THE 1998 NATIONAL FUSARIUM HEAD BLIGHT FORUM

CHAPTER 3

CHEMICAL AND BIOLOGICAL CONTROL

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U.S. Wheat & Barley
Scab Initiative

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The 1998 National Fusarium Head Blight Forum

CHAPTER 3

Chemical and Biological Control

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Survival of *Fusarium graminearum* in Wheat Residue

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Introduction

The principal pathogen associated with Fusarium Head Blight (FHB or scab) of wheat and barley in Minnesota is *Fusarium graminearum* Schwabe and its perfect stage *Gibberella zeae* (Schwein.) Petch (Wilcoxson *et al.* 1988). This fungus overwinters on the residues of host crops including wheat, corn, barley, and other cereals. While *F. graminearum* can also survive in the soil it appears to be a poor competitor with other fungi, thus its survival is generally associated with presence of plant residues. Studies have shown that the proportion of residues colonized by the fungus reduces with the decomposition of residues (Sutton, 1982).

Following the devastating FHB epidemic in the Red River Valley in 1993, and moderate to severe epidemics in subsequent years, a national effort to examine disease control options has been established (McMullen *et al.* 1997). Control options being examined include resistance breeding, chemical and cultural control. Cultural control options have focussed on the role of crop residues in the buildup and survival of inoculum of *F. graminearum*. Of particular concern were the greater volumes of residues left at the soil surface following the widespread adoption of reduced tillage practices. Soils in the Red River Valley are generally fine textured, medium to poorly drained and frozen up to six months of the year. Residue decomposition is thus generally and unquantifiably defined as slow. Establishing strategies for the management of Fusarium infected residues will require an improved understanding of the survival of *F. graminearum* in relation to residue decomposition. A field experiment was established to examine the relationship between the decomposition of residues of spring wheat and the survival and inoculum potential of *F. graminearum*.

Materials and Methods

Wheat residue (cv. Russ) comprised primarily of stem tissues, in sections 24 cm long, were placed in fiberglass mesh bags. The bags containing 20 grams of residue, equivalent to 2550 pounds of residue per acre, were placed in the field in October 1997 at the Northwest Experiment Station, Crookston MN. The residue was placed on the soil surface, and at a depth of 7.5-10 cm and 15-20 cm in plots that had been previously chisel plowed. Residue was also placed at a 15-20 cm depth during a moldboard plow tillage operation. The soil type at the site is a deep loam. Paired sets of residue were used for studies of residue decomposition and *F. graminearum* survival. Sufficient bags were placed to allow sampling at 4 week intervals throughout the growing season (seven or eight samplings from April through November). The residue is left undisturbed throughout the winter months when the ground is frozen. In 1998, sampling began in April, with the most recent sampling being conducted on Oct 8, 1998.

The residue used for determining the survival of *F. graminearum* was inoculated with *F. graminearum* by submerging the residue in an aqueous spore suspension (1.1×10^5 macroconidia/ml) of a mixture of 10 *F. graminearum* isolates for one minute. Following inoculation the residue was drained briefly, placed in a dew chamber at 100% relative humidity for 72 hours, then air dried at room temperature. Isolations were made from nodes on both inoculated and non-inoculated residue to determine the effect of inoculation on the colonization of tissues by *F. graminearum*. *F. graminearum* was successfully isolated from 96% and 97% of uninoculated and inoculated nodes, respectively, suggesting inoculation had little impact on the colonization of plant residues by *F. graminearum*. The residue used to study residue decomposition was not inoculated.

Following the retrieval of residue bags paired samples of non-inoculated and inoculated residue were evaluated for residue decomposition and *F. graminearum* viability, respectively. Residue decomposition was determined using dry weights to determine dry matter loss. Analyses

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of the biochemical components of the residue was conducted to determine the cellulose, hemicellulose, and lignin content of residues. Nitrogen analysis was conducted to determine the nitrogen immobilization and mineralization.

Determinations of the survival of *F. graminearum* in residues were initiated as soon as practical after removal of the residue from the field. Stem tissue pieces (30 per bag), 1.5 cm long and including a single node, were surface sterilized in a 0.5% sodium hypochlorite solution for one minute, rinsed in distilled water, and drained. Sterilized nodes were then placed onto PCNB agar and incubated for 7 days at 20-22 C with 12 hour light per day. *Fusarium* spp. colonies were counted and *F. graminearum* colonies determined by transferring the colonies to carnation leaf agar (CLA). Following transfers to CLA cultures were incubated for 10 days at 20-22 C with 12 hour light per day. The formation of perithecia indicated the presence of *F. graminearum* group II isolates. *Fusarium* cultures not forming perithecia were also identified.

Results and Discussion

At the time of writing this report six samplings from the first year had been conducted. Preliminary results for the dry matter remaining and the colonization of residues with *F. graminearum* are presented in Tables 1 and 2, respectively.

Buried residue decomposed substantially faster than residue placed at the soil surface (Table 1). Residue placed at 7.5-10 cm decomposed slightly faster than residue samples at 15-20 cm. No differences were evident in the rate of decomposition between the chisel plowed and moldboard plowed treatments at 15-20 cm depth. Across all treatments, approximately 30% and 60% of residue remains in buried and surface residue treatments respectively (Table 1). Lab analyses are currently underway to determine loss of the biochemical components of the residue.

