

# Integrated Disease Management of Leaf Spots and Crown Rust of Oat

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## Abstract

Crown rust and leaf spots can reduce the yield and quality of oats. The objective of this research was to determine the effect of conventional fungicides, Actigard® and oat cultivars that vary in resistance to crown rust on leaf spot and crown rust severity, and oat yield and quality. Two experiments were established at each location in Saskatchewan: Saskatoon and Melfort. Experiment one consisted of three oat varieties: AC Morgan (crown rust susceptible), CDC Dancer (intermediate) and CDC Morrison (resistant) and three fungicide treatments: check (unsprayed), propiconazole and pyraclostrobin. Experiment two consisted of the application of Actigard® at two rates: 8.75 g ai/ha and 26.25 g ai/ha; three crop growth stages: seedling, boot and heading; on two varieties: CDC Dancer and CDC Morrison, with an unsprayed check for each variety. At Saskatoon, crown rust was observed while leaf spot severity was low. At Melfort, no crown rust was observed but leaf spot severity was low to moderate. Fungicide reduced the severity of crown rust and increased yield and quality of oat at Saskatoon for the susceptible variety (AC Morgan) and somewhat for the moderately susceptible variety (CDC Dancer). The crown rust resistant variety (CDC Morrison) did not benefit from fungicide. Leaf spots were reduced by fungicide application at Melfort, but little increase in yield or quality was detected. There was little difference between AC Morgan and CDC Morrison for leaf spot symptoms, but CDC Dancer appeared to suffer slightly more than the other varieties. There was no impact of fungicide on beta-glucan content at either location, although there were differences among varieties, but only at Saskatoon. Actigard® was not observed to have any positive or negative effects on disease severity (crown rust or leaf spots) or any of the factors measured, including nutritional characteristics, at either location, although there were differences among varieties for many of the factors measured.

## Introduction

Crown rust (*Puccinia coronata* Corda f. sp *avenae* Eriks) and leaf spots (*Pyrenophora avenae* Ito & Kuribavayashi and *Phaeosphaeria avenae* (Weber) Eriks) on oat cause yield and quality reduction. Crown rust is considered the most economically important disease of oat in Saskatchewan (McCallum et al., 2007), while leaf spotting diseases are observed annually, usually at low to moderate levels. Oat growers are questioning the benefit of fungicides and resistant varieties to control these diseases. In addition, products that have no direct activity against target pathogens, but stimulate induced systemic acquired resistance (SAR) in the plant are available, such as Actigard®.

## Materials and Methods

Two field plot experiments at each location were established at the East Sutherland Farm, just outside Saskatoon and on the research field of the Northeast Agriculture Research Foundation at Melfort (Agriculture and Agri-Food Canada, Melfort). Both experiments were designed as randomized complete blocks (RCBDs) with four replicates. All varieties were seeded at 250 seeds/m<sup>2</sup>.

At Saskatoon, both experiments were inoculated with a mixture of crown rust races to ensure a high risk of infection. Inoculation was made onto spreader rows of AC Morgan, which had been planted between the replicates and as borders to the plots to ensure good crown rust development. Inoculation occurred at the 2-3 leaf stage, when the weather was cool and moist. A few days after inoculation the weather became hot and humid; this was conducive to crown rust development. Experiments at Melfort were not inoculated.

At both locations disease ratings were conducted on the check plots before fungicide and Actigard® application. All plots were assessed at flowering and the soft dough stages. Only results from the soft dough stage are reported here. Leaf spotting diseases were rated using the Horsfall – Barratt scale (0-11), which were then converted to a percent leaf area affected by the diseases (Appendix 1) as illustrated by (Horsfall, J.G. et al. 1945). The modified Cobb scale (Appendix 2) as illustrated by (Peterson et al. 1948) was used to assess crown rust based on the average severity (% leaf covered in pustules) of the flag and penultimate leaves.

Data was analyzed with analysis of variance (ANOVA) and treatment means separated by least significant difference tests using Statistical Analysis System (SAS) software.

Experiment 1 consisted of three oat varieties and three fungicide treatments. Oat cultivars were selected based on resistance to crown rust. AC Morgan was chosen as the crown rust susceptible, CDC Dancer as the intermediate, and CDC Morrison as the resistant cultivar. Fungicide treatments included: an unsprayed check, propiconazole (Bumper®) and pyraclostrobin (Headline®). Fungicides were applied at the flag leaf fully unfurled, growth stage 39 of the BBCH growth stage scale (Lancashire et al. 1991), using a tractor mounted sprayer.

Experiment 2 consisted of the application of Actigard®, a product that stimulates plant defense reactions against pathogens (systemic acquired resistance) but has no direct activity against target pathogens. Actigard® was applied at two rates: 8.75 g ai/ha and 26.25 g ai/ha, with a check (unsprayed). Timing of application was at the three crop growth stages: seedling, boot and heading on each of the two cultivars; CDC Dancer and CDC Morrison.

## **Results**

### **Evaluation of fungicides and oat varieties for crown rust and leaf spot diseases, yield, and nutritional characteristics**

#### **Disease Severity**

At Saskatoon in 2013, crown rust was the most prevalent disease observed. The unsprayed treatment on AC Morgan exhibited crown rust severity of 93% (Figure 1). Fungicides propiconazole and pyraclostrobin reduced crown rust severity to 70% and 46%, respectively. Results were similar with CDC Dancer, but less dramatic than for AC Morgan. Crown rust severity of untreated CDC Dancer was 53%, which was reduced to 35% by treatment with propiconazole, and 26% with pyraclostrobin. CDC Morrison did not exhibit any crown rust symptoms illustrating its excellent resistance.

Crown rust was not observed at Melfort in 2013. Leaf spot symptoms were only slightly more severe at Melfort (Figure 2), compared with Saskatoon, but were still considered low. CDC Dancer had the highest level of leaf spot of the unsprayed checks (13%), followed by AC Morgan at 8%, and CDC Morrison at 6%. Both fungicides decreased leaf spot severity in all varieties; however, the reduction in severity was limited because of the low levels of leaf spot symptoms.

