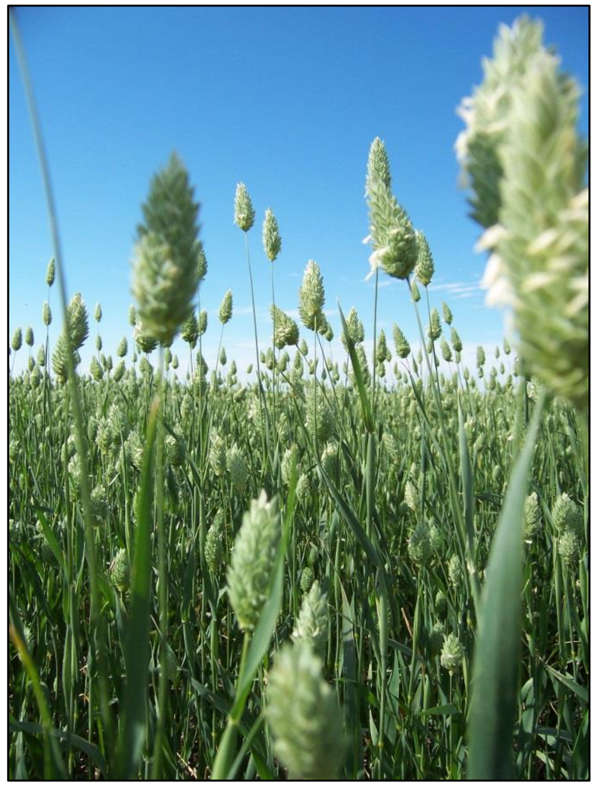
2013 Annual Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Field-scale evaluation of foliar-applied fungicide options for various crops

(Project #20120409)



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Project Identification

1. **Project Title:** Field-scale evaluation of foliar applied fungicide options for various crops.
2. **Project Number:** 20120409
3. **Producer Group Sponsoring the Project:** Indian Head Agricultural Research Foundation
4. **Project Location(s):** Indian Head, Saskatchewan, R.M. #156
5. **Project start and end dates (month & year):** September 2012-January 2014
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

Field-scale fungicide trials were completed with a variety of crops and fungicide products near Indian Head, Saskatchewan each year since 2004. The objective of this project was to continue and expand upon these evaluations in 2013 and to summarize all of the results to date in order to:

   1. Demonstrate the effects of various fungicide products on the yields (and quality in some cases) of spring wheat, barley, oat, canaryseed, field pea and canola.
   2. Provide insights into the frequency and magnitude of yield responses of commonly grown crops to annual foliar fungicide applications in the thin Black soil zone.

8. **Project Rationale:**

There has been an increase in disease pressure for most crops in the thin Black soil zone over the past number of years, primarily due to above average precipitation. For example, in 2012 producers encountered unprecedented levels of both fusarium head blight in cereals and sclerotinia stem rot in canola, resulting in dramatically reduced yields and quality. Many producers in this region have not routinely used fungicides and are not confident in making the decision of whether or not to invest in this technology. Since 2004, IHARF has been conducting field-scale evaluations of a variety of fungicide products and crops. This data, acquired over a large number of years and a wide range of conditions has potential to provide valuable insights into the frequency and magnitude of yield responses to annual fungicide applications for a variety of crops. The intended benefit of this project is to provide producers with information on both the benefits and risks of applying registered fungicide products for major crops grown in the area, including canola, oat, wheat, barley, field pea and canaryseed. Conducting these trials with commercial field equipment and having the plots spread out over nearly 1200 acres made it somewhat impractical to physically tour the plots during the growing season; however, the results from these demonstrations is directly transferable to producers without some of the potential biases and issues of scale sometimes associated with small plot research and demonstrations.

