Agriculture Demonstration of Practices and Technologies (ADOPT)

Project Final Report

The final project report should be made available electronically (MS Word). Additional data tables and or graphs may be submitted in spreadsheet format. Due to formatting, printing and distribution requirements, final reports will not be accepted as PDF documents. Completed reports must be returned by email to Evaluation.Coordinator@gov.sk.ca.

Project Title: Demonstrating the efficacy of new foliar fungicides in flax

Project Number: 20230442

Producer Group Sponsoring the Project: Saskatchewan Oilseeds Development Commission

Project Location(s): *Provide the name or number of the rural municipality, nearest town or legal land location if possible. Provide the name of any cooperating landowner(s).* NARF (Melfort), IHARF (Indian Head)

Project start date *(month & year):* 5/1/2024

Project end date *(month & year):* 2/15/2025

Project Manager Contact

Full Name: Kade Kettenbach

Organization: Saskatchewan Oilseeds Development Commission

Mailing Address: 225-415 Wellman Crescent, Saskatoon, SK S7T 0J1

Phone Number: (306) 975-6621

E-mail: Kkettenbach@saskoilseeds.com

Abstract *(maximum 200 words)*

In this project, applications of five fungicides registered for flax (Headline EC, Proline 480 SC, Acapela, Dyax, and Veltyma) were compared to an untreated/unsprayed control to evaluate their efficacy and effect on disease control, days to maturity, yield, lodging, and test weight of harvested flaxseed. Small-plot, randomized trials were conducted at IHARF (Indian Head, SK) and NARF (Melfort, SK) in 2024. CDC Glas was grown at each location and disease ratings were done pre- and post-fungicide product applications. The trials were established successfully at both sites, but hot and dry weather in July resulted in lack of disease and hastened crop maturity. Consequently, there was no response of fungicide applications or products on disease severity or control. A significant difference between days to maturity was seen at Melfort, where the application of Headline EC delayed flax maturity by 2 days compared to the unsprayed control and the application of Proline 480 SC. However, yield and test weight of harvested flaxseed were not affected by treatments of fungicides at either site. Results suggest that fungicide choice is irrelevant in a year when weather conditions are not conducive to disease development.

Sustainable Canadian Agricultural Partnership

Saskatchewan

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Extension: The project was highlighted at the NARF & AAFC Joint Annual Field day on July 18th, 2024 with 97 attendees. At IHARF, this trial was toured by the University of Saskatchewan International Farm Management Conference on July 2nd, 2024 with 28 attendees.

Project Objectives

The objective of this project was to demonstrate and evaluate the efficacy of newer fungicides registered in flax with varying, and, in some cases, multiple modes of action compared to older options. Fungicides included in this project were Headline EC (older fungicide), Proline 480 SC (older fungicide), Acapela (newer), Dyax (newer), and Veltyma (newer fungicide).

Project Rationale

Flax is susceptible to fungal diseases such as sclerotinia stem rot and pasmo especially when conditions are wet (1). Studies done by IHARF at Indian Head have shown that pasmo infections, if left untreated until harvest, can cause yield losses of 5 to 7 bushels per acre (1). Sclerotinia, on the other hand, is a minor disease in flax that causes stem mould, shredding, and breakage when flax is heavily lodged (2).

There are fungicide options available for flax that control pasmo and sclerotinia, and the 2023 Guide to Crop Protection lists a total of 10 fungicide products registered for flax (3). These products contain one or a combination of the following active ingredients – pyraclostrobin or picoxystrobin (Fungicide Group 11, strobilurin – inhibit fungal mitochondrial respiration), prothioconazole (Fungicide Group 3, triazolinthione – inhibit fungal cell membrane formation), and fluxapyroxad (Fungicide Group 7, carboxamide – inhibit energy production in fungal cells) (4, 5). Extensive work has been done on pyraclostrobin and fluxapyroxad in Saskatchewan. A study published in 2021 by researchers at the University of Saskatchewan on pyraclostrobin, fluxapyroxad, and their combination showed significant improvement in disease severity as well as yield compared to untreated control (6). The study showed that single applications of pyraclostrobin and fluxapyroxad reduced disease by 22% and 47% respectively, and a combination of pyraclostrobin and fluxapyroxad reduced disease by 52% (6). A yield increase of 37% compared to the untreated control was also observed from the combined application of pyraclostrobin and fluxapyroxad (6). Demonstration trials done at Indian Head by IHARF have shown similar results where fungicides Headline EC (active ingredient – pyraclostrobin) and Priaxor (pyraclostrobin and fluxapyroxad) significantly reduced disease incidence compared to the untreated control (7).

