Western Extension/Education Research Activity WERA066
Integrated Management of Russian Wheat Aphid and Other Cereal Arthropod Pests.

Minutes of Annual Meeting:

February 13, 2008

The 2007 WERA-066 meeting was held in conjunction with the International Plant Resistance to Insects conference (February 10-13) at the Hilton Ft. Collins (See attached agenda). Therefore, the annual meeting consisted of a brief business meeting that was scheduled from 1:00-4:00 pm, February 13, 2008. Chair Phil Sloderbeck, called the meeting to order at 1:00 pm and began the meeting with a round of introductions by those in attendance. Phil then introduced administrative co-advisor Tom Holtzer to address the group.

Tom Holtzer, Colorado State University, Administrative Advisor, provided a charge for the group and encouraged all to enroll into the NIMSS system http://www.lgu.umd.edu/lgumanual/toc.html. This meeting worked well as a partner meeting with IPRI meeting. Accountability is important, shows accomplishments and impacts of research and educational programs. John Reese led discussion about developing collaborations with IPRI as Gary Thompson discussed.

1:15 PM – State Reports -- Verbal reports were given by representatives from each state (Name in Parentheses) summarizing their written reports of recent insect activity and research results:

Colorado – (Frank Peairs): Discussed the importance of spiders in system. Need for RWA-1 and RWA-2 resistant differentials to evaluate RWA biotypes.

Kansas – (John Reese) Evaluating resistance to RWA-2 in wheat and barley. Looking at soybean aphid resistance

Nebraska- (Gary Hein) Barley, relationships to barley natural enemies. Areawide project in winter wheat completed. RWA research that is being conducted by Tiffany Heng-Moss is looking at gene expression profiling. Cereal arthropod research includes wheat curl mite, characterizing genetic diversity, virus transmission and mite movement potential. RWA populations were down from a year ago but other cereal aphids were present. BCO, English grain aphids, Greenbug. Barley Yellow Dwarf Virus were more prevalent than usual.

North Dakota – (Kirk Anderson for Marion Harris) 2007 IPM Survey. 1000 wheat fields in 53 counties, for diseases and insects. Grasshopper populations were low, wheat stem maggot numbers are higher. Hessian fly: an independent survey showed that it is at an economic level in some fields. Orange wheat blossom midge survey: the trend is lower levels of wheat midge, but a few areas had treatable numbers.

Oklahoma –ARS (Do Mornhinweg) Released 7 winter barley resistant lines. Many spring barley resistant lines for RWA. Are developing (developed) a seedling screen for BCOA. (Cheryl Baker): Resistance lines for RWA1 and RWA1 are being identified. (Gary Purterka) Collaborative agreement with Dr. Dillwith, looking at salivary gland constituents.

Oklahoma (Tom Royer) Hessian fly is prevalent, we are finding some wheat stem maggot in our plots, and don't know what impact that would have for this spring. We are validating the Glance 'n Go sampling system for greenbugs in Kansas, Oklahoma and Texas with growers (8 per state).

South Dakota (Louis Hesler) BCOA fall with BYDV. High populations in spring, mostly English Grain Aphid, some BCOA and greenbug. Looking for HPR for BCOA, found some in triticale, but breeders are not interested in crossing.

Following reports, discussion was initiated to determine the location and date of the next meeting. After a discussion with Dr. Holtzer about the time span needed for each meeting, the group agreed to explore the possibility of holding the meeting on September 22 or September 29, 2009 in Ardmore, OK, or Stillwater, OK. John Burd will make contacts with personnel at the Noble Research Center to see if they would host this meeting.

The next item of business was to identify the next secretary for WERA-66. Christie Williams, Purdue University, was identified by the nominations committee as a willing candidate, so Do Mornhinweg moved that she be nominated, seconded by Frank Peairs, and passed unanimously. Meeting was adjourned at 4:00 pm.

Agenda: International Plant Resistance to Insects Conference, Hilton Ft. Collins, Ft. Collins, CO 80526 Feb 10-13, 2008

SUNDAY, FEBRUARY 10, 2008

4:00 p.m. – 5:00 p.m. Steering Committee Meeting

7:00 p.m. – 10:00 p.m. Joint IPRI/WERA-66 Mixer

MONDAY, February 11, 2008

8:00 a.m. – 12:00 p.m. IPRI Registration

7:00 a.m. – 5:00 p.m. Posters Available for Viewing

8:00 a.m. – 8:30 a.m. Welcome

8:30 a.m. – 9:00 a.m. Keynote Address

9:30 a.m. – 12:00 p.m. Session I. Contributed Papers

12:00 p.m. – 1:00 p.m. Lunch

1:00 p.m. – 2:53 p.m. Session II. Student Competition

3:30 p.m. – 4:45 p.m. Session III. Contributed Papers

7:00 p.m. – 10:00 p.m. IPRI Banquet

TUESDAY, February 12, 2008

7:00 a.m. – 5:00 p.m. Posters Available for Viewing

8:00 a.m. – 12:00 p.m. Session IV. Symposium: Workshop on Funding Strategies for the Future of Plant-Insect Interactions

12:00 p.m. – 1:30 p.m. Lunch

1:30 p.m. – 5:00 p.m. Session V. Symposium: Hessian Fly

WEDNESDAY, February 13, 2008

8:00 a.m. – 12:00 p.m. Session VI Insect Biotype Workshop

8:05 a.m. – 8:50 a.m. Invitational Paper

8:50 a.m. – 10:05 a.m. Contributed Papers

10:30 a.m. – 12:00 p.m. Panel – Audience Discussion

12:00 p.m. – 1:00 p.m. Lunch
1:00 p.m. – 5:00 p.m. Session VII WERA-66 Meeting

Call to Order and State Reports

Final Business Meeting

State Reports

Department of Bioagricultural Sciences and Pest Management
Colorado State University

I. Designated Representatives and Collaborators

A. Representative

F. Peairs
Department of Bioagricultural Sciences and Pest Management
Colorado State University
Fort Collins, CO 80523-1177
970-491-5945
Frank.Peairs@colostate.edu

B. Collaborators

S. Haley
Department of Soil and Crop Sciences
Colorado State University
Fort Collins, CO 80523
970-491-6483
shaley@lamar.colostate.edu

J. Johnson
Department of Soil and Crop Sciences
Colorado State University
Fort Collins, CO 80523-1170
970-491-1454
jjj@lamar.colostate.edu

II. Sub-Committee Objectives Addressed

A. Biological Control

1. Seek ways to improve biological control of the Russian wheat aphid through the use of diversified dryland cropping systems.

B. Host Plant Resistance

1. Incorporate genetic resistance to Russian wheat aphid into commercially acceptable winter wheats for Colorado.

2. Categorize the mechanisms of known genetic sources of resistance to Russian wheat aphid in order to determine the best combinations for stable resistance.

3. Test experimental wheat lines and varieties that are resistant to Russian wheat aphid at multiple locations for level and stability of quality, yield and resistance.

C. Biology and Management

1. Refine economic injury levels and thresholds for Russian wheat aphid in small grains to incorporate additional factors such as cultivar, cropping system, and presence of other pests. Monitor economic impact of Russian wheat aphid in Colorado.

2. Conduct studies on the field biology and ecology of the Russian wheat aphid to improve understanding and management of Russian wheat aphid.

3. Determine the influence of modified cultural practices, including grazing, planting date and volunteer control, on Russian wheat aphid densities.

4. Improve application technology including safer and more effective insecticides and more efficient application techniques.

III. Current Accomplishments

A. Biological control

1. Pitfall traps have been established at three cropping systems sites. Spiders are being collected and identified. A manuscript on carabid results is in press (Objective A1)

2. Uniform aphid natural enemy observations are taken at all three locations (Objective A1)

B. Host Plant Resistance

1. Russian wheat aphid biotype 1-resistant wheat cultivars are now planted on more than 25% of Colorado's wheat acreage. The level of use has remained constant even though RWA-1 seems to have been largely replaced by RWA-2.

2. Winter wheat lines with the 2414-11 resistance source continue to be advanced. Two will be evaluated for yield loss to Biotype 2 in the spring of 2008. (Objective B1)

3. Resistant feed barley varieties were tested on-farm in 2006 and 2007. 'Stoneham' and Sidney are resistant to known RWA biotypes and performed better than 'Otis', their recurrent parent, under very dry conditions and in the presence of Russian wheat aphid. (Objective B3)

4. Surveys were conducted to determine the presence of Dn4-virulent Russian wheat aphids. Russian wheat aphid was scarce in 2007, but the percentage of samples containing Dn-4 virulent aphids has continued to increase since the initial survey in 2004 (96% in 2007). No virulence to 2414-11 was detected.