Methodology and Results

9. **Methodology:**

All trials were arranged as a randomized complete block design (RCBD) and each treatment in a given test was replicated a minimum of three times throughout the field. The trials were seeded with a 10 m Flexicoil air seeder on 30 cm row spacing and fertilizer rates were varied over crop types and years. Fungicide products were applied using a high-clearance sprayer (24 m boom width) equipped with a global positioning system (GPS) with and automatic steering. Unless otherwise indicated, timing of the fungicide applications were always at the flag leaf stage for cereals, 20-50% bloom for canola and early flower for field peas. The crops were either straight-combined or swathed and, while the specific combine used has varied over the years, a modern New Holland twin rotor machine was used in all cases and yield data were collected using a New Holland yield monitoring system and GPS. All fungicide treatments (including the checks) were also mapped and this data were used to identify the treatments in the yield maps prior to analyses. Initial processing of yield monitor data were completed using SMS Advanced (Ag Leader) and ArcGIS (ESRI) GIS software and the final yield data were analyzed using Statistical Analysis Software (SAS 9.2). Yield and quality data were subjected to an analysis of variance (ANOVA) with Fisher's protected least significant difference (LSD) test used to separate individual treatment means. When more than one product was evaluated, the yield of the untreated check was also compared to the average of the treated plots using contrasts. All fungicide effects on grain yield and differences between means were declared significant at $P \leq 0.05$ and considered marginally significant at $P < 0.10$. Weather conditions were monitored using data from an Environment Canada weather station located on the AAFC Indian Head Research Farm, within 5 km of any of the individual trials.

10. Results:

Site & Weather Information

All of these trials were completed on fields managed by IHARF within a 6 km radius northeast of Indian Head, Saskatchewan (50° 32' N; 103° 40'). All fields were under long-term no-till management and the soils are an Indian Head Heavy Clay (Rego thin Black Chernozem) soil. Growing season weather information for 2004-2013, along with the long-term (1981-2010) averages are provided in Table 1. Typically, warm wet weather in early summer favors the development of disease in western Canadian spring crops; however, this is not necessarily the case with all diseases and the monthly averages do not always reflect specific conditions encountered during the critical periods of crop development.

Table 1. Mean monthly growing season temperatures and precipitation at Indian Head, Saskatchewan (2004-2013) along with the long-term (LT) normal values (1981-2010).

Year	*May*	*Jun*	*Jul*	*Aug*	***Avg***	*May*	*Jun*	*Jul*	*Aug*	***Tot***
	---------------- Temperature (˚C) ----------------					-------------------- Precipitation (mm) --------------------				
2013	11.9	15.3	16.3	17.1	**15.2**	17	104	50	6	**177**
2012	9.9	16.5	19.2	17.1	**15.7**	79	51	125	30	**285**
2011	9.5	15.1	18.8	17.8	**15.3**	71	133	42	44	**290**
2010	9.6	15.6	17.4	16.3	**14.7**	63	122	28	93	**306**
2009	8.1	14.0	14.4	15.3	**13.0**	15	61	58	77	**211**
2008	8.6	13.9	16.8	17.5	**14.2**	21	60	90	47	**218**
2007	10.7	15.0	19.9	15.5	**15.3**	81	47	51	64	**243**
2006	11.2	16.0	17.9	17.3	**15.6**	39	80	6	12	**137**
2005	8.8	14.8	16.9	15.6	**14.0**	58	99	59	98	**314**
2004	6.8	12.6	16.3	13.1	**12.2**	105	85	75	71	**336**
LT	**10.8**	**15.8**	**18.2**	**17.4**	**15.6**	**52**	**77**	**64**	**51**	**244**

Hard Red Spring Wheat

Since 2004, a total of six trials have evaluated the effects of fungicide application at the flag-leaf stage on hard red spring wheat (Table 2). The specific products evaluated have varied over the years but included Stratego 250 EC (125 g l^{-1} propiconazole + 125 g l^{-1} trifloxystrobin), Headline EC (250 g l^{-1} pyraclostrobin), Tilt 250E (250 g l^{-1} propiconazole), Quilt (75 g l^{-1} azoxystrobin + 125 g l^{-1} propiconazole) and Twinline (130 g l^{-1} pyraclostrobin + 80 g l^{-1} metconazole). In 2013, there was no true untreated check as the entire study area was oversprayed with 324 ml/ac Prosaro at the early heading stage.

