USDA-ARS / USWBSI
FY04 Preliminary Final Performance Report
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Cover Page

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Year:	**FY2004** (June 04 – June 05)
FY04 ARS Agreement ID:	**59-0790-4-123**
Agreement Title:	**Fusarium Head Blight of Wheat: Epidemiology and Management by Genetic and Chemical Means.**
FY04 ARS Award Amount:	**$ 84,639**

USWBSI Individual Project(s)

USWBSI Research Area*	**Project Title**	**ARS Adjusted Award Amount**
CBC	Uniform Fungicide Trials for Control of Fusarium Head Blight.	$ 10,980
EDM	Effect of Inoculum Abundance and Weather on Fusarium Head Blight of Wheat.	$ 39,512
GIE	Characterization of New Sources of Resistance to Fusarium Head Blight of Wheat.	$ 34,146
	Total ARS Award Amount	**$ 84,639**

Principal Investigator Date

* BIO – Biotechnology
CBC – Chemical & Biological Control
EDM – Epidemiology & Disease Management
FSTU – Food Safety, Toxicology, & Utilization
GIE – Germplasm Introduction & Enhancement
VDUN – Variety Development & Uniform Nurseries

(Form – FPR04)

Project 1: *Uniform Fungicide Trials for Control of Fusarium Head Blight.*

1. What major problem or issue is being resolved and how are you resolving it?

The shift to conservation tillage methods of crop production was a major contributor to destructive epidemics of *Fusarium* head blight (FHB) of wheat and barley in the U.S. in the 1990s. Production of susceptible cultivars and favorable weather also promoted disease. Control of FHB will require several disease management strategies, coupled with greater understanding of its epidemiology. Crop rotations or tillage to destroy residues have not been widely used because efficacy has not been clearly demonstrated or because of negative impacts on soil conservation. Genetic resistance may provide only partial control. Cultivars with any degree of resistance are only now becoming available. Other disease management practices may be needed to augment partial resistance, especially under conditions very favorable for FHB.

Fungicides would provide growers with a management option when susceptible cultivars are grown, and may help protect grain yield and quality of cultivars with partial resistance under conditions particularly favorable for disease. A few fungicides have shown some efficacy against FHB, but do not provide complete control or the desired consistency. Some fungicides reduce DON contamination of grain, but others may cause an increased amount of DON.

The purpose of this cooperative study is to compare a core set of fungicide treatments at several locations throughout the Corn Belt and upper Midwest for their efficacy against FHB of wheat and barley and for their ability to preserve grain quality and prevent accumulation of DON.

2. What were the most significant accomplishments?

Accomplishment: Management of Fusarium head blight requires an integrated approach. There is insufficient genetic resistance in currently available wheat cultivars to protect the crop when weather conditions are favorable for infection and disease development. Fungicides may provide some control of the disease, and may complement partial resistance, as it becomes available, to essentially eliminate damage. However, there are no fungicides labeled for use on wheat against Fusarium head blight. This project was part of a coordinated system of uniform trials, in which fungicides were evaluated for their ability to suppress head blight symptoms in the field, to protect yield and test weight, and to suppress formation of deoxynivalenol in grain.

Impact: This work showed that under weather conditions favorable for severe head blight, experimental fungicides were superior to registered products for suppression of head blight symptoms and prevention of formation of deoxynivalenol formation in grain. One fungicide in particular, JAU6476, greatly reduced incidence of head blight and also retarded spread of symptoms in those heads that were infected. It also was the most effective at reducing levels of deoxynivalenol in grain. Although some fungicides reduced severity of head blight, they had no effect on concentration of deoxynivalenol in grain.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?:

This study, in combination with studies at other locations, provides data that may support registration of new fungicides that will reduce head blight severity and deoxynivalenol concentration in grain much more than currently registered products. If these new products are registered, this will provide farmers an effective means of controlling Fusarium head blight of wheat.

Project 2: *Effect of Inoculum Abundance and Weather on Fusarium Head Blight of Wheat.*

1. What major problem or issue is being resolved and how are you resolving it?

The shift to conservation tillage methods of crop production is thought to be a major contributor to destructive epidemics of *Fusarium* head blight (FHB) of wheat and barley in the U.S. in the 1990s. Susceptibility of widely grown cultivars also contributed to epidemics. Bringing FHB under control will require multiple disease management strategies, based on understanding its epidemiology. Crop rotation or tillage to reduce the amount of residue that harbors the pathogen might contribute to a disease management program, but the effects of these practices on reducing inoculum levels are poorly understood.

An important question for management of scab is the effect of local inoculum density versus a background density in a large area. That is, how effective is residue management, through crop rotation or tillage, in managing scab on a field-by-field basis, if inoculum-bearing residue (corn or small grain) is widespread in a region?

If inoculum level is limiting, then for any given set of weather conditions during flowering and early grain fill, the incidence of FHB should be quantitatively related to the abundance of inoculum. This study investigated this relationship by comparing the effects of different densities of corn residue in plots of wheat. We monitored production and dispersal of spores of *Gibberella zeae* during the period that wheat is vulnerable to infection, with volumetric spore samplers and by recovering spores from wheat heads. We also monitored development of head blight in the field, and assessed harvested grain for visible damage, infection by the fungus, and for content of deoxynivalenol. We also monitored head blight, grain damage, and deoxynivalenol content in wheat variety trials conducted throughout the state. Weather variables were monitored hourly at each experimental site. The data on weather and disease intensity are used to develop and refine weather-based risk prediction models.

