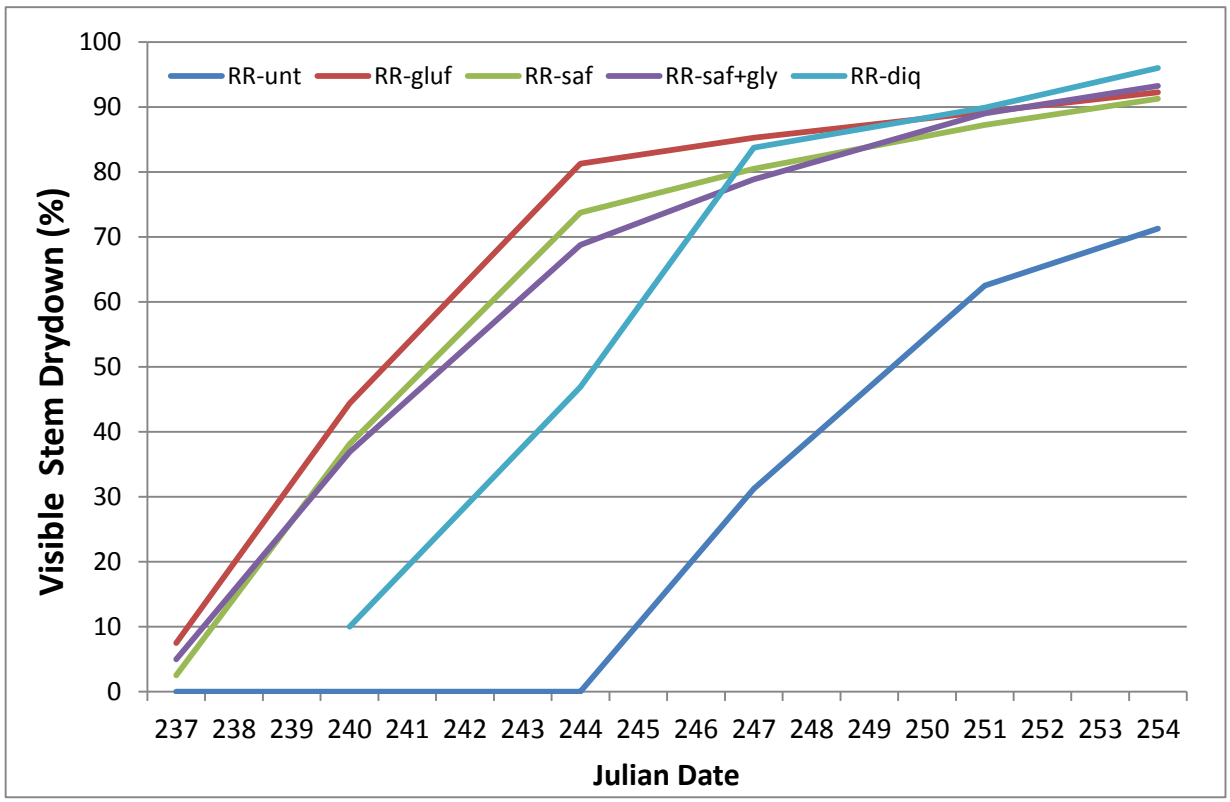

Figure 4. Rate of visible stem down for various pre-harvest treatments in glyphosate tolerant canola (Scott 2017).

Focusing on percent green seed, the overall F-test was not significant at the desired probability (*P* = 0.108); however, there was a tendency for more green seed in the plots treated with diquat, particularly for the RR hybrid (1.9% with diquat versus 0.2-0.5% for the remaining treatments). With LL canola, the effect was much less prominent and not significant with 0.5% green seed with diquat and 0.3-0.4% for the remaining treatments.

This difference in response was presumably due to the LL hybrid being more mature at the time of the treatment applications, despite their timing being specifically tailored to each hybrid at this site-year. The negative effect of diquat was also evident in the orthogonal contrasts where there was no overall effect of pre-harvest applications across hybrids and products (*P* = 0.356) but more green seed with diquat than either the untreated control or any other individual products to which it was directly compared (*P* = 0.018-0.038).