#### **Yield**

In Saskatoon, yield of AC Morgan (unsprayed check, 4157 kg/ha) increased with the use of both propiconazole and pyraclostrobin (Figure 3). Propiconazole increased yield of AC Morgan by 27% to 5272 kg/ha, and pyraclostrobin by 33% to 5518 kg/ha. There were no yield differences among fungicide treatments on CDC Dancer or CDC Morrison.

In Melfort, yield differences were observed among varieties, but no differences were observed among fungicide treatments (Figure 4). The mean yield across fungicide treatments of AC Morgan was 9297 kg/ha, CDC Dancer, 8209 kg/ha and CDC Morrison 6742 kg/ha.

### **Test Weight**

Test weight (also known as bushel weight) of AC Morgan oat at Saskatoon was improved from 46 kg/hL to 53 kg/hL using either propiconazole and pyraclostrobin fungicides (Figure 5). However, no improvement with use of fungicides was observed for CDC Dancer or CDC Morrison

In Melfort, there was no difference among varieties and no benefit of fungicide on test weight (Figure 6).

### **Beta-glucan**

At Saskatoon, Beta glucan was considerably higher for CDC Morrison (7.12%) than either CDC Dancer (4.96%) or AC Morgan (4.42) (Figure 7). There was no impact of fungicide on Beta-glucan content at Saskatoon.

Beta-glucan content followed the same trend in Melfort. CDC Morrison had the highest Beta-glucan content at 7.19% followed by CDC Dancer at 4.58% and AC Morgan at 4.51% (Figure 8). There was no impact of fungicide on Beta-glucan content at Melfort.

### **Effect of Actigard® on crown rust and leaf spot diseases, yield and nutritional of oat**

In Experiment 2, at both Saskatoon and Melfort, for both cultivars, no differences among treatments in disease severity, yield or beta glucan content were observed for either rate or timing of Actigard® application. Only results from Saskatoon are shown here.

### **Disease Severity**

At Saskatoon, crown rust was the most prevalent disease observed. Crown rust was very high on CDC Dancer (54%), but no symptoms were observed on CDC Morrison. There was no significant difference between the unsprayed CDC Dancer and the Actigard treatments (Figure 9).

### **Yield**

There were no differences in yield between varieties or among Actigard treatments at Saskatoon (Figure 10).

### **Test Weight**

There were no differences in TW between varieties or between the unsprayed check and the Actigard treatments at Saskatoon, except for CDC Dancer, where Actigard applied at the high rate at the heading stage at Saskatoon (Figure 11) had a slightly reduced TW compared to the unsprayed check.

### **Beta-glucan**

Beta-glucan content was higher for CDC Morrison (5.53%) than CDC Dancer (4.48%) in Saskatoon (Figure 12). There were no differences between Actigard treatments for Beta-glucan at either timing or rate.

## **Preliminary Conclusions**

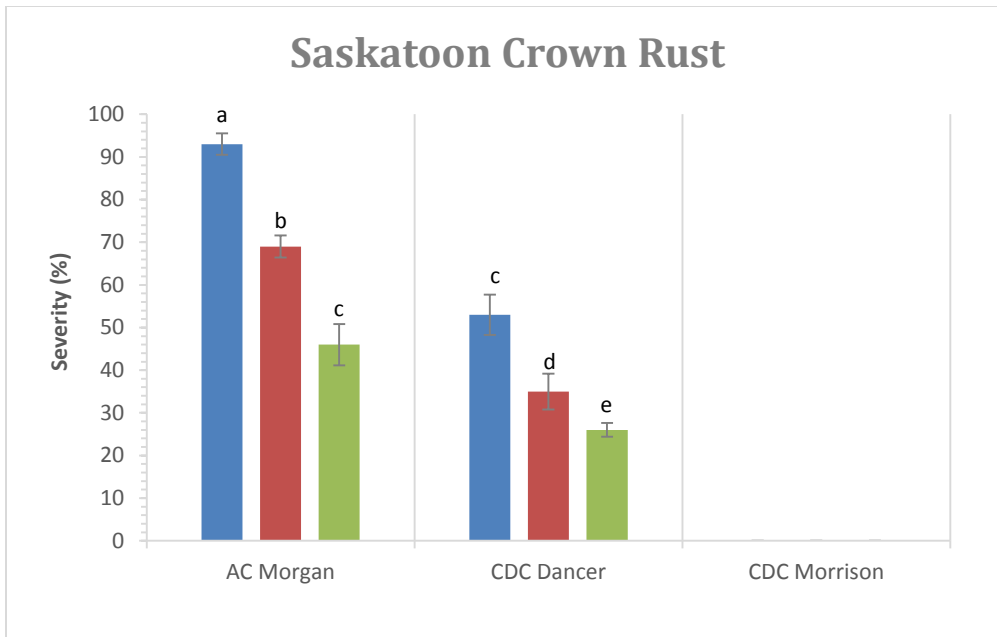
Crown rust, caused by *Puccinia coronata*, was the primary pathogen present at Saskatoon in 2013 and disease was severe in field plots and neighboring fields. At Melfort, crown rust was not observed while leaf spotting pathogens were identified in the field trials. Based on a single site-year of data, fungicide application reduced crown rust on the disease susceptible variety AC Morgan and resulted in improved yield and quality compared with the unsprayed check. The severity of crown rust was much reduced on the moderately susceptible variety CDC Dancer and the yield and quality improvement much less than for AC Morgan. CDC Morrison was highly resistant to crown rust and as a result did not benefit from fungicide application. Leaf spot diseases were very low at Saskatoon for all varieties. At Melfort, leaf spot severity was low to moderate, but all varieties were observed to have decreased disease severity with fungicide application. However, there was limited yield improvement due to fungicide at Melfort. There appeared to be no relationship between fungicide application and beta-glucan content at either location, although there were differences among varieties for some of these factors at Saskatoon only. Actigard® was not observed to have any positive or negative effects on disease severity (crown rust or leaf spots) or any of the factors measured at either location, although there were differences among varieties for many of the factors measured.

