

Weather-based models for forecasting and managing Fusarium head blight risk in western Canadian cereal production

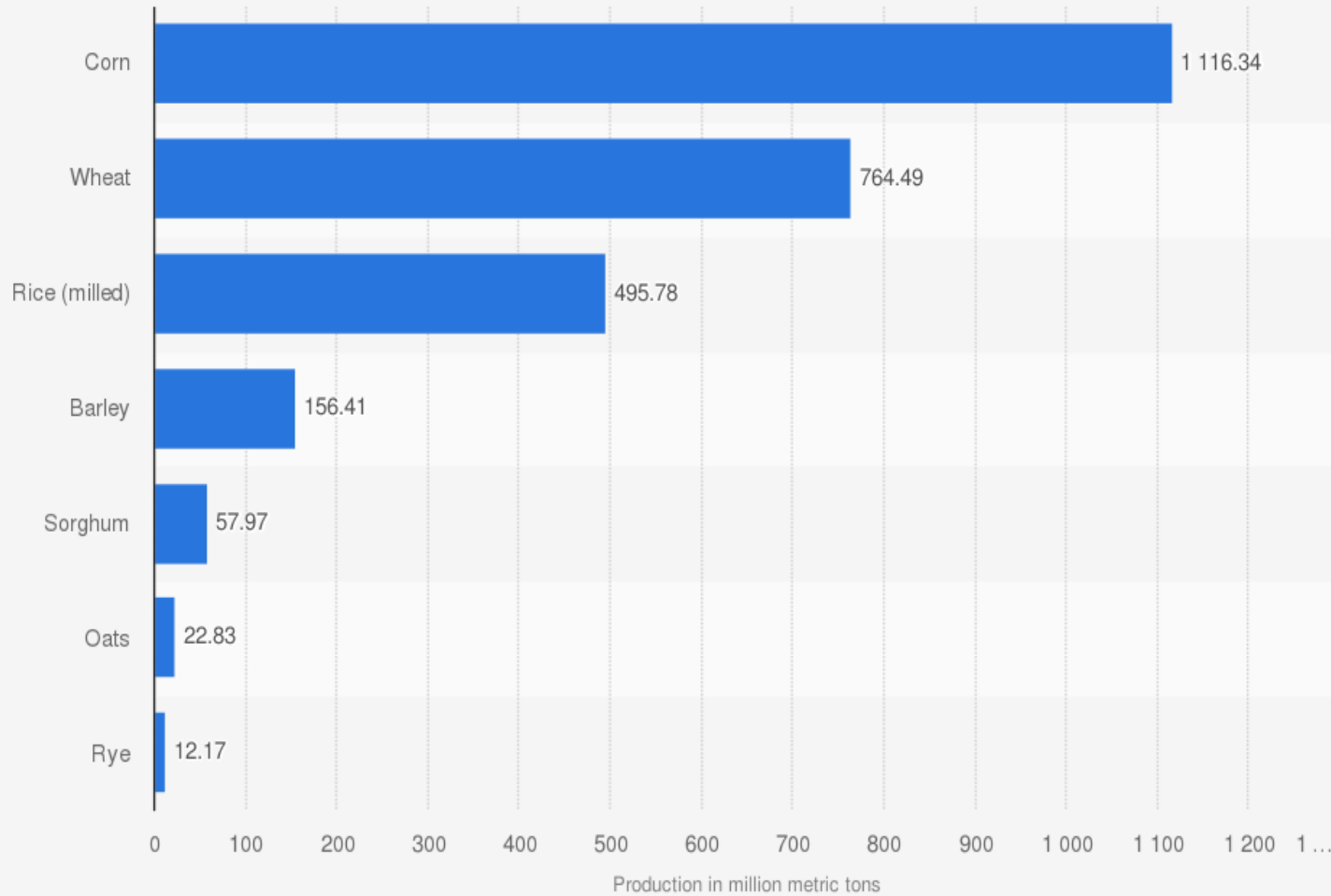
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**University
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Introduction

Worldwide production of grain in 2019/20, by type (in million metric tons)



Sources
FAO; US Department of Agriculture
© Statista 2020

Additional Information:
Worldwide; FAO; US Department of Agriculture; 2020



Source: Getty images



Source: Northern Crop Institute





Fusarium Head Blight (FHB)

- Infection occurs during flowering
- Warm humid conditions
- Symptoms occurs as bleached spikelets

Introduction



Fusarium Damaged Kernel (FDK)

- Shriveled light-weight kernels
- No. 1 Grade threshold: ranges from Barley FDK $< 0.2\%$ to Durum $< 2\%$

