

WESTERN COORDINATING COMMITTEE – 066
Integrated Management of Russian Wheat Aphid and Other Cereal Aphids

MINUTES OF THE ANNUAL MEETING
SEPTEMBER 26-28, 2004
MANHATTAN, KANSAS

Report Submitted by KA Shufran
Minutes recorded at meeting by D Mornhinweg

List of participants

1. Tom Holtzer, Administrative Co-advisor, Colorado St. Univ.
2. Sue Blodgett, Montana St. Univ.
3. Louis Hesler, Chair, USDA-ARS, Brookings, SD
4. Frank Peairs, Colorado St. Univ.
5. Keith Pike, Washington St. Univ.
6. David Porter, USDA-ARS, Stillwater, OK
7. Sean Keenan, Oklahoma St. Univ.
8. J.P. Michaud, Kansas St. Univ.
9. Do Mornhinweg, USDA-ARS, Stillwater, OK
10. Cheryl Baker, USDA-ARS, Stillwater, OK
11. John Reese, Kansas St. Univ.
12. Marion Harris, North Dakota St. Univ.
13. Juan Manuel Alvarez, University of Idaho
14. Norman Elliott, USDA-ARS, Stillwater, OK
15. Allan Fritz, Kansas St. Univ.
16. John Burd, USDA-ARS, Stillwater, OK
17. Michael Roberts, Kansas St. Univ.
18. Amanda Schroeder, Kansas St. Univ.
19. Gerald Wilde, Kansas St. Univ.
20. Gary Hein, University of Nebraska
21. Yiqun Weng, Texas Ag. Exper. Station-Amarillo
22. Kris Giles, Oklahoma St. Univ.
23. Tom Royer, Oklahoma St. Univ.
24. Mpho Phoofolo, Oklahoma St. Univ.
25. Mike Smith, Kansas St. Univ.

Minutes

Sept. 27.

8:30 AM - Louis Hesler, WCC-66 chair, opened the meeting. Kevin Shufran
(secretary/chair elect) was not in attendance due to an injury. Do Mornhinweg

acted as secretary for the meeting. Dr. Hesler thanked Mike Smith, John Reese, and Gerald Wilde for the local arrangements and welcomed participants to the meeting. A sign up sheet was passed around for attendance and to update professional information. A brief discussion of the schedule followed and Louis introduced our unscheduled guest speaker, Rick Meyers from CSREES.

8:40 AM – Tom Holtzer, administrative co-advisor, encouraged the group to keep up the good work and pointed out the importance of documenting our accomplishments and impact in WCC-66 reports. He encouraged attendees who were not official members to consider becoming members by applying at the WCC-66 website.

9:00 AM- Rick Meyers, National Program Leader for entomology, gave us a budget update for CSREES. He discussed the status of funds available for NRI grants and indicated that 25% of that funding would go to integrated IFAFS-like projects. He encouraged us all to continue to submit and resubmit grants.

9:10 AM– Louis introduced J. P Michaud to present data and lead a discussion on RWA biotypes - Field biology and Cultivar development.

J.P. presented information on the performance of a novel strain of RWA (RWA2), on 3 wheat cultivars, Trego (susceptible to RWA1), and Stanton and Halt (both resistant to RWA1). He reported the reproductive rate of RWA2 was high for all 3 cultivars whereas RWA1 had a high reproductive rate only on Trego and low reproductive rate on Stanton and Halt. Although RWA 2 damaged all three cultivars, that damage was not as high as the damage of RWA1 on Trego. Trego had the most leaf rolling from RWA2, but there was also more leaf rolling on Stanton and Halt than with RWA1. J.P. next reported results on the benefits of group feeding in *Diuraphis noxia* as affected by variety and temperature. For RWA1, at 20°C, there was significantly greater survival of young aphids feeding in a group compared to young aphids alone. At 24°C, the benefits of group feeding were negated. For RWA2, the reverse was true with better survival of singles at 20°C and better survival of group feeding aphids at 24°C. He concluded that there are different thermal optimums for the two biotypes.

Frank Peairs - Test environment is critical – especially temperature but also photoperiod length.

A discussion ensued concerning rearing techniques for biological studies centering on the host effect. Traditionally aphids are reared on susceptible.

Frank Peairs - In a controlled study you usually rear on the cultivar it will be tested on for several generations before the test. Rearing for screening one usually rears on a mixture of resistant and susceptible. Rearing on Halt resulted in 10% reduction in aphid weight compared to TAM107. Perhaps it is best to rear on a mix based on acreage in the state.

John Burd – began discussion on determination of biotypes based on plant response and suggested the necessity of a matrix of designated Dn genes.

Marion Harris – There are currently 31 genes for Hessian fly resistance and 31 differentials.

Mike Smith – CI 2401 which is resistant to RWA2 has Dn4 as well as another gene for resistance.

Gary Puterka – how many aphid populations exist in the field now? Colorado is looking at several beyond RWA2 and John Burd suspects he has at least 3 new biotypes. The discussion turned to uniformity in testing for biotype. Do you test on vernalized or nonvernalized seedlings? The kind of cage may affect test results.

Phil - CI and PI's used for testing will they all be the same genetically? Temperature is important as well as what cultivar or mix the aphids were reared on. Do we have enough knowledge to standardize? What rating scale would we use? We need to identify and define certain givens or set up parameters for standardized biotyping.

Sue Blodgett – we need to set up the best standard conditions we can at this meeting including the proposal of a matrix of plant differentials to characterize new populations. A formal paper needs to be submitted to JEE. Seed purity and sources for Dn resistance genes need to be discussed. This discussion was tabled to the Aphid-Ecology and Plant – Insect Interactions subcommittee meeting scheduled for 3:00.

1:00 PM– State reports from Colorado, Idaho, Kansas, Montana, North Dakota, Nebraska, Oklahoma, Stillwater – USDA-ARS, South Dakota, Texas, and Washington. See appendix (p. 6) for written reports.

3:00 PM– Breakout into Subcommittee Discussions

4:30 PM- Recess

4:30 -5:30 PM -Greenbug consortium meeting.

Sept. 28

8:15 AM- Subcommittee Reports

Aphid Ecology and Plant - Insect Interactions Subcommittee Report

Chair: David Porter

Secretary: Do Mornhinweg

Discussion began with an outline from Frank Peairs on important points concerning screening for biotypes:

1. differentials
2. test conditions
 - a. pre-vernalized plants
 - b. photoperiod – 16D/8N
3. aphid parameters
 - a. infestation rate – sieve to one aphid size, put on leaf pieces at bottom of each plant
 - b. culture on blend of field cultivars (susceptible and resistant)

Next discussed naming of biotypes and agreed on the following:

CO A = RWA1
CO B = RWA2
TX1 = RWA3
WY1 = RWA4
TX2 = RWA5
CO C = RWA6

A discussion on differentials followed and it was proposed by Dave that Cheryl Baker would raise and maintain founders seed which would be available soon for all interested in screening or biotyping to begin their seed increases. We would all start on the same page. The following differential list was proposed:

Dn4 - Yumar
Dny - Stanton
Dn7 - Gamtoos R
Susceptible - Yuma

Some discussion followed the presentation of the report to the whole membership and it was proposed that Gary Puterka would maintain cultures of all RWA biotypes and would send these aphids on request to those wishing to screen. Again we would all be on the same page. Dave thanked the group for their role in obtaining Gary's position at Stillwater. It was further decided that field collections in all states would be tested against Dn4 and Dn7. If a reaction to Dn7 was found, the aphids would be sent to Gary for further biotyping and maintenance. It is hoped that this would become a world wide effort to assess global diversity for virulence.