5. An additional 2300 lines from the national wheat germplasm collection, 600

other breeding lines and 4500 individual progeny were screened for resistance to Biotype 2. Additional potential resistance sources were identified for bothRWA-1 and RWA-2.

C. Biology and Management

1. Dryland cropping systems studies are ongoing at three locations in eastern Colorado. Stoneham, a RWA-resistant feed barley, has been added to some rotations. Generally, rotations have been modified to incorporate more forages, and sunflower has been eliminated. (Objectives A1, B3 and C3)

2. Aphid flights were monitored at four locations by means of suction traps. For the first time, zero Russian wheat aphids were collected in the Akron trap, and only one was collected from the Briggsdale trap. (Objective C2)

3.Nine foliar insecticide treatments were compared to commercial standard insecticide treatments for control of Russian wheat aphid in winter wheat. Cobalt (chlorpyrifos + gamma cyhalothrin) was similar in performance to the standard chlorpyrifos treatment, which currently is the product of choice for Colorado wheat producers. (Objective C4)

4.Methomyl was compared to chlorpyrifos and several pyrethroids for control of Russian wheat aphid in spring barley. Two applications of methomyl performed nearly as well as the chlorpyrifos treatment, providing barley producers with another potential control option. (Objective C4)

IV.Publications

Peng, J., H. Wang, S. D. Haley, F. B. Peairs, and N. L. V. Lapitan. 2007. Molecular mapping of the Russian wheat aphid resistance gene Dn2414 in wheat. Crop Sci. 47: 2418 - 2429.

Peairs, F. B. 2007. Russian wheat aphid. P. 42-43 in, Buntin, G. D., K. S. Pike, M. J. Weiss, and J. A. Webster, eds. Handbook of Small Grain Insects. Entomological Society of America, Lanham, MD.

Haley, S.D., J.J. Johnson, F.B. Peairs, J.S. Quick, J.A. Stromberger, S.R. Clayshulte, J.D. Butler, J.B. Rudolph, B.W. Seabourn, G. Bai, Y. Jin, and J. Kolmer. 2007. Registration of 'Ripper' wheat. J. Plant Reg. 1:1-6.

Randolph, T. L., F. B. Peairs, S. Merrill, M. Koch, and C. B. Walker. 2007. Yield response to Russian wheat aphid (Homoptera: Aphididae) in mixtures of resistant and susceptible winter wheats. Southwest. Entomol.32: 7-15.

Hesler, L.S., S.D. Haley, K.K. Nkongolo and F.B. Peairs. 2007. Resistance to *Rhopalosiphum padi* (Homoptera: Aphididae) in triticale and triticale-derived wheat lines with resistance to *Diuraphis noxia* (Homoptera: Aphididae). J. Entomol. Sci. 42 (2): 217-227.

Peairs, F. B., J. B. Rudolph, J. B., and T. L. Randolph. 2007. 2006 Colorado field crop insect management research and demonstration trials. Colorado State Univ. Agric. Exp. Sta. Tech. Rep.

TR07-07, 26 pp.

Indiana, Purdue University
WERA-66 State Report

Christie Williams, USDA-ARS Research Molecular Biologist and Associate Professor-Adjunct, Dept. Entomology, Purdue University West Lafayette, IN
Jill Nemacheck, USDA-ARS technician
Subhashree Subramanyam, postdoctoral research associate
Kurt Saltzmann, USDA-ARS postdoctoral research associate
Stephen Baluch , Ph.D. student and
Marcelo Giovanini, previous Ph.D. student

Response of wheat to virulent and avirulent Hf larvae.

Insect feeding disrupted by wheat lectin.
Production of the HFR-1 wheat lectin is triggered by avirulent Hessian fly larvae. Because these larvae are obligate parasites and cannot be cultured in vitro, the effect of this lectin was tested on Drosophila melanogaster larvae as they consumed an artificial diet. At low to intermediate concentrations, this lectin prolonged larval development. But at high concentrations it deterred feeding and repelled the larvae, causing them to leave the diet medium and reside on the sides of the glass vial until death, 4 days later. This lectin may be useful as a feeding deterrent in transgenic plants.

Amino acid content of susceptible plants is manipulated by virulent Hessian fly larvae.
Virulent Hessian fly larvae alter the production of certain amino acids in their host wheat plants. Essential amino acids that the larvae must obtain from their diet increase in abundance in susceptible wheat. This includes methionine, histidine and phenylalanine. The increased production of phenylalanine and tyrosine by the host wheat plant may be important for cuticle production in the immature insects.

Richard Shukle, USDA-ARS Research Entomologist, West Lafayette, IN
Alisha Johnson, Ph.D. student
Kristin Saltzman, technician
Weilin Sun, collaborating postdoctoral associate
Jacob Shreve, undergraduate technician

Molecular interaction between Hessian fly and wheat

Previous research directed toward transcriptional profiling of genes expressed in Hessian fly larvae during interactions with wheat has revealed the following: 1. On susceptible plants genes involved in establishing a sustained feeding site, manipulation of host-plant cells, feeding and growth/development are up-regulated; 2. On resistant plants genes involved in responding to stress and disruption of homeostasis (DAD – defender against apoptotic cell death, heat shock, detoxification, antioxidant defense, excretion, etc) are up-regulated; 3. On resistant plants larvae encounter toxic plant compounds, feeding deterrents, or cannot manipulate host-plant cells to develop a nutritive tissue. Current research is focused toward: 1. RNAi as a function genomics tool for genes expressed during Hessian fly/wheat interactions; 2. comparative salivary gland transcriptomics; 3. electron microscopy studies of the larval midgut during compatible and incompatible interactions with wheat.

Publications 2008

Subramanyam S, Sardesai N, Puthoff DP, Meyer JM, Gonzalo M, Williams CE. Expression of two wheat defense-response genes, *Hfr-1* and *Wci-1*, under biotic and abiotic stresses. Plant Sci. 170:90-103. 2006.

Mittapalli O, Shukle RH, Sardesai N, Giovanini MP, Williams CE. Expression patterns of antibacterial genes in the Hessian fly. J. Insect Physiol. 52:1143-1152. 2006.

Giovanini MP, Puthoff DP, Nemacheck JA, Mittapalli O, Saltzmann KD, Ohm HW, Shukle RH, Williams CE. Gene-for-gene defense of wheat against the Hessian fly lacks a classical oxidative bust. Mol. Plant Microbe Interact. 19:1023-1033. 2006.

Cho K, Torres N L, Subramanyam S, Deepak SA, Sardesai N, Han O, Williams CE, Ishii H, Kubo A, Iwahashi H, Agrawal GK, Rakwal R. Protein extraction/solubilization protocol for monocot and dicot plant gel-based proteomics. J. Plant Biology 49: 413-420. 2006.

Giovanini MP, Saltzmann KD, Puthoff DP, Gonzalo M, Ohm HW Williams CE. A novel wheat gene encoding a putative chitin-binding lectin is associated with resistance against Hessian fly. Mol. Plant Path. 8:69-82. 2007.

Hunt GJ, Amdam GV, Schlipalius D, Emore C, Sardesai N, Williams CE, Rueppell O, Guzmán-Novoa E, Arechavaleta-Velasco M. Chandra S, Fondrk MK, Beye M, Page, Jr. RE. Behavioral genomics of honeybee foraging and nest defense. Naturwissenschaften 94: 247-267. 2007.

Shukle, R. H., Yoshiyama, M., Morton, P.K., Johnson, A. J., and Schemerhorn, B.J. 2008 Tissue and developmental expression of a gene from Hessian fly encoding an ABC-active-transporter protein: Implications for Malpighian tubule function during interactions with wheat. Journal of Insect Physiology, 54(1); 146-154.

Omprakash, M., and Shukle, R. H. 2008 Molecular characterization and responsive expression of a defender against apoptotic cell death homologue from the Hessian fly, *Mayetiola destructor*. Comparative Biochemistry and Physiology Part B, 149; 517-523.

Sue Cambron, USDA-ARS Category III Support Scientist

Current status of the Hessian fly in the Eastern and Southern United States

Hessian fly damage in Indiana occurs infrequently with the exception of southwestern counties where it is an annual problem. Growers in Indiana are judicious in planting after the fly-free date, which greatly reduces outbreaks. There has been occasional damage in northeastern counties, but nothing consistent enough to monitor on an annual basis. Fly damage was reported in Tippecanoe County in 2006 in a breeder's nursery. No other damage of note has been reported.