Significant reductions in the colonization of residues by *F. graminearum* were not observed in any of the tillage/residue placement depth treatments until the residue had been in the field for at least eight months (Table 2). This means that any reduction in *F. graminearum*, significant or otherwise, was not observed until around the time of anthesis of the cereal crops growing in the valley. Although a decrease in the survival of *F. graminearum* occurred in July, the number of *Fusarium* spp. colonies isolated from the residue samples remained the same. This finding suggests that other *Fusarium* species, presumably of higher competitive ability, were colonizing residue in preference to *F. graminearum*. Other *Fusarium* species isolated from the residue include *F. sporotrichoides*, *F. equiseti*, *F. culmorum*, *F. semitectum*, and *F. avenaceum*. Preliminary studies are being conducted to determine if residue from which *F. graminearum* can be isolated will support the development of perithecia and the release of mature ascospores.

Reductions in the percent colonization of residues from July onward appears to correspond to the decomposition of residues. Surface residues, which decompose more slowly, appear to act as a host to *F. graminearum* for significantly longer time periods than buried residues. The continuation of this study into 1999 and research proposed to examine the relative importance of the components of residue, particularly infected grain, should provide valuable information on the survival of *F. graminearum* and production of ascospore inoculum. It is anticipated that the data from this research will assist in the development of effective recommendations for the management of *Fusarium* infected residues.

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Table 1. Percent wheat residue dry matter, relative to initial weight at placement (October 1997), at sampling times between April and September 1998 in four tillage/residue placement depth treatments.

Treatment	Percent dry weight of wheat residues remaining at sample time						
	1997	1998					
	Oct.	April	May	June	July	Aug.	Sep.
Chisel plow - surface	100[z]	94	86	85	76	72	61
Chisel plow - 7.5-10 cm	100	86	75	62	46	39	22
Chisel plow - 15-20 cm	100	88	77	66	51	41	28
Moldboard plow - 15-20 cm	100	87	79	68	55	41	32

[z] values given are the means of five replicates

Table 2. Colonization of the nodes of wheat residue by F. *graminearum* in four tillage/ residue placement depth treatments at time of residue placement (October 1997) and at monthly samplings between April and September 1998.

Treatment	Colonization of wheat residues by *F. graminearum* (%)						
	1997	1998					
	Oct.	April	May	June	July	Aug.	Sep.
Chisel plow - surface	96[y]	93	96	96 a[z]	69 a	76 a	80 a
Chisel plow - 7.5-10 cm	96	81	91	93 ab	57 ab	61 ab	60 ab
Chisel plow - 15-20 cm	96	97	83	80 b	46 b	40 b	56 ab
Moldboard plow - 15-20 cm	94	81	90	87 ab	47 b	40 b	50 b

[y] values given are the means of five replicates
[z] values followed by different letters are significantly different at P=0.05

OP

BIOLOGICAL CONTROL OF SCAB OF WHEAT INCITED BY *Gibberella zeae*

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OBJECTIVE

Determine if microbial antagonists can be used to reduce the severity of scab of wheat in greenhouse and field trials.

INTRODUCTION

Scab of wheat, also known as Fusarium head blight, pink mold, whiteheads and tombstone scab, is responsible for extensive damage of wheat in humid and semihumid regions of the world. The primary causal agent of scab of wheat, *Gibberella zeae* (anamorph= *Fusarium graminearum*) produces potent toxins during colonization of grain including the estrogenic toxin zearalenone (F-2) (Vesonder and Hesseltine, 1980) and the trichothecine deoxynivalenol (vomitoxin) (Snijders, 1990; Proctor et al., 1995) which can inhibit amino acid incorporation and protein production in plant tissues (Casale and Hart, 1988). Contaminated grain is frequently unsuitable for human consumption and may be refused as feed. Infection of wheat kernels by *G. zeae* reduces grain yield and affects grain quality (Clear and Patrick, 1990). The infection of seed reduces seed germination, seedling vigor and plant emergence (Bechtel et al., 1985). Chemical control and resistant varieties are potential options for scab control. Fungicide residues and cost would be potential problems with chemical usage. Wheat varieties with a high degree of resistance are not available at this time. Some success in controlling scab can be achieved by ploughing fields after harvest to bury crop residues, but the preference for minimal tillage agriculture renders this alternative unacceptable (Bai and Shaner, 1994). Biological control, though currently not available, could offer another environmentally safe option for reducing scab.

MATERIALS AND METHODS

Isolation of antagonists: Microbial antagonists were isolated from anther samples on a corn steep liquor medium, dilute tryptic soy medium (1/5 TSM) and a malt and yeast extract medium. A medium containing corn steep liquor was selected to isolate microorganisms since its primary ingredients are affordable for use in commercial cell production medium. One fifth TSM was selected because it is a general purpose medium that supports the growth of a wide variety of bacteria. Over 700 isolates were purified and preserved in 10% glycerin at -80 C.