Biological Control Subcommittee Report

Chair: Not recorded
Secretary: Not recorded

Discussion following:

Can predict control with parasitoids. Sorghum – lady beetle larvae hard to find – eaten by first hatched larvae plus other cannibals out there too. Sibling egg cannibalism 40%.

Kris Giles – planting of canola acreage has potential for major harboring of parasitoids. Cabbage aphids bad problem sprayed several times for control in experimental plots.

Suggested workshops for next meeting – Lady beetle or carabids identification problem suggested workshop organizers: Lady beetles – Jerry Michels Carabids – Frank or Sue

Discussion on Rice Root Aphid – Dean will soon have another paper out. Do we want to sample other states such as ND or TX? Counties in each state with confirmed RRA can be sent to Chris or Dean for identification - circulation of a sampling protocol involving sending soil sample through a Bulazie funnel

Keith Pike – when sampling for RRA may find other aphids on the roots of wheat and grasses – send Keith adults and he will identify them the biggest aphid you find a better chance of it being an adult. 70% alcohol and send to Keith.

9:15 AM– Nomination and election of officers. Kevin Shufron, current Vice Chair and Secretary, will assume duties as Chair and Do Mornhinweg was nominated and confirmed by vote as incoming Vice Chair and Secretary.

9:20AM – Site Selection. Ft. Collins was unanimously voted as the site for the next meeting with a tentative date of Sept. 18-20. A workshop is proposed for Sunday the 18.

9:25 AM– Other business. Send a list of members and information on membership to all attendees. Chair, Chair elect and Vice-chair elect will draft a renewal document and send to members for comments and suggestions sometime after the first of the year.

9:30 AM- Meeting adjourned

Appendix: State Reports Submitted For 2004

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Reports below

Annual Report to WRCC-66: 2004

Department of Bioagricultural Sciences and Pest Management
Colorado State University

I. Designated Representatives and Collaborators

A. Representatives

T. Holtzer
Department of Bioagricultural Sciences and Pest
Management
Colorado State University
Fort Collins, CO 80523-1177
970-491-5843
tholtzer@lamar.colostate.edu

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

B. Collaborators

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

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

II. Sub-Committee Objectives Addressed

A. Biological Control

1. Seek ways to improve biological control of the Russian wheat aphid through the use of

diversified dryland cropping systems.

B. Host Plant Resistance

1. Incorporate genetic resistance to Russian wheat aphid into commercially acceptable winter wheats for Colorado.
2. Categorize the mechanisms of known genetic sources of resistance to Russian wheat aphid in order to determine the best combinations for stable resistance.
3. Test experimental wheat lines and varieties that are resistant to Russian wheat aphid at multiple locations for level and stability of quality, yield and resistance.

C. Biology and Management

1. Refine economic injury levels and thresholds for Russian wheat aphid in small grains to incorporate additional factors such as cultivar, cropping system, and presence of other pests. Monitor economic impact of Russian wheat aphid in Colorado.
2. Conduct studies on the field biology and ecology of the Russian wheat aphid to improve understanding and management of Russian wheat aphid.
3. Determine the influence of modified cultural practices, including grazing, planting date and volunteer control, on Russian wheat aphid densities.
4. Improve application technology including safer and more effective insecticides and more efficient application techniques.

III. Current Accomplishments

A. Biological control

1. Pitfall traps have been established at three cropping systems sites. Carabids and spiders are

being collected and identified. (Objective A1)

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

B. Host Plant Resistance

1. Russian wheat aphid resistant wheat cultivars are now planted on more than 25% of Colorado's wheat acreage.
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 rye and goatgrass crosses. (Objective B1)
3. Resistant feed barley lines were tested in 2001 - 2004. Some lines have resistance to RWA as well as the ability to perform well agronomically under dryland conditions. Resistant malt barley lines have been tested on a more limited basis. (Objective B3)
4. Surveys were conducted to determine the presence of Dn4-virulent Russian wheat aphids. Of the 100 samples taken, 57 were Dn4-virulent. There were some indications of additional virotypes.
5. Approximately 3,000 of 7,000 Iranian landrace selections have been screened with "Biotype B", which identified a few dozen promising lines. In addition, 761 selections that had been identified as resistant in the 1980s were rescreened with "Biotype B", which identified several promising lines. Results of both screenings have been submitted to GRIN.

C. Biology and Management

1. Dryland cropping systems studies are ongoing at three locations in eastern Colorado. Both resistant (Dn4) and susceptible cultivars are used in treatments containing wheat. (Objectives A1, B3 and C3)

2. Aphid flights were monitored at four locations by means of suction traps. (Objective C2)
3. Ten foliar insecticide treatments were compared to commercial standard insecticide treatments for control of Russian wheat aphid. None were superior to what is currently available to Colorado wheat producers. (Objective C4)
4. Thiamethoxam seed treatments continued to look promising as a seed treatment alternative to foliar lambda cyhalothrin treatments for control of Russian wheat aphid in malt barley. (Objective C4)

IV. Publications

Haley, S. D., F. B. Peairs, C. B. Walker, J. B. Rudolph and T. L. Randolph. 2004. Occurrence of a new Russian wheat aphid biotype in Colorado. *Crop Sci.* 44:1589-1592.

Peairs, F. B. 2004. Wheat pests and their management. Pp. 2529 - 2545 in J. L. Capinera, ed. *Encyclopedia of Entomology*. Kluwer Academic Publishers, Boston.

Haley, S. D., J. S. Quick, J. J. Johnson, F. B. Peairs, J. A. Stromberger, S. R. Clayshulte, B. L. Clifford, J. B. Rudolph, O.K Chung, and B. W. Seabourn. 2004. Registration of 'Ankor' wheat. *Crop Sci.* 44: 1025 - 1026.

Walters, S. M., F. B. Peairs & A. Gebre-Amlak. 2003. 2003 Colorado field crop insect management research and demonstration trials. Colorado State Univ. Agric. Exp. Sta. Tech. Bull. LTB03-3, 37 pp.

Haley, S., J. Johnson, and F. Peairs. 2003. Hard white wheat breeding at CSU. Pp. 49 - 52 in, Haley, S., ed. *Colorado Wheat Production Handbook: Clearfield Wheat and Hard White Wheat*. Colorado Association of Wheat Growers, Lakewood, CO. 56 pp.

Haley, S., J. Johnson, F. Peairs, and P. Westra. 2003. Clearfield wheat breeding at CSU. Pp. 17 - 20 in, Haley, S., ed. *Colorado Wheat Production Handbook: Clearfield Wheat and Hard White Wheat*. Colorado Association of Wheat Growers, Lakewood, CO. 56 pp.

Miller, H. R., T. L. Randolph, and F. B. Peairs. 2003. Categories of resistance at four growth stages in three wheats resistant to the Russian wheat aphid (Homoptera: Aphididae). *J. Econ. Entomol.* 96: 673 - 9.

Randolph, T. L., F. B. Peairs, M. K. Kroening, J. S. Armstrong, R. W. Hammon, C. B. Walker, and J. S. Quick. 2003. Plant damage and yield response to the Russian wheat aphid (Homoptera: Aphididae) on susceptible and resistant winter wheats in Colorado. *J. Econ. Entomol.* 96: 352 - 61.

Hawley, C. J., F. B. Peairs, and T. L. Randolph. 2003. Categories of resistance at different growth stages in Halt, a winter wheat resistant to the Russian wheat aphid (Homoptera: Aphididae). *J. Econ. Entomol.* 96: 214 - 219.

