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# PROJECT FINAL REPORT

**Instructions:**

- **Please note that making changes to the project without prior written consent from the funder(s) could constitute sufficient grounds for termination of funding.**
- This report must be a stand-alone report, *i.e.,* must be complete in and of itself. Scientific articles or other publications cannot be substituted for the report.
- A signed electronic copy of this report must be forwarded to the funders' representative on or before the due date, as per the investment agreement.
- A detailed, signed statement of revenues received and expenses incurred during the entire funding period of the project must be submitted along with this report, as per the investment agreement.
- For any questions regarding the preparation and submission of this report, please contact the funders' representative.

## Section A: Project overview

| | |
|---|---|
| 1. **Project number:** 2013F134R | |
| 2. **Project title:** Night Spraying: Fungicides - Efficacy and crop tolerance of fungicides applied at distinct times of day | |
| 3. **Abbreviations:** Define ALL abbreviations used. | |
| 4. **Project start date:** (yyyy/mm/dd) **2013/04/01** | |
| 5. **Project completion date:** (yyyy/mm/dd) **2015/03/31** | |
| 6. **Final report submission date:** (yyyy/mm/dd) **2016/04/30** | |
| 7. **Research and development team data** | |
| **a) Principal Investigator:** (Requires personal data sheet (refer to Section 14) only if Principal Investigator has changed since last report.) | |
| **Name** | **Institution** |
| **Ken Coles, MSc. P.Ag.** | **Farming Smarter Association, Lethbridge, Alberta** |
| **b) Research team members** (List all team members. For each new team member, *i.e.*, joined since the last report, include a personal data sheet. Additional rows may be added if necessary.) | |
| **Name** | **Institution** |

| | |
|---|---|
| Dr. Michael Harding | Alberta Agriculture and Rural Development (ARD), Pest Surveillance Branch, Crop Diversification Centre South, Brooks |
| Dr. Ron Howard | Alberta Agriculture and Rural Development (ARD), Pest Surveillance Branch, Crop Diversification Centre South, |
| Dr. Thomas Kelly Turkington | Agriculture and Agri-Food Canada (AAFC), Lacombe |
| Vance Yaremko | **Smoky** Applied Research and Demonstration Association (**SARDA**), Falher |
| Brian Storozynsky | Alberta Agriculture and Rural Development (ARD), Agricultural Technology Centre, Lethbridge |

## Section B: Non-technical summary (max 1 page)

Provide a summary of the project results which could be used by the funders for communication to industry stakeholders (*e.g.*, producers, processors, retailers, extension personnel, etc.) and/or the general public. This summary should give a brief background as to why the project was carried out, what were the principal outcomes and key messages, how these outcomes and key messages will advance the agriculture industry, how they will impact industry stakeholders and/or consumers, and what are the economic benefits for the industry. This summary should be in plain, non-scientific language.

Our study clearly showed that crops are not likely to respond to fungicide applications under low disease pressures and will most likely maintain yield potential close to the pre-disease level. Therefore, producers could avoid unnecessary fungicides expenses under low disease severity without facing the risk of losing any yields while saving time, financial resources and the environment. These results agree with several other researchers who recommend using fungicides only when damage to crop is critical and significant yield loss potential is eminent. Our results also suggest that fungicides applied during the day, night or dawn time would be similarly effective on barley, wheat and canola, with some advantage of dawn or night time applications for peas. However, because, the study could not maximize differences statistically between the treatments due to the low disease pressures, further research would verify these results.

## Section C: Project details

### 1. Background (max 1 page)

Describe the project background and include the relevant scientific and development work providing the impetus for the current project.

Application timing can significantly alter pesticide effectiveness. However, because of Alberta's short growing seasons, most producers seed and spray in a very short time frame. Growers sometimes stretch the recommended boundaries of application conditions to farm more acres using the same equipment. Growers often have to juggle weather conditions, environmental consequences and economic considerations when choosing pesticide application timing.

This study examined night and dawn time applications as a practical alternative to the daytime spray application. Poor day time conditions, such as hot and windy conditions, can greatly reduce fungicide efficacy. Because, producers rely on pesticides, especially under zero-tillage systems, any reduction in chemical efficacy can quickly diminish financial returns on investment particularly in Alberta due to our short growing season. This causes producers to experiment with spray time applications. Because of cooler temperatures, less wind, higher humidity and lower evaporation potential, farmers think night and dawn time applications could improve efficacy due to greater absorption and provide a feasible alternative to poor daytime conditions. However, limited scientific research and huge knowledge gaps exist in this area. There are few studies available that could provide producers with objective information and tools for informed choice and determine if night/dawn time applications provide a practical alternative to daytime application. Therefore, this project was designed to determine if night or dawn time spraying offers any real potential.

## 2. Objectives and deliverables (max 1 page)

State what the original objective(s) and expected deliverable(s) of the project were. Also describe any modifications to the objective(s) and deliverable(s) which occurred over the course of the project.

### 2.1 Objectives

The main study goal is to provide detailed information from a systematic, science-based approach on the effects of night spraying using fungicides currently registered in Alberta on common cereal and canola diseases. Objectives are to:

1. evaluate efficacy and crop tolerance of fungicides applied at three distinct times
2. understand the linkages between environmental conditions and fungicide efficacy
3. quantify potential yield effects, quality and return on investment resulting from fungicide applications

### 2.2 Deliverables

This project considered producers, industry and other stakeholders in its design and delivery. It meant to: (a) generate unbiased data using small plot and field scale trials; (b) provide information on fungicide efficacy and crop tolerance across a range of environmental conditions at three application timings (mid-day, night, early morning); (c) generate new information on plant and disease responses to fungicide timings; (d) examine spray technologies in the context of precision agriculture to help farmers maximize yield and quality in their crops; (e) evaluate fungicide performances under common disease pressures in Alberta and provide unbiased info on disease management practices; and (f) assist with development or refinement of best management practices for common diseases in Alberta cereal and canola crops. Extension of project findings will reach growers via Farming Smarter and partner associations' magazine, newsletters, crop walks, tours, workshops/conferences, media, websites (www.farmingsmarter.com, ropintheweb) social media etc.

## 3. Research design and methodology (max 4 pages)

Describe and summarise the project design, methodology and methods of laboratory/field and statistical analysis that were actually used to carry out the project. Please provide sufficient detail to determine the experimental and statistical validity of the work and give reference to relevant literature where appropriate. For ease of evaluation, please structure this section according to the objectives cited above.

**Tables 1 and 2 are included in Appendix A**

The study ran for three crop years from 2013 to 2015. The study included a total of 472 small research plots established at four locations each year, Farming Smarter Association (FS) site in Lethbridge, Crop Diversification Centre (CDC) South in Brooks, Agriculture and Agri-Food Canada (AAFC) Centre in Lacombe and at Smoky Applied Research and Demonstration Association (SARDA) in Falher, Alberta (Table 1). Four crops, barley, wheat, canola and peas, were used. However, not all four crops were tested at each location. All trials were designed as randomized split-plots with four replicates. Plots were sprayed using hand held sprayers equipped with two meter booms, CO2 propellant and low drift nozzles to minimize drift. Herbicide labels informed the spray rates, application timing and other considerations. Nozzles were spaced 50 cm apart and held 50 cm above the canopy. Plot dimensions, number of rows, row spacing etc. were adjusted to accommodate different seeding and spraying equipment. Selected fungicides used in our study are listed in Table 2.

### 3.1 Data Collection, Processing and Analysis

We conducted randomized, split-plot design small plots trials with four replicates consisting of approximately five fungicide treatments with different modes of action, three spray timings (dawn, noon, midnight) and two water volumes/and or nozzle types. We evaluated the crop for common cereal leaf diseases such as tan spot, septoria and scald in wheat and barley and sclerotinia stem rot and black leg in canola. When appropriate, we inoculated crops with corresponding pathogens to ensure sufficient disease pressure. To create conditions conducive to infection and disease development, some plots received irrigation.

Data collection for each spray treatment included air and crop canopy temperatures, sunlight hours, cloud cover, relative humidity, overnight dew, soil temperature, wind speed and direction, disease symptoms present, growth stage, and pictures. Researchers evaluated plots for disease control (incidence and severity) and crop tolerance (phytotoxicity) at standard intervals (3-5 days, 7-14 days, 21+ days after fungicide application). Leaf samples went for laboratory analysis and pathogen confirmation. Data collection included yield and grain quality data. Further data collection details are presented here.

### 3.2 Disease Development for Effective Analysis

Effective measures to encourage sufficient disease pressure in the field allowed for statistical separation of treatments. Location selection favored history of disease and/or existing crop stubble from the previous year. Inoculation and/or irrigation initiated and/or encouraged disease pressure throughout the plots when required.

Disease Inoculation options included:

- Scald, net blotch: infected crop residues and/or conidial suspensions
- Tan spot, septoria/stagnospora: infected crop residues and/or conidial suspension
- Sclerotinia: ascospores suspension or spread sclerotia bodies: black leg: infected residue

### 3.3 Fungicide Application Timing

The first fungicide applications conformed to label specifications for rate and timing. If required, we applied a second application based on disease pressure in the plots. The second application may be a repeat application of the treatment fungicides or a one-product, blanket application for general disease management in the plots depending on the disease pressure and specific plot situations.

### 3.4 Agronomic Standards Used

We used these agronomy standards:

- Pre-seed burn down: glyphosate - used registered tank mix if required.
- Fertility: adopt soil test based recommended fertility program for optimum yields for wheat, barley, canola and peas
- Fungicides: applied at full label rates
- Fungicide timing: flag leaf stage application for cereals; early to full bloom application for sclerotinia in canola; prior to the 4-6 leaf stage in canola for blackleg; and the first flower/canopy closure in field peas.
- Herbicides: a registered herbicide applied according to label specifications. All locations tried to keep herbicide use consistent, but made selections based on weed pressures in the plots.
- Seeding rates:
    - Barley 300 seeds/m2
    - Wheat 300 seeds/m2
    - Canola 150 seeds/m2
    - Peas 100 seeds/m2.

