

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

Minutes of the Joint Meeting of WERA066 and the Greenbug Consortium
 September 19-20, 2006

List of Participants:

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* Visitors that did not sign attendance sheet

September 19, 2006

8:05 AM – Chair Do Mornhinweg, called the meeting to order and began the meeting with a round of introductions by those in attendance. Do then introduced administrative co-advisor Tom Holtzer to address the group. Tom recalled how the group was started at a meeting in Denver in 1988 and asked for a show of hands of those that had been in attendance at that meeting and several people in the group raised their hands. Tom announced that the petition to continue the project for the next five years had been approved. So we are good through till Sept 30, 2011. Comments on the review of the petition were generally excellent except for a couple of areas that only received ratings of good. One was that we need to encourage old members to officially rejoin the group and the other was that we needed to be more specific on reporting extension outreach efforts. Tom thought that the one was an artifact of the process itself and the other is just a reminder that we need to be ever vigilant to include accomplishments that relate to extension activities in our annual reports. While these areas do not have to be addressed at this time they should be addressed in future reports. Tom then stepped back and assumed the role of CSREES, National Program Leader, Rick Meyer and apologized for not being able to attend the meeting. Tom indicated that for more information on CSREES one should check out their web site at: <http://www.csrees.usda.gov/> or Rick's page at http://www.csrees.usda.gov/about/AllUnits/staff_view.cfm?record_id=195

8:20 AM -- Since the meeting was running ahead of schedule Do decided that it would be a good time to take a short break and for people to check over the minutes that were available on the front table. After a short break the minutes were approved as distributed.

Presentations

Progress toward understanding Hessian fly biotypes. Jeff Stuart, Purdue University, (in cooperation with Ming Shun-Chen, Sue Cambron, Rajat Aggarwal, and Thiago Benatti)

In 1930, RH Painter observed that field populations of the Hessian fly are composed of a mixture of genotypes that differ with respect to their abilities to survive and stunt specific wheat genotypes. Later referred to as “biotypes,” RL Gallun and JH Hatchett performed intermatings between genotypes and demonstrated that the ability of a Hessian fly larva to survive on an otherwise resistant wheat cultivar (virulence) was inherited as a simple Mendelian trait. They further demonstrated that the pattern of inheritance fit the gene-for-gene model as proposed by HH Flor; i.e. for each resistance gene in wheat there is a corresponding Avirulence (Avr) gene in the Hessian fly.

This overview focused on technological developments that impact our understanding these Hessian fly genotypes. Five Avr genes have been mapped to a chromosome in the Hessian fly that condition virulence and avirulence to the Hessian fly resistance genes H3, H5, H6, H9, and H13. These genes are called vH3, vH5, vH6, vH9, and vH13. Due to its chromosomal position and nearly 100% penetrance, vH13 has been mapped most precisely. It is positioned between flanking DNA markers 13 cM apart near the telomere of Hessian fly chromosome X2. This is the strongest evidence to date that wheat and Hessian fly do share a gene-for-gene relationship. In an effort to identify more closely linked markers and clone vH13, we have used bacterial artificial chromosome (BAC) libraries and fluorescence in situ hybridization (FISH) to construct a physical map of the Hessian fly genome. Over 12,000 BAC clones were DNA fingerprinted and analyzed for overlaps to identify contigs. Contigs were then ordered and oriented on the Hessian fly polytene chromosomes using FISH. Work in progress will determine the physical position of vH13 and other Avr genes within the contigs in which they reside.

Increasing penetration of host plant resistance to insect pest in wheat cultivars: What breeders want. Ming Chen, Kansas State University.

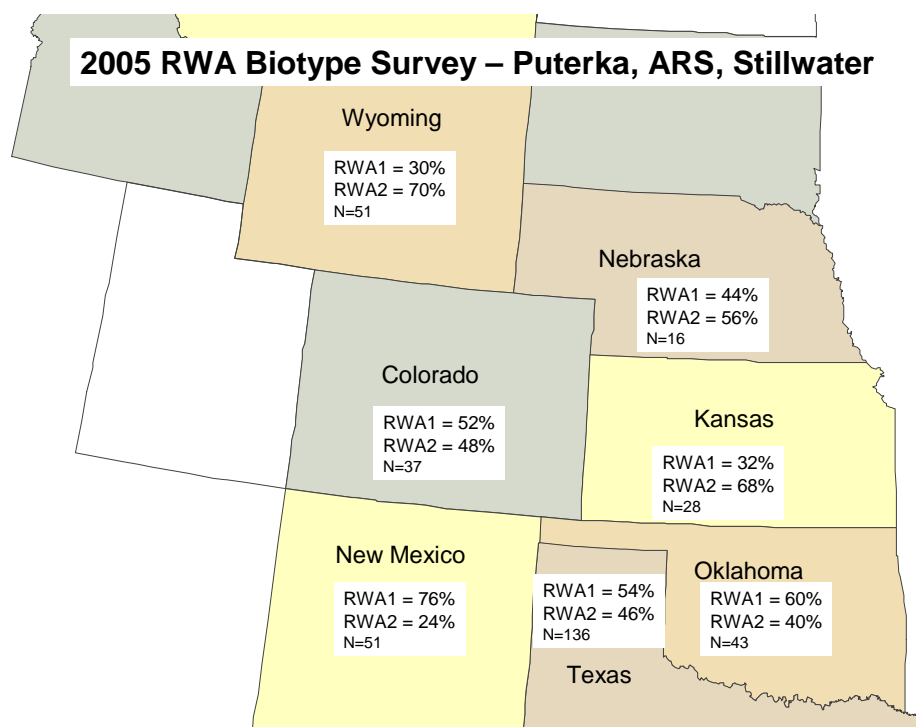
What we can do as entomologists to increase the penetration of host plant resistance to insect pests are:

1. To identify markers that are linked with resistance genes and use them for marker-assisted-selection during breeding.
2. To enhance pre-breeding programs to generate germplasm with improved genetic background for specific resistance genes.
3. To coordinate biotype survey within major wheat growing regions and make this information available to breeders.

Distribution of Russian wheat aphid biotypes in the Rocky Mountain region.

Gary Puterka, USDA-ARS Stillwater, OK.

Presentation of results from 2005 Russian wheat aphid survey which can be summarized by the following map:



9:40 to 10:10 AM -- Short Break

State Reports

Verbal reports were given by representatives from each state summarizing their written reports of recent insect activity and research results:

Colorado – Frank Peairs

Idaho – Juan Manuel Alvarez

Kansas – Mike Smith (Phil Sloderbeck, JP Michaud and John Reese)

Montana – Sue Blodgett

Nebraska- Gary Hein

North Dakota – Marion Harris

Oklahoma – Tom Royer

Texas – Roxanne Bowling (Yiqun Weng and Jerry Michels)

USDA – Gary Puterka

Washington – Steve Ullrich

Brief discussion on how to handle the afternoon's breakout sessions.

11:55 AM Break for Lunch

1:30 PM Do reconvened the meeting with discussion on how to proceed with the breakout sessions. Group decided that with the inclusion of the Hessian fly workers and the low number of bio-control workers attending the meeting that rather than having separate breakout sessions the

group would just continue on as a whole and discuss topics of general interest to the group.

The first topic for discussion was biotype monitoring. Suggestion was made that committee members could help Gary Puterka collect samples of Russian wheat aphids from different locations. John Burd reported that he keeps a greenbug library and offered to keep voucher specimens for members of the group.

Gary Puterka indicated that in doing the survey for RWA that he was finding that results for RWA1 and RWA2 were very repeatable but that the rest of the biotypes are often inconsistent leading to a discussion on what could be causing the inconsistent results. Possible reasons suggested were that environmental variation could affect results and that seed sources may not be pure. Which lead to a question of whether temperature sensitive resistant genes are useful? And whether resistance to chlorosis or to leaf rolling is more important when screening for resistance.

Bottom line is that breeders want to know what is effective. To be more accurate breeders would like to know: What will be effective 10 years from now as it takes time to bring cultivars to market? Since we can't predict durability there is a constant need to search for new genes.

Marion Harris suggested that maybe there is too much emphasis on plant defense and not enough emphasis on pest offence: What does the pest need? Which lead to a discussion of the term R-gene mediated resistance.

3:15 PM The discussion session concluded to allow for a meeting of the Greenbug Consortium.

3:20 PM Tom Royer convened the meeting of the Greenbug Consortium. After deciding that there was a quorum and a brief discussion the greenbug workers in attendance decide to dissolve the Greenbug consortium and use the remaining treasury to support future WERA066 meetings.

They then discussed recent observations on greenbugs in the region. Tom noted that he was continuing to measure the usefulness of the Glance 'n Go system in the field as part of the areawide management program and was working on a training manual and mentioned that there had been a significant amount of greenbug activity on wheat in the spring. While there have occasionally been problems with greenbugs on wheat in the fall and spring in the south, it was pointed out that greenbugs had not been a problem on sorghum for a long time. Phil Sloderbeck mentioned that greenbug numbers on sorghum in Kansas had also been low for several years and speculated that this may be a result of the wide spread adoption of reduced and no-till farming practices. He also indicated that there had been some greenbug activity in southern Kansas this spring, but that parasites had moved in and reduced the populations fairly quickly. Tom indicated that the Glance 'n Go system need more work to increase adoption. Roxanne Bowling suggested that consultants can sometimes be complacent in expecting to see problems develop in one area of a field first. For example: they tend to look for greenbugs or spider mites in the southwest corner of a field. She noted that this year spider mites on corn had developed first on the northwest corners of some fields and caught consultants by surprise. John Reese asked if anyone had seen significant numbers of greenbugs on corn? He thinks that eventually we will see a host shift for this aphid much like we saw when the greenbug became a pest of sorghum. He also made a plea that the group should publish a review paper in one of the ESA journals on greenbug biotypes. John Burd reported on an observation from South Carolina by Terry Pitts of greenbugs killing seeding corn, but also recalled a similar report from Texas in 1974. Gary Hein reported that he found greenbugs in Nebraska last January indicating that they probably overwintered at least that far north in 2005-2006.

4:24 PM Greenbug Consortium adjourned.