Damage in the southeastern U.S. has been sporadic over the last five to seven years. In Georgia, with the exception of the 2007 planting season, 75% of fields are planted to resistant varieties. Seed treatments are also commonly used for Hessian fly and aphid control. In the 2007 season Georgia suffered a severe seed shortage due to a drastic increase of acreage planted to wheat (approx. 250,000 acres in 2005 to 600,000 acres in 2007) and most wheat seed was not treated with insecticide prior to planting. Dry weather held up most planting until mid-December. Hessian fly damage is predicted to be higher in the spring of 2008 due to these conditions.

Hessian fly damage in Oklahoma and Missouri has been moderate to severe over the last four to five years. There are few resistant varieties that are adapted to this region. Approximately 90% of fields are seeded to varieties with no resistance, and the fly-free date is not reliable.

Jeff Stuart, Purdue University
Brandon Schemerhorn, USDA-ARS, Purdue University
Rajat Aggarwal, PhD student
Thiago Benatti, PhD student
Chao Yang Zhao, PhD student
Yan Crane, technician
Phillip Morton, PhD student

Progress toward understanding Hessian fly biotypes.

A bacterial artificial chromosome (BAC) based physical genetic map has been constructed of the Hessian fly genome. This map consists of 270 BAC fingerprint derived contigs (FPC) positioned in the genome by fluorescence *in situ* hybridization (FISH). The ends of the BACs in these contigs have been end-sequenced and an additional 100 simple sequence repeat (SSR) markers have been identified on BACs in the map. The BACs and the contigs can be identified using Hessian fly Web FPC: http://genome.purdue.edu/WebAGCoL/Hfly/WebFPC/.

Three genes that determine the biotype status of Hessian fly larvae have been positioned on the physical genetic map. These genes determine the ability of the larvae to survive and stunt wheat carrying the specific resistance genes *H6*, *H9*, and *H13*. Generally referred to as *Avriulence* (*Avr*) genes, they have been named according to their corresponding resistance gene as *vH6*, *vH9*, and *vH13*. *vH6* has been positioned between two adjacent contigs on the long arm of Hessian fly chromosome X2. Three genetic map units separate the contigs. *vH9* has been positioned within a single contig on the short arm of Hessian fly chromosome X1. *vH13* has been positioned within a single BAC clone within a contig on the short arm of Hessian fly chromosome X2.

Results clearly indicate that Hessian fly virulence and avirulence to specific resistance genes in wheat results from mutations in single genes. Thus, the wheat-Hessian fly interaction clearly appears to have a gene-for-gene basis.

Kansas State University
WERA-066 2007 Annual Report

STATEWIDE PERSONNEL:

C. Michael Smith (representative), Leslie R. Campbell, Ming-Shun Chen (USDA-ARS), Xuming Liu, John C. Reese, Paola Sotelo, Sharon Starkey, and R. Jeffrey Whitworth, Department of Entomology, Manhattan, KS 66506.
P. E Sloderbeck, Southwest Research and Extension Center, Garden City, KS 67846.
J. P. Michaud, Department of Entomology, Western Kansas Ag. Res. Ctr., Hays KS 67601.
Jianfa Bai, Department of Plant Pathology, Kansas State University, Manhattan, KS 66502.
Ken Kofoid, K-State Research and Extension Agricultural Research Center-Hays, KS.
G. R. Reeck, Department of Biochemistry, Kansas State University, Manhattan, KS 66506.
W. T. Schapaugh, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

COLLABORATORS:

Mustapha El Bouhssini and Stefania Grando; International Center for Agricultural Research in the Dry Areas, P.O. Box 5466, Aleppo, Syria.
Marion Harris, Department of Entomology, North Dakota State University, Fargo, ND 58105.
Gary L. Hein, University of Nebraska Panhandle Research & Extension Center, Scottsbluff, NE 69361.
Sonia Lazzari, Universidade Federal do Paraná, Departamento de Zoologia, Curitiba, PR Brasil.
Frank B. Peairs and Terri Randolph, Department of Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.
Mahmoud Saker, Department of Plant Biotechnology, National Research Center, Giza, Egypt.
Jeff Stuart, Department of Entomology, Purdue University, West Lafayette, Indiana 47907.
Junxiang Wu and Shize Zhang, Department of Entomology, College of Plant Protection, Northwest A&F University, Yangling, Shaanxi, China 712100
Yu-Cheng Zhu, USDA-ARS-JWDSRC, Stoneville, MS 38776.

PROJECTS:

Comparisons of Wheat and Barley Resistance to Russian Wheat Aphid Biotype 2.

Said Enali, Radhika Anathakrishnan, Teru Niide, Laura Starkus, Sharon Starkey, Mustapha El Bouhssini, Stefania Grando and C. Michael Smith.

This research project reports the categories of resistance (antibiosis, antixenosis, tolerance) to Russian wheat aphid, *Diuraphis noxia* (Kurdjumov), biotype 2 present in a cereal introduction Triticeae (CItr) 2401, and a barley breeding line (IBRWAGP04-7), when compared to control resistant and susceptible wheat and barley genotypes. CItr2401 and IBRWAGP04-7 exhibit no antixenosis to *D. noxia* biotype 2, but both lines demonstrate antibiosis to *D. noxia* in the form of reduced aphid populations in comparison to susceptible controls. Leaf and root dry weight changes exhibited by infested CItr2401 and IBRWAGP04-7 plants were significantly less than those of infested plants of the susceptible control varieties. However, when a tolerance index was calculated to correct for differences in aphid populations, these differences in *D. noxia* tolerance to were negated.

Categories of Resistance to the Russian Wheat Aphid Biotype 2 Operating in Parents of

Aphid-Resistant CIMMYT Synthetic Wheat Lines.

Paola Cardona Sotelo, Priyavatha Voothuluru, Sharon Starkey, Gerald E. Wilde and C. Michael Smith.

To identify and characterize sources of North American to *D. noxia* biotype 2 resistance, synthetic hexaploid wheat lines created at the International Maize and Wheat Improvement Center (CIMMYT) were evaluated for potential resistance. Several CIMMYT genotypes and their parents were resistant to aphid induced - leaf rolling and chlorosis, and sustained significantly less damage than plants of the susceptible control Jagger. In general, fewer biotype 2 aphids were produced on genotypes with reduced chlorosis and leaf rolling, and aphid numbers were highly correlated with chlorosis and with leaf rolling. However, large biotype 2 populations developed on the parent line *Ae. tauschii* 518, although this genotype was highly resistant to leaf rolling and chlorosis. These biotype 2 resistant lines, which are also resistant to *D. noxia* populations in Mexico and to greenbug, *Schizaphis graminum* Rondani, biotype G, are strong candidates for use in improving the genetic diversity in bread wheat for resistance to different biotypes of both *S. graminum* and *D. noxia*.

Categories of Resistance to Russian Wheat Aphid Biotype 2 in Bread Wheat Genotypes.

Sonia Lazzari and C. Michael Smith.

Diuraphis noxia North American biotype 2 is virulent to the *D. noxia* resistance genes *Dn1*, *Dn2*, *Dn4*, *Dn5* and *Dn6*. Thus, a need exists for an improved understanding of the categories of resistance in all sources of biotype 2 resistance. In this study, wheat genotypes containing the resistance genes *Dn4*, *Dn6*, *Dn7*, *Dnx*, and a susceptible control (*Dn0*) were infested with *D. noxia* biotype 2 to determine the extent of the antibiosis and tolerance categories of resistance operating in each genotype. All infested resistant genotypes expressed some chlorosis and leaf rolling. Tolerance indices (TI) for shoots, roots and plant height of *Dn6* were significantly lower (more tolerant) than those of *Dn0*. Plant height TI of *Dnx* plants was also significantly less than that of *Dn0*. Thus, both Dn6 and Dnx plants are tolerant to *D. noxia* biotype 2 infestation. Both *Dn7* and *Dnx* plants exert antibiosis effects and significantly reduce *D. noxia* populations compared to *Dn0*. Despite the strong resistance of the *Dn7* genotype from rye, *Dn7* has deleterious effects on bread wheat baking quality. *Dnx*, from bread wheat, carries no negative quality traits and offers a suitable genotype for ready adaptation into Kansas wheat cultivars.

