

HISTORY OF FHB RESEARCH IN (WESTERN) CANADA

Andy Tekauz

9th CWFHB, Winnipeg MB, Nov 22, 2018

OVERVIEW: FROM CPDS

× 1919 - 1979

× 1980 - 1992

× 1993 - 1998

× 1999 - 2018

WHY FHB IS 'WHAT IT IS': A MAJOR CEREAL DISEASE

1. Loss of yield

- fewer, smaller, lighter kernels

2. Loss of grade

- presence of FDK (e.g. 0.25%, 0.8%)

3. Contamination by DON (end-use compromised)

- raw grain unsuitable for feeding
- barley not selected for malting
- oats not selected for milling
- processing quality reduced (e.g. flour properties)
- ethanol and distillers grain

4. Reduced germination when grain is used as seed

5. Loss of export markets due to international tolerance limits

OCCURRENCE OF FHB: 1919 - 1979

- × **1919** – First record of FHB (fusarium head blight, head blight, scab) in Canada (E)
- × **1920** on – Sporadic reports of FHB/Fusarium in cereal crops or on seed/grain (E+W)
 - + 1927/28
 - + 1940
 - + 1942
 - + 1948

WHEAT SCAB OR HEAD BLIGHT - *Gibberella Saubinettii*
(Mont.) Sacc.

PRINCE EDWARD ISLAND

1927 - This disease caused considerable damage in Huron
and Red Tife.

NEW BRUNSWICK

1927 - Isolated infections only observed. Of no serious
consequence.

QUEBEC

1928 - One two-per cent infection found in experimental
plots at Ste. Anne de la Pocatiere.

MANITOBA

1928 - This disease was very prevalent in Manitoba this
year, the warm moist season providing favourable
conditions for its development. Plants were
attacked by a light general infection varying
from a trace to 3 per cent, except in certain
low spots where plants were heavily attacked.
In plots of Reward at Winnipeg 80 to 100 per
cent of the plants were infected.

SASKATCHEWAN

1927 - Traces found at Indian Head and Saskatoon.

1928 - Slight infection found on Marquis wheat at
Saskatoon and Trossachs.

CPDS VOL. 20: FHB IN WHEAT IN 1940

HEAD BLIGHT (chiefly Fusarium spp.). Slight to moderate infections were observed at Vegreville and in the plots at Lethbridge, Alta. Blighted heads of the Fusarium type were fairly common in fields at Melfort, Tisdale, and Pontrillas, Sask. and scabby kernels were present in threshed grain from Indian Head. Material showing blight due to Helminthosporium sativum was received from Gronlid and Scott. In Man., 2% of the heads were affected at Roblin, as well as a trace at Binscarth (Fusarium Scirpi var. acuminatum and Helminthosporium sativum isolated)

and at Winnipeg (F. Poae, F. Scirpi and F. Scirpi var. acuminatum). About 10% of the heads were said to be affected in winter wheat in western Ontario; isolations were made from two samples, one from Ailsa Craig (F. graminearum) and one whose location was not stated (F. graminearum and H. sativum). Diseased specimens were collected at Ottawa (F. graminearum and F. Poae). Head blight was virtually absent in Que., N.B., N.S., and P.E.I.; 3% of the heads were affected at Gillespie, N.B. (F. graminearum); a trace occurred in Garnet at Truro, N.S., and a trace was present at Charlottetown, P.E.I. (F. graminearum and F. Poae). The fungi reported within the brackets were isolated and determined by W. L. Gordon.

COMMON ROOT ROT (Helminthosporium sativum and Fusarium spp.).

CPDS VOL. 21: FHB IN WHEAT IN 1941

HEAD BLIGHT (chiefly Fusarium spp.). Trace to slight damage was caused by Fusarium spp. in fields at Athabaska and Dewberry, Alta.; slight infection by Helminthosporium sativum was found in the plots at Edmonton (A.W. Henry). Blighted heads of wheat yielded the following fungi when isolations were made: Ste. Anne, Man.: Thatcher - F. graminearum; Winnipeg: Regent x Thatcher - F. graminearum and F. Scirpi var. acuminatum, Iumillo - F. Poae; Kemptville, Ont.: C.T. 129 - F. avenaceum; Lennoxville, Que.: Vernal Emmer - F. graminearum; Ste. Anne de la Pocatiere: Marquis x Kanred - F. avenaceum; Fredericton, N.B.: Coronation - F. Poae, Epicoccum purpurascens, Alternaria, etc. Only a trace of infection was recorded at all locations. This is the first time that F. gramineum was isolated from head blight of wheat in Man., although it was isolated once from a sample of durum wheat seed of the 1939 crop obtained at Oak Bluff, and again once from a sample of common wheat seed of the 1940 crop obtained at Portage la Prairie (W.L. Gordon). In general only traces of head blight were recorded in Que., N.B., and P.E.I.; in some of the plots, however, particularly at Fredericton, N.B., up to 15% of heads were affected.

CPDS VOL. 28: FHB IN WHEAT IN 1948

HEAD BLIGHT (Fusarium spp.). Continued most and relatively cool weather during the summer appeared to favour the development of head blight in Man. By the end of July, it was found in moist fields of wheat and barley examined and in 15 of the 25 varieties of the co-operative test of wheat varieties at Winnipeg. Occasionally as many as 5% of the spikes were affected. Of the 6 collections of wheat head blight that were cultured, Fusarium Poae was isolated from one collection, F. Scirpi var. acuminatum from 3, F. culmorum from 2, and F. graminearum and Helminthosporium sativum from one.

Gibberella Zeae, the perfect stage of Fusarium graminearum, was found in profusion on corn stubble of the 1947 crop on the University farm by J.E. Machacek on Aug. 8, 1948. (This collection of perithecia was the second recorded for Man., the first having been reported by Dr. G.R. Bisby in 1923). Formation of perithecia evidently took place between mid-June and early August for perithecia were not found on the same stubble on June 12. Empty perithecia, as well as mature and in some collections immature perithecia, were found on the corn stubble at the same location on Sept. 12. No perithecia were found on corn stubble of the 1948 crop when it was examined in mid-November (W.L. Gordon, J.E. Machacek, W.A.F. Hagborg).

Six other collections of head blight on wheat and one on barley from outside Man. were cultured. The species isolated were as follows: Agassiz, B.C., F. avenaceum; Fort William, Ont., F. culmorum; Appleton, wheat 2 collections F. graminearum and barley F. Poae, Helminthosporium sativum; Normandin, Que., F. graminearum (W.L. Gordon).

Traces of head blight occurred in the plots at Ste. Anne de la Pocatiere, Que. (A. Payette).

CPDS VOL. 28: FHB IN BARLEY IN 1948

HEAD BLIGHT (Fusarium spp. and Helminthosporium sativum). Traces were noted on most varieties in the Q.S.B. plots in Que. (T. Simard, D. Leblond).

STRIPE (Helminthosporium gramineum). Infection was 11-tr, 3-sl, 2-mod./99 fields in Alta. (T.R.D.); and a trace in one field in Queens Co., P.E.I. (R.R. Hurst).

OCCURRENCE: 1980 - 1992

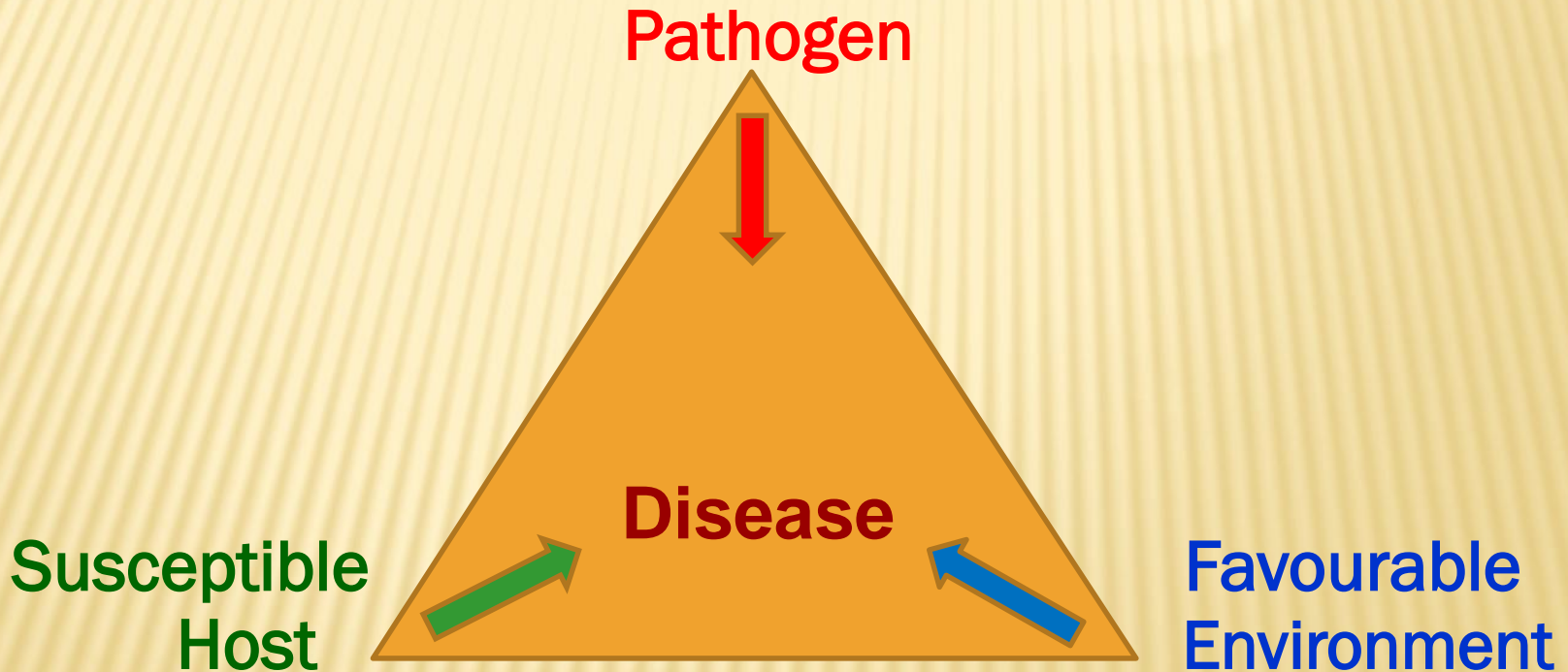
- × **1980** – Epidemic of FHB in winter wheat in S-W Ontario
- × **1984** – Evidence of FHB seen in two harvest samples of wheat from southern MB ('tombstone', Fg)
- × **1985** – Additional wheat samples in southern MB found to be affected by FHB, and subsequently, 'vomitoxin'
- × **1987** – First contemporary survey data of FHB prevalence and severity in a wheat crop (Fg)
- × **1991** – FHB widespread on wheat in southern MB with 75% of fields affected and 1/3 having severity/incidence of 10%

OCCURRENCE: 1993 - 1998

- × **1993** – Severe epidemic of FHB on wheat in southern MB (and adjacent US states); Fg
- × **1994** – A second severe FHB epidemic in MB; barley also found to be affected Fg involved
- × **1997** – FHB found at higher levels in central and western MB than previously (Fg)
- × **1998** – FHB becomes endemic throughout MB and south-eastern SK
- × **1998** – FHB evident in MB winter wheat, an expanding commodity in MB and elsewhere

PLANT PATHOLOGY '101'