September 20, 2006

8:30 AM – The group reconvened with a short discussion on the future of subcommittees for the WERA066 meetings. Do announced that there was a proposal to have the next WERA066 meeting in conjunction with the International Plant Resistance to Insects meeting to be held in Fort Collins Colorado in February of 2008. This was suggested by John Burd and Frank Peairs who are in-charge of the program and local arrangements for the IPRI meeting. This option fits in with our rotation of the next meeting to be held in the West , but it will mean that we miss a meeting during the 2007 physical year. Tom indicted that this would be acceptable as long as there was at least half of a day devoted to the WERA066 meeting at the IHPR. John Reese indicated that he maintains a list-serv for the IPRI and to contact him if interested in being added to the e-mail list. Motion was made and passed to hold the next WERA066 meeting in conjunction with the IPRI meeting. It was decided to have a whole day meeting on February 13, 2008 with a business meeting, state reports and a topic of general interest to the group. In addition WERA066 members will develop a symposium for the IPRI meeting for the afternoon of the 12th. The next item of business was to elect the next secretary/chair of the group. Kevin Shufran reported that the nomination committee had selected Tom Royer as their nominee. John Reese moved that the nominations cease and Tom was elected to be the next secretary/chair of WERA066. Cheryl indicted that the Guidelines on Biotyping need to highlighted on the web site, which lead to a discussion of the web site(s). A discussion followed about the need for more information on how to sign-up as a participant of WERA066. The group requested that Tom Holtzer to put together a description on the exactly how to sign-on as a participant both for university and ARS personnel. Do thanked the local arrangement committee of John Reese and Mike Smith and adjourned the meeting at 9:10 AM.

Respectfully Submitted by Phil Sloderbeck – Secretary WERA066 – Oct. 16, 2006

WERA-066

Western Extension/Education Research Activity

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State Reports 2006

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Annual Report to WERA-66: 2006

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A. Collaborators Representatives

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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 being prepared (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. Lines with multiple resistance genes were included again in preliminary yield tests. New genes are being combined and backcrossed with adapted wheat cultivars. Efforts continue to incorporate RWA resistance from goatgrass, rye and triticale into bread wheats. (Objective B1)
3. Resistant feed barley varieties were tested on-farm in 2006. 'Stoneham' is resistant to known RWA biotypes and performed better than 'Otis', its recurrent parent, under very dry conditions. (Objective B3)

4. Surveys were conducted to determine the presence of Dn4-virulent Russian wheat aphids. 4/110 (3.6%) samples processed to date were categorized as RWA-1, compared to 22/124 (17.7%) in 2005. No virulence to 94M370 or 2414-11 was detected.
5. Screening of 12,000 new accessions from the national collection was completed. Roughly 300 were identified as having useful resistance to both RWA-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. (Objective C2)
3. Nine foliar insecticide treatments were compared to commercial standard insecticide treatments for control of Russian wheat aphid in winter wheat. None were superior to what is currently available to Colorado wheat producers. (Objective C4)
4. Methomyl was compared to chlorpyrifos and lambda-cyhalothrin for control of Russian wheat aphid in spring barley. Two applications of methomyl performed as well as the chlorpyrifos treatment, providing barley producers with another potential control option. (Objective C4)

IV. Publications

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Meyer, R. F. & F. B. Peairs. 2006. Harvest and storage considerations. Pp. 63 - 66 in, Peairs, F. B., ed. Colorado Wheat Production Handbook, 2 ed. Colorado Association of Wheat Growers, Lakewood, CO. 96 pp.

Peairs, F. B. Russian wheat aphid management. 2006. Pp. 28 - 32 in, Peairs, F. B., ed. Colorado Wheat Production Handbook, 2nd ed. Colorado Association of Wheat Growers, Lakewood, CO. 96 pp.

Walker, C. B. & F. B. Peairs. 2006. Grazing winter wheat. Pp. 73 - 76 in, Peairs, F. B., ed. Colorado Wheat Production Handbook, 2 ed. Colorado Association of Wheat Growers, Lakewood, CO. 96 pp.

Peairs, F., T. Randolph, S. Haley, J. Johnson, J. Rudolph, J. Stromberger, T. Walker, M. Koch, and R. Hammon. 2006. Managing new Russian wheat aphid biotypes. Pp. 28 - 29 in Johnson, J. J., ed. 2006. Making better decisions: 2005 Colorado wheat variety performance trials. Colorado State Univ. Agric. Exp. Sta. Tech. Rep. TR06-09, 40 pp.

Randolph, T. L., F. B. Peairs, M. Koch, and C. B. Walker. 2006. Yield response to Russian wheat aphid (Hemiptera: Aphididae) in three resistant wheats in eastern Colorado. *Southwestern Entomologist* 31: 25 - 32.

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Chander, S., L. R. Ahuja, F. B. Peairs, P.K. Aggarwal, and N. Kalra. 2006. Modeling the effect of Russian wheat aphid, *Diuraphis noxia* (Mordvilko) and weeds in winter wheat as guide to management. *Agricultural Systems* 88: 494 - 513.

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Haley, S. D., J. J. Johnson, F. B. Peairs, J. S. Quick, P. H. Westra, J. A. Stromberger, S. R. Clayshulte, B. L. Clifford, J. B. Rudolph, B. W. Seabourn, O. K. Chung, Y. Jin, and J. Kolmer. 2006. Registration of 'Protection' wheat. *Crop Sci.* 46: 995 - 996.

Collins, M. B., S. D. Haley, T. L. Randolph, F. B. Peairs, J. B. Rudolph, 2005. Comparison of Dn4- and Dn7-carrying spring wheat genotypes artificially infested with Russian wheat aphid (Homoptera: Aphididae) Biotype 1. *J. Econ. Entomol.* 98: 1698 - 1703.

Peairs, F. 2005. Insect and mite pests of wheat. Pp. 63 - 78 in 2005 Colorado Wheat Handbook. Colorado Association of Wheat Growers, Centennial, CO.

Peairs, F., T. Randolph, S. Haley, J. Johnson, J. Rudolph, T. Walker, M. Koch, and R. Hammon. 2005. Managing new Russian wheat aphid biotypes. Pp. 23 - 26 in Johnson, J. J., ed. 2005. Making better decisions: 2004 Colorado wheat variety performance trials. Colorado State Univ. Agric. Exp. Sta. Tech. Rep. TR05-09, 28 pp.

Haley, S. D., J. S. Quick, J. J. Johnson, F. B. Peairs, J. A. Stromberger, S. R. Clayshulte, B. L. Clifford, J. B. Rudolph, B. W. Seabourn, O. K. Chung, Y. Jin, and J. Kolmer. 2005. Registration of 'Hatcher' wheat. *Crop Sci.*

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Randolph, T. L., F. B. Peairs, M. Koch, C. B. Walker, J. R. Stubbs, J. S. Quick, and S. D. Haley. 2005. Yield response and categories of resistance to Russian wheat aphid in four Dn4 hard red winter wheat cultivars. *J. Econ. Entomol.* 98: 588 - 594.

Rudolph, J. B., T. L. Randolph, S. M. Walters, F. B. Peairs, and A. Gebre-Amlak. 2005. 2004 Colorado field crop insect management research and demonstration trials. Colorado State Univ. Agric. Exp. Sta. Tech. Rep. TR03-01, 43 pp.

**CEREAL APHID RESEARCH
2006 STATE REPORT
IDAHO**

I. CURRENT RESEARCH AND ACCOMPLISHMENTS

Aphid population monitoring

In 2006, the five suction traps in Idaho were put into operation early in June. Traps were located in Aberdeen, Arbon, Rexburg, Rockland, and Soda Springs. Trapped aphids were collected weekly and mailed to the Research and Extension Center at Aberdeen, where they were sorted, identified and counted. The total collection count for the season was 9,509 aphids belonging to 21 species. Although there was disparity in the abundance of aphids between sites (ex. 5293 aphids were collected in Aberdeen vs. 335 aphids were found in Soda Springs), the aphid species diversity was very similar between localities (ex. 21 aphid species were collected in Aberdeen vs. 14 aphid species were found in Rockland).

The purpose of this project is to provide timely information to potato and cereal producers about risks of aphid pests and virus epidemics. According to these preliminary results, adjusting fall potato vine-killing dates to avoid aphid flights would be impossible. However, the identification of the PVY aphid vectors would allow us the establishment of better management tools to reduce the spread of PVY and all non-persistently transmitted viruses. Adjusting planting dates for winter wheat, however, would be possible based on these data.

Comparison of aphid composition and phenologies across suction trap localities

The relative composition of aphid fauna in southeastern Idaho was very consistent among the five locations. Bird cherry oat aphid (*Rhopalosiphum padi*) was the most abundant aphid species in all of the localities examined. Bird cherry oat aphid numbers varied from 203 (Soda Springs) to 3988 specimens (Aberdeen) per locality. The second most prevalent aphid species was the rose grass aphid (*Metopolophium dirhodum*). Rose grass aphid numbers varied from 35 (Rockland) to 464 specimens (Aberdeen) per locality.

The remaining cereal grain aphid species were not very prevalent at any of the collecting sites. A total of 29 specimens of Russian wheat aphid (*Diuraphis noxia*) were found in Rockland. Fifteen Russian wheat aphids were recovered from Arbon. Russian wheat aphid was found in very low numbers (less than 10 specimens) at the remaining collecting sites. A total of 11 specimens of greenbug (*Schizaphis graminum*) were captured in Aberdeen. Greenbug also occurred in Arbon and Rockland in very low numbers (less than 10 specimens). No more than 6 specimens of English grain aphid (*Sitobion avenae*) were recovered from any collecting locality. English grain aphid occurred in all areas except Rockland.

Most of these localities displayed the same proportionate abundance of cereal aphid species. Bird cherry oat aphid accounted for 61% (Soda Springs) to 86% (Rexburg) of the total aphid populations. Rose grass aphid accounted for 8% (Rockland) to 14% (Arbon, Soda Springs) of the total aphid population.

Aphid species were most active during July in southeastern Idaho. The peak in bird cherry oat aphid activity was in the middle of July across all five collecting localities. Rose grass aphid was also most active in the middle of July. Greenbug was

most prevalent during the end of July. Russian wheat aphid was most abundant during the latter half of July in four of the five collecting sites. The activity level of Russian wheat aphid oscillated during July in Aberdeen. English grain aphid was also most active during the latter half of July.

As in previous years, results of the trap in Rexburg are of special interest to potato growers, considering that most of the Idaho seed potato growers are located in this region. It is generally accepted that the most important vectors of PVY are actually aphid species that do not colonize potatoes. All species of aphids but one caught in Rexburg do not colonize potatoes. The only colonizing species was the green peach aphid. Potentially, all species caught could vector non-persistently transmitted viruses into a potato crop. Two of the most abundant species (bird cherry-oat aphid, rose-grass aphid) in Rexburg were all previously confirmed as vectors of PVY in Idaho. Though the transmission rates of bird cherry-oat aphid are not as high as that of green peach aphid, the number of the bird cherry-oat aphid caught compared to the number of green peach aphid (one female collected at the end of June) suggest that cereal aphids in general contribute more to the spread of PVY than green peach aphid.

