NCR-184 2001 ARKANSAS STATE REPORT

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WHEAT PRODUCTION

Arkansas growers harvested 970,000 acres of soft red winter wheat with a average yield of 52 bu/acre. Growing conditions were extremely cold during November and December and extremely dry during April and May. The major constraints to production were the cold conditions that hampered stand establishment and the dry conditions that hastened maturity. The dry conditions favored Fusarium root and crown rot, and this was the most prevalent disease during the season.

FHB SITUATION

FHB was non-existent because of the extremely dry conditions before, during, and after flowering. However, the widespread occurrence of *Fusarium* root and crown rot demonstrates the ubiquitous nature of *Fusarium* species in the wheat production areas of Arkansas.

CURRENT FHB PROJECTS

Personnel: Robert Bacon and John Kelly are working on the development of scab-resistant varieties. Gene Milus, Peter Rohman, and Chris Weight are working on transferring genes for scab resistance to southern soft red winter wheat, screening lines for scab resistance, and evaluating fungicides and biocontrol agents for efficacy against scab.

Breeding: The breeding program has several advanced lines that appear to have FHB resistance from early CIMMYT spring wheat selections and Chinese lines, and several of these lines have been entered in the Uniform Southern Winter Wheat Scab Nursery. Additional crosses were made using adapted Arkansas breeding lines and resistant soft red winter wheats and eastern European winter wheats.

Germplasm Enhancement: Eighty-four F_7, BCF_6, or TCF_6 lines from populations derived primarily from recent CIMMYT spring wheat cultivars and lines were selected during 2001. All of these lines also are resistant to contemporary races of the leaf rust, stripe rust, and leaf blotch pathogens. Steve Harrison, wheat breeder at Louisiana State University, is collaborating with this project by screening lines at two locations in Louisiana. Selections made in Louisiana and Arkansas have been exchanged each year. A recurrent selection program was begun to combine resistances.

Screening: The Uniform Winter Wheat Scab Nursery, Uniform Southern Winter Wheat Scab Nursery, Bacon's scab-resistant selections, and lines from the germplasm enhancement program were evaluated for scab resistance in field screening nurseries at two locations and in the greenhouse for type 2 evaluations.

Fungicide Evaluations: Treatments in the Uniform Fungicide and Biocontrol Trial and additional treatments were evaluated for efficacy against scab. Scab developed later than normal, and the biocontrol agent, OH 182.9, was the most efficacious.

NCR-184 MANAGEMENT OF HEAD SCAB IN SMALL GRAINS ILLINOIS REPORT - DECEMBER, 2001

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Illinois Wheat Production:

The estimated wheat yield in Illinois in 2001 was 61 bushels per acre. This was four bushels per acre greater than last year's average of 57 bushels per acre, and equal to the record state average of 61 bushels per acre set in 1997. Acreage harvested was about 720 thousand acres, down about 21 % from 2000. Wheat production in Illinois in 2001 was about 43.9 million bushels. This was a 16 % decrease from the 2000 production of 52.4 million bushels. In general, conditions for wheat production were excellent in 2001. Wheat came through the winter in excellent condition, and spring weather conditions were very favorable. Some leaf rust and crown rust were observed, but, in general, diseases did not limit yields. The most serious production problem in 2001 in Illinois was a severe armyworm infestation. Armyworms completely stripped leaves from wheat in some areas and a significant percentage of the wheat acreage was sprayed with insecticide for armyworm control. Scab damage was very limited in 2001 in Illinois due to dry weather at flowering and below normal temperatures for about a week during early grainfill. In spite of excellent yields for many farmers in 2001, the number of wheat acres planted for 2002 is projected to be about the same as in 2001 or somewhat reduced. Excessive rainfall in much of southern Illinois at the optimal planting time most likely limited the amount of wheat planted for 2002.

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.

About 228 single and 161 three-way crosses were made with one or more scab resistant parents in each cross. In addition, about 36 crosses were made with the objective of combining scab resistance from 6 new sources with other sources of scab resistance and with adapted lines. Many of the crosses in the second set involve parents with excellent scab resistance, but many of these parents are unadapted. In 2001 about 550 breeding lines were evaluated in replicated rows in the misted, inoculated scab evaluation field nursery. In addition, about 700 entries from single plots, and about 800 headrows were also evaluated in the field inoculated nursery. Heads were selected from 36 F_3 bulk populations grown in

the field scab nursery, and about 1700 headrows resulting from these selections were planted this fall (2001-02 season). Plants from four segregating populations were screened in the greenhouse. A total of 1707 plants were evaluated, and 567 plants (33.2%) were selected (most with Type II resistance better than Ernie). Scab resistant lines were evaluated for many traits in the field. Many of the lines with good scab resistance are poor for other traits such as grain yield, milling and baking quality, standability, or resistance to other diseases. We are working on combining different sources of resistance and combining resistance with other desirable traits. Five lines from the Illinois program were entered into the 2001 Cooperative Eastern Winter Wheat Scab Screening Nursery. These lines were made available to other breeders by entering them into the Cooperative Eastern Winter Wheat Fusarium Head Blight Screening Nursery. Seed increases of 213 doubled haploid lines originating from 26 crosses were grown.

Research on Molecular Markers:

Research is continuing on identification of molecular markers associated with genes for scab resistance. A number of markers associated with one quantitative trait locus (QTL) on 3BS have been identified. These markers should be useful for marker-assisted selection for scab resistance. We are beginning to use some of these markers as an aid for selection of scab resistant breeding lines, but additional research needs to be done before marker assisted selection can be used routinely in the breeding program.

Six microsatellites on chromosome 3BS, Xgwm389, Xgwm533, XBARC147, Xgwm493, XBARC102, and XBARC131 were integrated into an amplified fragment length polymorphism (AFLP) linkage group containing a major QTL for scab resistance in a mapping population of 133 recombinant inbred lines (RILs) derived from Ning7840/Clark. Based on single factor variance analysis of scab infection data from four experiments, Xgwm533 and XBARC147 were the two microsatellite markers most tightly associated with the major scab resistance QTL. Interval analysis based on the integrated map of AFLP and microsatellite markers showed that the major QTL was located in a chromosome region of about eight cM in length around Xgwm533 and XBARC147. Mapping of six microsatellite markers on eight 3BS deletion lines showed that the major QTL was located distal to breakage point 3BS-8. In total, eighteen microsatellites were physically located on different sub-arm regions on 3BS. Two microsatellites, Xgwm120 and Xgwm614, were significantly associated with QTL for scab resistance on chromosome 2BL and 2AS, respectively. Significant interaction between the major QTL on 3BS and QTL on 2BL was detected based on microsatellite markers linked to them.

To further validate a major QTL for scab resistance on chromosome 3BS in hexaploid wheat we identified near-isogenic lines for this QTL using flanking simple sequence repeat (SSR) markers. We developed two resistant by susceptible populations, both using Ning 7840 as the resistant parent to examine the 3BS QTL in different genetic backgrounds. Data for scab resistance and markers linked to the resistance QTL were analyzed in the $F_{2:3}$ generation of one population and in the $F_{3:4}$ generation of the other population. Selected SSR markers on chromosome 3BS were closely associated with scab resistance in both populations. Selection with the aid of SSR markers was more efficient in selecting homozygotes for the 3BS

QTL than was selection based on phenotypic evaluation of scab resistance. Near-isogenic lines with this major QTL were isolated in the $F_{6:7}$ generation of one population using two flanking markers, Xgwm389 and XBARC147. Two lines were identified with scab resistance similar to Ning 7840. This research is in cooperation with Guihua Bai, Oklahoma State University; Greg Shaner, Purdue University; and Les Domier, USDA-ARS at Urbana, Illinois.

