Coordinated Effort to Isolate a Fusarium Head Blight Resistance Gene

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Research Questions

Fusarium head blight (FHB) is a major disease problem for Minnesota wheat growers. A major resistance gene located on chromosome 3BS referred to as Fhb1, exhibits partial resistance to FHB. Fhb1 has been incorporated into breeding programs and resulted in new varieties with improved resistance. However, the new varieties are still susceptible during a severe FHB epidemic. Unfortunately, the Fhb1 gene that underlies resistance has not been isolated. We are using a combination of genetic and physical mapping, gene expression analysis and mutant characterization to isolate the gene. This is a collaborative project with Drs. Jim Anderson (U of MN), Mike Pumphrey (Wash. St. U.), Bikram Gill (K-State U.) and Eduard Akhunov (K-State U.).

Results

We established three experiments to examine gene expression in plants carrying either the Fhb1 resistant or susceptible allele. We used next-generation sequencing of RNA from the following experiments to obtain the gene expression data: (1) point inoculation of spikelets with F. graminearum and sampling the inoculated spikelets at 96 hours after inoculation; (2) point inoculation of deoxynivalenol (DON) and sampling the inoculated spikelets at 12 hours after inoculation; and (3) point inoculation of F. graminearum and sampling of the rachis at 96 hours after inoculation. In experiments 1, 2 and 3 we identified 5,973, 4,771 and 2,210 differentially expressed genes between the resistant and susceptible genotypes, respectively. Of particular interest to identifying the Fhb1 gene are those genes that are expressed in the resistant genotype but not expressed in the susceptible genotype. In the three experiments, we identified 54 genes that were expressed in the resistant genotype but not in the susceptible genotype. Currently, we are examining these genes in more detail.

Application/Use

Having the Fhb1 gene will result in the perfect marker for marker-assisted selection for FHB resistance in breeding programs and will be an ideal candidate for genetic engineering. This will ultimately benefit the growers through improved FHB resistant varieties.

Materials and Methods

We are using genetic stocks developed by Dr. Jim Anderson (University of Minnesota) that contain either the Fhb1 resistant or susceptible gene. We established three experiments: (1) F. graminearum inoculated spikelets and the spikelets were sampled at 96 hours after inoculation; (2) F. graminearum inoculated spikelets and the rachis was sampled 96 hours after inoculation; and (3) deoxynivalenol treated spikelets and the treated spikelets were sampled 12 hours after inoculation. RNA from the experiments was sequenced using next generation sequencing technologies. In collaboration with Dr. Akhunov, we conducted an analysis of the genes that are differentially expressed between the resistant and susceptible genotype in the three experiments.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Fusarium head blight is a major disease problem in the wheat growing regions of Minnesota. Yield and quality losses due to this disease can be devastating. Prophylactic fungicide treatments can cost $15/acre. In addition, in severe FHB disease years the crop is not worth harvesting. Therefore, the economic benefits to this research are large.

Related Research

We developed transgenic wheat carrying a barley UDP-glucosyltransferase gene. These transgenic plants exhibit a high level of FHB resistance in the greenhouse and field. In three greenhouse screens for FHB resistance of these lines, we identified transgenic lines that exhibited as low as 5% disease severity. For comparison, Sumai3 (a FHB resistant genotype used in breeding programs around the world) exhibited ~10% disease severity and Bobwhite the nontransgenic control exhibited ~50% disease severity in these screens. These results demonstrate that we have developed transgenic wheat with higher FHB resistance than the best genotypes used in breeding programs. In field trials conducted by Dr. Ruth Dill-Macky, we identified two lines that exhibited between 5-8% disease severity, which was equivalent to the level of resistance we observed in Sumai3. We have developed BC1 lines of crosses of the transgenic plants with Rollag, a moderately FHB resistant variety developed by Dr. Jim Anderson (University of Minnesota). We plan to screen the BC1 lines for resistance in the greenhouse in the winter of 2013.
Recommended Future Research

There are three areas of future research that I think are important.

1. Continue to identify and test putative genes for FHB resistance. My laboratory has an active gene discovery project that is focused on identifying genes with the potential to confer FHB resistance. When we identify genes that may confer FHB resistance we develop and test transgenic wheat for resistance to Fusarium head blight.

2. Isolate the Fhb1 resistance gene. Fhb1 exhibits a high level of FHB resistance. My laboratory in collaboration with Drs. Jim Anderson, Mike Pumphrey, Eduard Akhunov and Bikram Gill have developed a coordinated approach to isolate the Fhb1 resistance gene.

3. Develop a regional approach to testing germplasm collections for wheat improvement. A regional approach to developing and testing germplasm collections for traits that are of interest to the growers should be a top priority. These collections should be composed of germplasm that contains either induced or natural variation that captures the majority of the variation worldwide. The utility of these populations is that they can be repeatedly phenotyped for new traits as they become important.

Other Sources of Funding for this Project

Endowed chair in molecular genetics applied to crop improvement U.S. Wheat and Barley Scab Initiative Minnesota Small Grains Initiative

Appendix

Abstracts related to the project:


Talks related to the project:
“Genomics approaches to Triticeae Improvement”, at the Plant Biological Sciences Colloquium, St. Paul Campus, University of Minnesota

“Wheat and barley improvement in the genomics era”, at the MCIA annual meeting, Mahnomen, MN

“The role of trichotheccenes in the Triticeae-Fusarium graminearum interactions” at the American Phytopathological Society Meeting, Providence, RI

Publications

Three oral presentations and six abstracts (see appendix).

Two publications related to Fusarium head blight were published: