NCR-184
ARKANSAS STATE REPORT - 1999

Gene Milus

In 1999, Arkansas farmers planted 930,000 acres and harvested 870,000 acres of soft red winter wheat with an average yield of 56.0 bushels per acre (an all-time record!). Fusarium head blight symptoms could be found at trace levels in many wheat fields across the State, but losses due to head blight were negligible. A survey of 91 certified wheat seed lots found *Fusarium* spp. associated 18 to 81% of the seeds, and the most frequently isolated species was *F. graminearum*. The combination of low head blight incidence in the field and high *Fusarium* incidence on seeds was likely caused by the rainy weather between crop maturity and harvest. These data suggest that head blight would have been more severe if the rainy weather had come several weeks earlier.

Personnel working on FHB at the University of Arkansas include Gene Milus, Louis Prom (research associate), and Chris Weight (research specialist) in the Department of Plant Pathology and Robert Bacon (breeder) and John Kelly (research associate) in the Department of Crop, Soil, and Environmental Sciences. Louis Prom accepted a USDA scientist position at Texas A&M, and there will be a research specialist position available in December 1999. Novartis Seeds at Bay, AR, (June Hancock, breeder and Luis Lazo-Anaya, pathologist) and Agripro Seeds at Jonesboro, AR, (Barton Folgleman, breeder) also do some selection for FHB resistance.

Backcross F_2, topcross F_2, and F_3, populations from crosses designed to transfer FHB resistance to the southern soft red winter wheats were selected in the field for heading date, plant height, yield potential, and resistance to FHB, leaf rust, and Septoria tritici leaf blotch. Two hundred heads were selected from the best plants in each of 76 populations. Each head was threshed individually, the seeds were selected for plumpness and low levels of scab, and seed from the best 120 heads per population were planted as headrows in the field for evaluation in an inoculated, irrigated screening nursery in 2000. More than 200 Arkansas advanced breeding lines with sources of FHB resistance in their pedigree were planted as replicated single-row plots for FHB evaluation in 2000 and as yield plots at several locations. See the report in the Proceedings of the Scab Forum for additional details.

The uniform winter wheat scab nursery and the uniform scab fungicide test were evaluated in inoculated, irrigated plots. Significant differences in FHB resistance were found among the winter wheat lines, but no practical level of control was achieved with any of the fungicides. See reports in the Proceedings of the Scab Forum for additional details.

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NCR-184 MANAGEMENT OF HEAD SCAB IN SMALL GRAINS ILLINOIS REPORT – NOVEMBER 1999

Frederic L. Kolb*, Larry K. Boze, and Norman J. Smith

ILLINOIS WHEAT PRODUCTION

The estimated wheat yield in Illinois in 1999 was 60 bushels per acre. Acreage harvested was about 1.05 million acres, down about 16 % from 1998. Wheat production in Illinois in 1999 was about 60.6 million bushels. In spite of the lower acreage wheat production increased about 5 percent compared to1998 because yields were higher in 1999 than in 1998. In general, the winter was very mild in Illinois, and the crop developed rapidly in the spring. Wheat was harvested earlier than average in some of the southern regions, but rainy weather delayed harvest in some areas. Scab damage was spotty in 1999 with significant losses in some localized areas and little damage in others. Glume blotch also caused significant losses in yield and grain quality in some areas.

UNIVERSITY OF ILLINOIS RESEARCH

Breeding for Scab Resistance in Soft Red Winter Wheat

Development of scab resistant germplasm and varieties is a major research emphasis in the wheat breeding program. The long-term objective is the development of soft red winter wheat genotypes with excellent resistance to scab combined with resistance to other diseases, high yield potential, and acceptable winter hardiness and milling and baking quality. Our short-term objectives are: 1) to combine genes for resistance to scab from diverse sources; 2) to evaluate the genotypes produced from crosses and identify those with resistance to scab; 3) to identify molecular markers associated with genes for resistance to scab; and 4) to work toward using molecular markers to assist in breeding for scab resistance.

Two Illinois breeding lines entered into the 1999 Cooperative Winter Wheat Scab Screening Nursery were among the most scab resistant lines in the nursery. These lines have potential as parents, represent sources of resistance that are different from the Chinese sources or resistance, and are in soft red winter wheat backgrounds. These lines were made available to other breeders by entering them into the Cooperative Winter Wheat Fusarium Head Blight Screening Nursery.

About 575 breeding lines were evaluated in the misted, inoculated field nursery in 1999. Additional evaluations were conducted in the greenhouse. Material evaluated included germplasm reported to be tolerant/resistant, current varieties, and experimental breeding lines. At least 55 advanced breeding lines with scab resistance equal to or better than Ernie were identified, and the best of these will be evaluated further. Individual heads were selected from 27 segregating populations grown in the field nursery. About 4000 headrows resulting from these selections have been planted this season (1999-2000). About 1700 individual plants from six segregating populations were evaluated in the greenhouse scab screening, and about 210 plants with excellent scab resistance were selected.

We are continuing to select lines from segregating populations, evaluate lines, and increase the number of lines selected from crosses with

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potential scab resistance using both greenhouse and field procedures with misting systems and inoculation. In summary, new lines with scab resistance were identified, and the agronomic performance of previously identified lines was evaluated.

Research on Molecular Markers

Using a population of lines from a cross of resistant and susceptible cultivars, we conducted research on identification of molecular markers linked to scab resistance. About 300 combinations of AFLP (amplified fragment length polymorphism) primers were screened, and eleven AFLP markers showed significant association with scab resistance. These molecular markers were located in one chromosome region. A manuscript on these markers was published in *Phytopathology*, and additional research with these markers is in progress. Two additional QTL have also been identified in this population. This research is in cooperation with Guihua Bai,USDA-NCAUR and Oklahoma State University; Greg Shaner, Purdue University; and Les Domier, USDA-ARS at Urbana, Illinois.

Personnel

A post-doc, Irie Vroh Bi, joined the University of Illinois wheat breeding and research project in August. Irie received his Ph.D. in Genetics and Plant Breeding from the University of Agronomic Sciences, Gembloux, Belgium and is working on molecular markers associated with scab resistance. Two graduate students also joined the wheat breeding program this year. Wenchun Zhou began working toward a Ph.D. in June, and Andrew (A.J.) Stewart began work on his M.S. in August.

Publications

Bai, G-H., F. L. Kolb, G. Shaner, and L. Domier. 1999. AFLP markers linked to a major QTL controlling scab resistance in wheat. Phytopathology 89:343-348.

Bai, G-H., F. L. Kolb, G.E. Shaner, and L.L. Domier. 1999. Using AFLP map to identify scab resistance QTL in wheat. Agron. Abstr. p. 159.

MANAGEMENT OF SCAB OF SMALL GRAINS NCR-184 1999 INDIANA STATE REPORT

Gregory Shaner

SCAB WAS NOT GENERALLY SEVERE IN INDIANA IN 1999, ALTHOUGH SOME RAIN FELL DURING FLOWERING

Scab could be found in many fields, but usually no more than 6% of the heads were affected, and in many fields the incidence of infection was much lower. However, there were limited areas in the state, such as near Sullivan, in which losses due to head blight were as high as 25% in some fields.

CURRENT RESEARCH PROGRAMS

We are continuing our research on the recombinant inbred population of Chokwang/Clark in hopes that the resistance genes will differ from those Ning 7840 and Sumai 3. We have a poster that shows our results of this study (Shaner and Buechley).

