USDA-ARS / USWBSI
FY04 Final Performance Report
July 15, 2005

Cover Page

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Year:	**FY2004** (approx. May 04 – April 05)
FY04 ARS Agreement ID:	**58-5430-3-315**
FY04 ARS Agreement Title:	**Enhancing Scab Resistance in Wheat by Overexpressing Wheat and Arabidopsis NPR1.**
FY04 ARS Award Amount:	**$ 40,000**

USWBSI Individual Project(s)

USWBSI Research Area*	Project Title	ARS Adjusted Award Amount
BIO	Enhancing Scab Resistance in Wheat by Overexpressing Wheat and Arabidopsis NPR1.	$ 40,000
	Total ARS Award Amount	**$ 40,000**

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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: ***Enhancing Scab Resistance in Wheat by Overexpressing Wheat and Arabidopsis NPR1.***

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

Scab has re-emerged as a devastating disease of wheat and barley. In the US, annual loss of wheat to scab averages between $ 200-400 million; at times having reached $ 1 billion. Multiple strategies are required to combat scab. Biotechnology provides a promising approach for rapidly developing scab resistant wheat. Past studies involving over-expression of individual defense genes have met with limited success. These studies have suggested that to develop wheat with resistance to scab, multiple defense genes will need to be simultaneously expressed. This offers many challenges. However, a regulatory gene like the Arabidopsis *NPR1* (AtNPR1) gene, which controls expression of multiple defense genes, could overcome these difficulties in wheat. Previously, the *AtNPR1* gene was constitutively expressed at elevated level in Arabidopsis, tomato and rice to enhance disease resistance. We have used the *AtNPR1* gene to enhance scab resistance in the spring wheat cultivar, Bobwhite.

2. What were the most significant accomplishments?

In the greenhouse, type II resistance to scab was observed in two independently derived transgenic spring wheat (Bobwhite) lines, which constitutively express the *AtNPR1* gene from the maize *Ubi1* promoter. During this funding period we have extended our studies to T3 and T4 progeny derived from these two transgenic *AtNPR1* expressing lines. Scab resistance is retained in the T3 and T4 progeny plants, confirming that the resistance is heritable. Moreover, a tight correlation was observed between the expression of the *Ubi1:AtNPR1* chimeric gene and scab resistance. In the greenhouse, the transgene expression did not confer grain yield penalty. Moreover, upon inoculation with *F. graminearum*, the transgenic plants had higher yields, than the pathogen-inoculated non-transgenic control plants.

In comparison to the non-transgenic controls, when challenged by *F. graminearum*, expression of the pathogenesis-related 1 (*PR1*) gene was induced faster and to a higher level in the *Ubi1:AtNPR1* expressing transgenic wheat plants. Similarly, the *AtNPR1* expressing transgenic wheat plants were more responsive to benzothiadiazole (BTH), a functional analog of salicylic acid. This is similar to the response of the resistant cultivar, Sumai, to *F. graminearum*. Our results confirm that NPR1 and the NPR1 regulated pathway is an excellent target for engineering scab resistance in wheat. Furthermore, the involvement of this pathway in conferring resistance to *F. graminearum* is likely conserved between wheat and *Arabidopsis.* A paper on this work has been submitted to the Proc. Natl. Acad. Sci. USA.

Accomplishment: We have expressed the *AtNPR1* gene in wheat to enhance scab resistance. Our studies confirm that expression of the *AtNPR1* gene provides an alternative strategy, and these transgenic lines provide an alternative resource for enhancing scab resistance in wheat. Our studies also indicate that the NPR1-mediated resistance to *F. graminearum* is likely conserved between wheat and Arabidopsis. This should expedite the identification of other plant genes involved in resistance/susceptibility to *F. graminearum*.

Impact: This study demonstrates that the NPR1-regulated pathway is amenable to engineering in wheat, and that it can be used to engineer scab resistance in wheat. Preliminary experiments suggest that the *AtNRP1* expression also enhances resistance to powdery mildew in wheat. Hence, *AtNPR1* expression could confer resistance beyond *F. graminearum*. The conservation of the *NPR1* mediated resistance mechanism to *F. graminearum* between wheat and Arabidopsis will provide wheat researchers a rapid means for identifying other genes associated with resistance/susceptibility to *F. graminearum*. This pathway can be targeted genetically or chemically, by activators of systemic acquired resistance, to enhance scab 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?

Further development of these *AtNPR1* transgenic lines could allow for their integration into wheat breeding projects. Moreover, these transgenic lines provide excellent genetic material to test the mechanism behind scab resistance in these plants.

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 you 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., and Shah, J. Genetically engineered resistance to Fusarium head blight in wheat by expression of the *Arabidopsis NPR1* gene. ***Proc. Natl. Acad. Sci. USA*** (submitted)

Presentations:

Oral

Meeting: 2nd International Symposium on Fusarium Head Blight, Orlando, FL, December 11-15, 2004
Title: Expression of Arabidopsis NPR1 in wheat confers resistance to Fusarium Head Blight.
Speaker: Jyoti Shah

Poster

Meeting: 2nd International Symposium on Fusarium Head Blight, Orlando, FL, December 11-15, 2004
Title: Expression of Arabidopsis NPR1 in wheat confers resistance to Fusarium Head Blight.
Authors: Ragiba Makandar, Harold N. Trick and Jyoti Shah