NCERA-184 - Management of Small Grain Diseases Annual Report

Date of Annual Report: 08/03/2010

Report Information:

- Annual Meeting Dates: 06/08/10 to 06/09/10
- Period the Report Covers: 10/2008 to 09/2009

Participants:

- Bradley, Carl - Univ. of Illinois
- Burrows, Mary - Montana St. Univ.
- De Wolf, Erick - Kansas St. Univ.
- Esker, Paul - Univ. of Wisconsin
- Isard, Scott - Penn St. Univ.
- Langham, Marie - South Dakota St. Univ.
- McMullen, Marcia - North Dakota St. Univ.
- Malvick, Dean - Univ. of Minnesota
- Padgett, Guy - Louisiana St. Univ.
- Paul, Pierce - Ohio St. Univ.
- Stein, Jeff - South Dakota St. Univ.
- Stromberg, Erik - Virginia Tech.
- Tenuita, Albert
- Wegulo, Stephen - Univ. of Nebraska

Minutes of Annual Meeting:

Minutes of the Annual Meeting
Grand Gateway Hotel - Rapid City, SD
June 8-9, 2010

The meeting of NCERA-184: Management of Small Grain Diseases Committee was held at the Grand Gateway Hotel, Rapid City, SD on June 8-9, 2010.

June 8:

The meeting was called to order at 1:30 p.m. by Chair, Carl Bradley (Univ. of Illinois).
The meeting began with introductions of each attendee.

Oral presentations of state reports followed.

Erick De Wolf (Kansas State Univ.) led a discussion on stripe rust. He said many varieties that were previously resistant to stripe rust were observed in 2010 to be at least moderately

susceptible. He mentioned as examples the varieties Jagger, Jagalene, and Fuller. He asked whether resources such as those developed for stem rust Ug99 should be expanded to stripe rust.

Scott Isard (Penn State Univ.) said models showed that the only possible transport of rust spores from Africa by air would be from West Africa in the tropical trough. He also gave an update on the Cereal Rust Information Platform web site.

Carl Bradley (Univ. of Illinois) led a discussion on fungicide trials. Results from trials indicated that Headline applied at different growth stages at the rate of 6 oz/acre increased the mycotoxin deoxynivalenol (DON) in wheat grain. Jeff Stein (South Dakota State Univ.) said triazoles provided the best protection against stem rust. Mary Burrows (Montana State Univ.) said for testing fungicide efficacy on stem rust, it works best if inoculation is at the tillering stage and is done by injecting the stem with spores and then assessing disease starting two weeks after inoculation.

G. Boyd Padgett (Louisiana State Univ.) noted that strobilurin fungicides are as not as good any more on rust control. He said for his group in Louisiana, pre-mixes of fungicides work better followed by triazoles. It was the group's consensus that a warning on the effect of strobilurins on DON be included on the fungicide efficacy chart developed and updated annually by members of NCERA-184.

The meeting adjourned for dinner at 5:45 p.m.

June 9:

The meeting started at 8:00 a.m. Marty Draper (NIFA representative) called in and made a slide presentation highlighting NIFA funding, the principles NIFA considers important, NIFA's priority areas, and NIFA's institutes. A discussion between the whole group and Marty Draper followed the slide presentation. The group agreed that systems approaches were well suited to support the transition to sustainable agriculture.

There was a brief discussion on stem rust surveillance training. Erick De Wolf (Kansas State Univ.) would provide Marty Draper with an update on the status of this training. Jeff Stein (South Dakota State Univ.) suggested that CCA credits be built into the registration packet for the training on stem rust surveillance.

Erick Stromberg (Virginia Tech.) expressed concern that presently we are not training practical plant pathologists/entomologists. He said undergraduate students should be encouraged to get interested in science.

Marcia McMullen (North Dakota State UNiv.) noted that mycotoxins are not included in the NIFA Food Safety priority. Marty Draper encouraged the group to write a letter to NIFA expressing this concern. Erick Stromberg suggested that mycotoxins could be tied in with biofuels.

After the session with Mary Draper, the business meeting continued with Carl Bradley seeking ideas for where NCERA 184 would meet in 2011. It was agreed that the next meeting be held jointly with the Eastern Wheat Workers and the Southern Small Grains Workers in Dallas, TX on April 17-20. Stephen Wegulo would contact these groups to arrange for the joint meeting.

Kendall Lamkey (Advisor) called in. He said NCERA-184 passed the latest review with flying colors. He said that October 2010 would be the end of the third year of NCERA-184's current 5-year period and urged the group to be thinking about renewal. He suggested that a running committee be put together to prepare for renewal. He reminded the group to look at the list of participants to make sure it is up to date. He said for NCERA-184 to retain the same number, a request should specifically be submitted for this purpose. He said he would send a schedule for renewal of NCERA-184.

After the session with Kendall Lamkey ended, Paul Esker (Univ. of Wisconsin) motioned for acceptance of the minutes of the 2009 meeting. Pierce Paul seconded the motion. The minutes were accepted as distributed.

Paul Esker (Univ. of Wisconsin) was unanimously elected as secretary for the 2011 meeting. Stephen Wegulo (Univ. of Nebraska) will be the chair for the 2011 meeting.

Mary Burrows (Montana State Univ.) and Stephen Wegulo (Univ. of Nebraska) led a discussion on viruses. Mary Burrows gave an update on a GDPN-funded virus survey she is leading. Stephen Wegulo gave a brief presentation on small grain viruses in the Great Plains. The group favored the idea of having a virus symposium at the 2011 APS meeting.

Erick De Wolf (Kansas State Univ.) led a discussion on efforts on DON modeling and stem rust surveillance and management through fungicide trials and variety selection. The group felt efforts on stem rust should remain focused on stem rust and not include leaf and stripe rusts since management strategies are already in place for the latter two rust diseases. It was noted that management information for stem rust will keep changing as new fungicides and varieties become available.

Erick De Wolf updated the group on recent efforts to refocus outreach for the Fusarium head blight commentary. Through the U.S. Wheat and Barley Scab initiative, commentary entered by each state can be disseminated to clientele by e-mail and other electronic channels. A consensus was reached that the resolution on the risk map generated by the Fusarium Head Blight Risk Tool should be left as it currently is.

Carl Bradley (Univ. of Illinois) asked whether the Fusarium Head Blight Risk Tool web site is compatible with mobile technology. Currently it is not.