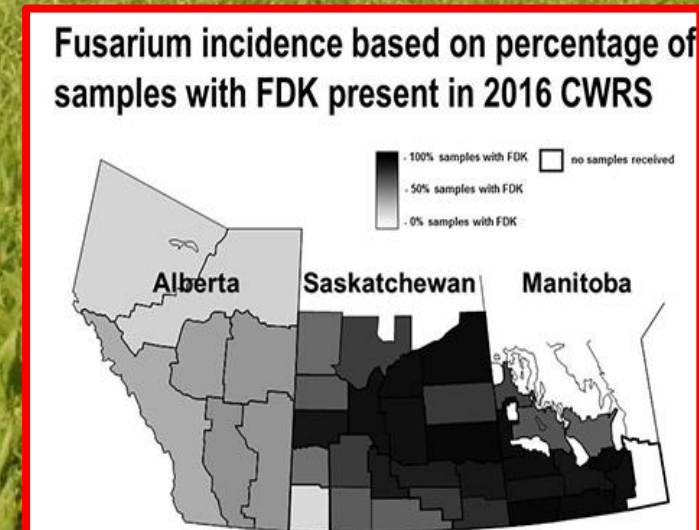
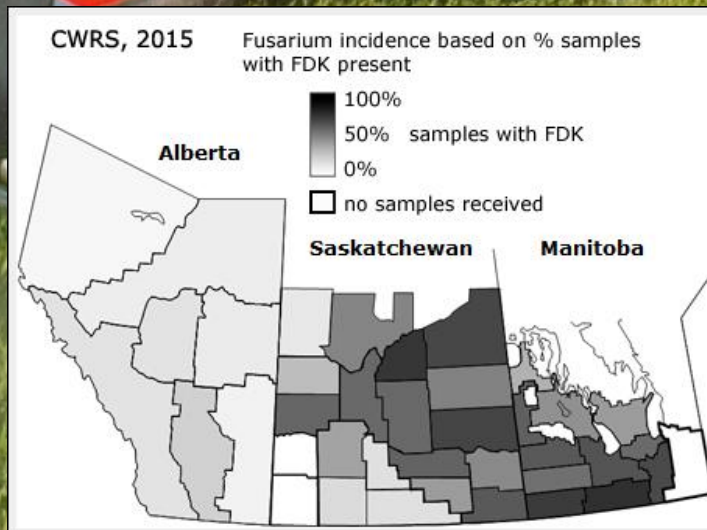
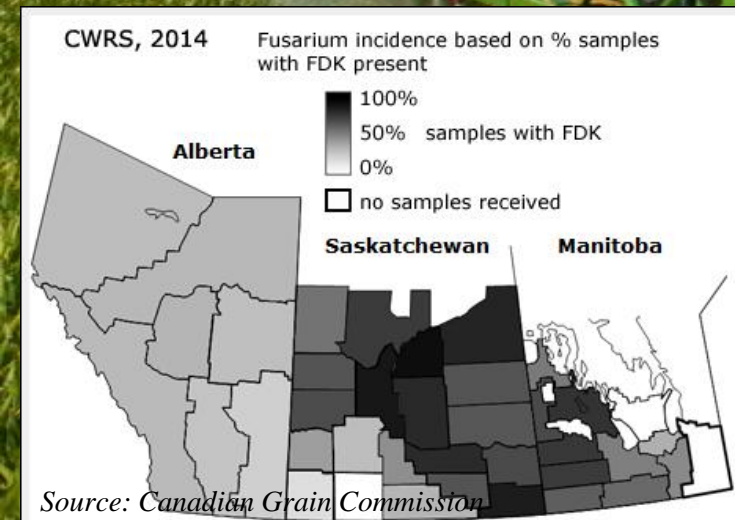
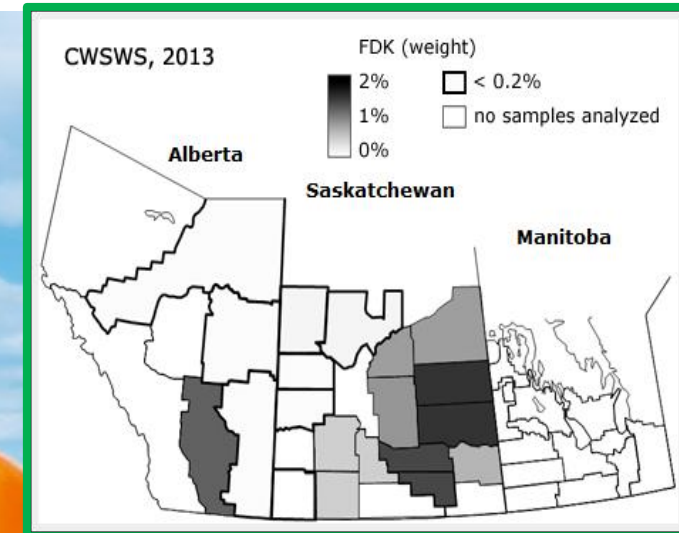
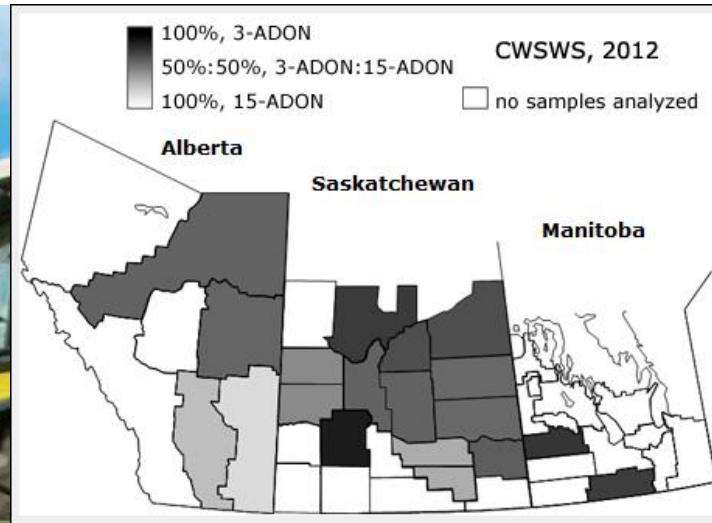
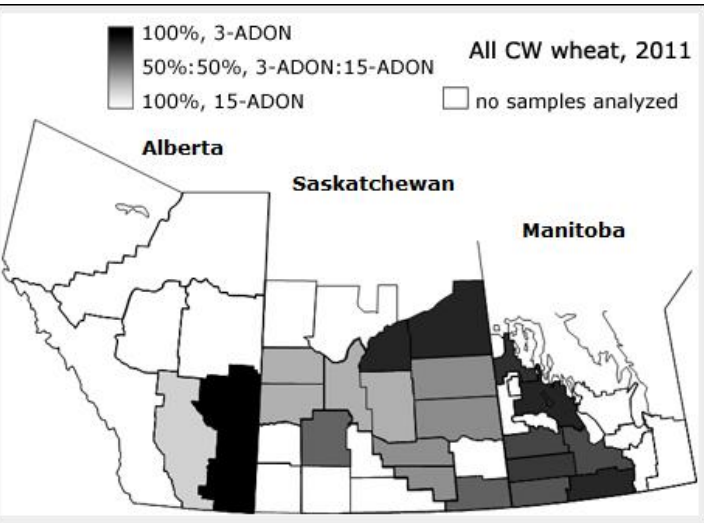


