2016 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Pre-harvest Options for Straight-Combined Canola: Effects on Crop Dry-down and Fall Weed Control

(Project #20150396)

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Project Identification

1. **Project Title:** Pre-harvest Options for Straight-Combined Canola: Effects on Crop Dry-down
2. **Project Number:** 20150396
3. **Producer Group Sponsoring the Project:** Indian Head Agricultural Research Foundation
4. **Project Location(s):** Indian Head, Saskatchewan, R.M. #156
5. **Project start and end dates (month & year):** Apr-2016 to Feb-2017
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

The objective of this project was to demonstrate differences amongst registered pre-harvest herbicide and desiccant options for straight-combining canola with an emphasis on crop dry-down and fall weed control.

8. **Project Rationale:**

With improvements in cultivars and equipment combined with increasing experience and confidence in this practice, interest in straight-combining has continued to grow over the past several years in western Canada. A survey commissioned by BASF in 2014 found that an estimated 65% of canola growers were interested in straight-combining and, while most of those currently straight-combining were still experimenting, 15% of the respondents are straight-combined all their canola. Throughout western Canada, straight-combined canola acres were higher than ever in 2015 and, while precise numbers are uncertain, most estimates put the total canola acres straight-combined in 2015 at 10% or higher. If tolerance to shattering continues to improve and be incorporated into more varieties, the percentage of straight-combined canola will likely keep increasing in future years.

One of the most critical factors for successful straight-combining is proper timing. While green stems and plant material can dramatically reduce efficiency while combining, it is important to avoid unnecessary delays in harvest which can result in greater potential for yield loss from shattering. Consequently, timing can be a challenge when straight-combining canola, especially in wet falls or variable fields. Pre-harvest herbicide or desiccant applications can make this operation easier to time by allowing for earlier harvest, less variability, and (depending on the product) providing weed control benefits extending into the subsequent season. That said, such applications do increase input costs and labour requirements, and some growers are reluctant to drive through mature crops with a ground sprayer unless there are clear benefits in doing so. Aerial applications are an option but increase costs especially when high water volumes are required. While many growers experienced with straight-combining canola tend to favour a pre-harvest application, it is important to recognize that it may not always be necessary, and that not all products are equal depending on the circumstances and specific objectives of the grower.

Methodology and Results

9. Methodology:

A field trial with canola was established at Indian Head, Saskatchewan in the spring of 2016. The purpose of the demonstration was to show the difference in crop dry-down and fall weed control amongst registered pre-harvest herbicides and desiccant options for straight-combining canola. Five pre-harvest herbicide / desiccant treatments were arranged in a randomized complete block design (RCBD) with four replicates.

Pre-harvest treatments for canola (target growth stages in parenthesis)

1. Untreated
2. Glyphosate (0.67 l/ac Roundup Transorb HC at 60-75% seed colour change)
3. Saflufenacil (59 ml/ac Heat LQ + 0.5% v/v Merge at 60-75% seed colour change)
4. Heat + Saflufenacil (0.67 l/ac Roundup Transorb HC + 59 ml/ac Heat LQ + 0.5% v/v Merge at 60-75% seed colour change)
5. Diquat (0.7 l/ac Reglone + 0.1% v/v Agrol 90 at 80-90% seed colour change)

