2018 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Seed Treatment and Foliar Fungicide Options for Flax

(Project #20170449)

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Project Identification

1. **Project Title:** Seed treatment and foliar fungicide options for flax
2. **Project Number:** 20170449
3. **Producer Group Sponsoring the Project:** Saskatchewan Flax Development Commission
4. **Project Location(s):** Indian Head (#156), Redvers (#61), Swift Current (#137), Scott (#380), and Prince Albert (#461), Saskatchewan
5. **Project start and end dates (month & year):** April-2018 to February-2019
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

The objective of this project was to demonstrate the response of flax to various seed-applied and foliar fungicide options with a focus on establishment, maturity, and yield.

8. **Project Rationale:**

The average seeded area for flax in western Canada over the past five growing seasons was 509,000 ha (1.26 million acres) with over 70% of this area in Saskatchewan.

While most flax growers have not traditionally used seed-applied fungicides, the registration of Insure Pulse (16.7 g/L pyraclostrobin, 16.7 g/L fluxapyroxad, and 13.3 g/L metalaxyl) in 2016 sparked renewed interest in this practice. Previous ADOPT and industry funded trials with seed treatments have shown potential for improved establishment (i.e. higher plant populations) but, in most cases, no significant impact on yield. An exception was Indian Head in 2013 where, with high yield potential and extremely wet conditions early in the season, seed-applied fungicide (Vitaflo-280) resulted in 32% more plants and a 10% (4.3 bu/ac) yield increase. Past research in North Dakota (Bradley et al. 2007) evaluated multiple products over four site-years and observed reduced root rot incidence at one of four site-years but no effects on plant densities or yield in any cases. With the increased interest and potential merits demonstrated in various field trials, producers now question whether they might expect similar results with older and presumably less expensive registered options such as Vitaflo-280 (15.6% carbathiin and 13.25% thiram). It should be acknowledged that seed treatments are most likely to be beneficial under challenging environmental conditions (i.e. cold and wet soils) and in the presence of potential pathogens (i.e. infected or cracked seed, poor crop rotation). In addition, higher plant populations will not necessarily lead to higher yields depending on the overall number of plants established and environmental conditions.

As for in-season applications of fungicides, many flax growers, particularly in wetter areas of the province, have seen good results with registered products and will consider applying a foliar fungicide at full bloom in most years. Field trial data generally supports this practice. Flax response to fungicide was assessed in various IHARF field trials at Indian Head over a seven-year period (2010-16) and showed an overall average yield increase of 10% (3.3 bu/ac) with foliar fungicide application. The observed response was statistically significant in five out seven years with actual yield differences ranging from -2% (2015, not significant) to as high as +27% (2010). Research in Melfort (Vera et al. 2014) showed significant yield increases in three out of four years and also found that pasmo severity frequently increased with N fertility (due to denser crop canopy) and that foliar fungicide reduced lodging when it occurred (usually at high N rates). The first foliar fungicide registered for flax was Headline E.C. (250 g/L pyraclostrobin) which is also the product that has been utilized in most previous research and demonstration trials. Priaxor (167 g fluxapyroxad/L and 333 g/L pyraclostrobin) received registration for pasmo and sclerotinia stem rot of flax in 2017 and has multiple modes of action (MOA). More recently registered foliar fungicide options for controlling pasmo in flax are Acapela (250 g/L picoxystrobin) and Delaro (175 g/L prothioconazole and 150 g/L trifloxystrobin). While more expensive, products with multiple MOA are valuable tools for preventing the onset of disease resistance and may also provide better control in the year of application. Improved disease control could be a result of the broader spectrum of diseases controlled in some conditions or simply due to more complete or persistent control of the primary disease, pasmo. Similar to the seed treatments, flax growers and agronomists commonly question whether or not there are short-term agronomic advantages to the newer, multi-group products to help justify the added cost.

The current project was initiated to demonstrate the response of flax to a selection of registered seed-applied and foliar fungicide options in order to help growers and agronomists quantify the potential agronomic gains (or lack thereof) of using these technologies under field conditions and natural infection levels/disease pressure.