THE PLANT DISEASE TRIANGLE



FIELD SYMPTOMS OF FHB ON **BREAD WHEAT**



OCCURRENCE: 1999 - 2018

- × **1999** on – Comprehensive surveys for FHB continue in western Canada showing varying levels of seasonal severity (Fg, Fp, Fa, Fs)
- × **2002** – FHB noted on oat in MB; most fields surveyed putatively affected (Fp, Fg, Fs)
- × **2010** – Levels of FHB higher in SK (Fa); Fg levels in seed samples rise dramatically
- × **2012** – Second instance of higher FHB and Fg levels in SK

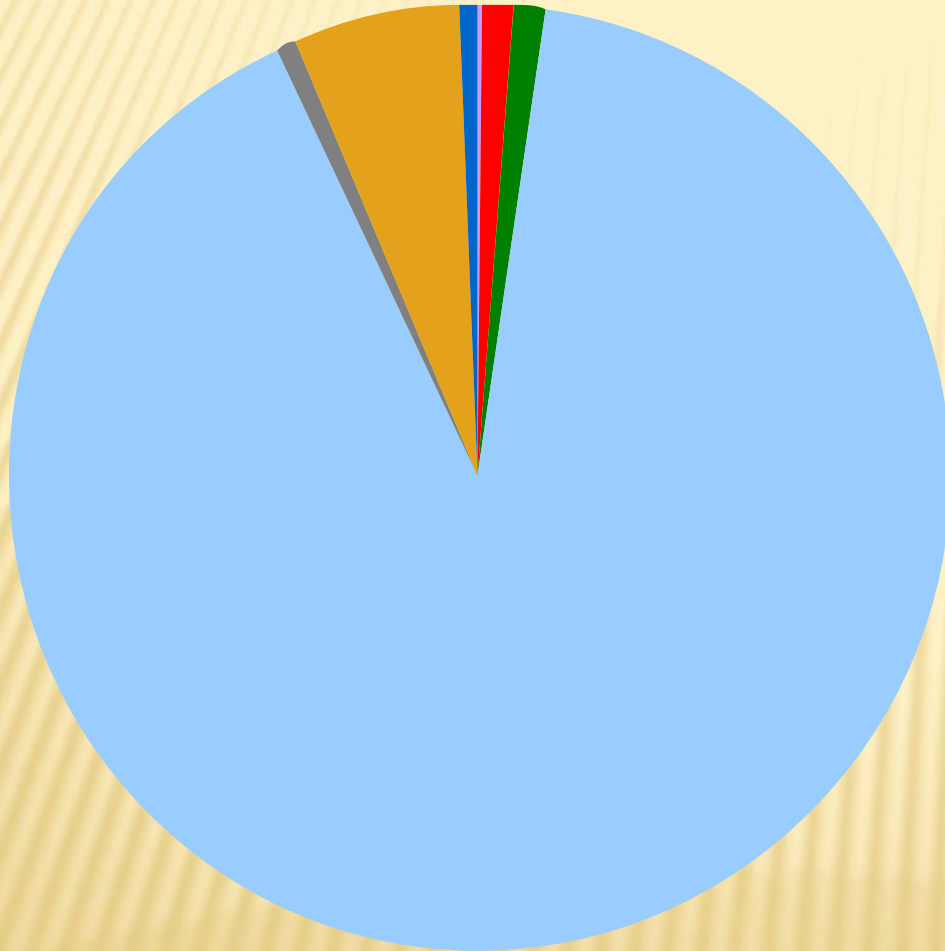
LEVELS OF *FUSARIUM* AND *F. GRAMINEARUM* IN CEREAL SEED SAMPLES SUBMITTED TO SEED-TESTING LABORATORIES IN SK 2005-2013

Year	<i>Fusarium</i> mean (%)	<i>Fg</i> mean (%)	Total samples	% with <i>Fg</i>
2005	7.3	1	726	38
2006	4	0.1	479	21
2007	3.6	0.5	675	30
2008	4.9	0.6	626	40
2009	4.9	0.8	362	42
2010	19	4.2	470	64
2011	6.3	1.1	953	51
2012	11.2	5.6	1981	82
2013	5.8	2.2	1660	73

CPDS – REPORTS OF ANNUAL FHB DISEASE DATA

× MB wheat FHB surveys	1987	31 yrs
× MB barley FHB surveys	1994	24 yrs
× MB winter wheat FHB surveys	1998	20 yrs
× MB oat FHB surveys	2002	16 yrs
× SK wheat FHB surveys	1997	
× SK barley FHB surveys	1997	
× SK oat FHB surveys	2004	
× AB wheat (for 1999-2002)	2002	

RELATIVE FREQUENCY OF *FUSARIUM* SPECIES ISOLATED FROM KERNELS OF **SPRING WHEAT** IN MANITOBA, 2001-2010



F. avenaceum 0.2

F. culmorum 1.2

F. equiseti 1.0

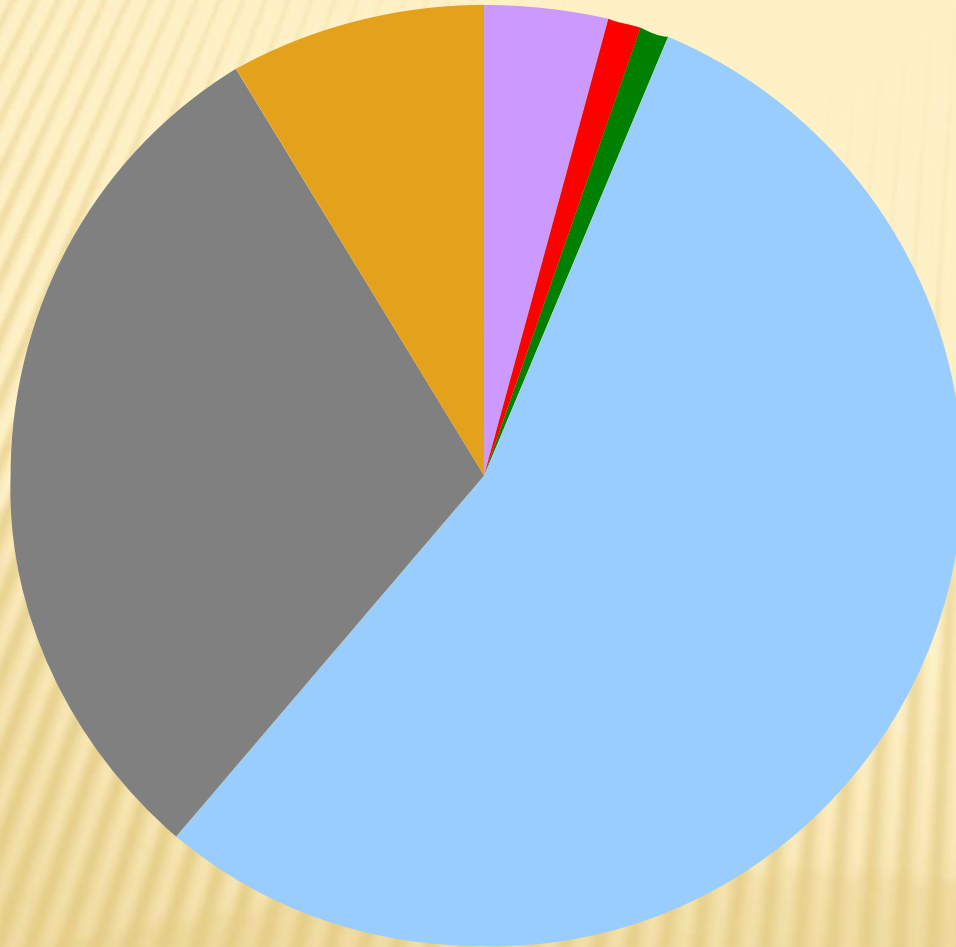
F. graminearum 90.8

F. poae 0.6

F. sporotrichioides 6.0

Other *Fusarium* spp. 0.5

RELATIVE FREQUENCY OF *FUSARIUM* SPECIES ISOLATED FROM KERNELS OF BARLEY IN MANITOBA, 2001-2010



F. avenaceum. 4.3

F. culmorum 0.6

F. equiseti 1.0

F. graminearum 55.1

F. poae 30.4

F. sporotrichioides 6.0

Other *Fusarium* spp. 0.0

FUSARIUM ON CEREAL SEED FROM MANITOBA AND SASKATCHEWAN 2003-2007

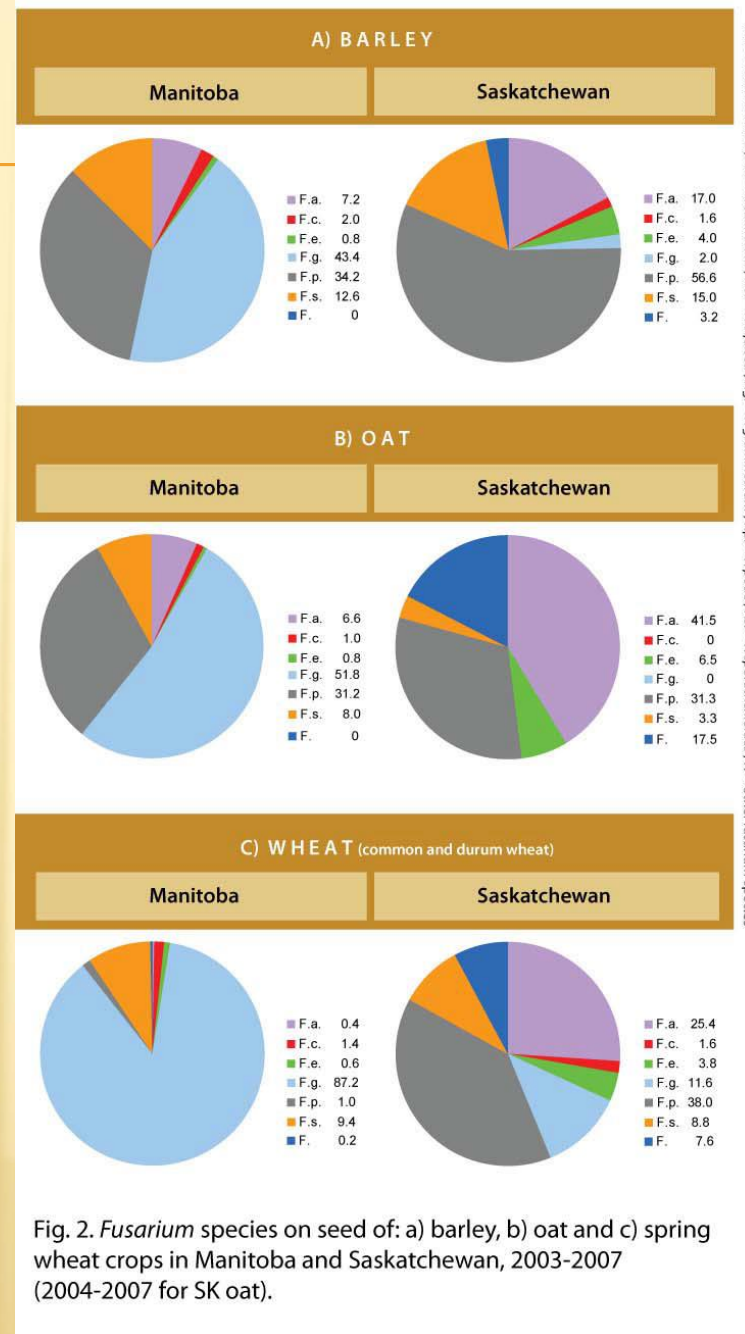


Fig. 2. *Fusarium* species on seed of: a) barley, b) oat and c) spring wheat crops in Manitoba and Saskatchewan, 2003-2007 (2004-2007 for SK oat).