Choline and betaine utilization: Isolates were screened for their ability to utilize choline and betaine, compounds known to be present in wheat anthers and stimulatory to the growth of *G. zeae* (Strange and Smith, 1978). Selection of isolates based on their ability to utilize these compounds would theoretically increase the likelihood of discovering microbes superior in colonizing anthers and in suppressing the growth stimulatory effect of choline and betaine on *G. zeae*. Choline and betaine utilization were tested using either a Biolog MT plate technique or HPLC analysis of liquid culture broths for choline utilization after microbial growth.

Greenhouse plant bioassay of biocontrol: Inoculum of *G. zeae* (10^4-10^6 conidia/ml) was mixed with microbial isolate (10^6-10^8 cfu/ml) and the middle floret of a head co-inoculated with 10 µl of the suspension. Heads inoculated only with conidia of *G. zeae* served as the control. Treatments were distributed in four replications in a completely randomized experimental design. After inoculation, plants were kept in a plastic humidity chamber for 72 h and then transferred to greenhouse benches. Disease severity was visually estimated (Stack and McMullen, 1995) 10 days (data not shown) and 16 days after inoculation. One-hundred kernel weight and the percentage of healthy kernels were also assessed. Kernels were defined as "healthy" if they did not appear to be shriveled or discolored.

Field bioassay of biocontrol: Isolates showing promise in the greenhouse bioassay were tested in field plots at Peoria, IL, using a completely randomized experimental design. Isolates were grown in shake cultures (semidefined complete liquid medium, Slininger et al., 1994) for 72 h prior to spraying microbial solutions (10^8-10^9 cfu/ml) onto plants using a CO_2 backpack sprayer.

RESULTS AND DISCUSSION

Approximately 40 isolates of over 700 assayed utilized choline. About one-third of the 40 isolates showed promise in preliminary two head greenhouse plant bioassays and three reduced disease severity (Tables 1, 2) in multiple replication plant bioassays. Choline utilization, therefore, appears to be a useful attribute to utilize in preliminary screening of antagonists for ability to biologically control scab of wheat. All five microbial treatments reported here increased 100 kernel weights in greenhouse trials (Table 2). Several of these isolates also showed promise in first year field testing at Peoria, IL (Table 3). Thus, micro-

bial strains that consistently and significantly reduced scab disease severity and/or increased yield have now been identified. Significantly, this reduction in disease was obtained using microbial biomass produced in a liquid culture medium that would be affordable for use on a commercial scale. Biological control continues to show potential as part of an IPM program for controlling scab of wheat.

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Table 1. Contrast analysis of a microbial treatment and the control for disease severity. Data was pooled from three greenhouse experiments and arcsin transformed prior to analysis.

Contrast	P>F
Control Vs AS 43.3[1]	0.0001
Control Vs AS 43.4	0.0001
Control Vs OH 131.1	0.0726
Control Vs OH 181.1	0.2565
Control Vs OH 182.9	0.0001

[1]AS 43.3, AS 43.4, OH 131.1, OH 181.1 and OH 182.9 represent bacterial, bacterial, bacterial, yeast and yeast strains, respectively.

Table 2. Influence of microbial antagonists on scab of wheat development as measured by percent disease severity, 100 kernel weight and percent healthy kernels on pooled data from three greenhouse experiments.

Treatment	% Disease Severity	Mean 100K Wt. (gms)	% Healthy Kernels[1]
Control	90	1.53	10
AS 43.3	20 **	3.57 **	87 **
As 43.4	6 **	3.86 **	89 **
OH 131.1	79	2.06 **	37 **
OH 181.1	82	1.94 **	25 **
OH 182.9	39 **	3.04 **	64 **

[1]Kernels were visually assessed and defined as healthy if not shriveled or discolored.
[2]Within a column, values followed by one or two asterisks are significantly different from the control based on Fisher's protected LSD test ($P \leq 0.05$, $P \leq 0.01$, respectively).

Table 3. Effect of microbial antagonists on wheat scab development as measured by disease severity and percent disease reduction for data from a field experiment at Peoria, IL. One-way analysis of variance and mean comparisons were performed on arcsin transformed data. Nontransformed values are presented.

Treatment	% Disease Severity[1]	% Disease Reduction
Control	4.6[1]	-
AS 43.4	3.5	24
OH 71.4	2.6 *	43
OH 131.1	3.0 *	35
OH 181.1	4.5	2
OH 182.9	3.2 *	30

Within a column, values followed by an asterisk are significantly different from the control ased on Fisher's protected LSD test ($P \leq 0.05$).

Fungicide Technology Network of the National FHB Initiative - 1998 Report

Marcia McMullen - 1998 Coordinator-North Dakota State University, Fargo

Cooperators: Roger Jones, MN; Marty Draper, SD; Laura Sweets, MO; Pat Lipps, OH; Greg Shaner, IN; Don Hershman, KY; Terry Gregoire, Greg Endres, Jim Harbour, John Lukach, Kent McKay, Blaine Schatz, Scott Halley, Jeremy Pederson, Vern Hofman, Suranjan Panigrahi, ND

INTRODUCTION:

The overall goal of the Fungicide Technology Network of the National Fusarium Head Blight Initiative is to provide producers rapid and effective tools to control Fusarium Head Blight (FHB). Two major objectives to reach this goal were examined in 1998: to identify safe fungicides that are most effective in the field in controlling FHB; and to identify application technologies that will maximize fungicide efficacy against FHB. This summary report describes the methods and provides some preliminary results from the studies conducted to reach those objectives. Future efforts in this area, under the more broad-based title of *Chemical and Biological Control,* with Marcia McMullen, ND, and Gary Bergstrom, NY, as co-coordinators, will continue examining examine efficacy of fungicides and application technology, plus will examine biological control agents, residue treatment, and the linking of epidemiological information with disease forecasting for optimum timing of application.

