Because all these hybrids have a *T. timopheevii* subsp. *timopheevii* cytoplasm, we concluded that mostof the plants obtained from a backcross with durum wheat and all plants from pollination by *T. persicum* had cytoplasmic male sterility. Sporadic plants with relatively high fertility obtained from backcrosses with durum wheat carried *Rf* genes inherited from *T. timopheevii* subsp. *timopheevii*.

Thus, awn pubescence may be combined with light and dark colored glumes, the presence or absence of pubescent glumes, dark and light colored awns, cytoplasmic male sterility, and presence of fertility restoration genes. Regarding the genetic nature of the pubescent awns, this feature is not evident in any of the parental forms or F_1 hybrids, but only appears in the progeny of step crossings and backcrosses. Its expression in *T. timopheevii* subsp. *timopheevii* apparently is suppressed by an inhibitor gene, which is not inherited in all progeny except descendants of backcrosses as a result of recombination. These plants manifest the awn pubescence.

Presence of awn pubescence in forms with enough fertility for distant hybrids, from 18–34%, it is possibility to obtain pubescent forms. We offer to combine these forms into a group of morphological races under the name convar. *pilosoaristatum* E. Tverdokhleb. Awn pubescence is a trait that may be easy recognized and can serve as a morphological marker in identifying wheat gene pool accessions. In particular, they can mark awned cultivars of wheat for ensure their protection using a DUS test. In the family Poaceae, this feature is well manifested in species of feather grass (*Stipa* L.). In the Triticinae subtribe, according to our observations, this feature is manifested in *Dasypyrum villosum* at the bottom of the awns as an extension of the glume keel pubescence by hard trichomes.

References.

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Dorofeev V.F. 1979. Kulturnaya Flora SSSR (Under common edition of V.F. Dorofeev). N.I. Vavilov Institute of Plant Industry,.Leningrad. 346 pp (Cultivated flora of USSR. Vol. 1: Wheat, in Russian).
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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, and J.M. Anderson (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 2010 totaled 250,000 acres. Acreage seeded to wheat in the autumn of 2009 was unusually low due to wet soil conditions in September and October, 2009; this significantly delayed harvest of corn and soybean and, thus, delayed and reduced seeding of wheat. Wheat production was down from 470,000 acres in 2009. Total production was estimated at 13.8 x 10^6 bushels, with an average yield at 60 bu/acre. 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 the autumn 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, in contrast to normal weather/soil conditions in the sutumn in Indiana, rainfall during mid-August through October was unusually low. Thus, low soil moisture caused significantly variable and delayed emergence of wheat, resulting in little growth and tillering prior to onset of winter. Surprisingly, wheat survived the winter conditions quite well; very little winterkill.

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.

Performance of new cultivars.

Herb Ohm.

Cultivar INW1021 yielded well in Indiana and nearby regions. INW1021 has moderate resistance to Fusarium head blight (*Fhb1*), soilborne wheat mosaic virus, and wheat spindle streak mosaic virus. The cultivar is adapted to southern Indiana and surrounding regions. INW1021 has survived winters very well in central and northern Indiana, but winters have been mild since 1996.

Cultivar INW0801, which has the gene *Bdv3*, also performed well. INW0801 is well-suited to southern Indiana and adjacent areas because yellow dwarf is present many years, and its early maturity is suited to doublecropping, seeding soybeans no-till after wheat harvest.

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, Judy Lindell, Andy Linvill, Yanyan Liu, Dan McFatridge, Mahboobullah Nang, Wali Salari, Samantha Shoaf, Jin Sun, and Xiangye Xiao.

Fusarium head blight. We are backcrossing the combination of *Bdv3* and *Qfhs.pur-7EL* on 7DL (*Qfhs.pur-7EL* is more distal than *Bdv3*) into elite winter wheat lines. We are also combining these with *Bdv2*, which was moved from 7DL to 7BL, and *Fhb1*, on 3BS. We are also combining type-I FHB resistance, from combinations of three unrelated sources, with the type-II resistance to FHB.

Stem rust and stripe rust. We have identified and obtained germ plasm lines that have resistance to stem rust race TTKS (Ug99) and stripe rust. In collaboration with the 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. 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.

Wheat management. In studies at Lafayette and Evansville, Indiana, in three seasons, 2008, 2009, and 2010, a second topdress of 45 #/acre N in early to mid-March (prior to Feekes growth stage 6 or 7), in addition to a first application of

95 #/acre N in early February, significantly increased grain yield, but had little negative effects on flour milling and baking qualities. We noted that in all three seasons, February–mid-April in one of the seasons, and February to mid-May in two of the seasons, conditions were more wet and cool than is typical in Indiana.

Personnel. Dan McFatridge, Technical Research Assistant with Herb Ohm, retired in December, 2010. Ph.D. students Joshua Fitzgerald, Jenae Skelton, and Rima Thapa joined the Herb Ohm laboratory in August 2010.