We are also continuing the research on approximately 50 selected lines from the USDA NSGC. About two thirds of these lines exhibit type 2 resistance and the other third exhibit type 1 resistance. (Shaner and Buechley)

We are beginning a research project that includes examination of corn stubble for presence of *G. zeae* and development of ascospores in the spring. A new graduate student, Amanda Gevens, is working on this project. (Gevens, Buechley, and Shaner)

The two new FHB low-incidence cultivars, Goldfield and INW9853, performed well and in test plots near Sullivan, IN in which blight incidence in cultivars Patterson, Goldfield, and INW9853 averaged 25, 10 and 8%, respectively. Incidence in plots of cv. INW9824, with one resistance gene from Ning 7840, averaged 15% and 1/3 - 2/3 of the spikelets of infected spikes became diseased compared to 95% of spikelets of infected spikes of Patterson. (Herb Ohm, Xiaorong Shen, David Drake, Ted Kisha, Hari Sharma)

Although natural infections of head blight in nursery plots at Lafayette, IN were low, 2-5 %, single-floret inoculations, both in the greenhouse and field, were successful and allowed selection in limited populations. Resistance from a number of source parental lines is being combined in various crossing schemes and F_3-F_6 populations are in nurseries in the field. Hopefully, effective selection can be accomplished in the field in 2000. (Herb Ohm, Xiaorong Shen, David Drake, Ted Kisha, Hari Sharma)

The venture of growing F1 plants in Argentina for generation advance under field conditions was highly successful in the first attempt in the 1998-1999 season. F_1 seeds produced in the greenhouse in April were seeded in Argentina in early May and harvested in late November. The F_2 generation was seeded in late November at Evansville, IN. Seedlings were established and survived the winter in fine shape. F_3 populations from single F_2 plants were seeded in nurseries at Lafayette and Sullivan, IN at normal seeding dates in October 1999. (Herb Ohm, Xiaorong Shen, David Drake, Ted Kisha, Hari Sharma)

CEREAL CLASSES AND ACREAGE IN INDIANA

Indiana produces soft red winter wheat. In 1999, Indiana farmers harvested 510,000 acres, at an average yield of 66 bu/A, for a total production of 33.6 million bushels.

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ANNUAL NCR-184 REPORT FOR 1999
IOWA

Gary Munkvold* and John Shriver

WHEAT PRODUCTION AND HEAD BLIGHT IN IOWA IN 1999

Wheat for grain was planted on only 31,000 acres and the average yield was 43.0 bu/acre, for a total production of 1.33 million bu. Wheat production is concentrated in the SE portion of the state. Weather in 1999 in this part of the state was characterized by excessive rainfall in the late spring, followed by extremely dry conditions during the mid- to late summer. The result was that Fusarium head blight had a significant effect on yields in some fields, but both yield and disease development were limited by the dry conditions later. My estimate for losses due to scab was approximately 5 bu/acre.

FUSARIUM HEAD BLIGHT RESEARCH

In 1999 we conducted a small spring wheat nursery at Ames in collaboration with Bob Stack, NDSU. Plots were planted in soybean stubble and no irrigation or inoculum was provided. Head blight severity reached about 30% in susceptible checks and was 2-4% in the best experimental lines. Iowa State University does not have an active wheat breeding program. Currently the Department of Agronomy is in the process of hiring a new small grain breeder, but the emphasis is likely to be on oats.

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NCR-184 STATE REPORT
KANSAS 1999

R.L. Bowden

FHB SITUATION IN 1999 IN KANSAS

Kansas wheat generally had high yields and low to moderate disease levels in 1999. There were traces of Fusarium head blight (scab) in central and north central Kansas. Southeast Kansas had a little more, up to 2% in some fields. In contrast, northeast Kansas experienced a significant scab epidemic. Disease incidence in excess of 30% was observed in several fields. Fortunately, the planted acreage of wheat in northeast Kansas was relatively low this year due to excessive moisture during planting time in the fall of 1998. This limited the impact of scab on statewide production. The average estimated loss due to scab in Kansas was 0.2%.

PROGRAMS AND PERSONNEL INVOLVED IN FHB RESEARCH

Breeding program and scab resistance screening

In the spring of 1999, Rollie Sears resigned as the KSU wheat breeder at the Manhattan location and moved to AgriPro. He will remain in Manhattan and continue to breed hard red or white winter wheat for the central and southern Great Plains region. KSU will hire a new wheat breeder to continue the Manhattan breeding program. The KSU wheat breeding program at the Hays location directed by Joe Martin will continue uninterrupted.

Most varieties grown in Kansas are susceptible to FHB. For example, the two most popular varieties in Kansas in 1999 were Jagger and 2137. Both were released by KSU and both are susceptible. In fact, 2137 is very susceptible to scab. Only varieties Karl 92 and Agripro Hondo seem to have useful levels of resistance among hard red winter wheat varieties that have been screened to date. Heyne, a new hard white variety, also has useful levels of resistance. The lack of resistant varieties has contributed to the decline of wheat acres in eastern Kansas by two thirds since 1980.

Gina Brown-Guedira (USDA geneticist) has made some crosses (Heyne/TAM 107) to learn more about the number of genes involved in resistance in our Kansas material. She has also introgressed transgenic chitinase resistance (see below) into Heyne to determine if it improves resistance.

For the second year, a field screening nursery was operated at Manhattan by Bill Bockus, Bob Bowden, and Mark Davis. Plots were inoculated with corn kernels infested with one aggressive isolate of *Gibberella zeae*. Plots were irrigated with fine impact sprinklers for 3 minutes per hour each night starting at heading. Results were better than last year in that we avoided drowning the plants as happened in some plots in 1998. The Uniform Winter Wheat Fusarium Head Blight Nursery was rated at three dates. Soft red varieties OH522, IL95-4162, and NY87048-7387 looked the best in our plot this year. The Kansas Intrastate Nursery was screened and several highly susceptible lines were identified and will be discarded. This nursery will be expanded for the 2000 season. Additions will

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include a commercial cultivar nursery, Hays breeding program nursery, USDA Geneticist nursery, and a special nursery to examine whether polyphenol oxidase (ppo) is related to scab resistance in several populations. This is important because our breeding programs are currently selecting against ppo because it reduces noodle quality. André Rosa, a student in plant breeding, is conducting this project as part of his Ph.D. thesis.

Alien resistance

Bikram Gill (Plant Pathology) and Bernd Friebe (Plant Pathology) are cooperating with Dajun Liu and Peidu Chen (Nanjing Agricultural University) on several projects funded by a McKnight grant. A variety of addition, substitution, and translocation lines from *Roegneria* and *Leymus* into wheat are being characterized cytologically and for resistance phenotype. We are also continuing to look at a set of synthetic hexaploids from Mujeeb-Kazi of CIMMYT.

Transgenic resistance

Bikram Gill (Plant Pathology), S. (Krishnan) Muthukrishnan (Biochemistry), and George Liang (Agronomy) are continuing to cooperate with Wenping Chen, Dajun Liu and Peidu Chen (of Nanjing Agricultural University). Transgenic plants had an increased level of resistance to scab. The following paper was published on expression of chitinase in transgenic plants.
Chen,-W.P.; Gu,-X.; Liang,-G.H.; Muthukrishnan,-S.; Chen,-P.D.; Liu,-D.J.; Gill,-B.S. 1998. Introduction and constitutive expression of a rice chitinase gene in bread wheat using biolistic bombardment and the bar gene as a selectable marker. Theor-appl-genet. 97 (8) 1296-1306.

Cloning pathogenesis-related genes from plants

Wanlong Li, John Fellers (USDA geneticist), Bikram Gill, Peidu Chen and Dajun Liu are continuing to work on a DNA library of pathogenesis-related sequences from infected spikes. John Fellers recently purchased a high-throughput sequencer that will be used to analyze the library.

Pathogen genetics and variability

Jim Jurgenson, Bob Bowden, and John Leslie continued work on a genetic map of a cross between a strain from Kansas and a strain from Japan using AFLPs. To date, 1039 markers have been placed on nine linkage groups. Ron Plattner (USDA mycotoxin unit at Peoria) has preliminary data that toxin type (DON vs. NIV) and amount are segregating in this cross. We are also cooperating with Nancy Alexander (USDA-Peoria) on mapping the trichothecene gene cluster.

A pilot study to compare populations from Kansas and North Dakota using AFLPs is being done by Kurt Zeller in cooperation with Bob Bowden and John Leslie. Analysis of approximately 40 isolates from each location using 80 markers revealed to significant differences between the populations. Samples have been collected or obtained from cooperators in Illinois, Kansas, Minnesota, New York, North Dakota, Ohio, and Virginia. These will be used to look for differences in marker frequencies at the regional level.

The following paper on pathogen genetics was published:
Bowden, R. L., and Leslie, J. F. 1999. Sexual recombination in *Gibberella zeae*. Phytopathology 89:182-188.

NCR-184
1999 KENTUCKY STATE REPORT

Donald Hershman* and David Van Sanford

FUSARIUM HEAD BLIGHT STATUS DURING 1999

Excessively dry conditions during 1999 resulted in very low levels of Fusarium head blight throughout Kentucky.