REFERENCES

Kolb, F. L., G-H. Bai, G. J. Muehlbauer, J. A. Anderson, K. P. Smith, and G. Fedak. 2001. Host plant resistance genes for Fusarium head blight: Mapping and manipulation with molecular markers. Crop Sci. 41: 611-619.

MANAGEMENT OF SCAB OF SMALL GRAINS NCR-184
2001 INDIANA STATE REPORT

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Scab was sporadic and generally not severe in Indiana in 2001, although some rain fell during flowering. Where scab was found, incidence was generally low.

Current research programs include:

Host resistance: development of resistant varieties of soft red winter wheat, germplasm enhancement, genetic studies of resistance, and identification of molecular markers associated with resistance.

Pathogen genomics: Additional ESTs (expression sequence tag) were generated from the nitrogen-starved cDNA library. Gene replacement mutants were generated from two *F. graminearum* genes. One of them, CHV1, was found to be important for plant infection. In addition, subtraction libraries enriched for genes specifically or highly expressed during plant infection were also sequenced. All sequence information is available at http://www.genomics.purdue.edu/~jxu/Fgr.

Epidemiology: the relation between weather variables, quantity of airborne inoculum of *Gibberella zeae*, and development of head blight symptoms.

Biological and chemical control: evaluation of fungicides and biocontrol agents for efficacy against head blight of wheat.

Reports on these various projects are available on the USWBSI Web site and in the Forum proceedings.

Cereal classes and acreage in Indiana: Indiana produces soft red winter wheat. In 2001, Indiana farmers harvested 380,000 acres of wheat, substantially down from the production during 2000, but continuing a trend of declining production. Average yield was 66 bu/A, for a total production of 25.08 million bushels.

ANNUAL REPORT FOR 2001 NCR-184 - IOWA

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Wheat production and head blight in Iowa in 1999. Iowa's winter wheat yield of 54 bushels per acre was a record high level and seven bushels above the yield of 47 bushels per acre in 2000. The state's production of 972,000 bushels was up nearly 15 percent from the previous year. Acres harvested for grain was 18,000 acres, equal to last year's record low harvested acreage. Although rainfall was abundant during April and early May, dry weather followed and there were few reports of scab problems.

Fusarium head blight research. In 2001 we participated in the uniform scab nursery for spring and winter wheat. Winter wheat plots were completely destroyed during the winter of 200-2001. In the spring wheat, scab levels were very low in spite of frequent irrigation and infestation of the plots with *F. graminearum* inoculum. We do not have DON results at this time. We also participated in the uniform fungicide trials with a winter wheat variety, but scab levels again were very low. There were some statistically significant differences in scab severity. Only the TrigoCor and BAS 505 treatments were significantly different from the control. The BAS 505 treatment had the highest test weight, the lowest incidence and severity of scab, and the highest 100-kernel weight. We do not have DON results at this time. This fall we planted the uniform scab nursery for winter wheat.

NCR-184 STATE REPORT FOR KANSAS 2001

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FHB Situation in Kansas in 2001

Kansas produced approximately 328 million bushels of wheat in 2001, which was down from 348 million bushels the previous year. The major disease problem in the state was stripe rust, which was promoted by unusually cool weather in May. There were only traces of Fusarium head blight reported in the state in 2001.

Breeding for Resistance

Bill Bockus is in charge of the scab field nursery. Additional members on the team include Mark Davis, Allan Fritz, Joe Martin, Gina Brown-Guidera, and Bob Bowden Because of the scab screening efforts, a new column for reaction to Head Scab has been added to the popular extension publication *Wheat Variety Disease and Insect Ratings* for the 2001 issue. For the first time, this will allow producers in Kansas to use the reaction to scab to help select cultivars for planting. Additionally two commercial cultivars in Kansas (Hondo and Heyne) were identified in 2000 (and confirmed in 2001) as having good levels of resistance (3 and 4 on the 1-9 scale where 1=immune and 9=highly susceptible). During 2001, these cultivars had an average of 12 and 20% scab, respectively compared with over 50% in highly susceptible cultivars. Similarly, the advanced breeding line KS96HW115 (released in August, 2000 as Lakin) showed moderate levels of resistance with 26-34% scab in 2001. Five other commercial cultivars displayed some level of resistance in the 2001 nursery; however, these results need to be confirmed. Therefore, there is scab resistance already present in cultivars adapted to Kansas that can potentially be used in the development of future cultivars.

Inheritance of resistance and allelism tests are currently underway with those cultivars. Additionally, several advanced breeding lines (mostly in the Kansas Intrastate Nursery) have been identified with improved levels of resistance. Both KSU wheat breeders (T. J. Martin, and A. K. Fritz) and the USDA wheat geneticist (G. Brown-Guedira) have been having material screened.

Relationship of PPO and Resistance to FHB

Andre Rosa is working on an interesting question about white wheat. The enzyme polyphenol oxidase (PPO) confers a detrimental discoloration to noodles and other wheat products. To offset this problem, breeders select wheats with lower levels of PPO in the kernels. PPO is known to be involved in plant resistance to disease. Two studies were designed to determine the relationship between levels of PPO in wheat kernels and plant response to diseases in Kansas. Plant response to disease was evaluated directly by visual scoring or, indirectly, by evaluating traits affected by diseases. Ninety-two F4 and 206 F5 lines selected

for their contrasting PPO levels and representing three crosses were evaluated for two years in a replicated head-scab nursery. Lines were scored for heading date (HD), green leaf duration (GLD), and scab resistance (scab). The second study involved 16 F6 lines with contrasting PPO levels representing five crosses. A split-plot design with four replications was used to test these lines for two years in up to four locations for HD, GLD, scab, test weight, and yield. The means for the evaluated traits were similar for lines with high and low levels of PPO indicating that plant response to diseases was not affected by the levels of PPO in the kernels. Therefore, selecting for low levels of PPO should not hamper disease resistance in Kansas breeding programs.

Transgenic resistance to FHB

Subbaratnam Muthukrishnan, Harold Trick, and Bikram Gill generated several transgenic wheat plants containing different combinations of genes for pathogenesis-related proteins by a biolistic transformation protocol. Ten of these were found have high level expression of the transgenes. The inheritance and expression of these genes have been followed up to the T4 generation in some cases. Two transgenic lines that are homozygous for the transgenic loci have been tested for resistance to scab by the single floret inoculation assay. One of them was found to be significantly more resistant to scab compared to the control. Crosses involving some transgenic lines and Heyne are in progress.

Can we debilitate the scab fungus with a virus?

Lou Heaton screened over 100 *F. proliferatum* isolates collected in Kansas and found four isolates harboring dsRNAs. The dsRNAs range in size from approximately 700 bp to approximately 3,300 bp, and each of the four isolates harbors a distinct set of dsRNAs. The dsRNAs of isolates D-720, D-591, and D-599 are transmitted to approximately 97% of single-conidiospore cultures, while the dsRNAs of D-890 are only rarely transmitted to single-conidiospore cultures (approximately 3%). None of the dsRNAs were transmitted to single-ascospore cultures resulting from crosses in which the isolates were males. Attempted crosses in which the isolates were the female parent are thus far sterile. Since the transmission patterns were consistent with a mitochondrial location, sub-cellular fractions were examined for the presence of dsRNAs. The dsRNAs of all four of the *F. proliferatum* isolates were found in mitochondrial fractions. We are in the process of screening our e:*F. graminearum* isolates. Thus far, we have identified one isolate that contains dsRNAs. Additionally, we have obtained a Korean *F. graminearum* isolate with a dsRNA that renders the isolate hypovirulent on wheat.