METHODS:

Uniform Fungicide Trials A uniform fungicide trial, with five fungicide treatments compared to an untreated check, was established across seven states (Table 1). The trial was established across spring and winter grain regions to help evaluate a set of products for consistency in performance over a number of environments. Standard rates, timing of application, and disease and yield measurements were used across environments. Some states had multiple testing sites or tests over multiple varieties. Nozzle type, water gallonage, psi, and type of adjuvant varied slightly across sites. Some initial FHB Initiative funding ($20,000) was used to support this effort. Participating states may also have conducted fungicide trials with additional registered or experimental products and with additional rates or timing of application. For example, in North Dakota, 49 trials were established to evaluate fungicide efficacy in controlling FHB and leaf diseases and to evaluate optimum methodology for disease control.

Fungicide Application Technology: Wheat and barley heads are not the traditional target for foliar fungicides. Unlike grain leaves, the grain spikes have a vertical architecture, are often waxy, and generally have awns or beards that interfere with fungicide deposition and retention. A number of studies were done in North Dakota during the growing season to examine the effects of changing nozzle types, gallonage, sprayer speed, and adjuvants, to increase deposition and disease control. Additional FHB Initiative monies ($29,000) were provided to support this effort.

PRELIMINARY RESULTS:

At the time of writing this report, measurements and data analysis from all trials had not been completed. The results given here are preliminary, a more comprehensive report will be compiled.

Measurements in each trial: % leaf disease; DON ppm; % scab incidence; % scab head severity; % scab field severity; yield; test weight; % tombstones

Uniform fungicide trials: Only three states (MN, ND, SD) in the cooperative uniform fungicide trial had severe enough levels of FHB for treatment differentiation. FHB was detectable in the trials in KY, MO, and IN, but FHB field severity levels of the untreated plots were below 1.0% and thus this data is not included in this summary. The average percent reduction in FHB field severity across all trials in the three spring wheat states ranged from 30.6 to 50.4% (Table 2), but the range of reduction in individual trials was from 4.7 to 73.2%. Reductions in FHB severity were reflected in percent yield increases (Table 2), although some of the yield increases could also be attributed to control of leaf diseases as well (Table 4). DON testing is not complete in the trials, but results from two locations in ND, one in MN, and one in IN indicate that DON levels were approximately reduced by one-fourth to over 50 percent (Table 3).

Table 1. Uniform fungicide Trials, 1998

Cooperator	Location	Crop	Fungicide trts	Rate	Feekes Stage
Don Hershman	Kentucky	Soft RWW	untreated		
Pat Lipps	Ohio	Soft RWW	Folicur	4 fl oz	10.3-10.51
Greg Shaner	Indiana	Soft RWW	Tilt	4 fl oz	10.51
Laura Sweets	Missouri	Hard RWW	Benlate+Mancozeb	0.5 lb + 1 lb	10.51
Roger Jones	Minnesota	Hard RSW	Quadris	12.5 oz	10.51
Marty Draper	South Dakota	Hard RSW	Quadris+Benlate	12.5 oz + 0.5lb	10.51
Marcia McMullen (ND contact, many others contributed)	North Dakota	Hard RSW	**Measurements in each trial:** % leaf disease; DON ppm; % scab incidence; % scab head severity; % scab field severity; yield; test weight; % tombstones		

Table 2. Average % decrease in FHB field severity (and range), and average % yield increase (and range) over untreated check in ND, MN, and SD trials (preliminary results)

Measurement	Tilt	Folicur	Benlate+Mnczb	Quadris	Quadris+Benlate
avg. % FHB reduction	30.6	50.4	41.3	35.8	43.9
Range % FHB reduction	17.8 - 59.1	29.6 - 65.1	19.0 - 65.1	4.7 - 72.7	8.9 - 73.2
avg. % yield increase	8.1	13.1	10.1	15.6	14.2
Range % yield increase	5.8 - 25.1	4.1 - 48.5	6.8 - 28.3	15.7 - 31.9	3.6 - 32.2

Table 3. Average % reduction in DON (vomitoxin) levels over 2 ND trials, one MN trial, and one IN trial (FHB and DON levels low in IN, but significant differences in DON levels occurred)

Measurement	Tilt	Folicur	Benlate+Mnczb	Quadris	Quadris+Benlate
Avg. % DON reduction	27.4	60.1	45.7	34.8	42.7

Table 4. Average % decrease in leaf disease (and range) in trials in ND, MN, SD, OH, MO, IN, and KY (preliminary results)