Source: www.biomin.net

Deoxynivalenol (DON)

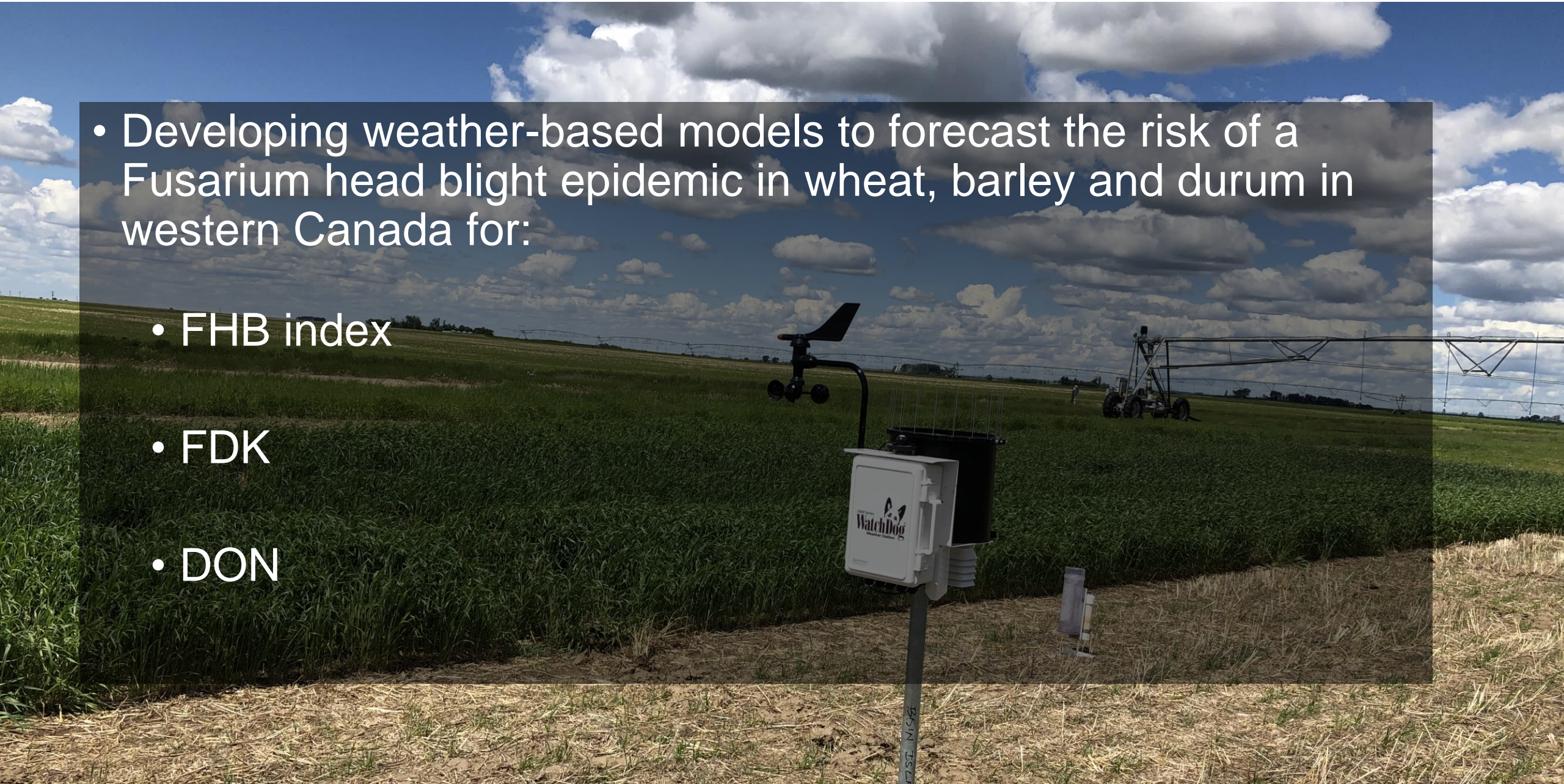
- Maximum Levels set at **2 ppm** for grain intended for use in food products
- Grain with **>1 ppm** can be rejected by some buyers

When can you apply fungicides?

