2021 Annual Report

for the

Saskatchewan Ministry of Agriculture's

Agricultural Demonstration of Practices & Technologies (ADOPT) Program

Project Title: Pre-harvest Weed Control and Desiccation Options for Flax

Project #20200522 (SaskFlax 202102)

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Project Identification

1. **Project Title:** Pre-harvest weed control and desiccation options for flax
2. **Project Number:** 20200522 (SaskFlax #202102)
3. **Producer Group Sponsoring the Project:** Saskatchewan Flax Development Commission (SaskFlax)
4. **Project Location(s):** Indian Head (#156), Swift Current (#136), and Yorkton (#244), Saskatchewan
5. **Project start and end dates(s):** April-2021 to February-2022
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project Objectives:**

The objectives of this project were to:

1) Demonstrate the effects of pre-harvest herbicide and desiccant options for flax on seed and straw dry-down.
2) Provide a forum for discussion on the potential advantages and disadvantages of the pre-harvest options evaluated with respect to both weed control and efficacy as a harvest aid.

8. Project Rationale:

Harvestability has been and continues to be a significant challenge for flax growers and, when considered along with subsequent residue management issues, is an important reason that many non-flax growers express resistance to this crop. It is not uncommon for cool, wet fall weather and/or early snowfall to leave many flax acres unharvested and growers looking for ways to accelerate crop dry-down and improve harvestability for this crop. Depending on the weather, regrowth in the fall can also create significant challenges. One of the more obvious things to consider for improving flax harvestability, particularly with straight-combining, is the use of pre-harvest herbicides and desiccants. Because of the relatively open canopy of mature flax and the potential for regrowth of both the crop and certain weeds, pre-harvest glyphosate can be an excellent fit for straight-combined flax. Since it does terminate the crop, however, pre-harvest glyphosate may also assist with straw dry-down and overall harvestability to a certain extent. That said, it is expected that the effects of glyphosate applied alone on flax dry-down can be slow and potentially inconsistent depending on environmental conditions. Diquat (i.e. Reglone Ion) is a crop desiccant in the truest sense in that it is not translocated, relies entirely on contact, and results in rapid dry-down of any plant tissue that it comes into contact with. The downside to diquat is that it will not necessarily completely terminate the crop and provides only limited weed control (top growth only) with regrowth of both crop and weeds possible, especially under prolonged wet conditions or with perennials.

Evaluating these pre-harvest options for a selection of the dominant flax varieties grown in Saskatchewan will increase the overall robustness of our results along with our ability to detect treatment differences while potentially providing insights towards genetic variation in flax ripening and stem dry-down.

<u>Methodology and Results</u>

9. Methodology:

In the spring of 2021, flax field trials were initiated with locations at Indian Head, Swift Current, and Yorkton. The treatments were a factorial combination of three varieties (CDC Bethune, CDC Glas, and CDC Sorrel) and three pre-harvest herbicide/desiccation options for a total of nine treatments. The pre-harvest treatments were an untreated control, glyphosate, and diquat. The specific equipment used to apply the pre-harvest treatments varied across locations; however, the target crop stage was when 75% of the bolls had turned brown and a minimum solution volume of 185 l/ha was used for all treatments. Although this solution volume was higher than what is required for glyphosate applied alone, it was in line with what is recommended for diquat and, importantly, the higher water volume made it easier to accurately apply the treatments to individual plots using a field sprayer.

Research has shown that “hard water” reduces the activity of glyphosate products through binding with minerals in the water. Saskatchewan Ministry of Agriculture guidelines indicate that a water hardness above 350 ppm $CaCO_3$ is a potential concern when low rates of glyphosate are used (i.e., for grassy weed control) and that hardness above 700 ppm is a concern when high rates of glyphosate are used (i.e., for perennial weed control). The water used for spraying at Indian Head, Yorkton, and Swift Current had hardness values of 308, 309, and 392 mg/L (ppm) of $CaCO_3$, respectively. Therefore, the water hardness at Indian Head and Yorkton fell below the minimal threshold of concern. At 392 ppm, the hardness of the water at Swift Current would be a concern for a low rate of glyphosate application but not with the moderate rate of 894 g ae/ha of glyphosate used in this trial, and therefore no mitigation measures were taken.

The treatments were arranged in a four replicate RCBD and are listed in Table 1.

Table 1. Variety by pre-harvest herbicide/desiccant options evaluated for flax at Indian Head, Swift Current, and Yorkton in 2021.

#	Variety	Pre-harvest Application [Z]
1	CDC Bethune	Untreated
2	CDC Bethune	894 g glyphosate/ha
3	CDC Bethune	400 g diquat/ha
4	CDC Glas	Untreated
5	CDC Glas	894 g glyphosate/ha
6	CDC Glas	400 g diquat/ha
7	CDC Sorrel	Untreated
8	CDC Sorrel	894 g glyphosate/ha
9	CDC Sorrel	400 g diquat/ha

[Z] Applied in a minimum solution volume of 185 l/ha when 75% of bolls had turned brown

Seeding dates ranged from May 7-17 and seeding equipment varied across locations with a 14 opener Conserva-Pak used at Indian Head, a 9 opener Fabro (equipped with Atom-Jet openers) used at Swift Current, and a 10 opener SeedMaster used at Yorkton. For all locations, the flax was seeded directly into cereal stubble with a target depth of 2-3 cm; however, the actual depth at Indian Head was greater than desired which resulted in slow, variable establishment and lower than targeted plant populations. For seeding rates, a flat rate of 55 kg/ha was used for all varieties at Indian Head while, at Swift Current and Yorkton, adjustments for seed size were made in an attempt to equalize plant populations across varieties. Weeds were controlled using registered pre-emergent and post-emergent herbicides. Foliar fungicides were applied preventatively at Indian Head and Yorkton to reduce the potential for pasmo as a yield limiting or confounding factor. No fungicide was applied at Swift Current; however, the risk of disease was extremely low at this location. The plots at Indian Head were sprayed for grasshoppers late in July. The pre-harvest treatments were applied as per protocol and the application dates were July 28 at Swift Current, August 15 at Yorkton, and August 25 at Indian Head. The plots were straight-combined using small plot harvesters. Outside rows and/or wheel tracks were excluded from the harvest area at al locations and all plots within a location were harvested on the same date so that treatment effects on the crop could be objectively evaluated at a specific point in time.

Various data were collected during the growing season and from the harvested grain samples. Weather data were compiled from the nearest Environment and Climate Change Canada weather stations which were always located within a few kilometers of the field trial sites. Plant densities were assessed by counting plants in 2 x 1 m sections of crop row for each plot. The maturity date was recorded for each plot whereby maturity was declared when approximately 75% of the bolls had turned brown. Visual stem dry-down ratings were completed at predetermined times relative to the pre-harvest treatment applications. These ratings were completed at 0 days after application (DAA), 4 DAA (Indian Head only), 7 DAA, and 14 DAA. More information on the rating scale that was used is provided in Table 8 of the Appendices. Straw moisture content at harvest was determined from wet/oven-dry weights of unchopped straw subsamples that were collected from behind the combine. The samples were considered dry after a minimum of three days in an oven at a minimum of 60 °C with percent moisture calculated on a wet-basis. Seed moisture was determined in a similar manner at Indian Head (i.e. wet/oven-dry weights) while, at Yorkton and Swift Current, electronic moisture testers were used. Similar to straw moisture, seed moisture was also expressed on a wet-basis. Although not a key response variable for achieving our objectives, grain yields were determined from the harvested plot areas and are adjusted for dockage and to a uniform seed moisture content of 10%. Selected agronomic information and dates of operations are provided in Table 9 of the Appendices.