### 3.5 Data Collection

Plots evaluation included disease control (incidence and severity) and crop tolerance (phytotoxicity) at standard intervals (3-5 days, 7-14 days, 21 + days after fungicide application). Leaf samples were collected for laboratory analysis and pathogen confirmation. Yield and grain quality data were also collected.

1. Plant stand at spraying
    a. Count two 1m rows per plot, at least 1m from the front or back. Count row 2 in the front and row 5 in the back.
2. Environmental data
    a. before and after spraying (air temp, soil temp, wind speed, wind direction, RH, cloud cover, precipitation)
    b. Dew period (measured and collected through weather station)
    c. Evapotranspiration (measured and collected through weather station)
3. Crop growth stage (e.g. Zadoks for cereals) and density at spraying
4. Disease ID
5. Disease Incidence and severity ratings. See APPENDIX 1 - Ratings
    a. Minus 3-5 DAT (days after treatment)
    b. 0 DAT
    c. 7-14 DAT
    d. 14-21 DAT
    e. 35+DAT
6. Pictures: weekly. Specifically treatment effects.
7. Maturity ratings
8. Lodging ratings
9. Yield
10. Grain Quality

### 3.6 Ratings

Ratings were scored using the following tables:

Crop Stage: Zadoks Scale (Zadoks et al., 1974)

Disease ratings:

- Barley (Scale 1 – 9) - scald: (In-crop assessments: Couture, 1980; Lacombe Research Center; assessment of percentage leaf area disease on flag – 1 [penultimate] leaves sampled at late milk early dough)
- Barley (Scale 1 – 9) – Net blotch (In-crop assessments: Couture, 1980; Lacombe Research Center; assessment of percentage leaf area disease on flag – 1 [penultimate] leaves sampled at late milk early dough [James, 1971])
- Wheat (Scale 1 – 9) – tan spot (In-crop assessments: Couture, 1980; Lacombe Research Center; assessment of percentage leaf area disease on flag leaves sampled at late milk early dough [James, 1971])
- Wheat (Scale 1 – 9) – septoria (In-crop assessments: Couture, 1980; Lacombe Research Center; assessment of percentage leaf area disease on flag leaves sampled at late milk early dough [James, 1971])
- Canola (Scale 0 – 5) – sclerotinia (Johnston et al., 2005; or Kutcher & Wolf, 2006).
- Canola (Scale 0 – 5) – black leg (WCCRRC, 2012; Van Den Berga et al., 1993)

- Peas – ascochyta, mycosphaerella (Mueller et al, 2001)

Trial data analysis used the PROC GLM procedure of SAS (SAS Institute Inc., Cary, NC) for ANOVA to detect significant differences ($p<0.1$) among the treatment means. The study used Tukey's Studentized Range (HSD) Test ($p=0.1$) to separate treatment means with significant differences.

## 4. Results, discussion and conclusions (max 8 pages)

Present the project results and discuss their implications. Discuss any variance between expected targets and those achieved. Highlight the innovative, unique nature of the new knowledge generated. Describe implications of this knowledge for the advancement of agricultural science. For ease of evaluation, please structure this section according to the objectives cited above.

***NB: Tables, graphs, manuscripts, etc., may be included as appendices to this report.***

**Tables 3 through 16 are included in Appendix A**

Tables 3 through 6 give average disease ratings for barley, wheat, canola and peas. Disease severity scale ranged between 1 and 9 for barley and wheat; 0 and 5 for canola and peas. Tables 7 through 10 compare effectiveness of the selected fungicides for three application timings on yields of barley, wheat, canola and peas. We ranked treatment (yield) means in ascending order between the highest and lowest yields ranked as 1 and 4. Treatment means followed by the same letter are not statistically different at $p=0.1$ level.

Tables 7 through 10 give ANOVA results of selected fungicide treatments, and with respect to the three distinct application timings for barley, wheat, canola and peas, respectively. Performances of selected individual fungicides with respect to the three distinct application timings for barley, wheat, canola and peas, respectively, are given in Tables 11 through 14. A results summary appears at the bottom of each table indicating how often (percent of the total occurrences) a particular application timing produced higher yields compared to the other timings over the 3-year period. These tables also list disease severity ratings as assessed by field staff visual inspection during the course of the study. An aggregate listing of the results summaries from Tables 7 through 10 appears in Table 11. Table 12 summarizes the results comparing how often (percent of the total occurrences) yield corroborated disease ratings. Disease severity ratings were ranked in descending order between the highest and lowest severity (no disease) as 4 and 1, respectively.

### 4.1 Overall Disease Pressure on Crops

The disease severity ratings results given in Tables 3 through 6 indicate that, on average, disease pressure was low on all crops and crop damage did not seem critical across all locations. Because crops respond to fungicides application when severely damaged from the high pressure of foliar diseases, low levels of disease severity with noncritical crop damage could mute crops' response to fungicides, as was observed in our study (Dokken-Bouchard, 2015; Hershman, 2011; Paul et al., 2011; Swoboda and Pedersen, 2009).

## 4.2 Effects of Fungicides' Application on Crop Yields

Table 7 gives results of ANOVA on different fungicides and application timings for barley for Brooks, Lethbridge and Lacombe locations, respectively. Results show that in 2013 and 2014, Twinline out yielded all other treatments, either statistically higher (p=0.1) or numerically, at three locations. In 2015, the three fungicides treatments yielded lower than the Control at Brooks with Quilt yielding the most in Lacombe. The table also shows that in 2014 at Lethbridge, Prosaro yielded the highest compared to Caramba, Bravo and Control. These treatments were not used at other two locations. The results summary on the application timings given at the bottom of the table shows that dawn time at Brooks (67%) and night time at Lethbridge (75%) most frequently resulted in better yields at these locations. At Lacombe, however, no application timing did better than others.

Table 8 shows ANOVA results for wheat from Brooks and Lethbridge locations. Although, treatment means at both locations were not significantly different (p=0.1) from respective Controls in three years, Prosaro yielded highest in 2013 at Brooks and at both locations in 2014. Further in 2014 at Lethbridge, yield from Twinline was significantly higher than other treatments. Results summary of application timings show that day and night timings were the most effective timings at both locations.

Table 9 presents ANOVA results for canola seeded at three locations. Overall, Quadris was the most effective treatment producing the highest yields over three years at Brooks, in 2014 at Lethbridge and in 2014 and 2015 at Falher. For application timings, day and night times were equally effective in 67% of the instances at Brooks, day time in 100% of the time at Lethbridge and dawn time 100% of the time at Falher. Dawn time scored the least at Brooks and Lethbridge and day time at Falher.

ANOVA results for peas are shown in Table 10. Priaxor yielded consistently higher than other treatment for consecutive three years at Brooks. Priaxor also yielded highest in 2013 at Lethbridge and Falher. However, performances of Acapela and Lance were mixed at these two locations. Results for application timings also given in this table show that night and dawn timings produced higher yields equally frequently in 67% of the instances. However, dawn time was most effective at Lethbridge and Falher in 100% and 67% of the instances, respectively.

In conclusion, our results show that Twinline, Prosaro, Quadris and Prixor were most effective fungicides for barley, wheat, canola and peas, respectively. However, most of these results lacked statistical significance (p=0.01). One apparent reason for yields response to fungicides treatments lacking statistical significance was the low disease severity that couldn`t cause critical injury to crops and crops` response to fungicides' applications. These results agree with several other researchers who recommend using fungicides only when damage to crop is critical and significant loss of yield potential is eminent (Bradley, 2012; Hershman, 2011; Paul et al., 2011).

## 4.3 Effects of Fungicides' Application Timings on Crop Yields

Tables 11 through 14 compare performances of selected individual fungicides with respect to the three distinct application timings for barley, wheat, canola and peas, respectively. As stated before, the overall effects of fungicides and application timings on crop yields were weak due to low disease severity across all locations. However, the results still showed some trends summarized in Table 15 and discussed in the following.

Results summarized for barley in Table 15 show that at Brooks dawn applications were the most effective (56% of the instances) for producing higher yields compared to day and night times that both scored at 44%. However, at Lethbridge Night time application was the most effective (67% of the instances) and day and dawn timings scored 50%. Night applications also scored higher yields at Lacombe (83% of the instances) followed by the dawn time (67%) and day time (33%). These results indicate that day time was the least effective application timing for barley at all locations. However, considering weak trends, results were mixed at best and none of the application timings were clearly effective. Similar results were also observed for wheat at Brooks and Lethbridge; no application timing seemed clearly more effective than others at both locations.

For canola, similar but relatively stronger trends in application timing frequencies showed at two locations, Lethbridge and Brooks with day time most frequently effective (78% and 67%, respectively) followed by the night and dawn times, respectively (day time > night time > dawn time). At Falher, however, dawn time scored better in 56% of the instances compared to 44 and 33% for day and night times, respectively.

For peas, the trend was even stronger, but opposite to that observed for canola, with dawn time being the most frequently effective in 89, 56 and 67% of the instances at Lethbridge, Brooks and Falher, respectively. These results for peas appear in agreement with other studies on peanuts (both plants with a similar canopy structure). These studies found that spray coverage and density were higher and droplet size was bigger during early dawn and night application timings compared to the day application timing and wet and folded leaves in the early morning application allowed deeper penetration of fungicide with increased fungicide residual activity within the bottom canopy (Augusto et al., 2010ab). In contrast, however, canopy structures of the wheat, barley and canola plants were different from peas or peanuts plants and were not affected by diurnal effects (Mohr et al., 2007) as much as peas or peanut plants.