HISTORY OF CPDS

Canadian Plant Disease Survey – Disease Reports

- ✘ Vol 1-39 (to 1959) '10th Annual Report of the CPDS'
- ✘ Vol 40 (1960) now the 'CPDS'
- ✘ Vol 68 (1988) now an AAFC/CPS publication
- ✘ Vol 69 (1989) Section Editors appointed
- ✘ Vol 77 (1997) now a stand-alone CPS publication
- ✘ Vol 79 (1999) Robin Morrall new National Coordinator
- ✘ Vol 96 (2016) Morrall and Tekauz 'retire'
- ✘ Vol 97 (2017) J Elmhirst (NC) and K Turkington (Cereals)

TYPICAL FHB SURVEY REPORTS PUBLISHED IN CPDS

E.G. 2005 DATA PUBLISHED IN VOL. 86 (2006)

- × Tekauz et al. FHB in barley in MB in 2005
- × Xue et al. Diseases of barleyOntario in 2005
- × Pearse et al. FHB in barley and oat in SK in 2005
- × Morrall at al. Seed-borne *Fusarium* on cereals in SK in 2005

- × Rioux & Comeau Apercu des maladies des cereals au Quebec en 2004 et 2005

- × Tekauz et al. FHB of oat in MB in 2005
- × Tamburic-Ilincic & Schaafsma 2005 survey for FHB of oat in ON
- × Turkington et al. FHB survey of wheat, AB
- × Gilbert et al. 2005 survey of FHB of spring wheat in MB
- × Tekauz et al. 2005 survey for FHB on winter wheat in MB
- × Xue at al. Diseases of spring wheat in eastern ON in 2005

- × Tamburic-Ilincic et al. 2005 survey for FHB of winter wheat in SW ON

IT'S A CENTENNARY CELEBRATION

CPDS is 100 years old!!

SYMPTOMS OF FHB ON OAT



SELECTED RESEARCH PUBLICATIONS - TO 1980

× 1944 Gordon

The occurrence of Fusarium species in Canada

I: Species of Fusarium isolated from farm samples of cereal seed in Manitoba

× 1952 Gordon

The occurrence of Fusarium species in Canada

II. Prevalence and taxonomy of Fusarium species in cereal seed

W.L. GORDON

CANADIAN JOURNAL OF BOTANY - 1952

THE OCCURRENCE OF *FUSARIUM* SPECIES IN CANADA

II. PREVALENCE AND TAXONOMY OF *FUSARIUM* SPECIES IN CEREAL SEED¹

BY W. L. GORDON²

Abstract

During the present investigation, a total of 1579 seed samples of wheat, 1042 of barley, and 1152 of oats (100 kernels per sample), were examined microbiologically for the presence of *Fusarium*. Of these samples, 402 of wheat, 513 of barley, and 636 of oats originated in the seed inspection districts of Eastern Canada, and 1177 of wheat, 529 of barley, and 516 of oats in those of Western Canada. Isolates of *Fusarium* were obtained from approximately 41.8% of the samples of wheat (1.5% of the kernels), 76.2% of the samples of barley (3.9% of the kernels), and 79.6% of the samples of oats (5.7% of the kernels) that originated in Eastern Canada, whereas only 13.8% of the samples of wheat (0.2% of the kernels), 36.3% of the samples of barley (0.7% of the kernels), and 38.9% of the samples of oats (1.1% of the kernels) from Western Canada yielded *Fusarium*. In classifying the different wild types of *Fusarium* that were obtained from cereal seed the system of taxonomy and nomenclature of Wollenweber and Reinking was chiefly followed, but certain sections of the genus were revised extensively, partly in accordance with Snyder and Hansens' concept of species in this genus. Four new combinations are proposed, namely *F. compactum* (Wr.) n. comb., *F. lateritium* Nees emend. Snyder & Hansen forma *tajani* (Padwick) n. comb., *F. lateritium* Nees emend. Snyder & Hansen forma *erolalariae* (Padwick) n. comb., and *F. oxysporum* Schlecht. emend. Snyder & Hansen var. *redolens* (Wr.) n. comb. A total of 16 species and varieties of *Fusarium*, classified in nine sections of the genus, was isolated from cereal seed during this investigation. These species and varieties are, namely, *F. poae* (Pk.) Wr., *F. sporotrichoides* Sherb., *F. avenaceum* (Fr.) Sacc., *F. arthrosporioides* Sherb., *F. semitectum* Berk. & Rav., *F. equiseti* (Cda.) Sacc., *F. acuminatum* Ell. & Ev., *F. culmorum* (W. G. Sm.) Sacc., *F. graminearum* Schwabe, *F. sambucinum* Fuckel, *F. sambucinum* var. *coeruleum* Wr., *F. lateritium* Nees emend. Snyder & Hansen, *F. moniliforme* Sheld. emend. Snyder & Hansen, *F. oxysporum* var. *redolens* (Wr.) n. comb., and *F. solani* (App. & Wr.) Wr. emend. Snyder & Hansen. *F. poae*, *F. avenaceum*, and *F. acuminatum* were most frequently isolated. *F. concolor* Rg. and *F. sambucinum* f. 6 Wr., that were previously recorded from cereal seed in Manitoba, and three additional species, namely, *F. dimerum* Penz., *F. merismoides* Cda., and *F. nivale* (Fr.) Ces., that may be encountered in the future among isolates from cereal seed in Canada, were also included in this study.

Introduction

In Part I of this series of papers (13) data were presented on the incidence of *Fusarium* species in farm samples of cereal seed produced in Manitoba during the crop years 1937 to 1942. These data showed that *Fusarium* species were encountered in a relatively large percentage of the total number of samples of cereal seed examined but in a relatively small percentage of the kernels. The majority of the species that were isolated from the seed proved to be the same as those species which had been previously shown to be associated with root rots of cereals in Manitoba (12).

¹ Manuscript received October 20, 1951.

Contribution No. 1122 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

² Plant Pathologist, Dominion Laboratory of Plant Pathology, Winnipeg, Man.

PRESENCE OF *FUSARIUM* ON CEREAL SEED 1939-1943

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PRESENCE OF *FUSARIUM* ON CEREAL SEED 1939-1943

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SELECTED RESEARCH PUBLICATIONS - 1980s

× 1982 Sutton et al.

*Epidemiology of wheat head blight and ear rot of maize caused by *Fusarium graminearum**

× 1982 Seaman

Epidemiology and control of mycotoxigenic fusaria on cereal grains

× 1982 Martin & Johnston

Effects and control of fusarium diseases of cereal grains in the Atlantic Provinces

× 1982 Couture

*Reaction of spring cereal cultivars to kernel contamination by *Fusarium* spp*

× 1984 Teich & Nelson

Survey of fusarium head blight and possible effects of cultural practices in wheat fields in Lambton County in 1983

SELECTED RESEARCH PUBLICATIONS - 1980/90s

- ❖ **1986 Clear & Abramson**
Occurrence of fusarium head blight and deoxynivalenol (vomitoxin) in two samples of Manitoba wheat in 1984
- ❖ **1987 Abramson et al.**
Fusarium species and trichothecene mycotoxins in suspect samples of 1985 Manitoba wheat
- ❖ **1990 Clear & Patrick**
Fusarium species isolated from wheat samples containing tombstone (scab) kernels from Ontario, Manitoba and Saskatchewan
- ❖ **1992 Wong et al.**
Prevalence, distribution and importance of fusarium head blight in wheat in Manitoba
- ✗ **1995 Gilbert & Tekauz**
Effects of fusarium head blight and seed-treatment on germination, emergence and seedling vigour in spring wheat

SELECTED RESEARCH PUBLICATIONS - 1980/90s

× 1995 Wong et al.

Pathogenicity and mycotoxin production of Fusarium species causing head blight in wheat cultivars varying in resistance

× 1995 Mesterhazy

Types and components of resistance to Fusarium head blight in wheat

× 1995 Couture et al.

Incidence of scab in oat cultivars in Quebec in 1995

× 1996 Dexter et al.

Fusarium head blight: Effect on the milling and baking of some Canadian wheats

× 1996 Clear et al.

Occurrence and distribution of Fusarium species in barley and oat seed from Manitoba in 1993 and 1994

SELECTED RESEARCH PUBLICATIONS - 1990s

- × 1997 Gilbert et al.
Effect of storage on viability of Fusarium head blight-affected spring wheat seed
- × 1997 Clear et al.
The effect of hull removal and pearling on Fusarium species and trichothecenes in hullless barley
- × 1997 McMullen et al.
Scab of wheat and barley: a re-emerging disease of devastating impact
- × 1997 Miedaner
Breeding wheat and rye for resistance to Fusarium diseases
- × 1998 Miller et al.
Effect of tillage practice on fusarium head blight of wheat
- × 1999 Stack
Return of an old problem: Fusarium head blight of small grains

SELECTED RESEARCH PUBLICATIONS - EARLY 2000s

- × 2000 Tekauz et al.

Review: Fusarium head blight of barley in western Canada

- × 2000 Clear & Patrick

Fusarium head blight pathogens isolated from fusarium-damaged kernels of wheat in western Canada

- × 2000 Gilbert & Tekauz

Review: Recent developments in research on fusarium head blight of wheat in Canada

- × 2001 McCallum et al.

Vegetative compatibility groups among Fusarium graminearum (Gibberella zeae) isolates from barley spikes in southern Manitoba

- × 2002 Abramson et al.

Moniliformin in barley inoculated with Fusarium avenaceum

SELECTED RESEARCH PUBLICATIONS - EARLY 2000s

- × 2002 McCallum & Tekauz
Influence of inoculation method and growth stage on fusarium head blight in barley
- × 2002 Turkington et al.
Fungal plant pathogens affecting barley and wheat seed from Alberta, 1995 - 1997
- × 2003 Inch & Gilbert
Survival of Gibberella zeae in Fusarium-damaged wheat kernels
- × 2004 Tekauz et al.
Fusarium head blight of oat – current status in western Canada
- × 2004 McCallum et al.
Reaction of a diverse collection of barley lines to Fusarium head blight
- × 2004 Abramson et al.
HT-2 and T-2 production in barley inoculated with Fusarium sporotrichioides

SELECTED RESEARCH PUBLICATIONS - 2000s

- × 2004 McCallum et al.

*Barrage zone formation between vegetatively incompatible *Fusarium graminearum* (*Gibberella zeae*) isolates*

- × 2005 Gilbert et al.

*Effect of heat treatment to control *Fusarium graminearum* in wheat seed*

- × 2009 Xue et al.