Response data were analyzed separately for each location using the generalized linear mixed model (GLIMMIX) in SAS® Studio. For plant density and days to maturity, only variety (VAR) effects were considered fixed with pre-harvest treatment (TRT) effects excluded from the model. For the remaining response variables, VAR, TRT, and their interaction (VAR x TRT) were considered fixed. Replicate effects were always considered random. Individual treatment means for both main effects and their interactions were separated using the Tukey-Kramer test. Treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Mean monthly temperatures and total precipitation amounts for May through August (2021) are presented relative to the long-term averages (1981-2010) at each location in Table 2. Overall mean temperatures for the 4-month growing season were above normal at all three locations, averaging 103%, 109%, and 106% at Indian Head, Yorkton, and Swift Current, respectively. In terms of precipitation, Indian Head ended up receiving 295 mm between May 1 and August 31, 121% of the long-term average; however, much of this came in a few major storm events and nearly 100 mm was received late in August, past the point where it could be of much benefit to the crop but could promote regrowth and affect crop dry-down. Relative to the long-term average, Yorkton was the driest of the locations with 148 mm of precipitation received during the 4-month period which was only 54% of average. Again, a large percentage of the precipitation fell in August, too late to be of much benefit to the current crop. Swift Current received a total of 147 mm, 78% of the long-term average, but similar to the other two locations, over a third of this came in August. The drought at Swift Current also contributed to greater than anticipated salinity issues which presented major challenges in terms of site uniformity and subsequent data quality. Generally, the need for crop desiccation is greatest under cool and wet conditions during the period leading up to harvest which can promote green growth late in the season while also slowing or preventing the natural dry-down of plant material.

Table 2. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2021 growing seasons at Indian Head, Swift Current, and Yorkton, Saskatchewan.

Location-Year	May	June	July	August	May-Aug
	------------- Mean Temperature (°C) -------------				
IH – 2021	9.0	17.7	20.3	17.1	16.0 (103%)
IH – Long Term	10.8	15.8	18.2	17.4	15.6
YK – 2021	8.9	19.1	21	17.3	16.5 (109%)
YK – Long Term	10.4	15.5	17.9	17.1	15.2
SW – 2021	9.5	18.3	21.6	17.9	16.8 (106%)
SW – Long Term	11.0	15.7	18.4	17.9	15.8
	------------- Total Precipitation (mm) -------------				
IH – 2021	81.6	62.9	51.2	99.4	295 (121%)
IH – Long Term	51.8	77.4	63.8	51.2	244
YK – 2021	24.6	18.1	35.2	69.7	148 (54%)
YK – Long Term	51.3	80.1	78.2	62.2	272
SW – 2021	30.0	26.8	36.6	53.5	147 (78%)
SW – Long Term	42.1	66.1	44.0	35.4	188

Overall F-test results for each location and response variable are reserved for Table 10 of the Appendices. Significant VAR x TRT interactions were occasionally detected and will be discussed as required; however, individual treatment means are also reserved for the Appendices. Even where interactions were detected, pre-harvest treatment effects were largely consistent across varieties from a practical perspective and, as such, much of the discussion will focus on main effects.

Spring plant density was measured as an indicator of the overall establishment at each location and to document any differences between varieties. At Indian Head, the overall F-test was not significant for variety effects on plant density (P = 0.083; Table 10) and establishment for all varieties was statistically similar (Table 3). Actual densities at Indian Head were somewhat variable and ranged from 230-280 plants/m^2 which was lower than desired given that a minimum of 300 plants/m^2 is considered optimal for flax. At Yorkton, plant densities were higher overall but also quite variable; however, the overall F-test was significant (P = 0.033) with higher populations observed for CDC Sorrel (537 plants/m2) compared to CDC Bethune and Glas (417-418 plants/m^2). The opposite occurred at Swift Current where the overall F-test was highly significant (P < 0.001) but the observed plant densities for Sorrel (154 plants/m^2) were significantly lower than for the other two varieties (229-270 plants/m^2). Similar to Indian Head, albeit to a greater extent, plant populations were considerably less than ideal at Swift Current. This was attributed to drought and salinity while at Indian Head we speculate that the poorer establishment was due to the seed ending up somewhat deeper than targeted. As previously mentioned, a minimum population of 300 plants/m^2 is commonly recommended for flax and, although individual plants can often compensate for lower populations with extra branching, this can lead to delayed maturity and increased field variability relative to more optimal populations.

Table 3. Mean flax plant densities as affected by variety at Indian Head, Yorkton, and Swift Current in 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, *P* ≤ 0.05).

Main Effect	Indian Head	Yorkton	Swift Current
Variety	--------------------------- Plant Density (plants/m^2) ---------------------------		
1) CDC Bethune	280 A	418 B	229 A
2) CDC Glas	230 A	417 B	270 A
3) CDC Sorrel	235 A	537 A	154 B
S.E.M.	16.7	58.3	12.8

The maturity date (when 75% of bolls had turned brown) was recorded in order to document any differences between varieties that might affect optimal pre-harvest application timing and also as a general indicator of environmental conditions at individual trial sites. The target application date for each of the pre-harvest treatments was also when 75% of the bolls had turned brown. Although we did not test for differences between locations, the flax matured earlier at Swift Current (~85 days from seeding) and Yorkton (~90 days) compared to Indian Head (~103 days). The later maturity at Indian Head was attributed to a combination of slow, variable emergence and more favourable moisture conditions. According to the overall F-test tests, maturity was not affected by variety at Indian Head or Yorkton (P = 0.166-0.253) but was at Swift Current (P = 0.009). At Swift Current, CDC Sorrel matured approximately two days later than the other varieties; however, it was likely that this was due in part to the lower plant densities achieved with this variety.

Table 4. Mean flax maturities as affected by variety at Indian Head, Yorkton, and Swift Current in 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, *P* ≤ 0.05).

Main Effect	Indian Head	Yorkton	Swift Current
Variety	------------------------ Maturity (days from seeding) ------------------------		
1) CDC Bethune	103.7 A	90.4 A	84.1 B
2) CDC Glas	103.3 A	90.1 A	83.6 B
3) CDC Sorrel	103.3 A	90.8 A	86.0 A
S.E.M.	0.23	0.28	0.91

At approximately the same time as plots were declared mature, the pre-harvest treatments were applied as per protocol and visual stem dry-down ratings were initiated. The full, detailed results for these measurements can be found in Tables 11-16; however, the main effects of pre-harvest treatment are also presented more concisely and intuitively in Fig. 1 to 3 below. Again, the rating scale is described in detail in Table 8 with a visual depiction provided in Fig. 4 of the Appendices.

At Indian Head, the stems started out quite green and, at the time of the pre-harvest applications, differed between varieties according to both the overall F-test (P < 0.001) and multiple comparisons (Table 11). The greenest stems were observed with CDC Bethune (2.2), followed by CDC Glass (2.4), and then CDC Sorrel (2.9). As time went on and stem dry-down progressed, differences between varieties diminished but the trend persisted to some extent. Although VAR x TRT interactions were detected on Day 4 (P = 0.030) and Day 7 (P = 0.020), the relative performance of the pre-harvest treatments generally appeared to be consistent amongst varieties (Table 12). Differences in stem dry-down between pre-harvest treatments were evident as early as 4 DAA with diquat having a strong effect and, somewhat unexpectedly, even the glyphosate treatments were visually distinguishable from the control (Fig. 1, Table 11). At 7 DAA, all treatments were drying down relative to 4 DAA and treatment rankings were the same, averaging 4.1, 6,7, and 7.9 for the control, glyphosate, and diquat, respectively. One week later at 14 DAA, stems in the untreated control plots had not changed much from the previous rating period (4.3) and the differences between glyphosate (7.7) and diquat (8.1) were less obvious; however, diquat still had slight but significant visual advantage. To aid in understanding the visual differences between plots at Indian Head, Fig. 5 of the Appendices includes photographs of CDC Glas at each rating date for all three of the pre-harvest treatments.