Since the completion of above-mentioned studies, several new fungicide products have been registered for flax, including Acapela, Dyax, and Veltyma. Information on these products and their active ingredients is provided in Table 1. Currently there is a lack of trials demonstrating the efficacy, or lack thereof, of these new fungicides in Saskatchewan.

Table 1. Fungicides with unique formulations registered for use in Canada according to SK Crop Protection Guide, 2023.

Fungicide	**Manufacturer**	**Disease(s) controlled**	**Active ingredient(s)**	**Year of registration for use in flax**
Headline EC	BASF	Pasmo	Pyraclostrobin (Group 11) at 250 g/L	2009
Proline 480 SC	Bayer	Sclerotinia	Prothioconazole (Group 3) at 480 g/L	2009
Acapela	Corteva	Pasmo	Picoxystrobin (Group 11) at 250 g/L	2018
Dyax	BASF	Pasmo, Sclerotinia	Fluxapyroxad (Group 7) at 250 g/L, and	2021
			Pyraclostrobin (Group 11) at 250 g/L	
Veltyma	BASF	Pasmo	Pyraclostrobin (Group 11) at 200 g/L and	2022
			Mefentrifluconazole (Group 3) at 200 g/L	

Since the majority of prior fungicide work has been done in Headline, which was registered in 2009, it is in

Saskatchewan flax producers' interest to test newer available fungicide options under natural disease pressure in Saskatchewan. This is also relevant in view of concerns of fungicidal insensitivity, or fungal diseases developing resistance to the mode of action of Headline which only consists of pyraclostrobin (Group 11). Moreover, this project could be an effective way to demonstrate new fungicide options to producers who might not be aware of them.

(1) https://www.grainews.ca/features/control-the-pasmo-in-your-flax/
(2) https://www.saskflax.com/growing/diseasecontrol.php
(3) Saskatchewan Ministry of Agriculture (2023). *2023 Guide to Crop Protection.* https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/crop-guides-and-publications/guide-to-crop-protection
(4) Parker JE, Warrilow AG, Cools HJ, Fraaije BA, Lucas JA, Rigdova K, Griffiths WJ, Kelly DE, Kelly SL. Prothioconazole and prothioconazole-desthio activities against Candida albicans sterol 14-α-demethylase. Appl Environ Microbiol. 2013 Mar;79(5):1639-45. doi: 10.1128/AEM.03246-12. Epub 2012 Dec 28. PMID: 23275516; PMCID: PMC3591943.
(5) https://extension.psu.edu/sdhi-fungicides-for-turfgrass-diseases
(6) Islam T, Vera C, Slaski J, Mohr R, Rashid KY, Booker H, Kutcher HR. Fungicide Management of Pasmo Disease of Flax and Sensitivity of Septoria linicola to Pyraclostrobin and Fluxapyroxad. Plant Dis. 2021 Jun;105(6):1677- 1684. doi: 10.1094/PDIS-06-20-1175-RE. Epub 2021 May 5. PMID: 33206013.
(7) https://iharf.ca/wp-content/uploads/2019/05/Seed-treatment-and-foliar-fungicide-options-for-flax.pdf

Methodology

The project consisted of one small-plot trial set up at two Agri-ARM sites - Indian Head Agriculture Research Foundation (IHARF), Indian Head, SK (located in the thin Black soil zone, long-season), and Northeast Agriculture Research Foundation (NARF), Melfort Research Farm, Melfort, SK (located in the moist Black soil zone, short-season). At each site, the trial was set up as Randomized Complete Block Design with 6 treatments and 4 replicates (Table 2).

Table 2. List of treatments for the trial.