Berzonsky, W. A., H. Ding, S. D. Haley, M. O. Harris, R. J. Lamb, R. I. H. McKenzie, H. W. Ohm, F. L. Patterson, F. B. Peairs, D. R. Porter, R. H. Ratcliffe, and T. G. Shanower. 2003. Breeding wheat for resistance to insects. *Plant Breeding Reviews* 22: 221 - 96.

Walters, S. M., F. B. Peairs & A. Gebre-Amlak. 2003. 2002 Colorado field crop insect management research and demonstration trials. Colorado State Univ. Agric. Exp. Sta. Tech. Bull. LTB03-2, 45 pp.

Haley, S. D., M. D. Lazar, J. S. Quick, J. J. Johnson, G. L. Peterson, J. A. Stromberger, S. R. Clayshulte, B. L. Clifford, T. A. Pester, S. J. Nissen, P. H. Westra, F. B. Peairs, and J. B. Rudolph. 2003. Above winter wheat. *Can. J. Plant Sci.* 83:107-108.

Lazar, M. D., S. D. Haley, J. S. Quick, J. J. Johnson, G. L. Peterson, J. A. Stromberger, S. R. Clayshulte, B. L. Clifford, T. A. Pester, S. J. Nissen, P. H. Westra, F. B. Peairs, and J. B. Rudolph. 2003. AP502 CL winter wheat. *Can. J. Plant Sci.* 83:109-110.

Haley, S. D., J. S. Quick, T. J. Martin, J. J. Johnson, F. B. Peairs, J. A. Stromberger, S. R. Clayshulte, B. L. Clifford, and J. B. Rudolph. 2003. Registration of 'Avalanche' wheat. *Crop Sci.* 43:432.

Kansas State University

WRCC66
2004 Annual Report

C. Michael Smith (representative), Dhanaraj Boina, Elena V. Boyko, Leslie R. Campbell, Ming Chen, John Diaz-Montano, Xuming Liu, Nandi Nagaraj, Sheila Prabhakar, John C. Reese, Sharon Starkey, and Lieceng Zhu, Department of Entomology, Manhattan, KS 66506; J. P. Michaud, J. L. Jyoti, Tom Harvey, Department of Entomology & Ken Kofoid, Department of Agronomy, Kansas State University, Agricultural Research Center, Hays, KS 67601
Alan Fritz, Bill Schapaugh, Mitch Tuinstra, Department of Agronomy;
Gerald R. Reeck, Navdeep Mutti, Department of Biochemistry;
Bikram Gill, Department of Plant Pathology

Categories of Resistance to Greenbug Biotype I in Wheats Expressing the *Gby* and *Gbz* Genes

Dhanaraj Boina, Sheila Prabhakar, C. Michael Smith, Sharon Starkey, Lieceng Zhu, Elena Boyko and John C. Reese

Experiments were conducted to determine the categories of resistance to greenbug biotype I controlled by two different resistance genes in wheat germplasm lines ‘KS89WGRC4’, containing the *Gbx* gene, and ‘Sando’s 4040’, containing the *Gby* gene. Antixenosis (non-preference), antibiosis (lowered greenbug intrinsic rate of increase) and tolerance (reduced plant tissue and chlorophyll loss) assays were conducted using plants of Sando’s 4040, KS89WGRC4, ‘Jagger’ (susceptible control), ‘Largo’ (antibiosis control), and ‘TA1675’ (tolerance control). Neither Sando’s 4040, KS89WGRC4 nor the controls exhibited antixenosis to greenbug biotype I. There was an antibiotic effect on the greenbugs confined to Sando’s 4040 ($r_m = 0.122$), that was no different than the r_m of aphids on the resistant control, Largo ($r_m = 0.1433$). Antibiosis was not present in KS89WGRC4. Both Sando’s 4040 and KS89WGRC4 exhibited tolerance to greenbug biotype I feeding damage, based on measurements of proportional dry plant tissue weight change and leaf chlorophyll loss. Sando’s 4040 and KS89WGRC4 provide useful new sources of resistance to greenbugs for wheat breeding programs.

Functional Genomics of *Dn4* and *Dn6* Genes Expressing Russian Wheat Aphid Resistance

Elena Boyko, C. Michael Smith, and Sharon Starkey

There was a trend for resistance in wheat to Russian wheat aphid, (RWA) to be enhanced by jasmonic acid (JA), a naturally occurring elicitor released during plant response to insect attack. Antibiosis (RWA population reduction) and tolerance (plant biomass production) resistance exhibited by different wheat lines containing either the *Dn4* or *Dn6* gene was increased by topical application of JA, but the differences were not significant. Application of JA to plants of Wichita, a RWA - susceptible wheat, significantly increased their tolerance to RWA attack, but did not make Wichita plants antibiotic. A SSH cDNA library was constructed from leaves of wheat plants possessing the *Dn6* gene and a susceptible cultivar challenged by Russian wheat aphid. The transcriptome of the challenged tissues has yielded over 1,020 differentially expressed clones. Northern expression analyses of the library revealed many sequences that were differentially expressed in *Dn6* plants. Several sequences show no similarity to any sequences with assigned functions at NCBI (Boyko et al. 2004). Sequences of cDNAs unique to *Dn6* plants under RWA attack will provide some of the first information about cereal plant responses to

RWA feeding at the molecular level. This information will be useful in the genetic design of future RWA resistant wheat cultivars.

Soybean Resistance to Soybean Aphids and Non-Host Behavior

John Diaz-Montano, Bill Schapaugh, Mike Smith, Andrea Ray-Chandler, and John C. Reese

While the soybean aphid is not a pest of cereals *per se*, it certainly can be a severe pest of legumes (Sloderbeck et al. 2003a and 2003b). We have screened 200 entries. Eight show some promise, with one showing quite strong antixenosis.

Allelic Relationships Among Russian Wheat Aphid Resistance Genes

Xuming Liu, C. Michael Smith and Bikram Gill

The identification and mapping of Russian wheat aphid resistance genes and the development of resistant wheat cultivars can be facilitated through the use of molecular markers. Our previous results indicate that the aphid resistance genes *Dn1*, *Dn2*, *Dn5*, *Dn6*, and *Dnx* are tightly linked to the microsatellite marker *Xgwm111* on wheat chromosome 7DS. In the present study, results of allelism tests showed no segregation for susceptibility among F₂ plants derived from intercrosses between wheat lines containing each of these *Dn* genes, or BC₁F₁ plants from the test crosses. Results of both marker linkage analyses and allelism tests revealed that these *Dn* genes are either allelic or tightly linked to one another. Aphid resistance in four uncharacterized wheat lines (PI 47545, PI 222666, PI 222668, and PI 225245) is also associated with *Xgwm111*, indicating that the *Dn* genes in these wheat lines are also either tightly linked or allelic to the above known *Dn* genes. All these *Dn* genes, are clustered in a region linked to *Xgwm111*, and are either alleles at a single locus, or closely related members of a *Dn* gene family. *Dn4* in PI 372129 and an uncharacterized *Dn* gene in PI151918 are linked to *Xgwm106* and *Xgwm337* on chromosome 1DS, indicating they are most likely either allelic or linked.