## 4.4 Correspondence between Visual Disease Ratings to Crop Yields

On the average, yields corresponded with the in-season crop disease ratings in < 40% of the instances (Table 16). This low level of correspondence between disease ratings and yield means could be because of low disease pressures during the period of the study. Because when disease pressure is slight, ratings may not be able to reflect the variation in the yield. The results further illustrate this fact when out of 79 instances the yield followed the corresponding disease ratings, 44 of those instances (~56%) were paired up as 14, i.e., highest yield (1) and lowest disease severity (4), or as 41, i.e., lowest yield (4) and highest disease severity (1).

## 4.5 Conclusion

Below are major conclusions drawn from our study:

- Severity of fungal diseases remained low for all crops and across all locations during the 3-year study period
- Crops yields were not affected by fungicides statistically. By extension, it means that under low levels of disease conditions, producers could avoid using fungicides without losing any yield potential while saving time, financial resources and the environment
- In general, Twinline, Prosaro, Quadris and Prixor were most effective fungicides for barley, wheat, canola and peas, respectively
- For barely, day time was the least effective application timing at all locations; Dawn applications at Brooks were most effective (56% of the instances) for producing higher yields compared to day and night times that both scored at 44%; Night time application was most effective at Lethbridge at (67% of the instances) compared to day and dawn timings (scoring 50% each); Night applications also scored higher yields at Lacombe (83% of the instances) followed by the dawn time (67%) and day time (33%)
- For wheat, no application timing seemed clearly effective
- For canola, day time application was most frequently effective at Lethbridge and Brooks (78% and 67%, respectively) followed by the night and dawn times, respectively (day time > night time > dawn time); Dawn time scored better at Falher in 56% of the instances compared to 44 and 33% for day and night times, respectively
- Dawn time and night time applications were effective for peas. Likely because of pea canopy structure and the diurnal folding of leaves in the absence of daylight allowed deeper fungicide penetration with increased fungicide residual activity within the bottom canopy
- These results require further research for verification because trends in treatment means differences with respect to the application timings were not statistically significant at p=0.1

In general, our study results suggest that fungicides applied during the day, night or dawn time would be similarly effective on barley, wheat and canola, with some advantage of dawn or night time applications for peas. However, because of low disease pressure, the study could not maximize the differences between treatments. Further research might verify these results.

## 5. Literature cited

Provide complete reference information for all literature cited throughout the report.

Augusto, J., Brenneman, T. B., Culbreath, A. K., and Sumner, P. 2010a. Night spraying peanut fungicides I. Extended fungicide residual and integrated disease management. Plant Dis. 04:676-682.

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Hershman, D.E. 2011, Fungicide use in wheat. Plant Pathology Fact Sheet (PPFS-AG-SG-05), UK Coop. Extension Service, Univ. of Kentucky. USA.

Mohr, K., B.A Sellers and R.J Smeda. 2007. Application time of day influences glyphosate efficacy. Weed Tech, 21: 7-13.

Paul, P. A., Madden, L. V., Bradley, C. A., Robertson, A. E., Munkvold, G. P., Shaner, G., Wise, K. A., Malvick, D. K., Allen, T. W., Grybauskas, A., Vincelli, P., and Esker, P. 2011. Meta-analysis of yield response of hybrid field corn to foliar fungicides in the U.S. Corn Belt. Phytopathology 101:1122-1132.

Swoboda, C. and P. Pedersen. 2009. Effect of fungicide on soybean growth and yield. Agron. J. 101:352-356.

Statistics Canada, 2006. http://statcan.gc.ca

## 6. Project team (max ½ page)

Describe the contribution of each member of the R&D team to the functioning of the project. Also describe any changes to the team which occurred over the course of the project.

**Farming Smarter**

Ken Coles M.Sc. B.Sc. P.Ag – Project Lead

**SARDA**

Vance Yaremko – Site Supervisor Falher

**Alberta Agriculture**

Dr. Mike Harding – Site Supervisor Brooks

**Agriculture Canada (AAFC)**

Dr. Kelly Turkington - Site Supervisor Lacombe

## 7. Benefits to the industry (max 1 page; respond to sections *a)* and *b)* separately)

a) Describe the impact of the project results on the Alberta or western Canadian agriculture and food industry (results achieved and potential short-term, medium-term and long-term outcomes).

**Contributions to Alberta's Agriculture and Agri-Food Knowledge**

This project alleviates the paucity of information on the comparative performance of the day and night time applications of fungicides and improves the ability of producers to make informed decisions, especially on regional basis. The project will help fill knowledge gaps and provide producers with unbiased reliable information on efficacy and tolerance for common fungicides sprayed on common crops in Alberta. This study will also update background research and enhance existing knowledge on plant physiology, fungicide mode-of-action and sprayer technology in relation to night spraying and provide further awareness on determining application rates, selecting proper fungicide and reducing spray off target drifts. It would further provide information about the general efficacy (disease control) and crop tolerance (phytotoxicity) of fungicides sprayed at night.

**Benefits to Alberta's Agriculture and Agri-Food Industry**
Night time application of fungicide would significantly expand the opportunity time window for the producers to avoid potential economic and environmental consequences resulting from the waiting for ideal conditions required for day time application. In a short growing season as in Alberta, application timing is very critical for optimal fungicide performance. Producers would be able to reduce economic losses caused by high application rates, unintended damage to the off target crops as well as environmental pollution of surface and subsurface water bodies by taking advantage of relatively calmer and cooler environmental conditions at night, potentially favorable in limiting off target drifts, reducing high evaporative losses and improving upon plant deposition and adsorption. Night time spraying would greatly improve the producers' options to select from when faced with difficult choices about which fungicide to spray, how to spray and when to spray (e.g. a producer may select a more effective fungicide if the danger of spray drift to adjacent crops is lower). It would also provide the producers with the opportunity of expanding the application acreage in same window of time. Furthermore, besides providing the potential economic and environmental benefits, night spraying could also assist the Alberta agri-food industry in enhancing public perception of its environmental stewardship.

**Benefits to Environment – Reducing Alberta Agricultural Environmental Footprint**
Night time spraying would help in reducing the environmental footprint of agricultural industry in Alberta. Through improved efficacy, lower application rates, lower water volumes, improved fungicide options, reduced off target drifts and less residual fungicide, night time spraying would help in optimizing the total amounts of fungicide used, increasing plant uptake and reducing leakage to the environment. Efficient and optimized use of fungicides would help in alleviating detrimental effects on human and animal health, contamination of food products, destruction of beneficial natural insects, contamination of ground and surface waters, loses of off target crops and crop product, fishery losses as well as direct and indirect economic costs associated with these impacts.

b) Quantify the potential economic impact of the project results (*e.g.,* cost-benefit analysis, potential size of market, improvement in efficiency, etc.).

Our study clearly showed that crops are not likely to respond to fungicides applications under low disease pressures and are most likely to maintain their yield potential at disease free levels. Because, costs of fungicides can substantially reduce profit margins, producers could avoid using fungicides under low disease pressures, without the risk of losing any yields while saving time, financial resources and the environment. These results agree with several other researchers who recommend using fungicides only when damage to crop is critical and significant loss of yield potential is eminent.

8. **Contribution to training of highly qualified personnel (max ½ page)**
Specify the number of highly qualified personnel (*e.g.*, students, post-doctoral fellows, technicians, research associates, etc.) who were trained over the course of the project.

Staff from all four partnering organizations gained invaluable knowledge regarding the complicated interactions between weather conditions and pesticide applications. Knowledge gained in included 3 PhDs, 2 masters, 6 degrees and 12 students across all locations.

9. **Knowledge transfer/technology transfer/commercialisation (max 1 page)**
Describe how the project results were communicated to the scientific community, to industry stakeholders, and to the general public. Please ensure that you include descriptive information, such as the date, location, etc. Organise according to the following categories as applicable:
   a) Scientific publications (*e.g.*, scientific journals); attach copies of any publications as an appendix to this final report
   b) Industry-oriented publications (*e.g.*, agribusiness trade press, popular press, etc.); attach copies of any publications as an appendix to this final report
   c) Scientific presentations (*e.g.*, posters, talks, seminars, workshops, etc.); attach copies of any presentations as an appendix to this final report
   d) Industry-oriented presentations (*e.g.*, posters, talks, seminars, workshops, etc.); attach copies of any presentations as an appendix to this final report
   e) Media activities (*e.g.*, radio, television, internet, etc.)
   f) Any commercialisation activities or patents

***N.B.: Any publications and/or presentations should acknowledge the contribution of each of the funders of the project, as per the investment agreement.***

## Dr. T. Kelly Turkington, Agriculture and Agri-Food Canada (AAFC), Lacombe

## 2013

- Toured and outlined ongoing barley, canola, and winter wheat research at AAFC Lacombe as part of an Australian farmer consultant tour at Lacombe, July 12, 2013. Provided an overview of integrated crop and disease management research. Not sure how many we had.
- Participated with J.T. O'Donovan and K.N. Harker as part of a tour of AAFC Lacombe for the Agricultural Research and Extension Council of Alberta (ARECA) and staff from several provincial applied research associations, July 15, 2013. Provided an overview of integrated crop and disease management research.

- Toured and outlined ongoing barley, canola, and winter wheat research at AAFC Lacombe as part of a tour of growers and consultants, July 26, 2013, Machelmi Ag. Consulting, Sexsmith Alberta. Provided an overview of integrated crop and disease management research.
- Toured and outlined ongoing barley, canola, and winter wheat research at AAFC Lacombe as part of a tour of consultants, July 29, 2013, Edberg Crop Management, Edberg, AB. Provided an overview of integrated crop and disease management research
- Toured and outlined ongoing barley, canola, and winter wheat research at AAFC Lacombe as part of an Australian farmer consultant tour at Lacombe, August 6, 2013. Provided an overview of integrated crop and disease management research. Tour organized by Sam Holmes, Consultant, Maitland, South Australia. Approximately 10 Australian farmers and consultants were on the tour.
- Toured and outlined ongoing barley research at AAFC Lacombe as part of a tour for Russell Shuttleworth, Agronomist with Rahr Malting Inc., Alix, AB Provided an overview of integrated crop and disease management research especially in relation to malt barley production.
- Toured and outlined ongoing barley, canola, and winter/spring wheat research at AAFC Lacombe as part of a tour of consultants, July 29, 2013, Farmers Edge Inc., from various locations in AB. Provided an overview of integrated crop and disease management research.

