USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
July 13, 2012

Cover Page

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Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0790-8-060
USDA-ARS Agreement Title:	Engineering Fusarium Head Blight Resistance and Plant Defense Signaling.
FY11 USDA-ARS Award Amount:	$ 58,537

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
GDER	Targeting Host Defense Mechanism for Enhancing FHB Resistance in Wheat.	$ 58,537
	Total ARS Award Amount	**$ 58,537**

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Principal Investigator Date

* MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
HWW-CP – Hard Winter Wheat Coordinated Project
VDHR – Variety Development & Uniform Nurseries – Sub categories are below:
SPR – Spring Wheat Region
NWW – Northern Soft Winter Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: *Targeting Host Defense Mechanism for Enhancing FHB Resistance in Wheat.*

1. What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

Fusarium head blight (FHB; also known as Scab) is an important disease of wheat and barley for which monogenic resistance is not available. A combination of planting partially resistant varieties with fungicide application and crop rotation is used to control FHB. Genetic engineering is being utilized as a parallel approach to develop wheat and barley germplasms with heightened resistance to FHB. Novel genes and chimeras that are not in the partially resistant germplasms can be introduced into wheat and barley, thus adding to the repertoire of genes that can be utilized in FHB resistance breeding programs. For example, ectopic expression of the *Arabidopsis thaliana NPR1* (At*NPR1*) gene enhanced FHB resistance in wheat. Enhanced resistance was observed under greenhouse and field conditions. *NPR1* controls the activation of salicylic acid-dependent defense responses (e.g. systemic acquired resistance) in plants, which is important for resistance to *F. graminearum* in *Arabidopsis thaliana* and wheat. *PAD4* and *WRKY18* are two other genes that when overexpressed in *Arabidopsis thaliana* and wheat enhance resistance to *F. graminearum*. *PAD4* modulates salicylic acid synthesis and *WRKY18* is a transcription factor functioning in the SA signaling pathway. In addition, as described below, we have also targeted non-host resistance mechanism for enhancing FHB resistance. Host factors that contribute to susceptibility to *F. graminearum* have also been targeted for enhancing FHB resistance. Our results indicate that silencing expression of a lipid oxidizing lipoxygenase enhances resistance against *F. graminearum*, presumably by promoting the rapid activation of plant defenses.

2. List the most important accomplishment and its impact (i.e. how is it being used) to minimize the threat of Fusarium head blight or to reduce mycotoxins. Complete both sections (repeat sections for each major accomplishment):

(a) **<u>Accomplishment:</u>** Two *AtPAD4* expressing wheat cv. Bobwhite have been studied in green house experiments. Both these lines exhibits enhanced resistance to *F. graminearum*.

<u>Impact</u>: AtPAD4 transgenic wheat are currently undergoing field trials in Minnesota to determine the effectiveness of *AtPAD4* in enhancing FHB resistance under field conditions. These AtPAD4 wheat lines will provide germplasms that potentially can be utilized in future FHB breeding programs.

(b) **<u>Accomplishment</u>**: Two of three transgenic wheat AtWRKY18 lines that were developed exhibited enhanced FHB resistance in greenhouse experiments. Mycotoxin content was also lower in one of these lines.

<u>Impact</u>: The introduction of the *AtWRKY18* construct into wheat is expected to provide new FHB resistant germplasms.

(c) **<u>Accomplishment</u>:** Salicylate hydroxylase expressing NahG wheat consistently demonstrated enhanced FHB severity in greenhouse studies and in a field trial. Furthermore, *NahG* suppressed *AtNPR1* conferred FHB resistance.

Impact: These results conclusively demonstrate that salicylic acid is critical for wheat defense against FHB and that this mechanism is potentially a good target for engineering enhanced FHB resistance. The NahG wheat will be useful for studying the mechanism of action of other inducers of FHB resistance, and will provide a genetic resource for the community to study wheat defense against other pathogens, as well.

(d) Accomplishment: Expression of wheat *LOX* genes was silenced by RNAi in transgenic wheat. Although still segregating for the transgene, the LOX-silenced plants exhibited enhanced resistance against *F. graminearum*, thus suggesting that the corresponding *LOX* gene(s) contributes to host susceptibility to *F. graminearum*. Experiments in Arabidopsis indicate that the fungus targets these *LOX* genes to suppress the timely activation of host defenses and thus facilitate infection.
Impact: These RNAi-silenced lines will be used to further characterize the impact of these genes/processes on FHB resistance. Lines exhibiting enhanced resistance will provide novel germplasms for breeding FHB resistance.

(e) Accomplishment: A construct that will target flg22 peptide expression to the apoplast has been introduced into Arabidopsis and wheat to determine the impact of constitutive apoplastic expression of the flg22 peptide on host resistance against *F. graminearum*. In addition, a construct to constitutively express the flg22-responsive *WRKY29* gene in wheat has been bombarded into wheat and transgenic plants identified.
Impact: Stimulation of non-host defenses to enhance FHB resistance could provide an alternative strategy that complements existing approaches to control a broad-spectrum of diseases in wheat.

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.

Publications

Peer reviewed

- Makandar, R., Nalam, V., Lee, H., Trick, H.N., Dong, Y., and Shah, J. (2012). Salicylic acid regulates basal resistance to Fusarium head blight in wheat. Mol. Plant-Microbe Interact. 25, 431-439.

- Chaturvedi, R, Venables, B., Petros, R.A., Nalam, V., Li, M., Wang, X., Takemoto, L.J., and Shah, J. (2012) An abietane diterpenoid is a potent activator of systemic acquired resistance. Plant J. 71, 161-172.

Proceedings

- Nalam, V.,Klossner, G., Sarowar, S., Lee, H., Trick, H, and Shah, J. (2011) Engineering defense regulatory genes and host susceptibility factors for enhancing FHB resistance in wheat. In: S. Canty, A. Clark, A. Anderson-Scully, D. Ellis and D. Van Sanford (Eds.), Proceedings of the 2011 National Fusarium Head Blight Forum (pp.90), East Lansing, MI/Lexington, KY, US Wheat and Barley Scab Initiative.

- Syyerson, R.L., Elakkad, A.M., Dahleen, L.S., Nalam, V.J., Klossner, G., Shah, J., and Dill-Macky, R. (2011). Testing transgenic spring wheat and barley lines for reaction to Fusarium head blight: 2011 field nursery report. In: S. Canty, A. Clark, A. Anderson-Scully, D. Ellis and D. Van Sanford (Eds.), Proceedings of the 2011 National Fusarium Head Blight Forum (pp.97), East Lansing, MI/Lexington, KY, US Wheat and Barley Scab Initiative.

Oral Presentations

- *Title*: An overview of wheat transformation at K-State
  Conference: 011 National Fusarium Head Blight Forum, St. Louis, MO, De.r 4-6, 2011
  Author: Trick, HN

- *Title*: Abietane diterpenoid in plant defense signaling
  Conference: PR-Proteins and Induced Resistance against Pathogens and Insects held at University of Neuchâtel, Switzerland, 4 - 8 September 2011
  Authors: Chaturvedi R, Venables BJ, Petros R, Takemoto LJ, Nalam V, Maoyin L, Wang X, and Shah, J

- *Title*: Identification of a diterpenoid as a vasculature translocated signal associated with the activation of systemic acquired resistance
  Conference: 22nd International Conference on Arabidopsis Research Arabidopsis meeting, Madison, WI, June 22-25, 2011
  Authors: Chaturvedi R, Venables BJ, Petros R, Takemoto LJ, Nalam V, Maoyin L, Wang X, and Shah, J