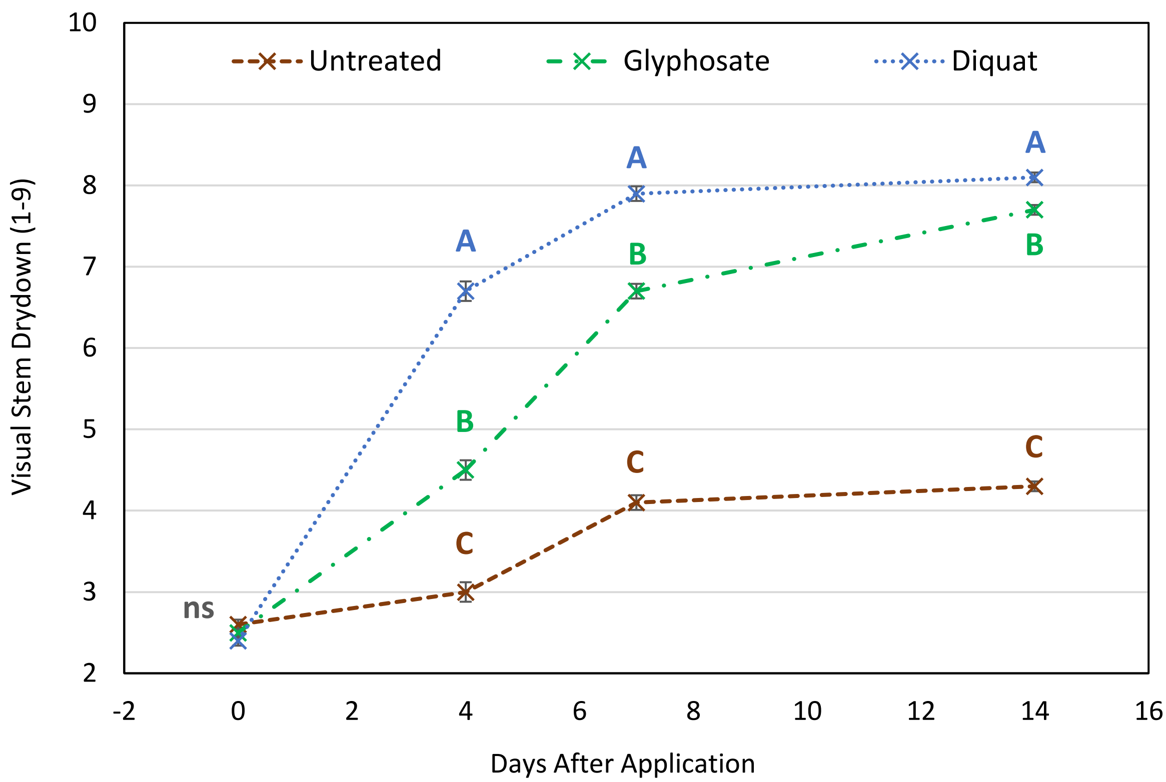

Figure 1. Visual stem dry-down ratings at 0, 4, 7, and 14 days after application (DAA) for various pre-harvest treatments at Indian Head, Saskatchewan (2021). Values within a date denoted by the same letter do not significantly differ and error bars are the standard error of the treatment means.

At Yorkton, the overall dry-down ratings at 0 DAA were higher compared to Indian Head, presumably due to greater drought stress (Table 13; Fig. 2). At the time of the treatment applications, the overall F-test indicated that visible stem dry-down was similar across varieties (P = 0.372) with values ranging from 5.3-5.8. At 7 DAA, the values were still similar across varieties (P = 0.371; 5.9-6.3). At this time, however, pre-harvest treatment effects were emerging, despite the overall F-test not being significant (P = 0.113) and the variation being much less than what was observed at Indian Head. As expected, the least visible dry-down was observed in the control (5.8) and the most occurred with diquat (6.4), while ratings with glyphosate were intermediate (6.0). At 14 DAA, there were, again , no differences in visible stem dry-down between varieties (P = 0.584), but strong pre-harvest treatment effects were detected (P < 0.001). Contrary to the previous assessments, at 14 DAA the greatest visible dry-down was observed with glyphosate (8.5) as opposed to diquat (6.6); however, both were improvements over the control (5.6). The VAR x TRT interaction was marginally significant (P = 0.064) at 14 DAA at Yorkton and this appeared to be due to there being no difference in visible stem dry-down between the control and diquat with CDC Sorrel but significant improvements with diquat for the other two varieties (Table 14). This differential response is difficult to explain and may have been due to other sources of variability.

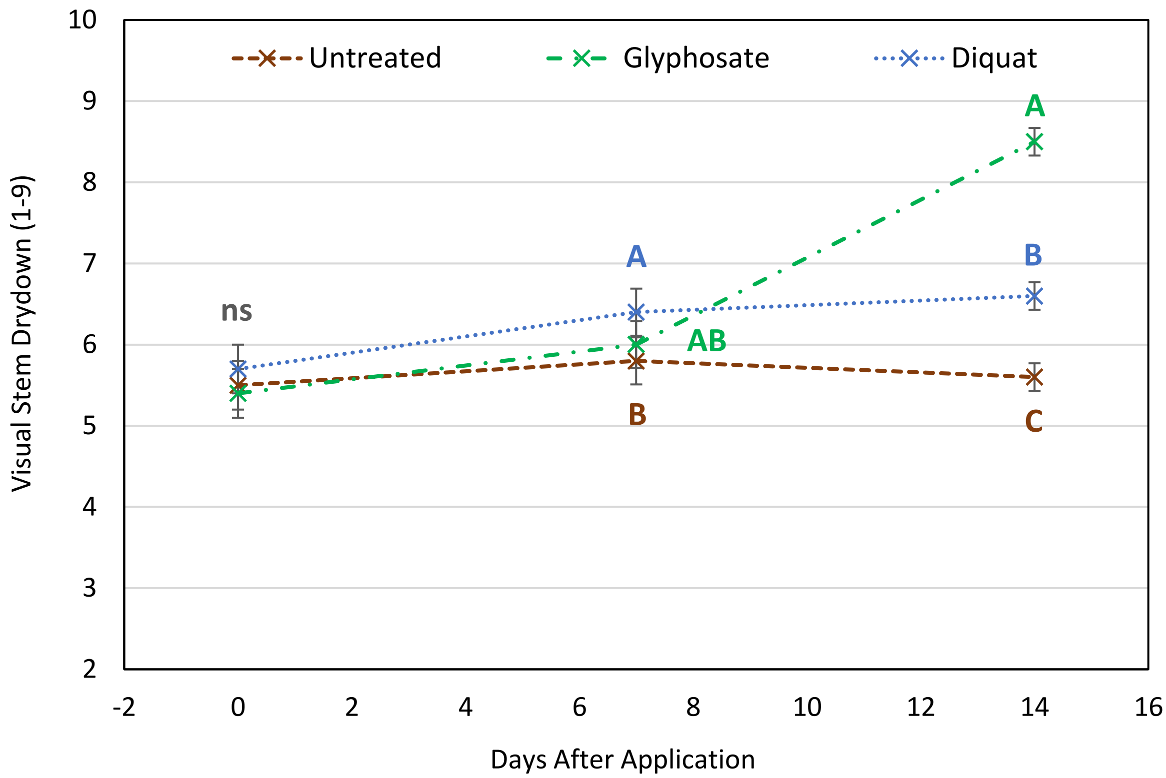

Figure 2. Visual stem dry-down ratings at 0, 7, and 14 days after application (DAA) for various pre-harvest treatments at Yorkton, Saskatchewan (2021). Values within a date denoted by the same letter do not significantly differ and error bars are the standard error of the treatment means.

At Swift Current, the stem dry-down rating values increased with time (Fig. 3; Table 15); however, there were no differences between pre-harvest treatments (Fig. 3) at 0 DAA (P = 0.462), 7 DAA (P = 441), or 14 DAA (P = 0.154). Varietal differences in stem dry-down were significant for all three assessment dates (P < 0.001-0.048) with the greatest dry-down consistently observed with CDC Glas relative to the other two varieties. Interactions (VAR x TRT) for visible stem dry-down at Swift Current were never significant at the desired probability level (P = 0.078-0.197) and inspection of the individual treatment means (Table 16) revealed that these ratings were variable and inconsistent, regardless of the assessment date.