The need was expressed for someone to coordinate efforts on the Scab Smart web site maintained at North Dakota State Univ.

Erick De Wolf (Kansas State Univ.) demonstrated DON prediction models on an experimental web site still under development. The group felt millers should be educated about risk versus

actual happening as far as DON. Jeff Stein (South Dakota State Univ.) asked whether we needed DON prediction pre-flowering as well as post-flowering. The group noted the need for validation of DON models.

Carl Bradley (Univ. of Illinois) asked the group to look at a memo sent by Gene Milus (Univ. of Arkansas) voicing concern about the secrecy involved in marketing branded varieties of soft red winter wheat. This secrecy prevents accurate assessment of the U.S. Wheat and Scab Initiative's impact on scab resistant varieties and prevents dissemination of accurate, timely scab reactions via venues such as the Scab Smart web site. The group felt that this is not an NCERA-184 issue.

Carl Bradley thanked Jeff Stein for putting together the meeting program.

The meeting adjourned at 12:17 p.m.

State Reports:

Kansas:

Personnel news. There were no major personnel changes in KSU Plant Pathology during the past year; the Department is at "full strength" for faculty.

Disease loss estimates for 2009. Data are from: Appel, J. A., De Wolf, E., Bockus, W. W., Bowden, R. L., and Todd, T. 2009. Preliminary 2009 Kansas Wheat Disease Loss Estimates. Kansas Cooperative Plant Disease Survey Report. (http://www.ksda.gov/includes/document_center/plant_protection/Plant%20Disease%20Reports/2009KSWheatDiseaseLossEstimates.pdf)

Disease	Loss in 2006	Loss in 2007	Loss in 2008	Loss in 2009	20-yr avg.
Leaf rust	0.1	13.9	4.72	1.37	3.93
Stripe rust	0.001	0.2	0.01	0.01	1.54
Wheat streak mosaic	7.0	0.01	0.02	0.001	1.17
Septoria complex	0.001	1.8	0.5	1.0	1.14
Barley yellow dwarf	0.8	0.2	0.01	0.44	1.13
Tan spot	0.2	1.3	0.45	0.26	0.95
Fusarium head blight	0.001	0.2	1.9	0.9	0.53
Soilborne mosaic	0.05	0.01	0.001	0.001	0.30
Take-all	0.05	0.001	0.001	0.01	0.21
Powdery mildew	0.1	0.2	0.03	0.02	0.19
Root and crown rot	0.1	0.01	0.001	0.001	0.08
Stem rust	0.0	0	0.001	0.001	0.07
Strawbreaker	0.001	0	0	0	0.02
Bunt and loose smut	0.05	0.02	0.01	0.04	0.02
Bacterial leaf blight	0.001	0.001	0.03	0.04	0.01
Total	8.5	17.9	7.7	4.1	10.48*

* Equivalent to about 35 million bushels or $120 million dollars at current cash grain prices (June 15, 2010).

Wheat progress and potential wheat disease losses for 2010. Wheat harvest stopped almost as soon as it began as farmers were delayed in many areas due to the heavy rain and winds. Winter wheat turning color was 77 percent complete, ahead of 76 percent for last year but behind the 5-year average of 81 percent. Warm weather helped as 27 percent of the crop has matured, ahead of 8 percent last year and 26 percent for the 5-year average. Only 1 percent of wheat has been harvested, compared to none this time last year and 6 percent for the 5-year average. Condition was rated as 4 percent very poor, 9 percent poor, 30 percent fair, 48 percent good, and 9 percent excellent. Disease infestation was 29 percent with light infestation, 14 percent with moderate infestation, and 4 percent with severe infestation. Stripe rust and leaf rust continue to be a concern with the wheat crop. (From June 14, 2010; http://www.nass.usda.gov/Statistics_by_State/Kansas/Publications/Crop_Progress_and_Condition/current.pdf)

Ohio:

The 2008-2009 Crop: Approximately 1,010,000 acres of SRWW were planted in the fall of 2008, down 10% from the previous year. Good planting conditions lead to very good tiller development going into the winter and excellent stand establishment in the spring. Spring and early-summer conditions were cool, and although it rained fairly consistently throughout the development of the crop, cooler-than-usual conditions prevented major disease problems. Powdery mildew developed in the lower canopy early in the season but never really progressed up the plant. Scab levels were very low, confirming predictions made by the scab risk assessment tool.

Cool conditions and nominal disease levels lead to an extended grain full period, resulting in excellent yields and test weighs across the state. An estimated 980,000 acres were harvested. Yields were consistently in the 60 to 90 bu/ac range, with some fields yielding over 100 bu/ac.

The 2009-2010 Crop: Approximately 800,000 acres of SRWW were planted in the fall of 2009, down 20% from the previous crop. Late soybean harvest and poor planting conditions led to wheat being planted well after the Hessian fly-safe date in some fields. Planting intentions were up after an excellent crop in 2009, however, the inability to harvest beans interfered with wheat planting, which was either later than desirable or not at all. In spite of the late planting, however, warm early-winter conditions resulted in very good tiller development and stand establishment.

Spring and early-summer 2010 were wet, with consistent rainfall during the last week of April and throughout the month of May. This lead to moderate to high FHB intensity in some areas, especially fields that reached anthesis between May 19 and 25. Incidence ranged from 3 to 60% and DON contamination from 1 to 18 ppm. Stagonospora leaf and glume blotch severity was also high in some fields, as well as cereal leaf beetle pressure. There were localized outbreaks of leaf rust and loose smut.

Temperatures exceeded 90^{o}F on several days in May. This, coupled with damages caused by diseases and insects, resulted in a shorter grain fill period, and consequently, lower yields and test weights than in 2009. Early reports indicate that yields were in the 45 to 80 bu/ac and test weight in the 45 to 65 lb/bushel range in some fields.

Personnel Changes: Dave Coplin, phytobacteriologist, and Landon Rhodes, Mycologist and Forage Pathologist, retired at the end of 2009. Mike Boehm resigned as chair of the department to take up a position as vice provost for academic planning. The department is conducting an outside search for a new chair. Larry Madden will serve as interim chair until a new chair is hired.

Illinois:

2009 and 2010 – Review and Projection of Growing Seasons

Approximately 820,000 acres of soft red winter wheat out of 850,000 acres planted were harvested in Illinois in 2009. The state average yield was 56 bu/A with a total production of 45.9 million bushels of wheat. The prior 4-year average yield for Illinois (2005-2008) was 62 bu/A. the lower state average observed in 2009 was due mostly to high levels of disease.