Interactions Among Biological Control, Cultural Control and Barley Resistance to the Russian Wheat Aphid in Colorado, Kansas and Nebraska.

Paola Sotelo, C. Michael Smith, Frank B. Peairs, Terri Randolph, and Gary L. Hein.

This research is being conducted to determine the interaction among biological control, cultural control and barley resistance to the Russian wheat aphid resistance in fields located in Colorado, Kansas, and Nebraska. The experimental design is a split-plot design with two main plot treatments (early, and delayed planting dates). Within each main treatment plot, four split-plot treatments (varieties) are randomized. In 2007, these treatments included two new *D. noxia* biotype 1 and 2 resistant barley cultivars, Stoneham and Sydney, and the susceptible cultivar Otis under triamethoxam-protected and unprotected regimes. Aphid, natural enemy and incidence sampling was conducted at four dates from late May through early July in 2007. Differences in the mean number of aphids were detected by location and variety during the second sampling, when unprotected Otis plants contained the highest numbers of aphids in Colorado and Kansas. On the third sampling date, unprotected Otis plants in Nebraska contained the highest numbers of aphids. There were complex interactions between the natural enemies observed in the three fields and these are being subjected to further analyses.

Entomological and Genetic Variation of Cultivated Barley from Egypt.

Mahmoud Saker and C. Michael Smith.

Assessment of the genetic diversity of new barley germplasm (landraces) at both the genotypic and phenotypic levels may increase the efficiency of plant breeding and marker assisted selection of desirable barley plant traits. The objective of this project is to use amplified fragment length polymorphisms (AFLPs) to assess genetic diversity among 24 Egyptian barley landraces and to identify resistance to the Russian wheat aphid (*Diuraphis noxia* (Mordvilko) in the landraces. To date, out of 273 polymorphic bands obtained using eight primer combinations, 35 bands are discriminative AFLP markers and could be used to distinguish the Egyptian barley landraces at the DNA level. An AFLP-based dendrogram, generated by UPGMA cluster analysis, indicates that there is a correlation between genetic similarities and location. The obtained dendrogram clustered the investigated landraces into three main groups. There was significantly less *D. noxia* mean total feeding damage on plants of several landraces originating near Giza, compared to those originating in Sinai or Marsa Matrouh.

Expression Analyses of Genes Encoding Peroxidases in Rice Seedlings Following Hessian Fly Attacks.

Xuming Liu, Jianfa Bai, and Ming-Shun Chen.

Wheat is the preferred host of the Hessian fly, *Mayetiola destructor*. The insect can also live on barley, rye, and wheat-related wild grasses. However, the Hessian fly cannot survive on rice plants. To investigate nonhost resistance mechanisms, we systematically analyzed the expression levels of rice genes following Hessian fly attacks using Affymetrix microarrays. Among the genes that were affected by Hessian fly attacks was a diverse group of peroxidase genes. There were 193 peroxidase probes in the rice microarray. The peroxidase probes represented 161 unique genes, including 4 glutathione peroxidase, 9 thioredoxin peroxidase, 12 ascorbate peroxidase, and 136 class III peroxidase genes. The glutathione peroxidase, thioredoxin peroxidase, and ascorbate peroxidase genes were not significantly affected by Hessian fly attacks. However, 17 of the 136 class III peroxidase genes were up-regulated at least two fold, and half of the affected genes were up-regulated more than 10 times. The up-regulation of peroxidase genes was very quick. Most of the up-regulated genes reached maximum RNA level within 12 hours after the initial Hessian fly attack. Nearly all up-regulated peroxidase genes encoded secretory proteins, which were predicted to locate extra-cellularly. Considering class III peroxidases are mainly involved in cell elongation, cell wall construction and differentiation, the specific, prompt, and dramatic up-regulation of class III peroxidase genes suggested that the strengthening of cell walls in rice seedlings following Hessian fly attacks was likely part of the non-host defense mechanisms.

Differential Responses of Wheat Inhibitor-Like Genes to Hessian Fly Attacks during Compatible and Incompatible Interactions.

Junxiang Wu, Xuming Liu, Shize Zhang, Yu-Cheng Zhu, R. Jeffrey Whitworth, and Ming-

Shun Chen.

Four groups of inhibitor-like genes encoding proteins with diverse structures were identified from wheat. The majority of the genes were up-regulated by avirulent Hessian fly larvae during incompatible interactions, and were down-regulated by virulent larvae during compatible interactions. The up-regulation during incompatible interactions and down-regulation during compatible interactions resulted in 4- to 30 fold differences between the expression levels in resistant plants and those in susceptible plants. The increased expression of inhibitor-like genes during incompatible interactions suggested that these genes are part of defense mechanisms in wheat against Hessian fly attacks, whereas the down-regulation of these genes during compatible interactions suggested that virulent larvae suppress plant defenses. Both the up-regulation of the inhibitor-like genes during incompatible interactions by avirulent larvae and the down-regulation during compatible interactions by virulent larvae were through mechanisms that were independent of the wound response pathway.

P. E Sloderbeck, J. P. Michaud and R. J. Whitworth

K-State Wheat Insect Extension Activities

We have updated our wheat insect web site at: http://www.entomology.ksu.edu/DesktopDefault.aspx?tabindex=195&tabid=405 to add more pictures and information on major wheat pests in Kansas. In addition we continue to revise our wheat insect management guide annually (http://www.oznet.ksu.edu/library/ENTML2/MF745.PDF) and we cooperate with the Plant Pathology Department to revise the Wheat Variety Disease and Insect Ratings each year (http://www.oznet.ksu.edu/library/plant2/samplers/MF991.asp). Plus we make presentations at numerous County Extension meetings and crop tours as requested.

J. C. Reese, J. Louis, L. R. Campbell, and W. T. Schapaugh, Ken Kofoid and G. R. Reeck.

We have made a good deal of progress in identifying sources of resistance to the soybean aphid, and have conducted studies on the categories of resistance, including detailed Electrical Penetration Graph (EPG) work. We continue to study C002, a transcript from aphid salivary glands, and showed that when this transcript is silenced by RNAi technology, the aphid cannot live on it host plant. We are also carrying on extensive studies of the protein that this transcript encodes. Collaborative projects include sorghum resistance to greenbugs, Hessian fly interactions with wheat, and the genetics of green peach aphid interactions with Arabidopsis. And, finally, Ken Kofoid is releasing 12 germplasm lines of sorghum that exhibit good levels of tolerance to greenbug feeding damage.

Publications:

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Nebraska Report to the WERA-066 Committee - 2007
Integrated Pest Management of Russian Wheat Aphid and Other Cereal Arthropod Pests

Nebraska Representative: Gary Hein, Entomologist ghein1@unl.edu
Panhandle Res. & Ext. Center (308) 632-1369
University of Nebraska
Scottsbluff, NE

Cereal arthropod status in 2007:

Russian wheat aphid activity in western Nebraska was down in 2007 with very few fields developing measurable Russian wheat aphid infestations. Low populations were present in barley trials but did not seem to build up to a significant presence. Other cereal aphids showed an important presence in Nebraska with bird cherry oat aphid, English grain aphid and greenbug being present in much higher numbers than usual. The incidence of these aphids increase as you moved east in Nebraska. Barley yellow dwarf also became increasingly more important as you moved east with some fields being significantly impacted by the presence of barley yellow dwarf.

There were several areas of serious wheat streak mosaic infections across the state indicating that previous wheat curl mite problems had occurred and resulted in virus transmission. The increased occurrence of warm extended fall conditions over the last several years has resulted in greater mite/virus problems.

We have been seeing the presence of wheat stem sawfly in southeastern Wyoming for over 20 years and in western Nebraska for over 10 years; however, it has been limited to a few small production areas in two counties. In 2007, we verified serious sawfly infestations in additional areas well removed from earlier known infestations. All of these infestations have been found in winter wheat grown under no till production practices.

Research/Extension Activities:

Demonstration Trials of New Resistant Barely Varieties

This project was done cooperatively with Frank Peairs (CSU) to test the new RWA resistant barley varieties (Sidney, Stoneham) in larger strip trials in various environments for yield and aphid response. Through the Nebraska panhandle and Colorado we had twelve trial sites out. The four sites in Nebraska varied a great deal due to moisture stress. Two of the locations had severe stress were not carried to harvest. The other two locations had moderate yields. Growers were pleased with the performance of the barley and remain interested in growing resistant barley; however drought conditions over the last several years have reduced the interest level in all spring/summer crop alternatives.