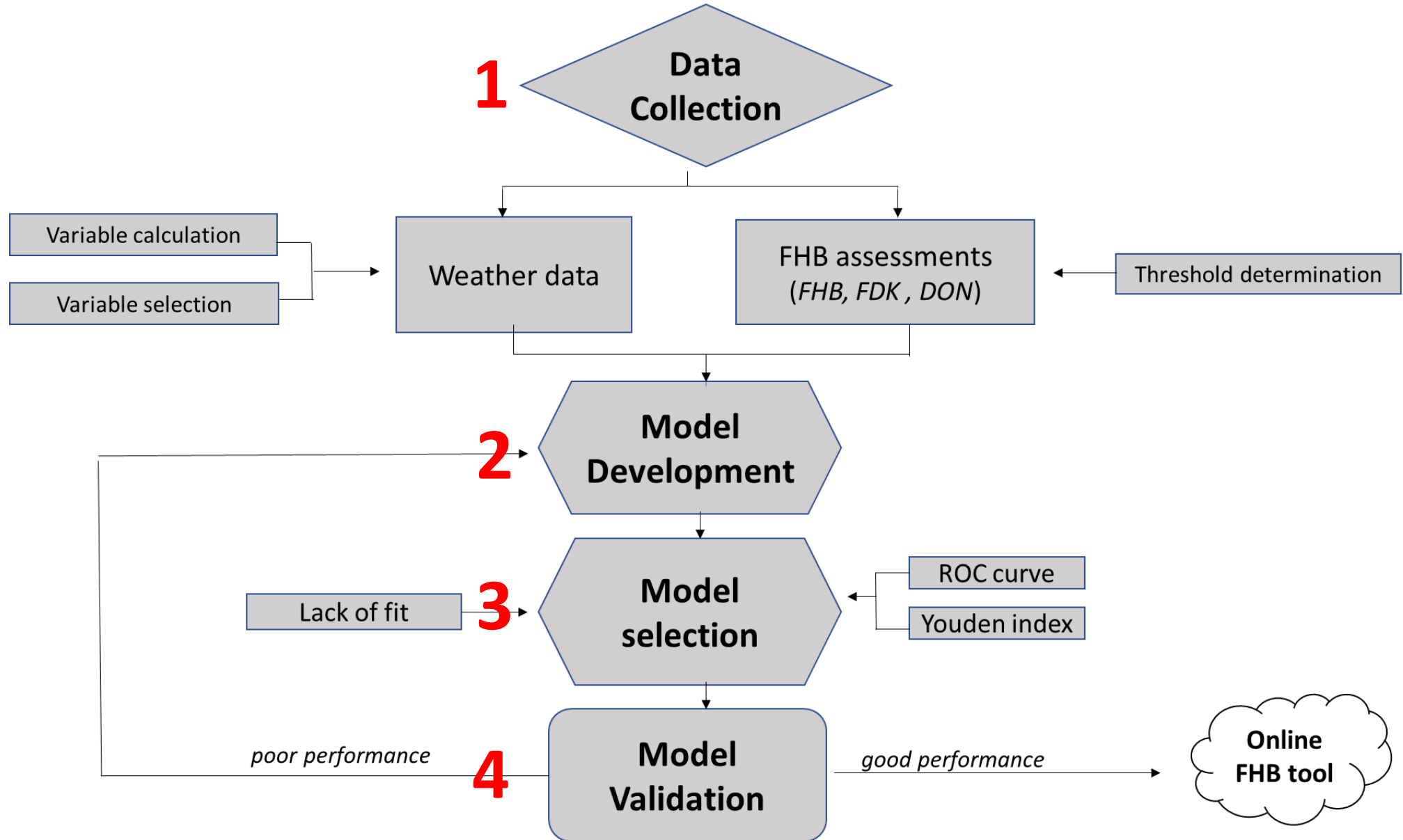


Objectives

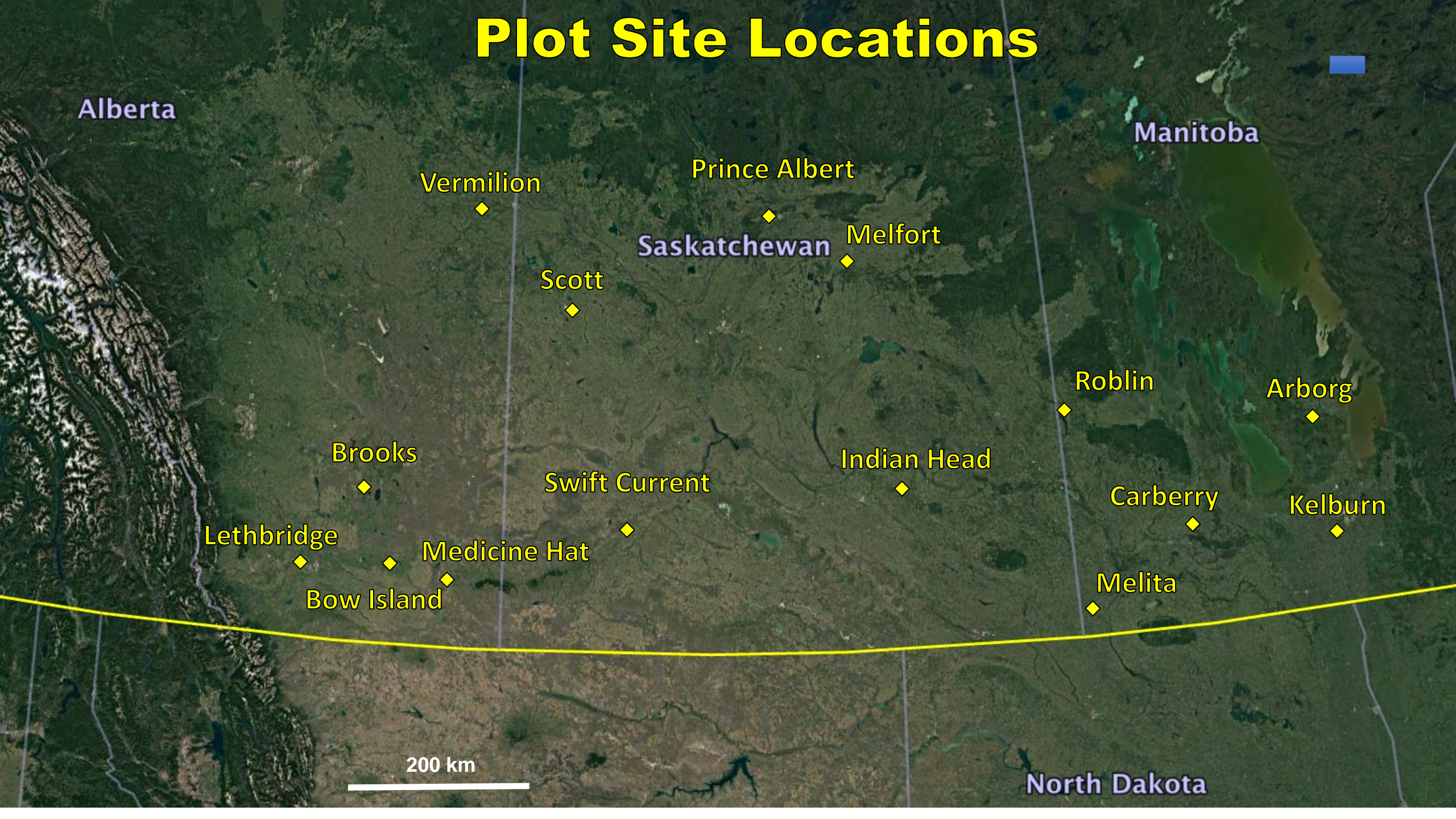
- Developing weather-based models to forecast the risk of a Fusarium head blight epidemic in wheat, barley and durum in western Canada for:
 - FHB index
 - FDK
 - DON