Wheat diseases were a major production issue for the 2009 wheat crop in Illinois. Fields in southern Illinois had high levels of Fusarium head blight (FHB), foliar diseases, and glume blotch (Table 1). Poor quality wheat with low test weight and high levels of deoxynivalenol (DON) were common in southern Illinois. DON levels over 2 ppm were very common, with some fields having DON levels over 10 ppm. Growers were docked significantly for their low test weight – high DON grain at the elevator, and some loads were rejected outright.

Table 1. Incidence and severity of leaf and head diseases in southern Illinois wheat fields in 2009.

	Fields	Leaf blotch		Leaf rust		Head scab		Glume blotch	
County	surveyed	Incidence[a]	Severity[b]	Incidence[a]	Severity[b]	Incidence[a]	Severity[b]	Incidence[a]	Severity[b]
Clay	5	85.2	19.6	1.6	0.3	17.6	4.9	68.0	14.3
Gallatin	3	86.7	7.4	16.0	.6	56.0	22.1	52.0	3.7
Jefferson	3	88.0	6.2	13.3	0.2	34.7	8.5	58.7	2.3
Pope	1	100	6.3	0	0	56.0	24.6	56.0	3.5
Randolph	3	77.3	3.3	4.0	0.1	41.0	9.5	50.7	1.8
Saline	1	100	26.0	56.0	1.8	100	27.8	80.0	9.0
Washington	5	76.8	16.2	0.8	0.2	44.0	15.4	53.6	11.0
Wayne	5	86.4	20.4	1.6	0.3	32.8	9.7	85.6	21.1
White	3	97.3	9.8	1.3	0.1	65.3	14.5	92.0	7.0

[a]Incidence: % of flag leaves (leaf blotch and leaf rust) or heads (head scab and glume blotch) affected.
[b]Severity: % area of flag leaf or head affected.

For the 2010 season, approximately 350,000 acres of winter wheat were seeded in the Fall of 2009. This is the lowest wheat acreage in Illinois on record. The low acreage in Illinois is due primarily to the late harvest of soybean and corn fields in the state, which prevented timely planting of winter wheat. High levels of FHB and DON in the 2009 season likely had some impact on the decision of some growers to not plant as many wheat acres in the Fall of 2009.

Preliminary disease observations for the 2010 season indicate that FHB is present in most fields, but at a much lower incidence than in 2009. Stripe and leaf rust can be found in most fields throughout the state. Except for only a few fields, stripe rust levels were generally low. Leaf rust levels have been increasing, and will likely cause observable yield reductions in fields that did not receive a foliar fungicide application.

Research trials

Wheat disease survey. A disease survey of wheat fields was conducted throughout the state. Partial results of the survey from southern Illinois can be found in Table 1. As part of this survey, leaf samples were collected for detection of bacterial mosaic and viruses. Bacterial mosaic was found in a large percentage of the collected leaves. The virus assays are on-going.

Uniform fungicide trials. Fusarium head blight – uniform fungicide trials were conducted at Dixon Springs, Brownstown, Urbana, Carbondale, and Monmouth. In general, Prosaro and Caramba were the best at reducing FHB and DON at locations with moderate to high FHB pressure.

Fungicide timing. As part of the uniform fungicide trial, Prosaro and Caramba were evaluated at different timings (10.5; 10.5.1; and 5 days after 10.5.1) for its control of FHB and DON. In general, applications at 10.5.1 and five days after 10.5.1 provided better control of FHB and DON than applications at 10.5.

Effect of strobilurin fungicides on DON. Headline fungicide was applied at flag leaf, boot, and heading stages to determine its effect on DON. Applications at boot and heading significantly increased DON levels at the Carbondale and Brownstown locations.

Fungicide x cultivar trial. In collaboration with Fred Kolb, a fungicide x cultivar trial was conducted at Urbana. The fungicide treatments included Prosaro, Folicur, and an untreated control. These treatments were applied to twelve different winter wheat cultivars that differed in susceptibility to FHB. In general, the combination of Prosaro plus a high level of host resistance had the lowest FHB and DON levels and the highest yields.

Integrated management trials. FHB integrated management trials that evaluated previous crop (soybean or corn), cultivar (ranging from S to MR for FHB), and fungicide (Prosaro or untreated) were conducted at Carbondale, Dixon Springs, Urbana, and Monmouth. Highest yields were achieved when wheat was planted into soybean stubble and applied with Prosaro fungicide.

Fred Kolb projects:

Breeding for FHB resistance. One current project is focused on identifying genes for FHB resistance in a biparental cross with IL97-1828 crossed to the FHB susceptible cultivar 'Clark'. Recombinant Inbred Lines (RILs) have been developed and DNA has been sent for DArT marker analysis. Phenotypic data are being collected this summer.

"Spray and bag" inoculation technique for FHB. The objective of this project is to determine if evaluations from this technique agree with evaluations from the FHB nursery.

BYDV tolerance in oat (in collaboration with Joe Anderson, USDA-ARS, Purdue). We have two RIL populations(very sus. x very tol. crosses) that we have quite a bit of phenotypic data for. We are growing them in the BYDV nursery again this season and have collected DNA from these populations for DArT marker analysis. This is an exciting study because now we actually have quite a few markers in oat that can be used. We tried to identify genes for BYDV tolerance

in these populations a few years ago, but at that time there were literally only a handful of molecular markers available, so I'm optimistic that we'll have a better chance of finding genes now.

Oat cultivar releases. 'Saber' and 'Corral' were released as oat varieties. Saber is an early variety adapted in the Midwest, and Corral was released in cooperation with Mark Sorrells at Cornell. Corral has performed quite well in New York and is targeted primarily for the Northeast.

Wisconsin:

2009 and 2010 Production Statistics

Small grains production (barley, oats, and wheat) totaled approximately 620,000 acres in 2010. Both barley and oats acreage were up when compared to 2009 (+10% and +3%, respectively), while the wheat crop was down (-25%). One of the key factors that caused a reduction in wheat acres (in particular winter wheat production) was the late harvest in 2009 for corn and soybean. The current USDA-NASS estimate for winter wheat yield in WI in 2010 is 68 bu/A, similar to 2009.

Growing conditions in 2010 have been quite favorable for wheat, as our data suggests we are 7-14 days ahead of 2009 growing conditions.