Biological Performance of Russian Wheat Aphid ‘Biotype B’ to Aphid Collections from Western Kansas

J. P. Michaud and J. L. Jyoti

We conducted two laboratory experiments to compare the biological performance of the new Russian wheat aphid ‘biotype’ to that of two *D. noxia* collections from western Kansas using three wheat varieties as host plants; Trego, a susceptible variety, and Stanton and Halt, two varieties with different genetic sources of resistance. Survival of solitary nymphs from first instar to adult for the two Kansas clones on Trego was 96% and 90%, respectively, compared to 67 % and 43% on Stanton, and 65% and 57% on Halt. In contrast, the Colorado clone had 60% survival on Trego, 43% survival on Halt, and 85% survival on Stanton. One source of Kansas aphids required longer to mature on Halt compared to Trego or Stanton, but no other differences in developmental time among varieties were significant. The standardized fecundity of solitary foundresses of the two Kansas populations was 19.6 and 20.1 nymphs on Trego, compared to 4.6 and 0.9 on Stanton, and 2.8 and 1.1 on Halt, respectively, over the same period. In contrast, fecundity of the Colorado clone was 21.1, 20.8 and 19.7 on Trego, Stanton and Halt, respectively. When larger colonies developed on individual plants over longer periods, Trego supported the largest number of Kansas collection 1 aphids by experiment’s end, whereas

Stanton and Halt yielded the larger numbers of Colorado aphids. The order of overall plant damage was Trego > Stanton > Halt when infested with Kansas aphids, with no significant differences for Colorado aphids. Trego had more pronounced leaf rolling than other varieties independent of aphid source. Collectively, the results suggest that the Colorado *D. noxia* biotype has evolved cross-virulence to both *Dn4* and *Dny*-based resistance sources, but at a cost in terms of reduced performance on the formerly susceptible Trego. We are currently investigating how group-feeding benefits *D. noxia* in terms of accelerating development and reproduction on susceptible varieties.

Marker Assisted Selection for Searching for Greenbug Tolerance in Sorghum

Nandi Nagaraj, John C. Reese, Mitch Tuinstra, and Mike Smith

Informative markers are being searched for in order to use marker assisted selection to assist the search for tolerant sorghums. 300 microsatellite markers were screened on a recombinant inbred line population. 80 of them were found segregating and used in creating a genetic linkage map. Initial analysis on this linkage map has shown at least 8 markers to be associated with QTLs (Quantitative Trait Loci) conferring tolerance to greenbug feeding damage. The amount of phenotypic correlations explained by these QTLs varies from 9 to 23%. These QTLs may serve as promising regions for marker assisted selection programs for greenbug tolerance in sorghum.

Molecular Genetics of Insect Salivary Secretions

Gerald R. Reeck, Ming Chen, Navdeep Mutti, and John C. Reese

A cDNA library has been constructed from pea aphid [*Acyrtosiphon pisum* (Harris)] salivary glands. 400-450 sequences formed 220 clots or clusters of nearly identical sequences. We are currently focusing on the most abundantly expressed code, C002. In the future, we will be using RNAi technology to demonstrate the essentiality of specific codes, and begin to tease apart the functionality of targeted genes.

Sorghum Tolerance to Greenbug Feeding Damage

John C. Reese, Ken Kofoid, Nandi Nagaraj, and Leslie R. Campbell

In order to decrease any possible selection pressure for yet more virulent biotypes of the greenbug, *Schizaphis graminum* (Rondani), we have focused our efforts on the development of sorghum germplasm that exhibits tolerance to greenbug feeding damage. A chlorophyll meter was utilized to nondestructively measure chlorophyll of areas fed upon four days by greenbugs. We are now close to releasing tolerant material.

Identification of Russian Wheat Aphid Biotypes Virulent to the *Dn4* Resistance Gene

C. Michael Smith, Peter Starry, University of South Bohemia, Ceske Budjovice, Czech Republic; and **Christian Stauffer**, Institute of Forest Entomology, Vienna, Austria

Experiments with plants containing several different *Dn* genes demonstrated that populations from Chile, the Czech Republic, and Ethiopia are also virulent to *Dn4* (Smith et al. 2004). The Czech population was also virulent to plants containing the *Dnx* gene in wheat plant introduction

PI220127. The Ethiopian population was also virulent to plants containing the *Dny* gene in the Russian wheat aphid-resistant 'Stanton' produced in Kansas. The Chilean and Ethiopian populations were unaffected by the antibiosis resistance in *Dn4* plants. There were significantly more nymphs of the Chilean population on plants of *Dn4* than on *Dn6* plants at both 18 and 23 d post-infestation, and the Ethiopian population attained a significantly greater weight on *Dn4* plants than on plants containing *Dn5* or *Dn6*. These newly characterized virulent Russian wheat aphid populations pose a distinct threat to existing or proposed wheat cultivars possessing *Dn4*.

Genetic Analysis and Molecular Mapping of a Wheat Gene Conferring Tolerance to the Greenbug

Lieceng Zhu, C. Michael Smith, Elena Boyko, Alan Fritz, and Michael B. Flinn, (Dept. of Zoology, Southern Illinois University)

Several F₂ wheat populations derived from crosses between susceptible cultivars and resistant germplasm carrying different greenbug resistance genes were used to characterize the inheritance of a wheat gene (*Gbx*) conferring tolerance to the greenbug biotype I, to identify molecular markers linked to *Gbx*, and to investigate the allelic relationship between *Gbx* and *Gb3*. Results indicate that *Gbx* is inherited as a single dominant gene, linked to the microsatellite markers *Xbarc53* and *Xgwm428* at map distances of 4.6 and 5.7 cM, respectively, in the distal region of the long arm of the wheat chromosome 7 (Zhu et al. 2004). *Gbx* is either allelic or closely linked to *Gb3*.

Publications:

- Boina, D., S. Prabhakar, C. M. Smith, S. Starkey, L. Zhu, E. Boyko, and J. C. Reese. 200#. Categories of resistance to greenbug (Homoptera: Aphididae) biotype I in wheats expressing the *Gby* and *Gbz* genes. *J. Kansas Entomol. Soc.* (accepted).
- Boyko, E. V. and C. M. Smith. 2004. Expression of Pto and Pti-like genes is involved in wheat resistance response to aphid attack. In: *Plant & Animal Genome XII. Final Abstracts Guide. Workshop abstracts. January 10-14, 2004, San Diego, CA, W200.*
- Boyko, E. V., S. R. Starkey, and C. M. Smith. 2003. Genetic mapping of genes expressing resistance to greenbug and Russian wheat aphid in bread wheat. *Theor. Appl. Genet.* 109:1230-1236.
- Liu, X. M., C. M. Smith and B. S. Gill. 200#. Allelic relationships among Russian wheat aphid resistance genes. *Crop Sci.* (submitted).
- Nagaraj, N., J. C. Reese, M. R. Tuinstra, P. St. Amand, M. B. Kirkham, K. D. Kofoid, L. R. Campbell, C. M. Smith, and G. E. Wilde. 2004. Molecular mapping of sorghum genes expressing tolerance to damage by the greenbug (Homoptera: Aphididae). *J. Econ. Entomol.* (In Press).
- Sloderbeck, P., J. C. Reese, R. J. Whitworth, C. Michael Smith, R. A. Higgins, W. T. Schapaugh, R. E. Wolf, and D. J. Jardine. 2003a. The soybean aphid: A new pest in Kansas soybeans. Kansas State University Agr. Expt. Station and Cooperative Extension Service. MF-2582.
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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.

Our long-term goals are to extend these findings to other aphid-crop interactions (Russian wheat aphid-wheat, greenbug-sorghum, and soybean aphid-soybean) and the model plant system of green peach aphid-Arabidopsis.

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.