Pathogen Variability and Genetics

People working on this project include; K. A. Zeller, J. I. Vargas, Y.-W. Lee, R. L. Bowden, and J. F. Leslie. We isolated populations of *Gibberella zeae* (*Fusarium graminearum*) from field samples of wheat, barley, maize or sorghum from North and South America, and from South Korea. We compared the phylogenetic lineage composition from these sources using AFLP markers produced by three standard primer combinations. United States populations of *G. zeae* from wheat are composed of a single phylogenetic lineage (lineage VII) and are diverse but relatively homogeneous across the country. South Korean populations from barley

were dominated by a single lineage (lineage VI). South Korean populations from maize are dominated by lineage VII, but lineage III is a relatively common component. Populations of *G. zeae* from wheat in Brazil also appear to be dominated by lineage VII, but at least one other lineage is present. We have also examined *G. zeae* populations from wheat and sorghum in Uruguay.

NCR-184 2001 KENTUCKY STATE REPORT

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FUSARIUM HEAD BLIGHT STATUS DURING 2001

Fusarium head blight (FHB) levels were extremely low throughout Kentucky during the spring of 2001. Nonetheless some fields experienced significant problems with unacceptable levels of deoxynivalenol (DON), in spite of the fact that FHB was not evident. This is thought to be the result of delayed harvest due to untimely rain events following crop maturity. Most impacted fields were seriously lodged.

CURRENT RESEARCH PROJECTS

Field and Greenhouse Screening

Brenda Kennedy, Marla Hall and David VanSanford

Numerous soft red wheat cultivars, breeding lines, entries in the Uniform Northern and Southern Scab Nurseries, and approximately 1400 exotic accessions were evaluated under mist irrigation in two field nurserys: one near Lexington, KY and the second at Princeton, KY. Cracked corn infested with various pathogenic isolates of *Fusarium graminearum* was used as inoculum in both nurseries. Most of the lines evaluated in field nurseries were also evaluated in the greenhouse for Type II resistance. Variation was observed, with some breeding lines showing good Type II resistance as well as apparent combining ability for this trait.

Inheritance Studies

Marla Hall, Liu Hua, and David VanSanford

A number of populations were synthesized from wheat parents with reportedly different sources of resistance to FHB. S_1 lines in three populations were evaluated under mist irrigation in an inoculated nursery to elucidate inheritance of resistance. Highly significant variation for Type I/Type II resistance was observed in the populations. Two diallel series of crosses were made for Type II resistance and DON accumulation in the field and greenhouse. Significant genetic variation was observed for severity of infection and accumulation of DON. While much of the variation appears to be additive, there was evidence of non-additive variation in the form of significant specific combining ability. It appears that significant progress could be made within the soft red wheat market class without excessive reliance on exotic sources of resistance. S2 lines from several populations were evaluated in the greenhouse for Type I resistance using an air brush to apply spores of the causal organism. Populations had been previously characterized in the field for open vs. closed flower types, head length, and other morphological traits. In one of the populations, there

appeared to be a significant difference among open vs. closed flower lines in terms of severity of infection. The S3 progeny of these lines will be evaluated in the field in 2001.

Breeding Program
David VanSanford

Numerous crosses have been made to various sources of resistance, within and outside the soft red wheat market class. Several elite breeding lines look promising in terms of reduced severity of infection at two field locations and in the greenhouse. One of these lines is being increased for possible release.

FHB Fungicide and Biocontrol Test
Donald Hershman, Paul Bachi, Dennis TeKrony and David VanSanford

Ten foliar treatments, eight involving foliar fungicides and two involving biocontrol agents (BCA's) were evaluated for efficacy against FHB at a mist-irrigated, inoculated test site in Princeton, KY during 2001. Seven of the ten treatments were part of the National FHB Uniform Fungicide and Biocontrol Test. Chemical products evaluated were Folicur, AMS 12619, BAS 505, and Tilt; the BCA's tested were a yeast (OH 182.9) and a bacterium (TrigoCor 1448). All treatments involved single applications applied at early flowering. Moderate disease levels were produced as a result of the inoculation and misting protocol used in the test. BAS 500 alone and in combination with Folicur and AMS 12619 resulted in significantly reduced disease incidence compared with the control. No treatment significantly reduced severity of FHB on individual heads. However, BAS 500 alone, at the highest tested rate (0.2 lb a.i.), and AMS 12619 significantly reduced field severity of FHB. Yields of plots treated with AMS 12619 yielded significantly higher than check plots. This difference was thought to be the result of partial FHB control in that other diseases were not a factor in the test. All treatments except Folicur applied and by itself and the yeast BCA significantly lowered levels of DON compared to the non-treated check. Percent visually scabby kernels and standard germination levels were significantly lower and higher, respectively, than the check plots for treatments involving AMS 12619 and BAS 500 alone at the highest test rated. Overall the most consistent performer in the test was AMS 12619 applied at 5.7 fl oz/A plus 0.125% Induce.

NCR-184 2001 MICHIGAN STATE REPORT

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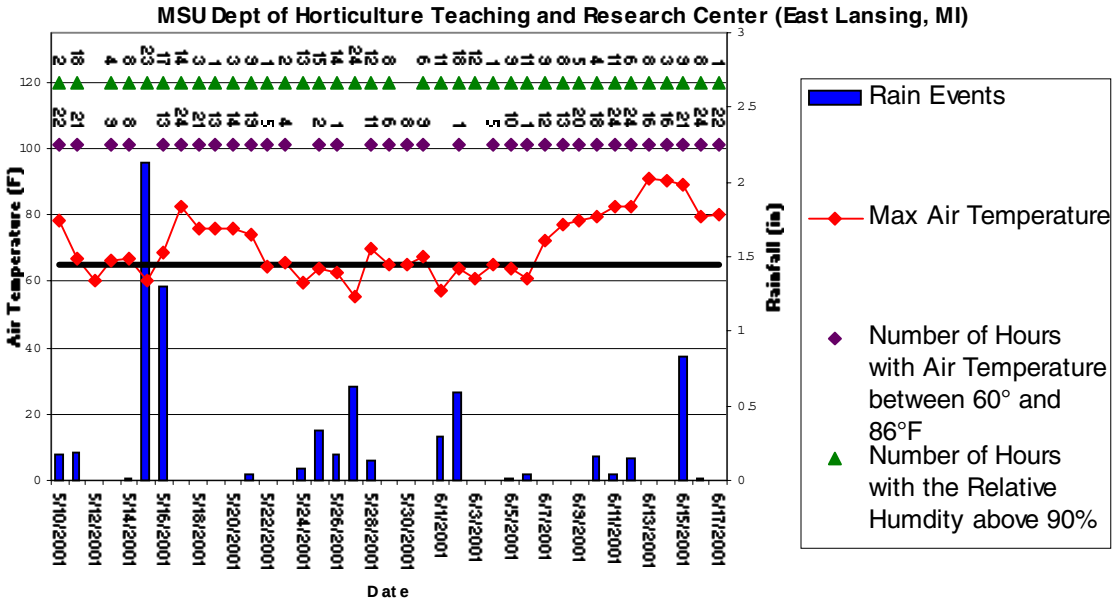
STATE SITUATION:

FHB occurred at epidemic proportions in Michigan in 2001. The incidence varied across the state. Mild to moderate field symptoms occurred in the southern counties, and in the thumb. Moderate to severe symptoms occurred across the central counties. DON levels were low to moderate in the central counties, and low to very low in the rest of the state. Generally, the incidence and severity of head symptoms suggested that DON levels on the average should have been higher. The chart below shows rain events and temperature during flowering. The FHB prediction models indicated FHB was unlikely to occur based on these data. Flowering started about May 20-25 across the state, but because of the cool temperatures flowering progressed slowly and didn't end until the middle of June. It appears that the rain events of June 10-12th may have contributed significantly to the FHB epidemic, and because the infection period was late in flowering development this may explain why DON levels were low. DON data shown at http://www.cips.msu.edu/wheat/Vomitoxin analysis July 2001.htm was collected by analyzing grain threshed from heads collected pre-harvest and submitted to MSU by extension agents and agri-business dealers. Processors of white wheat were affected by the DON levels, and remain concerned about future FHB problems.