Pertinent agronomic information is provided in Table 1. Canola was direct seeded into barley stubble on May 19 with all fertilizer applied at the time of planting. Seeds were planted deeper than desired (>1”) which slowed down and reduced emergence to some extent; however, conditions were favourable for emergence and overall plant stands were considered adequate. Weeds were controlled using registered herbicides and fungicides were applied for disease control. The plots were terminated with pre-harvest herbicides or desiccants as per protocol and straight-combined on a single date (Sep-21) when the earliest treatments were slightly over-dry but the greenest were still somewhat tough. All the preharvest treatments were applied using a field sprayer and 220 l/ha solution volume – for Trt. 3 the glyphosate and saflufenacil were applied as a tank mix. Higher water volumes are required for saflufenacil and diquat but not glyphosate; however, the higher volume was still used because smaller volumes are difficult to accurately hold when spraying individual plots with the field sprayer that was utilized (due to excessive pump capacity). Recognizing that diquat can be sensitive to sunlight and application time, this was applied in the early evening on a cloudy day. Glyphosate (Trt. 2) was applied the earliest (Aug-29, 60-65% SCC), 4 days ahead of the saflufenacil (Trt. 3 & 4, Sep-2, 70-75% SCC) and 12 days ahead of the diquat (Trt. 5, Sep-8, 90-95% SCC).

Stem and pod dry down were rated on a scale of 0-100 at 2, 4, 8, and 14 days after treatment application and all plots were rated prior to harvest. While shattering was monitored, it was negligent for all treatments so detailed shatter ratings for individual plots were not completed. At harvest, straw moisture content was measured by hand harvesting approximately 10 plants per plot and drying at 60 degrees Celsius to calculate gravimetric moisture content. Seed moisture at harvest was evaluated by using an electronic moisture meter and by calculating gravimetric moisture content from the wet and dry weights of 100 g sample (dried at 90 degrees Celsius for 48 hours). Yields were determined from the harvested grain samples which were cleaned and corrected to 10% seed moisture content. Dockage (for correcting yields) and test weights were determined using CGC methodology and test weights are expressed as g $0.5\ L^{-1}$. Seed size was determined by mechanically counting and weighing a minimum of 500 seeds and calculating g 1000 $seeds^{-1}$ (TKW). Green seed was determined by counting the number of distinctly green seeds from a 500-seed crush and calculating percent green seed. Fall weed control was observed for approximately 30 days after harvest; however perennial or winter annual weeds were too sparse to justify intensive counts. Weather data were estimated from a private weather station located on the site. Data was statistically analysed using the GLM procedure of SAS with pre-harvest treatment effects considered fixed and rep effects considered random. Fisher's protected LSD test was used to separate individual treatment means. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

Table 1. Selected agronomic information for canola preharvest options for straight-combining demonstration at Indian Head, Saskatchewan.

Factor / Field Operation	IH-16
Previous Crop	Barley
Pre-emergent herbicide	890 g glyphosate/ha (15-May-2016)
Cultivar	L140P (Liberty Link®)
Seeding Date	19-May-2016
Row spacing	30 cm
kg $N\text{-}P_2O_5\text{-}K_2O\text{-}S$ ha^{-1}	140-30-15-15
In-crop herbicide 1	593 g glufosinate ammonium/ha + 30 g clethodim/ha (15-Jun-2016)
Fungicide	246 g boscalid/ac (8-Jul-2016)
Pre-harvest herbicide	Applied as per protocol (29-Aug – Trt 2) (2-Sep – Trt 3 & 4) (8-Sep – Trt 5)
Harvest date	21-Sep-2016

10. Results:

Growing season weather conditions

Mean monthly temperatures and precipitation amounts are presented with the long-term averages for Indian Head in Table 2. While May was initially warm and dry, large amounts of precipitation were received late in the month and the total amounted to 140% of the 1981-2010 average. Total precipitation for June was 81% of average while July was wet (177%) and August was relatively dry (58%). The total amount of precipitation from April 1 through August 31 was 292 mm (11.7"), approximately 9% above the long-term average. Temperatures were substantially higher than normal for May and June and then approximately normal in July and August. Despite the slower emergence due to seeding too deep, with abundant but generally not excessive precipitation and overall canola yield potential was high. The plots were lightly damaged by hail on July 18 (late bloom) however effects on yield were considered negligible (<5%). While disease pressure was relatively high, fungicide appeared to have kept sclerotinia infection levels acceptably low.