# 2014

- Toured and outlined ongoing barley, canola, and winter wheat research at AAFC Lacombe as part of an All Crop Tour at AAFC and AARD Lacombe, AB, July 9, 2014. Provided an overview of integrated crop and disease management research.
- Toured and outlined ongoing barley, canola, and winter wheat research at AAFC Lacombe as part of a tour of a grower and consultant, July 29, 2014, Machelmi Ag. Consulting, Sexsmith Alberta. Provided an overview of integrated crop and disease management research at AAFC Lacombe.

## DR. Mike Harding, Alberta Agriculture and Rural Development (ARD), Pest Surveillance Branch, Crop Diversification Centre South, Brooks

# 2013

- Plant Pathology Society of Alberta Annual General Meeting, November 2013, Brooks, AB, ~50 people
- Canola Galla, July 2013, Brooks, AB ~100 people

# 2014

- Agronomy Update, January 2014, Red Deer, ~400 people (I had one slide in my presentation where I mentioned some things related to this study)
- Diagnostic Field School, June 2014, Lethbridge, ~300 people

- Canola Galla, July 2014, Brooks AB ~100 people

# 2015

- CDCS Internal Field Tour, August, 2015, Brooks, AB, ~50 people

## Smokey Applied Research & Demonstration Association (SARDA)

# 2013

- Self-Guided Tour **-** SARDA provided materials for Self-Guided Tours at the entrance of trial sites. This allowed producers, families and industry representatives to choose when to visit sites. Trial site directions appeared in SARDA's printed newsletter (The Back Forty) in June each year, mailed to 3,000 mail boxes and electronically sent to 450 persons. From start of July to end of Sept., a mail box at the site entrance held site maps (showed locations of all trials at the site) and trial maps (for each trial).
- **July 18, 2013**: SARDA Plot tour (18 attendees)

# 2014

- Self-Guided Tour (see above)
- **July 8, 2014**: Field School (54 attendees) a tour of plots

# 2015

- Self-Guided Tour (see above)
- **June 24, 2015**: Field School (50 attendees) a tour of plots

## Farming Smarter
## Popular Press

# 2013

- Spraying at first light may cost you herbicide efficacy

# 2014

- AFE Spray fungicides before breakfast July 9, 2014
- Does the time of day matter when applying herbicides
- Is spraying by moonlight effective? Western Producer July

# 2015

- Early morning best time to spay fungicides: trials

## Events

# 2013

- Feb. 19, MNP Farm Management Group, 10 people
- Feb. 28, Farming Smarter AGM 61 people
- June 13, Crop Walk, 63 people
- June 25-27 Farming Smarter Field School, 235 people

- Dec. 3-4, Farming Smarter Conference, 230 people

## 2014

- June 5, Crop Walk, 46 people
- June 19, Alberta Barley Commission tour, 3 people
- June 24, 25 & 26, Farming Smarter Field School, 263 people
- July 24, Pat Flatten, 1 person
- August 6, Bob Nixon (Nuffield Scholar), 1 person
- August 7, Disease Crop Walk, 43 people
- August 29, Chris Reichstein (Nuffield Scholar), 1 person
- Dec. 2-3, Farming Smarter Conference, 250 people

## 2015

- March 12, LARA (Ken invited speaker), 23 people
- July 6 – 10, BTAP Training, 24 people
- July 21, Dow Agronomy Tour – Hutterite, 110 people
- July 30, Disease Crop Walk, 49 people

# Appendix A

## Tables

Table 1. Project site locations, crops tested and the number of corresponding research plots established for the study.

| Location/Crop | Barley | Wheat | Canola | Peas | Total |
|---|---|---|---|---|---|
| | Number of research plots established | | | | |
| **Lethbridge** | 40 | 40 | 40 | 40 | 160 |
| **Brooks** | 48 | 48 | 48 | 48 | 192 |
| **Lacombe** | 40 | N/A | N/A | N/A | 40 |
| **Falher** | N/A | N/A | 40 | 40 | 80 |
| | | | | **Total plots/trials** | 472 |

Table 2. Selected fungicides with corresponding crops used in the study.

| Crop | Trade Name | Chemical Ai | Group | Activity* | Mobility | Classification | Treats | BB Rate | Units |
|---|---|---|---|---|---|---|---|---|---|
| **Barley** | Tilt 250E | Propiconazole | 3 | P & C | Systemic | Triazoles | Net blotch, scald | 101-202 | mL/ac |
| | Twinline | Pyraclostrobin Metconazole | 3, 11 | PRO & C | Systemic | Triazoles + Strobilurin | Net blotch, scald | 154-202 | mL/ac |
| | Quilt | Azoxystrobin Propiconazole | 3, 11 | P & C | Systemic | Triazoles + Strobilurin | Net blotch, scald | 303 | mL/ac |
| **Canola** | Quadris | Azoxystrobin | 11 | P | Systemic | Strobilurin | Sclerotinia | 283-404 | mL/ac |
| | Rovral RX | Iprodione | 2 | PRO | Contact | dicarboximide fungicides - *also, imidazole fungicides* | Sclerotinia | 0.85-1.25 | L/ac |
| | Vertisan | Penthiopyrad | 7 | P & C | Systemic | Amide | Sclerotinia | 500-600 | mL/ac |
| **Peas** | Acapela | Picoxystrobin | 11 | P & C | Systemic | antibiotic fungicides - strobilurin fungicides | Mycosphaerella | 240-350 | mL/ac |
| | Priaxor DS | Pyraclostrobin Xemium | 7, 11 | PRO & C | Systemic | Strobilurin | Mycosphaerella | 160 | mL/ac |
| | Lance | Boscalid | 7 | PRO | Contact | amide *Also, pyridine fungicides* | Ascochyta, mycosphaerella | 170 | g/ac |
| **Wheat** | Bravo 500 | Chlorothalonil | M | P | Contact | Aromatic fungicides | Tan spot, spot blotch, septoria | 0.6-1.0 | L/ac |
| | Caramba | Metconazole | 3 | P | Systemic | Triazoles | Tan spot, spot blotch, septoria | 202-283 | mL/ac |
| | Prosaro | Prothioconazole Tebuconazole | 3 | PRO & C | Systemic | Triazoles | Tan spot, spot blotch, septoria | 320 | mL/ac |

*** P = "Preventative", PRO = "Protective" and C = "Curative".**

**Table 3. Disease severity ratings for Wheat crop.**

| Treatment/Fungicide | Brooks Crop year | | | Lethbridge Crop year | | |
|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2013 | 2014 | 2015 |
| | Disease severity ratings for Wheat (Scale: 1 - 9) | | | | | |
| Control | 4.2 | 6.2 | 3.9 | 6.1 | 5.6 | 4.7 |
| Bravo | 4.3 | 6.3 | 3.9 | 5.6 | 3.0 | 4.0 |
| Caramba | 4.1 | 6.2 | 3.7 | 4.7 | 2.0 | 3.8 |
| Prosaro | 4.1 | 6.3 | 3.6 | 4.5 | 2.0 | 3.1 |
| Quilt | N/A | N/A | N/A | N/A | 4.5 | N/A |
| Tilt250E | N/A | N/A | N/A | N/A | 5.3 | N/A |
| Twinline | N/A | N/A | N/A | N/A | 4.2 | N/A |
| Average ratings | **4.2** | **6.3** | **3.8** | **5.2** | **3.8** | **3.9** |

**Table 4. Disease severity ratings for Barley crop.**

| Treatment/Fungicide | Brooks Crop year | | | Lethbridge Crop year | | | Lacombe Crop year | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2013 | 2014 | 2015 | 2013 | 2014 | 2015 |
| | Disease severity ratings for Barley (Scale: 1 - 9) | | | | | | | | |
| Control | 4.7 | 7.2 | 3.1 | 2.6 | 1.9 | 4.7 | 3.4 | 4.8 | N/A |
| Quilt | 4.5 | 7.7 | 3.2 | 2.0 | 0.2 | 3.6 | 3.1 | 3.8 | N/A |
| Tilt | 4.5 | 7.2 | 3.2 | 2.1 | 0.2 | 4.2 | 3.2 | 3.9 | N/A |
| Twinline | 4.6 | 7.3 | 3.3 | 2.0 | 0.2 | 3.7 | 3.2 | 3.8 | N/A |
| Bravo | N/A | N/A | N/A | N/A | 3.4 | N/A | N/A | N/A | N/A |
| Caramba | N/A | N/A | N/A | N/A | 3.2 | N/A | N/A | N/A | N/A |
| Prosaro | N/A | N/A | N/A | N/A | 2.4 | N/A | N/A | N/A | N/A |
| Average ratings | **4.6** | **7.3** | **3.2** | **2.2** | **1.7** | **4.0** | **3.2** | **4.1** | N/A |

**Table 5. Disease severity ratings for Canola crop.**

| Treatment/Fungicide | Brooks Crop year | | | Lethbridge Crop year | | | Falher Crop year | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2013 | 2014 | 2015 | 2013 | 2014 | 2015 |
| | Disease severity ratings for Canola (Scale: 0 - 5) | | | | | | | | |
| Control | 0.34 | N/A | N/A | 3.26 | 0.00 | 1.03 | N/A | N/A | N/A |
| Quadris | 0.26 | N/A | N/A | 2.85 | 0.00 | 0.59 | N/A | N/A | N/A |
| Rovral | 0.21 | N/A | N/A | 3.15 | 0.00 | 0.61 | N/A | N/A | N/A |
| Vertisan | 0.26 | N/A | N/A | 3.04 | 0.00 | 0.48 | N/A | N/A | N/A |
| Average ratings | **0.3** | N/A | N/A | **3.1** | **0.0** | **0.7** | N/A | N/A | N/A |