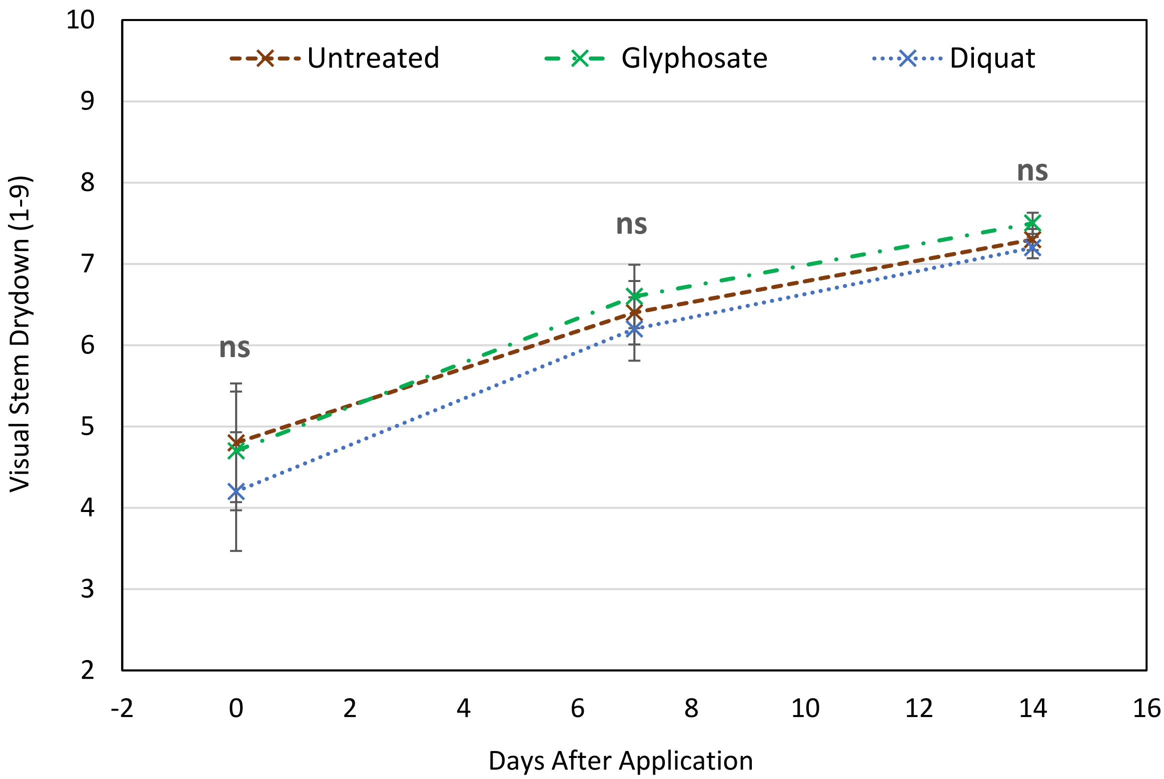

Figure 3. Visual stem dry-down ratings at 0, 7, and 14 days after application (DAA) for various pre-harvest treatments at Swift Current, Saskatchewan (2021). Values within a date denoted by the same letter do not significantly differ and error bars are the standard error of the treatment means.

Main effect means for seed moisture content at harvest time are presented in Table 5 below. At Indian Head, where harvest was completed 21 days after the treatment applications (Table 9), seed moisture content was affected by both variety (*P* = 0.050) and pre-harvest treatment (*P* < 0.001) while the VAR x TRT interaction was also significant (*P* = 0.020; Table 10). On average, seed moisture content was higher in CDC Bethune (11.6%) than CDC Sorrel (10.4%) and intermediate with CDC Glas (10.8%). Focussing on pre-harvest treatments, seed moisture content was extremely high in the untreated control (19.6%) and much lower with both glyphosate (6.2%) and diquat (7.0%) which did not significantly differ from one another according to the multiple comparisons test. Individual treatment means are provided in Table 17 of the Appendices. The significant interaction was due to varietal differences in seed moisture content being detected in the untreated control plots (17-22%) but not where either glyphosate or diquat was applied (6.1-7.4%). The relative rankings of the pre-harvest treatments were identical for all varieties at Indian Head whereby seed moisture content was slightly but not significantly lower with glyphosate than with diquat.

Comparable to Indian Head, harvest at Yorkton was completed 24 days after the pre-harvest treatments were applied. According to the overall F-tests (Table 10), seed moisture content at this location was similar across varieties (*P* = 0.431), averaging 9.3-9.7% (Table 5). The effect of pre-harvest treatments on seed moisture content was highly significant (*P* < 0.001). As expected, the values were highest in the untreated control (10.5%), slightly but significantly lower with diquat (9.4%) and lowest with glyphosate (8.6%). The VAR x TRT interaction for seed moisture content at

Yorkton was marginally significant (*P* = 0.078), seemingly due to diquat having more impact on seed moisture content with CDC Bethune and CDC Glas than with CDC Sorrel (Table 17).

At Swift Current, harvest was completed 15 days after the treatment applications. Seed moisture content was highly variable and, according to the overall F-tests, only affected by variety (*P* = 0.018) with no pre-harvest treatment effects (*P* = 0.437) and no VAR x TRT interaction (*P* = 0.292). Consistent with the maturity assessments and, as previously suggested, likely due in part to the lower plant populations, seed moisture content at this location was higher with CDC Sorrel (10.1%; Table 5) than with CDC Bethune and CDC Glas (8.6-8.7%). Again, seed moisture differences between pre-harvest treatments were not significant and no meaningful trends were observed for this variable at Swift Current.

Table 5. Mean flax seed moisture content at harvest time as affected by variety and pre-harvest treatment at Indian Head, Yorkton, and Swift Current in 2021. Main effect means within a column followed by the same letter do not significantly differ (Tukey-Kramer, *P* ≤ 0.05).

Main Effect	Indian Head	Yorkton	Swift Current
Variety	------------------------------- Seed Moisture (%) -------------------------------		
1) CDC Bethune	11.6 A	9.3 A	8.6 B
2) CDC Glas	10.8 AB	9.7 A	8.7 B
3) CDC Sorrel	10.4 B	9.6 A	10.1 A
S.E.M.	0.44	0.22	0.58[Z]
Pre-Harvest Treatment	------------------------------- Seed Moisture (%) -------------------------------		
1) Untreated Control	19.6 A	10.5 A	8.8 A
2) Glyphosate	6.2 B	8.6 C	9.1 A
3) Diquat	7.0 B	9.4 B	9.5 A
S.E.M.	0.44	0.25	0.53[Z]

[Z]SEM values from Swift Current are averages, actual values varied for individual means due to missing values

We considered straw moisture content to be a good indicator of the overall harvestability of the flax and one of the most important variables for evaluating the efficacy of the pre-harvest applications. At Indian Head, straw moisture was affected by pre-harvest treatment (*P* < 0.001; Table 10) while variety effects were marginally significant (*P* = 0.071) and no VAR x TRT interaction was detected (*P* = 0.135). According to the multiple comparisons (Table 6), straw moisture content was less in CDC Sorrel (22%) than CDC Bethune (25%) and intermediate with CDC Glas (24%). This is consistent with the trends observed in the visual dry-down ratings. Focussing on pre-harvest treatment effects, straw moisture content was extremely high in the untreated control (46.5%) relative to the treated plots (11.5-13.1%). While the values for glyphosate and diquat did not significantly differ when averaged across varieties, the trends were similar to those observed for seed moisture whereby the values trended lower with glyphosate (11.5%) than with diquat (13.1%). With no VAR x TRT interaction, the pre-harvest treatment effects on straw moisture were similar across varieties; however, consistent with the main effects and, to a lesser extent, results for seed moisture content, values in the control treatment were significantly lower for CDC Sorrel (42.5%) than for the other two varieties (48.4-48.5%).

At Yorkton, straw moisture was not affected by variety (*P* = 0.594) but was affected by pre-harvest treatment (*P* < 0.001) and there was no VAR x TRT interaction (*P* = 0.356). Averaged across pre-harvest treatments, straw moisture content ranged from 12.6% for CDC Sorrel to 14.7% with CDC Bethune (Table 6). The straw moisture trends for variety were similar to those observed at Indian Head but, with lower overall values (i.e. drier plants) and higher variability, not statistically significant. Looking at the main effects of pre-harvest treatments, as expected, straw moisture was, by far, the highest in the untreated control plots with an average of 21.7%. Diquat substantially reduced this to 14% and with glyphosate, straw moisture content was further reduced to 6%. Similar to seed moisture content, the lack of a VAR x TRT interaction suggests that pre-harvest treatment effects were reasonably consistent across varieties; however, diquat did appear to have a comparatively small effect on CDC Sorrel compared to the other varieties. Straw moisture in the control was also lower for CDC Sorrel than the other varieties which may have contributed to the weaker response to diquat.