CURRENT RESEARCH PROJECTS

Field and Greenhouse Screening

Marla Hall, Brenda Kennedy, and Dave VanSanford

Numerous soft red wheat cultivars, breeding lines, and entries in the Uniform "Scab" Nursery were evaluated under mist irrigation in a field nursery near Lexington, KY. Fusarium-infected corn was used to infest the nursery and encourage FHB development. However, difficulty in establishing timely irrigation following distribution of inoculum and lack of rain fall resulted in very low disease levels. Certain lines from this study were evaluated in the greenhouse for Type II resistance.

Inheritance Studies

Marla Hall and Dave VanSanford

A number of populations were synthesized from parents with reportedly different sources of FHB resistance. Several types of genetic analyses will be performed on progeny of these crosses to elucidate inheritance of resistance.

Breeding For FHB Resistance

Dave VanSanford

Numerous crosses have been made and continue to be made to various sources of FHB resistance, within and outside of the soft red winter wheat market class.

Uniform FHB Fungicide Test

Don Hershman and Scott Jones (WheatTech, Inc.)

Tests were performed at two locations in west Kentucky during 1999. The tests relied on natural inoculum and moisture, and because of excessively dry weather befor, during and immediately following crop flowering, very little FHB developed. As a result, none of the fungicide treatments performed better than the non-treated plots.

FHB Survey

Don Hershman, Scott Jones (WheatTech, Inc.), and Phillip Needham (Miles Opticrop)

1999 marked the second year where grower fields were surveyed to determine if there is an association between FHB incidence or severity and the amount of corn surface residue left in a field from the previous crop. Ninety-five and 91 fields were surveyed in 1998 and 1999, respectively. The amount of corn surface residue was significantly correlated with FHB incidence in both years, and with severity in one of two years; however, in all cases, relationships were highly variable as indicated by R^2 values in the low .20s or less. This suggests that other factors are more important than corn residue in determining the incidence and severity of FHB in Kentucky. We hypothesize that the nature of corn production in Kentucky, i.e, small, widely-scattered corn fields throughout the wheat producing areas, results in sufficient FHB inoculum any time weather conditions favor spore production and dissemination. This survey will be extended one final year into the 2000 growing season.

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1999 NCR-184 STATE REPORT
MANAGEMENT OF HEAD SCAB OF SMALL GRAINS

L. Patrick Hart

STATE SITUATION

FHB occurred in Michigan in 1999, but the incidence was less than 1%, and occurrence was generally limited to the central portion of the state. DON was not considered a problem in 1999.

RESEARCH REPORTS

Variability of deoxynivalenol in truckloads of wheat

In a 1996 statistical study on winter wheat, a grain probe sampling protocol was developed to predict levels of deoxynivalenol (DON) in FHB infected grain. The statistical study was expanded in 1998 to examine the variability of DON distribution between probes and within probes in truckloads of spring wheat harvested from FHB infected fields. The variability was greater between probes in the 1998 study compared with the 1996 study. In the 1996 study, the DON average from four probe samples was within 1 ppm of the upper limit of the estimated truck average (95% confidence), or within 0.5 ppm on either side of the estimated truck average (95% confidence). Four probes from the 1998 study predicted the average within 3 ppm of the upper limit (95% confidence), or within 1.5 ppm on either side of the average (95% confidence), thus reflecting the increased variability of DON distribution in the trucks. Two of the five trucks from 1998 had DON means below 10 ppm (5.9 and 9.2 ppm), and four probes predicted the mean (95% confidence) within 2 ppm and 1 ppm, for the upper limit and for either side of the mean respectively.

This statistical study is continuing in 1999 to examine how storage and moving of wheat affects the variability of DON distribution in trucks of wheat. A GIPSA study on DON distribution in barley after removal from storage bins suggested reduced variability compared to variability in our studies using freshly harvested grain. In addition, we would like to examine DON variability in wheat with truck averages in the range of 1-10 ppm.

Identification of peptides that mimic the binding of DON to DON specific antibody

A random 7-mer peptide phage expression library was screened for sequences that bound to the antigen binding region of DON specific monoclonal antibody, and displacing DON-HRP marker enzyme. Two clones were identified with the following sequences:SWGPFPF and SWGPLPF. Both clones were competitive in direct and indirect ELISA for DON. A translation fusion with bacterial alkaline phosphatase was also active in a direct ELISA for DON. The peptide appeared to have 10X greater affinity than DON to the antibody (0.39 µm vs 3.9 µm required to inhibit binding of DON-HRP by 50%, respectively). The peptide also appeared to prevent protein synthesis inhibition by DON in an *in vitro* protein translation system.

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Fungicide trials on wheat to reduce FHB and DON levels

The effect of different applications techniques using Folicure were evaluated to reduce the incidence of FHB, and the levels of DON. Folicur was applied at two rates (4 oz/acre and 2.5 oz/acre), and by two application methods, 1) flat fans at an angle (approximately 60-75^{o} above the horizontal). Disease incidence and severity were not significantly different between treatments and untreated controls. However, DON levels in the treatments were significantly lower than the controls, but not from each other. Average treatment mean for DON was 4.5 ppm compared to 13.4 ppm for the untreated control. These results suggest that standard flat fans placed at an angle can effectively reduce DON levels in grain associated with FHB, but that the apparent incidence and severity are not affected. Reduced rates of Folicur may be as effective as higher rates.

Michigan participated in a Uniform fungicide trial to evaluate different fungicides efficacy on FHB and DON. The fungicides were benlate/ manzate, quadris (2 rates), penncozeb, BASF 500 00F, stratego (2 rates), and folicur. Differences in yield, FHB incidence and severity, and DON levels were not significant between treatments, although folicur had the highest yield and the lowest levels of DON. In the previous two years, application of Quadris to control FHB resulted in higher levels of DON. This year, levels of DON were lower (not significantly) than in the untreated controls.

The relationship between variety (Freedom, Pioneer 2510, and Frankenmuth), and timing of fungicide application (folicur, 4 oz/acre applied at Feekes GS 10.1 or 10.5, except fungicide was applied to Frankenmuth only at GS 10.5) was evaluated for effect on DON levels. Folicur applied at GS 10.5 significantly reduced levels of DON in each variety compared to untreated controls. Folicur only slightly reduced DON in Pioneer 2510 when applied at GS 10.1, but significantly reduced DON in Freedom when applied at GS 10.1. Yields tended to be higher in treated plots, but were not significantly greater than untreated controls.

USEFULNESS OF FINDINGS

Food grain intended for human consumption must be safe and free from harmful chemicals. DON contaminated grain is unsafe for human consumption. The ability to accurately and precisely identify levels of DON in grain is a critical aspect of ensuring food safety. This sampling study has provided a protocol, that if followed, can provide the purchasers of raw grains the means by which to divert grain for appropriate uses, and ensure that DON contaminated grain is not used for human consumption. The incidence of DON like symptoms in school children in 1998 was been associated with burrito tortillas made from wheat. Our past experience with how elevators sample freshly harvested wheat for DON testing suggested that significant errors in accuracy were likely to occur. If implemented by buyers of grain, the protocols developed as a result of this research should reduce the potential of DON contaminated grain being used in the preparation of food.

The peptide mimic of DON may be useful in developing a new generation of analytical tests that are less expensive to produce, more sensitive and capable of detecting lower levels with greater precision, and broader applications. In addition, because preliminary findings suggest the peptide mimic of DON may protect against protein synthesis inhibition, the mimic may be useful in the development of transgenic grain plants with resistance to DON, and therefore result in reduced FHB incidence, severity, and DON levels.

In the absence of other control measures, fungicides have been shown to be an effective means of reducing disease. Our FHB control studies examine fungicide efficacy to provide the wheat industry with appropriate recommendations for reducing FHB and DON. In addition, some studies directed toward application timing, and method of application may result in better control, and possibly in reduced rates of fungicides being applied. This is not only economically beneficial to the grower, but reduces the risk of pesticide residues on the grain.

Because the research on fungicides has been collaborative between states, the ability to draw comparisons across different environments and agro-ecosystems, has resulted in unified recommendations for FHB managment with fungicides. Most states with a potential FHB problem request on a yearly basis a special EPA permit (section 18) allowing the use of Folicur on wheat if the environmental conditions suggest an epidemic could occur. Through educational efforts elevators and other purchasers of grains should be aware of the necessity of applying a specific sampling protocol to trucks of wheat in order to accurately estimate the DON level in the truck.