## **Acknowledgments**

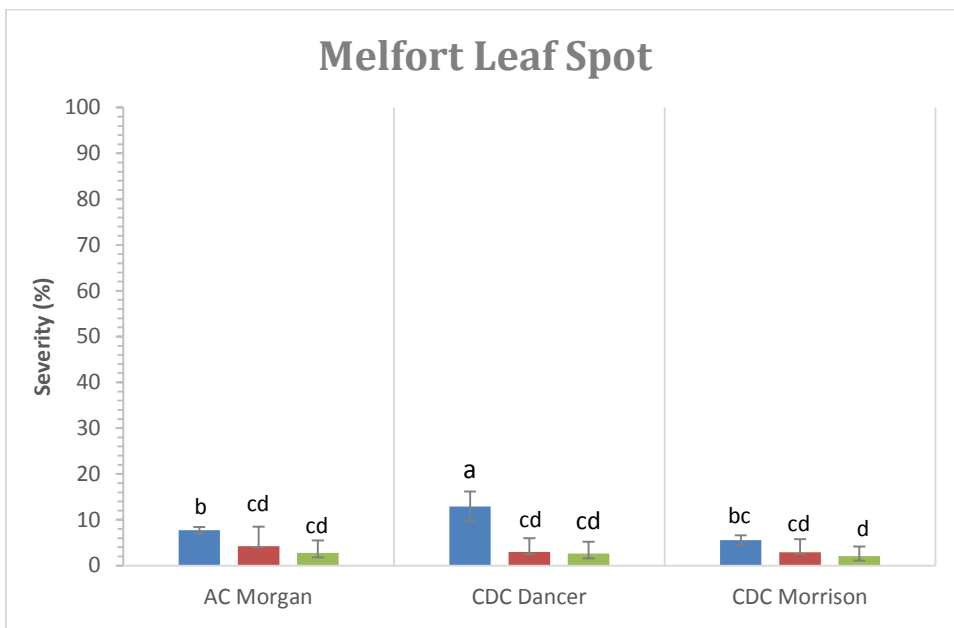
Thank you to the Northeast Agricultural Research Foundation at Melfort for technical support with these experiments. Thanks to Giselle Camm for running the nutritionals on the samples, and to our dedicated summer students: Mallory Dyck, Meghan Lawson, Everett Boots and Arnud Durand. Thank you to Dr. Dave Kendra and the Quaker Oat Company (QTG Canada Inc.) for financial support.

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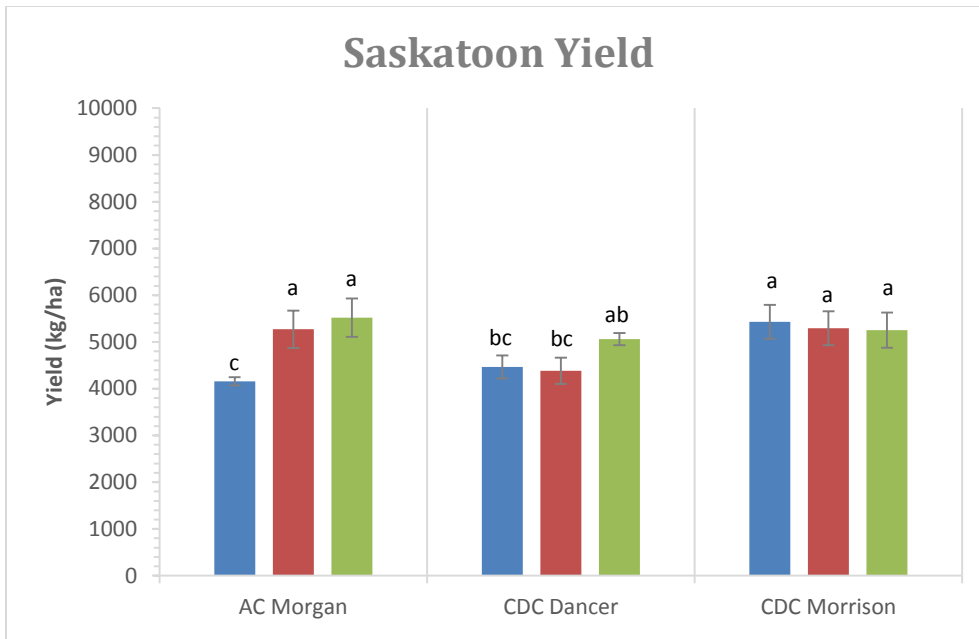
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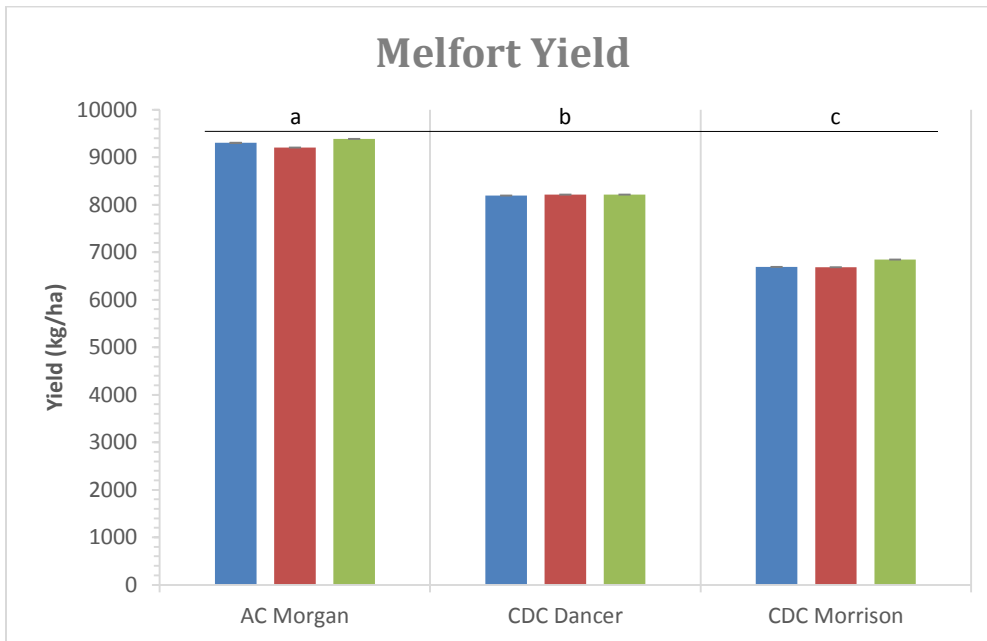
**Figure 1.** Crown rust symptoms on oat (cvs. AC Morgan, CDC Dancer and CDC Morrison) treated with unsprayed check (■), propiconazole (■), and pyraclostrobin (■) at Saskatoon, SK in 2013. Severity was measured as the leaf area covered by crown rust pustules (average of the flag and penultimate leaves). Note that CDC Morrison did not display crown rust symptoms.



