USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY05 Final Performance Report (approx. May 05 – April 06)
July 14, 2006

Cover Page

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Fiscal Year:	**2005**
FY05 ARS Agreement ID:	**58-5430-3-315**
Agreement Title:	**Diversity, Genetics, and Engineered Resistance to Fusarium Head Blight.**
FY05 ARS Award Amount:	**$ 69,876**

USWBSI Individual Project(s)

USWBSI Research Area*	Project Title	ARS Adjusted Award Amount
BIO	Engineering NPR1 to Enhance Scab Resistance in Wheat.	$ 69,876
	Total Award Amount	**$ 69,876**

July 11, 2006
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

Project 1: *Engineering NPR1 to Enhance Scab Resistance in Wheat*

1. What major problem or issue is being resolved and how are you resolving it?
Fusarium head blight (Scab) caused by *Fusarium graminearum* is a devastating disease of wheat and barley. In the US, yearly losses of wheat to Scab have averaged between $ 200-400 million. The absence of any known source of monogenic resistance against Scab has limited the development of resistant varieties of wheat and barley. Biotechnology provides a promising alternative approach for rapidly developing Scab resistant wheat. Past studies have suggested that to engineer Scab resistance multiple defense genes will need to be simultaneously expressed. This offers many challenges. However, a regulatory gene like the Arabidopsis *NPR1* (At*NPR1*), which controls expression of multiple defense genes, could overcome these difficulties in wheat. Previously, constitutive overexpression of the At*NPR1* gene was demonstrated to enhance disease resistance in Arabidopsis, tomato and rice. As part of this USWBSI-sponsored project, we have successfully demonstrated the utility of the At*NPR1* gene in enhancing Scab resistance in the spring wheat cultivar, Bobwhite.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):
Accomplishment: In the greenhouse and in the two independent field trials, constitutive expression of At*NPR1* from the maize *Ubi1* promoter was found to confer enhanced resistance in two independently derived *Ubi1:*At*NPR1* transgenic wheat cv Bobwhite plants. Expression of the *Ubi1*:At*NPR1* transgene and Scab resistance has been stable over six generations in these transgenic lines. Furthermore, in greenhouse and field studies no adverse growth phenotypes and yield penalties were observed in these transgenic *Ubi1*:At*NPR1* plants. Like the naturally Scab resistant cultivar Sumai 3, scab resistance in these transgenic plants correlated with the faster and stronger response of the transgenic *Ubi1:*At*NPR1* plants to salicylic acid (SA) and its synthetic functional analog, benzothiadiazole (BTH), both known inducers of systemic acquired resistance. Our studies provide strong evidence that constitutive expression of At*NPR1* provides an alternative strategy for enhancing Scab resistance in wheat, thus laying the groundwork for the application of this strategy to elite cultivars. The *Ubi1*:*AtNRP1* plants also exhibit enhanced resistance to powdery mildew suggesting that it may provide the additional benefit of enhancing resistance to a broad-spectrum of fungal diseases in wheat.

Impact: This study demonstrates that the NPR1-regulated pathway is an excellent target for enhancing Scab resistance and provides an alternative strategy for combating Scab in wheat. The *Ubi1*:At*NPR1* construct can now be introduced into elite hexaploid wheat and Durum cultivars to test its ability to enhance Scab resistance in different cultivars.

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?
Introduction of the At*NPR1* gene into elite cultivars of wheat is expected to enhance Scab resistance and provide genetic material suitable for integration into wheat breeding projects. Furthermore, the transgenic *Ubi1*:At*NPR1* cv Bobwhite plants provide excellent genetic material to test the mechanism behind Scab resistance 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:

Makandar, R., Essig, J. S., Schapaugh, M. A., Trick, H. N. and Shah, J. 2006. Genetically engineered resistance to Fusarium head blight in wheat by expression of *Arabidopsis* NPR1. Mol. Plant-Microbe Interact. 19:123-129.

Chaturvedi, R., and Shah, J**.** 2006. Salicylic acid in plant disease resistance. In "Salicylic Acid-A Plant Hormone" ed. S. Hayat and A. Ahmad, Springer, Dordrecht, The Netherlands. In press ISBN: 1-4020-5183-2

Makandar, R., Trick, H. N. and Shah, J. Fusarium head blight resistance conferred by At*NPR1* expression in transgenic wheat is associated with hyper-responsiveness to salicylic acid. Manuscript in preparation for submission to Plant Journal.

Presentations:

Oral

Invited Lecture at Proceedings of the 2005 National Fusarium Head Blight Forum, Milwaukee, WI. Dec 11-13, 2005
Title: Engineering Scab Resistance in Wheat with Plant Defense Signaling Genes.
Author: J. Shah, R. Makandar, V. Nalam and H.N. Trick
Speaker: J. Shah

Invited lecture at University of North Texas, Denton, Texas; November 10, 2005
Title: Plant response to biotic stress
Author: J. Shah
Speaker: J. Shah

Invited lecture at Jawaharlal Nehru University, College of Life Sciences, New Delhi, India; June 15, 2006
Title: Plant Defense against Pathogen and Insect
Author: J. Shah
Speaker: J. Shah

Poster

Proceedings of the 2005 National Fusarium Head Blight Forum, Milwaukee, WI; Dec 11-13, 2005
Title: Engineering Scab Resistance in Wheat with Plant Defense Signaling Genes.
Authors: J. Shah, R. Makandar, V. Nalam and H.N. Trick
Presenter: R. Makandar

Meeting: Kansas Lipidomics Research Center 2006 Annual Meeting, Kansas State University Student Union, Manhattan, Kansas; March 16 2006
Title: *Fusarium graminearum* co-opts the *Arabidopsis thaliana* lipoxygenase gene for pathogenicity.
Authors: Darcy Maier, Ragiba Makandar and Jyoti Shah
Presenter: Darcy Maier

Meeting: 17th International Conference on Arabidopsis Research, Madison, Wisconsin; June 28-July 2 2006,
Title: Arabidopsis as a model system to study plant defense against *Fusarium graminearum*, the causative agent of Scab in wheat and barley
Authors: Vamsi Nalam, Ragiba Makandar, Darcy Maier, Harold Trick and Jyoti Shah
Presenter: Vamsi Nalam