Immunological approaches to diagnostics, and disease resistance have been major accomplishments over the past five years. Recombinant antibody technology has resulted in the development of antibodies with enhanced affinity to mycotoxins, gene fusions between recombinant antibody DNA and reporter enzyme DNA has resulted in a potentially new way to develop diagnostic tests, and expression of functional recombinant antibody in plants opens the possibilities of using foreign genes to develop new and novel forms of resistance to *Fusarium* plant pathogens that produce mycotoxins. Peptide mimics of toxins may provide an opportunity to study interactions between toxins and their receptor ligands.

WORK PLANNED FOR NEXT YEAR

The statistical study on sampling will be continued for validation of probe collection protocols, and evaluation of how storage and shipment affects the distribution/variability of DON in grain. Work on the peptide mimic will be expanded to the development of transgenic plants and a determination of the possible role the mimic may have in reducing the toxic effects of DON as a virulence factor in wheat and possibly barley. Work will also continue on the development of recombinant antibody to DON, and identification of other peptide mimics that may be useful in elucidating the receptor ligands associated with DON toxicity.

PUBLICATIONS

Yuan, Q. Y., L. P. Hart, and J. J. Pestka. 1999. Identification of mimotope peptides which bind to the mycotoxin deoxynivalenol-specific monoclonal antibody 6F5. Appl. Environ. Microbiol. 65:3279-3286.

Schabenberger, O., L. P. Hart, and F. Kong. 1998. Evaluating sampling strategies for vomitoxin in the midwestern U. S. Porceedings 1998 National Fusarium Head Blight Forum p 35-39.

NCR-184 COMMITTEE-MANAGEMENT OF HEAD SCAB IN SMALL GRAINS 1999 MISSOURI REPORT

Laura E. Sweets* and Anne L. McKendry

WINTER WHEAT PRODUCTION IN MISSOURI AND THE 1999 FHB SITUATION IN MISSOURI

Winter wheat is grown on all of the Missouri wheat acreage. Most of the acreage is soft red winter wheat with a minimal number of hard red winter wheat acres. Missouri wheat production in 1999 totaled 44.16 million bushels, down 23.2% from last year's production of 57.5 million bushels. Of the 1.02 million acres planted, farmers harvested 0.92 million acres for grain (1.25 million acres were harvested in 1998). Missouri yields averaged 48 bushels per acre, up 2 bushels from last year's average yield of 46 bushels per acre.

1999 was a fairly good year for wheat production and a fairly poor year for Fusarium head blight in most of Missouri. The early part of the season was cool and wet, but most of the state was dry as the wheat crop was flowering resulting in low levels of scab. Localized rainfall lead to scab problems in those areas but the incidence and severity of scab was minimal in Missouri in 1999.

Aphid levels and barley yellow dwarf virus were concerns in the southeastern part of the state. Leaf rust and Septoria leaf blotch came in late in the season and did not move up to the flag leaves until well past heading. Losses from foliage diseases were low for most of Missouri. Missouri did have a Special Local Need Registration (Section 24c Registration) for Tilt which extended the time of application to Feeke's Growth Stage 10.5. However, because of the low level of foliage diseases few growers took advantage of the Tilt label change or the new federal label for Quadris on wheat.

Quality of wheat seed tested by the Missouri Seed Improvement Association was very good this season. There was very little scab, very little black point and little bleaching, shriveling or low test weights. Germinations rates were very good.

There are no official estimates of the number of acres planted to wheat this fall. Seed dealers reported good sales with many selling all their wheat seed. The general feeling is that wheat acres will be up from last year but not perhaps not back to the 1997 level. Increases in wheat acres may be due to several factors including 1) disappointing corn and soybean yields and prices have led to a need for wheat for early cash flow in 2000, 2) corn acreage may be down in 2000 which leads to an increase in wheat with doublecrop soybean, 3) good fall weather meant the soybean crop was harvested in a timely fashion leaving time to plant winter wheat and 4) an increase in acres of pasture wheat to graze this fall or for forage next year to supplement forage supplies decimated by dry conditions during the summer and fall of 1999.

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CURRENT SCAB RESEARCH AT THE UNIVERSITY OF MISSOURI

Uniform Scab Fungicide Trial

The University of Missouri did participate in the Uniform Scab Fungicide Trial coordinated by Dr. Marcia McMullen, NDSU. Nine fungicide treatments were evaluated on Madison. FHB occurred in low levels throughout the plot. There were no statistically significant differences in yield, ppm of DON, % incidence of FHB, % FHB severity or % field severity between the untreated control and any of the nine fungicide treatments. Results of this trial are given in more detail in the report for this initiative project.

Breeding Program

The University of Missouri's Wheat Breeding Program has a major emphasis on accelerating the development of scab resistant soft red winter wheat that was initiated in 1993 and significantly enhanced in the last 2 years with funds from the National Wheat and Barley Scab Initiative. In 1993, an initial screen of genotypes in the breeding program along with those entered into the Missouri Winter Wheat Performance Tests led to the identification of a high level of Type II resistance in the Missouri experimental line MO 12256 which was later released as "Ernie". Resistance in the line has subsequently been verified by several programs and Ernie now serves as the early maturity resistant check in the Uniform Winter Wheat Scab Nursery.

Routine screening of all advanced lines in the breeding program has been introduced in the past 2 years. This screening permits the identification of otherwise unknown sources of resistance in adapted breeding lines, thereby accelerating the release of scab resistant lines to the grower. At the same time it facilitates the elimination of highly susceptible lines from breeding streams. In 1999, 34 advanced lines from among 120 screened were identified that had levels of Type II and III resistance comparable to the resistant check varieties Sumai 3 and Ernie. Once verification is complete, genetic studies will be initiated to investigate the nature of the resistance in lines which differ from Ernie by descent.

Beyond screening, the incorporation of resistance genes identified through germplasm screening programs is essential to the continued improvement of Fusarium head blight resistance in winter wheat. We currently are incorporating genes from Sumai 3, Ning 7840, Frontana, and several CIMMYT sources. In addition, we routinely use soft red winter wheats sources including Ernie, Patton, Goldfield, Freedom and several of our own lines expressing good levels of resistance. Once verified, several Chinese accessions showing good levels of resistance will be added to our crossing block.

Germplasm Evaluation Center

Missouri was identified as a germplasm evaluation center for the National Wheat and Barley Scab Initiative with responsibility for identifying new sources of resistance in winter wheat. During 1998/99, 937 landraces, breeding lines and cultivars from China, South Korea, Japan, Brazil and Italy, were screened for Type II and III resistances. The initial screening resulted in the identification of 240 plants representing 87 accessions with Type II resistance comparable to Sumai 3 and excellent kernel quality. During the fall and winter of 1999/2000, these accessions will be progeny tested and resistance will be verified. Approximately 1000 landraces, breeding lines and cultivars from Yugoslavia will be screened in the greenhouse and field during the 1999/2000 season.

Genotype x Isolate Interaction Study

We are completing a study involving 20 genotypes and 5 geographically diverse isolates to

determine if there are genetic interactions with isolates that might limit the stability of resistance over wide geographical areas. This work has clearly shown a wide range of aggressiveness in isolates currently in use in breeding programs in the eastern United States. In addition, data suggests a possible interaction of isolate with genotype impacting both Type II and III resistances. Work will be completed in the winter of 2000.

Genetic Studies

Studies investigating the inheritance of resistance in Ernie are currently underway utilizing the Missouri breeding line MO 94-317, a widely adapted and highly inbred (F_{12}) line, as the susceptible parent. It has high yield and excellent milling and baking quality but is highly susceptible to scab with a FHBI of $ 0.9 and poor kernel quality under disease pressure.

Conventional Six Generation Means and Variance Analyses

A set of populations (F_1, reciprocal F_1, F_2, BC_1 and BC_2) from the cross Ernie x MO 94-317 is currently under development for conventional genetic analysis of the scab resistance in Ernie. Population development will be completed in 1999/2000 and genetic analyses will be conducted in the fall of 2000. Both Type II and Type III resistance data for each generation initially will be examined for goodness-of-fit (based on P^2 analysis) to simple Mendelian ratios. Where data collected fail to fit a simple dominant/recessive genetic model, generation means and variance analyses will be conducted.