*Biological control of fusarium head blight of wheat with *Clonostachys rosea* strain ACM941*

- × 2010 Gilbert et al,

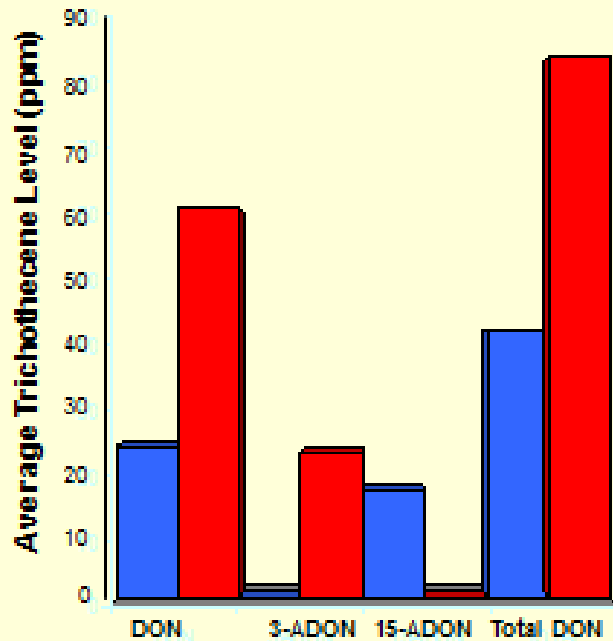
*Relative aggressiveness and production of 3- or 5-acetyl deoxynivalenol by *Fusarium graminearum* in spring wheat*

- × 2011 Gilbert & Tekauz

Strategies for management of fusarium head blight (FHB) in cereals

F. GRAMINEARUM CHEMOTYPE COMPARISON

3-ADON Isolates: More Toxin and More Toxic

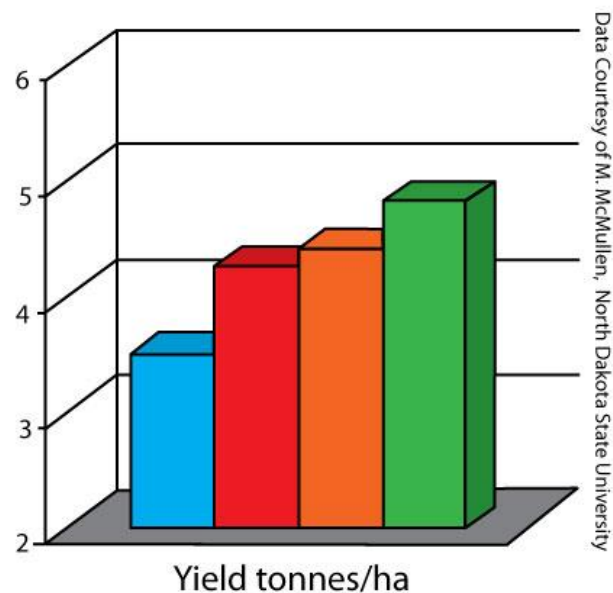
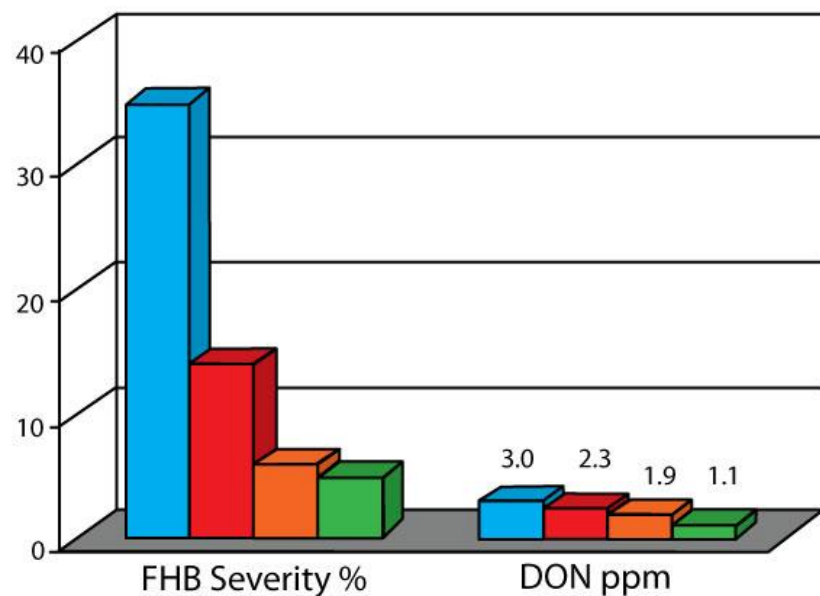


➤ 3-ADON isolates make significantly ($P < 0.001$) more total DON

- 3-ADON may be more toxic
 - 3-ADON $LD_{50} = 49$ mg/kg
 - 15-ADON $LD_{50} = 113$ mg/kg



INTEGRATED APPROACH TO FHB MANAGEMENT



Data Courtesy of M. McMullen, North Dakota State University

- Susceptible 'Monroe' durum planted into wheat stubble
- Susceptible 'Monroe' durum planted into canola stubble
- Moderately resistant 'Divide' durum planted into canola stubble
- Moderately resistant 'Divide' durum planted into canola stubble and treated with foliar fungicide Prosaro (prothioconazole + tebuconazole)

Fig. 3. Effect of integrated management strategies (varietal selection, rotation, fungicide) on fusarium head blight (FHB) severity, deoxynivalenol (DON) accumulation and yield of durum wheat.

SELECTED RESEARCH PUBLICATIONS - 2000s

× 2011 Haber at al.

Epigenetics serves genetics: fusarium head blight (FHB) resistance in elite wheat germplasm

× 2015 Xue et al.

Timing of inoculation and Fusarium species affect the severity of fusarium head blight on oat

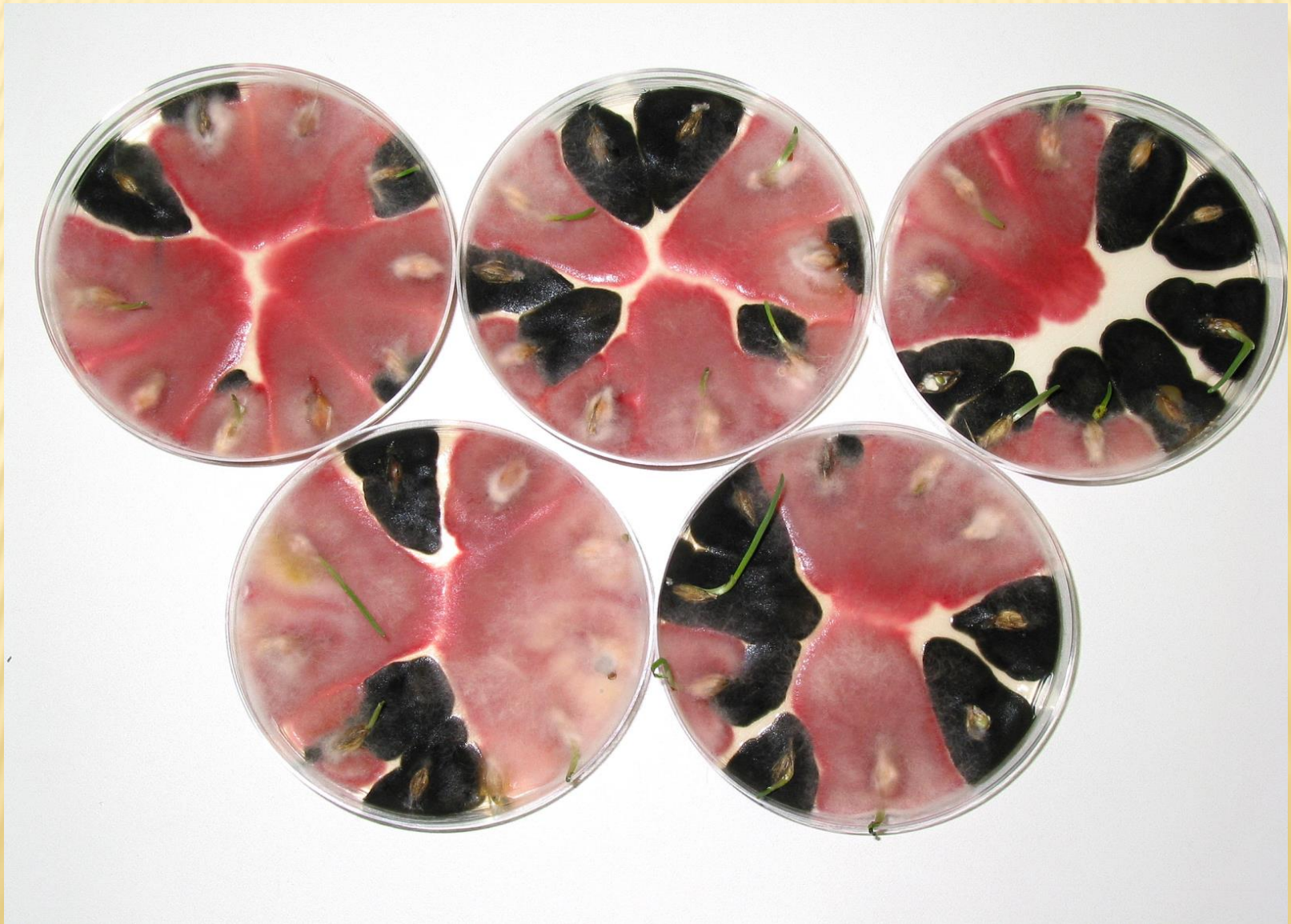
× 2016 Rampitsch at al.

Inhibition of Fusarium graminearum and other Fusarium species by Cochloibolus sativus in culture and on barley plants

× 2018 Bai et al.

Wheat resistance to Fusarium head blight

ISOLATION OF Fg (AND Cs) FROM BARLEY SEED



GRANTING AGENCIES THAT SUPPORTED AND FOSTERED RESEARCH ON FHB IN W CANADA

- × **WGRF** – Western Grains Research Foundation
- × **ARDI** – Agri-Food Research Development Initiative
- × **ADF** – Agricultural Development Fund
- × **AARI** – Alberta Agricultural Research Institute

SUPPORT STAFF AND STUDENTS RE. FHB RESEARCH

Cereal Research Centre 1986 – 2013

Eric Mueller
Meconnen Beyene
Marcos Stulzer
Mitali Banik

Ron Kaethler
Uwe Kromer
Kirstin Slusarenko
Kevin Morgan

James Tucker

Post Docs

Linda Wong
Brent McCallum

Grad Students

Sharon Inch
Saber Golkari
Manika Pradhan

Also

Denise Orr
Noryne Rauhala

'OTHER RESEARCHERS' RE. FHB

Eastern Canada

- × Kathy Clough
- × Luc Couture
- × Alain Devaux
- × Sylvie Rioux
- × Andre Comeau
- × Art Schaafsma
- × Lily Timburic-Ilincic

Western Canada

- × Claude Bernier
- × Gary Platford
- × Dilantha Fernando
- × Tom Graefenhan
- × Xiben Wang
- × Maria Antonia Henriquez
- × Holly Derksen
- × Myriam Fernandez
- × Penny Pearse
- × G Holzgang
- × Faye Dokken-Bouchard
- × Randy Kutcher
- × Kelly Turkington

SYMPTOMS OF FHB ON TWO-ROW BARLEY



REGIONAL MEETINGS ON FHB - 1993 TO 1996/7

Plant Pathologists, Breeders, etc.