Vectors and Volatiles

Immigration bioassays were performed to assess responses of *Rhopalosiphum padi* to *Barley yellow dwarf virus* (BYDV)-induced volatiles during disease progression in wheat plants. Treatments included non-transformed (Lambert) and transgenic (103.1J, which expresses the BYDV-PAV coat protein gene) wheat genotypes infected with BYDV and sham-inoculated, and a paper leaf model. Sham-inoculated plants were challenged with non-viruliferous aphids as a control to assess responses induced by aphid feeding. We hypothesized that immigration rates will be higher towards BYDV-infected Lambert plants compared to other treatments. Plants were inoculated at the 2 to 3-leaf stage. Observations were taken 15, 22, 29, and 36 days after virus inoculation for every treatment simultaneously. We measured immigration rates of virus-free apterae at intervals of 5 minutes for 60 minutes in darkness. Thirty aphids were placed in an arena that consisted of a 150 mm Petri dish fitted with a false floor of polyethylene screening (mesh size *ca.* 1 mm) on which the aphids could walk freely but could not contact the leaves, which were still attached to the plants. Aphids above the leaves were considered immigrants. Aphids recorded on each observation were subsequently removed from the arena. Volatiles were collected from each plant and ELISA tests were performed to determine virus titer. Data are still being analyzed, but initial results suggest attraction rather than arrestment might be involved in the aphid response to virus-infected plants.

The evaluation of weeds as potential inoculum sources for aphid-mediated transmission of plant viruses

Potato leafroll virus (PLRV) and *Potato virus Y* (PVY) are probably the most serious diseases affecting yield and quality of potatoes grown in the US. These viruses are vectored to the potato plant by different aphid species. Even the most strict aphid control strategy may not prevent the spread of these viruses unless measures also are taken to keep virus-source plants within and outside the crop at a minimum. Studies in Aberdeen have revealed that weeds such as the hairy nightshade (HNS), *Solanum sarrachoides* (Sendtner), are an important inoculum source of potato viruses and an excellent host for their aphid vectors. HNS is one of the four most prevalent weeds in Idaho. With the use of several molecular tools we have demonstrated that PLRV transmission from HNS to

potato by the green peach aphid is four times the transmission rate of potato to potato. Natural *S. sarrachoides* PLRV infection in the field could be as high as 6%. Our laboratory and field studies have revealed a preference of aphids for HNS and for infected plants, and the involvement of visual, gustatory, tactile and olfactory cues in the response of aphids. We have found that olfactory cues generated by HNS and also by virus infected plants attract and/or arrest aphids, thereby influencing the spread of the disease in the field. We are currently cooperating with PSES colleagues N. Bosque-Perez and S. Eigenbrode in the work with the olfactory cues emitted by infected plants.

Mixed-viral infections of PVY and PLRV are a regular occurrence in Idaho's potato cropping systems. Several authors have extensively studied the mixed infection phenomenon but to the best of my knowledge none have examined the effect of such infections on vector biology and preference. Our laboratory studies show that the fecundity of the potato and green peach aphids was significantly higher on mixed-infected plants than on singly-infected plants or non-infected plants. We also found that both winged and wingless potato and green peach aphids preferentially settled on PVY-PLRV infected plants than on singly-infected plants (PVY or PLRV) or non-infected plants.

As part of my extension program, we have developed education talks to caution growers to keep their nightshade well in check, especially in seed-growing areas where disease prevention is essential. Four peer-reviewed journal articles on this research have been published and three more will be submitted for publication in the following months. We have also produced two extension publications on the subject (please see publications for additional projects on the subject).

II. PERSONNEL

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Illinois (Illinois Natural History Survey)

**WERA066
2006 Annual Report**

A suction trap network was set up in Illinois in 2001 to monitor movement and relative abundance of the soybean aphid. In 2005 and 2006 it was expanded and this Midwest suction trap network now has 40 traps located in 10 states. Weekly samples are sent to David Voegtlin's lab for sorting and identification. The distribution of the network can be seen at:

<http://www.ncpmc.org/traps/index.cfm>

Although the trap was set up to document the relative abundance and flight phenology of the soybean aphid, identifications are provided for the common aphids of economic interest and all others that can be determined accurately in alcohol at dissecting scope magnification. Cereal aphids are a major part of the catch with *Rhopalosiphum padi* and *R. maidis* dominating at some period in each year. Other grass/cereal aphids commonly occurring are *R. insertum*, *R. rufiabdominalis*, *Sitobion avenae*, and *Sipha elegans* and *S. flava*.

Examination of the data from Illinois since 2001 has shown high variation in the phenology and abundance of both *R. padi* and *R. maidis*. For example during the last two years the populations of these two species have peaked in September. During previous years in Illinois *R. maidis* populations have peaked from the last week of July into the first two weeks of August. Phenological and distributional patterns will show up only after many years of data are obtained. The root aphids such as *R. rufiabdominalis* and *R. insertum* are wide spread but in much lower numbers.

It is our goal to have a web page dedicated for the deposition of this weekly data for some of these species such as *R. padi* and *R. maidis*. We plan to copy or modify the page noted above that has the weekly catches of the soybean aphid on it.

David Voegtlin
October 19, 2006

Kansas State University

WERA066 2006 Annual Report

C. Michael Smith (representative), Elena V. Boyko, Leslie R. Campbell, Ming Chen, John Diaz-Montano, Xuming Liu, John C. Reese, Sharon Starkey, Priyamvada Voothuluru and Lieceng Zhu, Department of Entomology, Manhattan, KS 66506; J. P. Michaud, J. L. Jyoti, Tom Harvey, J.A. Qureshi, Department of Entomology & Ken Kofoed, Department of Agronomy, Kansas State University, Agricultural Research Center, Hays, KS 67601; Alan Fritz, Bill Schapaugh, Department of Agronomy; Bikram Gill, Department of Plant Pathology; and Phil Sloderbeck, Entomologist, Southwest Research and Extension Center, Garden City, KS 67846.

Molecular Basis of Plant Gene Expression During Aphid Invasion: Wheat *Pto*- and *Pti*-Like Sequences Are Involved in Interactions Between Wheat and Russian Wheat Aphid (Homoptera: Aphididae)

Boyko, E. V., C. M. Smith, V. K. Thara, J. M. Bruno, Y. Deng, S. R. Starkey, D. L. Klaahsen

Differential gene expression in *D. noxia* biotype 1-resistant wheat plants containing the *Dnx* gene and *D. noxia* biotype 1 feeding on *Dnx* plants was investigated using suppressive subtraction hybridization. The derived subtracted cDNA library includes sequences similar to *Pto* and *Pti1*, genes involved in gene-for-gene recognition of and resistance to bacterial speck disease in tomato, *Lycopersicon esculentum* (L.). *Pto*- and *Pti1*-like sequences contain an activation domain with conserved amino acid residues crucial for avr protein recognition and binding by Pto, and avr-Pto phosphorylation of Pti1. Wheat defense signaling is represented by sequences putatively involved in producing sterols, jasmonates, Ca²⁺, and abscisic and gibberellic acids. We suggest that reductions in populations of *D. noxia* fed *Dnx* plants are related to the expression of sequences involved in defensive chemical production, cellular transport, and exocytosis. *Dnx* plant tolerance of *D. noxia* feeding is proposed to be based on the expression of sequences putatively involved in self-defense against reactive oxygen species and toxins, and proteolysis; DNA, RNA, and protein synthesis; chloroplast and mitochondrial function; carbohydrate metabolism; and maintenance of cell homeostasis. *D. noxia* unsuccessfully counter *Dnx* by expressing sequences putatively involved in detoxification; proteolysis; DNA, RNA, protein, and lipid synthesis; carbohydrate metabolism; and mitochondrial function.

Virulence of two Russian wheat aphid biotypes to eight wheat cultivars at two temperatures.

Jyoti, J.L., J.P. Michaud, & J.A. Qureshi.

Biotype 2 of the Russian wheat aphid, *Diuraphis noxia* (Mordvilko), is virulent to both sources of resistance presently available in commercial wheat, *Triticum aestivum* L. The performance of biotype 2 was compared with that of biotype 1 on eight wheat cultivars at two constant temperatures and the plants evaluated for overall damage and leaf rolling. Colonies of biotype 2 grew an average of 2.3 and 24.9 times faster in the first and second generation, respectively, than did their biotype 1 counterparts at 20 °C, reaching 80-125 aphids per plant after 20 days, compared to 10-31. The numbers of aphids per plant at 10 d and 20 d after infestation displayed a significant biotype-temperature interaction. There was also a biotype-temperature interaction for plant damage at 10 d, and for damage and leaf rolling at 30 d. After 20 d at 24 °C, damage ratings ranged from 7.3-8.6 on a scale of

1.0-9.0, and leaf rolling ranged from 2.4-2.9 on a scale of 1.0-3.0 for biotype 2, whereas values for biotype 1 ranged from 2.8-5.1 and 1.4-2.2, respectively. There were no differences among cultivars in plant damage or leaf rolling induced by biotype 2 and ratings of both were higher than for biotype 1 in all cultivar-temperature combinations. Biotype 2 *D. noxia* has overcome both *Dn4*- and *Dny*-based sources of resistance, was more virulent than biotype 1 to all the cultivars tested, and induced plant injury more rapidly than biotype 1, especially at higher temperatures.

Differential colonization of wheat cultivars by two biotypes of the Russian wheat aphid (Homoptera: Aphididae).

Qureshi, J.A., Jyoti, J.L. & J.P. Michaud.

Susceptible and resistance wheat cultivars, *Triticum aestivum* L, were presented to two biotypes of Russian wheat aphid, *Diuraphis noxia* (Mordvilko), in multiple choice tests to assay their relative acceptability as host plants. Both apterae (third and fourth instars) and alate adults were offered plants at the two-leaf stage in different cultivar combinations at $22 \pm 1^\circ\text{C}$ and 16:8 (L:D) hour photoperiod. Apterae were released from Petri dishes in the center of a circle of test plants, whereas alatae dispersed from a mature aphid colony to settle on plants arranged in rows. Both alatae and apterous nymphs of both biotypes readily colonized all cultivars tested: '2137', 'Akron', 'Ankor', 'Halt', 'Jagger', 'Prairie Red', 'Stanton', 'TAM107', 'TAM110', 'Trego', 'Yuma', and 'Yumar'. Fewer biotype 1 apterae responded (settled and fed) in the combination containing more resistant (*Dn4*- and *Dny*-expressing) cultivars, compared to the combinations that had fewer. The reverse was true for biotype 2 apterae; more aphids responded in the combination containing the largest number of *Dn4* expressing cultivars. Differential colonization of cultivars was observed in only one combination in which biotype 2 apterae colonized Akron and Yumar in larger numbers than they did Stanton and Yuma. A separate experiment confirmed that, 48 hours after infestation, more biotype 2 apterae abandoned plants of Yuma than plants of Yumar. This differential response was likely due to genetic differences between the two 'near isogenic' lines, that include the lack of *Dn4* expression in Yuma. Choice tests with alatae did not result in differential rates of cultivar colonization by either biotype in any combination tested. These results suggest that young wheat plants appear to lack any meaningful antixenosis toward *D. noxia*, even though the aphids appear to perceive, and sometimes respond to, certain differences in cultivar suitability.