Monosomic Analyses

Monosomic plants from each of the 21 Chinese Spring monosomics developed at the University of Missouri by Dr. E.R. Sears have been crossed with Ernie in an effort to identify critical chromosomes influencing scab resistance in Ernie. In addition, the results of this study will help focus molecular work aimed at identifying markers associated with genes for scab resistance in this cultivar.

Molecular Analysis

A set of F_3 derived F_7 recombinant inbred lines (RIL's) has been developed from the cross Ernie x MO 94-317 which will be used to map resistance genes in Ernie. Results from screening F_6 RIL's suggest that resistance in Ernie is heritable and relatively simply inherited. Of 1330 lines screened in the spring of 1999, 308 plants were classified as resistant (FHBI # 0.2), 192 as moderately resistant (0.3 # FHBI # 0.5), 295 as susceptible (0.6 # FHBI # 0.8) and 535 as very susceptible (FHBI $ 0.81). Bulks of 10 to 15 lines each of the most highly resistant and susceptible RIL's will be used for bulk segregant analyses. The two bulks and the parents will be screened for polymorphisms initially using 1345 probes currently held at University of Missouri, and if necessary for greater resolution and tighter linkage, by AFLP primer combinations and/or SSR's.

PERSONNEL

Kara Salzman has joined the program as a Research Specialist with responsibilities in the area of germplasm evaluation and introgression of identified resistance genes.

Mr. Shuyu Liu is a doctoral student working on the genetic analyses of scab resistance in Ernie.

FUSARIUM HEAD BLIGHT IN NEBRASKA IN 1999 NCR-184 STATE REPORT

John E. Watkins*[1], P. Stephen Baenziger[2], Amit Mitra[1], Marty Dickman[1], and Tom Clemente[3]

FUSARIUM HEAD BLIGHT INCIDENCE

John Watkins, Plant Pathology

The incidence of Fusarium head blight in commercial wheat fields varied considerably in Nebraska. It ranged from a trace in southwest Nebraska, i.e. near McCook area, to as high as 50+ percent in eastern Nebraska. One third (approximately 600,000 acres) of Nebraska's wheat crop is grown in southwest Nebraska with slightly less than one third grown in eastern Nebraska. The largest wheat-producing region is Nebraska's panhandle where drought is common and Fusarium head blight is rare, except in irrigated fields. There is a growing concern that irrigated wheat may be affected by Fusarium head blight if rains come at flowering because these fields are intensively managed and there is ample moisture provided to support the wheat crop. Hence small amounts of additional moisture from rain may lead to a higher incidence of Fusarium head blight than would normally be expected in this otherwise drought-prone region. Wheat from at least one field in eastern Nebraska was rejected by the elevator because of scabby grain.

Fusarium head blight was present in virtually every field in eastern Nebraska, but in only a few of those fields was the severity high enough to be of concern. The weather at the critical flowering period played a major role in the incidence and severity of Fusarium head blight in Nebraska. Another factor that probably is partially responsible for our variable Fusarium head blight incidence and severity was that many of the wheat fields in eastern Nebraska follow soybeans rather than wheat or corn, which probably helped to keep the initial inoculum level down. In surveys, those fields with the highest incidence of Fusarium head blight usually are ones in which the wheat is planted into corn or sorghum residue. The other factor that affected Fusarium head blight in eastern Nebraska is that many of the popular lines (2137 and Wesley) seem to be more susceptible to Fusarium head blight than other lines which are not as well adapted.

Out of 287 certified seed samples tested by the Nebraska Crop Improvement Association in 1999, 40 samples (14%) tested positive for Fusarium head blight. This was a higher number of samples testing positive for Fusarium head blight than in 1997 and 1998, but would not be considered exceptionally high.

ENHANCED VARIETY DEVELOPMENT OF FUSARIUM HEAD BLIGHT RESISTANT VARIETIES

P. Stephen Baenziger, Agronomy

The Nebraska program is attempting to breed Fusarium head blight resistant lines using conventional plant breeding techniques, specifically: 1. Collecting Fusarium head blight resistance germplasm, 2. Crossing Fusarium head blight resistant germplasm onto elite lines adapted to Nebraska, and 3. Screening the progeny of these crosses for Fusarium head blight resistance.

Fusarium head blight resistant germplasm was collected from Korea and the spring wheat breeding programs. We are especially grateful to Drs. Jackie Rudd and Yue Jin of South Dakota

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State University and to Dr. Bob Busch who have graciously shared their most resistant germplasm. Crosses were made onto this germplasm in our spring, 1999 crossing block. It is to early to screen the progeny of this material. In addition, one elite line which is believed to have a low level of Fusarium head blight tolerance (suggested by Dr. Yue Jin) was submitted to the Uniform winter Wheat Scab Nursery for testing in 1999-2000.

The most important accomplishment was the collection of the germplasm and the identification of a line that may already have a higher level of tolerance than many hard red winter wheat cultivars.

ENHANCED FUSARIUM HEAD BLIGHT RESISTANCE IN WINTER WHEAT GERMPLASM BY PLANT TRANSFORMATION

Amit Mitra & Marty Dickman, Plant Pathology
Tom Clemente, Biotechnology Center

Research efforts have concentrated on transferring novel genes, from diverse sources, with known disease resistance activity into wheat using plant transformation. The four genes, we have attempted to insert into wheat encode: a) CED9, b)IAP (inhibitor of apoptosis), c) lactoferrin and a related derived protein, lactoferricin, and d) oxalyl-CoA-decarboxylase. We also wish to insert both lactoferrin and oxalyl-CoA-decarboxylase in hopes the two genes combined may have enhanced antifungal properties. These four genes were chosen because these genes in transgenic tobacco plants have shown potential for combating economically important fungal diseases of crop plants. In addition, these four genes represent distinctly different target specificities (modes of action). Our interest in CED9 and IAP is that host recognition of a pathogen triggers a cell death pathway resulting in a zone of dead cells around the infection site, a hypersensitive reaction. CED9 and IAP are known regulators of programmed cell death. Lactoferrin is a granule-associated glycoprotein present in mammalian fluids such as milk or tears that has long been reported as a major component of infant defense systems against microbial pathogens. Both lactoferrin and lactoferricin have been shown to be highly antifungal against yeasts and filamentous fungi at concentrations ranging from 3 to 25 g/ml. Oxalyl-Co-A-decarboxylase gene has been cloned from a soil bacterium to specifically degrade oxalic acid which is a pathogenic determinant of certain plant pathogenic fungi such as *Sclerotinia* and *Rhizoctonia*. Although it is not know if oxalic acid is involved in *Fusarium* pathogenesis, this gene might be helpful in providing resistance against the fungus by alteration of pH, chelation and/or neutralization.

Eleven transgenic events were created for IAP (8 using Agrobacterium and 3 using microprojectile bombardment), 24 events for lactoferrin (using microprojectile bombardment), 10 events for oxalyl-Co-A-decarboxylase (using microprojectile bombardment) and 18 events for lactoferrin and oxalyl-Co-A-decarboxylase (using microprojectile bombardment). We were able to create only 2 transgenic plants for CED9. We are unsure of why we have a low frequency of CED9 transformants and will change the construct to see if perhaps there is something unusual with our construct. It is also possible that CED9 is deleterious to transgenic plans and few survive. Seeds from the most advanced lines are being grown in the greenhouse for screening for Fusarium head blight.

The most significant accomplishments of the last year were to put three of our four target genes into wheat and to advance the generations of the advanced lines to a point where we can begin screening R_2 plants for Fusarium head blight resistance. We have also successfully adapted Agrobacterium transformation technology to be routinely used in wheat.

NCR-184 STATE REPORT
NEW YORK 1999

Gary C. Bergstrom

FHB SITUATION IN 1999 IN NEW YORK

Much of New York's cereal production area was under a moderate drought during wheat's stem elongation through grain formation stages in May and June. FHB occurred at only trace levels in winter wheat. No yield losses or contamination of grain by deoxynivalenol were reported. Because there was adequate moisture for early development of the crop and virtually no foliar diseases developed, the crop yielded near record highs. Drought intensified during July and August predisposing corn to extraordinarily high levels of Gibberella stalk rot. We are concerned that this could result in elevated regional levels of airborne *Gibberella zeae* ascospores in May and June of 2000, coming from overwintered, infected corn residues. Incidentally, there were also pockets of severe Gibberella ear rot of corn (with associated deoxynivalenol contamination) in western New York locations that received moisture from scattered thunderstorms during corn silk emergence in July.