- × Fargo, North Dakota 1993
- × ? Minnesota 1994
- × Brookings, South Dakota 1995
- × Winnipeg, Manitoba 1996

CANADIAN NATIONAL MEETINGS ON FHB

Canadian Workshops on Fusarium Head Blight

- × 1st 1999 Winnipeg MB
- × 2nd 2001 Ottawa ON
- × 3^d 2003 Winnipeg MB
- × 4th 2005 Ottawa ON
- × 5th 2007 Winnipeg MB
- × 6th 2009 Ottawa ON
- × 7th 2011 Winnipeg MB
- × 8th 2016 Ottawa ON
- × 9th 2018 Winnipeg MB

SPONSORS/PARTNERS OF CWFHB

- × BASF
- × Bayer Crop Science
- × Dow AgroSciences
- × Syngenta
- × **Canterra**
- × **CSGA**
- × **Secan**
- × **BMBRI**
- × **Rahr Malting**
- × **Canadian Grain Commission**
- × **Canadian National Millers Association**
- × **Canadian Wheat Board**
- × **Province of Manitoba**

EUROPEAN FUSARIUM SEMINAR

The EFS was the *de facto* international meeting on FHB, until the 'Interntional Symposium on FHB', and likely still is (?)

- | | | |
|---|------|-------------------------|
| ✘ Warsaw, Poland (1 st) | 1987 | |
| ✘ Martina Franca, Italy (4 th) | 1995 | |
| ✘ Szeged, Hungary (5 th) | 1997 | |
| ✘ Poznan, Poland (7 th) | 2002 | |
| ✘ Berlin, Germany | | |
| ✘ Orlando, Florida (8 th) | 2004 | (2 nd ISFHB) |
| ✘ Szeged, Hungary | 2008 | (3 rd ISFHB) |
| ✘ Radzikow, Poland (11 th) | 2010 | |
| ✘ Bordeaux, France (12 th) | 2013 | |
| ✘ Martina Franca, Italy (13 th) | 2015 | |
| ✘ Tulln, Austria (14 th) | 2018 | |

11TH EFS – RADZIKOW (WARSAW) POLAND 2010



SYMPTOMS OF FHB ON **SPRING WHEAT**



THE VARIETY REGISTRATION SYSTEM IN WESTERN CANADA (HISTORICAL)

1950s - 2018

NRC Associate Committees* - '50s, '60s, '70s

Expert Committees on Grain* - 1978

Prairie Registration Recommending Committees#- 1990

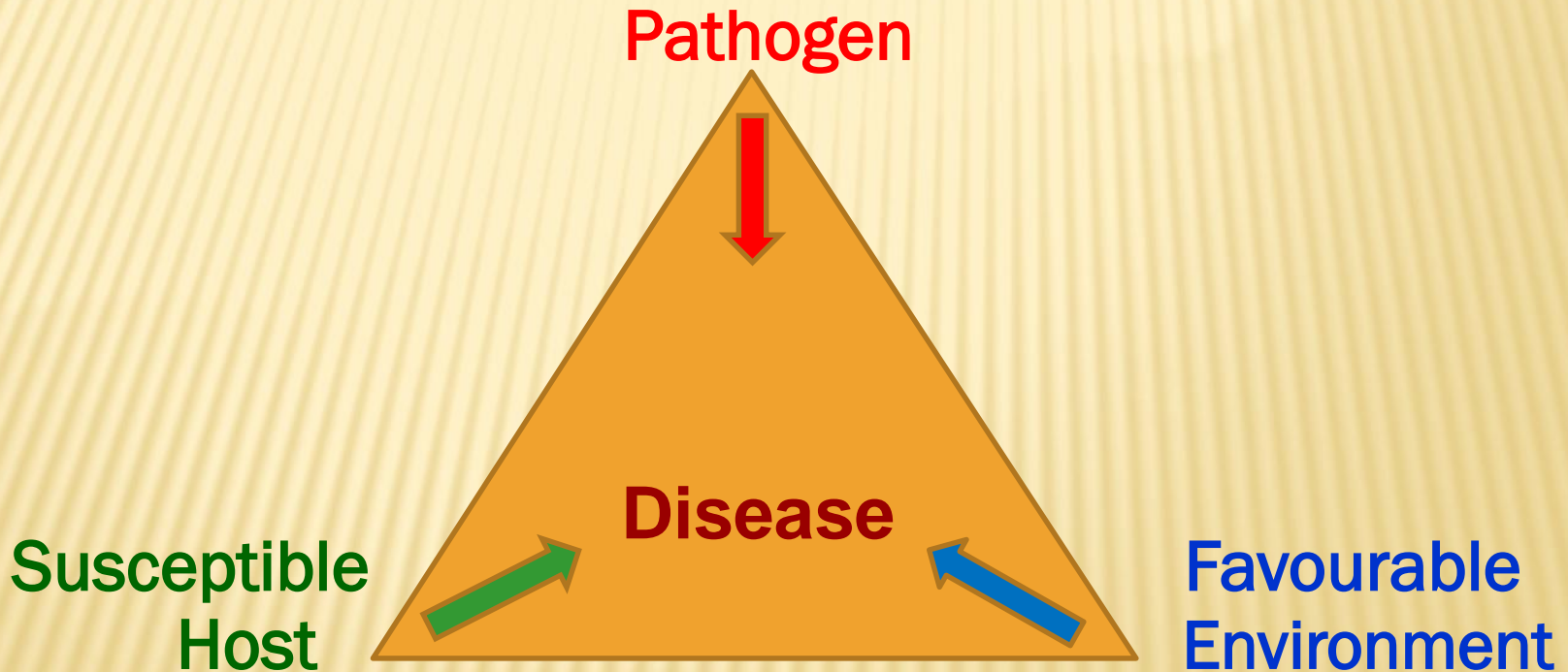
Prairie Grain Development Committee#- 2008

* of Breeding, Diseases, Quality

of **Wheat, Rye and Triticale**, **Barley and Oat**, **Oilseeds**, Specialty Crops

PLANT PATHOLOGY '101'

THE PLANT DISEASE TRIANGLE



THE VARIETY REGISTRATION SYSTEM IN WESTERN CANADA (CURRENT)

PGDC (Prairie Grain Development Committee)

www.pgdc.ca

- Prairie Registration Committee for **Wheat, Rye and Triticale**
- Prairie Registration Committee for **Oat and Barley**
- Prairie Registration Committee for **Oilseeds**
- Prairie Registration Committee for **Pulse and Special Crops**
 - Breeding and Agronomy Evaluation Team
 - Disease Evaluation Team
 - Quality Evaluation Team

'DO NOT OBJECT TO' GUIDELINES FOR PRIORITY 1 DISEASES OF **WHEAT & TRITICALE** IN W. CANADA

<u>Disease</u>	<u>CWRS/ CWHW</u>	<u>CPS CWGP</u>	<u>CWAD</u>	<u>SWS</u>	<u>Winter Wheat</u>	<u>Triticale</u>	<u>Spelt</u>
Leaf rust	MR	I	MR	-	I	MR	MR
Stem rust	I	I	MR	-	I	MR	-
Common bunt	I	I	MR	-	I	I	MS
FHB	I	I	MS	-	-	MS	MS
Leaf spots	MS	MS	I	-	-	-	MR
Loose smut	MR / MS	MS	MS	-	-	-	-
Stripe rust	-	-	-	MR	-	-	-

PRRCG/PGDC DISEASE EVALUATION TEAM FIRST-YEAR ENTRIES (25)

2008 WESTERN CO-OPERATIVE TWO-ROW BARLEY REGISTRATION TEST

TR Entry	NNB	SNB	SB	(sb)	Scald	(scald)	(ls)	FHB	Stem rust	Surface smuts	CRR	Loose Smut	Sept	Recommendation
08115	+	+	+	+	-	-	+	0	0	+	0	-	-	+
08116	+	0	0	-	-	-	-	0	0	+	+	-	-	0
08117	+	+	0	0	-	-	-	0	0	+	0	-	-	0
08118	-	+	0	0	-	-	0	+	0	+	0	-	-	0
08202	-	+	0	+	-	-	0	-	0	+	0	0	-	-
08203	+	+	+	+	-	-	+	0	0	+	++	+	-	++
08204	+	+	+	+	-	-	+	0	0	+	+	+	-	++
08205	0	+	+	0	-	-	0	0	0	+	+	-	-	0
08206	+	+	+	++	-	-	++	+	0	+	+	n/a	-	++
08207	0	+	+	++	-	-	++	++	0	+	+	+	-	++
08394	-	+	+	0	-	-	-	+	0	+	-	0	-	0/+

FUSARIUM 'CORN SPAWN' INOCULUM USED IN FIELD TRIALS

Corn kernels
infested with species
of *Fusarium*, clockwise
from top left:

F. graminearum

F. poae

F. sporotrichioides

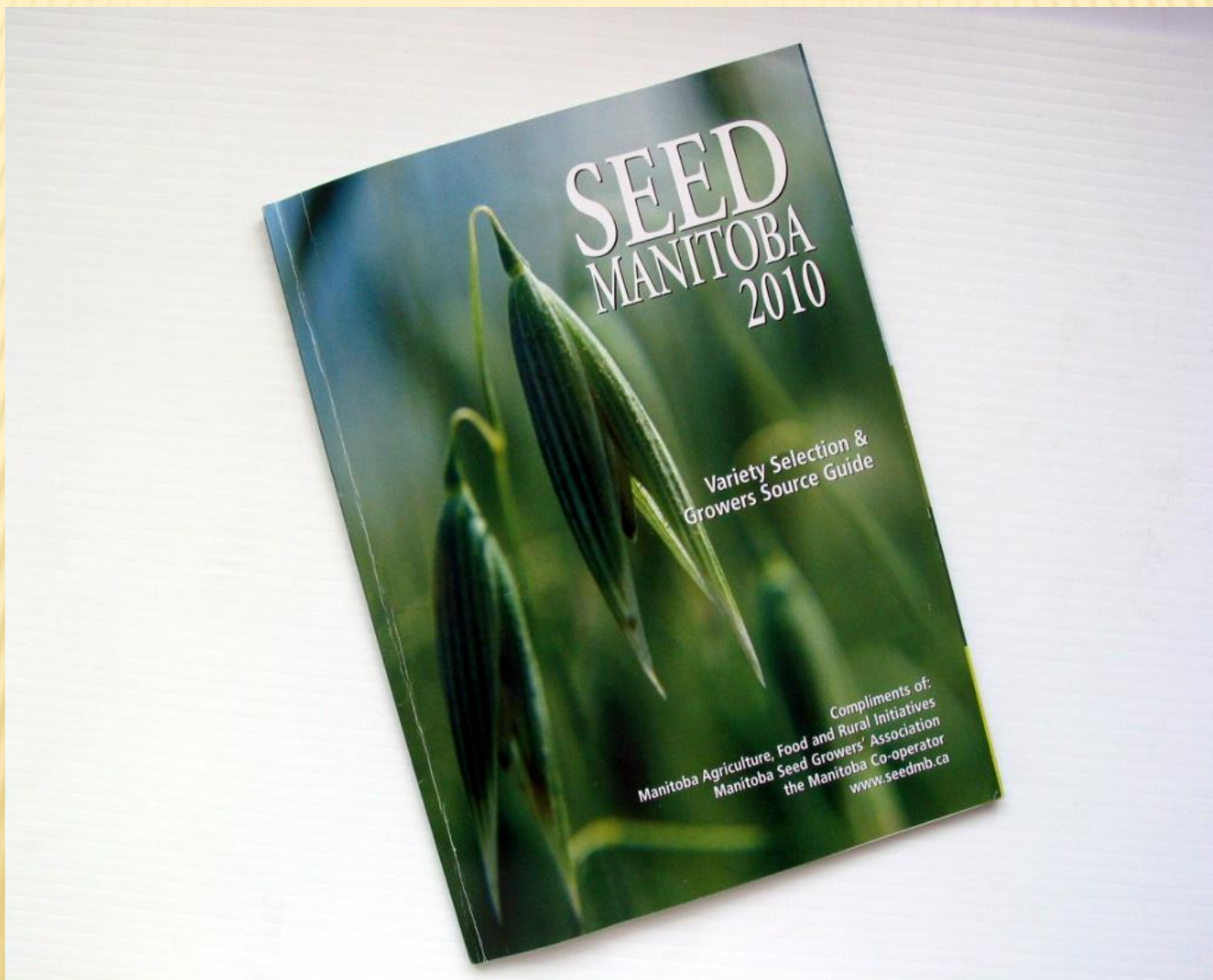
F. avenaceum



FIELD INOCULATION WITH *FUSARIUM GRAMINEARUM*



SEED GUIDES: *DISEASE MANAGEMENT INFORMATION*



MANITOBA SEED GUIDE - 1974



1974 FIELD CROP RECOMMENDATIONS FOR MB (WHEAT, N=6)

Wheat Variety Descriptions

Variety	Yield as % of Neepawa	Days to Maturity	Seed Size	Resistance to Lodging	Resistance to			
					Stem Rust	Leaf Rust	Loose Smut	Bunt
Bread Wheat								
Neepawa	100 1/	91.6	medium	excellent	good	fair	good	fair
Napayo	94	91.3	small	good	good	fair	good	fair
Utility Wheat								
Glenlea	119	93.0	large	excellent	good	good	good	fair
Durum Wheat								
Hercules	111	92.8	large	fair-good	good	good	good	fair
Wascana	114	96.3	large	fair	good	good	good	fair
Wakooma	112	97.0	large	fair	good	good	good	fair