With varying environmental conditions over the years, yields of the untreated check ranged from 2927-5433 kg ha^{-1} and significant yield increases were obtained with flag-leaf fungicide application in 33% of the years where spring wheat trials were conducted. At $P \leq 0.10$, the yield response was considered marginally significant 50% of the time. Averaged across all six years and all products, the average spring wheat yield increase with flag-leaf fungicide application was 159 kg ha^{-1} (2.4 bu ac^{-1}), or 4.4%. In the specific years where a significant yield response was detected, yield increases ranged from 4-9%.

Table 2. Effects of flag leaf fungicide treatment on CWRS wheat yield at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Year	Check	Stratego	Headline	Tilt	Quilt	Twinline	CV	Check vs Rest
	kg/ha						%	p-value
2013 [Z]	5433 b	—	—	—	—	5631 a	1.4	0.038
2010	4087 b	4463 a	4391 ab	4440 a	4465 a	—	5.1	0.015
2009	4847 a	4984 a	4787 a	4585 a	—	—	8.3	0.981
2008	3575 a	—	3586 a	—	—	—	5.2	0.939
2007	3539 a	3584 a	3855 a	3899 a	—	—	8.7	0.232
2006	2927 a	3161 a	—	—	—	—	2.4	0.058

[Z] Entire study area sprayed with Prosaro at early heading in 2013

Flag leaf fungicide effects on spring wheat grain quality were assessed in 2009 and 2010 (Table 3). Test weight and 1000-seed weight were significantly increased with fungicide in both cases. In 2010, percent hard vitreous kernels were lower with fungicide, likely a result of the higher yields observed with fungicides and subsequent N availability becoming more limiting. Fusarium damage was also significantly lower with fungicide application but only by a small margin and the fungicide applications in these trials did not specifically target this disease. In 2010 flag leaf fungicide application significantly increased blackpoint, with infection levels which were three times higher when fungicides were applied. Fungicide applications from stem elongation to flag leaf emergence have previously been shown to increase black point incidence in durum wheat in western Canada, an effect that is usually associated with an increase in kernel size.

In 2013, a separate trial was completed to specifically evaluate fungicide products applied at the early heading stage to target fusarium head blight infection in spring wheat (Table 4). The specific products were Prosaro 250 EC (125 g l^{-1} prothioconazole + 125 g l^{-1} tebuconazole), Caramba (90 g l^{-1} metconazole) and Folicur 250EW (250 g l^{-1} tebuconazole). While individual treatment differences were not detected using Fisher's protected LSD test, there was an overall tendency for higher yields with fungicide and the check versus rest contrast was significant (P = 0.042). Similarly, percent fusarium damage tended to be lower with fungicide application, particularly with Prosaro and Caramba; however, no treatment effects were declared significant due to high overall variability. Fungicide application at early heading did not affect blackpoint infection in this trial.

Table 3. Effects of flag leaf fungicide application on spring wheat quality at Indian Head, Saskatchewan. *P*-values are from check versus rest contrast comparisons and the means presented under fungicide are averaged across all fungicide products for each year.