Melita 2017

Results for Melita in 2017 are presented in Tables 11-12 and Figs. 5-6. Emergence was variable with higher overall mortality for this site-year but establishment was noticeably better for the LL (35-56 plants/m^2) compared to the RR hybrid (13-21 plants/m^2). While some differences in emergence amongst the LL treatments were statistically significant, there were attributed to random variability and none of the contrast comparisons were significant (*P* = 0.297-0.922).

Visual stem dry-down ratings at harvest were affected by treatment with strong evidence of pre-harvest option effects and a highly significant overall F-test (*P* < 0.001). For the LL canola, percent visual dry-down was 71% in the control and significantly lower for glyphosate (both alone and tank-mixed with saflufenacil) and diquat (84-91%) but not for saflufenacil applied alone (71%). With the RR canola, visual stem dry-down was rated at 68% in the control and was significantly higher with all pre-harvest options where the values ranged from 83-98%. With the exception of diquat being more effective than saflufenacil applied alone, no other individual differences amongst products were significant according to the multiple comparisons test. The contrasts showed an overall benefit to pre-harvest applications (*P* < 0.001) and to saflufenacil + glyphosate and diquat over the control (*P* ≤ 0.001) along with a strong tendency for increased dry-down with saflufenacil alone over the control (*P* = 0.067). Information on the overall rate of dry-down at Melita (2017) is presented in Figs 5 and 6 for LL and RR canola, respectively.

Table 11. Treatment means and tests of fixed effects for selected response variables at Melita, Manitoba in 2017. The treatments are various pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola hybrids. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; *P* ≤ 0.05).

Treatment	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	-- plants/m^2 --	------- % -------	------- % -------	------- % -------	----- kg/ha -----	g/1000 seeds	------- % -------
1) LL – Control	37.8 bc	71.3 cd	8.7 abc	30.4 a-d	3584 a	3.28 a	0.3 bc
2) LL – Glyphosate	34.7 cd	88.8 ab	8.1 bcd	21.6 d	3496 a	3.21 a	0.1 c
3) LL – Saflufenacil	43.5 abc	71.3 cd	8.2 bcd	31.2 ab	3502 a	3.20 a	0.1 c
4) LL – Safl + Glyph	56.0 a	83.8 b	8.5 a-d	25.1 bcd	3689 a	3.18 a	0.4 bc
5) LL – Diquat	50.8 ab	91.3 ab	8.1 bcd	21.8 cd	3648 a	3.21 a	0.1 c
6) RR – Control	20.7 de	67.5 d	9.5 a	36.1 a	3613 a	3.24 a	0.9 b
7) RR – Gluf. Amm.	15.0 e	90.0 ab	7.8 cd	28.2 a-d	3524 a	3.21 a	0.7 bc
8) RR – Saflufenacil	19.2 e	82.5 bc	9.1 ab	33.9 ab	3436 a	3.27 a	0.5 bc
9) RR – Safl + Glyph	13.0 e	86.3 ab	8.7 abc	30.7 abc	3304 a	3.27 a	0.2 bc
10) RR – Diquat	19.2 e	97.5 a	7.5 d	26.5 bcd	3577 a	3.29 a	1.9 a
SE	5.76	5.23	0.43	3.06	122.4	0.073	0.24
LSD [X]	14.25	12.34	1.13	8.89	225.9	0.162	0.71
Pr > *F* (p-value)	**< 0.001**	**< 0.001**	**0.033**	**0.032**	0.070	0.864	**< 0.001**
AICC [W]	245.2	237.3	-184.2	-66.4	414.6	-21.9	58.2

[Z] Gravimetric water content of seed at harvest

[Y] Gravimetric water content of above-ground plant material at harvest

[X] Least Significant Difference values presented can be used to compare individual treatments but do not control experiment-wise error

[W] Akaike Information Criterion (corrected) - A measure of overall model-fit (smaller is better)

The overall F-test for percent seed moisture was significant (*P* = 0.033) but with greater pre-harvest treatment separation observed in the RR compared to the LL canola. In the LL canola, seed moisture at harvest was 8.7% in the control and ranged from 8.1-8.5% amongst the treated plots – none of which differed significantly from the control according to the multiple comparisons test. For RR canola specifically, seed moisture in the control was 9.5% which was significantly higher than that observed with glufosinate ammonium (7.8%) and

diquat (7.5%) but not saflufenacil regardless of whether it was tank-mixed with glyphosate (8.7-9.1%). The contrast comparisons showed an overall benefit to pre-harvest treatments across hybrids and products (P = 0.012) and to diquat over the control (P < 0.001) but not saflufenacil or saflufenacil + glyphosate compared to the control (P = 0.245-0.284). Seed moisture content was also lower with diquat when compared directly to saflufenacil with or without the addition of glyphosate (P < 0.001-0.036).

