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ITEMS FROM THE UNITED STATES OF AMERICA

INDIANA

USDA–ARS AND PURDUE UNIVERSITY

Departments of Agronomy, Botany and Plant Pathology, Entomology, and the USDA–ARS Crop Production and Pest Control Research Unit at Purdue University, West Lafayette, IN 47907, USA.

C.E. Williams, S.E. Cambron, C. Crane, S.B. Goodwin, S. Scofield, B. Schemerhorn, R.H. Shukle (USDA–ARS); H.W. Ohm (Department of Agronomy); K. Wise (Department of Botany and Plant Pathology); and J. Stuart (Department of Entomology).

Wheat production. According to the USDA National Agricultural Statistics Service, harvested wheat acreage in Indiana in 2011 totaled 400,000 acres. Acreage seeded to wheat in fall of 2010 was 420,000 acres. Total production was estimated at 24.8 x 10^6 bushels, with an average yield at 59 bu/a. Winter survival of wheat during the winter of 2009–10 was excellent, but average temperatures from February to mid-April were significantly below normal and soil moisture was higher than normal due to frequent rainfall, resulting in delayed growth and development of wheat and limited uptake of nitrogen. Growth stage of wheat was 1 week later than normal at mid-April. However, from mid-April through June, temperatures were above normal and frequent rainfalls continued, so that wheat matured 1 week earlier than normal. Grain yields were below average, likely due to reduced plant development during the fall of 2009 and early spring of 2010.

Weather conditions were excellent for harvest of soybeans and corn in fall 2010, resulting in timely seeding of wheat and a return to typical acreage of wheat, estimated at 450,000 acres for the 2010–11 season. However, fall 2010 continued unusually dry throughout much of Indiana, especially southern Indiana; resulting in delayed and erratic emergence of wheat in some fields. Luckily there was good snow cover during cold weather periods resulting in little winterkill throughout Indiana, even given the late fall emergence and lack of wheat growth going into winter. Beginning in late January, the spring and summer through wheat harvest was unusually wet; and the unusually cool temperatures through April, together with the continually wet soil conditions resulted in loss of and limited uptake of nitrogen, causing

areas in fields to show signs of limited nitrogen and limited tillering and plant growth. Beginning mid- to late-April, temperatures were much higher than typical for that time of the season, and continued high into wheat harvest. Fortunately, rainfall was sufficient for wheat growth and development. Thus, by end of June, wheat maturity was on-schedule and wheat harvest was completed timely for Indiana. However, the unusually warm temperatures during May and June, cause wheat to mature sooner than normal, so test weight, and yield, was lower than typical.

Wheat disease summary. Fusarium head blight was present in most areas of the state, but severity of the disease varied widely. Other fungal diseases including glume blotch and leaf blotch were moderately severe, and more so in southern Indiana. Powdery mildew developed early in the season on susceptible varieties, but declined with onset of warm conditions. Leaf and stem rusts developed late and were not severe.

H.W. Ohm Laboratory.

New Cultivar. The new cultivar **INW1131** was performance tested as line 99751RA1-6-3-94 in multi-location tests in Indiana since 2007, and in tests in surrounding regions since 2009. INW1131 typically produces grain yield similar to or statistically not less than those of the current leading cultivars. INW1131 has acceptable pastry wheat milling and baking qualities, matures 2–3 days later than the early maturing cultivar Patterson, depending on latitude of the test location; has awnlets 1/16 to 5/16 inch long in the tip ½ of spikes, has yellow anthers, glumes are yellow at maturity, has strong straw that is typically 33 to 36 inches tall, and is moderately cold tolerant. An important contribution of INW1131 is it's effective resistance to Fusarium head blight (FHB), the same fungus that causes ear and stalk rot in corn, and that also produces the vomitoxin deoxynivalenol (DON). INW1131 has effective Type-I (reduced percentage of spikes that become infected) resistance, together with moderate Type-II (reduced spread of the disease within infected spikes) resistance to FHB; and DON content in the grain is consistently significantly less than that in susceptible cultivars. INW1131 has highly effective resistance to Hessian fly, and moderate resistance to Stagonospora glume blotch, Septoria leaf blotch, barley yellow dwarf virus, wheat spindle streak mosaic virus, and leaf- and stem rusts. Given its effective, but not complete, resistances to most of the important diseases, especially FHB, in Indiana and the eastern U.S. along with highly variable seasonal weather patterns, some being very favorable to disease organisms, wheat growers are strongly encouraged to monitor their wheat crop for presence and development of diseases, and apply fungicides when appropriate, to maximize crop performance and grain quality, particularly given the very low level of tolerance for DON in the food industry.