Treatment #	Treatment description
1	Untreated control - Unsprayed
2	Headline EC - applied at 161 ml/ac
3	Proline 480 SC - applied at 150 ml/ac with non-ionic surfactant, e.g. AgSurf or Agral 90 at 0.125% v/v
4	Acapela - applied at 355 ml/ac
5	Dyax - applied at 160 ml/ac
6	Veltyma - applied at 202 ml/ac

CDC Glas was seeded at both Indian Head and Melfort at target plant density of 400 plants/m^2 after adjusting for germination and assuming 40% mortality. At Melfort, plots were seeded using a Fabro seeder with 6 rows and 12-inch row spacing and seeds were placed at 0.5" depth. Plots were 1.8 m wide x 7 m long. At Indian Head, plots were seeded with a SeedMaster plot seeder and seed was placed at ¾" depth. Each plot had 8 rows with 30 cm row spacing and was 35 ft long. Soil tests at both sites were conducted in late October 2023 to determine residual soil nutrient levels, and the trial at each site was fertilized so that all nutrients were non-limiting. Results from the soil test are included in Appendix Table A1. Once seeded, best management practices were undertaken at each site to keep the trial free of weeds and insect pests. Fungicides were sprayed at proper timing according to their label, at 20%-50% flowering or approximately 7 days after the first flowers were observed. Minimum water volume of 40 L/ac was used. Detailed dates of operations for both sites are included in Appendix Table A2.

Data were collected on emergence, disease severity, days to maturity, lodging, yield, and test weight of harvested seed. Plant emergence was calculated by counting plants in two 1m rows per plot and converting measurements to plants per square metre. Disease ratings were done pre- and post-fungicide application on a scale of 0-11 using Horsfall-Barratt scale (https://plant-breeding-genomics.extension.org/horsfall-barratt-scale-quantitative-evaluation-of-disease/). Each individual rating was then converted to its respective grade formula % or estimated mean percentage using the Elanco conversion table to perform statistical analysis (Chart provided in Appendix Table A3). At Melfort, 10 plants per plot were rated pre-fungicide application and at Indian Head, 15 plants/plot were rated pre-fungicide application. Post-fungicide application, 25 plants/plot were rated for disease. At both timings, plants were picked randomly encompassing the entire plot area. Lodging ratings were done on a scale of 1 (upright) to 5 (flat) at each site. Yield was corrected for dockage and adjusted to a uniform moisture content of 10% at both sites.

Data were analysed with Statistix 10.0 software as Randomized Complete Block Design using treatment as the main factor and replication as the blocking factor. Data from each site were analysed separately. Analysis of variance (ANOVA) was performed and significant differences between treatment means were determined after Tukey's test using alpha = 0.05.

Results

Environmental conditions

Weather data from Indian Head and Melfort sites is shown in Table 3. Both sites were cooler in May and June compared to the long-term average. Melfort received higher than average precipitation in May and June while July and August were hotter and drier. Indian Head was drier than average in June and July but received more precipitation than the long-term average in August. Averaged between May and August, the growing season was 0.2°C cooler at Indian Head and 3.7 mm wetter, while Melfort was 3.4 mm drier but the mean temperature was the same in 2024 as the long-term average.

Table 3. Mean monthly temperature and total rainfall at Indian Head and Melfort in the 2024 growing season.

		Year	May	June	July	August	Avg/Total
IHARF (Indian Head)	**Temperature (°C)**	**2024**	10.6	13.6	19.5	17.9	15.4
		Long term	10.8	15.8	18.2	17.4	15.6
	Precipitation (mm)	**2024**	63.7	74.9	37.4	71.8	247.8
		Long term	51.7	77.4	63.8	51.2	244.1
NARF (Melfort)	**Temperature (°C)**	**2024**	10.1	13.2	19.4	17.4	15.0
		Long term	10.1	15.2	17.8	16.7	15.0
	Precipitation (mm)	**2024**	73.0	84.0	36.1	31.9	225.0
		Long term	33.4	79.5	69.6	45.9	228.4

Treatment means and results after conducting ANOVA are shown in Tables 4 and 5 for Indian Head and Melfort, respectively.

Table 4. Treatment means and results from ANOVA for IHARF (Indian Head). Pairwise comparisons between means were conducted using Tukey's HSD test with alpha = 0.05. Means followed by the same letter within a column do not significantly differ.