The overall F-test for whole plant moisture content was also significant at Melita in 2017 (P = 0.032). The mean values for the untreated controls were 30% and 36% for the LL and RR varieties, respectively, with some evidence of reductions amongst the treated plots. For the LL canola, no treatment differences were significant according to the multiple comparisons test; however, the observed values tended to be lower for glyphosate (25%), saflufenacil plus glyphosate (25%) and diquat (22%). At 31% (compared to 30% in the control), there was no evidence of reduced plant moisture content for the LL canola when saflufenacil was applied alone. For the RR canola at this site, the only statistically significant difference was between the control and diquat (36% versus 27%); however, the values were also noticeably lower for glufosinate ammonium (28%). Saflufenacil alone (34%) and with glyphosate (31%) had less impact on total plant moisture in RR canola although the values were numerically lower. For the contrasts, the untreated versus treated and untreated versus diquat comparisons were both significant (P = 0.006-0.022) while the untreated versus saflufenacil + glyphosate comparison was not significant at the desired probability level but was worth noting (P = 0.092). The only significant product to product comparison was between diquat and saflufenacil applied alone (P = 0.011).

Yields at this site ranged from 3304-3689 kg/ha and neither the overall F-test (P = 0.070) nor any of the contrast comparisons (P = 0.070-0.858) were significant at the desired probability level of $P \leq 0.05$.

The overall F-test for seed weight was not significant (P = 0.864) and the individual treatment means ranged from 3.2-3.3 g/1000 seeds. As expected given the consistency of the individual treatment means, none of the predetermined contrast comparisons were significant (P = 0.438-0.842).

While the overall F-test for percent green seed was highly significant (P < 0.001), the values were noticeably lower and more consistent for the LL hybrid which ranged from 0.1-0.4% with no significant differences amongst the pre-harvest treatments. For the RR canola, percent green seed was statistically similar for the control and all pre-harvest treatments except for diquat where, at 1.9%, percent green seed was significantly higher than all other treatments. The only significant contrast comparisons were between diquat and saflufenacil, with or without the addition of glyphosate (P = 0.008); however, the untreated versus diquat comparison was worth noting (P = 0.094).

Table 12. Contrast results for selected response variables in canola desiccation study at Melita, Manitoba in 2017.

Group Comparison	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	p-value						
Untreated vs treated	0.582	**< 0.001**	**0.012**	**0.022**	0.225	0.438	0.701
Untreated vs Saflufenacil	0.674	0.089	0.284	0.827	0.108	0.595	0.271
Untreated vs Saflufenacil + Glyphosate	0.297	**0.001**	0.245	0.092	0.202	0.465	0.271
Untreated vs diquat	0.255	**< 0.001**	**0.002**	**0.006**	0.858	0.773	0.094
Saflufenacil vs Saflufenacil + Glyphosate	0.528	0.067	0.924	0.139	0.727	0.842	1.000
Saflufenacil vs Diquat	0.467	**< 0.001**	**0.033**	**0.011**	0.076	0.807	**0.008**
Saflufenacil + Glyphosate vs Diquat	0.922	**0.036**	**0.040**	0.235	0.148	0.657	**0.008**