**Table 6. Table 5. Disease severity ratings for Peas crop.**

| Treatment/Fungicide | Brooks Crop year | | | Lethbridge Crop year | | | Falher Crop year | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2013 | 2014 | 2015 | 2013 | 2014 | 2015 |
| | Disease severity ratings for Peas (Scale: 0 - 5) | | | | | | | | |
| Check | 0.85 | N/A | 0.23 | N/A | 3.35 | N/A | N/A | N/A | N/A |
| Acapela | 0.87 | N/A | 0.28 | N/A | 4.72 | N/A | N/A | N/A | N/A |
| Lance | 0.88 | N/A | 0.28 | N/A | 4.41 | N/A | N/A | N/A | N/A |
| Priaxor | 0.86 | N/A | 0.24 | N/A | 4.43 | N/A | N/A | N/A | N/A |
| Average ratings | 0.87 | N/A | 0.26 | N/A | 4.23 | N/A | N/A | N/A | N/A |

**Table 7. Results of ANOVA and performance comparison of selected fungicides for barley crop with respect to the three distinct application timings. Treatment means with the same letter are not significantly different at p<0.1.**

| Barley Crop Year | Treatment | | Brooks Yield (kg ha$^{-1}$) | | Lethbridge Yield (kg ha$^{-1}$) | | Lacombe Yield (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | | | Treat. means | Rank | Treat. means | Rank | Treat. means | Rank |
| 2013 | Fungicide | Check | 7515 a | 3 | 3718 a | 3 | 12065 b | 4 |
| | | Quilt | 7416 a | 4 | 3845 a | 2 | 12554 ba | 2 |
| | | Tilt | 8320 a | 2 | 3702 a | 4 | 12398 ba | 3 |
| | | Twinline | 8990 a | 1 | 3854 a | 1 | 12629 a | 1 |
| | Application timing | Control | 7515 a | 4 | 3718 a | 4 | 12065 b | 4 |
| | | Day | 8363 a | 1 | 3752 a | 3 | 12379 ba | 3 |
| | | Night | 8322 a | 2 | 3832 a | 1 | 12688 a | 1 |
| | | Dawn | 8041 a | 3 | 3818 a | 2 | 12514 a | 2 |
| 2014 | Fungicide | Check | 6295 b | 3 | 7576 a | 2 | 8891 b | 4 |
| | | Quilt | 7330 a | 2 | 7548 a | 4 | 9716 a | 3 |
| | | Tilt | 6259 b | 4 | 7561 a | 3 | 9881 a | 2 |
| | | Twinline | 7688 a | 1 | 7604 a | 1 | 9993 a | 1 |
| | Application timing | Control | 6295 b | 4 | 7576 a | 2 | 8891 b | 4 |
| | | Day | 6986 a | 3 | 7789 a | 1 | 9973 a | 1 |
| | | Night | 7040 a | 2 | 7487 a | 3 | 9860 a | 2 |
| | | Dawn | 7251 a | 1 | 7438 a | 4 | 9757 a | 3 |
| 2014 | Fungicide | Check | N/A | N/A | 6710 b | 4 | N/A | N/A |
| | | Bravo | N/A | N/A | 6911 ba | 2 | N/A | N/A |
| | | Caramba | N/A | N/A | 6768 b | 3 | N/A | N/A |
| | | Prosaro | N/A | N/A | 7152 a | 1 | N/A | N/A |
| | Application timing | Control | N/A | N/A | 6768 a | 4 | N/A | N/A |
| | | Day | N/A | N/A | 6873 a | 3 | N/A | N/A |
| | | Night | N/A | N/A | 6874 a | 2 | N/A | N/A |
| | | Dawn | N/A | N/A | 7027 a | 1 | N/A | N/A |
| 2015 | Fungicide | Check | 1493 a | 1 | 7264 a | 4 | N/A | N/A |
| | | Quilt | 1467 a | 3 | 7670 a | 1 | N/A | N/A |
| | | Tilt | 1484 a | 2 | 7448 a | 3 | N/A | N/A |
| | | Twinline | 1380 a | 4 | 7635 a | 2 | N/A | N/A |
| | Application timing | Control | 1493 a | 1 | 7264 b | 4 | N/A | N/A |
| | | Day | 1448 a | 3 | 7447 ba | 3 | N/A | N/A |
| | | Night | 1416 a | 4 | 7690 a | 1 | N/A | N/A |
| | | Dawn | 1466 a | 2 | 7616 ba | 2 | N/A | N/A |
| **Application timing Summary with respect to yield ranking** (% of the total occurrences) | | | | | | | | |
| Day time more effective than Dawn time | | | 33 | | 25 | | 50 | |
| Night time more effective than Dawn time | | | 33 | | 75 | | 50 | |
| Dawn time more effective than Day and/or Night time | | | 67 | | 75 | | 50 | |

**Table 8. Results of ANOVA and performance comparison of selected fungicides for wheat crop with respect to the three distinct application timings. Treatment means with the same letter are not significantly different at p<0.1.**

| Wheat Crop Year | Treatment | | Brooks Yield (kg ha$^{-1}$) | | Lethbridge Yield (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|
| | | | Treat. means | Rank | Treat. means | Rank |
| 2013 | Fungicide | Check | 7040 a | 4 | 3673 a | 3 |
| | | Bravo | 7529 a | 1 | 3620 a | 4 |
| | | Caramba | 7400 a | 2 | 3789 a | 1 |
| | | Prosaro | 7262 a | 3 | 3759 a | 2 |
| | Application timing | Control | 7040 a | 4 | 3673 a | 3 |
| | | Day | 7758 a | 1 | 3650 a | 4 |
| | | Night | 7250 a | 2 | 3721 a | 2 |
| | | Dawn | 7183 a | 3 | 3797 a | 1 |
| 2014 | Fungicide | Check | 5445 a | 3 | 6703 a | 4 |
| | | Bravo | 5266 a | 4 | 6943 a | 2 |
| | | Caramba | 5558 a | 2 | 6914 a | 3 |
| | | Prosaro | 5622 a | 1 | 6953 a | 1 |
| | Application timing | Control | 5445 a | 2 | 6703 a | 4 |
| | | Day | 5415 a | 3 | 6927 a | 2 |
| | | Night | 5360 a | 4 | 7023 a | 1 |
| | | Dawn | 5671 a | 1 | 6860 a | 3 |
| 2014 | Fungicide | Check | N/A | N/A | 6189 c | 4 |
| | | Quilt | N/A | N/A | 6491 bc | 3 |
| | | Tilt250E | N/A | N/A | 6718 ab | 2 |
| | | Twinline | N/A | N/A | 7096 a | 1 |
| | Application timing | Control | N/A | N/A | 6189 b | 4 |
| | | Day | N/A | N/A | 6781 a | 1 |
| | | Night | N/A | N/A | 6778 a | 2 |
| | | Dawn | N/A | N/A | 6746 a | 3 |
| 2015 | Fungicide | Check | 3533 a | 4 | 6343 a | 1 |
| | | Bravo | 3861 a | 2 | 6252 a | 4 |
| | | Caramba | 3934 a | 1 | 6325 a | 2 |
| | | Prosaro | 3847 a | 3 | 6261 a | 3 |
| | Application timing | Control | 3533 b | 4 | 6343 a | 1 |
| | | Day | 3938 a | 1 | 6292 a | 3 |
| | | Night | 3888 a | 2 | 6325 a | 2 |
| | | Dawn | 3816 a | 3 | 6218 a | 4 |
| **Application timing Summary with respect to yield ranking** (% of the total occurrences) | | | | | | |
| Day time more effective than Dawn time | | | 67 | | 75 | |
| Night time more effective than Dawn time | | | 67 | | 75 | |
| Dawn time more effective than Day and/or Night time | | | 33 | | 25 | |

**Table 9. Results of ANOVA and performance comparison of selected fungicides for canola crop with respect to the three distinct application timings. Treatment means with the same letter are not significantly different at p<0.1.**

| Canola Crop Year | Treatment | | Brooks Yield (kg ha$^{-1}$) | | Lethbridge (Farming Smarter) Yield (kg ha$^{-1}$) | | Falher (SARDA) Yield (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | | | Treat. means | Rank | Treat. means | Rank | Treat. means | Rank |
| 2013 | Fungicide | Control | 2071 a | 4 | 2229 a | 4 | 3620 a | 2 |
| | | Quadris | 2445 a | 1 | 2240 a | 3 | 3586 a | 3 |
| | | Rovral | 2161 a | 3 | 2247 a | 2 | 3514 a | 4 |
| | | Vertisan | 2288 a | 2 | 2355 a | 1 | 3628 a | 1 |
| | Application timing | Control | 2071 a | 4 | 2229 a | 4 | 3620 a | 1 |
| | | Day | 2545 a | 1 | 2320 a | 1 | 3560 a | 3 |
| | | Night | 2254 a | 2 | 2283 a | 2 | 3559 a | 4 |
| | | Dawn | 2117 a | 3 | 2240 a | 3 | 3609 a | 2 |
| 2014 | Fungicide | Control | 4760 a | 2 | 3156 a | 4 | 2611 b | 3 |
| | | Quadris | 4971 a | 1 | 3317 a | 1 | 3142 a | 1 |
| | | Rovral | 4518 a | 3 | 3249 a | 2 | 2530 b | 4 |
| | | Vertisan | 4434 a | 4 | 3169 a | 3 | 2842 ab | 2 |
| | Application timing | Control | 4760 ab | 2 | 3156 a | 4 | 2611 b | 4 |
| | | Day | 4582 ab | 3 | 3322 a | 1 | 2800 a | 3 |
| | | Night | 4857 a | 1 | 3177 a | 3 | 2857 a | 1 |
| | | Dawn | 4484 b | 4 | 3237 a | 2 | 2856 a | 2 |
| 2015 | Fungicide | Control | 3800 a | 1 | 3339 a | 1 | 2945 ab | 3 |
| | | Quadris | 3707 a | 2 | 2986 a | 4 | 3684 a | 1 |
| | | Rovral | 3475 a | 3 | 3242 a | 3 | 3280 ab | 2 |
| | | Vertisan | 3318 a | 4 | 3308 a | 2 | 2753 b | 4 |
| | Application timing | Control | 3800 a | 2 | 3339 a | 1 | 2945 a | 4 |
| | | Day | 3395 a | 3 | 3223 a | 3 | 3230 a | 3 |
| | | Night | 3289 a | 4 | 3247 a | 2 | 3253 a | 1 |
| | | Dawn | 3817 a | 1 | 3066 a | 4 | 3235 a | 2 |
| **Application timing Summary with respect to yield ranking** (% of the total occurrences) | | | | | | | | |
| Day time application more effective than Dawn time | | | 67 | | 100 | | 33 | |
| Night time application more effective than Dawn time | | | 67 | | 67 | | 67 | |
| Dawn time application more effective than Day and/or Night time applications | | | 33 | | 33 | | 100 | |