	----- 2009 -----			----- 2010 -----		
Parameter	**Check**	**Fung**	**p-value**	**Check**	**Fung**	**p-value**
Test Weight (kg/hL)	83.9 b	84.3 a	0.024	80.5 b	81.3 a	<0.001
1000 Kernel Weight (g)	34.5 b	36.1 a	0.003	29.7 b	31.4 a	<0.001
% Protein Content	13.6 a	13.5 a	0.288	14.0 a	13.8 a	0.574
% Hard Vit. Kernels	81.4 a	79.0 a	0.457	79.5 a	76.2 b	0.024
% Fusarium damage	0.17 a	0.18 a	0.697	0.30 a	0.18 b	0.050
% Blackpoint	3.3 a	4.4	0.235	0.8a	2.4	0.005

Table 4. Effects of early heading fungicide treatment on CWRS wheat yield and quality in 2013 at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Check	**Prosaro**	**Caramba**	**Folicur**	**CV**	**Check vs Rest**
----- Grain Yield (kg/ha) -----				%	p-value
4348 a	4581 a	4536 a	4464 a	2.9	0.042
----- Fusarium Damage (%) -----					
0.30 a	0.11 a	0.13 a	0.21 a	71.6	0.114
----- Blackpoint Damage (%) -----					
0.85 a	0.65 a	1.0 a	1.1 a	104.3	0.918

Malting Barley

Since 2006, five replicated malting barley field trials have been completed with single mode-of-action fungicide products (Table 5) and separate trials were completed in 2012 and 2013 with fungicide products containing more than one active ingredient (Table 6). With the exception of Acapela (250 g l^{-1} picoxystrobin), all of the products tested on barley were also used on spring wheat and were described in the previous section.

In general, barley was more responsive to fungicide application than wheat with significant overall yield increases detected in 5 of 7 trials and in 3 of 5 years. Averaged across years and products, annual fungicide application at the flag leaf stage resulted in an average yield increase of 11%. In the field trials where significant yield responses were detected (2006, 2012 and 2013), the observed yield increases ranged from 5-30%. In 2012, the year with the heaviest disease pressure and greatest response to fungicide application (with all crops), significant differences amongst individual products were also detected with barley. All fungicide products resulted in a significant yield increase over the check, but the highest yields were achieved with Acapela and Headline followed by Tilt, Caramba and Stratego (Table 5). Significant yield differences amongst individual products were relatively rare in these trials, likely due to the low overall disease pressure and modest yield increases observed with foliar fungicide applications in most years. While one might note that the magnitude of the yield increase with multiple active ingredients appeared to be higher than with single actives in 2012 and 2013 (4.5-23% versus 6.1-30%), directly comparing responses between these two trials is scientifically inappropriate as the trials were conducted in separate fields and randomized separately.

Table 5. Effects of fungicide treatment on malting barley yield at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Year	Check	Headline	Stratego	Tilt	Acapela	Caramba	Folicur	CV	Check vs Rest
	kg / ha							%	p-value
2013	6329 a	6671 a	—	6546 a	6655 a	6632 a	6575 a	2.3	0.003
2012	3211 d	4119 ab	3637 c	3872 bc	4338 a	3742 c	—	4.9	<0.001
2009	4961 a	5276 a	5291 a	5519 a	—	—	—	8.9	0.172
2008	4974 a	5235 a	4937 a	5095 a	—	—	—	6.8	0.576
2006	4324 b	4982 a	—	4917a	—	—	—	3.3	0.010

Table 6. Effects of fungicide treatment on malt malting barley yield at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Year	Check	Quilt	Twinline	Prosaro	CV	Check vs Rest
	kg / ha				%	p-value
2013	6622 a	7008 a	6940 a	7128 a	4.1	0.038
2012	3519 b	4620 a	4497 a	4565 a	2.7	<0.001

In 2009, flag leaf fungicide application effects on malting barley quality were evaluated (Table 7). While test weights tended to be slightly higher with fungicide, the increase was not significant at the desired probability level ($P = 0.079$). Seed size was increased by an average of 2.9% with fungicide application ($P = 0.042$) but individual treatment means did not significantly differ. Protein concentration of malting barley was not affected by fungicide in 2009, which was not unexpected since we did not detect a significant yield response in this trial.