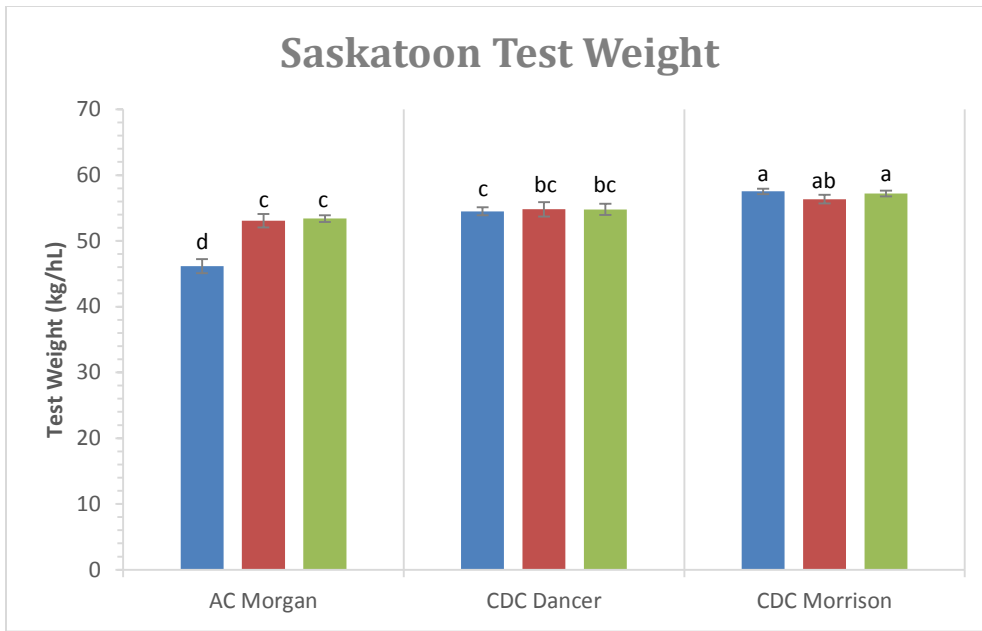
**Figure 2.** Leaf spot symptoms on oat (cvs. AC Morgan, CDC Dancer and CDC Morrison) treated with unsprayed check (■), propiconazole (■), and pyraclostrobin (■) at Melfort, SK in 2013. Severity was measured as the leaf area covered by leaf spot lesions (average of the flag and penultimate leaves).



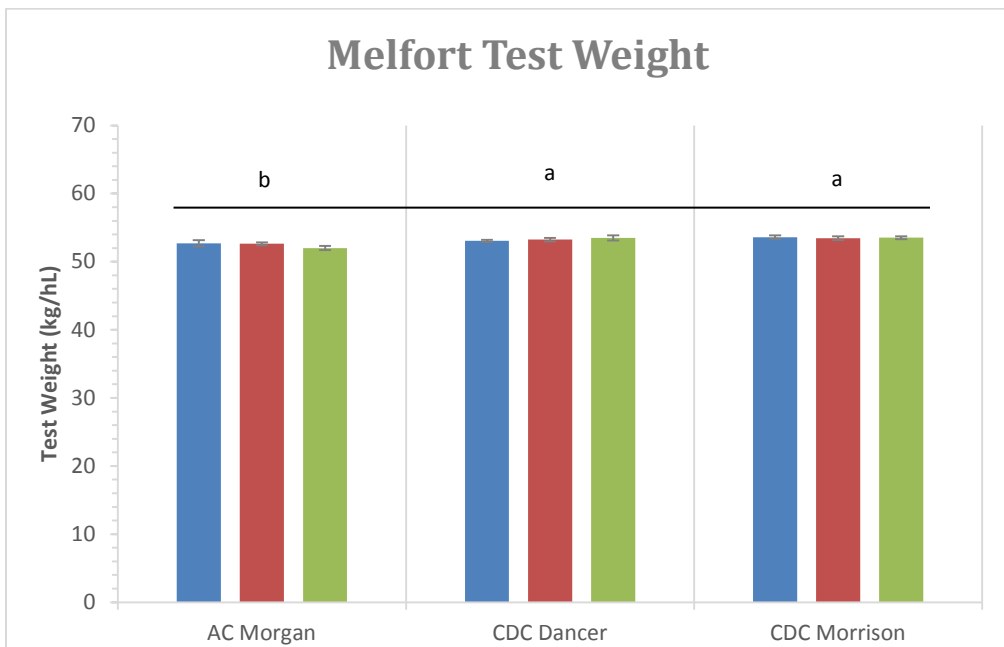
**Figure 3.** Yield (kg/ha) of oat (cvs. AC Morgan, CDC Dancer and CDC Morrison) treated with unsprayed check (■), propiconazole (■), and pyraclostrobin (■) at Saskatoon, SK in 2013. Yield was measured based on 13.5% moisture