Methods



Plot Site Locations



Methods

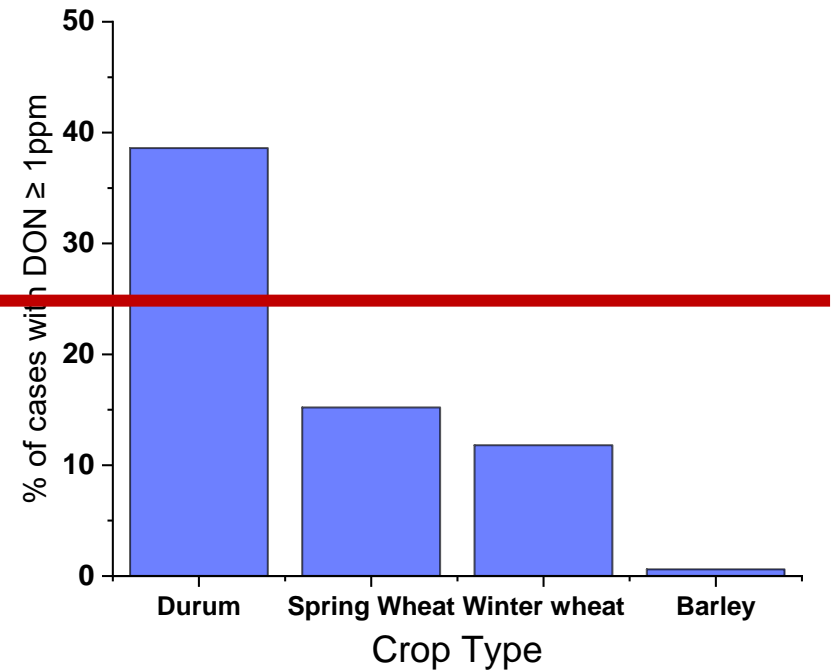
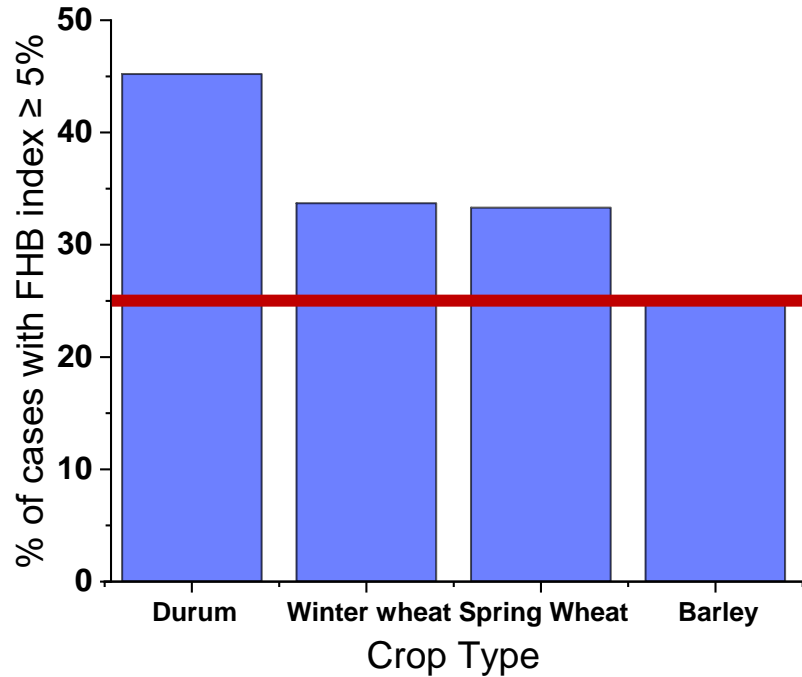
- Experimental design: RCBD with 4 reps
- Treatments: 3 FHB rating varieties
- Measurements: Growth stages, FHB index, FDK and DON and weather data
- Logistic regression - model relationship between the disease and weather variables