Table 2. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2016 growing season at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	------------ Mean Temperature (°C) ------------				
2016	14.0	17.5	18.5	17.2	16.8
Long-term	10.8	15.8	18.2	17.4	15.6
	------------ Precipitation (mm) ------------				
2016	72.6	63	112.8	29.8	278.2
Long-term	51.8	77.4	63.8	51.2	244

Effect of Pre-Harvest Applications on Canola Dry-down, Yield and Quality

Tests of treatment effects and means for each pre-harvest treatment for all response variables are presented in Table 3 and 4. The treatments affected visual dry down, seed moisture content (both meter and gravimetric), straw moisture content, and percent green seed (P < 0.001-0.002; Table 3). Seed yield, seed size (TKW), and dockage were not significantly affected by pre-harvest herbicides (P = 0.16-0.81).

Table 3. Treatment means and analyses of variance for canola visual dry down (VDD), seed moisture content (SMC) using electronic moisture meter (Meter) and the gravimetric method (Mass), straw moisture content, yield, thousand kernel weight (TKW), dockage, and green seed. (Fisher's protected LSD test; $P \leq 0.05$).

Variable	VDD %	Seed Moisture 1[Z]	Seed Moisture 2[Y]	Plant Moisture [X]
1) Control	60 d	10.4 a	11.6 a	88.1 a
2) Glyphosate	86 a	8.0 d	8.8 b	22.5 e
3) Heat	70 c	9.7 b	10.9 a	75.4 b
4) Glyph + Heat	79 b	9.6 bc	11.1 a	62.8 c
5) Reglone	79 b	9.0 c	9.5 b	43.7 d
SE	1.3	0.19	0.27	3.59
Pr > F (p-value)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
C.V. (%)	3.5	4.1	5.2	12.3
R^2	0.957	0.890	0.873	< 0.001

[Z] Determined using a Labtronics 919 moisture meter [Y] Gravimetric (wet/dry weights)
[X] Gravimetric water content of entire above-ground plant material at time of harvest

Only the final visual dry down ratings were statistically analyzed; however, the measurements over time are presented in Figure 1 – bear in mind that these ratings are quite subjective. Dry-down with glyphosate was initially slow, particularly for the first week after application, but by the time of harvest (23 days after application) resulted in estimated 86% dry-down. While the saflufenacil and saflufenacil plus glyphosate treatments began drying the crop down more quickly than glyphosate, the final dry-down ratings were lower at 70 and 79%, respectively. Diquat must be applied quite late but works very quickly and the product label recommends harvesting canola within 2 weeks after application to avoid over-drying. The final mean visual dry-down rating with diquat was 79%, the same as saflufenacil plus glyphosate and higher than saflufenacil applied on its own. Respectively, the products had 23, 19 and 13 days to work prior to harvest for glyphosate, saflufenacil (plus glyphosate) and diquat.