Treatment	Emergence (plants/m^2)	Disease grading (%)		Lodging (1-5) (1=upright, 5=flat)	Yield (kg/ha)	Test weight (g/0.5L)
		Pre-fungicide	Post-fungicide			
Untreated (UTC)	420 A	5.23 A	5.34 A	1 A	1502 A	337 A
Headline EC	482 A	5.07 A	4.96 A	1 A	1521 A	337 A
Proline 480 SC	442 A	5.15 A	4.91 A	1 A	1569 A	337 A
Acapela	434 A	5.07 A	5.01 A	1 A	1527 A	338 A
Dyax	501 A	4.99 A	4.91 A	1 A	1512 A	339 A
Veltyma	461 A	5.15 A	5.06 A	1 A	1518 A	338 A
p-value	0.13	0.95	0.06	1.00	0.86	0.25
Grand Mean	457	5.11	5.03	1	1525	338
Standard error	30	0.25	0.14	0.1	54	0.8
CV	9.30	6.85	3.83	22.22	4.98	0.32

Table 5. Treatment means and results from ANOVA for NARF (Melfort). Pairwise comparisons between means were conducted using Tukey's HSD test with alpha = 0.05. Means followed by the same letter within a column do not significantly differ.

Treatment	Emergence (plants/m^2)	Disease grading (%)		Days to maturity	Yield (kg/ha)	Test weight (g/0.5L)
		Pre-fungicide	Post-fungicide			
Untreated (UTC)	235 A	19.41 A	14.83 A	99.8 B	2577 A	355 A
Headline EC	244 A	21.72 A	15.07 A	101.8 A	2565 A	356 A
Proline 480 SC	249 A	18.38 A	16.62 A	99.5 B	2642 A	355 A
Acapela	284 A	28.24 A	14.62 A	100.0 AB	2519 A	355 A
Dyax	272 A	31.01 A	15.95 A	100.3 AB	2587 A	354 A
Veltyma	274 A	25.57 A	18.15 A	100.3 AB	2654 A	355 A
p-value	0.50	0.32	0.83	0.02	0.67	0.40
Grand Mean	260	24.05	15.87	100	2591	355
Standard error	29	6.27	2.97	0.56	89	1
CV	15.89	36.86	26.50	0.79	4.84	0.35

Plant emergence

Plant emergence was higher at Indian Head (average of 457 plants/m^2) compared to Melfort (average of 260 plants/m^2). Plant emergence was even across all treatments and did not vary significantly between any of the treatments at either site (p-value of 0.13 at Indian Head and 0.5 at Melfort).

Disease

Weather conditions in 2024 were not conducive to severe disease development at either site, and disease gradings were low pre- and post-fungicide application at both sites (average of 5.11% and 5.03% pre- and post-fungicide application, respectively, at Indian Head; and average of 24.05% and 15.87% pre- and post-fungicide application, respectively, at Melfort).

Due to hot and dry July at both sites, it was difficult to distinguish between disease symptoms and senescence in lower leaves of plants (Figure 1). Symptoms of pasmo such as alternating bands of brown and green on stems were absent in plants but browning of lower leaves was seen at both sites (Figure 1A). Bleaching and chlorosis were seen in some plants at Melfort too (Figure 1B) but it was unclear if this was due to another disease or biotic factor, or due to abiotic causes such as chemical injury or water stress. At Melfort, these symptoms, although not characteristic of pasmo or sclerotinia, were considered and included when rating for disease both pre- and post-fungicide application. Regardless, none of the treatments resulted in significant differences in disease grading both pre- or post-fungicide application at either site.