Straw moisture content was extremely variable at Swift Current and, as such, should be interpreted cautiously. The overall F-tests for straw moisture were marginally significant for variety ($P = 0.068$) and the VAR x TRT interaction ($P = 0.077$), but not for pre-harvest treatment ($P = 0.851$). Focussing on the varieties, straw moisture was, by far, the highest with CDC Sorrel (22.5%) compared to CDC Bethune (13%) or CDC Glas (11%). For pre-harvest treatments, the values ranged from 13.9-16.4% with the lowest mean values observed in the control; however, with such high variability, these values were essentially considered equal. The marginally significant interaction appeared to be mostly due to unusually high values with CDC Sorrel treated with glyphosate (Table 18); however, even if this treatment was ignored, variability was still extremely high with no meaningful trends observed for straw moisture content at Swift Current.

Table 6. Mean flax straw moisture content at harvest time as affected by variety and pre-harvest treatment at Indian Head, Yorkton, and Swift Current in 2021. Main effect means within a column followed by the same letter do not significantly differ (Tukey-Kramer, $P \leq 0.05$).

Main Effect	Indian Head	Yorkton	Swift Current
Variety		Straw Moisture (%)	
1) CDC Bethune	24.9 A	14.7 A	13.1 AB
2) CDC Glas	24.2 AB	14.4 A	11.0 B
3) CDC Sorrel	22.0 B	12.6 A	22.5 A
S.E.M.	1.04	1.55	3.92
Pre-Harvest Treatment		Straw Moisture (%)	
1) Untreated Control	46.5 A	21.7 A	13.9 A
2) Glyphosate	11.5 B	6.0 C	16.4 A
3) Diquat	13.1 B	14.0 B	16.3 A
S.E.M.	1.04	1.54	3.92

Yields were not considered particularly important for achieving the objectives of this project but could provide interesting background information on overall crop condition and environmental impacts on both data quality and treatment effects. Yields at all locations were well below average due to the dry weather and other environmental stresses (i.e. heat, salinity/weeds, insects).
At Indian Head, we detected significant overall F-tests for both variety ($P < 0.001$) and pre-harvest treatment ($P = 0.038$) for seed yield but there was no VAR x TRT interaction ($P = 0.996$; Table 10). Averaged across pre-harvest treatments, yields were lower for CDC Sorrel (940 kg/ha) than for CDC Bethune or CDC Glas (1107-1167 kg/ha) which were similar to one another (Table 7). Averaged across varieties, yields were slightly but significantly higher in the untreated control (1139 kg/ha) than with glyphosate or diquat (1036-1038 kg/ha). While this result could conceivably be attributed

to applying the pre-harvest treatments too early, it was largely a function of the unusual environmental conditions which were not necessarily predictable. The treatments were applied as soon as it was dry enough to do so after a wet period that followed extended hot and dry conditions. The combination of suboptimal plant populations, cooler weather, and abundant soil moisture following a period of drought and heat stress resulted in the plants resuming flowering and allowed some of the greener bolls to fill better in the untreated plots. With no killing frost events, this period of resumed flowering and extended boll filling may have contributed to higher yields in the untreated plots. Additionally, considerable seed cracking and peeling was observed in the over-dried treated plots which could have resulted in higher harvest losses and dockage relative to the untreated control plots.

At Yorkton, the overall F-tests indicated that yields were affected by variety (P = 0.039), pre-harvest treatment (P = 0.007), and the VAR x TRT interaction (P = 0.039). The highest yields at this location were achieved with CDC Sorrel (790 kg/ha), followed by CDC Glas (745 kg/ha), then CDC Bethune (701 kg/ha). Focussing on pre-harvest treatments, yields were higher in the control and with glyphosate (761-794 kg/ha) than with diquat (682 kg/ha). The significant interaction, however, was due to these effects being inconsistent whereby the lower yields with diquat were most evident with CDC Sorrel and, to a lesser extent, CDC Bethune, but did not occur with CDC Glas (Table 19).

At Swift Current, yields were extremely low and variable and not affected by variety (P = 0.218), pre-harvest treatment (P = 0.314), nor their interaction (P = 0.523). Individual treatment means ranged from 428-636 kg/ha at Swift Current and, to give a sense of the overall variability, the standard error of these means was 99.8 kg/ha or 20% of the overall average yield.

Table 7. Mean flax seed yield as affected by variety and pre-harvest treatment at Indian Head, Yorkton, and Swift Current in 2021. Main effect means within a column followed by the same letter do not significantly differ (Tukey-Kramer, $P \leq 0.05$).

Main Effect	Indian Head	Yorkton	Swift Current
Variety		Seed Yield (kg/ha)	
1) CDC Bethune	1107 A	701 B	482 A
2) CDC Glas	1167 A	745 AB	470 A
3) CDC Sorrel	940 B	790 A	577 A
S.E.M.	62.6	43.2	75.7
Pre-Harvest Treatment		Seed Yield (kg/ha)	
1) Untreated Control	1139 A	794 A	557 A
2) Glyphosate	1038 B	761 A	515 A
3) Diquat	1036 B	682 B	457 A
S.E.M.	62.6	43.2	75.7

Extension Activities

At Indian Head, this project was highlighted during the IHARF Crop Management Field Day on July 20, 2021. The event was attended by approximately 70 producers, agronomists, and industry representatives and the discussion primarily focussed on challenges in flax harvest and results from a similar demonstration conducted in 2020. In addition to this main tour, the trial was also shown to an assortment of industry representatives and producers during smaller, informal tours throughout the season. At Swift Current, the plots were shown during multiple tours throughout the season and also highlighted during a CKSW radio program entitled 'Walk the Plots' which is broadcast weekly throughout the growing season. This project was also discussed by Michelle Beaith (SFDC) during WCA's annual summer tour on July 15, 2021 which was attended by approximately 80 participants.

At Yorkton, the project was highlighted in video entitled '2021 Virtual Field Tour: Flax Desiccation' which was posted online (https://www.youtube.com/watch?v=5IGBZbYFW58) on July 15, 2021. Technical reports and extension materials will be available online through IHARF and/or Agri-ARM websites and results from this project will be incorporated into oral presentations as appropriate opportunities arise.

11. Conclusions and Recommendations

This project has demonstrated measurable benefits to using pre-harvest applications to enhance flax dry-down with some variation between the products evaluated but even greater differences in response across the environments under which they were tested

Indian Head was the wettest of the locations and actually received above-average precipitation during the 2021 growing season. While much of this precipitation came too late to truly benefit to the flax, it had a considerable effect on crop dry-down. Both glyphosate and diquat were effective in drying down seed and plant material but the specific nature of the responses to the two products differed. Diquat worked very quickly with striking differences noted as early as four days after application; however, under the wet conditions late in the season, a certain amount of re-growth occurred 14-21 days after application. Glyphosate was slower to take effect but still worked extremely well under the conditions encountered. Surprisingly, glyphosate was already having a visible effect at 4 DAA, albeit not nearly to the extent of diquat. By 14 DAA and, even more so at 21 DAA when the plots were harvested, visual differences between glyphosate and diquat had greatly diminished. With essentially no regrowth, glyphosate had actually dried both the seed and straw down to a greater extent than diquat; however, both products were highly effective in this regard. With the wet and cool finish to the season along with the lack of killing frost, the untreated control plots at Indian Head did not dry down well at all and were still green and wet when the crop was harvested 21 days after the treatment applications. This extended period of growth did result in a slight but significant yield advantage in the untreated control plots at Indian Head. It should be acknowledged that the treated plots, especially those treated with diquat, could have likely been harvested considerably earlier than they were at Indian Head.