Major Diseases in 2009-2010 Growing Season

To date, the major disease reported in Wisconsin during the 2009-2010 growing has been powdery mildew and even the occurrence of this disease has varied across locations. The highest levels we have seen so far have been in the northeast portion of the state. There have also been reports of Septoria leaf blotch, but the incidence and severity of this disease has been low during the growing season. We have had some very preliminary reports of very low levels of FHB during the week of June 7. Disease assessments are currently in progress.

Current Small Grains Disease Research Activities:

Current efforts in WI are focused on the development of disease management recommendations for small grains. To accomplish this goal, research currently encompasses several avenues that link with disease management concepts, including understanding the effect of genotype x environment, chemical management, pathogen biology and yield loss modeling. Multiple projects in WI are multi-state and collaborative with funding from USDA and the USWBSI.

1) Winter Wheat Variety Trials (Arlington, Chilton, Janesville, Lancaster) (Ongoing, Drs. Shawn Conley and Paul Esker)
2) Winter Wheat Fungicide Testing Program (Ongoing, Drs. Shawn Conley and Paul Esker)
3) North Central Integrated Pest Management research on *Stagonospora nodorum* and yield loss in winter wheat (Started 2009, Drs. Paul Esker and Shawn Conley, collaborating

with Drs. Pierce Paul (Ohio State U.), Carl Bradley (U. Illinois) and Kiersten Wise (Purdue U.)
4) USWBSI-Integrated Management Trials at Arlington and Lancaster, WI (Started 2009, Drs. Paul Esker and Shawn Conley)
5) HATCH Project – Improved Understanding of *Fusarium* spp. Using Long-Term Rotation Trials in Wisconsin (Started 2010, Drs. Paul Esker, Shawn Conley, and Joe Lauer)
6) Current emphasis in the oat-breeding program (Dr. Heidi Kaeppler) is focused on disease resistance for crown and stem rust, and for tolerance to *Barley Yellow Dwarf Virus*.

Extension Activities:

In 2010, two winter wheat workshops were held (Rockford, IL, joint with U. Illinois) and Brant, WI. Approximately 70 participants learned about wheat growth staging and disease, insect, and weed management. These workshops are currently funded through the NCIPM grant (item 3 listed in research activities).

Minnesota:

2009 season
The start of the 2009 small grains season in Minnesota, was delayed from both the wet fall of 2008 and above average winter snow fall which culminated in widespread flooding in the southern half of the Red River Valley in March. The cool conditions continued into June and heavy rains in May, especially over the Memorial Day weekend, resulted in saturated soils that impacted stand establishment. While the crops generally tillered well, concerns over low spikelets numbers per spike resulted in low initial yield estimates. The harvest was also late, although the final yields were better than expected averaging 54 bu/A. Despite the yield being the forth highest on record, crop quality was poor because of very low grain protein.

Disease problems in 2009 were minimal and few diseases were reported at economically damaging levels. As in 2008 the most common disease of wheat was tan spot. Growers have raised concerns over the increasing prevalence of Bacterial leaf streak in wheat and barley, though at this time it is unclear that BLS is an economic problem in either crop.

The 2009 wheat crop (winter and spring and durum) was 1.66 million acres (spring wheat, 1.6 million acres; winter wheat 55,000 acres). Spring wheat yields average 54 bu/A, 2 bu/A below the 2008 average. Winter wheat yields averaged 45 bu/A, 7 bu/A below 2008, but equivalent to 2007 yields. USDA National Agricultural Statistics are no longer available for durum wheat in Minnesota. Minnesota's barley acreage in 2009 was 95,000 acres, of which only 80,000 acres were harvested, the lowest barley acreage in Minnesota since 1875. The losses in acreage of barley and durum wheat likely reflect the long term impact of FHB on these commodities and poor prices, esp. for feed barley. Barley yields in 2009 averaged 62 bu/A, 3 bu/A below the average yields for 2008. The oat acreage, at 170,000 acres, was 3% below the 2008 crop. The Minnesota oat crop had an average yield of 71 bu/A, 3 bu/A above the 2008 crop.

2010 season
Despite a week or so of near record warm temperatures statewide early in the spring, the start to

the 2010 season was delayed by generally cool weather conditions from April that continued into June. Rain interrupted planting, resulting in a spread of planting dates. While powdery mildew on barley and susceptible wheats has been evident on the St Paul campus at higher levels than any year in the past decade, tan spot has been the most prevalent disease in the early portion of the season in the Red River Valley. In mid-May leaf rust had appeared with severities increasing on susceptible winter wheat varieties in southern portion of the state, while trace amounts of leaf and stripe rust were confirmed in the Red River Valley. Continued wet weather in late June meant fields in many parts of the Red River Valley were completely saturated. In late-June FHB infections were confirmed in winter and spring wheat in the south eastern portion of the state and in the winter wheat variety trial in Crookston. Incidence and severity in the winter wheat variety trial in Crookston was however quiet low and a spell of dry weather in July appears to have diminished the risk of severe FHB developing in the Red River Vallley. In early July, Jochum Wiersma (Small Grains Specialist, NWROC, Crookston) reported active stripe rust in several spring wheat varieties including RB07 and Vantage in plots near Fergus Falls and Bacterial Leaf Streak (BLS) in several production fields around Crookston. The excess precipitation earlier in the season appears also to have contributed to an increased incidence of common root rot. The weather conditions over the next few weeks will likely determine the trajectory of these diseases and determine their impact on crop yields.

New cultivar releases

'Sabin', a medium-maturity hard red spring wheat, is the latest release from the University of Minnesota Agricultural Experiment Station (MAES). Sabin as above average for yield, test weight and protein, average in height and has medium straw strength. Sabin has FHB resistance derived from Sumai 3, is resistant to stem rust, and moderately resistant to leaf and other foliar diseases including Septoria, tan spot, powdery mildew and BLS.

'Quest' is the first malting barley variety release from MAES with improved resistance for FHB. This 6-rowed variety accumulates only about half the level of deoxynivalenol compared to Tradition, Lacey and Robust. Quest is similar in yield and protein to Lacey and Tradition and has now successfully completed a first year plant-scale evaluation by the American Malting Barley Association.