RESEARCH REPORTS

A study was conducted in 2000 and 2001 to determine if wheat fields could be sampled before harvest to estimate DON levels of the harvested grain. The results of the two-year study can be found in the Proceedings of the 2001 National Fusarium Head Blight Forum.

Fungicide trials were conducted on wheat to determine if FHB and DON levels could be lowered. Specific information on the trials can be found in the Proceedings of the 2001 National Fusarium Head Blight Forum. None of the fungicide treatments increased yield. Disease severity and DON were reduced in a few treatments.

DON Diagnostic Services Laboratory

The National FHB Initiative provided funding for regional DON testing. A complete report can be found in the Proceedings of the 2001 National Fusarium Head Blight Forum. The Neogen 5/5 test was used analyzer all samples for DON. Samples ranged in size from 25 g to 1000g. The majority of samples required milling and sub-sampling prior to analysis. From 8-1-00 through 7-30-01 there were 2,480 samples analyzed, and from 8-1-01 through 11-6-01 there were 3,371 samples analyzed.

USEFULNESS OF FINDINGS:

The year 2001 FHB epidemic was unusual in that the visual expression of symptoms, both incidence and severity, would have predicted higher than detected levels of DON. This suggested the importance of estimating DON in individual fields. This is important not only to growers and processors, but estimates of DON variability in research plots has not been reported or studied.

WORK PLANNED FOR NEXT YEAR:

The statistical study on sampling will be continued. Work will also continue on the development of recombinant antibody to DON, and identification of peptide mimics that may be useful in elucidating the receptor ligands associated with DON toxicity.

NCR-184 MANAGEMENT OF FUSARIUM HEAD BLIGHT OF SMALL GRAINS MINNESOTA STATE REPORT – 2001

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Small Grains Crops and the FHB situation in Minnesota in 2001

The 2001 season was difficult for small grains production with state wheat yields averaging 44 bu/A, 5 b/A below last year. A cold spring and near-record rainfall in April delayed planting of most cereal crops into late May and contributed to reductions in the acreage of small grains. Minnesota's barley acreage continued to fall with only 145,000 acres harvested in 2001, making the year the smallest crop since 1881. Similarly, the oat acreage at 210,000 was the smallest crop since 1867. As much as 250,000 acres were not planted in Minnesota in the 2001 cropping season. Continued cold and wet weather in May slowed the establishment of crops. In June weather conditions favored small grains and crops that had gotten off to a late start developed well with few disease problems. By late June the cereal crops were looking great. In July temperatures above 85°F stressed crops and hastened crop development. Harvest was completed ahead of the 5-year average and the rapid maturing of crops likely contributed to the reduced yields. Rainfall in combination with the high temperatures in July promoted the development of some foliar diseases and Fusarium head blight. The late development of disease mitigated much of their impact and losses were generally below 5%. While Fusarium levels were low and yield losses minor in 2001, levels of deoxynivalenol in barley may prevent some of the crop from being sold for malt production.

Overview of Present Research Programs

The Fusarium head blight research effort in Minnesota continues as a large collaborative. Faculty from the four departments of the College of Agriculture, Food and Environmental Sciences, three University of Minnesota Research and Outreach Centers and two USDA-ARS units (Cereal Disease Laboratory & Plant Science Research Unit) are involved in FHB research. While many researchers in Minnesota have projects funded by the USWBSI, researchers have also been supported by state funding.

The research being conducted in Minnesota includes breeding for resistance to FHB in wheat and barley utilizing classical and molecular techniques, studies aimed at improving the efficiency of breeding methodologies and selection of resistance, investigations on the pathogenic variation in *Fusarium graminearum*, examinations into the pathways of entry by Fusarium head blight, and the chemical and cultural control of FHB.

NCR-184 COMMITTEE - MANAGEMENT OF HEAD SCAB IN SMALL GRAINS: 2001 MISSOURI REPORT

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Winter Wheat Production in Missouri and the 2001 FHB Situation in Missouri:

Most of the Missouri wheat acreage is soft red winter wheat with a minimal number of hard red winter wheat acres. Fall seedings for the 2001 winter wheat crop in Missouri totaled 900,000 acres, down 14 percent from the 2000 crop seeded acreage. Of the 900,000 acres planted, 760,000 acres were harvested. Missouri wheat production in 2001 totaled 41,040 million bushels, down 17 percent from last year's production of 49,400 million bushels. Missouri yields averaged 54 bushels per acre, up 2 bushels from last year's average yield of 52 bushels per acre.

2000-2001 was a good year for wheat production and a fairly poor year for Fusarium head blight in much of Missouri. Winter wheat planting began in southeastern Missouri in mid-September but planting was slow throughout the state as farmers waited for rain. Both planting and emergence were behind normal for most of the fall due to moisture shortages. Planting was completed by early November, and rains in November led to significant improvement in the crop. Record low temperatures during December and the first week of January were tempered by heavy snows and record snow cover duration. Winter survival was not a problem and spring stands were good. Wheat in southeastern Missouri began heading around April 15. Rainfall was normal during most of April and May but temperatures fluctuated from 7 to 8 degrees above normal during the weeks ending May 14 and May 21 to 6 to 10 degrees below normal during the week ending May 27 and 2-8 degrees below normal for the week ending June 3. Scab did occur in localized areas of the state, especially in central and northern Missouri.

The most serious pest problem on wheat during the 2001 season was true armyworm larvae. Although larvae fed heavily on foliage causing severe damage in fields in southern and central Missouri, little head clipping occurred. 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. For the second year in a row stripe rust was found in low levels throughout the state. 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.

Wheat harvest began around June 6 roughly 10 days behind 2000 and 4 days behind normal. However, harvest continued at a fast pace and was completed by about July 9, 6 days ahead of 2000 and 8 days ahead of normal.

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. Six fungicide treatments were evaluated on Elkhart. FHB incidence ranged from 57.5 % on the untreated check to a low of 39.5 % in the AMS 21619 + Induce treatment. Scab severity on heads showing scab ranged from 28.4% on the untreated check to a low of 15.6 % on the Folicur + Induce treatment. In spite of differences in both incidence and severity between treatments in the trial there were no statistically significant differences in yield between the untreated control and any of the six fungicide treatments. Results of this trial are given in more detail in the report for this initiative project.

Breeding Program: Since scab resistance was introduced as an objective within the Missouri wheat breeding program in1993 we have successfully identified resistance in a number of pedigrees within the program. Among the first scab resistant varieties released was 'Ernie'. Its functional levels of type II resistance and excellent kernel quality under natural infection have resulted in invaluable economic return to Missouri growers particularly in years when scab has been a concern. Field and greenhouse screening programs at Missouri, have resulted in the identification of several pedigrees, different from Ernie by descent, that are potentially useful as sources of scab resistance. Results from evaluations of ~ 300 entries being advanced into advanced yield trials in 2001 identified 68 lines from 49 pedigrees that had field indices (incidence x severity) and Type II reactions from greenhouse evaluations of $\leq$30%. Of these pedigrees, 37 differ from Ernie by descent and are not derived from Chinese sources of resistance. Lines were evaluated relative to the resistant check Ernie (greenhouse FHBI = 14% and field index = 11.5%) and the susceptible check MO 94-317 (greenhouse FHBI = 92% and field index = 60%). Of the 68 lines that will be retained, 32 had greenhouse scores $\leq$Ernie while 38 had field scoress $\leq$Ernie. They provide either different sources or different types of resistance in adapted genetic backgrounds and their combination with other exotic sources and types of resistance should enable accelerated development and release of scab resistant varieties that possess either more effective or more stable scab resistance.