At Yorkton, both glyphosate and diquat provided benefits in terms of improved seed and straw dry-down, but not to the extent observed at Indian Head. In particular, and attributable to the drier conditions and higher plant populations, the untreated control plots dried down much better at Yorkton than they did at Indian Head. While the visual ratings suggested that diquat may have started working more quickly, the later ratings and actual seed and straw moisture measurements revealed that it did not terminate the crop and dry it down to the extent achieved with glyphosate. It is likely that the weaker response to diquat at Yorkton was a function of both application timing and the environmental conditions after application. The treatments were applied on the morning of a hot, sunny day. Because diquat is activated by the sun, it is recommended to apply this product on cloudy days or in the evening to allow the herbicide to diffuse across plant surfaces prior to activation, thus ensuring more uniform and complete desiccation. It is also ideal to apply diquat when the longer-term weather outlook is for a warming trend and conditions will, in general, be conducive to drying. While the day after the treatment applications was hot (> 30 °C), much of the weather for two week period following the applications was relatively cool and wet. In contrast, at Indian Head, where diquat worked quite well, the treatments were applied late in the evening and at the end of cool, wet period with an extended stretch of warm, dry weather following the applications. Despite the weaker performance of diquat at Yorkton, it did provide significant seed and stem dry-down benefits in the end, just not necessarily as well as expected or to the extent of glyphosate.

Pre-harvest herbicides or crop desiccants are least likely to improve crop dry-down under hot, dry conditions where annual crops will often terminate and shed moisture reasonably well without being sprayed. Swift Current is in the dry Brown soil zone of Saskatchewan and, on average, is the driest of the regions where field trials were located. This was the sole location where we did not specifically measure benefits to the pre-harvest applications; however, high variability also limited our ability to do so. With less than 80% of normal precipitation and well-above normal temperatures, the conditions at Swift Current were not conducive to needing pre-harvest applications to assist with crop dry-down and this likely explains the lack of response to a large extent. The visual ratings confirmed that stem dry-down progressed steadily as the crop matured, regardless of variety or pre-harvest treatment and despite high variability.

In conclusion, this project has shown that whether or not a pre-harvest herbicide or desiccant application is likely to be beneficial will depend on the specific crop and environmental conditions leading up to and following application. Under low yielding, drought conditions with more dry weather in the forecast, the potential for realizing a benefit with respect to crop dry-down or harvestability is low, especially if it early in the fall with plenty of long days and time to complete harvest ahead. In contrast, if the weather is wet, stands are poor or uneven, and harvest will likely be delayed until late September or beyond, pre-harvest glyphosate or diquat can greatly accelerate crop dry-down leading to an earlier and easier harvest. Which of these two products is preferable will depend on several factors. Glyphosate has the advantages of being less expensive, providing excellent perennial weed control, and terminating the crop in a manner that regrowth will not occur even if harvest cannot be completed within a reasonable timeframe and wet conditions persist after the treatment applications. The disadvantage to glyphosate is that it often takes several weeks to thoroughly dry down physiologically mature crops and weeds and may not work consistently well if conditions are not conducive to herbicide uptake. In contrast, diquat, if used properly under favourable conditions, can rapidly dry down crop and weed material often allowing harvest to be completed within less than a week of application. The disadvantages to diquat are that it is generally more expensive, requires high solution volumes, will not provide control of perennial or grassy weeds, and, if wet weather persists after application, regrowth of both crop and weeds can occur while efficacy in general may be poor. If both perennial weed control and rapid crop dry-down are desired, there may be merit to utilizing both of these products with glyphosate applied first and following up with diquat in 5-7 days; however, this particular combination of treatments was not demonstrated. The results of this project built on a previous demonstration (ADOPT #20190425) which followed a similar protocol and is available online (https://iharf.ca/wp-content/uploads/2021/04/Pre-harvest-weed-control-and-desiccation-options-for-flax.pdf).

Supporting Information

12. Acknowledgements:

This project was funded through the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canadian Agricultural Partnership bi-lateral agreement between the federal government and the Saskatchewan Ministry of Agriculture. IHARF and WCA have a strong working relationship and a memorandum of understanding with Agriculture and Agri-Food Canada which helps to make work like possible and should be acknowledged. IHARF, WCA, and ECRF provided the land, equipment, and infrastructure required to complete this project at Indian Head, Swift Current, and Yorkton, respectively. Administration for the project was provided in-kind by SaskFlax and special thanks are also extended to Michelle Beaith (formerly of SaskFlax) who aided in proposal development and summer extension activities. Certain crop protection products were provided in-kind by FMC, Corteva and Bayer CropScience. Finally, this work would not have been possible without the contributions of various professional and technical staff of the collaborating organizations.

13. Appendices:

Table 8. Rating scale provided by the Saskatchewan Flax Development Commission [z] to assess treatment effects on visual stem dry-down at various stages relative to the pre-harvest treatment applications.

Rating #	Description of stem colour
1	Almost all stems grass green
2	50% mixture of grass green and green stems
3	Mostly green stems
4	50% mixture of green and pale green stems
5	Mostly pale green stems
6	50% mixture of pale green and yellow stems
7	Mostly yellow stems
8	50% mixture of yellow and brown stems or mostly light brown stems
9	Almost all stems medium or dark brown (very dry)

[z] The stem dry-down scale was developed by the Viterra/Crop Production Services flax breeding program for the purpose of making nursery selections and identifying later stage breeding material with improved straw dry-down. The same scale was also used to rate entries in the Northern Flax Cooperative trials (2012 to 2014) and has been adopted by the CDC flax breeding program. The rating scale was developed using observations made in the field on the progression of stem colour change during the maturation of flax plants and the variation that is seen at harvest.

Figure 4. Visual depiction of the stem dry-down rating.

Table 9. Selected agronomic information and dates of operations for flax desiccation demonstrations completed at three locations in 2021.

Factor / Field Operation	Indian Head	Swift Current	Yorkton
Previous Crop	Canaryseed	Barley	Wheat
Pre-Emergent Weed Control	894 g glyphosate/ha (Sep 28-2020) 292 ml Authority 480/ha (May-19)	894 g glyphosate/ha (May-3) 75 ml Aim EC/ha (May-3)	none applied
Seeding Date	May-12	May-7	May-17
Fertility (kg N-P_2O_5-K_2O-S/ha)	115-30-15-15	73-37-0-15	56-15-0
Emergence Counts	Jun-18	Jun-7	Jun-7
In-Crop Herbicides	370 ml Centurion/ha (Jun-13) 2 l Curtail M/ha (Jun-19)	470 ml Poast Ultra/ha (May 31) 247 ml Centurion/ha (Jun-16) 1000 ml Buctril M/ha (Jun-17)	2 l Curtail M/ha (Jun-15) 247 ml Centurion/ha (Jun-17)
Foliar Fungicide	395 ml Dyax/ha (Jul-5)	none applied	877 ml Acapela/ha (Jul-12)
Foliar Insecticide	855 ml Malathion 85E/ha (Jul-27)	none applied	none applied
Pre-harvest Application Date (time of day)	Aug-27 (late evening)	Jul-28 (mid-morning)	Aug-15 (early morning)
Stem Dry-down Ratings	Aug-25 (-2DAA), Aug-31 (4DAA), Sep-3 (7 DAA), and Sep-10 (14DAA)	Jul-28 (0DAA), Aug-4 (7DAA), Aug-11 (14DAA)	Aug-15 (0DAA), Aug-23 (7DAA), Aug-30 (14DAA)
Harvest date (Relative Humidity)	Sep-17 (27% RH)	Aug-12 (35% RH)	Sep-8 (47% RH)
Days from pre-harvest application to harvest	21	15	24

Table 10. Overall tests of fixed effects variety (VAR), pre-harvest treatment (Trt), and VAR x Trt for selected response variables at three locations in 2021. P-values ≤ 0.05 indicate that an effect was significant for the corresponding response variable.