Resistance to biotype 2 Russian wheat aphid (Homoptera: Aphididae) in two wheat lines.

Qureshi, J.A. J.P. Michaud & T.J. Martin.

Biotype 2 of the Russian wheat aphid, *Diuraphis noxia* (Mordvilko), was identified in the United States in 2003 and is virulent to all commercially available cultivars of winter wheat (*Triticum aestivum* L.) that are resistant to biotype 1. We compared the development and reproduction of biotype 2 *D. noxia* at $21.7 \pm 0.12^\circ\text{C}$ on 'Trego' (PI 612576), a susceptible commercial cultivar, and on lines CI 2401 and 03GD1378027 that represent putative resistance sources. CI 2401 is a pure wheat line originating in the former USSR (Tajikistan), whereas 03GD1378027 is a USDA-ARS breeding line originally developed from crosses with a South African line that carried a large rye translocation conferring *D. noxia* resistance. Both lines previously showed resistance to biotype 1 and are currently being used in the development of *D. noxia* resistant wheat cultivars. Both solitary apterous virginoparae of biotype 2 and their progeny experienced a reduction in survival and prolonged development times on CI 2401 and 03GD1378027

when compared to Trego, but the former lines did not differ significantly from each other with respect to either measure of aphid performance. Progeny developed faster than did their foundress mothers on CI 2401 and Trego, but not on 03GD1378027. Mean foundress fecundity did not differ between CI 2401 and 03GD1378027 but was reduced on these lines relative to Trego. Foundresses were also more often found off plants of CI 2401 and 03GD1378027 than Trego. Estimates of intrinsic rate of increase were higher on Trego than on either CI 2401 or 03GD1378027, the latter two lines yielding similar values. The negative impacts of CI 2401 and 03GD1378027 on development and reproduction of biotype 2 indicate that these lines represent sources of resistance effective against this novel biotype.

Repellency of conspecific and heterospecific larval residues to ovipositing *Hippodamia convergens* Guerin (Coleoptera: Coccinellidae) foraging for greenbugs on sorghum plants.

Michaud, J.P. & J.L. Jyoti.

We examined oviposition decisions by *Hippodamia convergens* Guerin in semi-natural arenas in the laboratory. Gravid females were presented individually with an array of four young sorghum plants, *Sorghum bicolor*, bearing (1) no additional stimulus, (2) an established colony of greenbug, *Schizaphis graminum*, (3) residues of conspecific larvae, and (4) greenbugs plus residues of conspecific larvae. Females laid no egg masses on type 3 plants, significantly fewer than expected by chance on type 4 plants, and significantly more on type 1 plants, with type 2 plants receiving expected numbers. However, females laid 50% of egg masses on elements of the arena other than the plants, especially the cage screen, suggesting that females sought to distance their eggs farther from larval residues than the spacing of plants in the arena permitted (15 cm). Females also oviposited less often than expected by chance on plants exposed to larvae of *Coleomegilla maculata* DeGeer, but the repellency was weaker. Once again, clean plants were the most preferred and larval residues reduced the acceptability of aphid-bearing plants, but only 18% of egg masses occurred off the plants and the presence of aphids increased the acceptability of plants bearing *C. maculata* larval residues, an effect not observed with conspecific larval residues. Simultaneous choice tests conducted with individual third instar larvae of both species revealed that *C. maculata* consumed *H. convergens* eggs as readily as conspecific eggs, but *H. convergens* larvae preferred conspecific eggs to those of *C. maculata*. We conclude that *H. convergens* oviposition decisions are shaped by the risks of both cannibalism and egg predation.

Induction of reproductive diapause in *Hippodamia convergens* (Coleoptera: Coccinellidae) hinges on prey quality and availability.

Michaud, J.P. & Qureshi, J.A.

In the High Plains of western Kansas, U.S.A., the convergent lady beetle *Hippodamia convergens* Guerin completes a spring generation feeding on cereal aphids in winter wheat before leaving fields in large numbers around the time of harvest. In late May, large aggregations of coccinellids form on wild sunflowers, *Helianthus annuus*, and certain other weeds, that appear to serve as important sources of hydration for the beetles, and other beneficial insects, during the dry prairie summer. Adult beetles were collected from sunflower plants and held in four treatments: 1) access to water only, 2) access to sunflower stalks only, 3) eggs of *Ephestia kuehniella* provided *ad libitum* + water and, 4) greenbug, *Schizaphis graminum* Rondani provided *ad libitum*. Most females fed greenbug matured eggs in less than a week and only a few entered reproductive diapause. In contrast, more than half of the females fed *Ephestia* eggs, an inferior diet, entered reproductive diapause, and those that matured eggs required an average of almost three

weeks to do so. Time to 50 % mortality was 7 days for beetles receiving only water, and 12 days for those receiving only sunflower stalks, whereupon all survivors were fed greenbug. Even after feeding on greenbugs for a month, less than half of the surviving females in these two treatments produced eggs. We conclude that reproductive diapause is an important adaptation for improving *H. convergens* survival during summer when aphids are scarce, although females will forgo diapause if they have continuous access to high quality prey.

Positive correlation of fitness with group size in two biotypes of Russian wheat aphid (Homoptera: Aphididae).

Michaud, J.P., J.L. Jyoti & J.A. Qureshi.

Changes in fitness parameters as a function of colony size (one vs. ten aphids) were measured in two biotypes (RWA1 and RWA2) of the Russian wheat aphid, *Diuraphis noxia* (Mordvilko) feeding on three cultivars of wheat, *Triticum aestivum* L., at two temperatures. Trego is a cultivar with no specific resistance to *D. noxia*, whereas, Stanton and Halt express *Dny* and *Dn4* resistance sources, respectively. Feeding in a group accelerated the development of RWA1 on Trego and Stanton at 20 °C, but not at 24 °C, whereas grouped RWA2 developed faster than solitary RWA2 on all three cultivars at 24 °C, but not at 20 °C. Survival (1st instar – adult) of RWA2 was also improved by grouping on Stanton and Halt at 24 °C, but solitary RWA2 survived better at 20 °C on all three cultivars. The reproductive rate of RWA1 was improved by grouping on Trego and Stanton at both temperatures, but only on Halt at 24 °C. Lifetime fecundity of RWA1 was also increased by grouping in all cases except for Trego at 20 °C. Grouped development increased the reproductive rate of RWA2 on all three cultivars at 24 °C, but had no effect at 20 °C. Grouped RWA2 developed and reproduced faster than grouped RWA1 on all three cultivars at 24 °C. Thus, the fitness of *D. noxia* was positively correlated with group size during colony establishment, but the effects were sensitive to temperature, being more pronounced at 20 °C for RWA1 and at 24 °C for RWA2.

Reproductive diapause in *Hippodamia convergens* (Coleoptera: Coccinellidae) and its life history consequences.

Michaud, J.P. & Qureshi, J.A.

Adult *Hippodamia convergens* (Guerin) in reproductive diapause were collected from a spring cohort in western Kansas and held in pairs for the duration of their lives to assess female reproductive schedules under conditions of limited food availability. Environmental conditions were set to mimic natural seasonal day lengths and diurnal temperature cycles for the region. To approximate conditions of limited food availability typical of summer conditions in western Kansas, beetles were provided continuous access to sunflower petioles and periodic access to protein sources, both animal (*Ephestia kuehniella* Zeller eggs) and vegetable (bee pollen). A total of 113 out of 171 females (66.1%) became reproductive over the next five months within a mean of 55.0 ± 3.0 d. These females lived an average of 134.5 ± 4.6 d and produced a mean of 106.9 ± 11.6 eggs in a mean of 6.6 ± 0.6 d of oviposition. Thus, reproductive diapause gradually decayed over time even when females did not encounter a high quality food supply. Egg production peaked every fourth day following provision of animal protein. A subset of 20 females, randomly selected from among those still non-reproductive on Aug. 14 and switched to an aphid diet (*ad libitum* provision of *Schizaphis graminum* Rondani) produced a mean of 654.6 ± 109.7 eggs each, almost 10 times as many as females on the maintenance diet with similar reproductive schedules. However, the longevity of greenbug-fed females was reduced by more than 30% compared to the latter group,

suggesting a tradeoff between reproductive effort and survival. The costs of reproductive diapause were evident as an increased risk of mortality prior to oviposition and declining fecundity and fertility with age. Our results suggest a variable number of overlapping generations can occur annually in western Kansas, potentially as many as five.

Aphid Feeding Activates Expression of a Unique Transcriptome of Wheat Genes Involved in Resistance to Herbivory

Smith, C. M., X. M. Liu, L. J. Wang, M. S. Chen, & S. Starkey

Smith et al. (unpubl.) have determined that at the onset of *D. noxia* biotype 1- *Dnx* plant interactions, aphid feeding results in the altered activation of peroxidases, intercellular chitinases, β -1,3-glucanases involved in the plant cell wall oligosaccharide release and sequences similar to *Pto* and *Pti1* - genes involved in gene-for-gene recognition of and resistance to bacterial speck disease in tomato, *Lycopersicon esculentum* (L.). The activity of some of these enzymes is up-regulated by reactive oxygen species (ROS) elicitors responding to aphid feeding. Genes involved in ROS signal transduction such as peroxidase (PER), and glutathione transferase (GST), catalase (CAT), nitrate reductase and quinone oxidoreductase are up-regulated in biotype 1-infested *Dnx* plants. Infested plants then up-regulate production of defense response signal cascades involving the plant hormones jasmonic acid (JA), salicylic acid (SA), ethylene (ET), abscisic acid (ABA), gibberellic acid (GA), and nitric oxide (NO). These signals then produce many sequences involved in the production of arthropod chemical defense response proteins, photosynthesis and photorespiration genes, cell wall and cell membrane strengthening genes, and water loss defense response genes, in ensure plant survival of aphid-inflicted stresses.