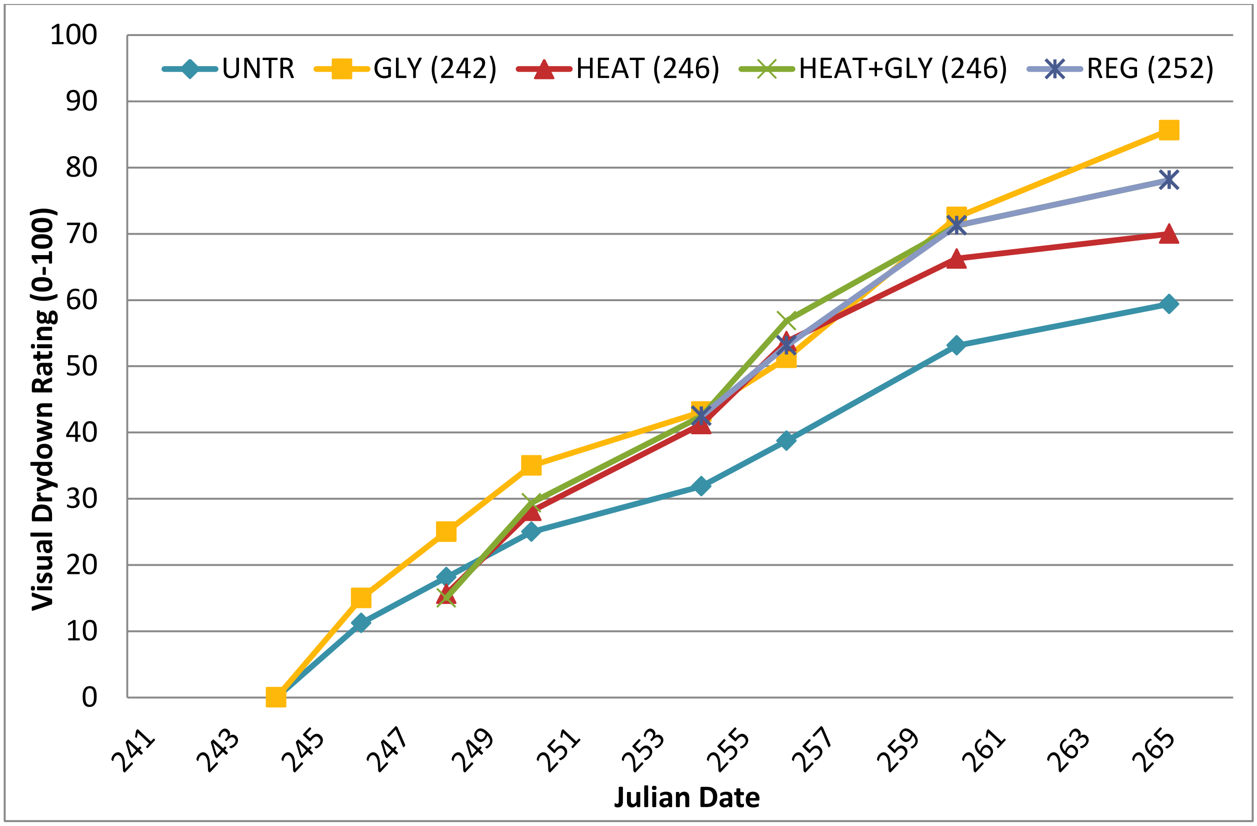

Figure 1: Visual stem dry down ratings from the time of treatment application.

Treatment effects on seed moisture were like those observed for visual dry-down and consistent for both measurement methods, despite differences in the absolute values. As a reference point, canola is considered dry at 10% moisture, 8% is often preferred for long-term storage. Seed moisture content ranged from 8.0-10.4% (depending on the treatment) when measured using the electronic meter (SMC1) and 8.8-11.6% when determined from the wet/dry weights (SMC2). Although the gravimetric moisture values were consistently higher than those determined electronically, the treatment effects were consistent. Focussing on SMC1, moisture content in the control was 10.4% and significantly lower for all treatments where pre-harvest treatments were applied. With saflufenacil (with and without glyphosate) seed moisture was 9.6-9.7%, with diquat it was 9.0% and the glyphosate (alone) treatment resulted in the driest seeds at 8.0%. For SMC2, the values were 11.6%, 10.9-11.1%, 9.5% and 8.8% for the control, saflufenacil, diquat and glyphosate treatments, respectively. When determined gravimetrically (SMC2), only the glyphosate and diquat treatment resulted in significantly lower seed moisture content than the control.