[Z] Gravimetric water content of seed at harvest

[Y] Gravimetric water content of above-ground plant material at harvest

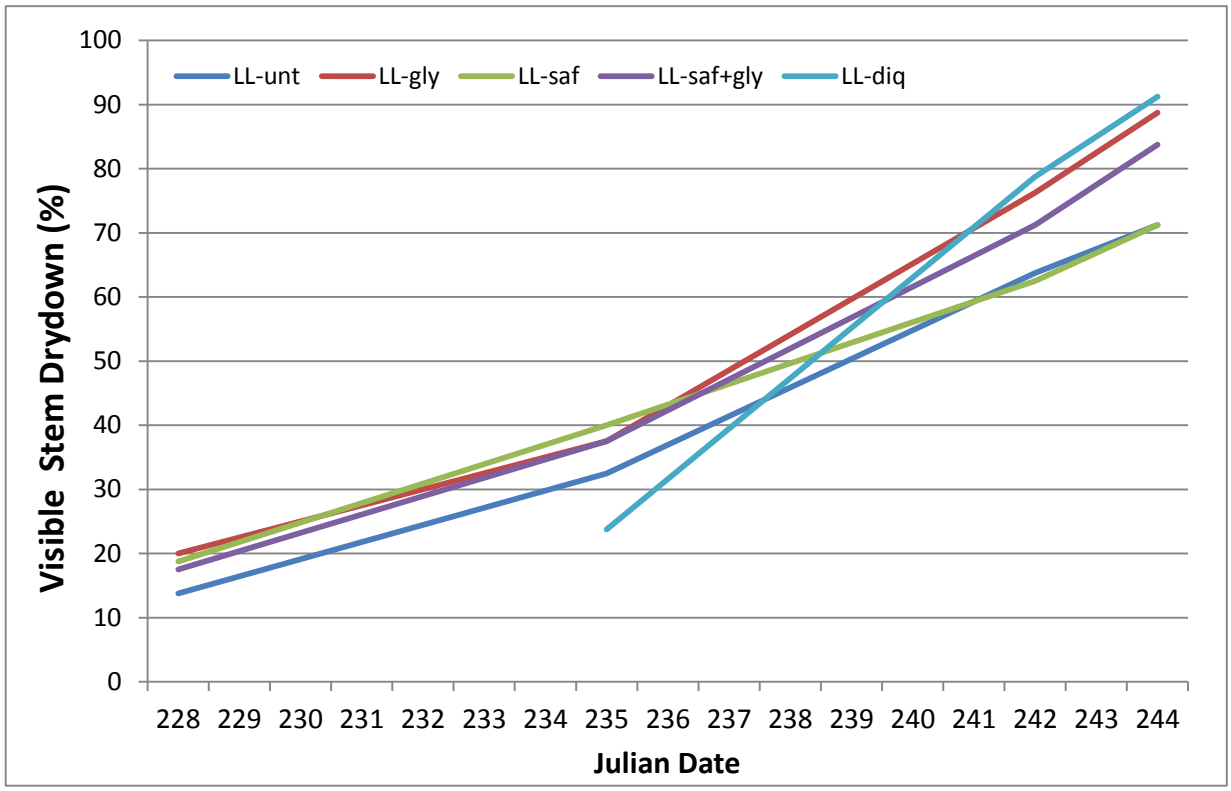

Figure 5. Rate of visible stem down for various pre-harvest treatments in glufosinate ammonium tolerant canola (Melita 2017).