Methods: Weather Predictor Variables

| 4 days Pre-anthesis | 7 days Pre-anthesis | 10 days Pre-anthesis | 14 days Pre-anthesis | 3 days Pre&Post-anthesis | Description |
|---------------------|---------------------|----------------------|----------------------|--------------------------|--|
| R4MA | R57MA | R10MA | R14MA | R3MAPA | Mean daily rainfall (mm) |
| R034MA | R037MA | R0310MA | R0314MA | R033MAPA | Duration (h) rainfall ≥ 0.3 mm |
| R54MA | R7MA | R510MA | R514MA | R53MAPA | Duration (h) rainfall ≥ 5 mm |
| RH4MA | RH7MA | RH10MA | RH14MA | RH3MAPA | Mean daily relative humidity (%) |
| RH804MA | RH807MA | RH8010MA | RH8014MA | RH803MAPA | Duration (h) RH ≥ 80 % |
| RH904MA | RH907MA | RH9010MA | RH9014MA | RH903MAPA | Duration (h) RH ≥ 90 % |
| RHmax4MA | RHmax7MA | RHmax10MA | RHmax14MA | RHmax3MAPA | Mean daily maximum relative humidity (%) |
| RHmin4MA | RHmin7MA | RHmin10MA | RHmin14MA | RHmin3MAPA | Mean daily minimum relative humidity (%) |
| SR4MA | SR7MA | SR10MA | SR14MA | SR3MAPA | Mean daily Solar Radiation (Wm^2) |
| T15304MA | T15307MA | T10MA | T14MA | T3MAPA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}C$ |
| T252804MA | T252807MA | T153010MA | T153014MA | T153003MAPA | Duration (h) air temperature $25 \leq T \leq 28^{\circ}C$ |
| T4MA | T7MA | T252810MA | T252814MA | T252803MAPA | Mean daily temperature ($^{\circ}C$) |
| Tmax4MA | Tmax7MA | Tmax10MA | Tmax14MA | Tmax3MAPA | Mean daily maximum temperature (%) |
| Tmin4MA | Tmin7MA | Tmin10MA | Tmin14MA | Tmin3MAPA | Mean daily minimum temperature (%) |
| TRH804MA | TRH807MA | TRH8010MA | TRH8014MA | TRH803MAPA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}C$, and RH ≥ 80 % |
| TRH904MA | TRH907MA | TRH9010MA | TRH9014MA | TRH903MAPA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}C$, and RH ≥ 90 % |

Preliminary results: Prevalence of epidemic cases



| Crop | Crop damage indicator | Crop damage threshold | Epidemic cases (%) |
|--------------|-----------------------|-----------------------|--------------------|
| Spring Wheat | FDK | 0.3% | 30.8 (N = 357) |
| Winter wheat | FDK | 0.8% | 17.9 (N =291) |
| Barley | FDK | 0.2% | 11.1 (N = 357) |
| Durum | FDK | 2.0% | 25.2 (N = 119) |

Preliminary results:

Kendall Coefficients for Spring wheat FDK models

| Variable | Description | Kendall | P-value |
|-------------------|---|---------|---------|
| RH804MA | Duration (h) RH \geq 80 % | 0.49 | <.0001 |
| RH904MA | Duration (h) RH \geq 90 % | 0.49 | <.0001 |
| TRH804MA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 80 % | 0.34 | <.0001 |
| TRH904MA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 90 % | 0.30 | <.0001 |
| R034MA | Duration (h) rainfall \geq 0.3mm | 0.29 | <.0001 |
| RHmax4MA | Mean daily maximum relative humidity (%) | 0.41 | <.0001 |
| RHmin4MA | Mean daily minimum relative humidity (%) | 0.41 | <.0001 |
| RH4MA | Mean daily relative humidity (%) | 0.49 | <.0001 |
| RH807MA | Duration (h) RH \geq 80 % | 0.43 | <.0001 |
| RH907MA | Duration (h) RH \geq 90 % | 0.43 | <.0001 |
| TRH807MA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 80 % | 0.42 | <.0001 |
| TRH907MA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 90 % | 0.39 | <.0001 |
| RHmax7MA | Mean daily maximum relative humidity (%) | 0.47 | <.0001 |
| RHmin7MA | Mean daily minimum relative humidity (%) | 0.43 | <.0001 |
| RH7MA | Mean daily relative humidity (%) | 0.46 | <.0001 |
| RHmax10MA | Mean daily maximum relative humidity (%) | 0.45 | <.0001 |
| RHmin10MA | Mean daily minimum relative humidity (%) | 0.41 | <.0001 |
| RH10MA | Mean daily relative humidity (%) | 0.46 | <.0001 |
| RH8010MA | Duration (h) RH \geq 80 % | 0.37 | <.0001 |
| RH9010MA | Duration (h) RH \geq 90 % | 0.37 | <.0001 |
| TRH8010MA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 80 % | 0.43 | <.0001 |
| TRH9010MA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 90 % | 0.39 | <.0001 |
| RHmax14MA | Mean daily maximum relative humidity (%) | 0.48 | <.0001 |
| RHmin14MA | Mean daily minimum relative humidity (%) | 0.40 | <.0001 |
| RH14MA | Mean daily relative humidity (%) | 0.47 | <.0001 |
| RH8014MA | Duration (h) RH \geq 80 % | 0.51 | <.0001 |
| RH9014MA | Duration (h) RH \geq 90 % | 0.51 | <.0001 |
| TRH8014MA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 80 % | 0.45 | <.0001 |
| TRH9014MA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 90 % | 0.40 | <.0001 |
| Tmin3MAPA | Mean daily minimum temperature (%) | 0.29 | <.0001 |
| RHmax3MAPA | Mean daily maximum relative humidity (%) | 0.38 | <.0001 |
| RHmin3MAPA | Mean daily minimum relative humidity (%) | 0.51 | <.0001 |
| RH3MAPA | Mean daily relative humidity (%) | 0.46 | <.0001 |
| RH803MAPA | Duration (h) RH \geq 80 % | 0.34 | <.0001 |
| RH903MAPA | Duration (h) RH \geq 90 % | 0.34 | <.0001 |
| TRH803MAPA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 80 % | 0.37 | <.0001 |
| TRH903MAPA | Duration (h) air temperature $15 \leq T \leq 30^{\circ}\text{C}$, and RH \geq 90 % | 0.43 | <.0001 |