Measurement	Tilt	Folicur	Benlate+Mnczb	Quadris	Quadris+Benlate
avg. % leaf disease reduction	63.0	64.2	36.8	67.6	68.6
Range % leaf disease reduction	26.9 - 96.1	38.4 - 80.3	3.8 - 65.1	38.4 - 99.2	29.4 - 99.2

Leaf diseases were present in all trials and severe in some, regardless of presence or absence of FHB. Leaf disease ratings were evaluated in all trials. Results averaged over trials in the seven states indicate that four of the five treatments reduced leaf disease on the flag leaf by over 60% (Table 4). The predominate leaf disease represented in these trials varied across states: the predominate leaf diseases were *Septoria tritici* and tan spot (*Pyrenophora tritici-repentis*) in trials in ND and MN, tan spot in SD, leaf rust (*Puccinia recondita*) in Ohio, *Stagonospora nodorum* (Septoria) in KY and MO, and powdery mildew (*Erisyphe graminis*), *Stagonospora*, and leaf rust in IN. In KY, all treatments also significantly reduced glume blotch severity. Table 4 provides an average % leaf disease reduction, but some products performed better on specific leaf diseases.

Fungicide application technology: Most of the analyses comparing fungicide application techniques have not been completed. However, some preliminary findings in ND indicate that types of nozzles used did affect disease ratings (Table 5), but generally differences were not statistically significant. Studies with a sprayer prototype in the winter and spring months of 1997-1998 in North Dakota indicated that traditional 8002 flat fan nozzles directed vertically did not provide as high of coverage on wheat and barley heads or to indicator paper as did various nozzle configurations or types that angled the spray toward the vertical grain spike (Figure 1)(1). Additional analyses are being done on nozzle types, kinds of adjuvants, droplet size, etc.

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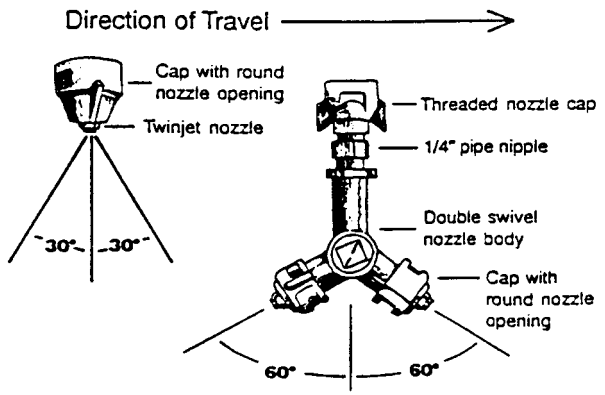
Figure 1. Example of Twinjet nozzle and double swivel nozzle bod that angles spray forward and backward.



Efficacy of Quadris and Benlate Applications on Wheat Scab in Arkansas

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Objective

Determine the efficacy of Quadris and Benlate fungicides

Introduction

High incidence and severity of wheat scab in Arkansas appear to be associated with warm, rainy weather before, during, and after flowering. Fortunately, these conditions have not occurred since the 1990 and 1991 seasons, and only scattered, light scab infestations have occurred during the past seven years. Given the susceptibility of wheat cultivars and the sporadic occurrence of scab, it would be useful to have an effective fungicide that could be applied when conditions were favorable for scab. This experiment was conducted in cooperation with Zeneca Ag Products to determine if Quadris or Quadris plus Benlate applications at heading stage would be effective under Arkansas conditions.

Procedures

Hazen soft red winter wheat was planted at Fayetteville, AR, on 20 October 1997. Seeding rate was 114 lb/A. Plots were fertilized in late February with 100 lb N per acre as urea and were sprayed with Harmony Extra for broadleaf weeds in early March. The design was a randomized complete block with four replications in low and high disease pressure environments. Plot size was approximately 5 x 10 ft for the high disease pressure and 5 x 5 ft for the low disease pressure. Fungicides were applied at 20 gal/A at 50% heading on 29 April 1998. Weather was abnormally cool at this time. A "mist system" consisting of Nelson D3000 Sprayhead sprinklers with 3TN-12 nozzles and FLFG plates (Hummert International, Inc) on 20-ft centers and regulated by Rain Bird UNIK battery-powered controls (Keeling Co.) was installed to provide a favorable environment for disease.

Inoculum of *Fusarium graminearum*(mixture of 7 isolates) was grown on mung bean agar and applied on 1 May (10% flowering, 150,000 spores per ml, 20 gal/A on low disease pressure, 60 gal/A on high disease pressure) and on 3 May (50% flowering, 90,000 spores per ml, 20 gal/A on low disease pressure and 40 gal/A on high disease pressure). Beginning 1 May and continuing through the morning of 15 May, plots were misted for approximately 16 15-minute intervals each day between late afternoon and early morning. Misting was resumed for one day beginning 20 May and ending the following morning. Plots in the low disease pressure environment were on the fringe of the mist system and received less water as well as less inoculum than plots in the high disease pressure environment.