PROGRAMS AND PERSONNEL INVOLVED IN FHB RESEARCH

Winter wheat cultivar evaluation

One site of the winter wheat cooperative scab nursery is located at Ithaca, NY. Conditions were abnormally dry from spike emergence through grain fill. Although the nursery was inoculated with infested corn kernels and was irrigated, moisture was still inadequate to produce more than incidental levels of scab. We are considering changing to a mist-type irrigation nozzle for 2000. In addition to the standard 30 cooperative lines, an additional 50 regionally-adapted varieties and lines are also being evaluated. Also, scab reaction of over 75 lines derived from crosses of New York-adapted winter wheat cultivars with Chinese sources of resistance is being assessed.
Personnel: Mark Sorrells and David Benscher (CU Plant Breeding); Gary Bergstrom and Stan Kawamoto (CU Plant Pathology)

Fungicide evaluation

One site of the uniform fungicide trial is located at Aurora, NY. See the overall report by McMullen *et al* in this volume. Even though the plots were inoculated, no scab developed because of the dry conditions from anthesis through grain fill. Treatments had no significant impact on yield (Table 1). Ascospore inoculum was plentiful at this site. These results underscore the need for irrigation to get reliable scab development.
Personnel: Stanley Kawamoto, Christine Stockwell, Gary Bergstrom (CU Plant Pathology); William Cox and Dilwyn Otis (CU Crop and Soil Sciences)

Biological control

Microbial antagonists of *Fusarium graminearum* are being isolated and characterized for potential application to wheat spikes, seed, and crop residue. See the report by Stockwell *et al.* in this volume.
Personnel: Christine Stockwell, Stanley

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Kawamoto, Gary Bergstrom (CU Plant Pathology); Wilmar da Luz (Embrapa Trigo, Passo Fundo, Brazil)

Aerobiology/epidemiology

Remote piloted aircraft are being utilized to study the aerobiology of *Gibberella zeae* ascospores in the lower atmosphere in order to better understand the potential of regional dispersal of airborne inoculum. See the report by Maldonado-Ramirez *et al.* in this volume. Also under investigation are the effects of environmental conditions on the discharge of mature ascospores from perithecia. Research is being conducted in laboratory chambers and under field conditions.
Personnel: Sandra Maldonado-Ramirez, Gary Bergstrom (CU Plant Pathology); Elson Shields (CU Entomology); David Gadoury (CU Plant Pathology, Geneva campus); Don Aylor (Connecticut Ag Experiment Station)

Table 1. Effect of foliar treatment at anthesis on yield and Fusarium infection in Caledonia winter wheat in Aurora, NY in 1999

Treatment and amount/A	% Grain infected by *Fusarium graminearum*	Yield (bu/A @ 13.5 % moisture)
Nontreated	0.8	83.3
Armicarb 100 5 lb	0.3	81.4
BAS500F 2.09EC 452.4 ml & Agridex (0.25 %v/v)	3.3	81.4
Benlate 50WP 0.5 lb & Manzate75DF 1 lb & Induce F (0.25 % v/v)	0.0	82.0
Folicur 3.6EC 6 fl oz	0.3	86.5
GB114 (bacteria) 1.6 lb & Induce F (0.06 % v/v)	1.3	84.0
GB114 (bacteria) 1.6 lb & Folicur 3.6EC 6 fl oz & Induce F (0.06 % v/v)	0.8	81.0
Penncozeb 75DF 2 lb	0.0	80.1
Quadris 2.08SC 9.3 fl oz	0.5	79.8
Quadris 2.08SC 12.4 fl oz	2.8	84.5
Stratego 2.1EC 10 fl oz	0.5	82.6
Stratego 2.1EC 14 fl oz	0.0	73.9
LSD (*P*=0.05)	0.8	NS

NCR-184 REPORT 1999
NORTH DAKOTA

Robert W. Stack

THE FHB SITUATION IN NORTH DAKOTA IN 1999 AND ITS IMPACT ON SMALL GRAINS

Results provided by Marcia McMullen, extension plant pathologist, who conducted a survey of 824 grain crops across ND in 1999. Statewide, Fusarium Head Blight (FHB) was much less severe in 1999 than in the several previous years. Individual severely affected fields of spring wheat and barley could be found in parts of northeastern ND and in fields of durum in north central ND, Several of the worst-affected counties are the same ones which have seen severe FHB problems each year since 1993. Overall, losses to FHB in 1999 were low, about 1 - 3% in eastern and central ND and less than 1% in the western regions.

OVERVIEW OF PRESENT RESEARCH PROGRAMS

The research effort at NDSU continued to be a large one in 1999. Six NDSU departments, three NDSU Research & Extension Centers, and the USDA-ARS Northern Crop Sciences Laboratory located on the NDSU campus, all had research efforts on FHB. Many of the projects receIved funding from the scab initiative and reports from those investigators are included in the forum proceedings. Several of the projects are cooperative efforts between state and federal scientists.

While the principal research emphasis at North Dakota State Univ. continues to be on breeding for, and genetics of resistance to FHB, there is active research in several other areas including epidemiology, soil microbial ecology, physiology and biochemistry, cereal science, disease survey, and chemical control.

FHB resistance is being sought in breeding programs for hard red spring wheat, white spring wheat, durum wheat, and barley. Methods to obtain resistant varieties include both conventional and molecular plant breeding methods. These efforts utilize inoculated-irrigated field nurseries and greenhouse testing. Sources of resistance being used include wheat lines from China, Japan, Hungary, and Brazil. Similar diverse sources are being used for durum and for barley.

UNITS INVOLVED IN FHB RESEARCH

NDSU:
*Dept. of Plant Pathology.
*Dept. of Plant Sciences.
*Dept. of Soil Science.
*Dept. of Cereal Science.
*Dept. of Food Science.
*Dept. of Agricultural Engineering.
*Dept. of Veterinary Science and Microbiology.
*NDSU Extension Service.
*NDAES Research-Extension Centers at Langdon, ND, Carrington, ND, Minot, ND.

USDA
USDA-ARS Northern Crop Sciences Laboratory, Fargo.

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NCR-184 MANAGEMENT OF HEAD SCAB OF SMALL GRAINS: 1999 OHIO REPORT

Patrick E. Lipps*[1], Laurence V. Madden[1], Erick D. De Wolf[1], Michael J. Boehm[1], Kimberly G. Campbell[2], and Anju Gupta[2]

WHEAT PRODUCTION, MARKET CLASS AND YIELD LOSS ESTIMATE, 1999

1,030,000 acres of soft red winter wheat were planted in Ohio in the fall of 1998 to be harvested in 1999. Highly favorable weather conditions for winter survival and production of tillers in the spring lead to a record state average yield of 70 bu/A. There was very little damage from scab in Ohio in 1999. Warm temperatures in April and May advanced the heading of the crop by about 7 to 14 days. The early wheat varieties went into bloom during the second week of May in southern Ohio, but most of the crop flowered during the third week of May throughout the rest of the state. Dry conditions prevailed throughout this time period except in the most northwestern counties in the state. Scab severity ranged from 0 to 25% of heads affected in individual fields in Fulton and Williams Counties in northwest Ohio. However, fields with over 5% of the heads affected were rare in these counties. Average yield loss to scab for Ohio was less than 0.1%.

RESEARCH

Research efforts at OSU were focused on: Disease forecasting, breeding for disease resistance, evaluation of fungicide efficacy and biological control.

Disease forecasting

DeWolf, Madden, Lipps

A) We are participating in a cooperative program with North Dakota, South Dakota, Indiana and Manitoba to monitor inoculum levels, environmental parameters and disease incidence and severity in replicated field plots. Information from multiple sites will be used to develop a disease forecasting system. The cooperative effort is necessary to assess the effect of regional variation in cropping practices, tillage and climate on inoculum levels and subsequent disease levels across the wheat producing regions. Volumetric air sampling and a wheat head bioassay are being used to monitor fluctuations in the levels of inoculum reaching heads. Automated environmental monitoring instrumentation is used to measure temperature, relative humidity, precipitation, solar radiation, wind speed and moisture status of the crop.