Whole (above-ground) plant moisture content followed the same overall trends as the seed moisture measurements but with greater separation whereby treatment averages ranged from 23-88% gravimetric water content. At 88% whole plant moisture content, all treatments resulted in significantly drier plants than the control and, in the order of highest to lowest moisture content were ranked saflufenacil (75%), saflufenacil plus glyphosate (63%), diquat (44%) and glyphosate (23%). Straw moisture content is particularly important to the ease of harvest when straight cutting canola and can have implications for harvest timing as it is not uncommon, particularly in wet falls, for the seed to be dry and fit to store well before the straw is dry enough to process. The results suggest if a (Liberty Link® canola) growers' objective is provide thorough dry-down, weed control and does not expect to harvest for 10-14 days or longer, glyphosate would be the most cost effective choice. If the objectives are to harvest quickly or the crop has already dried down passed the optimal stage for glyphosate application, saflufenacil or diquat are likely more appropriate choices. Both diquat and saflufenacil are considerably more expensive than glyphosate; however, the efficacy of these products is less likely to be adversely affected by crop stage (unless applied too early) or environmental conditions (i.e. glyphosate can be extremely slow if applied under cool and/or dry conditions). It must be emphasized that glyphosate is not registered as a harvest aid but rather for non-selective, pre-harvest weed control and, therefore, rapid crop dry-down with this product is neither promoted nor guaranteed when it is used as directed. Furthermore, from a herbicide resistant weed management perspective, it is increasingly being recommended that glyphosate always be tank-mixed with products from other herbicide groups.

Neither yield, thousand seed weight or dockage were affected by pre-harvest treatments (Table 5). This was not unexpected given that the registration process for products slated for pre-harvest use must be proven safe and effective, while maintaining yield and quality. It's important to note that to be effective while ensuring yield and quality, the products must be applied at the correct time. Yields were high overall, averaging 3468 kg/ha (62 bu/ac) across treatments. Thousand kernel weight averaged 3.3 g/1000 seeds and dockage averaged 2.8% in this trial.

Table 4. Treatment means and analyses of variance for canola visual dry down (VDD), seed moisture content (SMC) using electronic moisture meter (Meter) and the gravimetric method (Mass), straw moisture content, yield, thousand kernel weight (TKW), dockage, and green seed. (Fisher's protected LSD test; $P \leq 0.05$).

Variable	Yield	TKW	Dock	Green
	------ kg/ha ------	g/1000 seeds	% of gross	% of 500
1) Control	3483 a	3.28 a	3.03 a	0.1 b
2) Glyphosate	3396 a	3.23 a	2.64 a	0.1 b
3) Heat	3536 a	3.23 a	2.78 a	0.2 b
4) Glyph + Heat	3455 a	3.28 a	2.74 a	0.2 b
5) Reglone	3415 a	3.28 a	3.03 a	0.7 a
SE	74.1	0.024	0.284	0.072
Pr > *F* (p-value)	0.440	0.322	0.930	**0.002**
C.V. (%)	4.3	1.5	20.0	65.3
R^2	0.383	0.434	0.157	0.805

Treatment effects on percent green seed content were significant with more green seed in the diquat treatment (0.8%) than any other treatments (0.1-0.2%). While significantly higher than the other treatments, the percentage of green seed found where diquat was applied was still not high enough to result in down-grading. Canada #1 canola is allowed up to 2% distinctly green seeds. While the observed difference was not an agronomically important grading factor, it does illustrate the sensitivity of diquat to proper application timing. The label recommended window for applying diquat (Reglone, Reglone Ion) is 80-90% seed colour change and the canola was at the latter end of this range in the current trial.

Extension and Acknowledgement

Due to logistic / location considerations, in addition to the fact that treatments were not applied until very late in the season, this project was not shown as part of the Indian Head Crop Management Field Day in 2016. However, the trial was highlighted on tour coordinated by Seed Hawk during the Farm Progress Show with 15-20 Australian producers and agronomists (June 16, 2016) and on another co-hosted with Richardson Pioneer (July 27) with approximately 33 guests. In addition to these more formal tours, the site was visited by numerous growers, agronomists and researchers over the season. Chris Holzapfel presented the results at a canola harvest session in Moosomin (Cutting Edge Expo, November 3, 50-60 producers and agronomists), the 2016 Canada Western Agribition Grain Expo (November 22, >500 attendees) and during the IHARF Soil and Crop Management Seminar at Weyburn (Feb. 1, 2017, approximately 115 attendees). A summary of this work will be included in the 2016 IHARF Annual Report which, in addition to the full report, will be available online. Results will also be made available through a variety of other media (i.e. oral presentations, popular agriculture press, social media, fact sheets, etc.) as opportunities arise.