Plots were rated visually on 22 May (soft dough stage) for the percentage of florets in the plot that were blighted. An expanded rating scale (0,2,5,7,10,15,20,30,40,50,60,70, 85,93 & 98%) was used to more precisely record differences in disease incidence. Plots were harvested on 10 June using a plot combine. Yields were adjusted to 13% moisture, and test weights were measured after passing the grain once through a cleaner. DON analyses were conducted on the grain from each plot in the low disease pressure environment by Howard Casper at North Dakota State University using accepted procedures. The high and low disease pressure environments were treated as separate experiments, and all data were analyzed using analysis of variance.

Results and Discussion

Based on visual observations throughout the spring, no disease except scab affected the test. Scab incidence averaged approximately 10 and 50% in the low and high disease pressure environments, respectively (see table). The treatment effect for incidence was significant at P = 0.056 under low disease pressure and nonsignificant (P = 0.75) at high disease pressure. Depending on how one interprets a P value of 0.056 and if means are rounded to 2 decimal places, all treatments with Quadris could be considered to significantly reduce scab incidence under low disease pressure.

None of the treatments had any effect on yield or level of DON in the grain. All treatments were above the desired level of 2 ppm DON. Three of the Quadris treatments significantly increased test weight under low disease pressure. Quadris or Quadris + Benlate do not provide an economic level of protection against scab under Arkansas conditions.

Results of testing Quadris and Benlate for controlling scab of wheat in Arkansas, 1998

Treatment and rate	Yield	Test weight	Scab	DON
lb ai/A	bu/A	lb/bu	%	ppm
Low Disease Pressure				
Quadris, 0.2	45.6	56.9	7.8	6.5
Quadris, 0.125 + Benlate, 0.125	43.1	55.7	9.25	8.3
Quadris, 0.125 + Benlate, 0.25	50.8	57.3	6.0	6.6
Quadris, 0.2 + Benlate, 0.25	48.1	56.8	9.25	7.7
Benlate, 0.25	53.5	55.7	11.8	8.8
Nontreated	51.5	55.1	15.0	10.4
Prob> F	0.30	0.008	.056	0.21
LSD P = 0.05	NS	1.2	(5.7)	NS
CV (%)	13.8	1.4	38.5	28.4
High Disease Pressure				
Quadris, 0.2	41.9	50.6	42.5	–[1]
Quadris, 0.125 + Benlate, 0.125	42.6	50.7	42.5	--
Quadris, 0.125 + Benlate, 0.25	42.6	50.6	45.0	--
Quadris, 0.2 + Benlate, 0.25	45.9	50.6	47.5	--
Benlate, 0.25	38.4	49.0	56.3	--
Nontreated	39.3	49.3	55.0	--
Prob > F	0.75	0.49	0.75	
LSD P = 0.05	NS	NS	NS	
CV (%)	17.7	3.2	34.8	

[1] Not tested.

Susceptibility of winter wheat varieties to Fusarium head blight, and control by tebuconazole (FOLICUR 3.6) in artificially inoculated, misted plots

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Objectives

To test the winter wheat cultivars that would be potentially grown in Ontario for resistance to Fusarium head blight (FHB). To compare disease reaction, as well as deoxynivalenol (DON) content, and yield of these cultivars between non-FOLICUR treated plots and plots with foliar application of FOLICUR 3.6 F.

Introduction

Most of the winter wheat varieties in commercial production in Ontario are susceptible to FHB. As long as highly resistant varieties are not available, it is necessary to screen large number of winter wheat varieties against FHB. Also, other means of FHB management, which include effective chemical control are attractive. The active ingredient tebuconazole, which is present in FOLICUR 3.6 F has good efficacy against FHB by comparison with other fungicides (Mesterhazy and Bartok 1996). Fusarium-damaged kernels (FDK) often contain DON, which is one of the best known *Fusarium* toxins found in wheat in Ontario (Teich and Hamilton 1985). More importantly, under epidemics condition fungicide application could reduce the amounts of DON in grain. In 1998 we tested sixty nine winter wheat cultivars for culture in Ontario for resistance against FHB, and the effect of FOLICUR 3.6 F on disease severity and DON accumulation.

Materials and methods

The crop was planted on 17 October, 1997 at Ridgetown, Ontario using a 6-row cone seeder at 2,070 seeds per plot. Plots were six rows planted at a row spacing of 17.8 cm and 4 m in length placed in a randomized block design with four replications. The plots were fertilized and maintained using provincial recommendations. Half of each plots was sprayed with FOLICUR 3.6 F (431 g ai /L tebuconazole) when primary wheat heads were at 50% anthesis for each variety (Zadoks growth stage (GS) 60 to 69, Zadoks 1974) using a back pack precision sprayer with a 1-m boom fitted with 2 twin jet nozzles spaced at 50 cm delivering 240 L/ha of water. Each plot was inoculated with a 100-ml suspension of macroconidia of *F. graminearum* at 500,000 spores/ml two days following treatment with fungicide. The suspension was produced in liquid shake culture using modified Bilay's medium. Plots were misted daily beginning after the first plots were inoculated. The misters delivered about 7.5 mm of water each day. The mist system was engaged until three days after the last variety was inoculated. Each variety was assessed for visual symptoms when the early dough stage was reached. Primary wheat heads were selected at random out of each plot. Heads were placed into one of seven classes 0,5,15,30,50,75,100 % infected spikelets. A Fusarium head blight index (FHBI) was applied to the data, which was the product of the percent heads infected and the percent spikelets infected. The plots were harvested on 14 July and the yields were corrected to 14 % moisture. Percent of FDK by weight was calculated from 25 g grain samples. DON content was estimated from the three replications using a quantitative ELISA test, and a commercial preparation of the antibodies and wells was used from EZ-Quant DON Plate Kit, Beacon Analytical Systems, Inc., 4 Washington Avenue, Scarborough, ME 04074. The limit of detection was 0.1 ppm. Percentage data were transformed to SQR (arcsin%). Reported means are untransformed.