2006 Russian Wheat Aphid Biotype Assessments in Western Kansas

Sloderbeck, P. E., C. M. Smith & S. Starkey

Using an assay consisting of individual paired Dn4 (Yumar) and Dn7 (93M70) plants caged in individual containers, two leaf stage plants were infested with individual adult aphids from populations collected from Greeley Co. (April 20), Finney Co. (May 4) and Stevens Co. (May 29). At least 15 aphids per population were tested. At 21 days post infestation, all the Dn4 plants infested with each of the three populations had rolled, chlorotic leaves and were sustaining populations of 35-40 aphids per plant. None of the Dn7 plants showed leaf rolling, and 3-4 plants infested with each population occasionally had a few chlorotic feeding lesions. Aphid populations were ~1 aphid per plant on Dn7 plants. All of the plants infested with aphids from each of the three populations appeared to be biotype 2. These results indicate a shift in the *D. noxia* biotype composition in 2005, when aphids collected from Finney and Greeley Counties, were identified as biotype 1.

Registration of Seven Russian Wheat Aphid Resistant Near Isogenic Lines Developed in South Africa.

Tolmay, V.L., F. du Toit, and C. M. Smith

Betta-Dn1 (Reg. no. GP-785, PI 634768), Betta-Dn2 (Reg. no. GP-786, PI 634769), Betta-Dn9 (Reg. no. GP-787, PI 634770), Tugela-Dn1 (syn: Tugela-DN', Reg. no. GP-784, PI 591932), Tugela-Dn2 (Reg. no. GP-788, PI 634772), Karee-Dn2 (Reg. no. GP-789, PI 634774), and Karee-Dn8 (Reg. no. GP-790, PI 634775) Russian wheat aphid,

Diuraphis noxia, resistant near isogenic lines (NILs) were developed and released by ARC-Small Grain Institute, Bethlehem, South Africa during the past 15 yr (1990-2005).

Categories and Inheritance of Resistance to Russian Wheat Aphid (Homoptera: Aphididae) Biotype 2 in a Selection from Wheat Cereal Introduction 2401

Voothuluru, P., J. Meng; C. Khajuria; J. Louis; L. Zhu; S. Starkey; G. E. Wilde; C. A. Baker & C. M. Smith

Resistance to *D. noxia* biotype 2, identified in a selection from wheat cereal introduction (CItr) 2401, that is controlled by two dominant genes. CItr2401 has a strong antibiosis effect that is exhibited as a reduced intrinsic rate of increase of *D. noxia* biotype 2. CItr2401 plants also exhibit tolerance to leaf rolling and chlorosis. No antixenosis was detected in CItr2401.

Inheritance and Mapping of New Greenbug Resistance Genes in *A. tauschii* Germplasm

L. Zhu, C. M. Smith, A. Fritz, E. V. Boyko, & B. S. Gill

Genetic mapping of greenbug resistance genes in crop plants using molecular markers provides a powerful way to characterize these genes. The use of molecular markers linked to resistance genes will facilitate selection of greenbug resistant traits in wheat breeding through marker-assisted selection. The physical mapping of greenbug resistance genes using aneuploid and deletion lines will aid in locating the specific chromosome position of these genes and provide information on gene cloning by using map-based procedures. In the present study, we genetically mapped *Gbx*, a wheat gene conferring resistance to current prevalent greenbug biotypes, and physically mapped the microsatellite markers linked to *Gbx* and the related gene *Gbz*. Our results indicated that *Gbx* was inherited as a single dominant gene, and this gene was flanked by microsatellite markers *Xgdm150* and *Xwmc157* at distances of 3.3 and 2.7 cM, respectively. Both *Gbx* and *Gbz* were assigned to physical bins of the distal 18% region of the long arm of wheat chromosome 7D by using aneuploid and deletion lines of Chinese Spring wheat.

Categories of Resistance to Greenbug Biotype K in *Aegilops tauschii* Wheat Lines

L. Zhu, C. M. Smith, & J. C. Reese

The wheat lines Largo, TAM110, KS89WGRC4, and KSU97-85-3 conferring resistance to greenbug, *Schizaphis graminum* Rondani, biotypes E, I and K 3 were evaluated to determine the categories of resistance in each line to greenbug biotype K. Our results indicated that Largo, TAM110, KS89WGRC4, and KSU97-85-3 expressed both antibiosis and tolerance to biotype K. Largo, KS89WGRC4, and KSU97-85-3, which express antixenosis to biotype I, did not demonstrate antixenosis to biotype K. The results indicate that the same wheat lines may possess different categories of resistance to different greenbug biotypes. A new cage procedure for measuring greenbug intrinsic rate of increase (r_m) was developed, using both drinking-straw and Petri-dish cages, to improve the efficiency and accuracy of r_m - based antibiosis measurements.

Cereal Arthropod Insecticide Efficacy

G. Wilde

Seed treatments (Cruiser and Gaucho) were evaluated for their effect on Hessian fly, Russian wheat aphid, greenbugs and bird cherry oat aphid. Cruiser at 0.75 fl.oz./cwt and Gaucho at 1.0 fl.oz./cwt effectively reduced fall and spring aphid infestations. At these rates a fall infestation of Hessian fly was reduced about 50 % by both treatments. Yield from the Hessian fly plots infested plots were Untreated (45.1), Cruiser (47.3) and Gaucho (49.5) bu/acre (LSD 3.06).

Sorghum Resistance to Greenbug

John Reese and Ken Kofoid

We are in the process of releasing several sorghum materials that exhibit tolerance to biotype K greenbug feeding damage. Tolerance has the advantage of not placing selection pressure on the greenbug population for new, more virulent biotypes.

Publications:

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WERA66 Cereal Aphids Montana State Report - 2006

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Wheat Growing Conditions:

Total wheat: 5.2 million acres of wheat were harvested; 2.0 million acres of winter wheat, 2.8 million acres of spring wheat and 0.4 million acres of durum. Yields of spring wheat were 25 bushels/A, less than the previous two year average (31.5 bu/A), while winter wheat averaged 42 bushels, just below the previous two year average (43.0 bu/A).

Winter wheat: Although there was little snow cover for winter wheat, mild winter conditions resulted in little overwintering mortality. Mild spring conditions and rainfall in April helped the winter wheat break dormancy ahead of normal. Above normal temperatures during most of May accelerated crop development, although high winds and relatively dry conditions reduced yield expectations. Winter wheat crop development and harvest occurred well ahead of normal

Spring Wheat: The hot and dry conditions that persisted during June and July caused the spring wheat crop to ripen too quickly and negatively impacted both yield and quality.

Cereal Aphids: Russian wheat aphid was present in Montana, during the 2006 production season at low to moderate numbers. Percent infested tillers across all treatments and from untreated control plots taken from an insecticide trial conducted at the central Montana (Central Ag Research Center (CARC), near Lewistown, MT) are summarized below.

	13 July	20 July	27 July	3 Aug
% infested tillers (all)	10.4	15.4	20.9	34.9
% infested untreated tillers	8.6	11.9	32.1	47.8

Bird cherry oat aphid was found frequently during the 2006 production season. Because the crops matured rapidly due to hot weather insecticide applications were made rarely.

Haanchen mealybug (*Trionymus haancheni* McKenzie): Haanchen mealybug was verified for the first time this year from Teton County in June 2006. Haanchen mealybug was detected in August in Flathead County. The mealybug was first detected in the northern California Tulelake area of Siskiyou County as a pest of cv. 'Haanchen' barley in 1950s. A recently outbreak in Idaho (2003), and its occurrence this year in Montana and Alberta have raised concerns about this insect. While this insect has been detected in wheat its primary damage is to barley.

Foliar insecticides were tested for Haanchen mealybug efficacy. Pretreatment evaluation at this site found an average of 2.4 mealybugs per plant. Applications were made with a CO₂ – powered sprayer calibrated to deliver 8.8 GPA at 30 psi. Plot size was 13 by 20 ft. Activator 90 was added to each treatment. Results were analyzed using PC-SAS using PROC GLM procedure and means were separated using SNK (alpha = 0.10).

Number of mealybugs per plant post insecticide treatment, MSU, 2006.

Treatment	Rate per acre	7 DAT	14 DAT
Knack	10 oz	5.2 a	8.4 ab
Actara 25WG	3 oz	4.0 a	8.4 ab
Flonicamid 50SG	2.3 oz	5.7 a	6.3 ab
Neemix 4.5	16 oz	4.0 a	5.3 ab
Warrior 1E	3.84 oz	3.5 a	4.3 b
Untreated control	-----	6.2 a	11.1 a
P value		0.20	0.08

Orange Wheat Blossom Midge (*Sitodiplosis mosellana* (Gehin)): The orange wheat blossom midge (OWBM) was introduced to North America in the early 1800s. Since that time OWBM had emerged as an important and damaging pest of Northern Great Plains and wheat production areas of Canada. In 1983 it was considered an important wheat pest of Saskatchewan and Manitoba and by 1990s the outbreak had spread to North Dakota. In Montana its traditional distribution is in the northeastern corner of the state including Sheridan, Daniels, Valley and Roosevelt Counties where its population density as remained at relatively low levels. This year it was detected in northwestern Montana (Flathead County) at high population levels (100% crop loss).

Five fields in Flathead County were sampled by collecting 15 heads/field suspected to be infested by OWBM. Fields 2 – 5 were located between Flathead Lake and Flathead River. Field one was located east of the river. Percentage of infested heads, % of individual florets infested and average number of OWBM maggots/floret are summarized below.

Percentage of heads and florets infested with orange wheat blossom midge and average number of midge per infested floret, Flathead County, MT 2006.

Field	Variety	% heads infested	% florets infested	Avg no OWBM/infested floret
1	Hank	100	76.8	4.0
2	WB936	87.5	25.8	1.7
3	WB 936	100	64.3	3.8
4	Hank	100	89.7	7.6
5	Hank	100	93.4	8.3

A cooperative project to determine the distribution and relative population density is planned to include Montana Department of Agriculture, USDA,ARS,NPARRL and Montana State University personnel. A sampling program is planned at the section level (12 mile grid) for OWBM. Soil samples will be collected from across the northern tier of Montana wheat production areas in the spring. Extension programs will then be targeted to areas infested.

Hessian Fly

Hessian fly/Jointworm evaluations were conducted in August of 2005 on twenty spring wheat varieties and lines.

Variety/Line	Jointworm/Hessian fly ratings (% stem folding or breakage above 1 st joint)
Hank	8.3
MT9609/MT9806	25.0
ID 377S/MTHW9701	6.7
Agawam	5.0
Explorere	23.3
Outlook	13.3
MT9433/ND695	36.7
Choteau	6.7
Conan	13.3
Reeder	75.0
McNeal	30.0
Knudson	15.0
Alsen	56.7
MT9653/ND695	53.3
Scholar	16.7
ND695/MT9755	46.7
Westbred 926	10.0
Ernest	13.3
Fortuna	8.3
Norpro	18.3

2006: Trials were conducted to evaluate Hessian fly response to insecticide seed treatments and to evaluate spring wheat varietal response to HF during the 2006 growing season. A survey of counties in the central Montana wheat production area (Golden Triangle) to determine the presence and relative abundance of HF included Choteau, Hill, Toole, Pondera, Liberty and Cascade Counties.