11. Conclusions and Recommendations

Adoption of straight-combining canola is expected to continue increasing with varietal improvements and increased grower experience and confidence. Many of the recent questions surrounding this practice have been regarding the necessity of pre-harvest applications and appropriate product selection depending on crop conditions and objectives. While previous experience suggests that canola can be straight-combined successfully without the use of pre-harvest applications challenges can occur, particularly when dealing with spatial variability or slow dry-down of stems. Spatial variability can be caused by a variety of factors (i.e. plant density, soil moisture) while green stems are most commonly problematic with high yielding crops when moisture is abundant late in the season. When applied properly, pre-harvest herbicides can be a valuable tool to assist in straight cutting operations and improve timing without affecting yield or quality and, depending on the product, can also provide perennial weed control benefits. In general, pre-harvest applications are most likely to be beneficial when weed pressure is high, when using varieties susceptible to pod drop or shatter, on large farms with many acres of canola and narrow harvest windows and when within-field spatial variability makes proper timing difficult. It is important to bear in mind that this demonstration exclusively focussed on glufosinate tolerant (Liberty Link®) canola; however, the performance of saflufenacil and diquat should be consistent across canola herbicide tolerance types (i.e. Roundup Ready® and Clearfield®).

Results from this demonstration should be interpreted cautiously as actual performance may vary depending on the environmental/crop conditions encountered and specific application times used. When visual ratings, whole plant moisture and seed moisture from the current trial were all considered, the most thorough dry-down was achieved with glyphosate (applied at 60-65% SCC) followed by diquat (90-95% SCC), glyphosate plus saflufenacil (70-75% SCC) and saflufenacil (70-75% SCC). All products provided significant dry-down benefits relative to the untreated control. In the current trial (Indian Head 2016), glyphosate at 60-65% seed colour change (SCC) provided the most thorough dry-down; however, its initial activity is slow and glyphosate is not registered as a harvest aid but rather for pre-harvest weed control. The greatest potential advantages to glyphosate are low cost and effective weed control; however, efficacy as a harvest aid can be variable when used properly, particularly within the first 7-14 days after application. Diquat was the next most effective with respect to crop dry-down and, in contrast to glyphosate, works quickly (results evident within the first 4 days) and must be applied late in season close to the time of harvest. Diquat will desiccate any green weeds (including perennials) but generally will not provide full control. Saflufenacil, particularly when tank-mixed with glyphosate has both weed control and desiccant properties. The saflufenacil itself works primarily as a contact herbicide therefore is less likely to be affected by crop stage or environmental conditions than glyphosate; however, the glyphosate component of the mix still provides perennial weed control and assists with crop dry-down in Liberty Link® and Clearfield® canola types. While saflufenacil did not appear to dry-down the canola plant and seed material as thoroughly as the glyphosate or diquat treatments, this may have been partly due to application time (i.e. environmental conditions and crop stage) as opposed to product efficacy. Recall that the saflufenacil treatments were applied 4 days later than the glyphosate (alone) and at 70-75% SCC versus 60-65% SCC. While it would be acceptable for farmers to apply glyphosate slightly earlier than saflufenacil under most conditions (glyphosate is systemic, saflufenacil is contact), future work should ensure that these treatments are applied on the same date to remove timing / crop stage as a potential confounding factor.