Improved Management of Russian Wheat Aphid in Barley by Integration of Biological-Cultural Controls with Aphid-Resistant Cultivars

Project Personnel: C. M. Smith (KSU), F. B. Peairs (CSU), and G. L. Hein

The research objective of the project is to determine the cost and benefits of two new RWA resistant barley varieties (Stoneham and Sidney) compared to existing production varieties and aphid management strategies. We also have an educational component to the project with the objective to develop educational programming to promote the adoption of RWA-resistant barley and appropriate biologically intensive pest management practices as viable components of diversified cropping systems in the western High Plains. Data collection from the first growing season was completed with barley yields at Sidney in the mid 30's (bu/A).

Physiological Impacts of Cereal Aphid Feeding:

Project Personnel: T. Heng-Moss, A. Gutsche, G. Sarath, P. Twigg, Y. Xia, G. Lu, Leon Higley, John Burd, and D. Mornhinweg

Gene Expression Profiling of Tolerant Barley in Response to Aphid Feeding

Research Objectives:

To use the impaired transport/end product inhibition model of plant-aphid interaction to establish temporal patterns of barley physiological responses to injury by various aphid species (including initial injury and recovery)

To initiate differential gene expression of aphid injured and uninjured barley through the use of microarray analysis

To confirm differential expression of genes associated with aphid injury through standard molecular techniques documenting changes at the mRNA level.

Physiological responses of wheat and barley to Russian wheat aphid and bird cherry-oat aphid

Research Objectives:

To document the physiological responses to RWA and BCOA susceptible wheat and barley.

Physiological and Biochemical Responses of Resistant and Susceptible Wheat to Injury by the Russian Wheat Aphid (recently published in JEE)

Research Objectives:

To provide a comprehensive overview of several plant response parameters,

To document the physiological and biochemical responses of resistant and susceptible wheat to RWA over time,

To determine what plant parameters may be useful in identifying mechanisms of resistance.

Biology of the Wheat Curl Mite and its Relation to the Epidemiology of Wheat Streak Mosaic Virus

Project Personnel: Gary Hein, Stephen Wegulo (UNL), Roy French (USDA-ARS), Robert Graybosch (USDA-ARS), P. Stephen Baenziger (UNL)

A significant effort is underway to determine the biological and ecological factors that are important to the management of the wheat curl mite and its vectored viruses, wheat streak mosaic virus and high plains virus. The major objectives of this work include:

1. Characterization and identification of the wheat curl mite biotypes.
2. Predicting wheat curl mite movement and wheat streak mosaic virus spread.
3. Using wheat curl mite populations for screening wheat lines for resistance to wheat streak mosaic virus. This project has resulted in testing and verification of the high level of virus resistance in a soon to be released variety, 'Mace'.

Establishing the virus-vector relationships between the wheat curl mite and wheat streak mosaic with regard to transmission.

WERA-O66 Cereal Insect Pests
North Dakota Report
2007

Representative
Marion O. Harris (Plant Resistance to Cereal Insects)
Kirk Anderson (Presenting)
Department of Entomology
North Dakota State University
Fargo, ND 58105
Marion.Harris@ndsu.edu

Collaborators
Janet Knodel (NDSU Extension Entomologist)
Department of Entomology
North Dakota State University
Fargo, ND 58105

Marcia McMullen (coordinator of North Dakota Disease and Insect Survey)
Department of Plant Pathology
Fargo, ND 58105

Bill Berzonsky (HRSW and white wheat breeder)
Elias Elias (durum breeder)
Mohammed Mergoum (HRSW breeder)
Xiwen Cai (wheat cytogenetics)
Department of Plant Science
North Dakota State University
Fargo, ND 58105

Thomas Freeman
Botany and Imaging Technology
Department of Plant Pathology
NDSU/USDA Microscopy Lab
Fargo, ND 58105

Stephen Xu
Wheat Cytogenetics
USDA-ARS Northern Crop Science Laboratory
Fargo, ND 58105

Highlights of the 2007 Small Grains Season

Planting began in April, with slow progress due to cool, wet conditions. In May warm dry conditions accelerated planting with most small grains planted slightly ahead of the long term average. Ample moisture was received in early June which allowed for good crop development. Excessive precipitation in some locations made it necessary to replant some wheat. July was characterized by dry hot conditions. While the warmer dried conditions reduced the threat posed by disease (scab in particular), later planted crops were stressed and yield projections declined, particularly in the western part of the state. Harvest began at the end of July and progressed at a good pace due to the warm dry weather. Most growers were done harvesting by the beginning of September. Quality and yields were generally good. Quality was generally considered better than that previous year. The average yield for hard red spring wheat in ND was estimated at 36 bushels/acre. The average yield for durum wheat was estimated at 30 bushels/acre.

2007 IPM Survey

Maps from the 2007 IPM survey in North Dakota were uploaded onto the NDSU IPM website at the following address: (http://www.ag.ndsu.nodak.edu/aginfo/ndipm/)

A state-wide survey of small grain diseases and insects continued during the 2007 growing season. Types of insects monitored include: aphids (species not distinguished), grasshoppers, wheat stem maggot and cereal leaf beetle. A total of 1,100 wheat fields were surveyed covering all 53 counties of ND during 2007. This approximately represents one field surveyed per 6,700 acres of wheat. The survey was initiated on May 29 and continued through August 9, 2007. Crops were surveyed from the 1-leaf stage through hard kernel (ripening) stage. Field scouts surveyed for insect pests of winter wheat, hard red spring wheat, and durum wheat. All other judgments of pest problems encountered in 2007 are based on reports from County Extension Agents and farmers.

Grain aphids

Grain aphids occurred at relatively low levels in 2007. Aphid counts were conducted from mid-June to the end of July. Aphids were found in 95% of the fields surveyed. The average percent stem infestation was 2.4% with ranges from 0 to 82%. Peak population densities occurred during early July. The treatment threshold is when 85% of the stems have one or more aphids present, prior to the completion of heading. There was some sporadic insecticide spraying for control of wheat aphids in 2007.

Grasshoppers

Scouts swept for grasshoppers using a 15-inch sweep net in field edges in 2007. Populations of nymphs and adults were generally below treatment levels throughout the state. The summer weather conditions were not as favorable for grasshopper outbreaks during 2007 as in 2006. There were however some sporadic reports of higher grasshopper populations, primarily in the north central region.

Wheat stem maggot

Maggots were counted on 100 stems per field (20 stem at 5 locations in each field). Maggots boring in the stem cause characteristic ‘white heads’. These heads fail to develop seeds, and are found in otherwise uniformly green fields. Maggots were found in 46% of fields surveyed from heading to maturity. White heads were observed from late June to the end of July. In fields in which stem maggots were present, the average percent of stems infested was 17%, with ranges from 1 to 54%.

Little is known about the biology of this insect, and there are no current insecticide recommendations for control of this insect in ND. Farmers in the southwestern portion of the state have been particularly concerned about this insect in the last few years. Some of this concern is driven by the dramatic appearance of wheat fields with even a light infestation of stem maggot. To help address this insect problem, North Dakota State University researchers will study the basic biology of the wheat stem maggot with an aim to develop economic thresholds and calculate the appropriate time for insecticide applications.

Cereal Leaf Beetle

Cereal leaf beetle is an export concern for the shipment of hay from ND to California and is monitored for state regulatory purposes. No cereal leaf beetles were detected in ND in 2007.

2007 Hessian fly survey

Reports of Hessian fly were sporadic again in 2007. Most producers in ND have little experience or knowledge about the Hessian fly, therefore it is usually considered a pest of little importance in our region. However, to the north of us, entomologists in Manitoba have quantified yield losses to Hessian fly, decided that these losses are economic and are now incorporating Hessian fly resistance into elite cultivars.

We have been collaborating with Ylva Hillbur, a chemical ecologist in Sweden specializing in cecidomyiid sex pheromones. In 2005 we tested a 5-component blend in semi-field conditions and believe that this five-component blend will be useful for monitoring Hessian fly in the field. Field tests of the pheromone were conducted in Kansas (late September 2006) by Ylva's student, Martin Anderson, who is being helped by Kansas Country Extension Agent Dr Gary Cramer (Wichita). In 2007 field tests of the 5-component blend were conducted in ND. Crop scouts placed pheromone traps in 33 wheat fields across the state, starting in early June and continuing through late July. Hessian fly adults were observed in all 33 locations. Some of the highest concentrations were found in the southwestern and northeastern regions of the state. In the southwestern part of the state, trap counts averaged between 100 and 500 Hessian fly per trap per week. In the northeast one location averaged over 500 Hessian fly per trap per week.