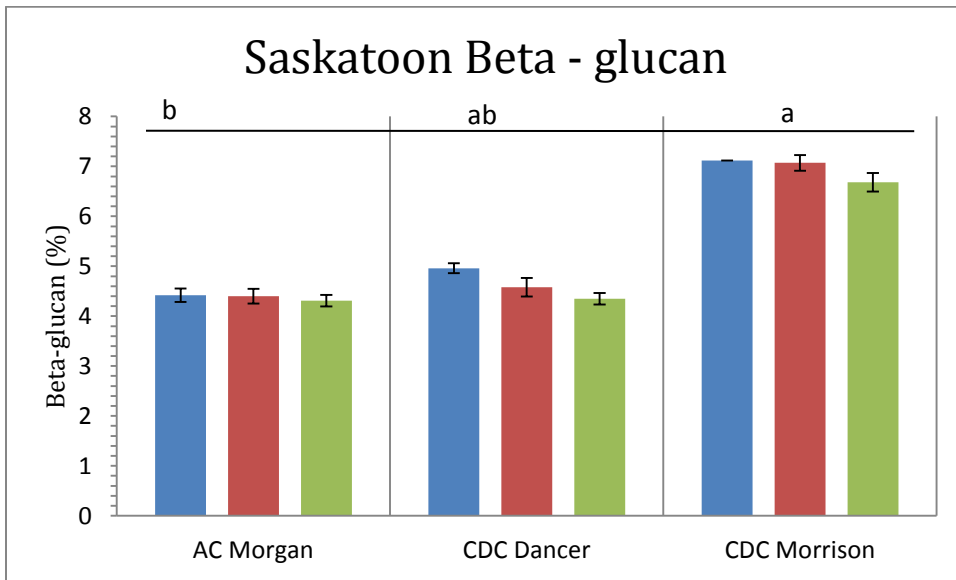
**Figure 4.** Yield (kg/ha) of oat (cvs. AC Morgan, CDC Dancer and CDC Morrison) treated with unsprayed check (■), propiconazole (■), and pyraclostrobin (■) at Melfort, SK in 2013. Yield was measured based on 13.5% moisture.



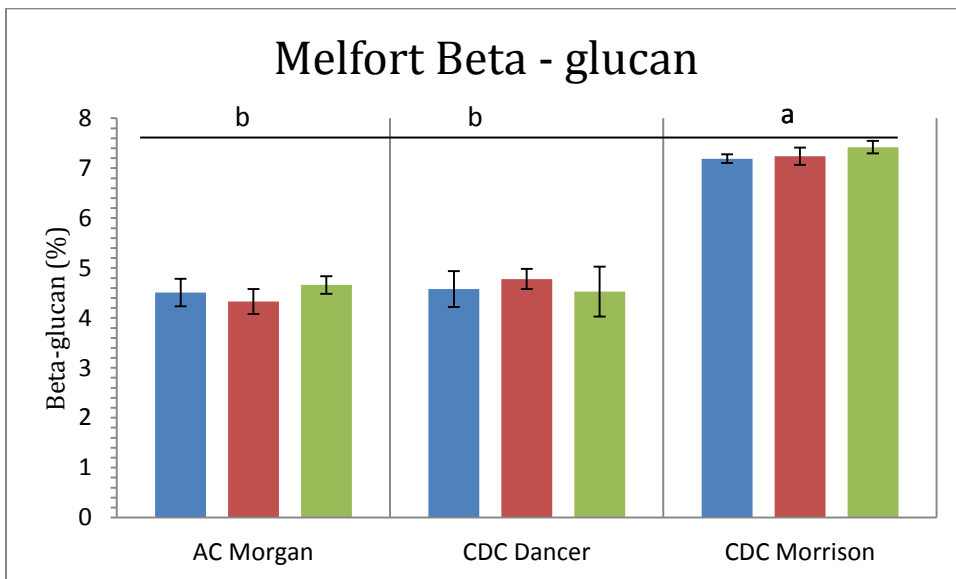
**Figure 5.** Test weight (kg/hL) of oat (cvs. AC Morgan, CDC Dancer and CDC Morrison) treated with unsprayed check (■), propiconazole (■), and pyraclostrobin (■) at Saskatoon, SK in 2013.



**Figure 6.** Test weight (kg/hL) of oat (cvs. AC Morgan, CDC Dancer and CDC Morrison) treated with unsprayed check (■), propiconazole (■), and pyraclostrobin (■) at Melfort, SK in 2013.

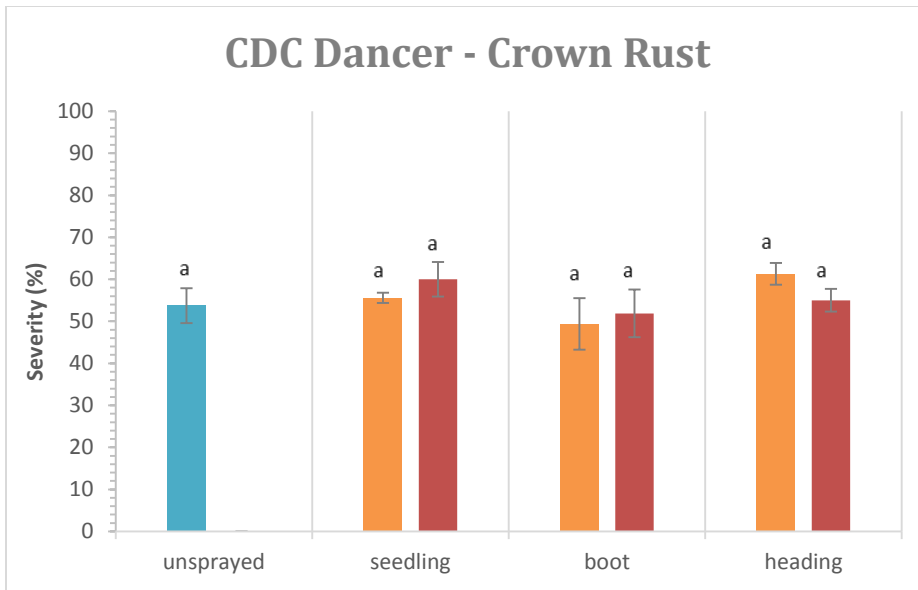


**Figure 7.** Beta-glucan (%) of oat (cvs. AC Morgan, CDC Dancer and CDC Morrison) treated with unsprayed check (■), propiconazole (■), and pyraclostrobin (■) at Saskatoon, SK in 2013.