Bradley, C., Halley, S. and R. Henson. 2007. Evaluation of fungicide seed treatments on flax cultivars differing in seed color. Ind. Crops Prod. **25:** 301-304.

Vera, C., Irvine, R., Duguid, S., Rashid, K., Clarke, F. and J. Slaski. 2014. Pasmo disease and lodging in flax as affected by pyraclostrobin fungicide and, N fertility and year. Can. J. Plant Sci. **94:** 119-126.

Methodology and Results

9. Methodology:

Field trials with flax were initiated in the spring of 2018 at multiple Saskatchewan locations to evaluate crop response to selected seed-applied and foliar fungicide options. The locations were selected to represent all of the major flax producing regions of Saskatchewan and provide a range of environmental conditions and potential natural disease levels. They included Indian Head, Redvers, Swift Current, Scott, and Prince Albert. The treatments were a factorial combination of three seed-applied fungicide treatments (untreated, Vitaflo-280, and Insure Pulse) and three foliar-applied fungicide treatments (untreated, Headline EC, and Priaxor). All products were used as per label recommendations and the foliar fungicide applications were targeted for 7-10 days after the first flowers were observed. The plots were arranged in a four replicate and a full treatment list is provided in Table 1.

Table 1. Flax seed treatment and foliar fungicide treatments at multiple Agri-ARM sites in 2018.

#	Seed Treatment	Foliar Fungicide
1	None	None
2	None	0.395 L Headline EC/ha (0.16 l/ac)
3	None	0.445 L Priaxor/ha (0.18 l/ac)
4	525 ml Vitaflo-280/100 kg seed	None
5	525 ml Vitaflo-280/100 kg seed	0.395 L Headline EC/ha (0.16 l/ac)
6	525 ml Vitaflo-280/100 kg seed	0.445 L Priaxor/ha (0.18 l/ac)
7	600 ml Insure Pulse/100 kg seed	None
8	600 ml Insure Pulse/100 kg seed	0.395 L Headline EC/ha (0.16 l/ac)
9	600 ml Insure Pulse/100 kg seed	0.445 L Priaxor/ha (0.18 l/ac)

Headline EC (250 g/l pyraclostobin); Priaxor (167 g/l fluxapyroxad plus 333 g/l pyraclostrobin)
Vitaflo-280 (15.59% carbathiin plus 13.25% thiram); Insure Pulse (16.7 g/l pyraclostrobin plus 16.7 g/l fluxapyroxad plus 13.3 g/l metalaxyl)

Selected agronomic information along with dates of certain measurements is provided in Table 10. Plot size varied with location due to differences in seeding and spraying equipment. At all locations, flax was direct-seeded into the previous stubble (wheat, field pea, or canola) and the variety CDC Glas was utilized with a seeding rate of 50 kg/ha and target depths of approximately 2-3 cm depending on equipment and spring soil moisture. Seed treatments were utilized as per protocol and, where applicable, applied at the label recommended rates. Weeds were controlled using registered pre-emergent and in-crop herbicides. Foliar fungicides were utilized as per protocol and applied 7-10 days into bloom with either a hand boom or field sprayer (depending on equipment availability and plot size) and water volumes of at least 150 l/ha. Pre-harvest herbicides or desiccants were used at the discretion of site managers and plots were straight-combined when the crop was mature and dry enough to harvest. Where ever possible, the outside rows of each plot were excluded from the harvest area to minimize the impact of potential edge effects.

Various data were collected during the growing season and from the harvested grain samples. Days to emergence was recorded for each plot and declared when an estimated 50% or more of the seedlings were out of the ground and crop rows were clearly visible. Spring plant densities were estimated when emergence was complete by counting the number of seedlings in three separate one meter sections of crop row per plot and converting the values to plants/m^2. Pasmo disease was quantified by rating 25 plants/plot on a scale of 0-9 (0 = no disease, 9 = more the 90% of the plant affected by disease) before and after the foliar fungicide applications but prior to maturity. The treatments were monitored for effects on physiological development and days to maturity (75% boll colour change) was estimated and recorded for each plot. Yields were determined by cleaning and weighing the harvested grain samples and are corrected for dockage, to a uniform moisture content of 10%, and expressed as kg/ha.