2007 Orange wheat blossom midge survey

Additional information on the orange wheat blossom midge as well as maps of the wheat midge survey for the last 12 years is available at the following address:
(www.ag.ndsu.nodak.edu/aginfo/entomology/entupdates/Wheat_Midge/owbm.html)

A soil survey conducted in the fall of 2006 predicted increasing levels of wheat midge for the 2007 growing season. This prediction held true for the most part. Field scouting during the 2007 field season found economic populations of wheat midge present in wheat fields in the northern half of North Dakota. Infestation levels were particularly bad in the north central part of the state. It is estimated that between 35,000 and 40,000 acres of wheat were treated with Lorsban® (Dow Agrosciences). Several anecdotal reports also came in from this region attesting to the abundance of the midge. In several instances aerial spraying pilots have reported that the wings of their aircraft turned orange due to flying through clouds of wheat midge. Our annual soil survey was started immediately after harvest. Sampling was done by the county extension agents taking soil samples from the current year's wheat fields. After collection the samples are sent to NDSU for processing. At this time the 2007 data is still being analyzed. However, it does appear that the wheat midge is still prevalent across much of the northern part of the state, but generally at low levels. The hot spots for the 2008 growing season will likely be in the north central and northeastern portions of the state. Due to the rapid increase in grain commodity prices, growers should be particularly careful when scouting this coming season.

A new alternative to night field scouting for wheat midge is through the use of sex pheromone traps or yellow sticky traps. Traps are placed into wheat fields at heading and collected every three to five days. Three sex pheromone traps ($7.20 a trap) per 160-acre wheat field or 10 yellow sticky traps (60 cents per trap) are recommended. Action thresholds are nine wheat midge per sex pheromone trap and five to 20 midge per yellow sticky trap. Sex pheromone traps are available through PheroTech International (http://pherotech.com/). Yellow sticky traps are available through Great Lakes IPM (http://greatlakesipm.com/) or PheroTech International.

Wheat stem sawfly in 2007

Wheat stem sawfly continues to be a concern for farmers in the southwestern and south-central parts of the state. Farmers do not like using the solid stem resistant varieties because of yield drag.

Background on North Dakota Survey for Diseases and Pests

For the last ten field seasons, aphid monitoring has been carried out as part of a larger effort to survey diseases and insect pests in North Dakota cereals. The state is covered by 5-6 scouts who monitor fields within a county every 1-2 weeks from May through August. The insects that are monitored in cereals include: aphids, grasshoppers, and cereal leaf beetle. Results of these surveys can be found at: www.ag.ndsu.nodak.edu/aginfo/ndipm/05IPMSur/HTML/WheatIPMsurvey.htm.

For aphids, a plant is scored as infested if one or more insects are found. Scouts record any aphid found on the plant rather than separating different aphid species. In North Dakota, common aphids in cereals are bird cherry oat aphid, English grain aphid, corn leaf aphid, and greenbug. Scouts also provide qualitative information on species composition and have been instructed to report the occurrence of the Russian wheat aphid. The cereal aphids that are found in North Dakota are assumed to fly north from breeding sites in Kansas and Nebraska. These same winds are believed to bring rust pathogens to the state. Natural enemies of aphids are not monitored in North Dakota.

Background on North Dakota Autumn Survey for Wheat Midge

In the mid 1980s, a major wheat midge outbreak began in northern Canada and subsequently spread in the 1990s to large areas of Manitoba, Saskatchewan, North Dakota, and northwestern Minnesota. Although wheat midge numbers have declined in recent years the North Dakota Wheat Commission is still concerned enough about wheat midge to pay for an annual soil survey that provides estimates of overwintering wheat midge populations. For this survey county agents send in soil samples in September and October from the current years wheat fields. In our lab, we examine these soil samples for wheat midge cocoons. Cocoons contain overwintering third instar larvae. When wheat midge cocoons are found, larvae are dissected to estimate parasitism levels. A map of wheat midge larval numbers, which takes into account expected mortality from parasitism, is made available to wheat farmers in February/March each year.

It should be noted that the wheat midge is an insect that is easy to miss unless wheat spikelets are opened and developing seeds examined. The wheat midge is very small and has an adult stage that lives for only a few days. Because the adult hides in the canopy during the day and is only seen on wheat heads at dusk (when high mosquito populations make it unpleasant to be out examining wheat fields) the wheat midge is rarely reported except when third instar larvae are noticed in large numbers during wheat harvest. Yet even at harvest, observations of wheat midge larvae only occur under particular conditions. If the weather is very dry in August (after larvae finish feeding and before wheat is harvested), larvae remain in the wheat head and are threshed from the heads as the grain passes through the combine. At this time the orange larvae are quite apparent covering the harvesting equipment and can frequently be found in large numbers in the harvested grain loaded onto trucks.

WERA-66 REPORT for the Period of Sept. 2006 through Feb. 2008
(Compiled by Gary Puterka)

USDA, ARS, SPA
Wheat, Peanut and Other Field Crops Research Unit
1301 N. Western Road
Stillwater, OK 74075
Phone: (405) 624-4141
FAX: (405) 624-4142

I. PERSONNEL

Cheryl A. Baker	ext. 222, 243	Cheryl.Baker@ars.usda.gov
John D. Burd	ext. 223	John.Burd@ars.usda.gov
Norman C. Elliott	ext. 227	Norman.Elliott@ars.usda.gov
Yinghua Huang	ext. 230	Yinghua.Huang@ars.usda.gov
Dolores W. Mornhinweg	ext. 237	Do.Mornhinweg@ars.usda.gov
Gary J. Puterka	ext. 257	Gary.Puterka@ars.usda.gov
Kevin A. Shufran	ext. 240	Kevin.Shufran@ars.usda.gov

II. OVERVIEW OF CURRENT RESEARCH AND ACCOMPLISHMENTS

A. Barley Breeding Program (Dr. Do Mornhinweg)

RWA-resistant, 6-rowed, spring malting barley germplasm lines STARS 0601B - STARS 0619B, 2-rowed spring malting barley germplasm lines STARS 0620B - STARS 0636B, and 2-rowed spring feed barley germplasm lines STARS 0637B- STARS 0643B were released. These lines were developed by backcrossing 31 different sources of resistance into spring barley cultivars of each barley type, 6- rowed malt, 2-rowed malt, and 2-rowed feed. These lines were developed by USDA-ARS in Stillwater, and evaluated and selected in Idaho, Colorado and/or Nebraska with assistance of. Phil Bregitzer, USDA-ARS, Aberdeen, ID, Frank Piears, Colorado State University, and Gary Hein, University of Nebraska. Increases have been made prior to release of 10, RWA-resistant, 6-rowed, winter, feed barley germplasm lines resistant to both Greenbug and RWA.

Barley cultivar was released by USDA-ARS in 2007. This cultivar was developed by USDA-ARS, Stillwater, OK and selected and evaluated by USDA-ARS, Aberdeen, ID. The main component of resistance in RWA 1758 is tolerance and is derived from STARS 9577B.

A breeding program has been initiated to develop winter, hulless, feed barleys resistant to both RWA and Greenbug, adapted to Oklahoma, and suitable for ethanol production. Hulless winter barleys, selected for adaptation to OK as well as percent starch, were crossed as males to RWA and greenbug resistant lines developed by USDA-ARS in Stillwater. Evaluation of female parents is ongoing as well as crossing and backcrossing of hulless lines to selected females. 615 F2 head rows were grown in Woodward, OK in the summer of 2007. Thousands of heads were selected and hulless heads were screened to RWA and greenbug in the fall of 2007. Resistant segregates will be increased in the greenhouse in the spring of 2008. 104 hulless F3 bulks were planted in Woodward in the fall of 2008.

A seedling screening test for BCOA resistance has been developed and tested for repeatability. Two replications of the Barley Core Collection (960 accessions) were screened with this new technique in the summer of 2006. Survivors were grown in pots in the greenhouse and data collected for plant height, grain yield, and yield components. Five seed each of 364 survivors were screened with BCOA in the summer of 2007. An aphid free set of identical flats was also grown. Selected survivors from the screening were rescued and, along with their matching non-infested checks, transplanted into pots in the greenhouse. Infested and non-infested pots for each line were placed side by side on greenhouse benches for increase. Plant height, grain yield, and yield components will be measured.