1/ Average 29 station years – All Manitoba – 26.5 cwt/acre (2970 kg/ha)

1984 FIELD CROP RECOMMENDATIONS FOR MB (WHEAT, N=10)

Variety Description

Variety	Yield as % of Neepawa	Relative Maturity	Seed Size	Height	Lodging	Resistance to			
						Stem Rust	Leaf Rust	Loose Smut	Bunt
Benito	99	99	Small	Medium	Good	Good	V. Good	Good	Fair
Columbus	100	104	Medium	Medium +	Excellent	Fair	Good	Fair	Good
Katepwa	108	100	Medium	Medium	Excellent	Good	Fair	Good	Good
Neepawa	100*	100	Medium	Medium	Excellent	Good	Poor	Good	Fair
Sinton	99	102	Medium	Medium	Excellent	Good	Good	Poor	Fair
Glenlea	115	104	Large	Medium +	Excellent	Good	V. Good	Good	Fair
Arcola	115	102	Large +	Medium	Fair-Good	Good	V. Good	Fair	Good
Coulter	111	102	Large	Medium	Fair-Good	Good	V. Good	Fair	Good
Medora	115	103	Large	Medium +	Good	Good	V. Good	Fair	Good
Wakooma	105	105	Large	Medium +	Fair	Good	V. Good	Fair	Good

* Average 69 station-years — all Manitoba — 2608 kg/ha (38.8 bu/acre).

SEED MANITOBA 1994 (WHEAT, N=22)

Variety Descriptions¹

Variety	Days to Maturity ²	Seed Size	Height	Lodging	Resistance to:			
					Stem Rust	Leaf Rust	Loose Smut	Bunt
Canada Western Red Spring								
AC Domain	97	M ³	M ⁻⁴	2.4 VG ⁵	G	VG	G	G
AC Minto	97	M+	M	G	G	VG	G	G
CDC Teal	96	M	M-	VG	G	VG	G	F
CDC Merlin	98	M+	M	G	G	G	G	G
Columbus	100	M	M+	G	F	VG	F	G
Invader	99	M+	M	G	G	VG	G	G
Katepwa	97	M	M	G	G	F	G	G
Kenyon	97	M	M	G	G	VG	F	F
Neepawa	97	M	M	G	G	F	G	F
Pasqua	97	M	M	G	G	VG	G	F
Roblin	95	M+	M-	VG	G	G	G	P
Experimental Grades								
Grandin	99	M+	S	VG	G	VG	F	G
Canada Prairie Spring (Red)								
AC Taber	103	M+	S	VG	G	VG	P	G
Biggar	101	M+	S	VG	G	F	P	P
Cutler	94	M+	S	VG	G	F	P	P
Oslo	98	M+	S	VG	G	G	VP	F
Canada Prairie Spring (White)								
Genesis	102	M+	M	P	G	F	F	VP
Canada Western Extra Strong								
Glenlea	99	L	M+	G	G	G	VG	F

SEED MANITOBA 2013 (WHEAT, N=52)

Variety Descriptions

Class/Variety	Site Years Tested	Yield bu/acre	Protein %	Maturity +/- 99 days	Height +/- 37 inches	Spike Awned	Lodging	Sprouting	Resistance Level:					
									Loose Smut	Common Bunt	Leaf ¹ Spots	Stem Rust	Leaf Rust	Fusarium ² Head Blight
Canada Western Red Spring														
5602HR☺	90	60	14.9	1	0	Y	F	F	R	MR	I	R	R	MR
5603HR☺	41	60	14.4	2	0	Y	G	VG	MS	I	MR	MR	R	I
5604HR CL☺	40	58	14.4	-1	-1	Y	G	G	MS	I	MS	R	R	I
AAC Bailey☺	4	54	14.9	-1	0	N	G	G	MS	MR	I	R	R	I
AAC Redwater☺	4	59	13.4	-1	-2	Y	G	—	MS	I	MS	R	R	I
AC Barrie☺	164	55	14.5	0	0	N	G	G	MR	I	MS	MR	MS	I
AC Cadillac	6	58	—	-1	3	N	F	F	R	R	I	R	MR	I
AC Domain	20	55	15.2	-2	-1	N	VG	VG	R	I	S	R	I	MS
Alvena☺	30	57	14.8	-2	0	N	G	P	MR	I	—	MR	I	MS
Carberry☺	40	58	14.6	2	-5	Y	VG	F	MR	R	MS	MR	R	MR
Cardale☺	4	60	13.5	2	-4	Y	VG	F	I	MR	MS	R	R	MR
CDC Abound☺	38	57	14.4	2	-4	Y	G	F	I	I	MS	R	MS	S
CDC Go	24	61	14.3	-1	-2	Y	G	VP	MS	I	S	R	I	MS
CDC Kernen☺	27	58	14.7	1	1	Y	G	F	R	I	MS	MR	MR	I
CDC Plentiful☺	4	57	14.7	-3	-2	N	VG	—	R	I	I	R	R	MR
CDC Stanley☺	22	57	14.6	0	-1	N	G	G	MR	S	I	R	MR	MS
CDC Thrive☺	26	54	14.6	-1	0	N	G	P	MR	I	I	MR	I	MS
CDC Utmost VB☺	15	58	14.6	-1	-1	N	G	G	MS	S	I	MR	R	MS
CDC VR Morris☺	4	60	14.8	0	0	N	G	—	I	I	I	MR	R	MR
Fieldstar VB ☺	43	60	14.6	0	1	Y	F	VG	I	I	I	MR	R	I
Glenn☺	45	59	14.6	2	-2	Y	VG	F	I	I	I	R	R	I
Goodeve VB☺	53	59	14.8	-2	-1	N	VG	G	MR	S	MS	MR	MR	S
Harvest☺	61	58	14.3	-1	-2	N	VG	VG	MR	S	MS	R	MR	S
Infinity☺	37	58	15.1	-2	0	N	G	G	MR	MR	MS	MR	MR	S
KANE☺	78	58	14.6	1	-2	Y	G	VG	MS	I	I	R	R	I
Muchmore☺	40	59	14.2	2	-6	Y	VG	G	MR	R	MS	R	R	MS

NO. RECOMMENDED CEREAL VARIETIES - 1974 TO 2018

	<u>AB</u>	<u>SK</u>	<u>MB</u>
<u>1974</u>			
Wheat			6
Barley			4
Oat			-
<u>1984</u>			
Wheat	22	15	10
Barley	14	16	6
Oat	9	7	2
<u>2004</u>			
Wheat	68	54	47
Barley	53	48	55
Oat	26	14	17
<u>2018</u>			
Wheat			108
Barley			51
Oat			28 (35)

MB SEED GUIDE 2018: **SPRING WHEAT**

Number of cultivars rated MR (R)

× CWRS	15	(52)
× CPS (R)	3	(15)
× CNHR	0	(5)
× CWSP	3	(14)
× CWHWS	0	(6)
× CWSWS	0	(5)
× CWES	0	(3)
× Supported	2	(8)
Totals	23	(108)

MB SEED GUIDE 2018: **BARLEY**

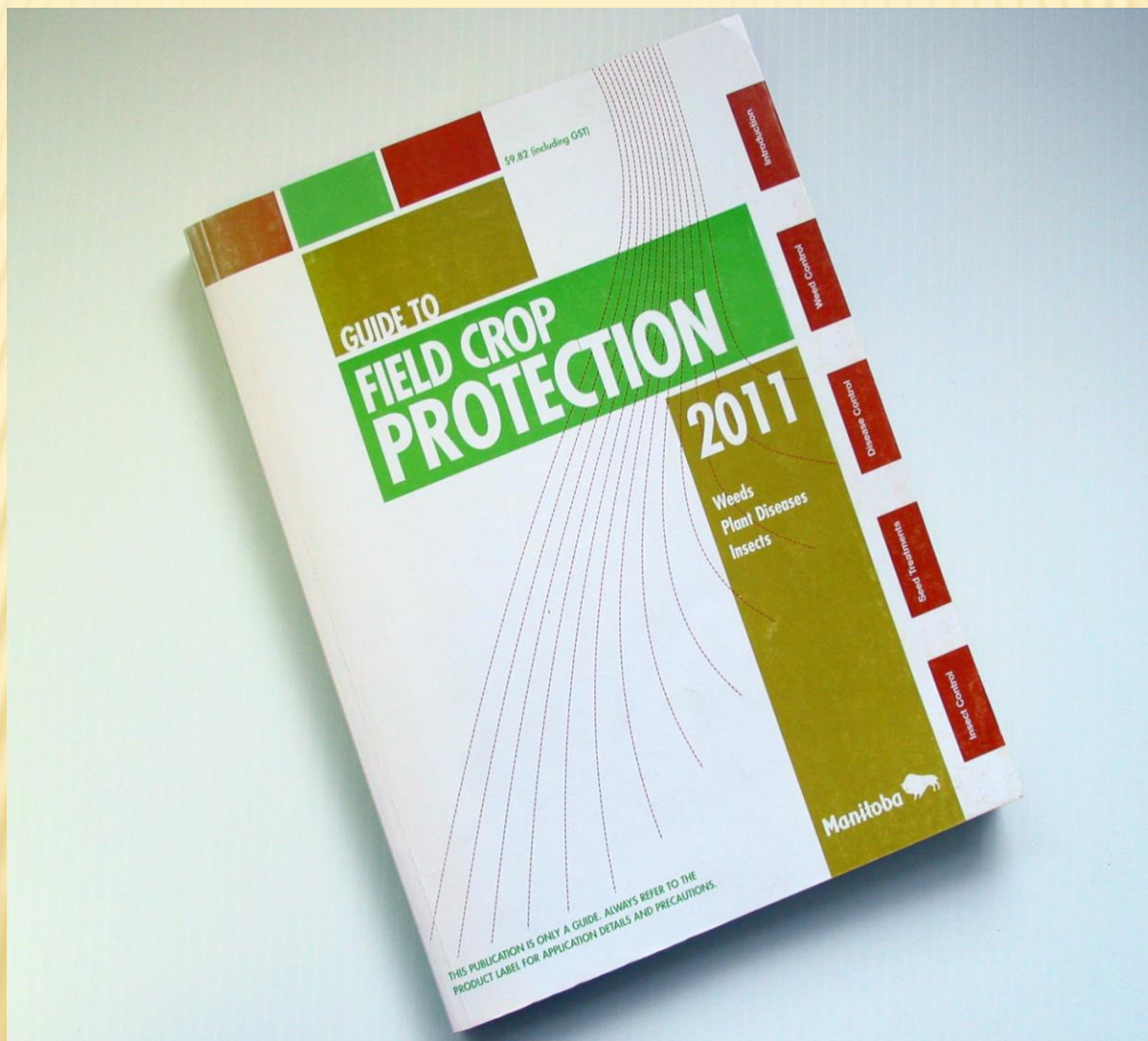
Number of Cultivars rated MR

✘ Malting, Accepted	1	(8)
✘ Malting, Other	4	(17)
✘ Food and Feed	4	(22)
✘ Hulless	3	(4)
Total	12	(51)