2. What were the most significant accomplishments?

Accomplishment: Differences in density of corn residue within wheat plantings had no effect on severity of Fusarium head blight when weather was particularly favorable for the disease. Airborne inoculum was sufficiently abundant and mobile to obscure local differences of inoculum source within a field. Head blight development at each of several locations around Indiana was much greater than predicted by a model that uses pre-flowering weather to determine risk. This most likely resulted from the fact that although pre-flowering weather was not conducive to inoculum production and infection, weather during flowering was conducive. Deoxynivalenol (DON) levels in grain were not closely related to severity of head blight symptoms in the field. For example, trials at southwest and northwest Indiana had similar mean severities, yet greatly different DON levels. A poor correlation between symptom severity and DON was observed among cultivars within each location. DON concentrations ≥2 ppm were associated with severities that ranged from 1.5% to 38.5%; DON concentrations <2 ppm were associated with severities from 0.6% to 34.8%.

Impact: This work shows that even when weather just before flowering of wheat is not conducive to inoculum production and infection, severe infection and disease development can develop if weather becomes favorable for these events during flowering. This allows sufficient time for the fungus to produce spores on corn residue and for these spores to infect wheat and produce head blight symptoms. DON is a major concern for wheat millers and processors. Our study shows that head blight severity in the field is a poor predictor of DON. Wheat with severe head blight may have little DON. Conversely, wheat with a low severity of head blight may have DON above 2 ppm.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?:

Results of this study suggest that predictive models based on weather after the commencement of flowering may be of value for alerting growers, grain buyers, millers, and bakers of a head blight problem. A model that relies on weather after commencement of flowering would be of limited value for making fungicide application decisions (unless such a model could use predicted rather than observed weather), but it would alert grain users to a potential problem in grain quality from certain locations. The poor correlation between head blight severity and DON indicates that there would be value in developing a weather-based risk model for specific prediction of DON. All modeling work so far has focused on head blight severity in the field as the predicted variable.

Project 3: ***Characterization of New Sources of Resistance to Fusarium Head Blight of Wheat.***

1. What major problem or issue is being resolved and how are you resolving it?

Resistant cultivars will be an essential component of management of FHB. Wheat breeders are using a few different sources of resistance, but none of these completely controls FHB or accumulation of DON (deoxynivalenol) in grain. Nearly all wheat breeding programs in the U.S. at first relied on the Sumai 3 resistance. Some additional sources of resistance are now being incorporated into breeding programs, although it is not clear to what extent these represent unique genes. Given the variability within *Fusarium*, if the same source of resistance were to be used widely in the U.S., strains of *F. graminearum* or other *Fusarium* species able to partially overcome this resistance may arise. It is prudent to seek other genes for resistance to diversify the genetic base of resistance.

The resistance of Sumai 3 (or of any other source of resistance yet identified) is not as complete as would be desired. Different resistance genes might interact with the genes in Sumai 3 to confer a greater degree of resistance. Sources of resistance other than the few being currently used need to be identified, characterized phenotypically and genetically, and made available to wheat breeders. Prebreeding, to develop transgressively resistant lines, can provide useful germplasm to wheat breeders.

Type II resistance is assessed in the greenhouse using single-floret inoculation. In segregating populations, severity of head blight (the number of blighted spikelets per spike) is continuously distributed, suggesting that several loci control the phenotype. However, a large nongenetic variance will smooth a distribution even if only 1 or 2 genes control the trait. Large nongenetic variance also reduces heritability. We need accurate estimates of nongenetic variance so as to design efficient selection schemes and to study inheritance of resistance. This is especially important as researchers attempt to identify unique resistance genes.

Type II resistance will probably not be sufficient for protection of wheat in the field when weather is highly conducive to development of head blight. Germplasm needs to be evaluated for resistance to primary infection (type I). We evaluated germplasm for both type I and type II resistance after controlled inoculation in the greenhouse. We also evaluated the effect of inoculum concentration, growth stage of wheat at inoculation, and pattern of inoculum application on the expression of type I resistance.

2. What were the most significant accomplishments?

<u>Accomplishment</u>: Wheat lines previously selected for type II resistance to *Fusarium graminearum* were tested for both type I and type II resistance. There was a fairly high correlation in expression of type II resistance between experiments, but a lower correlation in expression of type I resistance between experiments. There was no correlation between type I and type II resistance. Growth stage at inoculation, concentration of inoculum, and method of inoculation (spraying one or both sides of the spike) all influenced expression of type I resistance. Moreover, there were significant interactions among wheat lines and these variables. The same general results were found when a recombinant inbred population, derived from a

wheat cultivar with moderate resistance to *F. graminearum* crossed to a susceptible cultivar, was evaluated for both types of resistance.

Impact: This work shows that resistance to initial infection by *F. graminearum* (type I) is independent to a considerable degree to resistance to spread of symptoms within the spike after infection (type II). This means that wheat lines selected for one or the other type of resistance should be evaluated for the other type. In theory, spray inoculation could be used to evaluate type I resistance, by assessing symptom severity 5 days after inoculation. For those plants that showed type I resistance, their type II resistance could be evaluated by assessing severity at 15 or 20 days after inoculation. However, the non-genetic variability in expression of resistance following spray inoculation is much greater than for point inoculation, which only assesses type II resistance.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?:

This work suggests that different genes may confer type I and type II resistance. By combining a line with type I resistance with a line with type II resistance, it should be possible to develop a cultivar with a degree of resistance in the field superior to either parent. This work also demonstrates that evaluation of type I resistance in a manner that gives consistent results is difficult. The significance of interactions among lines and inoculation variables means that a line may need to be tested under several different conditions to determine the stability of its type I resistance.

Include below a list of the publications, presentations, peer-reviewed articles, and non-peer reviewed articles written about your work that resulted from all of the projects included in the grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.