All response data were analysed using the Mixed procedure of SAS with the effects of seed treatment (ST), foliar fungicide (FUNG) and their interaction (ST × FUNG) considered fixed and replicate effects treated as random. Separate analyses were completed for each location for simplicity and due to variation in the specific data that could be statistically analysed across locations. Wherever appropriate, Fisher's Least Significant Difference test was used for means separations with all treatment effects and differences between means considered significant at $P \leq 0.05$.

10. Results:

Growing season weather conditions

Growing season (May-August) temperature (Table 2) and precipitation (Table 3) data for the 2018 growing season are provided for each location along with the long-term (1981-2010) averages in Tables 2 and 3, respectively. Early spring seeding conditions were generally drier in the southern locations and wetter in the north; however, the growing season overall was much drier than normal at all locations. At all locations, temperatures were slightly above average over the four-month period with May-June being particularly warm but approximately average or slightly below average July-August temperatures. Broadly speaking, conditions were generally good for emergence but, with increasingly dry conditions as the season progressed, disease pressure was low and yield potential was generally below average. Although precipitation at all locations was less than normal, the relative conditions were as expected with the hottest and driest weather in the southwest (Swift Current) and cooler, wetter conditions at the more eastern and northern locations (i.e. Prince Albert and, to a lesser extent, Redvers).

Table 2. Mean monthly temperatures (°C) along with long-term (1981-2010) averages for Indian Head, Redvers, Swift Current, Scott, and Prince Albert during the 2018 growing season (May through August).

Year	May	June	July	August	Average
			Indian Head		
2018	13.9	16.5	17.5	17.6	16.4
Long-Term	10.8	15.8	18.2	17.4	15.6
			Redvers		
2018	15.1	19.1	19.4	18.9	18.1
Long-Term	11.1	16.2	18.7	18.0	16.0
			Swift Current		
2018	14.4	16.9	18.9	18.5	17.2
Long-Term	10.9	15.4	18.5	18.2	15.8
			Scott		
2018	13.6	16.1	17.4	16.2	15.8
Long-Term	10.8	15.3	17.1	16.5	14.9
			Prince Albert		
2018	13.3	16.3	17.4	15.7	15.7
Long-Term	10.4	15.3	18.0	16.7	15.1

Table 3. Total monthly precipitation amounts (mm) along with long-term (1981-2010) for Indian Head, Redvers, Swift Current, Scott, and Prince Albert during the 2018 growing season (May through August).

Year	May	June	July	August	Total
			Indian Head		
2018	23.7	90.0	30.4	3.9	148
Long-Term	51.8	77.4	63.8	51.2	244
			Redvers		
2018	11.4	100.8	54.1	23.5	190
Long-Term	60.0	95.2	65.5	46.6	267
			Swift Current		
2018	14.9	20.2	32.0	28.0	95
Long-Term	48.5	72.8	52.6	41.5	215
			Scott		
2018	29.6	58.0	48.2	85.8	194
Long-Term	36.3	61.8	72.1	45.7	216
			Prince Albert		
2018	12.5	49.8	112.4	38.4	213
Long-Term	44.7	68.6	76.6	61.6	252

The overall F-test results for all variables at each location are presented in Table 4 where p-values values greater than 0.05 indicate that the corresponding effect (seed treatment, fungicide, or their interaction) was not significant at that location.

The overall tests of fixed effects (seed treatment, foliar fungicide, and their interaction) for each location are provided in Table 4. No lodging was observed in any plots at any locations; therefore, results for this variable are not presented. Values less than or equal to 0.05 indicate that an effect was significant for the corresponding response variable.

Days to emergence was monitored as something that could potentially be affected by the seed treatments; however no variation whatsoever was recorded at Swift Current or Prince Albert and no treatment effects were significant at any of the locations where subtle variation from one plot to the next was recorded. The values recorded ranged from approximately eight days at Scott to thirteen days at Prince Albert (Table 5); however, in addition to being affected by environmental conditions, these measurements were also somewhat subjective. Foliar fungicides were not applied until later in the season and, as such, were not expected to affect days to emergence.

