USDA Research Kernels

Our Latest Research Results – February 2014

Wheat Mds-1 Encodes a Heat-shock Protein and Governs Susceptibility Towards the Hessian Fly Gall Midge

Authors: X. Liu, C. Khajuria, J. Li, H. Trick, L. Huang, B. Gill, G. Reeck, G. Antony, F. White, M. Chen
Submitted to: Nature Communications
Gall midges induce formation of host nutritive cells and alter plant metabolism to utilize host resources. Here we show that the gene *Mayetiola destructor* susceptibility (*Mds*)-1 on wheat chromosomes 3AS encodes a small heat-shock protein and is a major susceptibility gene for infestation of wheat by the gall midge *M. destructor*, commonly known as the Hessian fly. Transcription of *Mds-1* and its homoeologs increases upon insect infestation. Ectopic expression of *Mds-1* or induction by heat shock suppresses resistance of wheat mediated by the resistance gene *H13* to Hessian fly. Silencing of *Mds-1* by RNA interference confers immunity to all Hessian fly biotypes on normally susceptible wheat genotypes. *Mds-1* silenced plants also show reduced lesion formation due to infection by the powdery mildew fungus *Blumeria graminis* f. sp. *tritici*. Modification of susceptibility genes may provide broad and durable sources of resistance to Hessian fly, *B. graminis* f. sp. *tritici*, and other pests.
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Registration of Near-Isogenic Winter Wheat Germplasm Contrasting in *Fhb1* for Fusarium Head Blight Resistance

Authors: A. Bernardo, G. Bai, J. Yu, F. Kolb, W. Bockus, and Y. Dong
Submitted to: Journal of Plant Registrations
The Chinese facultative wheat Ning7840 contains *Fhb1,* a major gene for Fusarium head blight (FHB) resistance. We developed five near-isogenic lines (NILs) that contain the *Fhb*1 gene from Ning7840 but other genome content from a adapted US winter wheat, Clark. All resistant NILs had significantly higher FHB resistance and lower deoxynivalenol (DON), a mycotoxin produced by the pathogen, than Clark and the susceptible NIL. Resistant NILs yield similar to Clark. These *Fhb1* NILs should be useful parents for effective use of *Fhb1* in US winter wheat.
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Virulence and Biotype Analyses of Hessian Fly (*Mayetiola destructor*) Populations from Texas, Louisiana, and Oklahoma

Authors: S. Garcés-Carrera, A. Knutson, H. Wang, K.L. Giles, F. Huang, R.J. Whitworth, C.M. Smith, M. Chen
Submitted to: Journal of Economic Entomology
The Hessian fly, *Mayetiola destructor*, is a major pest of wheat, and is controlled mainly through deploying fly-resistant wheat cultivars. Changes in Hessian fly populations in the field is often rapid and wheat cultivars may lose resistance within 6-8 years. To ensure continuous success of host plant resistance, Hessian fly populations in the field need to be constantly monitored to determine which resistance genes remain effective in different geographic regions. This study investigated five Hessian fly populations collected from Texas, Louisiana, and Oklahoma, where infestation by Hessian fly has been high in recent years. Eight resistance genes including *H12*, *H13*, *H17*, *H18*, *H22*, *H25*, *H26*, and *Hdic*, were found to be highly effective against all tested Hessian fly populations in this region, conferring resistance to 80% or more of plants containing one of these resistance genes. The frequencies of biotypes virulent to resistance genes *H13* (biotype vH13), *H18* (vH18), *H21* (vH21), *H25* (vH25), *H26* (vH26), and *Hdic* (vHdic) were determined, and were found to vary from population to population, ranging from 0 to 45%. A logistic regression model was established to predict biotype frequencies based on the correlation between the percentages of susceptible plants obtained in a virulence test and the log-odds of virulent biotype frequencies determined by a traditional approach.
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Effect of abiotic factors on initiation of red flour beetle (Coleoptera: Tenebrionidae) flight