WCC-66 Cereal Insect Pests North Dakota Report 2004

Representative

Marion O. Harris (Cereal Insects)
Department of Entomology
North Dakota State University
Fargo, ND 58105
Marion.Harris@ndsu.nodak.edu

Collaborators

Phil Glogoza (NDSU Extension and Research)
Department of Entomology
North Dakota State University
Fargo, ND 58105

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

Thomas Freeman (botany and microscopy)
Department of Plant Pathology
NDSU/USDA Microscopy Lab
Fargo, ND 58105

Stephen Xu (wheat cytogenetics)
USDA Northern Crops Science Laboratory
Fargo, ND 58105

North Dakota Aphid Population Monitoring

For the last seven 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.

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.

The 2004 growing season had some unusual features. North Dakota had a warm sunny April which allowed many cereal farmers, especially those in the south, to plant early. This warm period was followed by unseasonably cold and wet weather in May and June (including a frost in the northern half of the state in June) that slowed the development of planted crops and prevented planting in the northern tier. A frost in the northern tier of the state in mid August created further problems for farmers in these areas. In all other areas but the southwestern part of the state (where it was dry), adequate moisture throughout June and July produced excellent cereal crops with relatively little disease pressure. The quality and yields of the 2004 crop are predicted to be good except in the northern tier where farmers may have problems harvesting as well as quality problems.

In 2004 aphids were not a problem in North Dakota cereals. In the survey, aphids were first observed during the third week of June. However, aphid numbers were not even remotely significant until mid-July, when most crops in the south had already headed. The vast majority of cereal crops had less than 25% infested stems (see maps) with aphids only reaching threshold levels after heading had occurred. Species composition of aphids was evenly distributed among the four common species. Chemical treatment of crops for aphids was not recommended. Barley yellow dwarf virus was observed rarely (see map).

The second subject of the NDSU Survey, the cereal leaf beetle, also was not a significant problem in 2004 cereals. In North Dakota the cereal leaf beetle was observed for the first time in 2000. Populations were limited to two western counties (McKenzie and Williams) and were only found in wheat fields near the Missouri and Yellowstone Rivers. In 2004 there were no reports of cereal leaf beetle from the statewide NSDU Extension Cereal Insects Survey; however, North Dakota State entomologists found cereal leaf beetles in 2/4 fields examined in McKenzie County. Both fields were irrigated and were in relatively sheltered locations (Justin Knott, ND State Agric., pers. comm.).

Grasshoppers, the third subject of the NDSU survey, were observed early in the 2004 season throughout the state. In most parts of the state, grasshopper populations were reduced by cool weather in June and August. The exception was in the southwestern corner of the state where populations of grasshoppers in June were high enough to warrant spraying. Because of dry conditions in this area and low expectations for the production of a harvestable crop, it is not clear whether many farmers with high grasshopper numbers actually ended up spraying.

Other Insect Pests of 2004 Cereals in North Dakota

In recent years North Dakota wheat commodity groups (e.g. North Dakota Wheat Commission and Dakota Growers) and North Dakota State University wheat breeders have shown little interest in developing aphid-resistant cereals. This lack of concern about aphids, and insects in general, probably arose because of more serious problems with cereal diseases, e.g. wheat scab.

The only insects that have competed with wheat scab for the attention of wheat farmers are the orange wheat blossom midge, *Sitodiplosis mosellana* (Gehin), the wheat stem sawfly, *Cephus cinctus* (Norton), and the Hessian fly, *Mayetiola destructor* (Say). None of these three insects is part of the NDSU summer survey of insects in cereals. Qualitative information about the wheat stem sawfly and Hessian fly comes mostly from county agents and from wheat breeders who sometimes notice when their research plots have been attacked. In the 2004 field season, a small number of reports of sawfly and Hessian fly damage came from the southwestern and north central parts of North Dakota, respectively.

In the mid 1980s, a major wheat midge outbreak began in northern Canada and subsequently spread in the 1990s to large areas of Manitoba, Saskatchewan, North Dakota, and northwestern Minnesota. Although wheat midge numbers have declined in recent years the North Dakota Wheat Commission is still concerned enough about wheat midge to pay for an annual soil survey that provides estimates of overwintering wheat midge populations. For this survey county agents send in soil samples in September and October from the current years wheat fields (see map for areas sending in soil samples). In NDSU labs, these soil samples are examined 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 2003 survey of overwintering wheat midge larvae (see maps handed out at WCC-66 Meeting or maps at [www. Ag.ndsu.nodak.edu](http://www.Ag.ndsu.nodak.edu)) 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. Low estimates of wheat midge numbers from the autumn 2003 soil survey created an expectation in the farming community that wheat midge numbers in the 2004 field season would also be low. This appeared to be the case in 2004. There were no reports of high wheat midge populations and few reports of spraying (Phil Glogoza, personal communication).

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.

Because the area planted to wheat in North Dakota is so vast and because the wheat midge is difficult to detect, additional tools for monitoring are needed. A female-produced sex pheromone for the wheat midge has been identified (Gries et al., 2000) but is not yet available commercially. Benefits of pheromone-based monitoring program for gall midges include sensitivity and convenience (Harris and Foster, 200). A limitation is that a female-produced sex pheromone only attracts males. Male wheat midges do not appear to move from eclosion sites to new wheat fields (as do females) and thus may not reflect the degree to which the crop will be attacked by ovipositing females.

Another possible tool for monitoring wheat midge are the volatile chemicals from young wheat heads, recently identified by a group in England (Birkett et al., 2004). These volatiles attract mated female wheat midge and therefore would give a better estimate of pest pressure on a particular wheat crop, as well as the timing of egg-laying. Host volatiles might also be used to time insecticide spraying. When insecticides are used to control the wheat midge (currently the only option for control), they are targeted at ovipositing females and eggs rather than larvae.

Research on Wheat Insect Pests

In our laboratory we conduct both applied and basic research on the wheat midge and Hessian fly. The following is a brief description of current projects.

Screening for host plant resistance to wheat midge: We are screening wheat germplasm provided by NDSU wheat breeders for resistance to wheat midge larvae. Breeders are working to incorporate the single known *R* gene (Berzonsky et al., 2003) into North Dakota-adapted durum and hard red and white spring wheat genotypes.

Screening for host plant resistance to Hessian fly: In 2003 we were able to collect Hessian fly from North Dakota wheat fields and establish a population in the greenhouse. In 2004/2005 the North Dakota Wheat Commission funded us to:

- 1) test currently-grown North Dakota red, white and durum wheats for resistance, and
- 2) determine the virulence status of our ND Hessian fly population relative to the 30 known *R* genes for resistance to Hessian fly.

Searching for new sources of resistance to Hessian fly and wheat midge: We are screening germplasm provided by wheat cytogeneticists at USDA and NDSU for resistance to Hessian fly and wheat midge. The genotypes are spring-type synthetic hexaploid wheat germplasms developed by USDA research geneticist L.R. Joppa in the 1980s from partially fertile F1 hybrids between durum wheat, *Triticum turgidum* L. ssp. *durum*, cultivar ‘Langdon’ and three accessions of *Aegilops tauschii* Cosson.

Light and electron microscopy studies of the compatible Hessian fly-wheat interaction: The plant pathologist Ralph Panstruga of the Max Planck Institute in Germany said in a 2003 article in *Current Opinion in Plant Biology* that discussions of ‘resistance’ have been much more common than discussions of ‘compatibility’. However, the two phenomena are “intimately

linked” and “progress in understanding one process inherently contributes to our comprehension of the other.”