Table 4. Overall tests of fixed effects (variety, N rate and their interaction) for various flax response variables. Data were analysed separately for each location. Probability values greater than 0.05 indicate that an effect was not statistically significant.

Location	Seed Treatment (ST)	Fungicide (FUNG)	ST × FUNG
	---------- Days to Emergence ----------		
Indian Head	0.243	0.243	0.072
Redvers	0.383	0.195	0.201
Swift Current	–	–	–
Scott	0.570	0.272	0.726
Prince Albert	–	–	–
	---------- Plant Density ----------		
Indian Head	0.535	0.502	0.942
Redvers	0.095	0.689	0.981
Swift Current	0.565	0.848	0.286
Scott	0.817	0.591	0.829
Prince Albert	0.003	0.490	0.897
	---------- Pasmo Ratings ----------		
Indian Head	0.363	<0.001	0.807
Redvers	–	–	–
Swift Current	–	–	–
Scott	–	–	–
Prince Albert	0.940	0.126	0.621
	---------- Maturity ----------		
Indian Head	0.281	0.543	0.276
Redvers	0.087	0.683	0.939
Swift Current	0.616	1.000	0.257
Scott	–	–	–
Prince Albert	–	–	–
	---------- Seed Yield ----------		
Indian Head	0.559	0.529	0.971
Redvers	0.447	0.082	0.730
Swift Current	0.631	0.072	0.027
Scott	0.835	0.909	0.545
Prince Albert	0.047	0.357	0.946

Seeding rates were held constant across treatments and locations; however, the seed source, stubble type and equipment varied across locations which, in addition to environmental conditions, could contribute to variation in the absolute stands from one location to the next. Similar to days to emergence, we did not expect plant densities to be affected by the foliar fungicides and no fungicide effects or interactions were detected (Table 4; P = 0.286-0.981). Seed treatment did not affect plant densities at Indian Head, Redvers, Swift Current, or Scott (P = 0.095-0.817); however, there was a significant response at Prince Albert (P = 0.003) which was also the coolest and wettest location. Overall average plant populations were lowest at Swift Current and Prince Albert (280-306 plants/m^2), intermediate at Redvers and Scott

(463-487 plants/m^2), and highest at Indian Head (585 plants/m^2). The commonly recommended minimum target plant population for flax is approximately 300-400 plants/m^2. At Prince Albert, where the seed treatment effect on plant density was significant, the actual populations were 249 plants/m^2 in the control, 300 plants/m^2 with Vitaflo-280, and 369 plants/m^2 with Insure Pulse (Table 6). With an LSD value of 54 plants/m^2, the difference between Vitaflo-280 and the control was not quite large enough to be declared statistically significant ($P \leq 0.05$) while the populations with Insure Pulse were significantly higher than both other treatments. While variation in plant populations frequently have no effect on yield, the densities at this site were approaching the threshold where further reductions might start to have a negative effect on both maturity and yield.

Table 5. Main effect means for treatment effects on days to emergence in flax. Data were analysed separately for each location. Means within each column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Main Effect	Indian Head	Redvers	Sw. Current	Scott	Prince Albert
	----------------------------- Emergence (days from seeding) -----------------------------				
Seed Treatment					
Control	12.1 a	10.6 a	10.0	8.7 a	13.0
Vitaflo-280	12.0 a	10.8 a	10.0	8.3 a	13.0
Insure Pulse	12.0 a	10.4 a	10.0	8.2 a	13.0
S.E.M.	0.05	0.21	–	0.34	–
Fungicide					
Control	12.0 a	10.3 a	10.0	8.3 a	13.0
Headline EC	12.1 a	10.8 a	10.0	8.1 a	13.0
Priaxor	12.0 a	10.7 a	10.0	8.8 a	13.0
S.E.M.	0.05	0.21	–	0.34	–

Table 6. Main effect means for treatment effects on plant densities in flax. Data were analysed separately for each location. Means within each column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Main Effect	Indian Head	Redvers	Sw. Current	Scott	Prince Albert
	-------------------------------- Plant Density (plants/m^2) --------------------------------				
Seed Treatment					
Control	569 a	460 a	273 a	492 a	249 b
Vitaflo-280	581 a	434 a	271 a	476 a	300 b
Insure Pulse	606 a	494 a	296 a	494 a	369 a
S.E.M.	24.2	21.2	20.2	24.8	27.9
Fungicide					
Control	567 a	450 a	283 a	503 a	285 a
Headline EC	582 a	472 a	286 a	489 a	321 a
Priaxor	606 a	467 a	272 a	470 a	312 a
S.E.M.	24.2	21.2	20.2	24.8	27.9