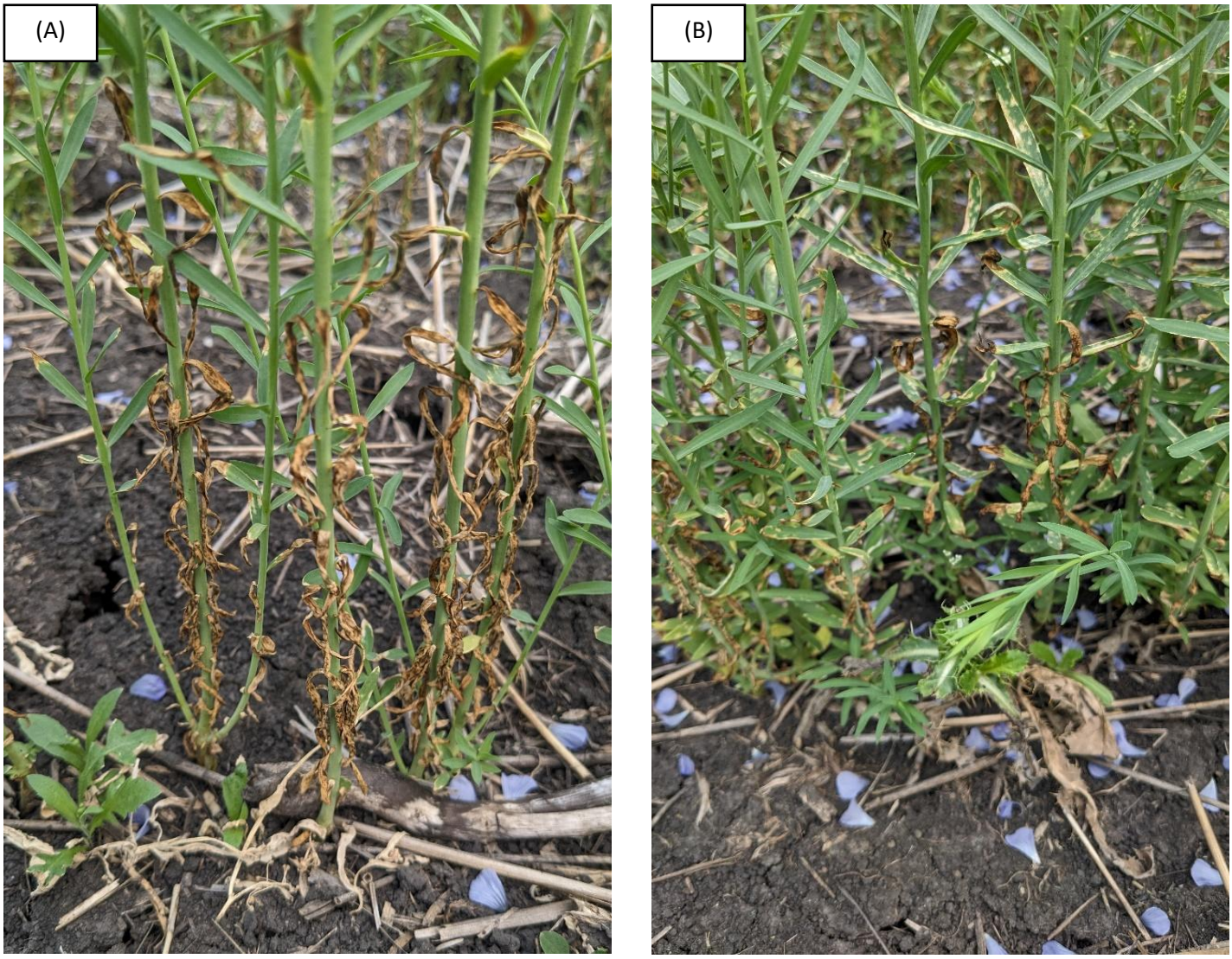

Figure 1. (A) Browning of lower leaves, and (B) bleaching and chlorosis of leaves observed while doing disease ratings at Melfort pre- and post-fungicide application.

Days to maturity

At Indian Head, all plots matured at 91 days after seeding so there was no difference in days to maturity between treatments at Indian Head. At Melfort, treating with Headline EC led to plants maturing approximately 2 days later than the untreated control and Proline 480 SC. Other treatments showed no significant difference among each other or compared to the untreated control, Headline EC, or Proline 480 SC with respect to days to maturity at Melfort.

Lodging, yield, and harvested seed quality

Yield at Melfort averaged 2591 kg/ha and was higher than Indian Head (average of 1525 kg/ha). Test weight of harvested seed at Melfort was also higher than that of Indian Head (average of 355 g/0.5L in Melfort vs. average of 338 g/0.5L in Indian Head). There was no statistically significant difference in yield and test weight between any of the treatments. Minimum to no lodging was observed in flax at Indian Head, and at Melfort there was no lodging in any plot of the trial. As a result, there was no significant difference in lodging between treatments at either site.