Source	Indian Head	Yorkton	Swift Current
	---------- Emergence (p-values) ----------		
Variety (VAR)	0.083	0.033	<0.001
	---------- Days to Maturity (p-values) ----------		
Variety (VAR)	0.253	0.166	0.009
	---------- Visual Stem Dry-down 0 DAA (p-values) ----------		
Variety (VAR)	<0.001	0.372	0.048
Treatment (Trt)	0.248	0.829	0.462
VAR x Trt	0.068	0.170	0.197
	---------- Visual Stem Dry-down 4 DAA (p-values) ----------		
Variety (VAR)	<0.001	–	–
Treatment (Trt)	<0.001	–	–
VAR x Trt	0.030	–	–
	---------- Visual Stem Dry-down 7 DAA (p-values) ----------		
Variety (VAR)	0.010	0.371	0.028
Treatment (Trt)	<0.001	0.113	0.441
VAR x Trt	0.020	0.719	0.107
	---------- Visual Stem Dry-down 14 DAA (p-values) ----------		
Variety (VAR)	0.317	0.584	<0.001
Treatment (Trt)	<0.001	<0.001	0.154
VAR x Trt	0.164	0.064	0.078
	---------- Seed Moisture Content (p-values) ----------		
Variety (VAR)	0.050	0.431	0.018
Treatment (Trt)	<0.001	<0.001	0.437
VAR x Trt	0.003	0.078	0.292
	---------- Straw Moisture Content (p-values) ----------		
Variety (VAR)	0.071	0.594	0.068
Treatment (Trt)	<0.001	<0.001	0.851
VAR x Trt	0.135	0.356	0.077
	---------- Seed Yield (p-values) ----------		
Variety (VAR)	<0.001	0.039	0.218
Treatment (Trt)	0.038	0.007	0.314
VAR x Trt	0.996	0.039	0.523

Table 11. Main effect (variety and pre-harvest treatment) means for flax visual stem dry-down ratings at Indian Head in 2021. Main effect means within a column followed by the same letter do not significantly differ (Tukey-Kramer, P ≤ 0.05).

Main Effect	0 DAA	4 DAA	7 DAA	14 DAA
Variety	----------------------------	Visual Stem	Dry-down (1-9)	----------------------------
1) CDC Bethune	2.2 C	4.6 B	6.1 B	6.6 A
2) CDC Glas	2.4 B	4.6 B	6.3 AB	6.7 A
3) CDC Sorrel	2.9A	5.1 A	6.5 A	6.8 A
S.E.M.	0.06	0.12	0.09	0.06
Pre-Harvest Treatment				
1) Untreated Control	2.6 A	3.0 C	4.1 C	4.3 C
2) Glyphosate	2.5 A	4.5 B	6.7 B	7.7 B
4) Diquat	2.4 A	6.7 A	7.9 A	8.1 A
S.E.M.	0.06	0.12	0.09	0.06

Table 12. Individual treatment (variety by pre-harvest treatment) means for flax visual stem dry-down ratings at Indian Head in 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, P ≤ 0.05).

Variety – Treatment	0 DAA	4 DAA	7 DAA	14 DAA
	----------------------------	Visual Stem	Dry-down (1-9)	----------------------------
1) Bethune – untreated	2.1 c	2.7 e	3.7 d	4.1 e
2) Bethune – glyphosate	2.2 c	4.3 c	6.5 b	7.6 c
3) Bethune – diquat	2.1 c	6.8 a	8.0 a	8.2 a
4) Glas – untreated	2.6 b	2.9 e	4.1 d	4.2 de
5) Glas – glyphosate	2.2 c	4.2 c	6.7 b	7.7 c
6) Glas – diquat	2.3 c	6.7 a	8.0 a	8.2 a
7) Sorrel – untreated	2.9 a	3.3 d	4.6 c	4.5 d
8) Sorrel – glyphosate	3.0 a	5.1 b	6.9 b	7.8 c
9) Sorrel – diquat	2.8 a	6.8 a	7.8 a	8.0 a
S.E.M.	0.09	0.17	0.15	0.11

Table 13. Main effect (variety and pre-harvest treatment) means for flax visual stem dry-down ratings at Yorkton in 2021. Main effect means within a column followed by the same letter do not significantly differ (Tukey-Kramer, P ≤ 0.05).

Main Effect	0 DAA	4 DAA	7 DAA	14 DAA
Variety	----------------------------	Visual Stem Dry-down (1-9)	----------------------------	
1) CDC Bethune	5.5 A	–	5.9 A	7.0 A
2) CDC Glas	5.8 A	–	6.3 A	6.8 A
3) CDC Sorrel	5.3 A	–	6.0 A	6.9 A
S.E.M.	0.30	–	0.21	0.17
Pre-Harvest Treatment				
1) Untreated Control	5.5 A	–	5.8 B	5.6 C
2) Glyphosate	5.4 A	–	6.0 AB	8.5 A
4) Diquat	5.7 A	–	6.4 A	6.6 B
S.E.M.	0.30	–	0.29	0.17

Table 14. Individual treatment (variety by pre-harvest treatment) means for flax visual stem dry-down ratings at Yorkton in 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, P ≤ 0.05).

Variety – Treatment	0 DAA	4 DAA	7 DAA	14 DAA
	----------------------------	Visual Stem Dry-down (1-9)	----------------------------	
1) Bethune – untreated	5.4 ab	–	5.6 b	5.4 d
2) Bethune – glyphosate	5.1 ab	–	5.8 ab	8.6 a
3) Bethune – diquat	6.1 a	–	6.4 ab	7.0 b
4) Glas – untreated	5.6 ab	–	5.8 ab	5.4 d
5) Glas – glyphosate	5.5 ab	–	6.4 ab	8.1 a
6) Glas – diquat	6.4 a	–	6.8 a	6.8 bc
7) Sorrel – untreated	5.6 ab	–	5.9 ab	6.0 cd
8) Sorrel – glyphosate	5.6 ab	–	6.0 ab	8.6 a
9) Sorrel – diquat	4.5 b	–	6.0 ab	6.0 cd
S.E.M.	0.51	–	0.35	0.29

Table 15. Main effect (variety and pre-harvest treatment) means for flax visual stem dry-down ratings at Swift Current in 2021. Main effect means within a column followed by the same letter do not significantly differ (Tukey-Kramer, P ≤ 0.05).

Main Effect	0 DAA	4 DAA	7 DAA	14 DAA
Variety	---------------------------- Visual Stem Dry-down (1-9) ----------------------------			
1) CDC Bethune	4.7 AB	–	6.3 AB	7.2 B
2) CDC Glas	5.2 A	–	6.9 A	7.7 A
3) CDC Sorrel	3.8 B	–	5.9 B	7.1 B
S.E.M.	0.73	–	0.39	0.13
Pre-Harvest Treatment				
1) Untreated Control	4.8 A	–	6.4 A	7.3 A
2) Glyphosate	4.7 A	–	6.6 A	7.5 A
4) Diquat	4.2 A	–	6.2 A	7.2 A
S.E.M.	0.73	–	0.39	0.13

Table 16. Individual treatment (variety by pre-harvest treatment) means for flax visual stem dry-down ratings at Swift Current in 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, P ≤ 0.05).

Variety – Treatment	0 DAA	4 DAA	7 DAA	14 DAA
	---------------------------- Visual Stem Dry-down (1-9) ----------------------------			
1) Bethune – untreated	4.3 abc	–	5.6 cd	7.0 d
2) Bethune – glyphosate	4.8 abc	–	6.5 abcd	7.6 abc
3) Bethune – diquat	5.1 abc	–	6.8 abc	7.1 cd
4) Glas – untreated	6.1 a	–	7.4 a	7.8 ab
5) Glas – glyphosate	5.7 ab	–	7.0 ab	7.9 a
6) Glas – diquat	3.8 bc	–	6.3 abcd	7.3 bcd
7) Sorrel – untreated	4.2 bc	–	6.1 bcd	7.1 cd
8) Sorrel – glyphosate	3.6 c	–	6.3 abcd	6.9 d
9) Sorrel – diquat	3.7 c	–	5.4 d	7.2 cd
S.E.M.	0.90	–	0.52	0.19

Table 17. Individual treatment (variety by pre-harvest treatment) means for flax seed moisture (at time of harvest) at Indian Head, Scott, and Swift Current in 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, *P* ≤ 0.05).