Preliminary results: FHB Index Models

| Crop Type | Model | Model ($p = 1/1 + (\exp(-))$) | Optimum predicted threshold | Sensitivity (%) | Specificity (%) | Accuracy (%) |
|--------------|-------|--|-----------------------------|-----------------|-----------------|--------------|
| Durum | A | -2.0665+0.0326TRH8010MA | 0.39 | 91.5 | 70.2 | 80.8 |
| | B | -8.3268+0.5906Tmin4MA+0.2714R4MA | 0.58 | 70.2 | 80.7 | 75.5 |
| Winter Wheat | C | -0.1188+0.0185RH807MA+0.7846Tmin7MA-0.6239T7MA | 0.37 | 73.2 | 75.9 | 74.6 |
| | D | -5.1095+0.0312RH8014MA | 0.17 | 96.9 | 61.3 | 79.1 |
| Spring Wheat | E | -6.1086+0.1267RH804MA+0.2461T252804MA- 0.1414TRH904MA | 0.25 | 82.4 | 68.9 | 75.6 |
| | F | -34.5786+0.3513RHmax14MA+0.0435T252814MA | 0.39 | 79.8 | 72.7 | 76.3 |
| Barley | G | -6.4679+0.1560RH804MA+0.2981T252804MA- 0.1137TRH804MA | 0.42 | 74.0 | 86.6 | 80.3 |
| | H | -37.7241+0.2146R14MA+0.0495T252814MA | 0.27 | 89.9 | 63.4 | 76.7 |