**Table 10. Results of ANOVA and performance comparison of selected fungicides for peas crop with respect to the three distinct application timings. Treatment means with the same letter are not significantly different at p<0.1.**

| Peas Crop Year | Treatment | | Brooks Yield (kg ha$^{-1}$) | | Lethbridge Yield (kg ha$^{-1}$) | | Falher Yield (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | | | Treat. means | Rank | Treat. means | Rank | Treat. means | Rank |
| 2013 | Fungicide | Check | 7310 b | 4 | 3060 a | 3 | 6669 b | 3 |
| | | Acapela | 8576 ba | 2 | 3183 a | 2 | 7405 a | 2 |
| | | Lance | 8280 ba | 3 | 2844 a | 4 | 6616 b | 4 |
| | | Priaxor | 9018 a | 1 | 3214 a | 1 | 7821 a | 1 |
| | Application timing | Control | 7310 b | 4 | 3060 a | 3 | 6669 c | 4 |
| | | Day | 8450 a | 3 | 3128 a | 2 | 7085 b | 3 |
| | | Night | 8609 a | 2 | 2820 a | 4 | 7218 ab | 2 |
| | | Dawn | 8864 a | 1 | 3293 a | 1 | 7538 a | 1 |
| 2014 | Fungicide | Check | 3510 a | 2 | 4280 a | 4 | 4675 a | 1 |
| | | Acapela | 3241 a | 3 | 4700 a | 1 | 4382 a | 3 |
| | | Lance | 3110 a | 4 | 4396 a | 3 | 4184 a | 4 |
| | | Priaxor | 3611 a | 1 | 4664 a | 2 | 4398 a | 2 |
| | Application timing | Control | 3510 a | 1 | 4280 a | 4 | 4675 a | 1 |
| | | Day | 3210 a | 4 | 4570 a | 3 | 4307 a | 4 |
| | | Night | 3394 a | 2 | 4612 a | 1 | 4344 a | 2 |
| | | Dawn | 3357 a | 3 | 4578 a | 2 | 4313 a | 3 |
| 2015 | Fungicide | Check | 9171 a | 3 | 6813 a | 1 | 2990 b | 4 |
| | | Acapela | 8930 a | 4 | 6377 a | 4 | 3089 b | 3 |
| | | Lance | 9485 a | 2 | 6560 a | 3 | 3677 a | 1 |
| | | Priaxor | 9619 a | 1 | 6616 a | 2 | 3416 ab | 2 |
| | Application timing | Control | 9171 a | 4 | 6813 a | 1 | 2989 b | 4 |
| | | Day | 9253 a | 2 | 6372 a | 4 | 3498 a | 1 |
| | | Night | 9560 a | 1 | 6522 a | 3 | 3287 ab | 3 |
| | | Dawn | 9222 a | 3 | 6742 a | 2 | 3398 ab | 2 |
| **Application timing Summary with respect to yield ranking** (% of the total occurrences) | | | | | | | | |
| Day time more effective than Dawn time | | | 33 | | 0 | | 33 | |
| Night time more effective than Dawn time | | | 67 | | 33 | | 33 | |
| Dawn time more effective than Day and/or Night time | | | 67 | | 100 | | 67 | |

**Table 11. Fungicides' performance comparison with respect to three application timings on Barley crop. Treatment yield means with the same letter are not significantly different at p<0.1.**

| Barley Crop year ↓ | Fungicide | Application Timing | Brooks | | | Lethbridge | | | Lacombe | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yield (kg ha$^{-1}$) | | Disease | Yield (kg ha$^{-1}$) | | Disease | Yield (kg ha$^{-1}$) | | Disease |
| | | | Trt. means | Rank | Rating Rank | Trt. means | Rank | Rating Rank | Trt. means | Rank | Rating Rank |
| 2013 | Quilt | Control | 7515 a | 2 | 1 | 3718 a | 4 | 1 | 12065 c | 4 | 1 |
| | | Day | 8248 a | 1 | 3 | 3846 a | 2 | 2 | 12400 bc | 3 | 3 |
| | | Night | 6736 a | 4 | 2 | 3869 a | 1 | 4 | 12795 a | 1 | 2 |
| | | Dawn | 7263 a | 3 | 4 | 3821 a | 3 | 3 | 12467 ba | 2 | 4 |
| | Tilt | Control | 7515 ba | 3 | 1 | 3718 a | 3 | 1 | 12065 a | 4 | 1 |
| | | Day | 6753 b | 4 | 2 | 3722 a | 2 | 2 | 12386 a | 2 | 4 |
| | | Night | 10616 a | 1 | 3 | 3807 a | 1 | 3 | 12379 a | 3 | 3 |
| | | Dawn | 7591 ba | 2 | 4 | 3578 a | 4 | 4 | 12430 a | 1 | 2 |
| | Twinline | Control | 7515 a | 4 | 2 | 3718 a | 3 | 1 | 12065 b | 4 | 1 |
| | | Day | 10089 a | 1 | 1 | 3688 a | 4 | 3 | 12353 ba | 3 | 4 |
| | | Night | 7613 a | 3 | 4 | 3819 a | 2 | 4 | 12890 a | 1 | 2 |
| | | Dawn | 9268 a | 2 | 3 | 4054 a | 1 | 2 | 12645 ba | 2 | 3 |
| 2014 | Quilt | Control | 6295 b | 4 | 4 | 7576 a | 3 | 1 | 8891 c | 4 | 1 |
| | | Day | 7784 a | 1 | 3 | 7608 a | 1 | 2 | 10031 a | 1 | 2 |
| | | Night | 7199 ba | 2 | 2 | 7583 a | 2 | 3 | 9650 ba | 2 | 4 |
| | | Dawn | 7007 ba | 3 | 1 | 7455 a | 4 | 4 | 9467 b | 3 | 3 |
| | Tilt | Control | 6295 a | 2 | 4 | 7576 a | 2 | 1 | 8891 b | 4 | 1 |
| | | Day | 6012 a | 3 | 1 | 8283 a | 1 | 2 | 9977 a | 1 | 4 |
| | | Night | 5902 a | 4 | 3 | 7164 a | 4 | 3 | 9881 a | 2 | 3 |
| | | Dawn | 6864 a | 1 | 2 | 7238 a | 3 | 4 | 9786 a | 3 | 2 |
| | Twinline | Control | 6295 b | 4 | 3 | 7576 a | 3 | 1 | 8891 b | 4 | 1 |
| | | Day | 7161 ba | 3 | 4 | 7477 a | 4 | 2 | 9913 a | 3 | 3 |
| | | Night | 8020 a | 1 | 1 | 7713 a | 1 | 3 | 10048 a | 1 | 2 |
| | | Dawn | 7884 a | 2 | 2 | 7621 a | 2 | 4 | 10017 a | 2 | 4 |
| 2014 | Bravo | Control | N/A | N/A | N/A | 6768 a | 3 | 1 | N/A | N/A | N/A |
| | | Day | N/A | N/A | N/A | 6486 a | 4 | 4 | N/A | N/A | N/A |
| | | Night | N/A | N/A | N/A | 6823 a | 1 | 3 | N/A | N/A | N/A |
| | | Dawn | N/A | N/A | N/A | 6822 a | 2 | 2 | N/A | N/A | N/A |
| | Caramba | Control | N/A | N/A | N/A | 6768 b | 3 | 1 | N/A | N/A | N/A |
| | | Day | N/A | N/A | N/A | 6883 ba | 2 | 3 | N/A | N/A | N/A |
| | | Night | N/A | N/A | N/A | 6687 b | 4 | 4 | N/A | N/A | N/A |
| | | Dawn | N/A | N/A | N/A | 7164 a | 1 | 2 | N/A | N/A | N/A |
| | Prosaro | Control | N/A | N/A | N/A | 6768 a | 4 | 1 | N/A | N/A | N/A |
| | | Day | N/A | N/A | N/A | 7250 a | 1 | 3 | N/A | N/A | N/A |
| | | Night | N/A | N/A | N/A | 7112 a | 2 | 2 | N/A | N/A | N/A |
| | | Dawn | N/A | N/A | N/A | 7094 a | 3 | 4 | N/A | N/A | N/A |
| 2015 | Quilt | Control | 1494 a | 2 | 3 | 7264 b | 4 | 1 | N/A | N/A | N/A |
| | | Day | 1447 a | 3 | 2 | 7632 ba | 2 | 3 | N/A | N/A | N/A |
| | | Night | 1418 a | 4 | 1 | 7870 a | 1 | 4 | N/A | N/A | N/A |
| | | Dawn | 1536 a | 1 | 4 | 7510 ba | 3 | 2 | N/A | N/A | N/A |
| | Tilt | Control | 1494 a | 3 | 4 | 7264 a | 3 | 1 | N/A | N/A | N/A |
| | | Day | 1561 a | 1 | 1 | 7239 a | 4 | 3 | N/A | N/A | N/A |
| | | Night | 1385 a | 4 | 2 | 7382 a | 2 | 4 | N/A | N/A | N/A |
| | | Dawn | 1505 a | 2 | 3 | 7725 a | 1 | 2 | N/A | N/A | N/A |
| | Twinline | Control | 1494 a | 1 | 4 | 7264 a | 4 | 1 | N/A | N/A | N/A |
| | | Day | 1335 a | 4 | 1 | 7471 a | 3 | 4 | N/A | N/A | N/A |
| | | Night | 1447 a | 2 | 2 | 7820 a | 1 | 3 | N/A | N/A | N/A |
| | | Dawn | 1357 a | 3 | 3 | 7615 a | 2 | 2 | N/A | N/A | N/A |
| **Application timing Summary with respect to yield ranking** (% of the total occurrences) | | | | | | | | | | | |
| Day time more effective than Dawn time | | | 44 | | | 50 | | | 33 | | |
| Night time more effective than Dawn time | | | 44 | | | 67 | | | 83 | | |
| Dawn time more effective than Day and/or Night time | | | 56 | | | 50 | | | 67 | | |