Results

The results are given in the table below. There were thirty three entries from the Ontario Performance trials, and thirty six entries from the registration trials. Table 1 contains disease reaction, DON, and yield data for the non-FOLICUR treated plots, and similar data but for the FOLICUR 3.6 F treated half of the plots. FHB indices (15.8 versus 37.2), percent Fusarium-damaged kernels (FDK) (1.8 versus 2.1), and DON content (0.6 versus 1.7 ppm) tended to be lower, and yield tended to be higher (5.4 versus 5.1 T/ha) when FOLICUR 3.6 F applications were made. Generally, fusarium-resistant varieties responded better to protection by FOLICUR 3.6 F than did the more susceptible varieties. These results agree with those of Mesterhazy and Bartok (1996). DON content was significantly reduced using FOLICUR 3.6 F across all varieties. There was no detectable DON in fifteen varieties when FOLICUR 3.6 F applications were made, and only in one

variety when FOLICUR wasn't applied. Mesterhazy (1996) also noted that in medium resistant cultivars DON contamination would be reduced to zero, but that susceptible genotypes can not be fully protected against FHB. Percent of FDK usually was related to DON content. PIONEER B experimental, and AC MORLEY had the lowest FHB index, percent of FDK, and DON level. Hanover, CM 96097, and PRC 9308 had the highest DON content with/without FOLICUR 3.6 F (3.6, 2.3, 2.1 ppm versus 4.3, 3.3, 3.0 ppm, respectively) by comparison with other varieties tested. Regardless of the mechanism of resistance, planting susceptible varieties should be discouraged.

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Table 1. Fusarium head blight control in sixty nine winter wheat varieties without/with foliar application of FOLICUR 3.6 F in artificially inoculated and misted plots at Ridgetown, Ontario. 1998.

Winter	----------no FOLICUR----------				-----FOLICUR 3.6 F-----			
wheat	FHB	Percent	DON	Yield	FHB	Percent	DON	Yield
cultivar	index	FDK	(ppm)	T/ha	index	FDK	(ppm)	T/ha
1 HARUS	40.1	1.5	1.7	5.8	16.8	1.2	0.6	5.7
2 KARENA	33.4	2.0	1.5	5.8	8.5	1.5	0.6	5.7
3 AC RON	42.3	1.7	1.1	5.3	11.7	1.8	0.3	5.8
4 OAC ARISS	33.4	1.8	2.8	5.6	12.3	2.0	0.8	5.5
5 FUNDULEA	48.4	2.5	2.2	4.5	36.1	1.8	1.4	5.0
6 MARILEE	35.2	2.0	1.8	5.2	9.1	2.1	0.7	5.3
7 FREEDOM	46.8	1.7	1.0	6.0	15.0	1.9	0.5	5.9
8 AC DEXTER	38.6	2.9	2.6	4.7	18.6	3.0	0.9	5.7
9 AC CARTIER	36.8	2.5	2.6	4.9	10.9	2.7	0.2	5.4
10 AC MORLEY	23.7	1.3	0.5	5.5	6.5	1.1	0.0	5.6
11 2737W	39.0	1.7	2.5	5.6	28.8	1.8	0.8	5.6
12 2510	43.7	2.3	2.8	5.0	25.1	3.6	1.5	5.7
13 25W33	39.1	1.6	2.4	5.8	24.0	1.5	0.7	5.9
14 HANOVER	55.0	9.2	4.3	4.2	29.0	7.3	3.6	4.7
15 MENDON	46.1	4.0	2.2	5.3	26.6	2.1	1.6	5.5
16 OAC MONTROSE	49.6	3.4	0.9	5.1	16.0	1.8	0.4	5.4
17 CM94090	49.6	3.3	2.7	5.3	22.0	2.3	0.7	5.2
18 2540	34.3	1.5	1.1	5.8	13.5	1.7	0.2	6.3
19 25R57	42.9	2.2	1.3	5.9	18.8	1.9	0.1	5.9
20 HURON(BAVARIA)	35.6	2.4	1.6	5.0	6.2	1.0	0.3	6.1
21 TW91203	36.3	3.3	1.5	4.8	9.4	3.5	0.8	5.2
22 TW93211	35.6	1.1	2.1	5.3	18.8	1.3	0.8	5.4
23 25R26	32.9	0.7	1.4	4.8	10.0	0.9	0.1	5.7
24 WBI0638E1	39.7	0.7	1.8	6.2	14.5	1.1	0.0	6.0
25 PRC9308	57.8	1.9	3.0	5.1	28.3	3.1	2.1	5.6
26 H649:14	37.2	1.6	2.5	5.0	17.9	1.4	0.6	5.9
27 H649:5	43.5	2.3	2.7	6.1	16.8	1.9	0.0	5.7
28 PRC9325	20.0	3.3	1.2	4.3	7.3	1.4	0.1	4.5
29 PRC9327	9.7	1.6	0.8	4.2	6.5	1.0	0.0	4.8
30 S93:1	15.3	0.6	0.6	4.5	1.8	0.5	0.0	4.7
31 MWH95:069531	54.1	2.3	2.1	5.2	26.6	1.1	0.7	5.4
32 LJH95:0189	62.0	3.4	1.6	5.0	27.5	1.9	0.9	5.5
33 TW94415	19.8	1.4	0.6	4.6	5.5	2.5	0.0	5.2
34 SALS 9721	46.1	2.6	2.2	4.3	19.6	1.1	0.7	5.3
35 P88288C1-6-1-2	28.2	1.0	1.1	4.9	18.1	1.2	0.1	5.1