B. Wheat Breeding Program (Cheryl Baker)

Included in the guidelines in the WERA 2006 report were recommendations for establishing set plant differentials for use as screening tools, thereby eliminating one of the obvious sources of variability in our screening techniques. In order to standardize the seed source for researchers, it was determined that these plant differentials would be available to RWA researchers via Stillwater USDA-ARS, as sufficient seed is available. Seed is now available for small screening tests, and if larger amounts of seed are required for an individual program, then starter seed can be obtained from Stillwater, and seed can then be increased as needed at the various locations. In order to establish this uniform set of differentials, the suggested differential lines were screened for homogeneity for RWA1 resistance, and plants were then grown and harvested with an eye for uniform maturity, height, and other observable characteristics. Off-types were discarded. Progeny screening is being done prior to further increases.

We have continued with the development of our breeding lines that are resistant to RWA1. Even though they may not be useful as germplasm or variety releases in the near future with the current prevalence of RWA2, different sources of RWA1 resistance that are due to different genes may provide additional differentials for screening against new RWA biotypes that may develop. In addition, several possible differentials resistant to RWA2, yet susceptible to RWA1, have been identified and increased.

The screening of current breeding lines for resistance to RWA2 is also underway, as space and conditions allow. Several of our winter breeding lines containing Dn7 appear to be resistant to all RWA biotypes against which they have been tested. Our germplasm release STARS-0601 has also been resistant to all RWA biotypes against which it has been tested.

C. Sorghum Breeding Program (Dr. Yinghua Huang)

Greenbug is an important insect pest, limiting crop production throughout the world. Since 1968, the greenbug has become the predominant pest of sorghum in the Great Plains. A few sources of sorghum germplasm were identified as resistance to greenbugs at various times; however new and virulent biotypes have been able to overcome most existing sources of genetic resistance. In order to exploit new sources of greenbug resistance, we initiated a project toward a systematic evaluation of the entire U.S. collection of sorghum germplasm (over 40,000 accessions). Now screening sorghum germplasm against greenbug biotype I has been done, and the evaluation results indicate that more than 40 germplasm accessions have some degrees of resistance to greenbug biotype I. These sources of greenbug resistance in sorghum germplasm, particularly those newly identified resistant lines, should be valuable for the development of new greenbug-resistant sorghum cultivars or hybrids.

Host-plant resistance has been used in many sorghum breeding programs for controlling the pest in the past. Molecular tools such as DNA markers can be used to identify and monitor the genetic components responsible for pest resistance, facilitating the breeding process. We have recently constructed a genetic linkage map for sorghum using SSR markers. With this genetic map, we have been able to identify several DNA (SSR) markers closely associated with a major QTL which conditions resistance to the greenbug. These DNA markers proved a useful tool for marker-assisted selection. The major QTL detected in this study and the tightly linked SSR markers will facilitate efficient development of resistant lines or hybrids in sorghum.

D. RWA Biotype Diversity and Ecology (Dr. Gary Puterka)

Studies have been ongoing since 2006 on the ecology of overwintering RWA in diverse environments to determine if and how sexual reproduction (holocycle) occurs and its role in biotype development. This research is further supported by studying the effects of photoperiod, temperature and host on sexual form induction in the laboratory. In 2007, This research was further expanded to include the overwintering ecology of three other *Diuraphis* spp. endemic to the U.S.A., *D. tritic*i, *D. nodulus*, and *D. frequens*. These species are known to go sexual in the fall and serve as positive controls in field and lab studies. Data is still being collected and conclusions not yet firm. However, it is obvious that *D. noxia* does not respond to environmental stimuli in the same manner as the three other *Diuraphis spp*.

A study was conducted in collaboration with Frank Peairs and Terri Randolph to determine if there was a uniform response of RWA biotypes RWA1 – RWA7 to 24 plant differentials under differing environmental conditions and locations. This study concluded that results were uniform between locations and researchers that used the same seed sources and RWA biotype sources.

Future plans are to arrange collaborations with State researchers to sample sites for monitoring RWA biotypic diversity.

E. Molecular Ecology of Cereal Aphids and their Natural Enemies (Dr. Kevin Shufran)

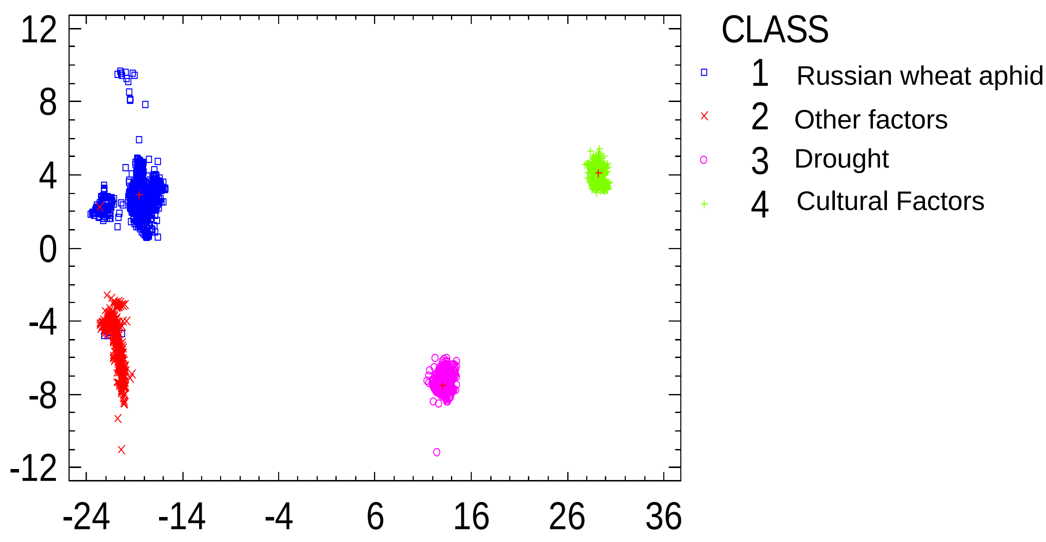
To date, all results support the hypothesis that RWA was introduced once into North America, and the path of the introduction was from South Africa to Mexico, then a natural spreading of populations north into the US. The occurrence of biotypes in 2003 came after planting of Dn4 resistant wheat varieties, which began in about 1996. All data supports the hypothesis that Dn4 virulent biotypes were not introduced, but arose from the extant population. Although RWA in the US lacks genetic variation (measured by various molecular markers), it is phenotypically diverse, i.e. shows variation in its ability to injure hosts with and without plant resistant genes.

F. Predicting the impact of predators and parasities (Dr. Norm Elliott)

In conjunction with collaborators from Oklahoma State University we continued research to develop a predictive population dynamics model for the greenbug. We are in the third year of a field study to quantify the spatially explicit population dynamics of the greenbug in relation to parasitism by *L. testaceipes* and predation by Coccinellidae and other predators. The research has potential to improve pest management practices for the greenbug in wheat. If successful, treatment decisions will be more accurate and based on improved knowledge of the potential for biological control.

G. Remote sensing of cereal aphids (Dr. Norm Elliott)

In conjunction with collaborators from the Texas Agricultural Experiment Station and TerraVerde Technologies we are developing remote sensing technology to detect and monitor Russian wheat aphid infestations in winter wheat. During the previous year we documented that multi-spectral remote sensing differentiated stressed areas in production winter wheat fields caused by the Russian wheat aphid from non-stressed areas. We also documented that it is possible to differentiate stressed areas in wheat fields caused by Russian wheat aphids from areas stressed by other factors based on spatial pattern analysis and multivariate discriminant function analysis (see figure below). The technology could improve pest management practices for the Russian wheat aphid in winter wheat because infestations in fields will be efficiently detected and delineated before treatment is required.



H. Greenbug Ecology and Biotypic Diversity (Dr. John Burd)
Greenbugs collected from 30 counties of Kansas, Nebraska, Oklahoma, and Texas are under genetic analysis to determine host race associations. Biotypes E and I exhibited the greatest host range and were the only biotypes collected in all four states. The great degree of biotypic diversity among noncultivated grasses supports the contention that the greenbug species complex is composed of host-adapted races that diverged on grass species independent of, and well before the advent of modern agriculture. A survey has been initiated on the Aphelinid parasitoids reared from cereal aphids collected from the western slope of the Rocky Mountains in states that include Colorado, Wyoming, New Mexico is being conducted. In addition, greenbug collections are being made at these locations to address biotypic status and host relationships.