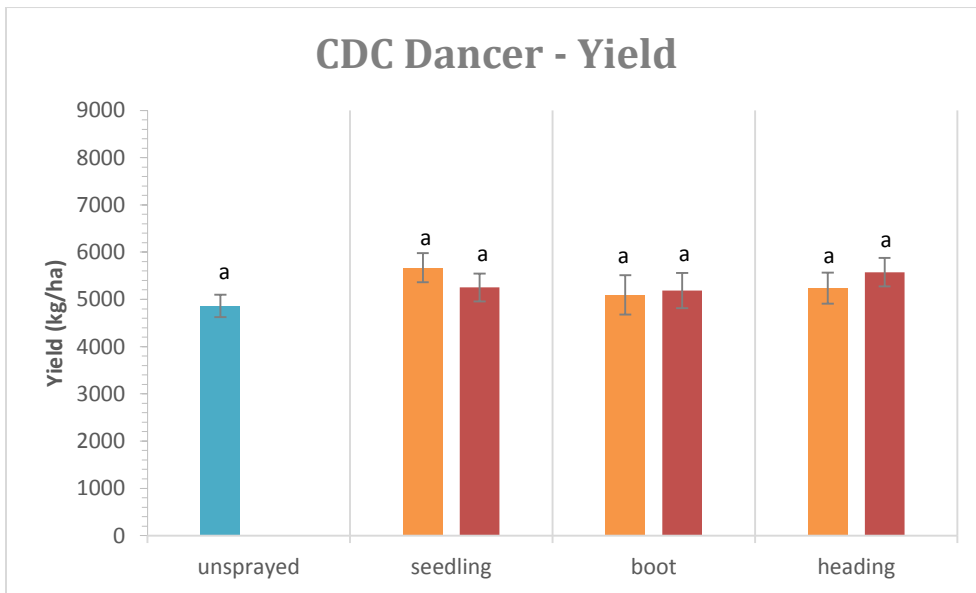


**Figure 8.** Beta-glucan (%) of oat (cvs. AC Morgan, CDC Dancer and CDC Morrison) treated with unsprayed check (■), propiconazole (■), and pyraclostrobin (■) at Melfort, SK in 2013.

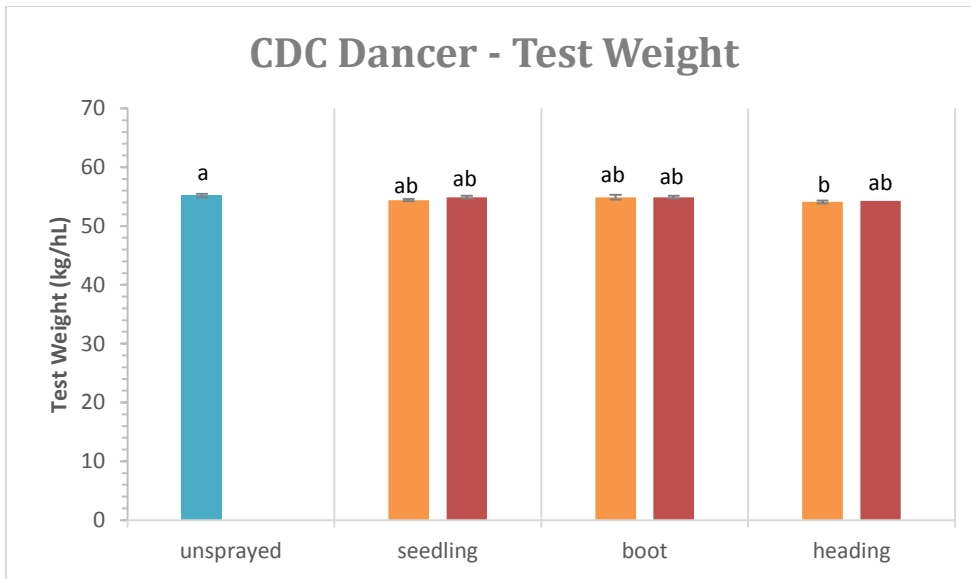




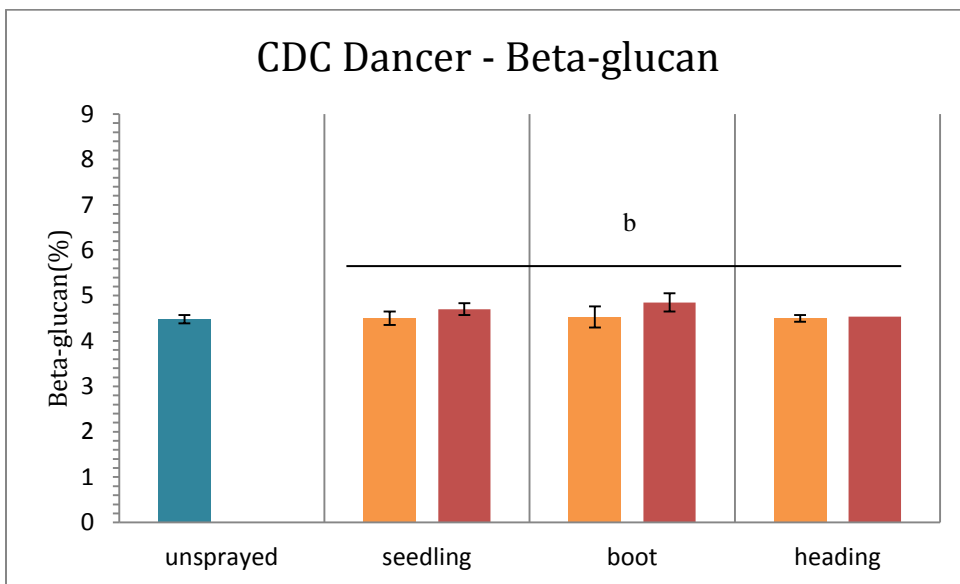
**Figure 9.** Effect of Actigard applied to oat (cvs. CDC Dancer and CDC Morrison) at three growth stages: seedling, boot and heading at two rates: 8.75 (orange) and 26.25 (red) g a.i./ha with a check (unsprayed) (blue) on crown rust symptoms at Saskatoon, 2013. Severity was measured as the leaf area covered by crown rust pustules (average of the flag and penultimate leaves). Note that CDC Morrison did not display crown rust symptoms.