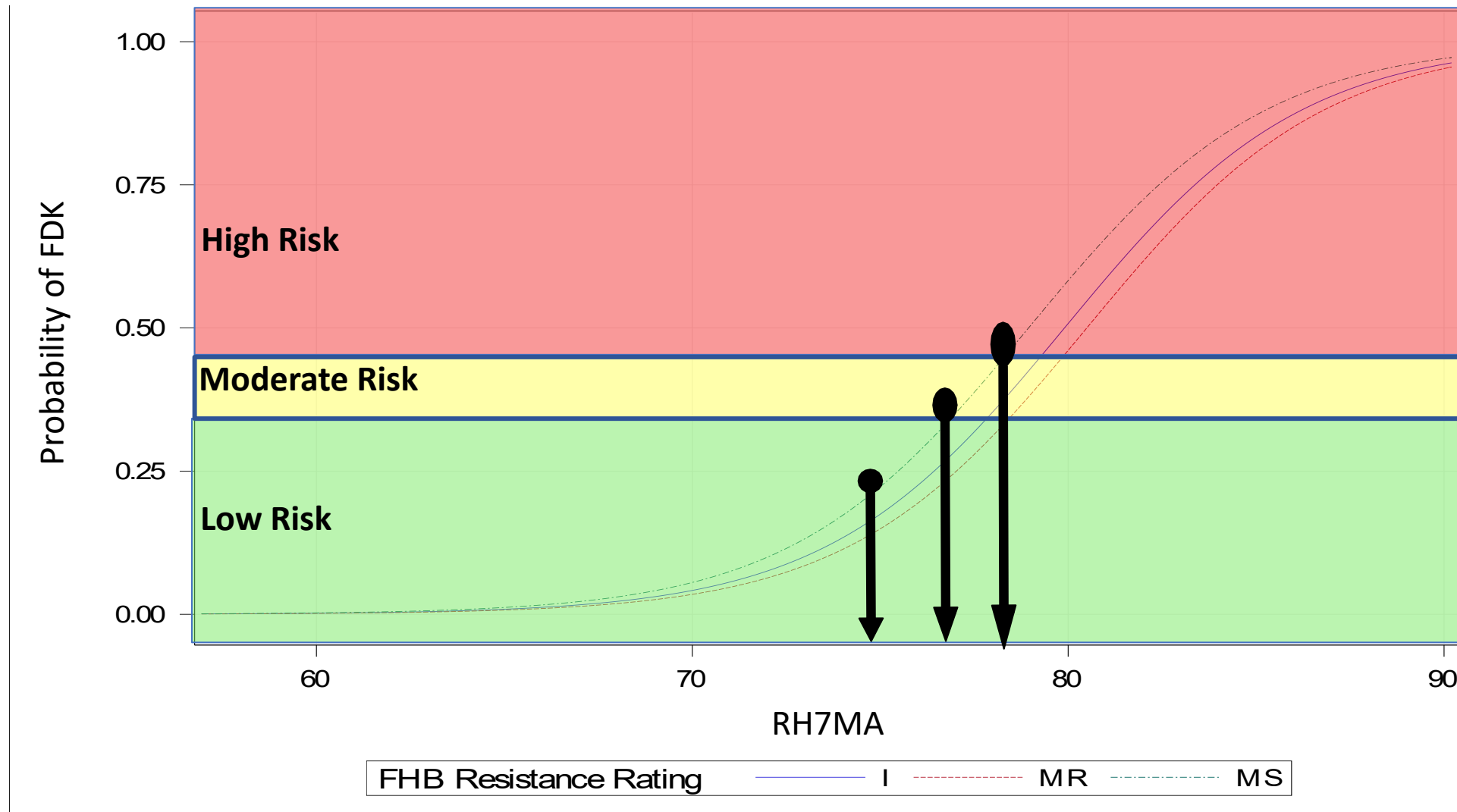


Preliminary results: FDK and DON models

| Crop Type | Crop Damage Indicator | Model | Model equation | Optimum predicted threshold | Sensitivity (%) | Specificity (%) | Accuracy (%) |
|--------------|-----------------------|----------|---|-----------------------------|-----------------|-----------------|--------------|
| Durum | FDK | A | Probability = $1/(1+ (\exp(-11.9932+0.0847RH8010MA)))$ | 0.29 | 83.3 | 74.2 | 78.7 |
| | | B | Probability = $1/(1+(\exp(-17.9341+0.2185RH4MA)))$ | 0.28 | 80.0 | 73.0 | 76.5 |
| Spring Wheat | FDK | C | Probability = $1/(1+ (\exp(-25.27+0.3167RH7MA)))$ | 0.32 | 83.6 | 72.5 | 78.1 |
| | | D | Probability = $1/(1+(\exp(-20.4640+0.2599RH4MA)))$ | 0.35 | 78.2 | 76.5 | 77.4 |
| Durum | DON | E | Probability = $1/(1+(\exp(-20.7748+0.2646RH10MA)))$ | 0.57 | 71.7 | 84.9 | 78.3 |
| | | F | Probability = $1/(1+\exp(-24.1039+0.3114RH14MA))$ | 0.51 | 69.6 | 89.0 | 79.3 |

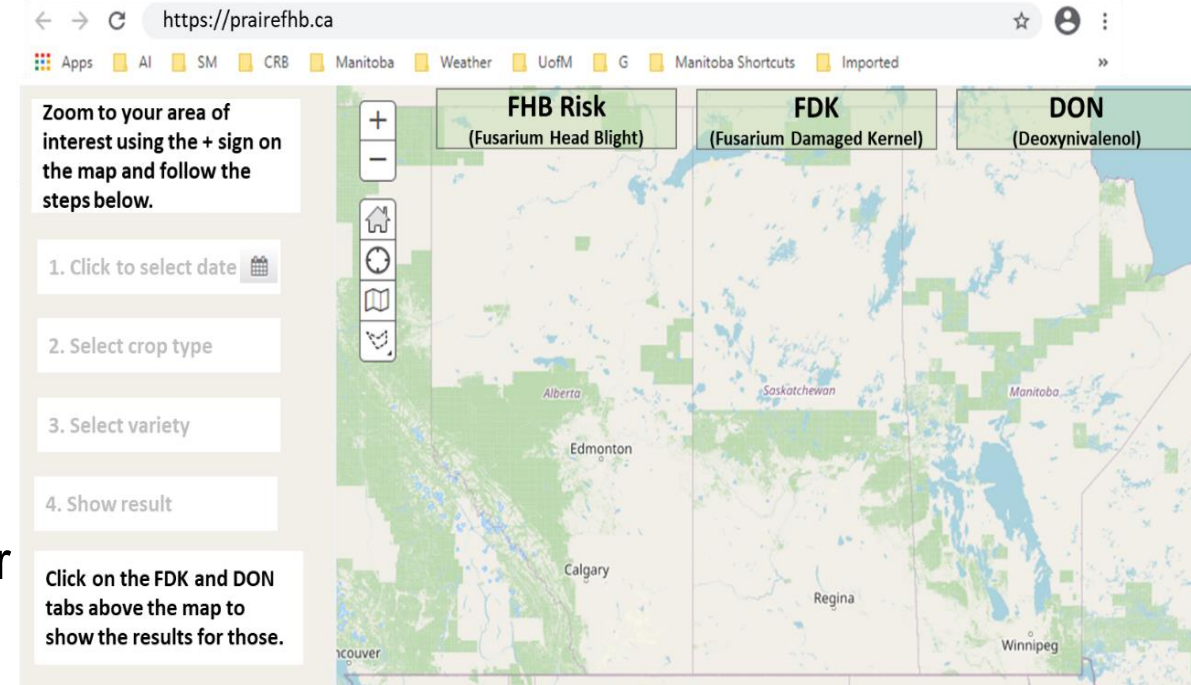


Graphical illustration of Spring wheat FDK Model



Summary and Conclusion

- FDK and DON models utilized only relative humidity
- Accuracy of models is greater than 73%
- Increased predictive accuracy is expected as data 2021 data will be added in model development
- Producer fields samples to validate the models
- Models will power an interactive, online digital viewer and provide early warning of potential FHBi, FDK, and DON epidemics in prairie cereal crops



Acknowledgments



Producer field's collaborators

Technicians

Summer students

Colleagues



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