Breeding/Genetics: Combining multiple genes for resistance to foliar diseases, yellow dwarf, and Hessian fly in improved germ plasm and soft winter wheat cultivars adapted to Indiana.

Herb Ohm, Benjamin Campbell, Joshua Fitzgerald, Andy Linvill, Yanyan Liu, Samantha Shoaf, Jenae Skelton, Jin Sun, Shaylyn Wiarda and Xiangye Xiao.

Fusarium head blight. We are backcrossing the combination of *Bdv3* and *Qfhs.pur-7EL* on 7DL into elite winter wheat lines; *Qfhs.pur-7EL* is more distal than *Bdv3*. The combination of *Fhb1* and *Qfhs.pur-7EL* continues to be highly effective Type-II FHB resistance. We also are combining Type-I FHB resistance from combinations of three unrelated sources with the Type-II resistance to FHB.

Stem rust, yellow rust. We have identified and obtained germplasm lines that have resistance to stem rust race TTKS (Ug99) and yellow rust. In collaboration with USDA–ARS laboratory (Dr. Yue Jin) at St Paul, MN (Ug99) and at Purdue University for resistance to our local isolates of the causal fungal pathogens, we are mapping the resistance.

Marker-assisted selection (MAS). We have significantly expanded MAS as an integral part of the breeding program to combine a large number of desired QTL/genes for various important plant traits. MAS is a necessary technology to genotype parent lines for various desired traits and to plan parental combinations for efficiently combining a large number of desired plant traits.

Personnel. Ph.D. student Shaylyn Wiarda and M.S. students Melissa McDonald and Kirsten Thomas joined the Herb Ohm lab in 2011.

Publications.

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S. B. Goodwin laboratory.

Septoria tritici blotch: disease resistance in wheat and pathogen genomics.

Stephen Goodwin, Jessica Cavaletto, and Ian Thompson.

Disease resistance. Work on developing isogenic lines for STB resistance continued during 2011. The genes *Stb1–Stb8* are being backcrossed into the susceptible lines Taichung 29 and Apogee. Some erosion of resistance has been seen in the Taichung 29 crosses, which may indicate dominant toxin sensitivity genes rather than resistance and has slowed the progress. BCF_2 populations are being made to select homozygous resistant plants for successive crosses. Large recombinant-inbred populations segregating for the *Stb2* and *Stb3* genes are being made for fine-scale mapping. Recessiveness of the *Stb2* gene seen with an Indiana isolate of the pathogen has slowed progress. Ultimately these lines can be used to analyze the effects of each *Stb* gene in a common susceptible background and the progenies being developed can be used to validate previously published map locations.

Fungal genomics. The genome sequence of the Septoria tritici blotch pathogen *Mycosphaerella graminicola* was published during 2011. Comparative analyses with sequences from other fungal pathogens and non-pathogens identified many candidate genes that may be involved in pathogenicity. Functional analysis of specific genes identified through bioinformatics analyses of the *M. graminicola* genome sequence is being pursued by developing knock-out and over-expression mutants. A c-type cyclin gene from *M. graminicola* was involved in many cellular processes including secondary metabolite production and also affected pathogenicity. A homolog of the velvet gene was knocked out and had many effects on fungal growth and light signaling. It also affected the production of melanin, which has not been seen in other fungi, but surprisingly did not affect pathogenicity. Manuscripts describing both knockout mutants were published during 2011. Work to improve the efficiency of the transformation process is continuing and will be used on many additional genes that have been identified for functional analysis.

Personnel. No changes from last year.

Publications.

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R. H. Shukle Laboratory.

Hessian fly/wheat interactions: effects of Galanthus nivalis agglutinin on Hessian fly larvae.