The plots were monitored for lodging as this is a commonly cited concern for many flax growers. Previous research has shown that lodging can be mitigated with fungicide applications; however, as previously mentioned, no lodging was observed in any treatments at any locations. As such, no data for this variable is presented. The lack of lodging can likely be explained by both the dry conditions and variety selection with CDC Glas having very good lodging resistance according to the 2019 SaskSeed Guide.

Pasmo disease levels were non-existent to low at all locations under the dry conditions. No disease was reported at Redvers, Swift Current and Scott; therefore, data from these locations could not be statistically analyzed (Table 7). Ratings were completed twice, once at the time of the fungicide application and again prior to maturity but only data from the second set of ratings is reported. Disease ratings from prior to the fungicide application were also statistically analyzed but there were no treatment effects and the values were even lower than at the final date. At Indian Head, pasmo symptoms were observed on the lower leaves at the time of the fungicide applications; however, with extremely dry conditions in July and August, the disease never progressed to the stems or upper plant. No effects of seed treatment were detected (P = 0.363) but the fungicide effect was significant (P < 0.001) although the values were all low and the difference between the treated and untreated plots was less than 0.5 (0-9 scale) on average. At Prince Albert, the mean pasmo ratings were low for all treatments, averaging only 0.6 (out of 9), and none of the treatment effects were significant (P = 0.126-0.940). These ratings can be quite subjective; however, at Indian Head, the observed values indicated leaf spotting and senescence in the lower third of the plant but none of the distinctive banding on the stems that occurs in the latter part of the season with more severe infections.

Table 7. Main effect means for treatment effects on pasmo disease ratings in flax completed after the fungicide applications (prior to maturity). Data were analysed separately for each location. Means within each column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Main Effect	Indian Head	Redvers	Sw. Current	Scott	Prince Albert
	------------------------------- Pasmo Disease Rating (0-9) -------------------------------				
Seed Treatment					
Control	2.8 a	0.0	0.0	0.0	0.6 a
Vitaflo-280	2.7 a	0.0	0.0	0.0	0.6 a
Insure Pulse	2.9 a	0.0	0.0	0.0	0.5 a
S.E.M.	0.12	–	–	–	0.08
Fungicide					
Control	3.1 a	0.0	0.0	0.0	0.6 a
Headline EC	2.6 b	0.0	0.0	0.0	0.4 a
Priaxor	2.7 b	0.0	0.0	0.0	0.6 a
S.E.M.	0.12	–	–	–	0.08

Maturity was declared when approximately 75% of the bolls had turned brown and was monitored at all locations. At Scott and Prince Albert, no variation in maturity amongst plots whatsoever was noted; therefore, data for this variable could not be statistically analyzed at these locations (Table 8). Overall, maturity was notably earlier at the southern locations, Indian Head, Redvers, and Swift Current (<90 days) compared to Scott or Prince Albert (106-110 days). Neither seed treatment nor foliar fungicide affected maturity at the sites where statistical analyses were possible (P = 0.087-1.000). While one common question or concern surrounding foliar fungicide use is delayed maturity, past field trial experience has shown that such impacts generally only occur when disease pressure is high and delays in maturity are generally accompanied by significant yield increases. Seed treatments might be expected to lead to earlier maturity if they result in more vigorous emergence or higher plant populations; however, no such effects were detected.