One of these pedigrees, MO 11769/Madison has yielded at least 4 lines that have levels of type II resistance that are < Ernie. We expect to release one of these, MO 980525, in 2002. After being verified in Missouri, MO 980525 was entered in both the 2001 and 2000 Uniform Winter Wheat Scab Nurseries where its type II resistance was confirmed by several programs. In the 2000 Northern Winter Wheat Scab Nursery, this line and an earlier maturing sister line MO 980725 ranked 1st and 2nd of 29 entries for type II resistance, 6th and 7th for field index and MO 980525 ranked 6th for low DON. In its first year of testing in the Eastern Soft Red Winter Wheat Cooperative Nursery, MO 980525 performed well across the US corn belt finishing 1st at Woodburn, IN 3rd at Urbana IL, and 6th at Wooster, OH. It was in the top yield group at other corn-belt locations suggesting it could be a valuable line, meeting the USWBSI objective of providing effective scab control.

Germplasm Evaluation Center: Research funded by the National Wheat and Barley Scab Initiative has led to the systematic evaluation of types I, and II resistance to scab and kernel quality under inoculation of accessions from targeted geographical regions of the world.

Approximately 3800 accessions from geographical areas in Asia, South America and Eastern Europe where resistance has been identified or where environmental conditions are conducive to scab development have now been screened at Missouri. From initial screens of Asian and Italian germplasm, 50 accessions that possess good to excellent levels of type II resistance, reduced incidence and good kernel quality under field inoculation have been identified, purified and verified through 2 generations of progeny testing. Twenty of these accessions were distributed to 15 collaborating programs within the initiative in 2000 and some have been shown by other researchers to possess resistance. The remaining 30 lines will be distributed to interested breeders following the scab forum in Cincinnati in December 2001. Approximately 2000 Yugoslavian accessions have also been screened for resistance. Sixty-eight accessions have held up well under two cycles of greenhouse and field evaluation at Missouri. An additional 246 accessions will be evaluated for the second cycle in the 2001/2002 crop season. Dr. Paul Murphy at North Carolina State University concurrently screened a sub-sample of this second group of lines and 70 lines of the 246 lines identified as promising at Missouri were also identified in the NC State program as having good to excellent levels of type II resistance. These lines will be purified and re-screened prior to distribution to interested breeders. The majority of resistant accessions (>90%) are landraces. Many are tall and late and significant pre-breeding will be required to transfer their otherwise excellent levels of resistance into adapted backgrounds. During the fall and winter of 2001/2002, 784 accessions from Romania (182), Hungary (283) and Bulgaria (319) will be evaluated for the first time under greenhouse inoculation. The lines will be planted in the field and the first data on resistance under spray inoculation will be collected in 2002. Based on the frequency of resistant accessions identified to date, it is anticipated that resistance will also be identified in this collection of germplasm.

CIMMYT Germplasm Introduction Partnership: Approximately 57 wheat lines introduced into the US through the National Scab Initiative's partnership with CIMMYT were distributed to interested breeders in the spring of 2001. In November 2001 wheat germplasm from Argentina (107 lines), Brazil (19 lines), Japan (15 lines) and CIMMYT (51 lines) will be introduced. In addition to genes for scab resistance, CIMMYT germplasm also contains resistance to other important US pathogens (e.g. Septoria spp., leaf rust, and barley yellow dwarf virus). Lines will be quarantined and distributed to interested breeders in the spring of 2002.

Genetic Studies: Studies investigating the inheritance of resistance in MO 980505 have been initiated and those characterizing resistance in Ernie are nearing completion. Both conventional and molecular genetic analyses of these sources of resistance are being conducted.

NCR-184 REPORT 2001 - NORTH DAKOTA

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The FHB situation in North Dakota in 2001 and its impact on small grain crops. Results provided by Marcia McMullen, extension plant pathologist, who conducted a survey of 1500 grain crops across ND in 2001. Statewide, Fusarium head blight (FHB) occurrence was about the same in 2001 as in 2000. Individual severely affected fields of spring wheat could be found in parts of central ND and fields of durum in north central, west central and northwest ND. In northwest ND there were many late planted durum crops which may have increased the problem in that region. FHB was noted in 70% of spring wheat and durum and 42% of barley fields statewide. Overall, wheat losses to FHB in 2001 were moderate, averaging about 4% (range 0.1 to 34.2%) in spring wheat, and 7.2% (range 0.1 to 80.%) in durum. Yield loss in barley averaged less than 1% (range 0.1 - 2.3%).

Overview of present research programs. The FHB research effort at NDSU continued to be a large one in 2001. Six NDSU departments, three NDSU Research & Extension Centers, and the USDA-ARS Northern Crop Sciences Laboratory located on the NDSU campus, all were involved in research 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 resistance to FHB, and classical and molecular genetics of resistance, there is active research in several other areas including epidemiology, soil microbial ecology, physiology and biochemistry, grain quality, food science, disease survey, and chemical control.

FHB resistance is being sought in breeding programs for spring wheat, durum wheat, and barley. Methods to obtain resistant varieties include both conventional and molecular plant breeding methods. These efforts utilize combinations of inoculated-irrigated field nurseries and greenhouse testing. Durum and barley breeding programs are also using screening nurseries in China.

As reported previously, the highlight of year 2000 was the release of ‘Alsen’, a hard red spring wheat combining moderately high resistance to FHB with excellent grain quality, good agronomics and resistance to leaf rust and stem rust. Over 450,000 A of Alsen were produced in ND in 2001 and there is every expection that it will be planted on more than 2 million production acres in 2002.

Units involved in FHB Research.

NDSU:

*Dept. of Plant Pathology

*Dept. of Plant Sciences.

*Dept. of Soil Science.

*Dept. of Cereal and Food Sciences.

*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

NCR-184 STATE REPORT NEW YORK 2001

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FHB situation in 2001 in New York

There was only minor occurrence of FHB in the soft winter wheat production area of New York in 2001. Although moisture was present during the early flowering period, conditions were not favorable for inoculum production in the period preceding flowering. Also, night temperatures during flowering were lower than optimal. Dry conditions prevailed during grain maturation. In general, the disease had no impact on grain yields or test weights. Vomitoxin contamination above 1 ppm was uncommon, though a few pockets of higher vomitoxin were observed. A cooperative survey between Cornell and the Star of the West Flour Mill in Churchville, NY was continued in 2001 to assess associations among vomitoxin level, incidence of Fusarium infected grains, and geographic location of production fields.