Overview of Present Small Grains Pathology Programs in Minnesota

Fusarium head blight (FHB) research in Minnesota continues as a large collaborative effort. Faculty from the four departments of the College of Food, Agricultural and Natural Resource 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 on wheat and barley. While many researchers in Minnesota have projects funded by the U.S. Wheat and Barley Scab Initiative, research is also supported by state funding and other competitive sources. The research being conducted in Minnesota includes breeding for resistance to FHB in wheat and barley utilizing classical and molecular techniques, investigations on the pathogenic variation in *Fusarium graminearum*, examinations into the

pathways of entry by Fusarium head blight, and the chemical and cultural control practices aimed at the control of FHB.
Drs Yue Jin and James Kolmer at the USDA-ARS Cereal Disease Laboratory (CDL)focus their research on the genetics of stem rust (Yue Jin) and leaf rust (James Kolmer) resistance in wheat. Yue Jin is examining US wheat and barley varieties for their reaction to the TTKSK race and related races of *Puccinia graminis* in seedling screenings in the US and field nurseries in Africa. Les Szabo, also at the CDL, works on the genetics of *Puccinia* species and molecular based diagnostics for race identification.
Research on the foliar diseases of cereals is being conducted by Ruth Dill-Macky (tan spot of wheat; net blotch of barley; loose smut of oat) and Brian Steffenson (Septoria speckled leaf blotch, spot blotch and stem rust of barley).
Jochum Wiersma, the small grains specialist is the Northwest Outreach and Extension Center in Crookston, handles extension for small grains in Minnesota.

Personnel changes in Minnesota

Matthew Rouse has accepted a Research Plant Pathologist position at the USDA-ARS Cereal Disease Laboratory. Matt will be working in the area of host-pathogen interactions of cereal rusts with particular attention to stem rust of wheat and barley. A native Californian, Matt received a B.S. in Zoology from Oklahoma State, and a M.S. from Kansas State where he worked on disease resistance in big bluestem. Matt is currently completing his PhD with Dr. Yue Jin at the CDL, working on mapping resistance genes in wheat to Ug99 stem rust and temperature adaptation of Ug99.

Deon D. Stuthman (1940-2010). Deon died June 18th, 2010 after a short, intense struggle with lung cancer. Deon spent 42+ years as an oat breeder and professor in the Department of Agronomy and Plant Genetics. Deon advised more than 50 graduate students, was a fellow i the American Society of Agronomy, Crop Science Society of America and the American Association for the Advancement of Science and had more than 100 publications to his credit.

North Dakota:

ND Wheat Crop:

Winter wheat acreage estimated to be about 400,000 acres, down some because of cold, wet Sept. and October didn't allow for timely harvest of other crops and didn't result in as much planting. Warm November temperatures were followed by some substantial snows in early Dec. These combinations of conditions resulted in:
good survival of winter wheat
good survival of winter wheat volunteers and spring wheat volunteers
some WSMV infection in fall, very evident in volunteers of winter and spring wheat; moving into adjacent spring wheats in some locations; a dilemma for some producers on whether to replant or leave. Contacted Gary Hein in NE to get his opinion with several fields.

Winter wheat fields in heading to flowering stage; some risk of FHB, according to disease forecasting site, last week in SE, this week in NE.

Spring wheat grown on about 6 million acres: An unusually warm April in much of state allowed earlier planting in 2010 for most of state, except for NW corner. Good planting conditions with considerable soil moisture available. Spring wheat crops look excellent if haven't been drowned out with some excessive, isolated rains, primarily in NE corner of state.

Most in 5 leaf stage now, but early planted fields approaching flag leaf stage.

Most common disease in spring wheat: tan spot, in 90% of fields surveyed in past week, with severity ranging from 1-22%. Many farmers applying fungicides in combination with herbicides; hopefully not on very hot days or days when temps dip down into 30s at night.

Grain aphids just starting to be detected; some BYDV confirmed in volunteer winter wheat and one winter wheat field.

NO stripe or leaf rust yet detected in ND, as of June 8.

Personnel:

Dept. of Plant Pathology hired two new pathologists in past year:
Dr. Robert Brueggeman as barley pathologist, from Andy Kleinhofs lab at WSU.
Dr. Maricelis Acevedo, as wheat rust pathologist, from USDA lab at Aberdeen.

Value of wheat crop in ND: ~ $2.3 to 2.5 billion/yr
Value of NDSU ExtensionNCERA 184 collaborative programs: $30-$50 million /yr from enhanced yield and quality of crop because of disease management recommendations and enhanced disease resistance

New York:

Personnel: Gary C. Bergstrom, Professor
Katrina Waxman, Research Support Specialist
Stanley Kawamoto, Research Support Specialist (part-time)
Julia Crane, Ph.D. Student

2009 Crop Season in Review:
The growing season was conducive for excellent yield of winter wheat in New York. State average yield was at a record high 65 bu/A, while many leading producers topped 100 bu/A. Foliar diseases were not severe, though leaf rust was prevalent during late grain-filling. Fusarium head blight and deoxynivalenol contamination were a problem primarily in late-planted wheat. The acreage shift to red wheat from white wheat continues because of problems with pre-harvest sprouting in white wheats in several recent years.

Current Wheat Pathology Research Projects:

- Seed treatment product evaluation
- Foliar fungicide product evaluation
- Integrated management of FHB (USWBSI)
- Epidemiology of FHB – contribution of in-field corn debris (USWBSI)
- Biological control of FHB by *Bacillus* (USWBSI)
- Cultivar evaluation for soilborne viruses, FHB, and leaf spots
- Epidemiology of *Phaeosphaeria nodorum*

Arkansas:

1. **Crop condition.** Wheat acreage is down to approximately 200,000 acres due to low prices for wheat grain and unusually wet conditions during the planting season last fall. Most wheat was planted later than normal. Wet conditions with lower than normal temperatures during the early winter were not favorable for wheat development. Weather during March and April were favorable for wheat development, and most fields showed improvements in apparent yield potential. Stripe rust was a significant problem in regions where it overwintered. A new race with virulence on *Yr17* attacked several previously resistant varieties. There may be another new race with virulence on a race-specific gene for adult-plant resistance. BYD was widespread, but incidence and severity were low. Leaf rust and Stagonospora leaf and glume blotch developed to significant levels on several varieties late in the season. Head blight was widespread late in the season, but incidence and severity were low.
2. **Impact of NCERA-184 activities.** Information on resistance of cultivars and efficacy of fungicides facilitates cost-effective disease management decisions across the state.