Table 8. Main effect means for treatment effects on flax maturity. Data were analysed separately for each location. Means within each column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Main Effect	Indian Head	Redvers	Sw. Current	Scott	Prince Albert
	------------------------------ Maturity (days from planting) ------------------------------				
Seed Treatment					
Control	89.5 a	89.6 a	87.7 a	106	110
Vitaflo-280	89.6 a	89.7 a	87.8 a	106	110
Insure Pulse	89.2 a	89.3 a	87.5 a	106	110
S.E.M.	0.18	0.18	0.32	–	–
Fungicide					
Control	89.3 a	89.5 a	87.7 a	106	110
Headline EC	89.5 a	89.4 a	87.7 a	106	110
Priaxor	89.4 a	89.6 a	87.7 a	106	110
S.E.M.	0.18	0.18	0.32	–	–

Under the dry conditions, yields were modest ranging from 1102 kg/ha at Swift Current to 2053 kg/ha at Indian Head when averaged across treatments (Table 9). At Indian Head, Redvers, Swift Current, Scott there was no effect of either seed treatment (P = 0.447-0.835) or foliar fungicide (P = 0.072-0.909) on flax yield; however, the interaction at Swift Current was significant (P = 0.027). Closer inspection of the individual treatment means from this site, however, did not reveal any readily explainable responses and the interaction appeared to be due to a large spread between the lowest and highest yielding treatments which may have simply been due to spatial variability and experimental error. At Redvers, there was a tendency for higher yields with seed treatments and with Priaxor fungicide but plot-to-plot variability at this location was high and no observed differences between main effect means could be declared significant. At Prince Albert, the seed treatment effect was significant (P = 0.047) and due to higher yields with Insure Pulse compared to both the control and Vitaflo-280. The observed yield advantage was 224 kg/ha (bu/ac), or 12%, and was only observed with Insure Pulse which, as previously discussed, also resulted in the highest plant populations. Furthermore, the absolute emergence numbers at this location were low enough to potentially be limiting; therefore, any increases in plant populations may have led to higher yield. Despite a trend for slightly higher yields with foliar fungicide at Prince Albert, the response was not even marginally significant (P = 0.357) and, although this was the wettest site, the lack of response was not necessarily unexpected given the low disease levels reported.

Table 9. Main effect means for treatment effects on flax seed yield. Data were analysed separately for each location. Means within each column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Main Effect	Indian Head	Redvers	Sw. Current	Scott	Prince Albert
	------------------------------------ Seed Yield (kg/ha) ------------------------------------				
Seed Treatment					
Control	2056 a	1481 a	1097 a	1449 a	1830 b
Vitaflo-280	2075 a	1608 a	1054 a	1434 a	1848 b
Insure Pulse	2027 a	1629 a	1156 a	1453 a	2063 a
S.E.M.	48.3	216.8	86.0	26.1	121.8
Fungicide					
Control	2047 a	1480 a	1063 a	1452 a	1834 a
Headline EC	2081 a	1496 a	1156 a	1438 a	1936 a
Priaxor	2031 a	1741 a	1033 a	1445 a	1973 a
S.E.M.	48.3	216.8	86.0	26.1	121.8

Extension Activities and Dissemination of Results

Where ever feasible, the field trials were highlighted during field days hosted by the participating organizations. The full project report will be made available online on the IHARF website (www.iharf.ca) and Agri-ARM (www.agriarm.ca) and potentially elsewhere in the winter of 2018-19. Results may also be made available through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as opportunities arise and where appropriate.

Conclusions and Recommendations

Although conditions were not ideal for the purposes of this project, these results were not inconsistent with previous research and demonstrations.

Focussing on seed treatments, past results have been variable with a fairly large percentage of trials showing no measurable benefit but increases in plant populations and, to lesser extent higher yields, occasionally occurring. It can be difficult to predict whether responses will occur but typically seed treatments are most likely to be beneficial when the seed source is contaminated with the pathogen being controlled or under stressful conditions at seeding. Examples of stressful seeding conditions might include cold, waterlogged soils or potentially very dry soils where emergence might not occur for extended periods and/or initial growth is likely to be poor. In the current project, a response (both plant populations and yield) occurred 20% of the time, or at one out of five locations. Other cases where growers should consider using a seed treatment would be when the disease (or insect) being managed has been problematic in the field or region in previous years. Otherwise, with clean seed, no known history of the pest, and normal seeding conditions, measureable benefits are relatively unlikely. It is worth noting, that the need for a seed treatment (and subsequent responses) may be variable across the landscape and, as such, difficult to detect in small plot trials. For example, there may be a greater need for a seed treatment in lower slope positions in wet years, particularly with crops that do not tolerate wet soils well and, as such, are stressed and susceptible to disease. While the response at Prince Albert was stronger with Insure Pulse, substantially more evidence would be required to say that this advantage is repeatable and applicable under a wide of conditions.