Programs and personnel involved in FHB research

Winter wheat cultivar evaluation

One site of the northern uniform winter wheat scab nursery is located at Ithaca, NY. Despite provision of grain spawn inoculum and overhead irrigation in the plots, only modest levels of scab occurred. See the report by Sneller, Lipps and Herald for a summary of results at all locations. One New York line, NY87047W-7388, was for the second year among the top entries for reduced FHB severity and lowered DON content. In addition to the standard 45 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 summary report by McMullen and Milus for multistate results. Fungicides and biocontrols were applied by foliar spray utilizing the dual (forward-backward) flat fan nozzle system configured by North Dakota researchers. Grain spawn inoculum was spread in the border areas and macroconidial suspension was also applied to flowering spikes. The plots were not irrigated. Only modest levels of FHB developed though harvested grain from nontreated plots averaged 4.6 ppm of DON. Leaf blights were not significant at this location. No treatment resulted in a significant increase in yield, though plots treated with Folicurplus the biocontrol TrigoCor 1448 had the highest yields (Table 1). Various treatments induced moderate reductions in scab incidence, Fusarium damaged kernels, DON contamination, and im-

provement of test weight, but only AMS21616 reduced DON to below 2 ppm.
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, characterized, and tested for for potential application to wheat spikes, seed, and crop residue. See the report by Stockwell et al in this volume for a summary of tests on field application to spikes.
Personnel: Christine Stockwell, Stanley Kawamoto, Gary Bergstrom (CU Plant Pathology); Wilmar da Luz (Embrapa Trigo, Passo Fundo, Brazil)

Aerobiology/epidemiology

Sandra Maldonado-Ramirez completed a Cornell University Ph.D. Dissertation entitled, "*Aerobiology of the Wheat Scab Fungus, Gibberella zeae:Discharge, Atmospheric Dispersal, and Deposition of Ascospores*" in August 2001. Ascospores were discharged from corn stalk substrates primarily during daylight hours. There appeared to be an association of major ascospore discharge with moderately warm temperatures. Using remote piloted aircraft we found that viable propagules of *Gibberella zeae :* are present in the planetary boundary layer of the lower atmosphere under a wide range of environmental conditions at the time of wheat flowering, suggesting a potential for regional dispersal of airborne inoculum. Gravitational settling of spores onto wheat spikes appeared to occur principally during late evening to early morning hours. See the report by Shah and Bergstrom in this volume on spatial aspects of FHB epidemics in New York that also points to the contribution of inoculum from outside of wheat fields. David Schmale has begun a Ph.D. project on the aerobiology of *G. zeae* relative to sources of inoculum for FHB.
Personnel: Gary Bergstrom, David Schmale (CU Plant Pathology); Elson Shields (CU Entomology); Sandra Maldonado-Ramirez (University of Puerto Rico, Mayaguez); Denis A. Shah (Private Consultant); David Gadoury (CU Plant Pathology, Geneva campus); Don Aylor (Connecticut Ag Experiment Station); Robert Bowden, Kurt Zeller (Kansas State University)

Table 1. Effect of foliar treatment at anthesis on scab incidence, *Fusarium*-damaged kernels, yield, test weight, and DON contamination in Caledonia winter wheat in Aurora, NY in 2001.

Treatment and amount	Scab (spike) incidence on 1 Jul (%)	*Fusarium* damaged kernels (%)	Test weight @ 13.5% moisture (lb/bu)	Yield @13.5% moisture (bu/A)	DON ppm
Nontreated	4.8	10.0	57.0	75.4	4.6
AMS 21616 (5.7 fl oz/A) + Induce (0.125% v/v)	3.1	2.7	59.0	76.2	1.2
BAS 500 (0.2 lb a.i./A) + Induce (0.125% v/v)	4.2	7.1	58.3	75.2	3.6
BAS 500 (0.1 lb a.i./A) + Induce (0.125% v/v) + Folicur 3.6F (2 fl oz/A)	4.8	3.9	59.2	72.7	3.2
Folicur 3.6F (4 fl oz/A) + Induce (0.125% v/v)	2.2	5.3	58.8	75.7	2.0
Messenger (2.25 oz/A) 3 applications*	3.7	6.6	58.4	76.2	3.2
Serenade (6 lb/A) biocontrol	7.0	8.3	57.5	73.4	5.6
TrigoCor 1448 biocontrol	4.8	7.7	58.0	66.8	4.0
TrigoCor 1448 biocontrol + Folicur 3.6F (4 fl oz/A) + Induce (0.125% v/v)	3.5	6.8	59.5	86.5	3.0
TrigoCor 4712 biocontrol	4.3	7.0	57.9	67.5	3.1
TrigoCor 4712 biocontrol + Folicur 3.6F (4 fl oz/A) + Induce (0.125% v/v)	4.0	5.6	59.0	77.3	3.0
LSD (*P*=0.05)	2.1	NS	NS	NS	NS
CV (%)	101.9	202.9	1.7	14.1	68.7

* Messenger was applied at Feekes growth stages 4.2, 10, and 10.5.

NCR-184 MANAGEMENT OF HEAD SCAB OF SMALL GRAINS: 2001 OHIO REPORT

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1,110,000 acres of soft red winter wheat were planted in Ohio in the fall of 2000, but due to winter injury and the more favorable price of soybeans only 900,000 acres were harvested in 2001. Frost heaving reduced stands in some fields that were shallow planted, but mild spring conditions favored tiller development. Weather conditions in April and the first week of May were relatively dry and cool which limited perithecial development on corn residues. Precipitation events became more frequent during mid to late May in many regions of the state with most locations reporting from 2 to 4 days of measurable precipitation during the 7 days prior to anthesis. However, average daily temperatures for most locations in the state were generally below 15C between 22 May and 4 June when most of the wheat was in anthesis.

There was moderate levels of head scab in some central and north west counties, though most counties had only trace levels of disease. Fields with the highest level of scab did not exceed 20% incidence. Yield losses probably range from 0 to 5%, but state wide the average yield loss was less than 1%. Dry temperatures during and after anthesis probably limited scab severity and DON accumulation in the grain.

Research

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

Disease forecasting: De Wolf, Madden, Lipps

A) Erick De Wolf and Larry Madden have developed a scab risk assessment model based on historical weather information and scab severities. The model was constructed from hourly temperature, relative humidity and precipitation data from 50 location years from Ohio, North Dakota, Kansas and Missouri. Stepwise regression identified two time periods in which three environmental parameters were critical to reasonably accurate prediction: 1) (Model 1) duration of precipitation and duration of temperature between 15 and 30°C for 7 days prior to crop anthesis and 2) (Model II) duration of temperature between 15 and 30°C and corresponding relative humidity above 90% for the 10 days post anthesis.

These two models were used to estimate the risk of head scab during the 2001 wheat growing season using hourly weather data from six weather stations in Ohio. Calculated head scab risk probabilities ranged from 32% to 84% for Model 1 and from 4% to 78% for Model II. In no case did both models predict a high risk for head scab at any location. Based on these results the head scab risk prediction was reported to be low to moderate

depending on the location in the state. Head scab risk predictions were posted on the Ohio State University Oho Field Crop Disease web page (www.oardc.ohio_state.edu/ohiofieldcropdisease/) during the critical time of disease development through harvest. Weekly reports were provided to wheat growers through the Ohio State University Extension electronic newsletter Crop Observation and Recommendation Network (C.O.R.N.) (www.ag.ohio_state.edu/~corn/agcrops.html/).

B)We are participating in a cooperative program with North Dakota, South Dakota, Indiana, Manitoba and Pennsylvania to monitor inoculum levels, environmental parameters and disease severity in replicated plots. Information from multiple sites is being used to validate and improve the head scab risk assessment models and to determine the importance of pathogen inoculum level in predicting disease occurrence. The cooperative effort is necessary to assess the effect of regional variation in cropping practices, tillage and climate on inoculum levels and subsequent disease level 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. This is the third year of our monitoring project.

C) Samia El-Allaf is examining the spatial and temporal distribution of scab in fields in order to have a better understanding of the disease epidemiology. Disease assessments were recorded from four research plots in two locations (Wooster and Hoytville). Data is currently being analyzed for the 2001 season.