Publications.

Zhang X, Shen X, Hao Y, Cai J, Ohm H, and Kong L. 2011. A genetic map of *Lophopyrum ponticum* chromosome 7E harboring resistance genes to Fusarium head blight and leaf rust. Theor Appl Genet (in press).

Hessian fly/wheat interactions, effects of antinutrient and toxic proteins on Hessian fly (Diptera: Cecidomyiidae) larvae: potential for transgenic resistance in wheat to complement native resistance.

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

Results from a recent evaluation of 21 of the 33 resistance (R) genes in wheat to Hessian fly documented that only five would provide protection of wheat in the southeastern United States where Hessian fly is a major pest. These results confirmed the need for new approaches to deployment of R genes and discovery of novel genetically engineered approaches to resistance that will complement native resistance. We have developed an in planta translocation feeding assay for Hessian fly larvae to initially screen antinutrient and toxic proteins as candidates for transgenic resistance. Although some of the antinutrient/toxic proteins we have evaluated may not kill infesting Hessian fly larvae quickly enough to prevent damage to a specific plant, they should prevent larvae from completing their development and virulent genotypes from emerging into field populations. Results from these studies will enable transgenic resistance in wheat to Hessian fly and significantly enhance the durability of deployed R genes.

Genotyping virulence to H13 wheat in field collections of Hessian fly from the southeastern United States.

Richard Shukle (USDA–ARS), G. David Buntin (Department of Entomology, University of Georgia, Griffin, GA), Kathy Flanders (Department of Entomology Auburn University, Auburn, AL), Alisha Johnson (USDA–ARS), Francis Reay-Jones (Department of Entomology Clemson University, Clemson, SC), Dominic Reisig (Department of Entomology North Carolina State University, Raleigh, NC), Brandi Schemerhorn (USDA–ARS), and Jeffrey Stuart (Department of Entomology).

In the southeastern United States, the Hessian fly is a major pest of wheat and causes significant yield losses to the region. Hessian fly is primarily controlled through the use of resistant wheat cultivars that carry resistance (R) genes. Wheat containing the R gene *H13* has been found to provide effective protection against Hessian fly attack in the Southeast. However, successive yearly deployment of *H13* wheat lines will put a selection pressure on field populations that contain a low frequency of virulence, which will eventually drive the population to become resistant to *H13*. Using pheromone traps, samples of Hessian fly were taken from fields across North Carolina, South Carolina, Georgia, and Alabama. Virulence was assessed using PCR to amplify vH13 (gene for virulence in the insect to *H13*). Avirulent (susceptible to *H13*) and virulent (can overcome *H13*) Hessian fly genotypes differed in amplicon size due to an insertion within exon 2 of vH13 that leads to inactivation of the gene in the insect and resistance to the R gene. 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. When additional avirulence genes are identified, this quick and easy genotyping method could replace the current detection system which requires more time, effort, money and flies.

Annotation of genes from Hessian fly (Diptera: Cecidomyiidae).

Richard Shukle (USDA–ARS), and Jacob Shreve and Jeffery Stuart (Department of Entomology).

The Hessian fly is the major insect pest of wheat in the southeastern United States and has traditionally been controlled through the utilization of Hessian fly-resistance (R) genes in wheat. Such R genes are a limited resource, and once deployed lose their field effectiveness with time. Using 21 of the named R genes, a recent evaluation determined that only five of the R genes tested were able to provide adequate protection for wheat. Thus, there is a need for novel genetically engineered resistance to this pest. One approach to genetically engineered resistance in wheat is the possible application of plant mediated RNAi to target Hessian fly genes essential in its biology and interactions with wheat. To identify efficacious targets for plant mediated RNAi in transgenic resistance we are utilizing the newly available Hessian fly genome sequence to annotate Hessian fly genes.

Publications.

Arrueta LD, Shukle RH, Weise IL, and Mittapalli O. 2010. Gene characterization of two digestive serine proteases in *Sitodiplosis mosellana*: Implications for alternative control strategies. The Can Entomol 142:532-545.

Behura SK, Shukle RH, and Stuart JJ. 2010. Assessment of structural variation and molecular mapping of insertion sites of Desmar-like elements in the Hessian fly genome. Insect Mol Biol 19:707-715.

Cambron, SE, Buntin GD, Weisz R, Holland JD, Flanders KL, Schemerhorn BJ, and Shukle RH. 2010. Virulence in Hessian fly (Diptera: Cecidomyiidae) field collections from the southeastern United States to twenty-one resistance genes in wheat. J Econ Ent 103(6):2229-2235.

Chen M-S, Liu XM, Yang Z, Zhao H, Shukle RH, Stuart JJ, and Hulbert S. 2010. Unconventional conservation among genes encoding small secreted salivary gland proteins from a gall midge. BMC Evol Biol 10:296, http://www.biomedcentral.com/1471-2148/10/296.