We are using light and electron microscopy to determine how the Hessian fly establishes a compatible or parasitic relationship with a wheat plant, i.e. how the larva successfully establishes a feeding site at the base of the plant. In the past year we have established that Hessian fly larvae establish a nutritive sink in a single young leaf of the plant. Nutrients are harvested by the larva from the nutrient sink after the nutritive cells break down. The creation of the nutrient sink is associated with limited development (i.e. stunting) of the youngest leaves of the plant. During the next year we will use our knowledge of the compatible Hessian fly-wheat interaction to investigate how *R* gene-defended wheat plants prevent avirulent larvae from establishing a feeding site.

Yield penalties/fitness costs of R gene defense against Hessian fly: Although entomologists and plant breeders have long claimed that wheat plants defended against Hessian fly by *R* genes do not suffer significant yield losses, this question has never been studied quantitatively. We used four near isogenic lines, Newton and three genotypes with the *H6*, *H9* or *H13* gene, and compared seed number and weight for uninfested versus larval-infested plants. These studies were conducted in the greenhouse and also in semi-field conditions. Data are now being analysed.

Behavioral studies of Hessian fly and wheat midge larvae: A common assumption of scientists studying cecidomyiids is that neonate larvae have a very limited behavioral repertoire. We are studying the behavior of Hessian fly and wheat midge neonate larvae to determine their role in the selection of feeding sites. We have found that the neonate Hessian fly larva is highly active and capable of moving, within the crown of the plant, from poor to good feeding sites, i.e. from older leaves to younger leaves. The neonate wheat midge larva appears to move over the surface of the developing wheat seed but, rather than randomly settling, tends to feed in particular locations on the wheat seed.

Behavioral studies of wheat midge adult females: To delay the evolution of virulence to the single known *R* gene, Canadian researchers hope to combine, in a single cultivar, antixenosis traits effective against the ovipositing female with the *R* gene conferring antibiosis to larvae (R. Lamb, pers. comm.). The Canadians have conducted oviposition choice tests and shown that wheat midge females lay more eggs on particular developmental stages, i.e. young wheat heads versus older post-anthesis wheat heads, and particular genotypes, i.e. some wheat genotypes consistently receive 20% of the eggs received by attractive genotypes (Berzonsky et al., 2003). We have used behavioral observation methods to quantify differences in behavior on wheat heads that receive high versus low numbers of eggs in choice tests. Females appear to distinguish between wheat heads while examining the modified leaves (glume and lemma) of the florets with the antennae and ovipositor.

Chemical ecology studies on the Hessian fly sex pheromone: It would be extremely useful to have better monitoring tools for the Hessian fly. The female-produced Hessian fly sex pheromone would be an effective tool for monitoring and population studies; however the single major pheromone component that was identified in 1990 (Harris and Foster, 1999) does not

attract males in the field. We are working in collaboration with two European labs, one in Sweden (electrophysiologist: Ylva Hilbur) and one in Germany (chemist: Wittko Franke) to identify the additional component(s) of the Hessian fly pheromone. We are testing possible pheromone components outdoors using greenhouse-reared males.

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Harris, M.O., J.J. Stuart, M. Mohan, S. Nair, R.J. Lamb, and O. Rohfritsch. 2003. Grasses and gall midges: Plant defense and insect adaptation. *Annual Review of Entomology* 48: 549-577.

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Aphid Research
Oklahoma
Oklahoma State University**

Project Leaders

Name:	Kristopher L. Giles	Tom Royer
Phone:	405-744-6298	405-744-9406
FAX:	405-744-6039	405-744-6039
E-mail:	kgiles@okstate.edu	rtom@okstate.edu

Laboratory: Oklahoma State University, 127 Noble Research Center, Stillwater OK 74078-3033

Collaborating agencies:	ARS-PSWCRL, Stillwater, Texas A&M University.
Cooperating ARS Scientists:	Norm Elliott, Dean Kindler, and Kevin Shufran.
Cooperating OSU Scientists:	Gerrit Cuperus, Bob Hunger, Tom Peeper, and Clint Krehbiel.

Research Projects.

*In cooperation with Senior Agriculturist Dennis Kastl, continued laboratory studies evaluating the effects of aphid diets on Coccinellidae predators. Completed studies on evaluating the effect of resistant wheat (TAM 105, 107, 110) on the nutritional suitability of greenbugs for Coccinellidae predators. No consistent differences were observed when daily prey level was controlled. Results of this study have been submitted for publication.

*In cooperation with Doug Jones, and Dr. Kevin Shufran scientists, demonstrated the ability to identify cereal aphids parasitoids within aphids by molecular gut analysis, and estimate parasitism rates. Results of this completed study have been submitted for publication.

*In cooperation with OSU and ARS scientists, completed studies on economic thresholds for aphids on wheat forage. Results are being summarized for publication.

*In cooperation with Ph. D. student Doug Jones, continued studies examining the winter ecology of *Lysiphlebus testaceipes* in winter wheat. Demonstrated that parasitoids forage for and attack greenbugs at temperatures as low as 4 deg. C. High attack rates at low temperatures may be the mechanism of aphid suppression observed during winter months in Oklahoma.

Continuing in 2005.

*In cooperation with M. S. Student Matt Rawlings, initiated studies evaluating the distribution and effect of rice-root aphids on wheat (Forage and Grain) in Oklahoma.

Continuing in 2005.

*In cooperation with Doug Jones and Dr. Tom Royer, continued studies to validate natural enemy thresholds for aphid parasitoids and predators in winter wheat, and document the efficiency of this technique. **Continuing in 2005.**

*Under the direction of Dr. Tom Royer and M.S. Student M. Lebusa studied the suitability of parasitized (mummified) greenbugs as a food source for predatory coccinellidae. Results thus far indicate no preference between mummified greenbugs and healthy greenbugs, but significant differences in survivorship and development were observed. Development of Coccinellidae (H-

con and C-7) on mummified greenbugs can only occur within the third **or** fourth instar, and it is significantly delayed. If provided with mummies during the fourth instar, the few adults surviving are deformed and non-functional. This feeding behavior, which appears to be common (this assumption needs testing) under low prey conditions, appears to be a toxic decision for Coccinellidae. **Continuing in 2005.**

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, Ph. D. student A. Kelly, and Postdoctoral Fellows Dr. Mpho Phoofolo and Vasile Catana initiated studies examining the ecology arthropod predators and *Lysiphlebus testaceipes* in simple versus diverse agricultural systems. *In cooperation with Ph. D. student Doug Jones, continued studies examining the winter ecology of *Lysiphlebus testaceipes* in winter wheat. Demonstrated that parasitoids forage for and attack greenbugs at temperatures as low as 4 deg. C. High attack rates at low temperatures may be the mechanism of aphid suppression observed during winter months in Oklahoma. **Continuing in 2005.**

**WCC-66 2004 State Report
Aphid Research
Oklahoma
Oklahoma State University**

Recent Publications (2003-2004).

Jones, D. B, K. L. Giles, R. C. Berberet, T. A. Royer, N. C. Elliott, and M. E. Payton. 2003. Functional responses of an introduced parasitoid and an indigenous parasitoid on greenbug at four temperatures. *Environ. Entomol.* 32: 425-432.

Giles, K. L., D. B. Jones, T. A. Royer, N. C. Elliott, and S. D. Kindler. 2003. Development of a sampling plan in winter wheat that estimates cereal aphid parasitism levels and predicts population suppression. *J. Econ. Entomol.* 96: 975- 982.