Table 7. Effects of fungicide treatment on malt barley quality in 2009 at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Parameter	Check	Headline	Stratego	Tilt	CV	Check vs Rest
					%	p-value
Test Weight (kg/hL)	66.6 a	67.2 a	67.2 a	67.1 a	0.8	0.079
1000 Kernel Weight (g)	47.4 a	49.2 a	48.5 a	48.5 a	2.0	0.042
% Protein Content	10.6 a	11.4 a	11.5 a	10.9 a	6.1	0.140

White Milling Oat

Seven field-scale fungicide trials with oat have been completed over five separate growing seasons since 2007, with two separate oat trials in 2011 and 2012 due to space limitations in individual fields (Table 8). With significant yield increases observed in 2011 (1 of 2 trials), 2012 (2 of 2 trials) and 2013, a significant oat yield response to fungicide application was detected 50% of the time. At a less conservative *P*-value of 0.10, the oat yield increase with fungicide was significant 70% of the time. The overall average yield increase associated with annual fungicide application was 5.9%, or 309 kg ha^{-1} (8.6 bu ac^{-1}) while, in the specific trials where responses were detected, the increases ranged from 6-19%. There were no cases were significant yield differences amongst individual fungicide products were detected for milling oat.

Table 8. Effects of fungicide treatment on oat yield at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Year	Check	Stratego	Tilt	Headline	Carumba	Twinline	CV	Check vs Rest
	--	-----------	kg/ha	-----------	--		%	p-value
2013	6879 a	7278 a	7223 a	7431 a	7202 a	7325 a	3.3	0.007
2012[2]	4940 b	5140 ab	—	—	—	5307 a	3.2	0.030
2012[1]	4381 b	—	5088 a	5324 a	5179 a	—	3.7	< 0.001
2011[2]	4311 b	—	—	—	4869 a	—	1.5	0.001
2011[1]	4241 a	4329 a	4203 a	4307 a	—	—	6.9	0.828
2010	5679 a	6019 a	6209 a	5976 a	—	—	5.3	0.062
2007	4683 a	4719 a	4442 a	—	—	—	5.7	0.546

Table 9. Effects of fungicide treatment on oat quality at Indian Head, Saskatchewan. *P*-values are from check versus rest contrast and the means presented under fungicide are averaged across all fungicide products.

	------------- 2010 -------------			------------ 2011[1] ------------			------------ 2011[2] ------------		
Parameter	**Check**	**Fung**	**p-value**	**Check**	**Fung**	**p-value**	**Check**	**Fung**	**p-value**
Test Weight (kg/hL)	50.6	51.4	0.097	51.5	53.9	0.055	49.3	50.3	0.023
1000 Kernel Weight (g)	31.9	32.4	0.537	34.3	37.5	0.071	36.8	38.0	0.153
% Plump Seed (>5.5/65)	86.4	88.7	0.088	86.4	92.6	0.027	94.5	95.5	0.026
% Thin Seed (<5.0/64)	2.3	2.4	0.861	3.2	1.6	0.025	1.0	0.9	0.173
% Groat Weight	73.5	74.8	0.035	73.7	75.9	0.044	73.3	74.7	0.009
% Oil Content	6.6	6.7	0.245	6.6	6.5	0.078	7.0	6.8	0.239
% Protein Content	15.2	14.7	0.054	14.4	15.4	0.021	14.0	14.4	0.209

Fungicide effects on oat quality were assessed in 2010 and in both trials completed in 2011 (Table 9). Test weights were generally increased with fungicide application but the increase was not significant at $P < 0.05$ in all cases. Effects on seed size were not significant at $P \leq 0.05$ in any cases there appeared to be a slight increase in 1000 kernel weights with fungicide in Test 1 in 2011 (P = 0.0.71), although there was no effect on grain yield. The percentage of plump kernels tended to be increased with fungicide application although this effect was not always significant at $P \leq 0.05$ in 2010; percent thin kernels were reduced with fungicide 33% of the time. Groat weights, an important parameter for reducing shipping and handling costs for oat millers, were significantly increased with fungicide in all possible cases. Oil content was not affected by fungicide application and effects on grain protein were not consistent (i.e. increased in one case, decreased in one case and not affected in one case).