Table 1. Fusarium head blight control...*continued*

Winter wheat cultivar	----------no FOLICUR---------- FHB index	Percent FDK	DON (ppm)	Yield T/ha	-----FOLICUR 3.6 F----- FHB index	Percent FDK	DON (ppm)	Yield T/ha
36 KY 86C-61-8	34.0	2.9	1.5	5.4	15.9	1.0	0.0	6.0
37 IL87-2834-1	40.1	0.9	0.6	5.7	14.6	0.7	0.0	5.2
38 IL90-9110	47.0	0.3	0.9	5.5	13.9	0.8	0.0	5.2
39 OAC93W.86P	33.6	2.0	0.9	5.9	16.0	2.2	1.2	5.9
40 OAC94W:51P	31.9	1.2	1.5	4.6	8.7	1.0	0.0	5.1
41 OAC93R.7	29.8	2.5	1.1	4.7	6.9	1.4	0.2	5.3
42 OAC93R.31P	39.3	0.7	1.2	5.5	11.0	0.4	0.1	6.0
43 OAC95R:8P	7.7	1.9	0.9	4.6	3.5	1.7	0.1	4.6
44 OAC95R:43S	24.4	3.0	0.9	4.9	25.9	2.2	0.4	5.2
45 AUGUSTA	36.3	2.0	2.1	5.2	12.7	1.2	0.0	5.9
46 KARAT	21.2	2.9	0.6	4.3	2.1	2.3	0.0	4.6
47 PRH97-05316	34.0	1.0	1.5	5.1	17.8	0.8	0.3	6.1
48 PRH97-054046	50.9	1.2	1.2	5.0	25.2	1.1	0.3	5.3
49 RML97-155	42.1	2.0	1.9	4.5	13.5	1.7	0.5	5.8
50 CM 95009	45.3	3.1	2.4	4.4	20.5	1.6	1.4	4.9
51 CM 96089	40.0	4.9	2.6	4.7	19.2	4.0	0.8	4.9
52 CM 96097	61.3	5.4	3.3	4.5	26.0	3.8	2.3	5.1
53 CM 97001	16.6	1.1	1.1	4.1	3.9	1.1	1.8	4.1
54 CM 97002	27.0	2.8	1.3	4.8	10.2	2.6	0.8	4.6
55 CM 97003	36.4	2.5	2.3	4.9	17.5	0.8	0.2	5.4
56 CM 97020	39.4	3.3	1.6	4.9	27.3	3.0	0.9	5.2
57 CM 951067	27.6	2.3	2.3	5.4	9.8	1.3	0.6	5.5
58 CM 950282	43.9	1.6	2.3	5.5	19.9	1.6	0.3	5.9
59 CM 950455	41.6	2.0	1.8	5.6	17.3	1.6	0.0	6.2
60 CM 951078	46.4	2.7	2.5	5.7	18.0	2.5	1.3	6.1
61 CM 546	26.3	1.1	0.7	5.2	15.6	0.9	0.3	5.8
62 F97-1326-0	50.4	1.0	1.9	5.1	24.0	1.6	0.8	.9
63 F96-1044-0	39.0	1.1	0.6	4.9	14.1	0.9	0.0	.1
64 F94-010-S1	47.5	2.5	1.0	4.6	20.1	1.5	0.2	.1
65 F97-1017-0	13.9	2.8	1.6	4.9	4.0	2.6	0.7	.6
66 PIONEER A*	35.0	1.6	1.7	5.2	13.7	1.7	0.3	.7
67 PIONEER B*	26.9	0.6	0.0	5.0	7.6	0.6	0.0	.7
68 PIONEER C*	45.0	0.9	0.3	5.7	15.5	0.8	0.2	.1
69 PIONEER D*	27.8	0.7	0.6	5.7	11.5	1.0	0.0	.5
LSD (P=.05)	15.8	2.1	1.4	0.9	13.7	1.6	1.2	0.7
CV	30.8	60.6	52.9	11.3	62.8	56.0	31.6	7.7
AVG	37.2	2.1	1.7	5.1	15.8	1.8	0.6	5.4

* experimental