Breeding for scab resistance: Sneller, Lipps, Gupta, Engle

A) The departments of Hort and Crop Science and Plant Pathology are cooperating to develop varieties with resistance to head scab. Four avenues of research are being followed; 1) evaluation of varieties and advanced lines for resistance, 2) evaluate and select lines with combined resistance to FHB and Stagonospora blotch, 3) incorporate resistance from sources identified within the breeding program into elite lines and 4) increase the level of resistance above current levels by incorporating new genes and gene combinations from diverse germplasm sources. During the year the following germ plasm were screened for resistance in field nurseries: Advanced breeding lines, scab resistant by Stagonospora resistant crosses, and early generation head row selections.

B) Anju Gupta completed a molecular and pedigree analysis of sources of resistance to Fusarium head scab. Twenty-three lines were evaluated based on pedigree relationships and resistance reactions. The analysis indicated that Ning 7840 and Sumai 3 possess unique alleles at 3BS which are not shared by other resistant genotypes. Based on geneetic studies, Ning 7840 and Frontana and Ning 7840 and Freedom have unique genes for resistance. Marker studies indicate that Freedom and Ning 7840 have different resistance alleles at 3BS. Results indicate that SSR genotyping of ancestral lines may help establish the degree of relatedness in resistant germplasm. Markers on 3BS and 2AS may be useful for identifying new sources of resistance with unique resistance genes.

C) Jessica Engle is evaluating inoculation procedures for identifying different reaction types and possible of resistance. Six lines previously screened for resistance in the 1999 Northern Uniform Winter Wheat Scab Nursery were selected based on their different reactions (incidence and severity). Plants were inoculated in the greenhouse using four different techniques: single floret syringe inoculation, atomizing conidia on the head, placing ascospores on glume juncture and placing ascospores onto extruded anthers. Results indicated that highest disease levels occurred from atomizer and anther inoculation procedures. Results indicated that ranking of wheat lines according to severity assessment varied with inoculation technique and did not necessarily predict reaction in the field.

Fungicide efficacy: Lipps, El-Allaf

We are participating in the cooperative effort of the US Wheat and Barley Scab Initiative Chemical and Biological Control research area headed by M. McMullen and G. Bergstrom. Five fungicide treatments and two biologicals were evaluated in 2001 using procedures and rates outlined by the project leaders. Plots were inoculated by spreading infested corn kernels on the soil surface. Mist irrigation was used to provide moisture levels favorable for infection and disease development during anthesis. The biological agents (TrigoCor 1448 and USDA OH182.9) did not limit scab development. AMS21619 and BAS 505 reduced the severity of scab and the level of DON to about 50% of the untreated control. BAS 505, BAS 505 plus Folicur and AMS21619 treated plots had significantly higher yield (LSD 7.2 bu/A) than the untreated control.

Evaluation of commercial wheat varieties: Lipps

Commercial wheat varieties submitted to the Ohio Wheat Performance Test were evaluated for Fusarium head blight in the test planted near Circleville, Oh. Severity assessments for the 46 soft red winter wheat lines ranged from 5% to 63%. Based on an LSD (P=0.05) of 11.5%, the varieties with the lowest scab severities were Valor, Patton, Dynasty, Hopewell, Classic RW1517, Coker 94774, Thompson TS 6020, Sabbe, and Wellman W9830. The four triticale lines in the test had scab severity levels less than 2%. Data for this trial can be obtained online (http://www.oardc.ohio-state.edu/wheat2001/).

NCR-184, MANAGEMENT OF HEAD SCAB OF SMALL GRAINS 2001 SOUTH DAKOTA STATE REPORT

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2001 SCAB DEVELOPMENT IN SOUTH DAKOTA

Minimal scab on wheat occurred in most part of South Dakota in 2001. The statewide average of scab indices was estimated at 1%. Higher scab on spring wheat was observed in the north central region. In some spring wheat fields near Selby (Walworth County), in excess of 40% scab index was observed. (M. Draper and Y. Jin).

CURRENT RESEARCH PROJECTS

Germplasm introduction and evaluation: The overall project goal is 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 inoculated field nurseries and in the greenhouse. A germplasm screening system utilizing three nurseries was implemented in the germplasm screening project. In 2001, 1262 accessions of spring wheat were evaluated in the Preliminary Screening Nursery (PSN) and 141 accessions were selected based on scab index and seed infection. These selections from PSN will be evaluated in the greenhouse to derive entries for Elite Germplasm Nursery (EGN) of 2002. One hundred thirty-one accessions selected from the 2000 PSN were evaluated in the 2001 EGN. These selections will continue to be evaluated in the 2002 EGN. Five accessions of resistant selections were entered into the Uniform Regional Scab Nursery for spring wheat for testing at multiple environments and for direct access by researchers. Elite selections were used for crossing to introgress the resistance into adapted germplasm. (X. Zhang and Y. Jin)

Epidemiology: The overall goal of our research in scab epidemiology is to understand the sources, production, and survival of scab inoculum to provide a knowledge base for the development of accurate disease forecasting systems and comprehensive disease management strategies. We initiated research to address questions concerning scab inoculum production and survival, specifically effects of environmental conditions on inoculum production, and inoculum (ascospores) survival and accumulation on plant surface. As part of a multi-state collaboration, environmental conditions and disease development were monitored in plots in eastern South Dakota to relate certain environmental factors to inoculum production and disease progress. We continue to develop and utilize the soil surface wetness sensor to monitor moisture at the soil/air interface and its effects on inoculum development. (L. Osborne and Y. Jin)

Breeding for scab resistance in spring wheat: The project emphasizes on simultaneous improvement of scab resistance and agronomic traits in breeding materials. Established off-season nurseries and mist-irrigated greenhouse and field screening nurseries are being

utilized to accelerate breeding efforts. Three generations of breeding materials are evaluated for scab resistance: two generations in the greenhouse and one generation in the field. Approximately 8,000 individual hills are evaluated in the greenhouse nurseries and 3,000 rows are screened in the field nurseries. Both the field and greenhouse nurseries are inoculated with infected corn and conidial suspensions. The breeding population contains sources of resistance that can be traced back to Sumai 3, from other introduced sources, and advanced breeding lines that have various “field tolerance” qualities. The off-season nursery aids in the simultaneous selection for resistance and desirable agronomic characteristics. We have seen a continued increase in the number of lines that have good agronomic performance along with good scab resistance. A new hard red spring wheat variety, "Walworth" (SD3348) was released in 2001. Walworth has high grain yield and good bread-making characteristics and has improved scab resistance. (D. Gustafson, R. Devkota, Y. Jin)

Breeding for scab resistance in winter wheat: The objective is to use traditional breeding techniques to develop scab resistant hard winter wheat cultivars. Breeding efforts for improved head scab resistance in winter wheat have been focused on i) characterizing scab resistance or tolerance among commercially grown cultivars and elite and preliminary lines from SDSU and regional breeding programs, ii) identifying winter wheat germplasm sources that show a high level of scab resistance, and iii) developing populations segregating for scab resistance and desirable agronomic traits. Mist-irrigated greenhouse and field screening nurseries have been used to evaluate the material. The following nurseries were screened for scab resistance in 2001: Northern Regional Performance Nursery; Winter Wheat Regional Scab Nursery; South Dakota Crop Performance Trials; SDSU Advanced Hard Red and Hard White Yield Trials; SDSU Preliminary Hard Red and Hard White Yield Trials. (A. Ibrahim, D. Gustafson, Y. Jin)