Canaryseed

Canaryseed fungicide trials were completed each year since 2008 for a total of six trials (Table 10). While IHARF has evaluated other potential fungicide options for this crop, Tilt remains the only registered product for canaryseed and results for other products are omitted from this report. The observed magnitude and consistency of the yield increases with fungicide application in this crop have been remarkable. Canaryseed yields have been significantly increased with fungicide application 100% of the time in these trials, with an average overall yield increase of 23%, or 405 kg ha^{-1} (7.2 bu ac^{-1}). Within individual years, this response has ranged from as low as 4% to as high as 67%, or from 85-596 kg ha^{-1} (2-11 bu ac^{-1}). In several cases, most notably in 2009, fungicide application also resulted in a substantial reduction in lodging (Fig. 1) and, in addition to the observed yield benefit, made harvesting the crop quicker and easier.

Table 10. Effects of fungicide treatment on canaryseed yield at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Year	Check	Tilt	CV	Check vs Rest
	--------------- kg/ha	---------------	%	p-value
2013	2551 b	3055 a	9.1	**0.043**
2012	890 b	1483 a	13.1	**0.003**
2011	1482b	1652ab	10.8	**0.016**
2010	1539b	2019a	12.9	**0.001**
2009	1922b	2518a	6.9	**<0.001**
2008	2097b	2182a	1.5	**0.033**

Figure 1. Visual response to fungicide observed for canaryseed at Indian Head in 2009.

Yellow Field Pea

With eight field trials completed over an eight year period, IHARF has completed more field-scale fungicide trials with field pea than any other crop. Headline has been the most regularly tested product but the more recent field trials have also included Acapela, Headline DUO (1: 25.2% boscalid + 12.8% pyraclostrobin and 2: 70% boscalid) and Priaxor DS (250 g l^{-1} fluxapyroxad + 250 g l^{-1} pyraclostrobin). Significant yield increases with fungicide were detected 38% of the time at $P \leq 0.05$, or 50% of the time at $P \leq 0.10$. While frequently not significant, there was an overall tendency for higher yields with fungicide in field pea and, averaged across all eight years, annual fungicide application resulted in a 346 kg ha^{-1} (5.1 bu ac^{-1}), or 12% yield increase at Indian Head. Annual yield increases with fungicide ranged from 145-794 kg ha^{-1}, or from 4-33% while, in the responsive years, the increases ranged from 13-33%. In 2013, Priaxor DS resulted in greater yield increase than either Headline or Acapela. In addition, visible reductions in lodging and, consequently easier, faster straight-combining (or swathing) were observed with fungicide in most years with field peas.

Table 11. Effects of fungicide treatment on field pea yield at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Year	Check	Headline	Acapela	Headline DUO	Priaxor DS	CV	Check vs Rest
	------------------	------------------	kg/ha	------------------	------------------	%	p-value
2013	3478 c	4147 b	4100 b	—	4368 a	2.5	**< 0.001**
2012	2373 b	3095 a	3179 a	3226 a	—	6.2	**< 0.001**
2011	1977 a	2133 a	—	—	—	8.1	0.275
2009	2942 b	3337 a	—	—	—	5.3	**0.044**
2008	3255 a	3424 a	—	—	—	2.4	0.056
2007	3630 a	3763 a	—	—	—	3.1	0.196
2006	3643 a	3788 a	—	—	—	6.5	0.516
2004	5085 a	5335 a	—	—	—	4.4	0.116