With regard to foliar fungicides, previous research and demonstration trials have shown strong responses when disease pressure is sufficiently high and a reasonably high frequency of response, especially through wetter periods. For example, from 2010 to 2016 at Indian Head, yield increases with Headline EC were detected 71% of the time five out of seven years) and provided an overall yield benefit of 10%, or 207 kg/ha (3.3 bu/ac) when averaged over this seven year period. However, there are also a large number of cases, including those in the current project, where disease pressure is low and there are no yield benefits or noticeable effects of fungicide on maturity detected. When noteworthy effects on maturity have occurred, they have always been accompanied by substantial yield increases. The recommendation, at least for wetter regions, would be to scout frequently starting just prior to bloom and through flowering and be prepared to apply a fungicide but only do so if the disease is present and conditions are conducive to further infection. A general recommendation is to apply fungicide about a week after the very first flowers are observed but later applications can be beneficial or even superior if conditions during flowering go from drier to wetter (do not apply outside of label recommended stage). Relative to many field crop diseases, pasmo is relatively easy to scout for as it progresses up the plant with precipitation and can still be managed after there are visible symptoms, unlike sclerotinia or fusarium head blight. Pasmo symptoms first appear on the bottom leaves, eventually moving to upper stems and even bolls if left unchecked and conditions are favourable for disease. In most cases disease will still be limited to leaves on the lower half of the plant at the time of fungicide application and, if it does not progress past this point, any impacts on yield will be negligible. In drier regions, such as Swift Current, flax yield responses to fungicide are unlikely but may occur in wet years; therefore, careful monitoring is still recommended. While crop rotation is certainly a factor to consider, disease can occur in fields where flax has not been grown in many years if the weather is conducive, thus scouting is still recommended under these circumstances as well. With no significant fungicide responses in the current project, no comment can be made on the relative performance of the two products evaluated (Headline EC versus Priaxor); however, utilizing products with multiple modes can help prevent the development of resistance to certain active ingredients and may also provide more complete disease control.

Supporting Information

11. Acknowledgements:

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12. Appendices

Table 10. Selected agronomic information for the canola phosphorus demonstration at Indian Head in 2018.

Operation	Indian Head	Redvers	Swift Current	Scott	Prince Albert
Previous Crop	Wheat	Field Pea	Wheat	Wheat	Canola
Pre-emergent herbicide	May 13 (140 g sulfentrazone/ha) May 14 (894 g glyphosate/ha)	May 15 (894 g glyphosate/ha + 280 g bromoxynil/ha)	May 3 (894 g glyphosate/ha + 21 g carfentrazone/ha)	May 19 (1334 g glyphosate/ha + 21 g carfentrazone/ha)	none applied
Seeding Date	May 11	May 16	May 4	May 22	May 18
Fertilizer (kg N-P_2O_5-K_2O-S/ha)	110-30-15-15	78-34-0-9	90-45-0-18	93-17-0-22	74-67-0-0
Emergence Counts	May 30	June 6	May 24	June 13	June 12
In-crop Herbicide	June 12 (280 g MCPA/ha + 280 g bromoxynil/ha + 60 g clethodim/ha)	June 9 (280 g MCPA/ha + 280 g bromoxynil/ha) June 18 (60 g clethodim/ha)	June 8 (280 g MCPA/ha + 280 g bromoxynil/ha)	June 18 (280 g MCPA/ha + 280 g bromoxynil/ha)	June 13 (554 g MCPA/ha + 99 g clopyralid/ha)
Foliar Fungicide	July 5	July 9	July 3	July 17	July 13
Pasmo Ratings	July 6 July 27	Late July (checked repeatedly)	July 3 July 25	July 17 July 31	July 9 August 9
Preharvest Herbicide	August 10 (894 g/glyphosate/ha)	September 5 (410 g diquat/ha)	August 4 (894 g/glyphosate/ha)	September 8 (894 g/glyphosate/ha)	none applied
Harvest date	August 21	September 28	August 7	September 28	October 4