Indiana:

2009 in Review

Harvested wheat acreage in Indiana in 2009 totaled 450,000 acres. Wheat production was down from 560,000 acres in 2008. Total production was estimated at 30.1 million bushels, with an average yield of 67 bu/A. Wheat diseases were generally at low levels throughout central and northern Indiana in 2009. Stagonospora leaf blotch and Septoria leaf blight were problematic in southern Indiana early, and a prolonged period of rainy and humid weather in early May initiated Fusarium head blight (FHB) throughout southern Indiana. The resulting disease caused yield loss and reduction in grain quality due to the mycotoxin DON. Leaf rust moved into Indiana late in the growing season, and stem rust was observed in far southern Indiana, however both diseases arrived too late in the growing season to cause significant yield loss. Several viral diseases of wheat, including wheat streak mosaic virus (WSMV), wheat spindle streak mosaic virus (WSSMV), soil-borne wheat mosaic virus (SBWMV), and barley yellow dwarf virus (BYDV) were confirmed in Indiana.

Projections for 2010

Rainy weather in the fall of 2009 prevented many farmers from planting wheat. Consequently, only 300,000 acres of wheat were planted in Indiana for 2010. Wheat viral diseases were confirmed in the southwest region of the state in early 2010, and in mid-May, rainy weather favored development of foliar diseases such as Septoria/Stagonospora leaf blotch. Stripe rust and leaf rust were also observed across the state, at low to moderate severity, depending on the variety. Fusarium head blight is also widely distributed in the state, with some fields at very low incidence and severity, while other fields will experience moderate to severe yield loss due to the disease. The impact of DON on grain quality may be severe in areas in northern Indiana.

Missouri:

Missouri Winter Wheat Production for 2008-2009 and 2009-2010

2008-2009: Acres planted to winter wheat in Missouri for the 2009 season decreased to 750,000 acres, down from 1,160,000 acres in 2008. Wet conditions during the fall of 2008 resulted in late soybean harvest and late wheat planting. In some cases wheat did not get planted.

Out of 800,000 acres planted in the fall of 2008 approximately 750,000 were harvested in 2009. The average yield in 2009 was expected to be 51.0 bushels per acre up from 48 bushels per acre in 2008.

2009-2010: Fall seedings for the 2010 winter wheat crop in Missouri totaled 420,000 acres, down 46% from the 2009 seeded acreage and 66% below the level of 2 years ago. This is the lowest winter wheat seeding on record, mainly due to an extremely late harvest for row crops.

Missouri Crop & Livestock Reported for May 2010:
Higher failed acres and a lack of yield potential have combined to bring winter wheat harvested acres to a record low. Excessive rainfall during the planting season delayed planting and hindered the development of the winter wheat crop. At the beginning of May, the crop was rated 26% very poor to poor compared with last year when only 9% fell into these categories.

Missouri production of winter wheat is forecast at 14.3 million bushels, based on conditions as of May 1, 2010, 58% below the 2009 crop and 74% below 2 years ago. This is third lowest production on record. The lowest record occurred in 1942 when 9.04 million bushels were harvested from 695,000 acres. Missouri's largest production occurred in 1981 when 116 million bushels were harvested from 2.75 million acres. Yields in the state are expected to average 46 bushels per acre, down 1 bushel from the 2009 yield and 2 bushels below 2008. Harvested acres are forecast at 310,000 acres, the lowest level since records began in 1909. This is down 58% from the 2009 acreage level and 73% below 2008.

Winter Wheat Issues and Disease Update
The major issue is the dramatic decline in winter wheat acres in Missouri. The decrease in wheat acres may have been related to the decrease in wheat prices and, most certainly, was related to

the wet fall which delayed harvest of both corn and soybeans. This harvest delay resulted in late planting of winter wheat and in some cases wheat did not get planted.

Late planted wheat went into the winter with less than normal growth. Wheat was slow to green up in the spring, slow to tiller and in some fields uneven in growth. Wet conditions during the spring of 2010 led to difficulties applying fertilizer and to leaching of fertilizer that had been applied.

Most of the state received rain as the wheat crop was flowering and conditions were quite favorable for the development of Fusarium head blight or scab. This is the third year in a row that Fusarium head blight or scab has been a statewide problem.

Cool conditions for much of the spring and early summer limited the development of most fungal foliage diseases. Septoria leaf blight came in late in the season. Leaf rust and stripe rust were not problems in most of Missouri during the 2010 season. Samples from various regions of the state tested positive for wheat soil-borne mosaic, wheat spindle streak mosaic and barley yellow dwarf; however, virus diseases were not widespread or severe.

Winter Wheat Research Projects

The past two years have seen an increase in request for winter wheat seed treatment trials. During the 2010 season, three seed treatment trials are being conducted. Stand establishment was a problem in the fall of 2009 and trials had to be replanted. Because of extended periods of wet weather the replanting was extremely late so plants were not well established going into the winter and stands still show effects of late planting and unfavorable environmental conditions.

Foliar fungicide trials in 2009 showed little benefit from fungicide application because disease pressure was low and foliage diseases did not become established until well after flowering. Similar results are expected for 2010 trials.

Missouri participated in the Uniform Scab Biologicals Trial during 2008, 2009 and 2010. Scab was a serious problem in central Missouri during both 2008 and 2009 so results have been very useful. Scab appears to be severe in susceptible varieties but low in moderately tolerant to tolerant varieties so it will be interesting to see what differences occur. In the 2009 Integrated Scab Management Trial, there were significant differences in the DON levels from the two rotations with the wheat in the corn residue having higher DON levels than the wheat in the soybean residue. There were also significant differences between varieties and fungicide treatments. Again, scab appears to be severe in the susceptible variety but low in the moderately tolerant to tolerant varieties. It will be interesting to see if this changes prior to harvest and what differences are significant.

Louisiana:

<u>Personnel:</u> Boyd Padgett – Professor
Myra Purvis – Research Associate

2009-10 Crop Season

One hundred fifty thousand acres of wheat were planted in Louisiana (09-10). This acreage was a substantial decrease from 2008-09 (235,000 acres). Weather was favorable at planting. Leaf and stripe rust were the predominant diseases in susceptible varieties. A race of the stripe rust pathogen was observed on AGS 2060 (classified as resistant). Samples were sent to the Cereal Rust Laboratory. Stem rust was observed in the LSU AgCenter variety test located at the Macon Ridge Research Station in Northeast Louisiana. Yields summaries are not available the time this report was prepared.