Argentine Canola

Trials have been completed over a span of six years since 2007, with no trials in 2010 due to excess precipitation and variable crop conditions. Six trials focused exclusively on treatments targeting sclerotinia stem rot (applied at the 20-50% bloom stage; Table 12) while, in 2011, 2012 and 2013, additional trials evaluated Headline applied at either the 4-6 leaf stage or 20-50% bloom (Table 13). Headline application at the 2-6 leaf stage is registered to control blackleg while Headline applied between 20% bloom and early pod filling is registered for alternaria blackspot suppression and control. The sclerotinia products that were evaluated were Lance WDG (70% boscalid), Proline 480 SC (480 g l^{-1} prothioconazole), Rovral-Flo (240 g l^{-1} iprodione), Astound (37.5% cyprodinil + 25% fludioxonil) and Vertisan (200 g l^{-1} penthiopryad). Canola response to fungicide application has been relatively inconsistent compared with most of the other crops; however, significant responses were detected in two of the six years, 2008 and again in 2012. In 2012, yield variability was high due to both disease and slight wind damage to canola swaths; however, yields with a fungicide application tended to be higher than the check ($P = 0.070$) and significant increases were detected with some products (Table 12). In the second trial in 2012 (Table 13), Lance applied at early bloom increased canola yields relative to the check; however, there was no effect of Headline applied at the 4-6 leaf stage on yield in either 2012 or 2013. In 2011 and 2013, Headline applied at early bloom did not affect canola yields. Averaged across products and years, fungicide applications targeting sclerotinia have resulted in a 4% average yield increase (99 kg ha^{-1}) but, in the absence of significant levels of the disease, yields have been unaffected. In 2012, sclerotinia pressure was very high and responses of nearly 30% were detected in both field-scale trials and also in small plot demonstrations located nearby. In 2008, sclerotinia infection was not especially high; however, small but significant yield increases were detected. Under most field conditions, sclerotinia incidence levels of 5% or lower will not affect grain yield.

Table 12. Effects of fungicide treatment on canola yield at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Year	**Check**	**Lance**	**Proline**	**Rovral-Flo**	**Astound**	**Vertisan**	**CV**	**Check vs Rest**
	kg/ha						%	p-value
2013	3041 a	3137 a	3040 a	—	3144 a	3148 a	4.2	0.312
2012	1821 bc	2165 ab	2265 a	—	2136 ab	1729 c	11.2	0.070
2011	1631 a	1626 a	1689 a	—	1628 a	—	9.3	0.866
2009	2920 a	2988 a	3109 a	2960 a	—	—	4.3	0.220
2008	3067 b	3240 a	3159 ab	3206 ab	—	—	3.1	**0.044**
2007	2575 a	2455 a	2493 a	2562 a	—	—	11.2	0.670

Table 13. Effects of fungicide treatment on canola yield at Indian Head, Saskatchewan. Mean yields within each row that are followed by the same letter do not significantly differ.

Year	**Check**	**Headline (4-6 leaf)**	**Headline (20-50 flow)**	**Lance (20-50 flow)**	**Lance + Headline**	**CV**
	kg/ha					%
2013	3387 a	3394 a	3375 a	—[z]	—[z]	3.8
2012	1489 b	1516 b	—	1925 a	1832 a	3.4
2011	2361 a	—	2342 a	2309 a	2343 a	5.0