**Figure 10.** Effect of Actigard applied to oat (cvs. CDC Dancer and CDC Morrison) at three growth stages: seedling, boot and heading at two rates: 8.75 (orange) and 26.25 (red) g a.i./ha with a check (unsprayed) (blue) on yield (kg/ha) at Saskatoon, 2013. Yield was measured based on 13.5% moisture.



**Figure 11.** Effect of Actigard applied to oat (cvs. CDC Dancer and CDC Morrison) at three growth stages: seedling, boot and heading at two rates: 8.75 (orange) and 26.25 (red) g a.i./ha with a check (unsprayed) (blue) on test weight (kg/hL) at Saskatoon, 2013.

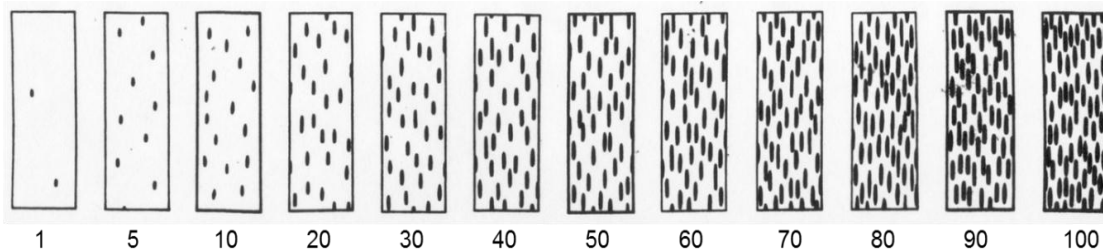


**Figure 12.** Effect of Actigard applied to oat (cvs. CDC Dancer and CDC Morrison) at three growth stages: seedling, boot and heading at two rates: 8.75 (orange) and 26.25 (red) g a.i./ha with a check (unsprayed) (blue) on Beta-glucan (%) at Saskatoon, 2013.

## Appendices

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

**Appendix 1.** Horsfall-Barratt scale (with conversion to percentage) used to rate flag and penultimate (flag-1) leaves for severity of leaf spots on oat (Horsfall et al. 1945).



**Appendix 2.** Modified Cobb scale used to rate crown rust on oat (Peterson et al., 1948).



# Integrated Disease Management of Crown Rust and Leaf Spotting Diseases of Oat

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## Introduction

Crown rust (*Puccinia coronata* Corda f. sp. *avenae* Eriks) and leaf spots (*Pyrenophora avenae* Ito & Kuribavayashi and *Phaeosphaeria avenae* (Weber) Eriks) on oat cause yield and quality reduction. Crown rust is considered the most economically important disease of oat in Saskatchewan, while leaf spotting diseases are observed annually, usually at low to moderate levels. Oat growers are questioning the benefit of fungicides and resistant varieties to control these diseases. In addition to synthetic fungicides, recent products are available that have no direct activity against target pathogens, but stimulate induced systemic acquired resistance (SAR) in the plant, such as Actigard®.

## Objective

To determine the effect of fungicides, Actigard® and oat cultivars with varying resistance to crown rust, by examining leaf spot and crown rust severity, oat yield and quality.

## Materials and Method

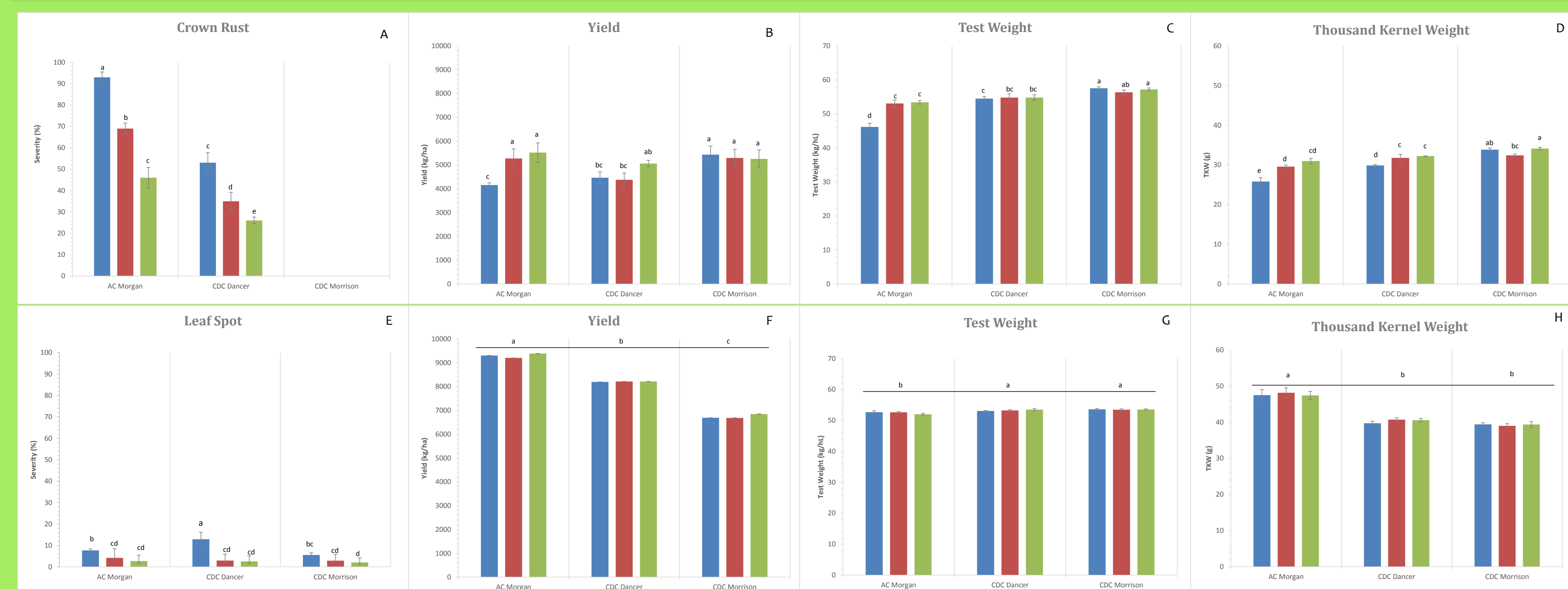
Two experiments were established at each location: Saskatoon and Melfort.