B) Erick DeWolf has developed a scab risk assessment model based on historical scab epidemics and environmental information. The model presently incorporates information from Ohio only. We are seeking information from other states for incorporation into the model and for validation. Please contact us if you have information on epidemic levels over several years, heading or flowering dates and corresponding weather data.

C) Erick De Wolf is attempting to evaluate the effect of residue moisture on perithecia development in corn stalks. He is adapting a residue moisture sensor to quantify the moisture status of corn stalks. The work plans to conduct trials in controlled environment chambers and in the field.

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Breeding for scab resistance

Campbell, Lipps and Gupta

A) The main objective of the scab resistance breeding project at Ohio State is to eliminate the most susceptible lines from the advanced breeding material and to incorporate resistance from exotic germplasm. Resistance screening has been accomplished using inoculated, misted field nurseries and greenhouse tests. A series of three nurseries were used to establish early generation scab resistance selections in: F3 bulk populations, head row selections, and progeny from crosses between Fusarium head scab resistance sources and Stagonospora glume blotch resistance sources. We are also interested in evaluating the relationship among scab severity, incidence, scab index, visual kernel damage rating, percent lightweight kernels, yield and DON.

B) Anju Gupta is currently screening germplasm from Yugoslavia obtained from the National Plant Germplasm System to identify new sources of resistance that could be incorporated into the breeding program. She has one year of field and greenhouse data completed and is presenting a poster on this at the Fusarium Head Blight Forum.

C) Anju Gupta has initiated a program to use marker assisted selection for scab resistance. The purpose of this research is to identify regions of the wheat genome linked to scab resistance using simple sequence repeat (microsatellite) markers. She is working with populations derived from a resistant by resistant cross (Ning 7840 x Freedom) and a resistant by susceptible cross (Freedom x OH542). The goal is to identify and combine resistance genes from both Ning 7840 and Freedom.

Fungicide efficacy and dissemination of research information

Lipps and De Wolf

We are currently participating in the Chemical Control Network of the National FHB Initiative headed by M. McMullen and G. Bergstrom. Five fungicides were evaluated in 1999 using procedures and rates directed by the Chemical Control Network. No disease developed in the study plots. Yields across treatments ranged from 70.3 to 76.6 (P = 0.335). It is our goal that once an effective disease forecasting system has been created and effective fungicides have been identified then fungicide recommendations can be disseminated to growers in a timely fashion. Data from inoculum monitoring efforts coupled with environmental information was provided to growers in a weekly update via an electronic information system [Ohio State University Extension's Crop Observation and Recommendation Network (C.O.R.N.)].

Biological Control

Boehm and Lipps

A cooperative research project is being conducted with Dr. David Schisler and Dr. Naseem Kahn (USDA-ARS, Peoria) to determine the efficacy of naturally occurring biological agents for control of head scab. Of over 700 isolates assayed, three reduced the severity of scab in greenhouse bioassays. Disease severity was reduced by 57-93%. Encouraging results were also obtained in the field where treatments reduced disease severity by as much as 43%. Putative biological control treatments will be evaluated again during the 2000 growing season.

NCR-184, MANAGEMENT OF HEAD SCAB OF SMALL GRAINS 1999 SOUTH DAKOTA STATE REPORT

Yue Jin

1999 SCAB DEVELOPMENT IN SOUTH DAKOTA

M. Draper, Y. Jin, and J. Rudd

Significant amount of scab developed in South Dakota. Scab index (statewide average) was 7.5% for spring wheat and 2.5% for winter wheat.

CURRENT RESEARCH PROJECTS

Germplasm introduction and evaluation

Y. Jin

The overall project goal was to identify new sources of scab resistance in spring wheat and to introgress the resistances into adapted materials. Spring wheat accessions from targeted regions of the world and relatives of wheat were evaluated in an inoculated field nursery. Selections from the field screening are being evaluated in the greenhouse to characterize the type and level of resistance. Accessions with acceptable levels of resistance are used for crossing to introgress the resistance into adapted germplasm.

Epidemiology

Y. Jin

Ongoing research on several aspects of scab epidemiology includes effects of soil moisture/ wetness on inoculum (ascospore) production, ascospore survival and accumulation on plant surface, and inoculum potentials from weedy grasses. We serve as a cooperator in the regional collaborative project of inoculum monitoring in the crop season.

Breeding for scab resistance in spring wheat

J. Rudd

Greenhouse and field screening nurseries are used to evaluate early generation and advanced lines for scab resistance. All entries in the advanced yield trials are at least moderately resistant to scab. This is dramatically different from a few years ago when the spring wheat breeding program first began to evaluate for resistance to scab. Several of the moderately resistant lines are equal to or better than existing cultivars for agronomic performance, but no highly resistant lines have been identified that have acceptable agronomic performance.

Breeding for scab resistance in winter wheat

J. Rudd

The first step in developing scab resistant hard winter wheat varieties is to assess the genetic variability for resistance in existing cultivars and advanced breeding lines. Regional and breeding nurseries were screened in a mist-irrigated, inoculated nursery in 1999. Scab resistance sources in the winter crossing block included adapted spring wheats from the SDSU breeding program, Sumai 3 derived spring wheat lines, eastern European winter wheat lines, entries from the 1998 regional winter wheat scab nursery, and adapted hard red and hard white breeding lines. Approximately 200 crosses with scab resistant sources were made and the segregating populations will be evaluated in 2000.

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Fungicide efficacy studies
M. Draper

South Dakota was one of 14 states participating in a set of ten uniform fungicide treatments for scab suppression. Two hard red spring wheat cultivars were planted at two locations each. Nine treatments of the ten treatments were also applied to two hard red winter wheat cultivars planted at a single location. Plots were evaluated for protection of the flag leaf against leaf diseases as well as for average incidence of scab infected heads, average head severity of scab, average plot severity of scab, Fusarium damaged kernels (FDK), deoxynivalenol (DON) content in the harvested grain, grain yield and test weight of harvested grain. The most severe disease occurred at the South Shore, SD location, but scab was also present at the Groton, SD location. All treatments significantly reduced diseased leaf area ($P_{0.05}$) on spring wheat at both locations. Leaf disease on winter wheat was reduced by most treatments. The following treatments significantly reduced scab in spring wheat at both locations: Folicur (6 fl. oz./A), Benlate (0.5#/A) + Manzate (1#/A), BAS 500 (0.25# a.i./A at Feekes 10.3 or 10.51), and Stratego (10 fl. oz./A). The same treatments were effective on winter wheat, as was Stratego (14 fl. oz./A). Winter wheat yields were significantly higher as a result of all treatments except Quadris (0.2# a.i./A). All treatments increased yield on spring wheat at Groton and only the Benlate/Manzate treatment did not increase yield significantly at South Shore. In other treatments, Folicur applied at the 6 fl. oz./A rate outperformed the 4 fl. oz./A rate on average plot severity of scab in spring wheat at both locations, but was not significantly different from the 4 fl. oz. rate on winter wheat. Even when scab was reduced numerically by the higher rate of Folicur, no significant increase in yield was attained.

Molecular biology and DNA markers for scab resistance
Y. Yen

The goal of this project is to understand the molecular biology of scab resistance in wheat while identifying breeder-friendly, PCR-based DNA markers for indirect selection in breeding. We have evaluated some newly introduced Chinese spring wheat lines and their parental lines for scab resistance. Our preliminary data indicated that Yiyuan 2, Chuanyu 12 and 3854 may have some degree of Type II and Type III resistance. Yiyuan 2 and 3854 were crossed with susceptible lines and the hybrid populations have been advanced to F2. A silver-staining-based AFLP protocol was optimized for screening user-friendly DNA markers. Our preliminary assay of parental lines with 64 PCR primer sets revealed 1 to 35 polymorphic bands, respectively, between Yiyuan 2 and Wheaton with an average of 13.3 polymorphic loci per primer set.