**Nebraska Report to the WERA-066 Committee - 2006
Integrated Pest Management of Russian Wheat
Aphid and Other Cereal Arthropod Pests**

Nebraska Representative:

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Russian wheat aphid status in 2006:

We have seen increasing presence and problems with Russian wheat aphid activity in western Nebraska. In 2006 Russian wheat aphid infestations were again light in most winter wheat fields through early spring; however, a number of economic infestations were present in the Panhandle. By late May, we had a heavy presence of Russian wheat aphids that infested late developing wheat fields and spring barley fields. Several of these fields had economic infestations of Russian wheat aphids.

Several locations in the Nebraska panhandle were sampled to determine the biotype of Russian wheat aphid present. Aphids from these samples were transferred to pots containing three wheat varieties, Yuma (susceptible), Yumar (biotype 1 resistant) and Gamtoos (biotype 2 resistant). Four of six samples were found to be biotype 2 (or a mixture of 1 and 2) and the remaining to be biotype 1. Although several of the trials resulted in heavy aphid presence on the Gamtoos, none were able to severely damage it.

Research/Extension Activities:

Areawide IPM Project:

Project personnel: Gary Hein, Drew Lyon, Paul Burgener, John Thomas, Rob Higgins, Dave Christian

We are evaluating diversified cropping systems incorporating aphid-resistant cultivars compared to the wheat-fallow systems with regard to economic, agronomic, and pest management parameters. In western Nebraska and eastern Wyoming, we are monitoring two pairs of diversified and wheat-fallow fields. Growing conditions varied across the panhandle with the southern panhandle under extreme drought. Moisture was limited in all areas but most other areas received some moisture. Russian wheat aphids were present in all fields but field-wide economic infestations were not seen in any of the fields sampled.

During the spring we used field cages to differentially screen out natural enemies to determine their effect on aphid populations in two of these fields. Fine-mesh (52 mesh) cages were used to exclude all predators and parasites, 20-mesh screen was used to exclude predators only, regular cages left open at the bottoms and no cage controls were used to allow free exchange of natural enemies. Greenhouse colony aphids were used to infest the plots early in the spring, and aphid and natural enemy populations were monitored through the rest of the season. Data indicate that significant aphid populations

built up in all plots but greater aphid numbers were seen in the screened cages where predators and parasites were excluded. Further evaluation of the data will indicate the extent of differences found in the fields sampled.

Demonstration Trials of New Resistant Barely Varieties

This project was done cooperatively with Frank Peairs (CSU) and Do Mornhinwig (USDA-ARS) to test the new RWA resistant barely varieties (Sidney, Stoneham) in larger strip trials in various environments for yield and aphid response. Through the Nebraska panhandle and northeast 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 and low yields. The other two locations had moderate yields but also a substantial presence of Russian wheat aphids. The yield at these locations was reduced by Russian wheat aphids by about 50-60% as compared to Otis, a susceptible variety. Growers were pleased with the performance of the barley and remain interested in growing resistant barley.

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

This project has been recently funded by the CSREES Crops at Risk program. The research objective of the project will be 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. This project will continue for three years and will provide an ideal platform for the return of barely into the cropping systems in the region.

Physiological Impacts of Cereal Aphid Feeding:

Project Personnel: Leon Higley, Tiffany Heng-Moss, Gautam Sarath, Lisa Franzen, and Andrea Gutsche

Differential Gene Expression of Barley in Response to Aphid Injury

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 and Biochemical Responses of Resistant and Susceptible Wheat to the Russian Wheat Aphid

Research Objectives:

- To document changes in photosynthesis as a major mechanism for plant resistance to the aphids and investigate the impact aphid feeding has on the photosynthetic responses of wheat.
- To explore the role of plant proteins in the defense response of susceptible and resistant wheat cultivars to aphid treatments and investigate protein and oxidative enzyme levels of plants after aphid feeding.

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. Establish the spatial distribution of wheat curl mite biotypes within and between wheat fields in the western plains.
3. Predicting wheat curl mite movement and wheat streak mosaic virus spread.
4. Using wheat curl mite populations for screening wheat lines for resistance to wheat streak mosaic virus.
5. 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 2006

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Highlights of the 2006 Small Grains Season

North Dakota had an excellent spring, with most small grains planted early. Heading of HRSW occurred in early July.

A state-wide survey of small grain diseases and insects continued in 2006. Three types of insects were monitored: aphids (species not distinguished), grasshoppers and cereal leaf beetle. All other judgments of pest problems are based on reports from County Extension Agents and farmers.

Summer drought was the big issue in 2006 for North Dakota farmers. In some parts of the state the drought was so bad that farmers did not even bother to harvest their crop. Thus, even if farmers had insect pests, county extension agents did not hear about it. In other parts of the state, small grains crops had reasonable yields and produced high quality grain.

The good thing about the 2006 drought was that small grain farmers got some relief from scab. 2005 was a terrible year for scab and farmers were so upset about their disease problems that we heard little about insects.

Grain aphids occurred at a higher level in 2006. Whereas ca. 5% of fields were sprayed last year for aphids, this year 20% were sprayed. Dry conditions were associated with low levels of diseased aphids.

Higher aphid numbers in 2006 did not result in greater barley yellow dwarf virus problems. Aphids appeared in fields quite late. Either less virus was transmitted or the later transmission did not have great impact on yield.

Aphid predators, e.g. ladybird species, occurred in high numbers throughout the season.

Grasshoppers were not a problem in 2006. Conditions for egg laying in autumn 2005 were poor, so populations started small. Populations built up during the summer, especially in the southwestern and south-central parts of the state. Conditions for egg laying this autumn have been excellent.

Wheat midge numbers in 2006 were predicted to be low by the autumn 2005 survey of overwintering larvae (see maps at www.ag.ndsu.nodak.edu/aginfo/entomology/entupdates/Wheat_Midge/owbm.html). This prediction held for the most part. There were some reports of economically significant wheat midge infestations in the northeastern part of the state.

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.

Highlights of the 2006 Small Grains Season (continued)

Wheat stem maggot was a concern for some farmers in southwestern ND in 2006. This was also the case in 2005. Maggots boring in the stem cause 'white head'. These heads fail to develop seeds. In some fields infestations were as high as 20% of heads. Little is known about the biology of this insect. Farmers want information on spray timing.

Reports of Hessian fly were sporadic. 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. We recently 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 are currently being conducted in Kansas (late September 2006) by Ylva's student, Martin Anderson, who is being helped by Kansas County Extension Agent Dr Gary Cramer (Wichita).

Basic research on Hessian fly/wheat interactions continues and is funded by the National Research Initiative of the USDA Cooperative State Research, Education and Extension Service. In this research, we are collaborating with Ming-shun Chen (USDA-ARS, Manhattan) and Jeff Stuart (Purdue) and studying mechanisms of Hessian fly virulence and mechanisms of R-gene-mediated resistance to Hessian fly.

We have established that virulent Hessian fly larvae establish a gall-like nutritive tissue at the base of the plant. We believe that this tissue acts like a nutrient sink and is the cause of the growth deficits associated with Hessian fly attack. This gall-like tissue is absent from plants with an effective R gene but is present when a 'defeated' R gene plant is attacked by virulent larvae.

Two papers on this research were published in 2006:

Harris, M.O., T.P Freeman, O. Rohfritsch, K.G. Anderson, S.A. Payne, and J.A. Moore. 2006. Hessian fly larvae induce a nutritive tissue during compatible interactions with wheat. *Annals of Entomological Society of America* 99: 305-316.

Anderson, K.G. and M.O. Harris. 2006. Does R gene resistance to Hessian fly allow wheat seedlings to escape larval-induced growth deficits? *Journal of Economic Entomology* (published in October issue).

Highlights of the 2006 Small Grains Season (continued)

We are collaborating with two wheat cytogeneticists, Dr Stephen Xu (USDA-ARS, Fargo) and Dr Xiwen Cai (NDSU), continuing research described in a recent publication (see below):

1. construct a high resolution map of *H26* for map-based cloning,
2. to develop user-friendly molecular markers for marker-assisted selection in breeding, and
3. to determine the physical and genetic relationships of *H24*, *H26*, and *H32*.

Wang, T., S.S. Xu, M.O. Harris, J. Hu, L. Liu, and X. Cai. 2006. Genetic characterization and molecular mapping of Hessian fly resistance genes derived from *Triticum tauschii* in synthetic wheat. *Theoretical and Applied Genetics* (in press).

New Extension Specialist at NDSU

In winter of 2005 Phil Glogoza quit NDSU Extension and began working as a small grains specialist for Minnesota Extension.

Jan Knodel, who formerly worked in NDSU Extension at the Minot Research Station, replaced Phil, beginning in December 2005. Her interests are:

Extension Interests:

1. extension entomology programming relevant to the Upper Great Plains,
2. integrated Pest Management, and
3. insecticide-fungicide efficacy testing including seed treatments and foliar sprays

Research Interests:

1. development and evaluation of different pest monitoring systems,
2. risk forecasting systems of pest populations and infestation risks in the field, $\alpha\gamma\delta$
3. evaluation of alternative pest management tactics (cultural, biological control, plant host resistance)

Opportunities for State Funding of Research

In the state of North Dakota, funding for research on small grains insects is available from two sources. The North Dakota Wheat Commission, funded by a levy on farmers, funds the annual wheat midge survey (\$4,200) and also funded an insecticide trial (\$400) for wheat stem maggot. They tend to fund research that has immediate applications for farmers and in recent years have funded projects for wheat breeders, scab researchers, and marketing.

Opportunities for State Funding of Research (continued)

The other funding body is SBARE, State Board of Agricultural Research and Extension. From 2001-2003, they funded research on breeding for resistance to orange wheat blossom midge. We worked with NDSU plant breeders and together succeeded in incorporating the single known R gene (Sm1) into breeding programs for HRSW, durum wheat and white wheat. Because wheat midge populations have been low during the past three years, breeders have not advanced wheat midge resistance into soon to be released elite cultivars.

This year Jan Knodel and Marion Harris plan to submit a proposal to SBARE asking for funding for two projects, one a study of basic biology of wheat stem maggot with an aim to developing economic thresholds and spray timing, and second, a study on resistance to wheat stem sawfly. Our chances for funding are greater because scab was of less significance in 2006 and because Jan is new faculty.