III. PUBLICATIONS

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SOUTH DAKOTA, WERA-066 ANNUAL REPORT, 2007-2008

Submitted by:
Louis Hesler
Research Entomologist
USDA-ARS North Central Agricultural Research Laboratory
2923 Medary Avenue
Brookings, SD 57006
(605) 693-5228, louis.hesler@ars.usda.gov

Overview of Cereal-Aphid Research Activities and Accomplishments:
1. *Rhopalosiphum padi* (L.) (bird cherry-oat aphid) and *Diuraphis noxia* (Kurdjumov) (Russian wheat aphid) are common aphid pests of wheat and can co-occur at relatively high levels within wheat fields. Resistance to both aphids has been identified in several triticale accessions. We conducted experiments to identify and characterize antibiosis-type resistance to *R. padi* in additional triticale lines and to test *R. padi*-resistance levels in several backcrossed, triticale-derived lines of *D. noxia*-resistant wheat. Triticale accessions '6A-558', 'H85-734' and 'M86-6174' were identified with moderate levels of antibiosis to *R. padi*. All three accessions limited *R. padi* population growth relative to 'Arapahoe' over 13 d. 6A-558 increased development time of *R. padi* compared to that on Arapahoe, and 6A-558, H85-734 and M86-6174 each decreased the number of nymphs produced by *R. padi* over 7 d. Additional tests confirmed 'N1185' triticale as a strong source of resistance to *R. padi*, and showed that 'Lamar' wheat was not resistant to *R. padi*. Tests of wheat lines derived from crosses between N1185 and Lamar and then selected for resistance to *D. noxia* showed that three of 13 lines reduced the number of *R. padi* per plant, with resistance levels comparable to N1185 in two lines. Nymphiposition by *R. padi* measured over a 24-h period did not differ among any lines in no-choice tests. The results provide further support that triticale is a significant source of resistance to *R. padi*, but further work is needed to understand transference of *R. padi*-resistance from triticale to wheat.

2. Meaningful sources of plant resistance are needed against the bird cherry-oat aphid, a worldwide pest of wheat. Moderate levels of resistance to this aphid were found in additional triticale and wheat accessions tested.

Publications

Hesler, L.S., S.D. Haley, K.K. Nkongolo & F.B. Peairs. 2007. Resistance to *Rhopalosiphum padi* (Homoptera: Aphididae) in triticale and triticale-derived wheat lines with resistance to *Diuraphis noxia* (Homoptera: Aphididae). J. Entomol. Sci. 42:217-227.

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WERA-066 (Cereal Aphid Research)
2007 Annual Report from
Wheat Improvement Program
Texas AgriLife Research at Amarillo

Submitted by Yiqun Weng
Texas AgriLife Research at Amarillo
6500 Amarillo Blvd. W., Amarillo, TX 79106
Email: y-weng@tamu.edu; Phone: (806) 677-5607

Project participants (Wheat Improvement Program, Texas AgriLife Research at Amarillo)

Yiqun Weng
Jackie C Rudd
Ravindra Devkota
Azhaguvel Perumal
Huangjun Lu
Xiong Chen
Vidya Saraswathi
Peihua Yan
Laura Hampton

Collaborators

G. Jerry Michels (Entomology Program, Texas AgriLife Research at Amarillo)
John D. Burd (USDA ARS, Stillwater)
Dolores W. Mornhinweg (USDA ARS, Stillwater)
Ming-Cheng Luo (University of California, Davis)
Jianfa Bai (Kansas State University, Manhattan)
Bikram S. Gill (Kansas State University, Manhattan)
Wanlong Li (Kansas State University, Manhattan)

Current research and accomplishments

1. Map-based cloning of greenbug resistance gene *Gb3* in wheat

This project aims to clone the *Aegilops tauschii*-derived greenbug resistance gene *Gb3* from wheat ('Largo' source). Previously *Gb3* was placed in the distal bin of wheat chromosome arm 7DL with several *Gb3*-linked microsatellite markers. We are conducting fine genetic and physical mapping of *Gb3*. Three complementary populations at diploid and hexaploid levels were used for high-resolution genetic mapping with SSRs, EST-, RFLP- or AFLP-derived STS markers. So far, 31 markers have been placed on the genetic map surrounding the *Gb3* locus and a 2.0 cM interval of *Gb3* is delimited by one AFLP-STS and one EST-STS marker. More markers are being developed by exploring the rice and *Brachypodium distachyon* whole genome sequences. Screening of an *Ae. tauschii* BAC library is also underway to initiate chromosome walking.

2. Marker-assisted selection and development of greenbug-resistant wheat cultivars

In the Texas Wheat Breeding Program, we are actively implementing the marker-assisted selection (MAS) strategy to expedite the breeding process. Priority traits for MAS include resistance to the greenbug, Russian wheat aphid, wheat streak mosaic virus and the wheat 1AL.1RS translocation. As a test case, one rye 1RS-specific marker and two *Gb3*-linked molecular markers are being used to screen large breeding populations. These markers seem to be highly predictable in selecting plants carrying the target genes.

The wheat cultivar, TAM 112 carrying the greenbug resistance gene *Gb3* and 1AL.1RS wheat-rye translocation is gaining increasing acreages in the Southern Plains since its release by the Wheat Improvement Program of Texas AgriLife Research at Amarillo in 2005.

3. Molecular mapping of greenbug resistance genes in wheat and barley

Molecular markers are being developed for the greenbug resistance genes *Gb2*, *Gb6* in wheat, and *Rsg1*, *Rsg2* in barley. These markers will be used in marker-assisted selection and development of wheat/barley germplasm with multiple resistances.

4. Exploring greenbug - *Brachypodium distachyon* as a new model system for cereal-aphid interaction research

Brachypodium distachyon ($2n = 2x = 10$) has been proposed as a model species in cereal crops and temperate grasses for genomics research. Responses to greenbug biotype E feeding among six diploid *B. distachyon* accessions were examined and distinct reactions were observed. Phylogenetic relationships of the six accessions were analyzed with 160 EST-SSR markers. Three grass species, rice, perennial ryegrass, and *Aegilops tauschii* were also included as outgroups in phylogenetic analysis. The genetic divergence among the six accessions was correlated with geographical distances. Marker data confirmed the earlier finding that *Ae. tauschii* is genetically closer to *B. distachyon* than to rice. It seems that the greenbug – *B. distachyon* may a system of choice in studying the molecular mechanisms of plant - aphid interactions in the grass genome.

5. *Gb3*-mediated host defense responses against greenbug feeding in wheat

In a 2-genotype (bulked segregant R and S super pools), 3-time-point (0, 24 and 48 hours after infestation, hai), 3-replicate experiment, 18 Affymetrix GeneChips were used to investigate *Gb3*-mediated defense responses upon greenbug feeding. Of the ~61,000 transcripts surveyed, 47 showed significant differences in constitutive expression between the R and S pools ($p = 0.05$). Nearly 10,000 probe sets exhibited significant changes in expression level in both genotypes at 24hai and/or 48 hai, among which about 6,000 have putative functions. Of the 6,000 transcripts, 706 showed significantly altered expression in the R pool as compared with those in the S pool at either 24hai or 48hai or both. Analysis of expression patterns of the 706 probe sets suggested that *Gb3*-mediated host defense responses in wheat to greenbug feeding are more similar o plant pathogen attacks, but wounding responses are also obvious.

6. Development of molecular markers in the greenbug

The abundance and distribution of simple sequence repeats (SSRs) were explored in the EST and genomic sequences of the pea aphid and the green peach aphid. A total of 1112 newly developed, together with 40 published SSR markers were investigated for their cross-species transferability among 6 aphid species. Genetic diversity among 24 greenbug biotypes was further examined with 30 transferable SSRs. It was found that the pea aphid genome is abundant in SSRs with unique frequency and distribution of SSR motifs. Cross-species transferability of EST-derived SSRs is dependent upon phylogenetic closeness between SSR donor and target species, but is higher than that of genomic SSRs. Neighbor joining analysis of SSR data revealed host-adapted genetic divergence as well as regional differentiation of greenbug biotypes.

Pertinent Publications

Weng Y., Azhaguvel P., Michels G. J., and Rudd J. C. (2007) Cross-species transferability of EST- and genomic-derived microsatellite markers from six aphids and their use for study of biotypic diversity in the greenbug and Russian wheat aphid (Homoptera: Aphidinae). *Insect Molecular Biology* 16:613-622.

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