Extension

This trial was toured at the Joint NARF and AAFC Field Day at the Melfort Research Farm on July 18th, 2024. There were approximately 100 agrologists and producers in attendance and the trial instigated conversation around fungicide resistance, flax management, and upcoming new flax varieties.

At IHARF (Indian Head), this trial was toured by attendees from a University of Saskatchewan International Farm Management Conference on July 2nd, 2024. There were 28 attendees in total, comprised of farmers and farm managers from Canada, US, South America, Europe, and Australia.

Conclusions and Recommendations

The demonstration was conducted successfully at both Melfort and Indian Head locations in 2024 with successful establishment of flax plots, proper timing of fungicide applications, and timely collection of data throughout the field season. However, due to low disease pressure and hot and dry weather conditions in July during flowering, results were not statistically significant between the treatments of unsprayed control and 5 fungicide products for disease, yield, and harvested seed quality of flax. Only days to maturity at Melfort was affected by treatment, and the application of Headline EC delayed maturity by 2 days compared to the unsprayed control and the application of Proline 480 SC. These results suggest that during a hot and dry growing season when no disease is observed, fungicide choice might not lead to significant differences in yield or test weight of harvested flaxseed compared to the unsprayed control.

Recommendation - To perform a proper comparison of new vs. old fungicide products registered for use in flax, and in the interest of getting this information out to producers, it will be worthwhile to conduct this project when there is high disease pressure and weather conditions are favourable for disease development.

Sustainable Canadian Agricultural Partnership (Sustainable CAP) Performance Indicators

a) List of performance indicators

Sustainable CAP Indicator	Total Number
Scientific publications from this project (List the publications under section b)	
• Published	0
• Accepted for publication	0
Highly Qualified Personnel (HQPs) trained during this project	
• Master's students	0
• PhD students	0
• Post docs	0

Knowledge transfer products developed based on this project (presentations, brochures, factsheets, flyers, guides, extension articles, podcasts, videos)[1]. List the knowledge transfer products under section (c)	2

[1] Please only include the number of unique knowledge transfer products.

b) List of scientific journal articles published/accepted for publication from this project. Please ensure that each line includes the following: **Title, Author(s), Journal, Date Published or Accepted for Publication and Link to Article (if available).** *Add additional lines as needed*.

1.
2.
3.
4.

c) List of knowledge transfer products/activities developed from this project.

Knowledge Transfer Product or Activity	Event/Location Where Knowledge Transfer Was Conducted	Estimated Number of Producers Participated in Knowledge Transfer	Link (if available)
Joint NARF and AAFC Field Tour	Melfort Research Farm, Melfort, SK	100	
Field tour by conference attendees	Indian Head, SK	28	

Acknowledgements

Signage for this trial included acknowledgment of support by Saskatchewan Ministry of Agriculture and SCAP during NARF and AAFC's Joint Field Day on July 18th, 2024.

Figure 2. Signage acknowledging project funders at NARF and AAFC's Joint Field Day held on July 18, 2024 in Melfort, SK.

Appendices

Include any additional materials supporting the previous sections, e.g. detailed data tables, maps, graphs, specifications, literature cited (Use a consistent reference style throughout).

Table A1. Soil residual nutrients at IHARF and NARF after conducting soil tests in October 2023.

Parameter	(Unit)	IHARF (Indian Head)			NARF (Melfort)		
Depth	**--->**	0-15 cm	15-60 cm	0-60 cm	0-15 cm	15-60 cm	0-60 cm
pH		7.9	8.2	-	5.9	6.7	-
O.M.	**(%)**	4.3	-	-	7.9	-	-
CEC	**(meq)**	41.8	-	-	30.8	-	-
Sol. Salts	**(mmho/cm)**	0.64	0.50	-	0.41	0.56	-
NO3-N	**(kg/ha)**	22.4	6.7	29.1	28.0	20.2	48.2
Olsen-P	**(ppm)**	7.0	-	-	28.0	-	-
K	**(ppm)**	440.0	-	-	402.0	-	-
Sulphur	**(kg/ha)**	11.2	26.9	38.1	31.4	74.0	105.4
Cl	**(kg/ha)**	-	-	9.0	-	-	18.0
B	**(ppm)**	1.1	-	-	0.5	-	-
Zn	**(ppm)**	0.29	-	-	2.52	-	-
Fe	**(ppm)**	13.9	-	-	158.0	-	-
Mn	**(ppm)**	4.0	-	-	6.0	-	-
Cu	**(ppm)**	1.9	-	-	1.3	-	-
Mg	**(ppm)**	918	-	-	867	-	-
Ca	**(ppm)**	6585	-	-	3376	-	-
Na	**(ppm)**	20	-	-	26	-	-