Background on North Dakota Survey for Diseases and Pests

For the last nine 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

Background on Autumn Survey for Wheat Midge (continued)

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.

The autumn 2005 survey of overwintering wheat midge larvae included samples from northern counties of North Dakota as well as four counties in the northeastern corner of Montana. Wheat midge larval numbers were extremely low across the surveyed regions. Parasitism rates (probably *Platygaster* spp.) continued to be high.

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 but become active when harvested wheat is loaded into trucks. At this time, the orange larvae are seen dropping from harvested wheat in trucks to the soil.

INSECTICIDE EFFICACY AGAINST SMALL GRAIN APHIDS ON WHEAT

Submitted by Janet Knodel

English grain aphid: *Sitobion avenae* (Fabricius)

Bird cherry-oat aphid: *Rhopalosiphum padi* (Linnaeus)

Wheat stem maggot, *Meromyza americana* Fitch

WHEAT: *Triticum aestivum* L., 'Alsen'

Experimental insecticides were evaluated for their efficacy at controlling aphids and protecting wheat, cultivar Alsen. The trial was located at the NDSU agricultural research plots in Fargo. Plots were 10 ft wide by 20 ft long. A RCB experimental design with three replicates was used. All applications were made using a handheld CO₂ boom sprayer at 40 psi, 10 gpa and XR8001VS nozzles. Insecticides - Herbicides were combined in treatments 2, 3 and 4 to test for phytotoxicity, and were applied at 14-16 Zadoks scale on 1 Jun. The remaining insecticide treatments (5 to 9) were applied for aphid control at 60 Zadoks scale on 4 Jul. Treatments 2 to 4 were evaluated for visual symptoms of phytotoxicity on 1, 3, and 7 Days After Treatment (DAT). For aphid control, ten plants per plot

were assessed by counting the number of aphids per plant and the number of stems per plant at 3 DAT on 7 Jul and 9 DAT on 13Jul. Due to the large number of white heads present from wheat stem maggot injury, the number of white heads per plot were also counted on 13 Jul. Plots were harvested on 10 Aug. Variables were subjected to ANOVA and means compared using Fisher's PLSD at the 5% significance level.

No phytotoxicity was observed for any of the insecticide - herbicide treatments (2 to 4) at 1, 3, and 7 DAT. There were no significant differences among treatments for the number of aphids per plant at 3 DAT and the number of aphids per stem at 9 DAT (Table 1). At 3 DAT, the number of aphids per stems were significantly lower for the high rate of Baythroid XL (2.4 fl oz/a), NUP 05077, and Warrior compared to the untreated check. The remaining treatments (2, 3, 4, 5, and 6) did not have significantly different number of aphids per stem from the untreated check at 3 DAT. [Note: Treatment 2 to 4 was applied for phytotoxicity testing and not aphid control.] The high rate of Baythroid XL (7) generally had lower numbers of aphids than the low (5) and mid (6) rates of Baythroid XL; however, it was not significantly different from these lower rates. NUP 05077 and Warrior were comparable to the high and mid- rates of Baythroid XL. At 9 DAT, the mid- and high rate of Baythroid XL, NUP 05077, and Warrior had significantly lower numbers of aphids per plant than the untreated check and treatment 2. The residual of insecticides tested provided control of aphids through 9 DAT.

For wheat stem maggot, the early Baythroid-herbicide treatments (2 to 4) applied at 14-16 Zadoks scale had fewer white heads than the untreated check and the insecticide treatments (5 to 9) applied at the later timing at 60 Zadoks. However, treatment 3 was also not significantly different from the other treatments and untreated check, except the high rate of Baythroid applied late. This was probably due to the long emergence period of adult flies, which would require multiple insecticide applications per season.

Note: Yield data is not available yet.

WERA 2005 Report from Oklahoma

Project Participants:

Dr. Kristopher Giles, Oklahoma State University

Dr. Tom A. Royer, Oklahoma State University

Collaborating agencies:

ARS-PSWCRL, Stillwater, Texas A&M University.

Cooperating ARS Scientists:

Norm Elliott, Dean Kindler, and Kevin Shufran.

Cooperating OSU Scientists:

Bob Hunger, Tom Peeper, Clint Krehbiel.

Postdocs

Dr. Mpho Phofolo

Dr. Vasile Catana

Dr. Sean Keenan

Graduate Students:

Matt Rawlings (M.S. Giles)

Sara Donelson (Ph.D, Giles)

Christopher Mullins (M.S. Giles)

Dayna Alvey (M.S. Giles)

Projects in 2006

Rice Root Aphid. Matt Rawlings, Kristopher Giles Field and laboratory studies are nearly finished to evaluate the pest potential of *Rhopalosiphum rufiabdominalis* Sasaki in winter wheat. Sampling data demonstrated that the aphid is present throughout the Oklahoma. Little to no impact on wheat forage and grain yields were observed in greenhouse and field studies.

Intraguild Interactions among *Schizaphis graminum*, *Lysiphlebus testaceipes*, and Coccinellidae in Winter Wheat. Christopher Mullins, Kristopher Giles and Tom Royer. C. Mullins will expand on this work, and document the level and consequences of intraguild predation in wheat fields.

Predator Movement in Wheat Cropping Systems. Sara Donelson, Kristopher Giles. Studies have been initiated to examine the colonizing ability of Carabidae into tilled and no-till fields. Trapping and molecular techniques will be used to describe movement.

Evaluations of Variety and Insecticidal Seed Treatments for Hessian Fly Management. Dayna Alvey, Kristopher Giles, Tom Royer Brett Carver. Field evaluations of elite lines of wheat for control of Hessian fly. Additionally, the impact of no-till on fly biology will also be evaluated.

USDA-ARS. Areawide Pest Management Program. Elliott, N. et al.

In cooperation with postdoctoral fellow Sean Keenan, continued studies examining the management characteristics of wheat producers throughout the central plains. Results have been summarized and submitted as a book chapter. In cooperation with Dr.

Norman Elliott and Postdoctoral Fellows Dr. Mpho Phoofolo and Vasile Catana continued studies examining the ecology arthropod predators in simple versus diverse agricultural systems. Project will terminate in 2007.

Synopsis of Arthropod Pest Activity in Wheat, 2005-06

The overall factor affecting wheat in Oklahoma was the drought. Oklahoma's state yield was about 50% below normal. Season started out with a severe infestation of fall armyworm in central and southwestern OK. Thousands of acres were treated. Aphid numbers were relatively low early but greenbugs became a problem in late winter and early spring. *Mayetiola destructor* was reported in several locations, especially in those fields that were produced under conservation tillage.

Publications

Elliott, N.C., F.L. Tao, K.L. Giles, T.A. Royer, M.H. Greenstone, and K.A. Shufran. 2006. First quantitative study of rove beetles in Oklahoma winter wheat fields. *Biocontrol* 51:79-87.

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Elliott, N. C., F. L. Tao, K. L. Giles, T. A. Royer, M. H. Greenstone, and K. A. Shufran. 2006. First quantitative study of rove beetles in Oklahoma winter wheat fields. *BioControl*. 51: 79-87.

Elliott, N. C., F. L. Tao, K. L. Giles, S. D. Kindler, B. W. French, M. H. Greenstone, and K. A. Shufran. 2006. Ground beetle density in Oklahoma winter wheat fields. *Southwest. Entomol.* 31: 121-128.

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WERA-66 REPORT for the Period of Sept. 2005 through Sept. 2006
(Compiled by Gary Puterka)

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II. OVERVIEW OF CURRENT RESEARCH AND ACCOMPLISHMENTS

A. Predicting the impact of predators and parasites

In conjunction with collaborators from Oklahoma State University we continued research to develop a predictive model for the predatory impact of Coccinellidae on the greenbug. During the previous year we conducted field and laboratory studies to quantify the spatially explicit population dynamics of the greenbug in relation to parasitism by *L. testaceipes* and predation by Coccinellidae and other predators and initiated development of a preliminary spatially explicit simulation model. 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.

B. Remote sensing of cereal aphids

In conjunction with collaborators from the Texas Agricultural Experiment Station and SST Development Group Inc. we are developing remote sensing technology to detect and monitor greenbug 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 greenbug infestation from non-stressed areas. Remote sensing technology has the potential to markedly improve pest management practices for the greenbug in winter wheat because infestations in fields will be efficiently detected and delineated at an early stage, which could result in more economically and environmentally sound management.

C. Distribution of RWA Biotypes.

Approximately 370 RWA clones we collected from 70 sites in Texas, Oklahoma, New Mexico, Colorado, Nebraska and Wyoming in 2005. The collections were made primarily from wheat with the exception of a few from wild grasses and a majority collected from barley in northern Wyoming. The clones were evaluated on *DN4* and *DN7* resistance in wheat in replicated trials. A subsample of 30% of the collections were evaluated on *DN1* - *DN9* RWA resistance in wheat and STARS 9301B and 9577B RWA resistance in barley for a complete biotype determination. Colorado, Texas, Oklahoma, Kansas and Nebraska had equal proportions of RWA clones virulent and avirulent to *DN4*. New Mexico had 76% of the samples avirulent to *DN4* (RWA1) while Wyoming had 70% of the samples virulent to *DN4*. No clones were found to be virulent to *DN7* or the two sources of RWA resistance in barley. The subsamples tested were found to be either RWA1 or RWA2, based on chlorosis ratings. Therefore, our survey indicates the RWA2 is now present in significant levels in the wheat and barley growing regions RWA infests.

D. Genetic Variation of Russian Wheat Aphid Biotypes and Populations in the US

Diuraphis noxia biotypes RWA1 and RWA2 (10 clones each) were subjected to RAPD and COI mtDNA sequence analysis. No variation was found within or between biotypes. Zero nucleotide variation in the COI was found in an additional 40+ field collected individuals of unknown biotype (collected from 2003 to 2005 in TX, CO, NM, KS, NE, OK, and WY). COI sequences from the USA were identical to those from Canada, Ethiopia, Turkey, Syria, and the Czech Republic as reported in GenBank by Belay and Stauffer (AY241697-AY241705). Microsatellite analysis revealed US populations were made up of multiple clones. Clonal variation was found within and between RWA1 and RWA2, however no biotype specific loci or alleles were found. Microsatellite markers are being used to study gene flow in US populations.

E. Greenbug Ecology and Biotypic Diversity

Biotypic diversity of the greenbug, was assessed among populations collected from cultivated wheat and sorghum, and their associated noncultivated grass hosts. Greenbugs were collected during May through August from 30 counties of Kansas, Nebraska, Oklahoma, and Texas. Discounting the presumptive biotype A, five of the remaining nine letter-designated greenbug biotypes were collected; however biotypes C, F, J, and K were not detected. Biotypes E and I exhibited the greatest host range and were the only biotypes collected in all four states. Sixteen greenbug clones, collected from eight plant species, exhibited unique biotype profiles. Eleven were collected from noncultivated grasses, three from wheat, and two from sorghum. The most virulent biotypes were collected from noncultivated hosts. 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.