Fungicide efficacy studies: South Dakota participated in the uniform fungicide trial for scab suppression. Two hard red spring wheat cultivars were planted at three locations each and treated at anthesis with fifteen treatments. The treatments were also applied to two hard red winter wheat cultivars planted at a single location. One spring wheat location was lost due to glyphosate drift injury. Erratic stand in the winter wheat added variability to the data. 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, protein and test weight of harvested grain. Under ambient conditions, scab was not severe at any of the study locations. Leaf diseases, predominantly leaf rust, occurred late in the test locations and no significant reduction in disease was realized. (M. Draper and K. Ruden)

Molecular biology of scab resistance: One of big obstacles in fighting scab epidemics is that little is known about the pathogen-host interaction, particularly at molecular level. Our research aims at addressing this problem by getting insight into the molecular mechanism of *Fusarium graminearum*-wheat interaction. Our goal is to identify, clone and study the essential genes that control the initiation of FHB pathogenesis in wheat spikes, so that their expressions can be manipulated in favor of controlling FHB. Comparing differential expression of genes at the early stages of FHB pathogenesis between the FHB-inoculated and the

health control wheat spikes should lead to the identification and cloning of, at least some of such essential genes. So far, seven expressed sequence tags (ESTs) have been observed to be specific to the FHB-inoculated Sumai 3 spikes in our repeated experiments. Four such ESTs were cloned and sequenced. Blasting Genebank with these ESTs as query sequences has revealed no homologue with any known R or PR gene. Northern and Southern Blottings revealed that two of the four cloned ESTs belong to pathogen *F. graminearum* and the rest are wheat. We are currently cloning the other three. (Y. Yen and D. Xing)

Implementation of marker-assistant selection in South Dakota wheat breeding programs: The goal of this project is to implement marker-assisted selection (MAS) in the SDSU spring and winter wheat breeding programs and the USWBSI spring wheat germplasm program. To reach our goal, we will adopt useful markers from other programs while incorporating new marker selection into our breeding routine. As the first step toward our goal, we have screened 78 elite breeding materials from SD spring wheat breeding program and 87 elite selections from USWBSI spring wheat germplasm program for SSR markers with primer sets gwm533, gwm493 and gwm389. Sumai 3 and Wheaton were used as the controls. The results showed that 38 of the 78 elite breeding lines screened have the Qfhs.ndsu-3BS-gwm493 marker identified by Anderson et al. (2001) but only five also have the Qfhs.ndsu-3BS-gwm533 marker. Of the 87 elite germplasm selections screened, 27 lines have the Qfhs.ndsu-3BS-Xgwm493 markers; 31 lines have the Qfhs.ndsu-3BS-Xgwm533 marker; and 26 lines have the Qfhs.ndsu-3BS-Xgwm389 marker. The Xgwm533-120bp, the Xgwm493-140bp and the Xgwm493-160-bp markers observed in our elite breeding lines were also observed among the elite germplasm selections. In addition, new markers Xgwm389-130bp, Xdwm533-300bp and Xgwm533-165bp were also observed among the selections. (Y. Yen, X. Zhang and Y. Weng)

Biological control studies: Screening trials of biological control agents to control FHB were continued in 2001. During the summer of 2001 two bacterial biocontrol agents from the SDSU collection were applied in field plots equipped with misting systems, together with biocontrol agents from other research groups. However, initial plantings in Brookings suffered from Roundup drift, and replantings experienced extensive insect damage. Two ground bed trials in the greenhouse were carried out. Folicur significantly reduced FHB, but none of the biocontrol agents employed (two from South Dakota and two from Brazil) significantly reduced FHB. However, some of these biocontrol agents reduced FHB, even though it was not statistically significant. The BCAs may have been washed off by the overhead misting apparatus that covered the plants in the greenhouse, and heavy pathogen inoculum may have overwhelmed the biocontrol agent inoculum. These problems will be corrected in next year's trials. Based on partial sequencing of ribosomal RNA, membrane fatty acid analysis, and standard physiologic testing, the four South Dakota biocontrol agents have been verified as members of the genus *Bacillus*, with an as yet uncertain species affiliation. (B. Bleakley and M. Draper)

PERSONNEL INVOLVED IN SCAB RESEARCH

Project and Researchers:

Small Grain Pathology: Y. Jin, X. Zhang, L. Osborne, Y. Weng
Extension Plant Pathology: M. Draper, K. Ruden
Winter Wheat Breeding: I. Ibrahim, S. Kalsbeck, R. Little, D. Gustafson
Spring Wheat Breeding: D. Gallenberg, R. Devkota, D. Gustafson, L. Peterson, G. Lammers
Cytogenetics-Molecular Biology: Y. Yen
Soil Microbiology: B. Bleakley

VIRGINIA 2001 NCR 184 REPORT ON FUSARIUM HEAD BLIGHT

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Production and Fusarium Head Blight Development

In Virginia, 175,000 acres of soft red winter (SRW) wheat were harvested in 2001, with a state average yield of 57 Bu/A. Annual declines in the price of wheat since 1996 have resulted in corresponding declines in harvested acres, which currently are 100,000 less than in 1996. Widespread epidemics of Fusarium head blight (FHB) have not occurred in Virginia since 1998, when the crop was devastated. The incidence of FHB was low, yet noticeable, in the 2000-2001 season due to dry conditions prevailing throughout much of the flowering stage. One seed grower in Hanover County suffered severe damage from FHB in an irrigated wheat-production field, and the seed failed to pass certification standards due to a high incidence of scabby seed.

Evaluation of Four Fungicides and Two Biological Agents for the Control of Fusarium Head Blight in the Soft Red Winter Wheat Cultivar Roane in Virginia in 2001.

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The soft red winter wheat cultivar Roane was no-tillage seeded into corn residues in the fall of 2000 to establish FHB control plots. Four fungicides (Folicur 3.6F, AMS 21619 F, BAS 505 G, Stratego 250E) and two biological agents (a yeast isolate and a *Bacillus subtilus* isolate) where applied to the wheat at Zadoks' Growth Stage 59 (9 May). The plots were scored for incidence and severity of FHB on 5 Jun at Zadoks' GS 85. The plots were harvested on 28 Jun. Seed samples were taken to determine 1000 kernel and bushel weights and sample were sent to Michigan State University for DON determinations for each treatment. The incidence and severity of FHB in the non-treated control was 9% and 10.5%, respectively. All treatments provided significantly lower incidences and severity ($P \leq 0.05$) over the non-treated control. The fungicide treatments had ranges of FHB incidences of 3.8-5.3% and severities of 2.3-2.8% while the two biological agents had incidences from 3.8-4.3% and severities from 3.0-3.8%. All treatments had significantly higher 1000 kernel weights (range: 31.5-32.9 g) ($P \leq 0.05$) over the non-treated control's 1000-kernel weight (30.7 g). Grain yield was significantly greater ($P \leq 0.05$) for three of the seven treatments (range: 7085-7267 kg/ha) over the non-treated control (6537 kg/ha) at a standard 13.5% moisture.

Breeding and Mapping Research on Fusarium Head Blight

Our program continues to identify and verify wheat genotypes possessing resistance to FHB through collaboration with colleagues in the Uniform FHB Winter Wheat Screening Nurser-

ies. Incorporation and pyramiding genes conferring scab resistance into high-yielding SRW wheat genotypes continues to be a major objective of our breeding program. This is being accomplished through the development and selection of top-cross, backcross and doubled haploid populations. Results from our initial mapping studies indicate that QTLs in addition to the one located on chromosome 3BS confer resistance to FHB in Chinese line W14. Mapping studies will be intensified via use of doubled haploid populations and concurrent mapping in populations with type II and other types of resistance. This research has the potential to identify new QTLs associated with scab resistance, provide additional markers linked to previously reported QTLs, and to identify markers that are effective across genetic backgrounds; all of which are essential for successful exploitation of marker-assisted selection.