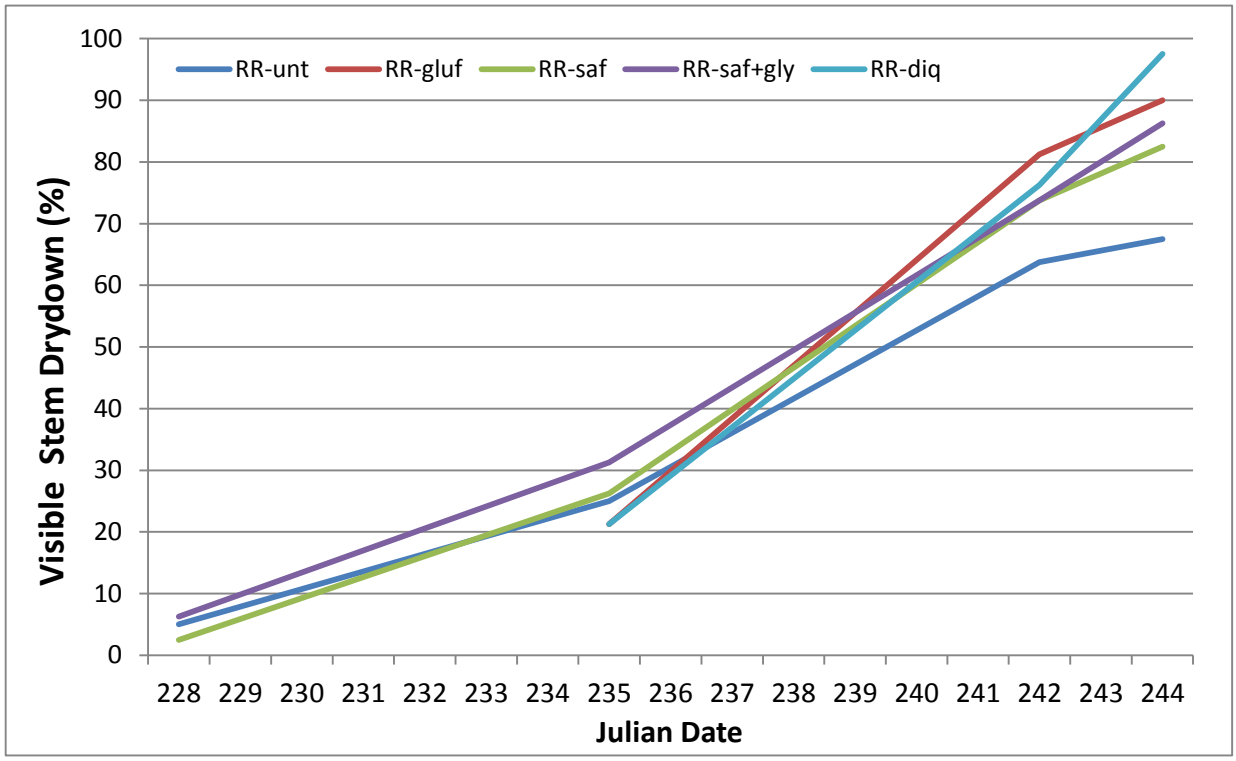

Figure 6. Rate of visible stem down for various pre-harvest treatments in glyphosate tolerant canola (Melita 2017).

4. Significant Progress/Accomplishments

The first year of field trials was completed at all four locations in 2017 (Indian Head, Melfort, Scott, and Melita) and everything went well, albeit with a few challenges and concerns. At Melfort, one treatment was misapplied, visual stem dry-down ratings were not completed, seed moisture contents were impossibly low and the plots were variable overall; however, this was primarily attributed to technical and weather/environmental challenges. At Scott, the calculated seed moisture contents were also unusually low but not to the extent observed at Melfort and the overall trends were consistent with those observed at other sites.

The trial was introduced to approximately 200 guests at the Indian Head Field Day with a broader discussion of straight-combining canola and considerations / past experiences with pre-harvest herbicide / desiccant options to potentially improve this practice. The project was also shown and discussed during two smaller guided tours which IHARF hosted for agronomists with FCL and Richardson Pioneer (approximately 100 guests in total).

All available results to date have been statistically analyzed, reviewed and summarized and will be made publicly available to interested parties and incorporated into extension activities (i.e. oral presentations, crop tours, popular press) where appropriate opportunities to do so arise.

5. Research and Action Plans/Next Steps

Preparations for the second year of field trials are underway. There are no fundamental changes to the protocols being considered; however, a few key refinements may be implemented.

First, while it was manageable, there were larger differences in maturity between the two test varieties (L233P-LL and 45H35-RR) than would be ideal; therefore, other options are being explored. The RR variety is still being confirmed but will ideally remain unchanged – 45H35 is currently sold out commercially but representatives with Dupont-Pioneer are working on securing new seed for the project. Other Pioneer-Protector® HarvestMax would also be suitable for the project. Representatives with Bayer CropScience (to become BASF) have been contacted and can provide either L233P or L255CP, the latter being a few days later and likely to be a closer match (with respect to maturity) to the RR hybrid. Hybrid selection will be finalized in the coming weeks with the ideal options being L255CP and 45M35 as the LL and RR test hybrids in 2018.

The principle reason for determining seed moisture off the combined using wet/dry weights was that it is quite accurate when done using appropriate methods/equipment and a representative sub-sample and also allows for assessment of seed which falls outside of the testable moisture range (i.e. ~5.5-14.5%). However, for this to be accurate the samples must be processed immediately after combining (before air-drying can occur) and collaborators must have access to a humidity controlled oven capable of temperatures exceeding approximately 70 °C. The methodology will be reinforced with emphasis on the time sensitivity of the measurements, need for high temperatures and, potentially, longer drying times. If appropriate drying equipment is not available for any reason, collaborators will be advised to use an electronic moisture meter, provided that the values do not fall outside of the testable range.

6. Budget impacts in the event major issues or variance between planned and actual is noted:

There were no major issues or deviation from the originally proposed activities that are expected to impact the budget requirements.

Please forward an electronic copy of this completed document to:

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