Biocontrol of wheat diseases
B. Bleakley

Four different strains of *Bacillus* isolated from South Dakota wheat foliage and residue which antagonize the fungi causing tanspot and head blight of wheat have been used in laboratory, greenhouse, and field trials. Cell-free ethyl acetate extracts of *Bacillus* broth culture supernatants have been analyzed by thin layer chromatography. Each strain produced a different fingerprint of ninhydrin-positive spots, which will individually be checked for activity against *F. graminearum*. During summer of 1999 whole cells of one of the *Bacillus* strains were applied to wheat in field plots (in cooperation with Marty Draper) to see if the bacteria afforded protection against head blight or other diseases. The summer was dry and did not favor extensive disease development, but data were collected and will be analyzed.

PERSONNEL

Researchers/Project

Y. Jin/Small Grain Pathology; M. Draper/Extension Plant Pathology; J. Rudd/Spring and WinterWheat Breeding; B. Bleakley/Soil Microbiology; Y. Yen/Cytogenetics-Molecular Biology.

Supporting staff

X. Zhang (Research Associate, Pathology); Terrence Hall (Research Assistant Pathology); R. Rudd (Research Assistant, Pathology/Breeding

NCR 184: VIRGINIA 1999 STATE REPORT ON FUSARIUM HEAD BLIGHT

Carl Griffey*, Erik Stromberg, Jianli Chen, Matthew Chappell, Jane Shaw, and Tom Pridgen

The incidence of Fusarium Head Blight (FHB) in Virginia was nil during the 1998-99 season due to drought conditions in the mid-Atlantic and Northeastern U.S., which extended from the flowering through grain ripening stages. During this period, total precipitation received in most of the wheat production regions of Virginia was very low. Only 0.03 inches (0.076 cm) of precipitation were recorded at the Eastern Virginia Agricultural Research and Extension Center in Warsaw, Virginia during this period.

Research aimed at developing a means to control FHB in wheat with the application of a single fungicide, multiple fungicides, or a biological agent on wheat heads prior to or during anthesis was conducted this past year. Effectiveness of fungicide treatments on the control of FHB could not be assessed this past year due to the absence of FHB development under the excessively dry conditions. This was despite planting plots no-till into chopped corn stubble and over seeding them with corn seed inoculated with *Fusarium graminearum*.

The ultimate goal of the breeding program is to pyramid different types of FHB resistance into superior soft red winter (SRW) wheat backgrounds. Among over 200 wheat lines tested in both greenhouse and field tests, we have identified or confirmed the presence of type IV (kernel infection) and type V (yield loss) resistance in SRW wheat cultivars such as Roane (Virginia), Freedom (Ohio), Ernie (Missouri), and INW9824 (Indiana). Yield losses due to scab among 20 SRW wheat genotypes tested in an inoculated, irrigated nursery varied from 4 to 48% and percentage of scabby seeds varied from 14 to 47%. Additional SRW wheat lines possessing these types of resistance have been identified in multi-state, cooperative, winter wheat screening nurseries. Also, we have identified and confirmed high levels of type II (invasion) resistance in 7 wheat lines from China, 5 from Canada, and 2 from France. Resistance from these sources is being incorporated into SRW wheat via traditional breeding methods and also is being back-crossed into several diverse SRW wheat cultivars. To date, more than 350 crosses involving scab resistant parents have been produced and 2500 advanced lines are being evaluated for resistance and agronomic performance.

To improve the precision in breeding and selection for scab resistance, genetics and mapping studies have been initiated and the wheat by maize hybridization system has been used to develop doubled-haploid populations. A 10 parent diallel including parents with diverse types of resistance has been produced for studying the inheritance of scab resistance. Preliminary genetic studies indicate that type II resistance in the cross W14 x Madison is governed by two complementary genes and, therefore, should be feasible to transfer. The $F_{2:3}$ population from this cross will be used to screen and select resistance-related molecular markers, which can be applied to marker-assisted selection and gene pyramiding.

A website for information on small grains disease control has been established as a primary means of distributing information on the biology, de-

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scription, cultural and chemical means of control of small grain diseases to county extension agents within Virginia, small grains producers in Virginia, the Agri-business community and others. This website can be assessed at: http://www.ppws.vt.edu/stromberg/smallgrain/sgrain.html

MANAGEMENT OF FUSARIUM HEAD BLIGHT IN SMALL GRAINS NCR-184 1999 STATE REPORT FOR WISCONSIN

Heidi F. Kaeppler

PRODUCTION

Growing conditions varied throughout Wisconsin in 1999. In general, enough moisture was received during the spring and early summer to produce good stands. Drier conditions during the later part of the summer resulted in good harvest conditions. Wisconsin farmers harvested 120,000 acres of soft red winter wheat in 1999. Yield per acre was 60 bushels, and total production was 7.20 million bushels, which was 3 percent lower that in 1998. Spring barley was harvested from 65,000 acres with an average yield of 52 bushels per acre. Total barley production of 3.38 million bushels was similar to that in 1998. Spring wheat acreage remained at approximately 7000 acres. The average yield of spring wheat was 40 bushels per acre, and production was 280,000 bushels, up 33% from 1998. Incidence and severity of head scab in wheat and barley were low in 1999, as in 1998. Estimates from the Wisconsin Department of Agriculture Trade and Consumer Protection rated incidence at trace to 1% in several counties, and not detected in many others. Disease severity, where detected, was estimated at around 1%. The low occurrence and severity of head scab in Wisconsin was similar to that observed in neighboring states in 1999.

Head Scab Research: Research is being conducted in several labs at the University of Wisconsin toward increased understanding and management of head scab in small grains. Brief descriptions of current research projects are provided.

Berne Jones, USDA-ARS and collaborator Anja Pekkarinen, VTT, Helsinki, are conducting research to identify barley compounds that inhibit proteases produced by *Fusarium graminearum*. To date, several *Fusarium* proteases have been isolated and purified, and results from recent experiments provide evidence that there are compounds in barley that inhibit the proteases. Dr. Jones and Dr. Pekkarinen are now working to isolate and purify the inhibiting compounds for further molecular characterization. In addition to this research, Dr. Jones has obtained two new malting machines to aid in high throughput malting quality screening of scab tolerant breeding lines being developed by breeding programs. With the new malting units, up to 40% more samples can be evaluated than previously. The increased efficiency will allow the lab to quickly test the usual numbers of standard breeding lines, plus additional lines from scab resistance breeding efforts.

Heidi Kaeppler and Ronald Skadsen are conducting collaborative research in the genetic engineering of wheat and barley for enhanced resistance to head scab. Two antifungal genes (permatin and hordothionin) have been transformed into barley and are being delivered into wheat. The permatin gene was cloned from oat by Ronald Skadsen and the hordothionin gene was cloned from barley by Dr. Skadsen in collaboration with Berne Jones. Additionally, two pathogen response genes which act as regulators of several resistance genes are being delivered into wheat. Transgenic barley lines are being evaluated for presence and expression of the transgenes, and resistance response to inocula-

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tion with *Fusarium graminearum*. Collaborators in preliminary testing of transgenic barley lines include Lynn Dahleen, USDA-ARS, Fargo, ND, and Steve Leath, NC State Univ. Research is also underway to investigate tissue specific expression of the resistance transgenes, and inter/intracellular targeting of the proteins for optimal expression. Postdoctoral research associates Sathish Puthigae and Jianming Fu, and graduate student Maria L. Federico are conducting the studies. To date, two promoters have been cloned from genes displaying tissue specific expression. The promoters have been fused to a synthetic green fluorescent protein (gfp) gene and are being tested for floral specific expression in transient and transformation assays. Research is also being conducted to study the timing and mode of infection of *Fusarium graminearum* in barley using a strain of *Fusarium* transformed to express gfp. Microscopic analysis are being conducted to determine what tissues are infected by *Fusarium* and how the fungus enters the tissue and grows. Information gained from this research will be used for designing optimal expression strategies for resistance transgenes.

Fun Sun Chu, UW Food Res. Inst., is conducting research aimed at improving ELISA methods for mycotoxin detection and developing rapid immunochemical methods for monitoring key enzymes and regulatory proteins involved in the biosynthesis of DON and related mycotoxins. Dr. Chu's research involves improvement of monoclonal antibody-based ELISA for DON. Additionally, his group is working on developing monoclonal antibodies for permatin, trichodiene synthase, and the protein encoded by the Tri6 gene (a regulatory gene controlling DON formation). Antibodies and ELISA methods developed in Dr. Chu's lab will be utilized for analysis in several of the studies described above.

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