Table 11. Individual seed treatment by foliar fungicide treatment effects on plant densities in flax. Data were analysed separately for each location. Results from the multiple comparisons test are only presented for sites where at least one of the fixed effects were significant. Means within each column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Main Effect	Indian Head	Redvers	Sw. Current	Scott	Prince Albert
Seed Trt – Fungicide	------------------------------ Plant Density (plants/m^2) ------------------------------				
None – None	571	441	295	494	232 d
None – Headline	548	468	273	514	253 cd
None – Priaxor	588	472	250	468	262 bcd
Vitaflo – None	554	434	303	497	262 bcd
Vitaflo – Headline	581	438	256	450	341 a-d
Vitaflo – Priaxor	609	431	255	480	297 a-d
Insure – None	578	475	251	518	360 abc
Insure – Headline	618	509	328	503	370 ab
Insure – Priaxor	621	498	310	462	378 a
S.E.M.	40.8	33.7	33.0	40.2	41.8

Table 12. Individual seed treatment by foliar fungicide treatment effects on seed yield in flax. Data were analysed separately for each location. Results from the multiple comparisons test are only presented for sites where at least one of the fixed effects were significant. Means within each column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Main Effect	Indian Head	Redvers	Sw. Current	Scott	Prince Albert
Seed Trt – Fungicide	--------------------------------- Seed Yield (kg/ha) ---------------------------------				
None – None	2051	1401	1069 bc	1462	1735 b
None – Headline	2074	1301	1115 abc	1444	1869 ab
None – Priaxor	2044	1740	1107 abc	1441	1885 ab
Vitaflo – None	2089	1547	931 c	1399	1719 b
Vitaflo – Headline	2095	1624	1261 a	1439	1885 ab
Vitaflo – Priaxor	2043	1653	971 c	1464	1941 ab
Insure – None	2001	1492	1188 ab	1496	2047 ab
Insure – Headline	2075	1563	1092 abc	1431	2052 ab
Insure – Priaxor	2005	1831	1021bc	1431	2091 a
S.E.M.	66.0	249.8	100.9	41.5	156.4

Abstract

13. Abstract/Summary:

Trials were established at multiple Saskatchewan locations in 2018 to demonstrate flax response to selected seed treatment and foliar fungicide options. The locations were Indian Head, Redvers, Swift Current, Scott, and Prince Albert. Growing season precipitation amounts and subsequent disease pressure was well below normal at all sites. Replicated four times, the treatments were a combination of three seed-applied fungicide treatments (untreated, Vitaflo-280, and Insure Pulse) and three foliar fungicides (untreated, Headline EC, and Priaxor). Where appropriate, response data were statistically analysed and included days to emergence, plant densities, pasmo ratings, maturity, and seed yield. There were no treatment effects on days to emergence, lodging, or maturity at any locations. Plant populations were increased with both Insure Pulse and, to a lesser extent, Vitaflo-280 at one out of five locations and Insure Pulse increased yield by 13% at the same site. The response was observed at Prince Albert, the coolest and wettest of the locations. Very little pasmo was observed, with no symptoms whatsoever recorded at three out of five sites. At Indian Head, the average pasmo rating was 2.8/9 with a small reduction in visible symptoms with fungicide; however, conditions went from wet to dry at this location and disease never progressed past the lower leaves. Under these conditions, foliar fungicides did not result in significant yield benefits at any locations. Although the dry conditions were not conducive for demonstrating the relative performance and potential benefits of seed-applied and foliar fungicide options, these results reinforce the importance of crop scouting and illustrate that benefits to crop protection products are unlikely in the absence of the pests that they are registered to control. Previous field trials with seed treatments have produced results ranging from no benefit to higher plant populations with a tendency for higher yields. The current results reinforce the recommendation that benefits of seed treatments under field conditions are variable and presumably less likely when using high quality seed and good seeding practices. While past field trials have shown potentially strong yield responses and effects on maturity with foliar fungicide applications under higher disease pressure, the current results are consistent with other previous cases where disease pressure was low.