In all situations, growers should take various factors into consideration when deciding whether to use a preharvest application and, if so, which product to apply. First, ask whether a pre-harvest application is necessary at all. In uniform, clean (i.e. weed free) fields when using a variety with good resistance to pod shatter / drop, the most cost effective option may often be to simply let the crop mature naturally. If variability or weeds are an issue or there are concerns about late harvest / environmental losses then consider producer objectives when selecting a product. If the estimated harvest is still approximately 2 weeks away (or more), weed control is a primary objective and the canola is not Roundup Ready®, applying glyphosate on its own will likely be a cost-effective and viable option. If conditions are cool and/or dry, or the anticipate harvest date is less than 2 weeks away, products with contact activity are likely more appropriate. The cost of saflufenacil plus glyphosate and diquat are similar (depending on the rates); however, there does appear to be some trade-off between weed control (saflufenacil + glyphosate is superior) versus rapid and thorough crop dry-down (diquat was superior in the current trial). In all cases, growers are urged to follow label directions which primarily means paying attention to crop stage (avoid applying too early) and using appropriate water volumes (~200 l/ha or 20 U.S. gal/ac are recommended for contact products like saflufenacil and diquat). Earlier harvest will often be an outcome of properly applied harvest aids / pre-preharvest applications; however, this should not be a primary objective as it can increase the temptation to spray too early and, under some conditions (particularly dry falls) will not always impact harvest date. Most growers are interested in straight-combining not only for increased efficiency but also because of the potential for higher yields associated with longer pod fill. In addition to potentially causing quality issues, spraying too early can greatly reduce the potential for yield advantages to straight-combining canola. The principal reasons for using pre-harvest applications should be to address variability (thereby making harvest easier to time and plan for), perennial weed control and increasing harvest efficiency / throughput when the time does come to put the crop through the combine. While pre-harvest applications will not necessarily result in earlier harvest, they will greatly reduce the potential unforeseen delays resulting from green stems or the crop not maturing as early as expected due to cool or wet conditions.

Supporting Information

12. Acknowledgements:

In 2016 this project was supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. Acknowledgement of the Saskatchewan Ministry of Agriculture's support for this demonstration will be included as part of all written reports and oral presentations that arise from this work. Many of the crop inputs were provided in-kind by Bayer CropScience, BASF and Syngenta. The technical, administrative and professional support of Danny Petty, Dan Walker, Karter Kattler, Carly Miller, Christiane Catellier and both technical contributions and assistance in report preparation by Andrea De Roo is appreciated.

13. Appendices

Figure 1. Canola crop stage at time of glyphosate (Trt. 2) application (Aug-29).

Figure 2. Canola crop stage at time of saflufenacil (Trt. 3 and 4) application (Sep-2).

Figure 3. Canola crop stage at time of diquat (Trt. 5) application (Sep-8).

Abstract

14. Abstract/Summary:

With improvements in cultivars and equipment, interest in straight-combining has continued to grow over the past several years in western Canada and is now thought to exceed 10% of the total acres in western Canada. This number will likely continue to increase. One critical factor for straight-combining canola successfully is proper timing, which can be challenging during wet falls or in variable fields. Pre-harvest herbicide/desiccant applications can make this operation easier to time, generally allowing for earlier harvest, less variability, increased combine efficiency and (depending on product) weed control benefits. Glyphosate, saflufenacil (with and without glyphosate) and diquat were evaluated relative to an untreated control on glufosinate ammonium tolerant canola at Indian Head (2016). Visual stem dry-down, seed moisture, straw moisture, yield, seed size, dockage and green seed were measured. Results showed that glyphosate applied alone (given 23 days to work) provided the most thorough dry-down but was also the slowest acting. Diquat was highly effective as a desiccant providing thorough dry-down and rapid activity but no perennial weed control. Saflufenacil did not dry down the crop to the same extent as glyphosate or diquat but, when tank mixed with glyphosate, has the benefits of both providing weed control and contact efficacy that is less sensitive to crop stage or weather conditions than glyphosate on its own. All treatments improved dry-down relative to the control and none adversely affected grain quality or yield.