**Experiment 1** consisted of three oat varieties: AC Morgan (crown rust susceptible), CDC Dancer (intermediate) and CDC Morrison (resistant) and three fungicide treatments: check (unsprayed), pyraclostrobin (Headline®) and propiconazole (Bumper®) applied at the flag leaf fully unfurled stage.

**Experiment 2** consisted of an application of Actigard® at two rates: 8.75 g ai/ha and 26.25 g ai/ha, with a check (unsprayed), at three crop growth stages: seedling, boot and heading on each of two varieties: CDC Dancer and CDC Morrison.

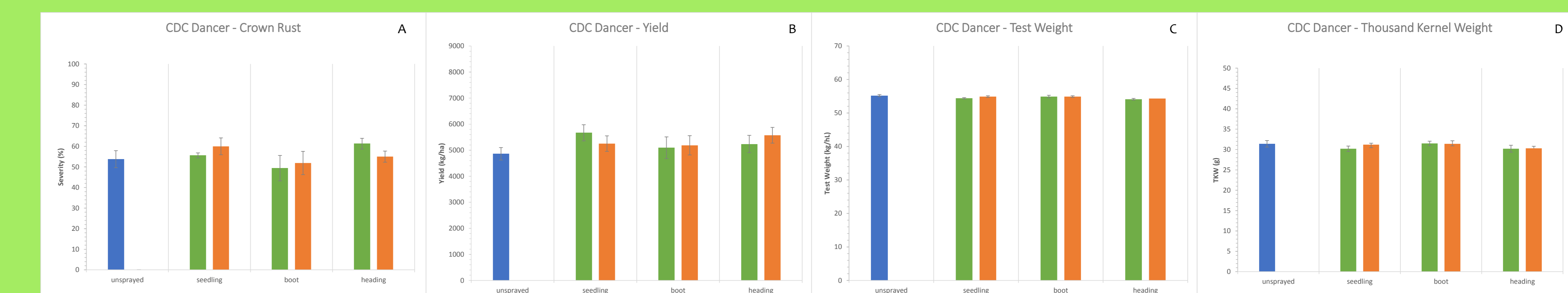
At the Saskatoon location, both experiments were inoculated with a mixture of crown rust races, while at Melfort, both were exposed only to naturally occurring plant pathogens. The flag and penultimate leaves were assessed for percentage of leaf surface area exhibiting symptoms of either disease.

## Results and Discussion



**Figure 1.** Saskatoon: A) crown rust severity, average of flag and penultimate leaves at soft dough (%), B) yield (kg/ha), C) test weight (kg/hL) and D) thousand kernel weight (g); Melfort: E) leaf spot severity, average of flag and penultimate leaves at soft dough (%), F) yield (kg/ha), G) test weight (kg/hL) and H) thousand kernel weight (g); of oat cultivars AC Morgan, CDC Dancer and CDC Morrison treated with unsprayed check, propiconazole and pyraclostrobin.

- Thousand kernel weight (TKW) was increased by fungicide application to AC Morgan and CDC Dancer, but not to CDC Morrison (Fig. 1D). For AC Morgan, TKW was increased by 15 and 20% with the use of propiconazole and pyraclostrobin, respectively. The TKW of CDC Dancer was increased by approximately 7% with fungicide application, but there was no difference in TKW between sprayed and unsprayed CDC Morrison.
- Severity of leaf spots was low at Melfort, and no crown rust was observed (Fig. 1E). Leaf spot severity of the fungicide unsprayed checks was greater for all cultivars, compared with either propiconazole or pyraclostrobin treated plots.
- In Melfort yield differences among fungicide treatments were not statistically significant for any variety (Fig. 1F). Without fungicide, the yield of AC Morgan (9304 kg/ha) was 14% greater than CDC Dancer (8197 kg/ha) and 39% greater than CDC Morrison (6693 kg/ha).
- There was no impact of fungicides on TW or TKW regardless of variety (Fig. 1G and Fig. 1H), although TKW was greater for AC Morgan than either CDC Dancer or CDC Morrison.



**Figure 2.** Saskatoon: A) crown rust severity, average of flag and penultimate leaves at soft dough (%), B) yield (kg/ha), C) test weight (kg/hL) and D) thousand kernel weight (g) of oat cultivar CDC Dancer in response to two rates of Actigard®: 8.75 and 26.25 g a.i./ha applied at three crop growth stages: seedling, boot and heading compared to the unsprayed check.

- In Experiment 2 at Saskatoon and Melfort, for both cultivars, no differences among treatments in disease severity, yield, TW or TKW were observed for either rate or timing of Actigard® application (only data for CDC Dancer at Saskatoon shown).

## Acknowledgements

Thank you to the Northeast Agricultural Research Foundation at Melfort for technical support with these experiments, to our dedicated summer students: Meghan Lawson, Everett Boots and Mallory Dyck and to Dr. Dave Kendra and the Quaker Oat Company (QTG Canada Inc.) for financial support.