**Table 12. Performance comparison of fungicides with respect to three application timings on Wheat crop. Treatment yield means with the same letter are not significantly different at p<0.1.**

| Wheat Crop year ↓ | Fungicide | Application Timing | Brooks | | | Lethbridge | | |
|---|---|---|---|---|---|---|---|---|
| | | | Yield (kg ha$^{-1}$) | | Disease Rating | Yield (kg ha$^{-1}$) | | Disease Rating |
| | | | Trt. means | Rank | Rank | Trt. means | Rank | Rank |
| 2013 | Bravo | Control | 7040 a | 3 | 2 | 3673 a | 2 | 1 |
| | | Day | 8478 a | 1 | 4 | 3603 a | 3 | 2 |
| | | Night | 7712 a | 2 | 3 | 3582 a | 4 | 4 |
| | | Dawn | 6397 a | 4 | 1 | 3675 a | 1 | 3 |
| | Caramba | Control | 7040 a | 3 | 1 | 3673 a | 4 | 1 |
| | | Day | 7955 a | 1 | 2 | 3744 a | 3 | 2 |
| | | Night | 6403 a | 4 | 3 | 3819 a | 1 | 3 |
| | | Dawn | 7843 a | 2 | 4 | 3804 a | 2 | 4 |
| | Prosaro | Control | 7040 a | 3 | 2 | 3673 a | 3 | 1 |
| | | Day | 6842 a | 4 | 4 | 3604 a | 4 | 3 |
| | | Night | 7636 a | 1 | 3 | 3763 a | 2 | 4 |
| | | Dawn | 7308 a | 2 | 1 | 3911 a | 1 | 2 |
| 2014 | Bravo | Control | 5445 a | 2 | 4 | 6703 a | 4 | 2 |
| | | Day | 5428 a | 3 | 1 | 7027 a | 1 | 3 |
| | | Night | 4741 a | 4 | 2 | 6960 a | 2 | 4 |
| | | Dawn | 5628 a | 1 | 3 | 6842 a | 3 | 1 |
| | Caramba | Control | 5445 a | 3 | 1 | 6703 a | 4 | 1 |
| | | Day | 5509 a | 2 | 2 | 6838 a | 2 | 2 |
| | | Night | 5425 a | 4 | 3 | 7142 a | 1 | 4 |
| | | Dawn | 5739 a | 1 | 4 | 6761 a | 3 | 3 |
| | Prosaro | Control | 5445 a | 3 | 2 | 6703 a | 4 | 1 |
| | | Day | 5307 a | 4 | 1 | 6915 a | 3 | 2 |
| | | Night | 5913 a | 1 | 3 | 6966 a | 2 | 4 |
| | | Dawn | 5646 a | 2 | 4 | 6978 a | 1 | 3 |
| 2014 | Quilt | Control | N/A | N/A | N/A | 6189 a | 4 | 1 |
| | | Day | N/A | N/A | N/A | 6412 a | 3 | 2 |
| | | Night | N/A | N/A | N/A | 6446 a | 2 | 3 |
| | | Dawn | N/A | N/A | N/A | 6615 a | 1 | 4 |
| | Tilt 250E | Control | N/A | N/A | N/A | 6189 b | 4 | 1 |
| | | Day | N/A | N/A | N/A | 6847 a | 1 | 2 |
| | | Night | N/A | N/A | N/A | 6686 ab | 2 | 3 |
| | | Dawn | N/A | N/A | N/A | 6622 ab | 3 | 4 |
| | Twinline | Control | N/A | N/A | N/A | 6189 b | 4 | 1 |
| | | Day | N/A | N/A | N/A | 7083 a | 2 | 2 |
| | | Night | N/A | N/A | N/A | 7203 a | 1 | 3 |
| | | Dawn | N/A | N/A | N/A | 7003 a | 3 | 4 |
| 2015 | Bravo | Control | 3533 a | 4 | 2 | 6343 a | 2 | 1 |
| | | Day | 3808 a | 2 | 4 | 6357 a | 1 | 2 |
| | | Night | 4063 a | 1 | 3 | 6241 a | 3 | 3 |
| | | Dawn | 3714 a | 3 | 1 | 6160 a | 4 | 4 |
| | Caramba | Control | 3533 a | 4 | 1 | 6343 a | 2 | 1 |
| | | Day | 4083 a | 1 | 4 | 6323 a | 3 | 4 |
| | | Night | 3775 a | 3 | 3 | 6481 a | 1 | 3 |
| | | Dawn | 3943 a | 2 | 2 | 6170 a | 4 | 2 |
| | Prosaro | Control | 3533 a | 4 | 1 | 6343 a | 1 | 1 |
| | | Day | 3923 a | 1 | 4 | 6204 a | 4 | 4 |
| | | Night | 3827 a | 2 | 2 | 6255 a | 3 | 2 |
| | | Dawn | 3792 a | 3 | 3 | 6325 a | 2 | 3 |
| **Application timing Summary with respect to yield ranking** (% of the total occurrences) | | | | | | | | |
| Day time more effective than Dawn time | | | 56 | | | 50 | | |
| Night time more effective than Dawn time | | | 56 | | | 58 | | |
| Dawn time more effective than Day and/or Night time | | | 44 | | | 50 | | |

**Table 13. Fungicides' performance comparison with respect to three application timings on Canola crop. Treatment yield means with the same letter are not significantly different at p<0.1.**

| Crop year ↓ | Fungicide | Application Timing | Brooks | | | Lethbridge | | | Falher | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yield (kg ha$^{-1}$) | | Disease Rating Rank | Yield (kg ha$^{-1}$) | | Disease Rating Rank | Yield (kg ha$^{-1}$) | | Disease Rating Rank |
| | | | Trt. means | Rank | | Trt. means | Rank | | Trt. means | Rank | |
| 2013 | Quadris | Control | 2041 a | 4 | 1 | 2229 a | 3 | 1 | 3620 a | 2 | N/A |
| | | Day | 2501 a | 1 | 2 | 2145 a | 4 | 3 | 3584 a | 3 | N/A |
| | | Night | 2420 a | 2 | 3 | 2273 a | 2 | 2 | 3536 a | 4 | N/A |
| | | Dawn | 2415 a | 3 | 4 | 2303 a | 1 | 4 | 3637 a | 1 | N/A |
| | Rovral | Control | 2041 a | 2 | 1 | 2229 a | 2 | 2 | 3620 a | 1 | N/A |
| | | Day | 2567 a | 1 | 4 | 2466 a | 1 | 4 | 3479 a | 3 | N/A |
| | | Night | 1953 a | 4 | 3 | 2062 a | 4 | 1 | 3478 a | 4 | N/A |
| | | Dawn | 1964 a | 3 | 2 | 2213 a | 3 | 3 | 3586 a | 2 | N/A |
| | Vertisan | Control | 2041 a | 3 | 1 | 2229 a | 3 | 1 | 3620 a | 2 | N/A |
| | | Day | 2572 a | 1 | 4 | 2350 a | 2 | 2 | 3618 a | 3 | N/A |
| | | Night | 2389 a | 2 | 3 | 2513 a | 1 | 4 | 3662 a | 1 | N/A |
| | | Dawn | 1974 a | 4 | 2 | 2203 a | 4 | 3 | 3604 a | 4 | N/A |
| 2014 | Quadris | Control | 4760 a | 4 | N/A | 3156 a | 4 | N/A | 2611 b | 4 | N/A |
| | | Day | 4891 a | 3 | N/A | 3333 a | 2 | N/A | 3182 a | 2 | N/A |
| | | Night | 4996 a | 2 | N/A | 3200 a | 3 | N/A | 3061 a | 3 | N/A |
| | | Dawn | 5026 a | 1 | N/A | 3418 a | 1 | N/A | 3183 a | 1 | N/A |
| | Rovral | Control | 4760 a | 2 | N/A | 3156 a | 4 | N/A | 2611 a | 1 | N/A |
| | | Day | 4532 a | 3 | N/A | 3287 a | 1 | N/A | 2409 a | 4 | N/A |
| | | Night | 4887 a | 1 | N/A | 3259 a | 2 | N/A | 2590 a | 3 | N/A |
| | | Dawn | 4136 a | 4 | N/A | 3201 a | 3 | N/A | 2590 a | 2 | N/A |
| | Vertisan | Control | 4760 a | 1 | N/A | 3156 a | 2 | N/A | 2611 a | 4 | N/A |
| | | Day | 4323 a | 3 | N/A | 3345 a | 1 | N/A | 2809 a | 2 | N/A |
| | | Night | 4688 a | 2 | N/A | 3072 a | 4 | N/A | 2922 a | 1 | N/A |
| | | Dawn | 4292 a | 4 | N/A | 3092 a | 3 | N/A | 2794 a | 3 | N/A |
| 2015 | Quadris | Control | 3841 a | 2 | N/A | 3339 a | 1 | 1 | 2945 b | 4 | N/A |
| | | Day | 3448 a | 3 | N/A | 3123 ab | 2 | 3 | 3802 a | 1 | N/A |
| | | Night | 3327 a | 4 | N/A | 3048 ab | 3 | 2 | 3566 ab | 3 | N/A |
| | | Dawn | 4348 a | 1 | N/A | 2787 b | 4 | 4 | 3684 a | 2 | N/A |
| | Rovral | Control | 3753 a | 2 | N/A | 3339 a | 2 | 1 | 2945 a | 4 | N/A |
| | | Day | 3209 a | 4 | N/A | 3137 a | 3 | 2 | 3361 a | 2 | N/A |
| | | Night | 3347 a | 3 | N/A | 3526 a | 1 | 4 | 3485 a | 1 | N/A |
| | | Dawn | 3870 a | 1 | N/A | 3062 a | 4 | 3 | 2994 a | 3 | N/A |
| | Vertisan | Control | 3806 a | 1 | N/A | 3339 a | 3 | 1 | 2945 a | 2 | N/A |
| | | Day | 3528 a | 2 | N/A | 3409 a | 1 | 2 | 2526 a | 4 | N/A |
| | | Night | 3192 a | 4 | N/A | 3167 a | 4 | 3 | 2708 a | 3 | N/A |
| | | Dawn | 3234 a | 3 | N/A | 3349 a | 2 | 4 | 3026 a | 1 | N/A |