Ismail, E. A., K. L. Giles, L. Coburn, T. A. Royer, R. M. Hunger, J. Verchot, G. W. Horn, E. G. Krenzer, T. F. Peeper, M. E. Payton, G. J. Michels, and D. A. Owings. 2003. Effects of Aphids, Barley Yellow Dwarf, and Grassy Weeds in Grazed Winter Wheat. *Southwest. Entomol.* 28: 121-130.

Elliott, N. C., K. L. Giles, T. A. Royer, S. D. Kindler, D. B. Jones, and F. L. Tao. 2003. The negative binomial as a probability distribution for describing counts of *Schizaphis graminum* on wheat. *Southwest. Entomol.* 28: 131-136.

Elliott, N. C., K. L. Giles, T. A. Royer, S. D. Kindler, F. L. Tao, D. B. Jones, and G. W. Cuperus. 2003. Fixed precision sequential sampling plans for the greenbug and birdcherry-oat aphid (Homoptera: Aphididae) in winter wheat. *J. Econ. Entomol.* 96: 1585-1593.

Kindler, S. D., N. C. Elliott, K. L. Giles, and T. A. Royer. 2003. Economic injury levels for the greenbug, *Schizaphis graminum*, in winter wheat. *Southwest. Entomol.* 28: 163-166.

Elliott, N.C., T.A. Royer, K. L. Giles, S. D. Kindler, D. R. Porter, D. T. Elliott, and D. A. Waits. 2004. A web-based management decision support system for greenbugs in winter wheat. *Crop Management*. In press.

Royer, T.A., K.L. Giles, T. Nyamanzi, R. Hunger, E.G. Krenzer, N.C. Elliott, S.D. Kindler, and M. Payton. 2004. Economic evaluation of the effects of planting date and application dosage of imidacloprid for management of cereal aphids and barley yellow dwarf in dual-purpose wheat. *J. Econ. Entomol.* Acceptable following revision.

Kindler, S. D., L. Hesler, N. Elliott, T. Royer, and K. Giles. 2004. Seasonal abundance of rice root aphid in wheat and effects on forage and grain yields. *Southwest. Entomol.* Acceptable following revision.

Jones, D. B., K. L. Giles, Y. Chen, and K. Shufran. 2004 Estimation of Hymenopteran parasitism in cereal aphids using molecular markers. *J. Econ. Entomol.* Acceptable following revision.

Royer, T.A., K.L. Giles, and N.C. Elliott. 2004. The Cereal aphid expert system and Glance 'n Go Sampling, questions and answers. CR-7191. Oklahoma Cooperative Extension Service, Stillwater, OK

Royer, T.A., K.L. Giles, and N.C. Elliott. 2004. Common insect and mite pests of small grains. F-7176. Oklahoma Cooperative Extension Service, Stillwater, OK

SOUTH DAKOTA, WCC-66 ANNUAL REPORT, 2004

Louis Hesler
Research Entomologist
USDA-ARS
Northern Grain Insects Res. Lab.
2923 Medary Ave.
Brookings, SD 57006
(605) 693-5228
lhesler@ngirl.ars.usda.gov

Robert Berg
Manager
S.E. Research Farm
Beresford, SD 57004

Michael Catangui
Extension Entomologist
South Dakota St. Univ.
Brookings, SD 57007

Overview of Cereal-Aphid Research Activities and Accomplishments:

- Small grains, like many other field crops, are increasingly grown in reduced tillage systems that exclude preplant operations such as chisel plowing, disking, and field cultivation. In a three-year field study in eastern South Dakota, infestation levels of cereal aphids were compared in spring-seeded wheat and barley grown with or without preplant tillage. *Rhopalosiphum padi* (bird cherry-oat aphids) comprised nearly 90% of all cereal aphids sampled. *Rhopalosiphum padi* routinely infested lower parts of tillers and were generally concealed by surface residue in plots with no preplant tillage. Across seven site-years, *R. padi* were more abundant in plots with no preplant tillage than with preplant tillage, but in comparisons at individual site-years *R. padi* were greater in no-preplant tillage plots only once. For all cereal-aphid species combined, infestations were greater in plots with no preplant tillage for one of eight site-years, but did not differ with tillage when compared across all site-years. Cereal aphids were never more abundant in plots with preplant tillage.

Hesler, L.S. and R.K. Berg. 2003. Tillage impacts cereal-aphid infestations in spring small grains. *J. Econ. Entomol.* 96:1792-1797.

- *Harmonia axyridis* (multicolored Asian lady beetle) was introduced into the U.S., and it was first recorded from South Dakota in 1996. We studied its ecology and distribution, and in 2000-2001 documented *H. axyridis* from seven eastern counties in South Dakota, but none in central South Dakota. These results indicated that populations in South Dakota represent a relatively slow to moderate westward expansion of *H. axyridis* from adjacent eastern states. *Harmonia axyridis* adults were found in many habitats surveyed, but initially larvae were found only in association with aphids on maize and ornamental plants. Subsequent surveys found *H. axyridis* larvae in a wide variety of habitats, including small-grain fields. Timed searches, sampling autumnal aggregations, and blacklight traps are all potentially useful methods in studying *H. axyridis* in the field, whereas sweep net collection and Malaise trapping appear inefficient.

Hesler, L.S. 2003. Large summer population of multicolored Asian lady beetle in North Dakota. *The Prairie Naturalist* 35:287-289.

Hesler, L.S., R.W. Kieckhefer & M.A. Catangui. 2004. Surveys and field observations of *Harmonia axyridis* and other Coccinellidae (Coleoptera) in eastern and central South Dakota. *Trans. Am. Entomol. Soc.* 130:113-133.

WCC-66 REPORT for the Period of Sept. 2003 through Sept. 2004

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

(Compiled by Kevin A. Shufran)

I. PERSONNEL

Cheryl A. Baker	ext. 222, 243	Cheryl.Baker@ars.usda.gov
John D. Burd	ext. 223	John.Burd@ars.usda.gov
Norman C. Elliott	ext. 227	Norman.Elliott@ars.usda.gov
Yinghua Huang	ext. 230	Yinghua.Huang@ars.usda.gov
S. Dean Kindler	ext. 234	Dean.Kindler@ars.usda.gov
Dolores W. Mornhinweg	ext. 237	Do.Mornhinweg@ars.usda.gov
David R. Porter	ext. 239	David.Porter@ars.usda.gov
Gary J. Puterka	ext. 257	Gary.Puterka@ars.usda.gov
Kevin A. Shufran	ext. 240	Kevin.Shufran@ars.usda.gov

II. OVERVIEW OF CURRENT RESEARCH AND ACCOMPLISHMENTS

A. Remote sensing of cereal aphids

Remote sensing experiments demonstrated that spatial variation in Russian wheat aphid infestations could be detected within wheat fields using false color composite imagery comprised of green, red, and near infrared (NIR) bands collected using a multi-spectral imaging system called the SST CRIS. There was a strong negative linear relationship between RWA density and the normalized differenced vegetation index (NDVI) calculated using the red and NIR bands of SST CRIS normalized reflectance imagery. The pattern was very evident even in the presence of drought stress, which was evident in both wheat fields studied southeastern Colorado during May of 2004. The project laid a foundation for future research to develop methodology to detect infestations of RWA at whole field and sub-field levels using the SST CRIS.