Current Research Projects and Impact on Wheat

U.S. Wheat and Barley Scab Initiative - Development of FHB Resistant Wheat Genotypes Adapted to the Gulf Coast. This project is a part of a nationwide effort to identify varieties/lines for genetic resistance to *Fusarium graminearum*. (Steve Harrison-P.I., Don Groth)

Louisiana Soybean and Feed Grain Research and Promotion Board – Disease Management in Louisiana Wheat. This is a multi-discipline effort to evaluate entries in LSU AgCenter wheat and oat variety tests for disease reactions to naturally-occurring diseases. Develop disease management strategies using genetic resistance and fungicides. Conduct yield loss studies to ascertain the impact of diseases on wheat produced in Louisiana. Information is used to develop recommendation for wheat produced in Louisiana and the Mid-South.

Collaborate with LSU AgCenter entomologists and agronomists in studies designed to develop effective management strategies for Hessian Fly.

Stem Rust Monitoring Effort – Responsible for coordinating efforts in the Mid-South and Southeast U.S. Project coordinator Erick DeWolf

Nebraska:

2009: Wheat harvested area was 1.63 million acres. Average yield was 48 bu/acre. Total production was 78.24 million bushels. May was dry, followed by prolonged rain in June. Fusarium head blight (FHB) was widespread but with much lower severity than in 2007 and 2008. FHB was most severe in southwest NE. It also occurred in the Panhandle, a rare event. Leaf spot diseases were mainly tan spot and Septoria tritici blotch. Bacterial leaf streak/black chaff occurred in some fields especially in southwest NE. Leaf rust onset was late in the season, therefore its impact was low except in late maturing fields planted with susceptible varieties. Virus diseases observed were Triticum mosaic, wheat streak mosaic, wheat soilborne mosaic, and wheat spindle streak mosaic.

2010: Wheat production is forecast at 69 million bushels, down 10% from 2009. Average yield is forecast at 46 bu/acre, down 2 bu/acre from 2009, but 5 bu/acre above the ten year average. Harvested acres are forecast at 1.5 million, down 6% from 2009. Major diseases observed as of early June are stripe rust , Septoria tritici blotch. Diseases observed to a less extent as of early June are leaf rust, wheat streak mosaic, barley yellow dwarf, and Triticum mosaic.

Current research: epidemiology and integrated management of Fusarium head blight; regional distribution, etiology, and epidemiology of Triticum mosaic virus.

Accomplishments:

The objectives of NCERA 184 are to: 1. Facilitate collaborative research on current and emerging diseases of small grains. Specifically: a) The integrated management of Fusarium head blight b) Fungicide efficacy trials for diseases of small grains c) Epidemiology and risk management d) Screening of uniform regional nurseries for resistance to economically important pathogens e) Studies of the population biology of small grain pathogens f) Develop disease and economic threshold models to improve foliar disease management in wheat g) Stem rust surveillance and preparation of stem rust race Ug99.

2. Promote the exchange of information, techniques, fungicide efficacy results, disease resistant germplasm and pathogen cultures among small grains researchers in order to coordinate the development of integrated management strategies for important diseases.

Accomplishments for Objective 1. Facilitate collaborative research on current and emerging diseases of small grains

a. Integrated Management of Fusarium head blight (FHB). Several members of NCERA 184 have been conducting FHB integrated management field research trials as part of a multi-state effort led by Pierce Paul (Ohio St. Univ.) and supported by the U.S. Wheat and Barley Scab Initiative (USWBSI). Results from these trials have been used in Extension programming across the U.S., and have been utilized for the development of a ScabSmart website supported by USWBSI.

b. Fungicide Efficacy Trials for Diseases of Small Grains. A Foliar Fungicide Efficacy Table has been developed and is updated annually by NCERA 184 members for the past several years. Results from foliar fungicide trials conducted by NCERA 184 members and others are utilized to develop this table. The table has been widely used by Extension specialists, crop consultants, industry personnel, and growers throughout the U.S., especially areas east of the Rocky Mountains.

c. Epidemiology and Risk Management. NCERA 184 members coordinated the national level deployment of disease prediction models for Fusarium head blight (hosted at: www.wheatscab.psu.edu). These prediction models are used in 24 states east of the Rocky Mountains. Specialists in each of these states have the opportunity to provide text commentary about disease observations in the state and to help provide additional information about their state's risk of FHB based on the prediction output. The FHB prediction center's website receives thousands of visits every year with peaks prior to and during flowering of small grain crops in each state. Erick de Wolf (Kansas St. Univ.) is leading a stem rust surveillance effort, in which several NCERA 208 members are cooperating. One of the goals of this effort is to help detect for the presence of the TTKS race of stem rust, which is an international threat to wheat. Members of NCERA 208 also are cooperating in developing educational material about TTKS stem rust

and other rust diseases of wheat. Additionally, NCERA 184 members submit rust observations during the season to the Cereal Rust Bulletin and list-serv. These specific state observations alert other states on their individual state's risk of rust diseases and provide information on when and where rust could arrive in a state.

d. Screening of Uniform Regional Nurseries for Resistance to Economically Important Pathogens. NCERA 184 members shared their latest research results on resistance of wheat cultivars and lines in coordinated regional nurseries to Fusarium head blight, Septoria tritici blotch, Stagonospora nodorum blotch, tan spot, stripe rust, leaf rust, stem rust, and several viral diseases. This shared information on varietal reaction is incorporated consistently into regional and state extension recommendations.

e. Studies of the Population Biology of Small Grains Pathogens. NCERA 184 members collected and submitted samples of the major rust pathogens of the small grains (e.g. leaf, stem and stripe rusts of wheat, crown rust of oats, etc.) to collaborating USDA-ARS scientists (Y. Jin, J. Kolmer, and X. Chen) for race and virulence determination. This project allows continual monitoring of the population/virulence structure of cereal rusts in North America and provides critical guidance to small grains breeding programs.

f. Members of NCERA-184 successfully acquired funding and initiated a two-year research-extension project to develop disease and economic threshold models to improve foliar disease management in wheat. Beginning in 2009, similar field experiments were conducted in OH, IN, IL, and WI to 1) evaluate the relative disease management, yield, and economic benefits of early-season (pre flag-leaf emergence) foliar fungicide application in soft red winter wheat, 2) evaluate the relevance of existing flag leaf-based foliar fungicide application thresholds and develop novel thresholds based on yield and economic criteria, and 3) Implement training programs for soft red winter wheat production in the North Central region using winter workshops and field demonstrations.

g. A proactive plan for surveillance of stem rust for changed virulence and assessment of small grain cultivars for resistance and foliar fungicides for management has been set in motion prior to the arrival of the Ug99 strain of stem rust in North America. A publication produced in preparation for Ug99 stem rust was customized with logos and contact information (generally the NPDN labs) for use in 26 states and 1 Canadian province. A national version of the publication (regional hubs of NPDN as contacts) was developed for the USDA-CDL, and 2 states that did not want a customized version of the publication. The 33,600 printed publications were also distributed as part of the project.