[z] Entire study area was over-sprayed with Lance in 2013

11. Conclusions and Recommendations

Having been completed over a large number of years and wide range of weather and crop conditions, these evaluations provide a good assessment of the long-term probability of response and average yield increases associated with annual fungicide applications (Table 14). It is important to note that yield increases with fungicide applications cannot be expected each and every year with most crops in the thin Black soil zone; however, when disease is present, fungicide application can prevent substantial yield loss. Consequently, to maximize returns on investment, fungicides should ideally only be applied to most crops when there is sufficient disease pressure and a reasonably high likelihood of response. Scouting for disease on each field and on a regular basis while monitoring environmental conditions and weather forecasts is the best way to make informed decisions regarding whether or not to spray. For some diseases, (e.g. scelerotinia and fusarium head blight) symptoms do not appear until long after the fungicide application window and past observations and disease issues should also be taken into consideration. While annual, preventive fungicide applications are quite likely to result in higher mean yields over the long-term, whether or not the average gains in this region are sufficient to increase long-term profits is less certain for many crops. That being said, large yield increases (15-30%) with fungicide application were detected occasionally with all of the crops and failure to apply a fungicide in these years resulted in substantial losses of both grain yield and, in some cases, quality. Spring wheat and canola tended to be the least responsive to fungicide with significant yield increases detected only 33% of the time and mean yield increases of only 4.3-4.4% over the long-term. While field pea yield increases were only statistically significant 38% of the time, there was a consistent trend for higher yields with fungicide which, over seven growing seasons, averaged nearly 12%. Both barley and oat responded positively to fungicide application with reasonable consistency, 50-60% of the years where trials were conducted; however, the magnitude of response tended to be higher for barley with an overall average increase of 11% compared to 6% for oats. Canaryseed yield increases with fungicide application were detected each year since 2008 when trials with this crop were initiated with an average yield increase of 23%. With wet weather and relatively high disease levels for much of Saskatchewan in recent years, fungicides need to be regarded as important tools for maximizing crop yields and maintaining grain quality. However, because responses do not occur under all conditions, growers are strongly encouraged to monitor their crops closely and base their decisions on the actual risk of disease, past disease issues, the crop's overall yield potential and economic considerations such as current grain prices and the cost of the fungicide application.

Table 14. General summary of all field-scale fungicide trials conducted by IHARF to date near Indian Head, Saskatchewan.

Crop Type	# of years	Response Frequency [Z]	Check Yield	Treated Yield	Yield Increase
		------ % ------	---------------- kg/ha [Y]	---------------	------ % ------
Spring Wheat [X]	6	33	3887	4046	4.4
Barley [V]	5	60	4819	5294	11.3
Oat [V]	5	50	5236	5545	5.9
Canaryseed	6	100	1747	2152	23.2
Field Pea	8	38	3298	3644	11.7
Canola [U, V]	6	33	2482	2571	4.3

[Z] Significant check versus rest contrast ($P \leq 0.05$), percentage of years where a response observed
[Y] Averaged across years and products
[X] Does not include data from Twinline trial in 2013 due to lack of a true untreated check
[V] Weighted averages used to avoid counting multiple trials within the same year twice
[U] Products / application timings targeting sclerotinia stem rot only

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Supporting Information

12. Acknowledgements

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13. Appendices

N/A

Abstract

14. Abstract/Summary

Since first initiated in 2004, a total of 44 fully replicated field-scale fungicide trials have been conducted near Indian Head, Saskatchewan with hard red spring wheat, barley, oat, canaryseed, field pea and canola as test crops. In 2013 alone, nine separate field trials were conducted. Over this 9-year period, a wide-range of both weather and crop conditions have been encountered therefore allowing for a robust assessment of the frequency and magnitude of yield responses to fungicide applications for major western Canadian crops in the thin Black soil zone. Averaged across all sites, yield increases with fungicide ranged from 4-23% depending on the crop type; however, with the exception of canaryseed, positive responses were not detected in all years. Followed by canaryseed, the most consistently responsive crops were malting barley, field pea, oat, spring wheat and canola. While annual, preventive fungicide applications are likely to result in higher mean yields over the long-term, whether or not the average gains in this region are sufficient to increase long-term profits is less certain. However, yield increases with fungicide as high as 30% were occasionally detected with several crops. In order to maximize annual profits, fungicides should only be applied when there is a reasonably high probability of a positive response. To achieve this, field scouting should be completed on a regular basis both prior to potential fungicide applications and again, for some diseases, post-harvest to assess overall disease risk for both the current and future crops. Decisions on whether or not to apply should be based on the overall disease risk, crop yield potential, current environmental conditions, weather forecasts and economic considerations.