Greenbug was first discovered damaging seashore paspalum (*Paspalum vaginatum*) turfgrass in November 2003 at Belle Glade, Florida. Several golf courses with seashore pasplum in central and southern Florida were subsequently infested by April 2004. Damage symptoms progress from water soaked lesions surrounding feeding sites within

24 hours to chlorosis and necrosis of leaves within 96 hours. Problems caused by greenbug feeding were initially misdiagnosed as fertilizer, disease or water management problems because aphids previously were not found on warm season turfgrasses in Florida. The Florida greenbug isolate exhibited a unique biotypic profile, which was most similar to the profiles of biotypes F, G, and H. These biotypes are typically not abundant on cultivated crops, but are commonly found on Kentucky bluegrass lawns and/or noncultivated grass hosts. Moreover, the Florida isolate was virulent to all currently available resistant sorghums and GRS1201, which is resistant to the principal agricultural biotypes that attack small grains.

F. Russian Wheat Aphid Resistant Barley

‘Stoneham’ and ‘Sidney’, RWA-resistant, drought hardy, 2-rowed, spring barley cultivars, were released jointly by USDA-ARS, Stillwater, OK, USDA-ARS, Aberdeen, ID, Colorado State University, and University of Nebraska. The source of RWA resistance in Stoneham and Sidney are STARS 9577B and STARS 9301B, respectively. Although STARS 9301B and STARS 9577B were developed for resistance to RWA1, they have been shown to be resistant against RWA1, RWA2, RWA3, RWA4, and RWA5 as well.

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 have been approved for release. These lines were developed by backcrossing different sources of resistance to 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 Aberdeen, Idaho.

Increases have been made prior to release of 10, RWA-resistant, 6-rowed, winter, feed barley germplasm lines resistant to both Greenbug and RWA.

A breeding program has been initiated to develop winter, hullless, feed barleys resistant to both RWA and Greenbug, adapted to Oklahoma, and suitable for ethanol production.

A seedling screening test for BCOA resistance has been developed and tested for repeatability. 960 lines of the Barley Core Collection were screened with this new technique.

G. Russian Wheat Aphid Resistant Wheat

At the 2005 WERA-066 meeting, it was determined that there was a pressing need for specific guidelines to be set and followed when screening for resistance to Russian wheat aphid- these guidelines were published in the 2005 WERA-066 Annual Meeting Minutes, which are available at the following link:

<http://www.oznet.ksu.edu/entomology/wera-066/WERA-066report.pdf>

Included in the guidelines 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, it was determined that these plant differentials would be available to RWA researchers via Stillwater USDA-ARS, as soon as sufficient seed is available. It is hoped that enough

seed will be 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 will be done prior to further increases.

In addition, it was determined that Stillwater ARS would be the official source for the RWA1 biotype and Colorado State University would be the official source for RWA2. When research is to be done with either of these biotypes, it would be advantageous to know that we are all working with the same aphids and not relying on new field collections of aphids. For example, if a new RWA collection is virulent on Dn4 wheat, it must be noted that it does not logically follow that the new aphid is RWA2- it merely confirms that it is not RWA1. Other additional biotypes have been collected that are also virulent on Dn4, so the use of a small number of differentials may not successfully distinguish between biotypes.

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, screening 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 of the RWA biotypes against which they have been tested. A germplasm release is planned for this fall.

III. PUBLICATIONS

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Elliott, N. C., F. L. Tao, K. L. Giles, T. A. Royer, M. H. Greenstone, and K. A. Shufran. First Quantitative Study of rove beetles in Oklahoma winter wheat fields. *Biocontrol* 51: 79-87. 2006.

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SOUTH DAKOTA, WERA-66 ANNUAL REPORT, 2006

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Overview of Cereal-Aphid Research Activities and Accomplishments:

1. The effects of planting date on infestations of cereal aphids and other insects in winter wheat was determined at 2 sites in South Dakota over 3 years. Planting on Sep. 20 or later decreased damage from chewing insects, the abundance of cereal aphids, and resulting incidence of Barley yellow dwarf virus in wheat.
2. Research continues on the biology and management of cereal aphids.
 - a. Meaningful sources of plant resistance are needed against the bird cherry-oat aphid, *Rhopalosiphum padi*, a worldwide pest of wheat. Moderate levels of resistance to this aphid were found in several lines of triticale and low levels of resistance in two wheat accessions. Follow-up studies with triticale accessions are in progress.
 - b. Studies continue on the host suitability, rearing, and economic impact of the rice root aphid, *Rhopalosiphum rufiabdominalis*, on small grains. Collaborative research on rice root aphid continues with the USDA-ARS Plant Science Laboratory in Stillwater, OK.
3. The abundance and community structure of ladybird beetles, one of the major groups that prey on cereal aphids, is being determined for South Dakota and adjacent states. Findings show that *Adalia bipunctata* and *Coccinella transversoguttata richardsoni* remain rare and *Coccinella novemnotata* continues to be absent from the area.

Publications

Hesler, L.S., W.E. Riedell, M.A.C. Langham & S.L. Osborne. 2005. Insect infestations, incidence of viral plant diseases, and yield of winter wheat in relation to planting date in the northern Great Plains. *J. Econ. Entomol.* 98:2020-2027.

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REMOTE SENSING FOR APHID INFESTATION IN SMALL GRAINS

Mustafa Mirik, Gerald J. Michels, and Sabina Mirik

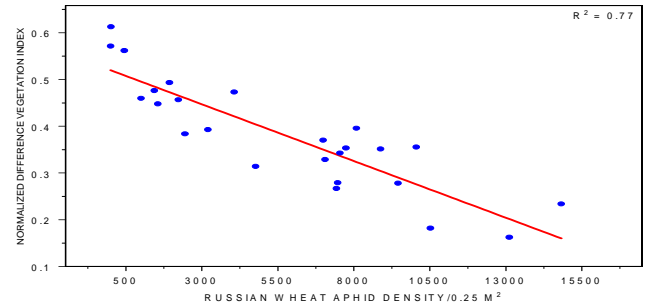
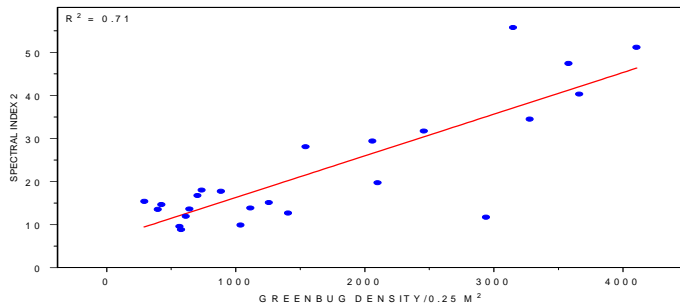


Timely and precise information is needed for aphid pest management because localized or widespread infestations of small grain aphids,

greenbug (*Schizaphis graminum* (Rondani)), and the Russian wheat aphid (*Diuraphis noxia* (Mordvilko)), occur almost every year in the Great Plains of the United States, causing significant economic damage to cereal production, especially on wheat, barley, and sorghum. Wheat production losses to the US economy due to greenbug infestation were estimated to average between \$60 and \$100 million annually. Economic loss from Russian wheat aphid infestation to wheat and barley crops in the US has been estimated at nearly \$1 billion since 1987. A monitoring strategy for estimating the density and damage caused by greenbug and Russian wheat aphid is critical to provide reliable information about the condition of the infestation. Remote sensing appears to be a quick, repeatable, unbiased, and cost-effective tool to detect naturally-occurring aphid outbreaks in fields at the canopy level.

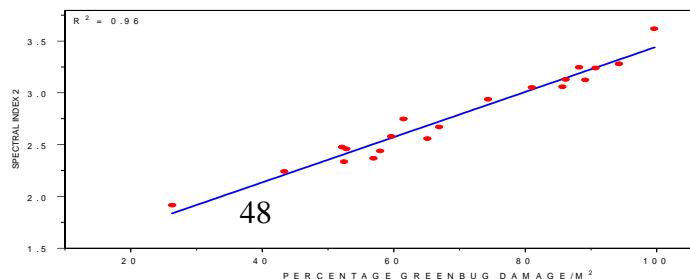
OBJECTIVES OF THE PROGRAM

- a) Use remote sensing as a quick, repeatable, unbiased, and cost effective technique for implementation of management practices for greenbug and Russian wheat aphid infestation in small grains.
- b) Develop aphid density and damage prediction models based on spectral indices using spectral reflectance data.
- c) Disseminate information obtained through this program to producers, scientists, and other interested persons and institutions.



RESULTS

The results obtained so far indicated that indices developed using spectral reflection data have the accuracy and precision necessary to reliably estimate greenbug and Russian wheat aphid densities and damage to wheat growing under field conditions. The spectral signatures of aphid-damaged wheat were distinctive through the visible to near infrared (400-900 nm) range of the electromagnetic spectrum.



PUBLICATIONS

Mirik, M., G. J. Michels, Jr., S. Kassymzhanova-Mirik, N.C. Elliott, V. Catana, D.B. Jones, and R. Bowling. 2006. Using digital image analysis and spectral reflectance data to quantify greenbug (Homoptera: Aphididae) damage in winter wheat. *Computers and Electronics in Agriculture*. 51: 86-98.

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**WERA066 Report
2006
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This brief summary is an introduction of my activities as a new member of the committee, a barley geneticist and breeder, and as related to this project.

The WSU barley breeding program has been working on breeding for resistance to Russian wheat aphid in barley germplasm adapted to the Pacific Northwest in general and specifically to dryland eastern Washington. I have been using resistant germplasm adapted to the western USA developed by Do Mornhinweg, USAD-ARS, Stillwater, OK. Currently advanced lines are being evaluated in non-replicated and replicated yield nurseries at Pullman, WA.

The breeding program is also working on breeding for resistance to Hessian fly in collaboration with Sue Cambron, USDA-ARS, West Lafayette, IN. Advance breeding lines are evaluated for Hessian fly reaction at West Lafayette. There is also a genetic study underway to determine inheritance of Hessian fly resistance in barley based on crosses with several lines resistant to biotype L.

Impact Statements: For WERA066 - 2006

Improve knowledge of cereal arthropods among scientists, producers and other interested clientele.

Develop new or improved management practices for cereal arthropods.

Monitor for newly introduced pests or the development and spread of new more damaging biotypes.