| **Application timing Summary with respect to yield ranking** (% of the total occurrences) | Brooks | Lethbridge | Falher |
|---|---|---|---|
| Day time more effective than Dawn time | 67 | 78 | 44 |
| Night time more effective than Dawn time | 44 | 44 | 33 |
| Dawn time more effective than Day and/or Night time applications | 33 | 22 | 56 |

Table 14. Fungicides' performance comparison with respect to three application timings on Peas yield. Treatment yield means with the same letter are not significantly different at p<0.1.

| Crop year ↓ | Fungicide | Application Timing | Brooks | | | Lethbridge | | | Falher | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yield (kg ha$^{-1}$) | | Disease | Yield (kg ha$^{-1}$) | | Disease | Yield (kg ha$^{-1}$) | | Disease |
| | | | Trt. means | Rank | Rating Rank | Trt. means | Rank | Rating Rank | Trt. means | Rank | Rating Rank |
| 2013 | Acapela | Control | 6832 a | 4 | 3 | 3060 a | 3 | N/A | 6669 c | 4 | N/A |
| | | Day | 8421 a | 3 | 2 | 3099 a | 2 | N/A | 7168 b | 3 | N/A |
| | | Night | 8565 a | 2 | 4 | 2900 a | 4 | N/A | 7367 ab | 2 | N/A |
| | | Dawn | 8743 a | 1 | 1 | 3549 a | 1 | N/A | 7681 a | 1 | N/A |
| | Lance | Control | 6577 b | 4 | 3 | 3060 a | 1 | N/A | 6669 a | 2 | N/A |
| | | Day | 8108 ab | 3 | 2 | 2942 a | 3 | N/A | 6505 a | 4 | N/A |
| | | Night | 8405 a | 1 | 4 | 2612 a | 4 | N/A | 6588 a | 3 | N/A |
| | | Dawn | 8344 a | 2 | 1 | 2977 a | 2 | N/A | 6754 a | 1 | N/A |
| | Priaxor | Control | 8521 a | 4 | 4 | 3060 a | 3 | N/A | 6669 b | 4 | N/A |
| | | Day | 8821 a | 3 | 1 | 3343 a | 2 | N/A | 7582 a | 3 | N/A |
| | | Night | 8856 a | 2 | 2 | 2947 a | 4 | N/A | 7700 a | 2 | N/A |
| | | Dawn | 9376 a | 1 | 3 | 3353 a | 1 | N/A | 8180 a | 1 | N/A |
| 2014 | Acapela | Control | 2800 ab | 3 | N/A | 4280 a | 4 | 4 | 4675 a | 1 | N/A |
| | | Day | 2537 b | 4 | N/A | 4602 a | 3 | 1 | 4629 a | 2 | N/A |
| | | Night | 3132 ab | 2 | N/A | 4722 a | 2 | 2 | 4298 a | 3 | N/A |
| | | Dawn | 4055 a | 1 | N/A | 4776 a | 1 | 3 | 4221 a | 4 | N/A |
| | Lance | Control | 3870 a | 1 | N/A | 4280 a | 3 | 4 | 4675 a | 1 | N/A |
| | | Day | 3058 a | 3 | N/A | 4526 a | 1 | 1 | 4022 b | 4 | N/A |
| | | Night | 3558 a | 2 | N/A | 4506 a | 2 | 3 | 4243 ab | 3 | N/A |
| | | Dawn | 2712 a | 4 | N/A | 4156 a | 4 | 2 | 4288 ab | 2 | N/A |
| | Priaxor | Control | 3860 a | 2 | N/A | 4280 a | 4 | 4 | 4675 a | 1 | N/A |
| | | Day | 4035 a | 1 | N/A | 4582 a | 3 | 2 | 4272 a | 4 | N/A |
| | | Night | 3492 a | 3 | N/A | 4609 a | 2 | 1 | 4491 a | 2 | N/A |
| | | Dawn | 3306 a | 4 | N/A | 4801 a | 1 | 3 | 4430 a | 3 | N/A |
| 2015 | Acapela | Control | 9569 a | 1 | 4 | 6813 a | 1 | N/A | 2990 a | 4 | N/A |
| | | Day | 8884 a | 3 | 3 | 6242 a | 4 | N/A | 3235 a | 1 | N/A |
| | | Night | 9290 a | 2 | 1 | 6355 a | 3 | N/A | 3041 a | 2 | N/A |
| | | Dawn | 8617 a | 4 | 2 | 6678 a | 2 | N/A | 2993 a | 3 | N/A |
| | Lance | Control | 9311 a | 3 | 3 | 6813 a | 1 | N/A | 2990 b | 4 | N/A |
| | | Day | 9289 a | 4 | 4 | 6514 a | 3 | N/A | 3789 a | 1 | N/A |
| | | Night | 9690 a | 1 | 1 | 6366 a | 4 | N/A | 3616 ab | 3 | N/A |
| | | Dawn | 9477 a | 2 | 2 | 6800 a | 2 | N/A | 3626 ab | 2 | N/A |
| | Priaxor | Control | 8634 a | 4 | 4 | 6813 a | 1 | N/A | 2990 b | 4 | N/A |
| | | Day | 9585 a | 2 | 3 | 6361 a | 4 | N/A | 3470 ab | 2 | N/A |
| | | Night | 9700 a | 1 | 1 | 6802 a | 2 | N/A | 3204 ab | 3 | N/A |
| | | Dawn | 9574 a | 3 | 2 | 6707 a | 3 | N/A | 3574 a | 1 | N/A |
| **Application timing Summary with respect to yield ranking** (% of the total occurrences) | | | | | | | | | | | |
| Day time more effective than Dawn time | | | 44 | | | 11 | | | 33 | | |
| Night time more effective than Dawn time | | | 56 | | | 11 | | | 22 | | |
| Dawn time more effective than Day and/or Night time | | | 56 | | | 89 | | | 67 | | |

**Table 15. Results summary comparing how often (percent of the total occurrences) the three distinct application timings, were effective for fungicide application. The effectiveness of the application timings was assessed using the rankings of crop yield averages.**

| Crop | Location | Day time more effective than Dawn time | Night time more effective than Dawn time | Dawn time more effective than Day and/or Night time |
|---|---|---|---|---|
| | | % of the total occurrences | | |
| Barley | Lethbridge | 50 | 67 | 50 |
| | Brooks | 44 | 44 | 56 |
| | Lacombe | 33 | 83 | 67 |
| | Falher | Not Applicable/Available (N/A) | N/A | N/A |
| Wheat | Lethbridge | 50 | 58 | 50 |
| | Brooks | 56 | 56 | 44 |
| | Lacombe | N/A | N/A | N/A |
| | Falher | N/A | N/A | N/A |
| Canola | Lethbridge | 78 | 44 | 22 |
| | Brooks | 67 | 44 | 33 |
| | Lacombe | N/A | N/A | N/A |
| | Falher | 44 | 33 | 56 |
| Peas | Lethbridge | 11 | 11 | 89 |
| | Brooks | 44 | 56 | 56 |
| | Lacombe | N/A | N/A | N/A |
| | Falher | 33 | 22 | 67 |

**Table 16. Results summary comparing how often (percent of the total occurrences) disease ratings assessed by our field staff during the season were corroborated by average crop grain yields. Yield means were ranked from the highest (rank 1) to the lowest (rank 4) with moderate (rank 2) and low (rank 3) in between. Disease severity ratings were scaled between the highest severity (rank 4) to the lowest severity/no disease (rank 1) with moderate severity (rank 2) and low severity (rank 3) in between.**

| Crop/Location | Brooks | Lethbridge | Lacombe | Falher |
|---|---|---|---|---|
| Barley | 8 out of 36 (22%) | 10 out of 48 (21%) | 10 out of 24 (42%) | N/A |
| Wheat | 13 out of 36 (36%) | 16 out of 48 (33%) | N/A | N/A |
| Canola | 6 out of 12 (50%) | 8 out of 24 (33%) | N/A | N/A |
| Peas | 6 out of 24 (25%) | 2 out of 12 (17%) | N/A | N/A |