Variety – Treatment	Indian Head	Yorkton	Swift Current[Z]
	Seed Moisture (%)		
1) Bethune – untreated	21.6 a	10.4 ab	8.1 ab
2) Bethune – glyphosate	6.1 d	8.6 e	9.5 ab
3) Bethune – diquat	7.0 d	9.1 de	8.2 ab
4) Glas – untreated	19.6 b	11.1 a	8.2 a
5) Glas – glyphosate	6.2 d	8.6 e	8.1 ab
6) Glas – diquat	6.6 d	9.2 cde	9.7 ab
7) Sorrel – untreated	17.4 c	10.0 bc	10.1 a
8) Sorrel – glyphosate	6.3 d	8.8 e	9.7 ab
9) Sorrel – diquat	7.4 d	9.9 bcd	10.5 ab
S.E.M.	0.65	0.33	0.78[Y]

[Z] Letter groupings for Swift Current do not include all significant differences. The following pairs also significantly differed: 3 vs. 7, 2 vs. 7, 1 vs 7

[Y] The SEM value from Swift Current is an average, actual values varied for individual means due to missing values

Table 18. Individual treatment (variety by pre-harvest treatment) means for flax straw moisture (at time of harvest) at Indian Head, Yorkton, and Swift Current in 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, *P* ≤ 0.05).

Variety – Treatment	Indian Head	Yorkton	Swift Current
	Straw Moisture (%)		
1) Bethune – untreated	48.5 a	25.1 a	17.6 ab
2) Bethune – glyphosate	12.4 c	6.0 de	8.3 b
3) Bethune – diquat	13.8 c	13.0 cde	13.3 b
4) Glas – untreated	48.4 a	23.3 ab	9.4 b
5) Glas – glyphosate	12.7 c	6.3 de	5.5 b
6) Glas – diquat	11.6 c	13.7 cd	18.1 ab
7) Sorrel – untreated	42.5 b	16.8 bc	14.6 b
8) Sorrel – glyphosate	9.5 c	5.7 e	35.3 a
9) Sorrel – diquat	13.9 c	15.3 c	17.6 ab
S.E.M.	1.63	2.68	6.36

Table 19. Individual treatment (variety by pre-harvest treatment) means for flax seed yield at Indian Head, Yorkton, and Swift Current in 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, *P* ≤ 0.05).

Variety – Treatment	Indian Head	Yorkton	Swift Current
	Seed Yield (kg/ha)		
1) Bethune – untreated	1163 ab	794 ab	498 ab
2) Bethune – glyphosate	1083 ab	687 bc	428 ab
3) Bethune – diquat	1074 b	629 c	519 ab
4) Glas – untreated	1235 a	777 ab	538 ab
5) Glas – glyphosate	1133 ab	789 ab	482 ab
6) Glas – diquat	1135 ab	804 a	391 b
7) Sorrel – untreated	1021 bc	809 a	636 a
8) Sorrel – glyphosate	899 c	805 a	636 a
9) Sorrel – diquat	898 c	620 c	460 ab
S.E.M.	76.1	54.2	99.8

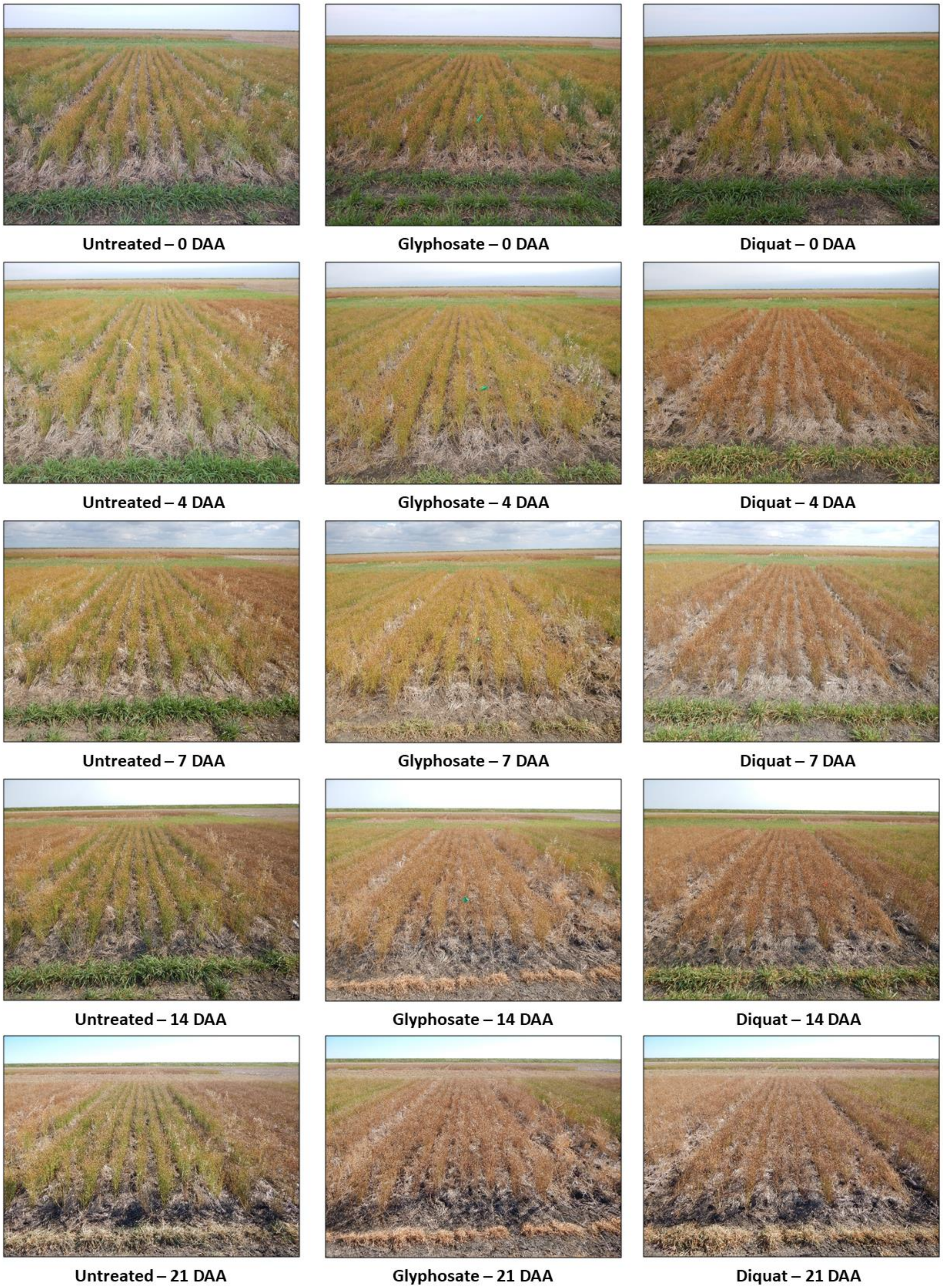

Figure 5. Change in appearance of CDC Glas (Indian Head 2021) after treatment with glyphosate and diquat.

Abstract

14. Abstract/Summary

Harvestability is a challenge for flax growers and, combined with residue management issues, an important reason that many express resistance to this crop. A project was initiated to address this issue with trials at Indian Head and Yorkton (Black soil zone) and Swift Current (Brown soil zone). The objective was to evaluate pre-harvest herbicide/desiccant options for their ability to accelerate crop dry-down, potentially allowing for an earlier, easier harvest, and fewer residue management issues. The treatments were a combination of three varieties (CDC Bethune, CDC Glas, and CDC Sorrel) and three pre-harvest options including an untreated control, glyphosate, and diquat. Treatments were applied when 75% of the bolls had turned brown and the variables of greatest importance were visible stem dry-down along with actual seed and stem moisture at harvest. At Swift Current, the season was dry and the site was variable with salinity exacerbating the drought effects. While variability made detecting treatment effects difficult, these conditions and that the flax reached maturity in July meant there was little need for pre-harvest applications to accelerate crop dry-down. It was also extremely hot and dry at Yorkton. Despite the drought, benefits to both diquat and glyphosate were observed; however, the diquat did not work as well as glyphosate nor as well as it did at Indian Head. We attributed this to application timing and the weather following the treatment applications. At Indian Head, it was also hot and dry, but to a lesser extent than the other locations and late-season soil moisture was actually quite abundant. Under these conditions, the untreated plots stayed green and both glyphosate and diquat worked well. Based on the visible dry-down ratings, diquat took effect in the least amount of time with striking differences already observed four days after application. The plots were combined 21 days after the pre-harvest treatment applications and dramatic, but similar, reductions in seed and straw moisture occurred with both of the products evaluated. In conclusion, this project demonstrated that both glyphosate and diquat can improve flax harvestability; however, which product is preferable and whether harvest aids are needed at all will vary with both environment and producer expectations.