Authors: J. Perez-Mendoza, J.F. Campbell, J.E. Throne
Submitted to: Journal of Economic Entomology
The red flour beetle is one of the major pests in stored grain and in grain processing facilities throughout the world. Traps are used to monitor their movement to aid in making pest management decisions, but we don't fully understand the factors that cause their movement. We found that flight initiation was greatest at 86 to 95°F, and no beetles flew at 72 and 113°F. Only 2% of beetles flew in complete darkness, and the photoperiod at which the maximum percentage of beetles flew (41%) was 18

hours of light. Rates of flight initiation did not vary with light intensities from 1,784 to 4,356 lux or relative humidities from 25 to 85%. Thus, temperature and photoperiod are the main abiotic factors tested that impact flight initiation in the red flour beetle, and red flour beetles have broad ranges of temperatures and photoperiods over which they can fly. These results will help to develop better methods for interpreting trap catches from pest monitoring programs.
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Detection of Internal-feeding Insects in Wheat Samples using a Laboratory Entoleter

Authors: T.C. Pearson, D.L Brabec, E.B. Maghirang, P.W. Flinn
Submitted to: Cereal Chemistry
Grain in storage is vulnerable to insect infestation that can lead to insect fragments in flour, which are regulated by the Food and Drug Administration. To date, there are no economically viable methods for detecting grain that may be infested by insects that live most of their life inside the kernels and to estimate the number of insect fragments that would be present when the grain is milled. This study demonstrated the use of a small mechanical device which breaks open infested kernels and releases the infesting insect, while leaving approximately 98% of the un-infested kernels intact. The insects that are released from the broken kernels can then be easily counted after sieving the wheat sample to separate the broken pieces from the whole kernels. The method is simple, does not require chemicals or supplies, and takes approximately five minutes per 500g grain sample. The amount of insect pieces counted after sieving was found to have a high correlation with expected insect fragments if the grain were milled. Detection of grain samples infested at levels well below the FDA limit of 75 insect fragments per 50g/flour are possible. Samples of grain infested at levels corresponding to as few as four insect fragments per 50g/flour can be detected. As such, the method can find use at many grain receiving stations to better ascertain the level of insect infestation in grain, and by grain storage managers to better learn effective timing of fumigations and insect mitigation procedures.
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Comparative gut transcriptome analysis reveals differences between virulent and avirulent biotypes of the Russian wheat aphid, *Diuraphis noxia*

Authors: R. Anathakrishnan, D. Sinah, M. Murugan, K. Zhu, M. Chen, C. Zhu, C. Smith
Submitted to: Arthropod-Plant Interactions
The Russian wheat aphid is a destructive pest of cereal crops. Growing resistant wheat is the best way to control the aphid. However, a new biotype (biotype 2) can overcome many known resistance genes in wheat cultivars. *Dn4* is a dominant resistance gene that protect wheat against Russian wheat aphid biotype 1 infestation, but is susceptible to biotype 2. To identify genetic factors related to Russian wheat aphid virulence, we analyzed the genes expressed in the guts of Russian wheat aphid biotypes 1 and 2, and found that different genes were expressed between these two biotypes. A gene encoding the tRNA-Leu was significantly up-regulated in the gut of biotype 2, suggesting that leucine metabolism is a critical factor for biotype 2 survival on plants that carry *Dn4*. Higher expression levels of protease inhibitor genes were detected in the avirulent biotype 1, but higher expression levels of several protease genes were detected in the biotype 2, suggesting that biotype 1 produces protease inhibitors in response to elevated plant proteases, whereas biotype 2 produces proteases to overcome *Dn4* resistance. This research is a step forward to understand how Russian wheat aphid biotype 2 overcomes plant resistance conferred by the *Dn4* resistance gene in wheat.
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Resistance to *Wheat streak mosaic virus* identified in synthetic wheat lines

Authors: J.L. Shoup Rupp, Z.G. Simon, B. Gillett-Walker, J.P. Fellers
Submitted to: Euphytica
Wheat streak mosaic virus (WSMV) is a serious wheat pathogen that causes stunting, with yellow streaks in the leaves, while reducing the yield of the crop. Unfortunately, there are few resistance genes available for WSMV. Bread wheat is a natural hybrid of three wild species and breeders can utilize wild relatives of wheat that have resistance genes. However, this is difficult to do because wild relatives do not easily cross pollinate with common wheat. So, researchers at the International Center for Maize and Wheat Improvement (CIMMYT) in Mexico developed a set of lines called synthetics which are hybrids of a wild species Aegilops tauschii, and durum wheat. We screened these for WSMV resistance. More than 400 synthetic lines were screened and four were found to have temperature-sensitive resistance to WSMV. These four lines can now be used as parental lines to transfer the resistance into wheat lines adapted to the Great Plains.

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