Shukle RH, Subramanyam S, Saltzman KA, and Williams CE. 2010. Ultrastructural changes in the midguts of Hessian fly larvae feeding on resistant wheat. J Insect Physiol 56:754-760.

Wheat resistance to Hesssian fly, characterizing wheat genes involved in defense against Hessian fly.

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

GDSL-lipase. We identified a GDSL-lipase gene (through microarray) that may be involved in delivery of defense molecules through the plant cuticle to Hessian fly larvae. Verified through qPCR that GDSL-lipase gene expression profile matches expectations for a gene that reorganizes cutin to allow defense molecules out of cell during the limited time frame when resistant cells are known to be permeable.

Class III peroxidase genes. Through qPCR, we verified that class-III peroxidase genes become up-regulated during induced resistance to Hessian fly, supporting speculation that they are responsible for increase in activity of reactive oxygen species noted to contribute to resistance.

Dirigent gene. Through microarray and qPCR, we characterized expression of a gene encoding a dirigent-like protein that appears to be involved in production of lignan defense molecules in response to Hessian fly.

Personnel. Andrea Hargarten has joined the lab as an ARS research technician.

Publications.

Anderson JM, Bucholtz DB, Sardesai N, Santini JB, Gyulia G, Williams CE, and Goodwin SB. 2010. Potential new genes for resistance to *Mycosphaerella graminicola* identified in *Triticum aestivum* x *Lophopyrum elongatum* disomic substitution lines. Euphytica 172:251-262.

Kosma DK, Nemacheck JA, Jenks MA, and Williams CE. 2010. Changes in properties of wheat leaf cuticle during interactions with Hessian fly. The Plant J 63:31-43.

Liu X, Williams CE, Nemacheck JA, Wang H, Subramanyam S, Zheng C, and Chen MC. 2010. Reactive oxygen species are involved in plant defense against a gall midge. Plant Physiol 152:985-999.
Saltzmann KD, Giovanini MP, Ohm HW, and Williams CE. 2010. Transcript profiles of two wheat lipid transfer protein-encoding genes are altered during attack by Hessian fly larvae. Plant Physiol Biochem 48:54-61.
Xu SS, Chu CG, Harris MO, and Williams CE. 2011. Comparative analysis of genetic background in eight near-isogenic lines for Hessian fly-resistance genes in wheat. Genome 54:81-89.
Yu GT, Williams CE, Harris MO, Cai X, Mergoum M, and Xu SS. 2010. Development and validation of molecular markers closely linked to *H32* for resistance to Hessian fly in wheat. Crop Sci 50:1325-1332.

KANSAS

KANSAS STATE UNIVERSITY
Environmental Physics Group, Department of Agronomy, 2004 Throckmorton Plant Sciences Center, Manhattan, KS 66506-5501, USA.

Edema.

M.B. Kirkham.

Current research concerns edema, which is an abnormal accumulation of fluid in plant cells. The research is being carried out in association with Kimberly A. Williams and Sunghun Park in the Department of Horticulture, Forestry, and Recreational Resources, along with graduate student Qingyu Wu. Nicole Rud, another graduate student who also worked on the project, graduated in December, 2009. Edemata are a physiological disorder, not caused by any pathogen. They occur only under greenhouse conditions, and in the past, they have been thought be due to overwatering. Because wheat is usually grown in the field, edemata on wheat apparently have not been documented. We reported last year that lack of ultraviolet light was a cause for edemata (also called intumescences or enations) in tomato plants. The glass of greenhouses filters out ultraviolet light, which makes the plants susceptible to the intumescences. When we added back UV-B light to the tomato plants grown under greenhouse conditions, they did not develop the intumescences. Kirkham and Keeney (1974) associated the formation of enations on leaves of potato, which they observed under controlled environmental conditions, with the presence of abnormal amounts of ethylene, a gaseous hormone. We are carrying out research to determine the biochemical reason for the formation of the intumescences in tomato.

Reference.
Kirkham MB and Keeney DR. 1974. Air pollution injury of potato plants grown in a growth chamber. Plant Dis Rep 58:304-306.

News.

Ms. Kalaiyarasi Pidaran is continuing work toward the master's degree. Under greenhouse conditions, she is studying the effect of water deficit on sorghum hybrids varying in maturity.

The book on carbon dioxide, cited last year, will be published by CRC Press in late March, 2011 (see Publications, below). Here is an excerpt from the epilogue:

> "Because elevated carbon dioxide stimulates growth, yield is usually increased under elevated carbon dioxide. In a classic paper, Kimball (1983) analyzed more than 430 observations of the yield of 37 species grown with CO_2 enrichment, which were published in more than 70 reports of experiments carried out in a 64 year period beginning in 1918. His analysis showed that, with a doubling of atmospheric CO_2 concentration, yield probably will increase by 33%. In this book I have not cited papers dealing with models, except in passing. My focus has been on data published in refereed journal articles. However, Ken Caldeira at the