Richard Shukle and Christie Williams (USDA–ARS), and Subhashree Subramanyam (Department of Agronomy, Purdue University).

We previously developed an *in planta* translocation feeding assay for Hessian fly larvae to screen antinutrient and toxic proteins as candidates for transgenic resistance. The most efficacious of the antinutrient proteins evaluated was *Galanthus nivalis* agglutinin (GNA) also known as snowdrop lectin. A property of GNA is its ability to cross the gut barrier in some insects and transport other toxic proteins into the hemocoel, resulting in toxic effects not displayed by either GNA or the toxin independently. Through a collaborative material transfer agreement, we have obtained a clone of GNA from John Gatehouse at Durham University as well as a chimeric construct expressing a fusion protein of GNA and an insect specific neurotoxin ButaIT. The GNA/ButaIT construct has been inserted into a vector for transformation of wheat and is currently being used to transform wheat to test the efficacy of the GNA/ButaIT fusion protein for transgenic resistance to Hessian fly and other major insect pests of wheat.

Cloning of genes for virulence in Hessian fly to R genes in wheat.

Brandi Schemerhorn and Richard Shukle (USDA–ARS), and Jeffrey Stuart (Department of Entomology, Purdue University).

In a collaborative interaction between Dr. Jeffrey Stuart and USDA–ARS scientists Brandi Schemerhorn and Rich Shukle genes controlling virulence in Hessian fly to R genes in wheat are being cloned. To date, genes for virulence to *H9*, *H13*, *H24*, and *Hdic* have been cloned. Using pheromone traps, samples of Hessian fly have been collected from fields across North Carolina, South Carolina, Georgia, and Alabama. Virulence to *H13* was assessed in the field collections using diagnostic PCR markers. Using this method, field populations can be monitored regularly to survey the efficacy of any R gene's ability to protect wheat by detecting the frequency of virulence in Hessian fly populations. With the identification of additional genes in Hessian fly for virulence to R genes in wheat, this quick and easy genotyping method can replace the current detection system which requires more time, effort, money, and flies.

Annotation of genes from Hessian fly.

Richard Shukle and Christie Williams (USDA–ARS), Jacob Shreve (Department of Entomology, Purdue University), and Subhashree Subramanyam (Department of Agronomy, Purdue University).

Using the Hessian fly genome sequence we are annotating genes essential in this insect's biology and interactions with wheat. Knowledge of such genes and gene networks will enhance our understanding of responses in Hessian fly such as its ability to elicit a systemic RNAi response and the feasibility of host induced gene silencing as a possible strategy for genetically engineered resistance in wheat.

Publications.

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Williams CE, Nemacheck JA, Shukle JT, Subramanyam S, Saltzmann KD, and Shukle RH. 2011. Induced epidermal permeability modulates resistance and susceptibility of wheat seedlings to herbivory by Hessian fly larvae. J Exp Bot 62:4521-4531.

C. E. Williams laboratory.

Wheat resistance to Hessian fly.

Christie Williams, Jill Nemacheck, Shubha Subramanyam, Andrea Hargarten, and Jacob Shreve.

Hessian fly-induced changes in wheat surface permeability. Salivary secretions of neonate Hessian fly larvae initiate epidermal permeability in wheat plants that is detected by absorption of neutral red stain. This permeability allows larval elicitors to enter the plant where they can trigger plant processes leading to resistance or susceptibility. The rapid increase in cell permeability allows the delivery of either plant defense molecules as incompatible interactions proceed or nutrients for larval consumption during compatible interactions. Resistant plants remain permeable just long enough to deliver molecules that kill the larvae. In contrast, susceptible plants continue to increase in permeability until the entire crown of the plant becomes a nutrient sink capable of overwhelming any localized defense response. The three-dimensional spreading of permeability initiated by virulent larvae within a few hours of attack rescues genetically avirulent larvae that may be present and sustains larval growth until nutritive tissue is established.

Personnel. No changes from last year.

Publications.

Shukle RH, Subramanyam S, and Williams CE. 2012. Effects of antrinutrient proteins on Hessian fly (Diptera: Cecidomyiidae) larvae. J Insect Physiol 58:41-48.

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