Accomplishments for Objective 2. Promote the exchange of information, techniques, fungicide efficacy results, disease-resistant germplasm, and pathogen cultures among small grain researchers in order to coordinate the development of integrated management strategies for important small grain diseases.

A wheat disease listserv (wheatdisease@listerv.ksu.edu) has been established and is hosted at Kansas State University. Subscribers to the listserv include NCERA 184 committee members as well as other university, extension, and government personnel that work on small grain diseases.

This listserv serves as an electronic forum in which NCERA 184 members can communicate throughout the year. NCERA 184 members also communicate and exchange information through other forums, such as the cereal rust survey listserv (cereal-rust-survey@lists.umn.edu) and regional and national meetings.

Because the 2010 North Central APS meeting overlapped with the NCERA-184 meeting, participants were able to interact with plant pathologists from the north central region. This provided the opportunity for members to learn about and discuss ongoing north central region disease issues. Many members from NCERA 184 developed grant proposals and collaborated in research grants funded by the U. S. Wheat and Barley Scab Initiative (USWBSI). Multi-state projects include Coordinated Uniform Fungicide Research Trials to control Fusarium head blight (FHB) and Integrated Management Research Trials to control FHB. NCERA-184 members continue to collaborate on research projects funded by other agencies.

Impact Statements:

1. The NCERA 184 meeting continues to serve as an annual forum for small grain pathologists to exchange information on regional, national, and international diseases. The NCERA 184 committee helps drive collaboration among members in research and outreach activities. The large number of collaborative research and extension publications among NCERA 184 members is evidence that NCERA 184 helps drive this collaboration.
2. Discussions among participants of the NERA-184 meetings have helped in the efficiency and accuracy of applied disease research efforts on small grain crops in participating states. The following types of experiments have been aided by these meetings: a. determining the reactions of breeding lines and commercial winter wheat cultivars to various diseases; b. dissemination of disease-reaction data of cultivars to wheat producers; c. the effect of seed-treatment and foliar fungicides on wheat diseases; and, d. the effect of cultivar mixtures, tillage practices, crop rotations, and epidemic age on foliar disease development. Progress toward identifying resistance to wheat pathogens has helped in the development of new, resistant cultivars.
3. Communication among small grains pathologists is strong and the means of communication have improved. The development of a wheat disease listserv (wheatdisease@listserv.ksu.edu) has been established. This fosters communication among small grain pathologists throughout the year. Members of NCERA 184 continue to communicate through the cereal rust survey listserv (cereal-rust-survey@lists.umn.edu) during the growing season as cereal rusts are reported in each state. This high-level of communication among NCERA 184 members helps improve disease management recommendations in each state.
4. Because of collaborative research efforts among NCERA 184 members, field research results have shown that the best control of Fusarium head blight (FHB) is achieved through integrated management practices. This information has been used in Extension programs across several states, and growers are adopting these practices to reduce FHB.
5. A multi-state Fusarium head blight disease forecasting system has promoted better stewardship of foliar fungicide applications by providing growers with information that can be used to help make fungicide application decisions based on the threat of disease.

This web-based risk prediction system received over 8,850 visits during the period when wheat was actively growing (April – August) in the 24 states in which it is deployed. A user survey conducted in 2009 which included 593 respondents indicated that 70% of these users were either farm advisors or farmers. Other users of the system included university extension personnel and members of the grain marketing and milling industries. The survey also indicated that 77% of the users applied the information provided by the prediction system for direct on-farm management decisions, or providing recommendations for disease management. In 2009, 92% of the users considered the information to be of high or moderate value for their farm operations or organization. The estimated net value of the disease prediction system to U.S. wheat growers exceeds $47 million.

6. NCERA 184 multi-state projects designed to investigate factors influencing the accumulation of DON in disease-free wheat grain, develop integrated management programs to minimize losses due to FHB/DON, and develop models to predict FHB/DON are ongoing. Findings thus far suggest that *F. graminearum* spore abundance and weather conditions interact with cultivar FHB resistance to affect toxin buildup in both diseased and healthy-looking grain, and have contributed to the development of new DON prediction models. Results from current studies could contribute to improving the accuracy of recently-developed DON prediction models and the overall efficacy of management strategies for FHB and DON. DON prediction models will serve as tools to help guide fungicide use and grain marketing decisions. Results also indicate that well-timed fungicide applications when combined with cultivar resistance can significantly reduce the impact of FHB and DON and increase yields.
7. Small grain disease surveys conducted in many of the NCERA 184 member states provided information on disease occurrence, distribution, and potential effects on yield and quality.
8. The information generated from the sampling of rust isolates (and race determination by the USDA-ARS-Cereal Disease Laboratory) are utilized to make informed recommendations to small grain breeders concerning the selection and introgression of effective rust resistance genes into elite germplasm and future varieties.
9. Due to collaborative efforts of NCERA 184 members, new outreach materials are being developed to educate the public about important diseases. These include new educational materials being developed for the Ug99 strain of stem rust, and the development of a ScabSmart web site that contains the best Fusarium head blight management information available.
10. The annually updated Foliar Fungicide Efficacy Table developed by the NCERA 184 Committee members continues to be utilized by Extension personnel, industry personnel, crop consultants, and growers. The development of this table has resulted in more accurate and realistic chemical control recommendations for small grain producers and has facilitated cost-effective disease management decisions in NCERA 184 states.
11. Members of the NCERA-184 successfully acquired funding and initiated a two-year research-extension project to develop disease and economic threshold models to improve foliar disease management in wheat. Beginning in 2009, similar field experiments were conducted in OH, IN, IL, and WI to 1) evaluate the relative disease management, yield, and economic benefits of early-season (pre flag-leaf emergence) foliar fungicide application in soft red winter wheat, 2) evaluate the relevance of existing flag leaf-based

foliar fungicide application thresholds and develop novel thresholds based on yield and economic criteria, and 3) Implement training programs for soft red winter wheat production in the North Central region using winter workshops and field demonstrations.