Table A2. Dates of operations for the trial at IHARF and NARF in 2024.

Dates of Operation	NARF (Melfort)	IHARF (Indian Head)
Seeded	May 29, 2024	May 15, 2024
Previous crop	Wheat	Canaryseed
Fertility	N: 118 kg/ha, P: 56 kg/ha, K: 0 kg/ha, S: 17 kg/ha	N: 125 kg/ha, P: 35 kg/ha, K: 18 kg/ha, S: 18 kg/ha
Pre-Emergent Herbicide	None	Roundup Transorb HC at 0.67 L/ac on May 20, 2024; Authority 480 at 0.118 L/ac on May 16, 2024.
Post-Emergent Herbicide	Buctril M at 400 ml/ac on Jun 19, 2024; Centurion at 150 ml/ac on Jun 21, 2024; Basagran Forte at 910 ml/ac on July 11, 2024.	Poast Ultra at 0.19 L/ac plus 0.5% Merge on June 20, 2024; Curtail M at 0.81 L/ac on June 21, 2024.
Insecticide	None	None
Treatment applications	July 23, 2024 at 4pm	July 15, 2024 in early morning
Emergence counts:	Jun 18, 2024	May 29, 2024
Disease ratings - Pre fungicide application	July 23, 2024	July 14, 2024
Disease ratings - Post fungicide application	Aug 7, 2024	July 31, 2024
Lodging	Sep 24, 2024 before harvest	Aug 14, 2024

Desiccated	Sep 11, 2024 with StartUp @ 0.67 L/ac	August 16, 2024 with Roundup Transorb HC at 0.67 L/ac
Harvested	Sep 24, 2024	Aug 23, 2024

Table A3. Horsfall-Barratt Scale for disease rating.

(Reproduced from Horsfall, J.G. and R.W. Barratt. 1945. An improved grading system for measuring plant diseases. Phytopathology 35:65 (abstract).)

Grade	% Diseased	% Healthy	Grade Formula (%)
0	0	100	1.17
1	0-3	97-100	2.34
2	3-6	94-97	4.68
3	6-12	88-94	9.37
4	12-25	75-88	18.75
5	25-50	50-75	37.50
6	50-75	25-50	62.50
7	75-88	12-25	81.25
8	88-94	6-12	90.63
9	94-97	3-6	95.31
10	97-100	0-3	97.66
11	100	0	98.62

Twelve grades between 0 and 100. Grades are large enough to be clearly distinguishable by eye and in accordance with the Weber-Fechner law that visual grades progress in logarithmic steps. Up to 50%, the eye tends to judge total area that is diseased, while above 50% it judges the percentage that is healthy. The ability to distinguish small differences in percentage is best near 0 and 100 and poorest near 50%. Limits of grades are set by progressively halving above and below 50% in rounded figures (0, 3, 6, 12, 25, 50, 75, 87, 94, 97, 100%). Each leaf or stem is scored according to the grade number. The grade number is converted to grade formula % according to the system given above. Calculate the mean grade formula % that equals estimated % disease.

Expenditure Statement

You must provide an expenditure statement showing how ADOPT funds were used. Expenditures must be reported using the budget categories shown in Appendix B of your contract. We recommend that you report your expenditures using the Excel spreadsheet we have developed for this purpose (ADOPT Expenditure Statement.xls). That spreadsheet is available from the research branch project manager or the evaluation coordinator.

Note that the ADOPT contract requires you to retain all receipts and financial records relating to the project for at least six years after the project is completed.