SYMPTOMS OF FHB ON SIX-ROW BARLEY



DISEASE MANAGEMENT – FUNGICIDES



FUNGICIDE MANAGEMENT OPTIONS – ‘FOLIAR’ FHB*

	Wheat	Barley	Oat
Bravo 500 + chlorothalonil	X		
Caramba metconazole	X	X	X
Folicur tebuconazole	X		
Proline prothioconazole	X	X	
Prosaro tebuconazole + Prothioconazole	X	X	

* All products registered for ‘suppression’ rather than ‘control’

FHB SYMPTOMS IN BREEDER TEST PLOTS - **WHEAT**



TYPICAL ABSTRACT OF 150-250 WORDS

Relationships among components of FHB in Manitoba winter wheat sampled mid-season and at maturity

Andy Tekauz et al. *Cereal Research Centre, Agriculture and Agri-Food Canada, 195 Dafoe Road, Winnipeg MB, R3C 2M9.*

Winter wheat grown in Manitoba is routinely affected by fusarium head blight (FHB). Monitoring for the disease has taken place annually since 1998, typically in mid-season, to signal FHB presence, estimate severity, and identify the causal *Fusarium* fungi. FHB can also be evaluated in harvested grain, as done routinely by the Canadian Grain Commission. To compare and evaluate earlier- and later-derived data sets, in 2010, ten winter wheat crops sampled mid-season were also sampled at maturity, just prior to commercial harvest. At maturity, *Fusarium* species were determined, along with levels of fusarium damaged kernels (FDK) and the mycotoxin deoxynivalenol (DON). Correlations among measured components were evaluated to identify relationships. At mid-season, mean disease severity (Fusarium Head Blight Index or FHB-I) was 17.6% (range 2.8 to 44.5%), and *F. graminearum* the sole causal species detected. In mature kernels (seed), only *F. graminearum* was isolated, mean FDK level was 10.4%, and mean DON 10.0 ppm. DON was highly and significantly correlated with mid-season FHB-I, and with FDK and *F. graminearum* levels in mature kernels. FDK was correlated with FHB-I and *F. graminearum*, and FHB-I with *F. graminearum*. These robust and significant relationships occurred in a year when the mean FHB severity, based on monitoring a total of 46 winter wheat crops, was considerably higher than normal. Such relationships may not hold when FHB is less severe, fewer crops are sampled, or when considering commercial seed lots in which a proportion of FDK, or otherwise lighter kernels, have been 'lost' during harvesting operations.



Relationships among components of FHB in Manitoba winter wheat sampled mid-season and at maturity

A. Tekauz, M. Stulzer and M. Beyene

Cereal Research Centre, Agriculture and Agri-Food Canada, 195 Dafoe Road, Winnipeg MB, R3T 2M9

Introduction

Winter wheat occupies about 10% of the total wheat acreage in Manitoba and provides producers with alternative seeding, harvesting and marketing options. The crop is generally susceptible to fusarium head blight (FHB), Seed Manitoba 2011), and normally is treated with foliar fungicide(s) to suppress FHB and foliar diseases. Monitoring the growing crop for the presence of FHB provides a first indication of the season's disease potential in winter wheat, and later maturing spring-sown cereals FHB levels can also be assessed at maturity by sampling kernels from harvested seed for various components related to FHB infection. The relationships between such mid- and late-season disease assessments are reviewed here.

Materials and Methods

Protocols for mid-season sampling of winter wheat (and other cereal crops) for FHB occurrence and severity, and identification of the pathogenic fungi responsible, are described in the on-line journal Canadian Plant Disease Survey (Tekauz et al. 2011). In 2010, ten winter wheat crops (out of 46) sampled mid-season were subsequently re-sampled at maturity by collecting spikes just prior to commercial (mechanical) harvesting. The mature crops chosen were representative of the range of FHB severities, light to more severe, observed at mid-season. Kernels (100 per sample) from threshed spikes were analyzed for *Fusarium* spp. present (on PDAL) levels of fusarium damaged kernels (FDK), and accumulation of the mycotoxin deoxynivalenol (DON), by ELISA.

Figure 1. Healthy (r) and FHB-affected spikes of winter wheat at mid-maturity.



Results

Conditions during the 2010 growing season in Manitoba were conducive to disease development as moisture levels in most regions were near 200% of normal. Based on the 46 commercial crops of winter wheat sampled, the mean mid-season (1-2 weeks after flowering) severity of FHB was estimated as 11.8% (a range of 2.9-44.5% (calculated as the FHB-index = % disease incidence x % spike proportion affected) / 100). *Fusarium graminearum* Schwbe was the sole *Fusarium* spp. isolated from the visually affected spikes/kernels sampled, with a mean kernel isolation frequency of 73%.

FHB components and their levels at maturity are shown in Table 1. *Fusarium graminearum* again was essentially the only *Fusarium* species detected. In these random samples (no selection for putative FHB infection in spikes/kernels), the mean *F. graminearum* level in kernels was 36%, FDK by number (n) or weight (w), 12.2 and 10.4% respectively, and DON 10 ppm. Pearson correlation coefficients among the components and FHB severity in mid-season are shown in Table 2. Final DON and FDK(w) levels were significantly correlated with disease severity in mid-season and FDK (w) and DON were highly correlated with levels of *F. graminearum*. FDK levels by their number (not analyzed in the correlations) generally paralleled those by weight, except for 'Field 10', for which there was considerable disparity between values.

Table 1. Components [*Fusarium* kernel infestation, fusarium damaged kernels or FDK by number (n) and weight (w), deoxynivalenol or DON levels in parts per million (ppm)] of fusarium head blight in 10 commercial crops of winter wheat grown in southern Manitoba in 2010, sampled at maturity.

Field Number	Total Fus %	Fg %	Fp %	Fv %	FDK % (n)	FDK % (w)	DON ppm
1	18	18	0	0	4.3	5.1	7.8
2	51	51	0	0	18.0	14.2	11.6
3	21	18	1	2	8.3	5.8	3.5
4	36	36	0	0	4.4	5.1	5.8
5	76	76	0	0	37.8	28.9	26.8
6	36	36	0	0	20.7	12.6	13.5
7	53	53	0	0	17.8	11.1	10.4
8	26	26	0	0	6.5	5.2	3.8
9	5	5	1	0	1.4	0.7	0.8
10	43	43	0	0	2.3	15.3	18.3
Average	36.6	36.0	0.2	0.4	12.2	10.4	10.0
Maximum	76.0	76.0	1.0	2.0	37.8	30.9	26.8
Minimum	6.0	5.0	0.0	0.0	1.4	1.3	0.8

Table 2. Correlations among FHB components in 10 Manitoba winter wheat fields in 2010.

	FHB Index	<i>F. graminearum</i>	FDK (w)
<i>F. graminearum</i>	0.634 0.007		
FDK (w)	0.641 0.046	0.831 <0.002	
DON (ppm)	0.668 0.035	0.881 0.002	0.944 <0.002

Discussion

The robust relationships among several FHB components measured were based on data obtained during a 'severe' outbreak of FHB in winter wheat in Manitoba - the second highest severity recorded since systematic monitoring began in 1998 (Tekauz et al. 2011). Such relationships may not hold under lighter disease pressure, when only few crops are examined, or if commercially harvested seed (kernels) is sampled. The latter likely would contain fewer FDK as many would be 'lost' during harvesting operations, a planned for and desired result to assure highest possible quality and grade.

The FHB data, whether obtained mid-season or at maturity, showed wide divergence (severity) despite the predominance of 'CDC Falcon' winter wheat in Manitoba (Tekauz et al. 2011). The variability likely was due to differences in previous crop, fall seeding date which influences spring growth, flowering, etc., local conditions, and the foliar fungicide(s) and spray nozzles/equipment used. The very high DON recorded for some crops would likely be considerably lower in commercial seed samples.

References

Tekauz, A., et al. 2011. Monitoring fusarium head blight in winter wheat, Manitoba 2010. Can. Plant Dis. Surv. 91, 96-97. (www.cpw-scsp.net/pubs/)

Acknowledgements

Thank you to Manitoba Agriculture Food and Rural Initiatives personnel for information on location of winter wheat crops in southern Manitoba in 2010.

POSTER EXAMPLE #1

TEKAUZ ET AL

Pathogen Variability and FHB Development in Manitoba Cereal Crops, 2001-2010

Andy Tekauz and Jeannie Gilbert

Cereal Research Centre, Agriculture and Agri-Food Canada, 195 Dafoe Road, Winnipeg MB, R3T 2M9



POSTER EXAMPLE #2 TEKAUZ & GILBERT

Introduction

Monitoring of Manitoba cereal crops for the prevalence and severity of fusarium head blight (FHB) and the pathogenic fungi involved has been ongoing for many years. The results have been reported annually in the Canadian Plant Disease Survey (www.cps-ipc.ca/cpds) - since 1987 for spring wheat, 1994 for barley, 1998 for winter wheat and 2002 for oat. A comprehensive comparison of FHB development in the various cereal crops is therefore possible by analysis of multi-year data.

Materials and Methods

Published results of monitoring (surveys) of commercial farm fields over a 10-year period, 2001 to 2010 (from 2002, or 9 yrs. for oat), were tabulated and averaged to obtain comparative data on FHB severity, measured as the FHB Index (% incidence x % spike area affected / 100), and the identity and relative frequency of the *Fusarium* fungi present. Disease severity was estimated on-site. Subsequently, kernels taken from visually affected spikes (panicles) collected from each site were plated on potato dextrose agar to isolate the fungi present.



Figure 1. Field symptoms of FHB in A) 2-row barley, B) 6-row barley, C) oat and D) spring wheat.

References

Tekauz et al. & Gilbert et al. 2000-2011. Canadian Plant Disease Survey, Vol. 42-51. (www.cps-ipc.ca/cpds)

Acknowledgements

Our thanks to Drs. Marilee, Ron Karsten, Marco Huber, Kirsten Stenroos, Marianne Berven, and Greg Kistner for their able technical assistance.

Results

Based on typical visual symptoms (Fig. 1), FHB was detected in most fields of spring- and winter wheat and of barley. In oat, symptoms of FHB usually were not evident, and estimates of disease severity, by necessity, therefore were equivocal and their value marginal. Over the multi-year period considered, mean FHB disease severities were calculated as FHB-I of 3.8% (range 0.3 - 14.7%) for spring wheat, 3.0% (range 0.3 - 10%) for winter wheat, 1.9% (range 0.4 - 5.3%) for barley and <0.1% (range <0.1 - 0.8%) for oat. As such, both yield and quality losses due to the presence of fusarium damaged kernels were expected in some years, but likely were minimal in others.

The *Fusarium* fungi isolated from putatively infected kernels and their relative levels are shown in Fig. 2. *Fusarium graminearum* was the dominant pathogenic species isolated from both spring- and winter wheat, comprising >90% of the *Fusarium* found. In barley and oat, *F. graminearum* levels were lower, near 50%, with other *Fusarium* species, particularly *F. poae* (~30%), making up the remainder. *Fusarium sporotrichoides* was the second most frequently isolated species from spring wheat (6.0%), and the third in barley and oat (8.5-11.6%). However, in certain years (2002, 2006, 2009, 2010), in barley and (or) oat, levels of *F. poae* were particularly high, equaling or surpassing those of *F. graminearum*, and levels of *F. sporotrichoides* considerably higher than their mean value and surpassing those of *F. poae* (2002, 2004).

Discussion and Conclusions

Based on the 10-year average, the *Fusarium* species complement affecting spring- and winter wheat in Manitoba differs from that on barley and oat. *Fusarium graminearum* appears to be the near sole agent causing FHB in wheat, whereas at least two, and possibly three additional *Fusarium* species are implicated in barley and oat. Since field monitoring takes place some two weeks following heading, and 3-4 wks prior to harvest, the *Fusarium* fungi isolated from kernels at this time can be regarded as the causal agents of FHB, rather than late-season opportunistic invaders.

Average FHB severities in spring- and winter wheat were identical, suggesting that growing winter wheat solely to "escape" FHB (due to its earlier heading and flowering compared to spring wheat) may not be prudent. In the 10 years considered, FHB severities in winter wheat were lower by an FHB-I of >1% versus spring wheat, only 4 times.

Based on the four cereal crops, severity of FHB in Manitoba during the first decade of the millennium was greatest in 2001 and 2005, and lowest in 2006.

The mid-season presence of *F. poae* and *F. sporotrichoides*, along with *F. graminearum* in Manitoba barley and oat crops suggests that mycotoxins other than deoxynivalenol or DON, the principal metabolite produced by *F. graminearum*, may accumulate in developing seed of these crops. Any such additional mycotoxins are much less likely to occur in wheat crops grown in the province.

Long-term, systematic monitoring for FHB and other diseases in cereal crops provides a valuable data base from which to mine useful strategic information on disease occurrence, epidemiology, and emerging trends.

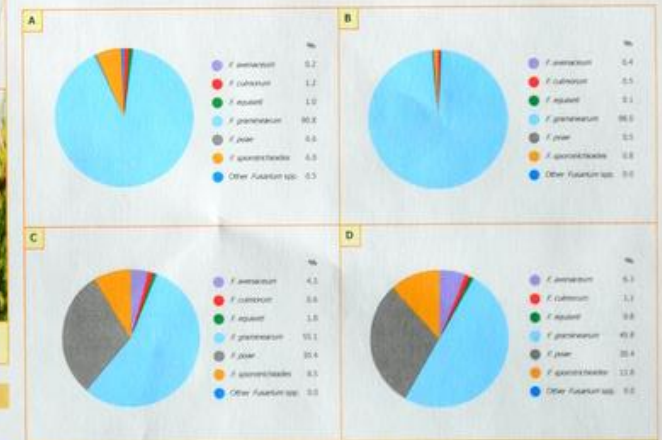


Figure 2. Relative frequency of *Fusarium* species isolated from kernels of A) spring wheat, B) winter wheat, C) barley and D) oat.

Getting Fusarium Head Blight Resistance Where it Really Counts in Commercial Cultivars (and QTLs may have nothing to do with it!)

Steve Haber, Jeannie Gilbert & Stephen Fox Cereal Research Centre, AAFC, 195 Dafoe Road, Winnipeg MB R3T 2M9, CANADA
Steve Robinson Saskatoon Research Centre, AAFC, 107 Science Place, Saskatoon SK S7N 0X2, CANADA

POSTER EXAMPLE #3 HABER ET AL

Introduction

For the deployment of host genetic resistance to Fusarium head blight (FHB) to confer meaningful benefits it must preserve, or possibly enhance, the combinations of useful traits expressed by elite germplasm. In wheat, multiple genes must interact in complex ways to express FHB resistance that is sufficient to protect against losses to yield and quality. This poses a severe challenge to efforts to achieve this level of resistance while retaining all the desirable attributes of a commercial cultivar. Indeed, no contemporary cultivar has derived a high level of FHB resistance by introgression of genes from known sources of resistance.

We saw that we might pursue an alternative approach after learning that FHB-resistant 'Sumai 3' and its susceptible near-isogenic lines do not differ in the general plant defence genes that are induced in response to inoculation by *Fusarium graminearum* Schwabe [1]. With this indication that improved FHB resistance might be gained by changing the control of expression of existing genes rather than introgressing new ones, we sought to evolve heritable traits *de novo* in the descendants of germplasm subjected to systemic stresses, an approach that has already yielded new sources of resistance in wheat to wheat streak mosaic virus (WSMV) and rust [2].

We then showed that improved FHB resistance could be evolved *de novo* among sublines descended by selfing from germplasm that had been subjected to inoculation with WSMV in one or more cycles. Sublines thus generated from the spring wheat cultivars 'McKenzie' [2] and 'Roblin' [3] do not derive their demonstrably improved FHB resistance from genes introduced from exotic germplasm. Rather, they resist FHB more effectively than their progenitors because of changes in gene expression that affect their response to attack by *F. graminearum*.

To demonstrate the practical utility of rapidly improving FHB resistance while retaining the competitive agronomic and quality traits of a contemporary cultivar, we have chosen as our starting material the Canadian hard red spring wheat 'Waskada'. This cultivar had been selected from a doubled haploid (DH) line with 'Sumai-3' in its pedigree via the experimental DH line BW278.

Waskada = BW278/2**Sapere* where BW278 = AC Domain*2/Sumai-3
 We show here that we have evolved *de novo* among direct descendants of 'Waskada', families of sublines with near-immunity to WSMV and improved FHB resistance. Using seed harvested from a preliminary agronomic trial conducted in the absence of disease pressure, we also address whether germplasm generated in this manner remains sufficiently similar to the cultivar progenitor in essential agronomic and quality traits.

Methods

Starting with 20 seeds of certified seed of the cultivar 'Waskada' which is moderately resistant to FHB and susceptible to WSMV, we subjected successive generations to systemic stresses including inoculation with WSMV, heat and cold. Taking care to avoid inbreeding or seed admixture, we selected and advanced in each cycle the best plants which differed from their progenitors in a range of traits including improved FHB resistance and WSMV resistance. Four sublines of the 1st cycle, selected for WSMV resistance, were evaluated in the 2009 FHB field nursery of which one was advanced on the basis of improved FHB and lodging resistance compared to 'Waskada'. After two cycles of detailed testing and selection indoors to confirm uniform expression of *de novo* resistance to WSMV, 34 sublines of the 6th cycle were tested in the 2010 FHB field nursery. Of these 3, were advanced for their superior FHB and lodging resistance and were chosen as the founders of 3 families of sublines that differed from one another in morphology and maturity. After two further cycles indoors to confirm that sublines in these families expressed strong resistance to both spray- and point inoculation with *F. graminearum*, 12 sublines from the 3 families were entered as the 6th cycle in the 2011 FHB field nursery. In the following indoor cycle, sublines were again selected so that one subpopulation could be increased without disease pressure to generate sufficient seed for a preliminary agronomic trial, and the other tested under pressure from WSMV and FHB to confirm dominant resistance.

In the 12th cycle, the 27 sublines (15 families) grown in agronomic plots for seed increase were matched with their best performing counterparts tested in the 2012 FHB nursery. A total of 5 sublines representing the 3 families were chosen to be advanced to testing in a replicated yield trial in New Zealand to rigorously compare their agronomic performance with their 'Waskada' progenitor.



Fig. 1. Waskada 47 dpi with WSMV

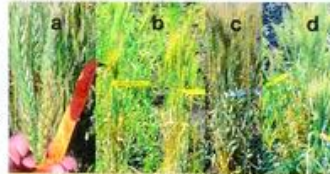


Fig. 2. Waskada sublines ('Ada') in FHB nurseries

417000 heads/37.00 t/2010, rows 25.00, 4/2010, row 24.00, 4/2010, row 21.00
 Individual heads from the best 'Ada' sublines in the 2009 FHB nursery were selected (Fig. 2a) to serve as founders of 4th and 5th-cycle sublines. These were evaluated indoors by inoculating with WSMV at tillering stage and spray-inoculating heads with *F. graminearum* at anthesis. At the 6th cycle, 32 head-row sublines from 7 families were entered in the 2010 FHB field-nursery (Fig. 2b). In winter 2010/11, we selected in indoor tests 1st & 8th cycle sublines from these 7 families which were uniformly resistant to FHB after point- and spray-inoculation of the same heads. In the 2011 nursery (Fig. 2c), 3 of the 7 families of 9th-cycle 'Ada' sublines were selected for phenotypic uniformity.



Fig. 3. Seeds of heads point- and spray-inoculated with *F. graminearum*

After confirming the uniformity of FHB resistance in 10⁴-cycle indoor tests (Fig. 3), 'Ada' sublines of the 3 selected families grown in agronomic plots (Fig. 4) in the absence of deliberate applied disease pressure yielded seed to compare quality with the 'Waskada' progenitor (Table 1); a parallel test in the 2012 nursery (Fig. 2d) compared FHB disease and DON accumulation (Table 2; Fig. 5).



Fig. 4. Field increase in the absence of FHB pressure

Results and Discussion

Much larger quantities of seed will be needed in order to conduct meaningful comparisons of the cultivar 'Waskada's agronomic and quality traits with those of the most promising 'Ada' sublines.

Seed harvested from the preliminary agronomic trial (Fig. 4) of the sublines that also performed best in the parallel trial in the 2012 FHB nursery will be increased in New Zealand (Table 2) in a replicated yield trial.

The seed harvested from this test will be adequate to permit multi-site, statistically sound determinations of the agronomic performance of the 'Ada' lines compared to their 'Waskada' progenitor in the areas intended for their production.

Conclusions & Future Directions

It is not necessary to introgress exotic genes to improve FHB resistance in a contemporary bread wheat cultivar. Genes already present in the cultivar change their expression as the host responds to systemic virus infection. This is signalled as early as the 2nd cycle of the iterative protocol by the expression *de novo* of near-immunity to the virus, a trait that becomes fixed in subsequent cycles in a subset of descendant sublines.

Cultivar sublines with improved FHB resistance show, in preliminary analyses, acceptable agronomic and quality traits. Agronomic tests conducted in the absence of deliberately applied disease pressure will determine on a sound statistical basis whether improved FHB resistance combines with the progenitor cultivar's competitive traits. The seed produced will be evaluated to determine whether grain quality traits satisfy requirements of the cultivar class.

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THANK- YOU!
GOOD LUCK!

**HISTORY OF FHB RESEARCH
IN (WESTERN) CANADA**

Andy Tekauz

9th CWFHB, Winnipeg MB, Nov 22, 2018