B. Seasonal Abundance of rice root aphid in wheat and effects on forage and grain yields

Aphid seasonal abundance in wheat, *Triticum aestivum* L. was studied over a two-year period in Central Oklahoma with emphasis on the field abundance of the rice root aphid *R. rufiabdominalis* (Sasaki). The corn leaf aphid, *Rhopalosiphum maidis* (Fitch); oat bird-cherry aphid, *R. padi* (L.), rice root aphid, *R. rufiabdominalis* (Sasaki); and greenbug,

Schizaphis graminum (Rondani), colonized winter wheat in Oklahoma during the autumns of 2001 and 2002. During each of the two years, rice root aphids infested winter wheat soon after emergence and continued to increase in number on the fall seeded crop until mid December when populations peaked and then began to decline, so that by early January the aphids were difficult to find. Rice root aphid populations of 3.6 aphids per tiller at the end of a 60-day infestation period significantly reduced the forage yield of wheat, which can be a significant economic impact since approximately 67% of the 6-7 million acres of winter wheat grown each year in Oklahoma is grazed by cattle. Grain yield was not significantly reduced by a 60-day rice root aphid infestation.

C. Genetics of Russian wheat aphid biotypes in the US

Two Russian wheat aphid (*Diuraphis noxia*) biotypes occur in the US and have been named biotypes A and B (non-damaging and damaging to *Dn4* resistant wheat, respectively). Fifteen Russian wheat aphid clones (10 biotype A and 5 biotype B) were collected from 5 different states and were studied for genetic variation. No variation was detected between or within the two biotypes based on random amplified polymorphic DNA (RAPD) and a 500 bp fragment of the cytochrome oxidase subunit I (COI) mtDNA gene. This lack of variation suggests the origin of biotype B is the extant population and argues against the introduction of the B biotype from another country. However, examination of (COI) sequences (published on GenBank by Belay and Stauffer) from Ethiopia, Syria, Turkey, Czech Republic and South Africa are identical, and are also identical to the two US biotypes. Because a *Dn4* virulent population from Syria was found in by Gary Puterka in 1989, and C. M. Smith et al. (2004) detected *Dn4* virulence in Ethiopia and Czech Republic, the possibility of a second introduction from outside the US cannot be ruled out. We are continuing this research and are now examining Russian wheat aphids for polymorphisms in microsatellite DNA.

D. Genetics of *Lysiphlebus testaceipes* and Its Secondary Parasitoids

Molecular markers have been developed to detect the presence of primary parasitoids in cereal aphids for use in estimating parasitism rates. However, the presence of secondary parasitoids (hyperparasitoids) may lead to underestimates of primary parasitism rates. Therefore, molecular markers to detect hyperparasitoids were developed. A 16S ribosomal RNA mitochondrial gene fragment was amplified by polymerase chain reaction (PCR) and sequenced from two secondary parasitoid species, *Dendrocerus carpenteri* (Curtis) and *Alloxysta xanthopsis* (Ashmead), four geographic isolates of the primary parasitoid, *Lysiphlebus testaceipes* (Cresson), and six aphid species common to cereal crops. Species specific PCR primers were designed for each insect on the basis of these 16S rRNA gene sequences. Amplification of template DNA, followed by agarose gel electrophoresis, successfully distinguished *D. carpenteri* and *A. xanthopsis* from all four isolates of *L. testaceipes* and all six cereal aphid species.

E. Frequency and Distribution of *Schizaphis graminum* mtDNA Haplotypes

Using the PCR-RFLP assay (J. Kans. Entomol. Soc. 76:551-556), we have continued determining mtDNA haplotypes of greenbugs from various hosts and locations. This continues to bear fruit in our understanding of greenbug ecology, evolution, and biotypic diversity.

F. Russian Wheat Aphid Resistant Barley

Six RWA resistant advanced generation adapted spring barley germplasm lines in an Otis background with 2 sources of RWA resistance were yield tested in the field at 5 locations in Colorado, 1 location in Nebraska, and 1 location in Idaho in the summer of 2004. The superior performing line from each resistant source will be tested on large scale tests in the summer of 2005 prior to their release as RWA resistant feed barleys for dry-land production.

109 barley germplasm lines developed with resistance to RWA-a were screened in the spring of 2004 with RWA-b. All previously highly resistant lines were clearly also highly resistant to RWA-b. A few of the moderately resistant lines did not survive the screening, however, conditions for the screening were not optimum for barley seedlings (low light, high temperatures and high humidity). This could explain the lack of survival. These lines should be retested before concluding that the resistance in these lines is overcome by RWA-b. 105 advanced generation adapted barley germplasm lines were also tested against RWA-b and found to be resistant.

G. Russian Wheat Aphid Resistant Wheat

With the identification of Russian wheat aphids that are virulent on all previously released wheat varieties 'resistant' to RWA, there was a concerted effort to determine if any of the resistance sources in the Stillwater ARS wheat genetics/breeding program were also resistant to the new biotype. Initially, a core group of Stillwater-ARS breeding lines were sent to Colorado for screening with the new biotype; this core group consisted of one breeding line derived from each of twenty-one different sources of resistance to the original RWA population. From that screening, four potential sources of resistance to the new virulent RWA were identified. PI 140207 appears to provide a moderate level of resistance. PI 366515 and PI 565429 both have good levels of resistance. The highest level of resistance was in a South African line provided to us by Dr. G.F. Marais, Department of Genetics, University of Stellenbosch, South Africa (see AWN Vol. 40, p. 194). This line was derived from a wheat/rye translocation line so there may be some quality issues associated with its use in a wheat-breeding program.

Following the screening in Colorado, we established a separate greenhouse for rearing the new virulent biotype and for screening large numbers of breeding lines under caged conditions. Even under the extremely hot and humid conditions within the cages, we were able to identify resistance to Biotype 2. Initial tests included 318 Plant Introductions (seed provided by GRIN) all of which had been identified as being resistant to Biotype 1, as well as all of our breeding lines available from the past several years. From the population of

breeding lines, we were able to identify lines derived from 20 different sources (Plant Introductions), with resistance that ranged from high to moderate levels. While a high level of resistance is certainly more impressive when looking at resistant plants, it should be noted that a moderate level may provide adequate protection under field conditions, especially when the plants are able to maintain flat leaves with infestation. The breeding lines derived from the different sources are at varying stages of purity and advancement within the program. Germplasm releases are planned as soon as purity of the seed is determined. Small samples will also be available for distribution.

It should be noted that there was some discrepancy in segregation when screening against the two different RWA biotypes. For example, breeding lines that were developed by screening with Biotype 1 and are homozygous resistant to that biotype, may be segregating for resistance to Biotype 2. In addition, with sister lines derived from the same source of resistance, where both lines were resistant to Biotype 1, only one may be resistant to Biotype 2. Unfortunately, this means that no generalizations can be made about whether or not a breeding line is resistant to a new biotype based on its source of resistance, and screening tests must be done with each line. These results may indicate that more than one gene is playing a role in conferring resistance, but it was impossible to determine that with Biotype 1 alone. Previously published information concerning RWA resistance gene designations may have to be rethought. Following the identification of additional new biotypes, we are now preparing to conduct caged screening tests with the additional biotypes.

III. PERSONNEL CHANGES

- A. **Gary J. Puterka**, Research Entomologist, has recently rejoined the unit in Stillwater. After receiving his Ph.D. from Oklahoma State University in 1989, he was a post-doctoral research here and published pioneering work on Russian wheat aphid biotypes and genetics. After that, Gary became a Research Entomologist with the USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV where he conducted research on alternative pesticides and host plant resistance in tree fruits. His new research assignment will focus on the biology and ecology of the Russian wheat aphid in relation to biotype development. “Welcome back, your dreams were your ticket out. Welcome back” Gary.

- B. **S. Dean Kindler**, Research Entomologist, will be retiring in December after 40 years of service. He earned his Ph.D. in Entomology during 1967 at the University of Nebraska. Dean has had a long and productive career in the ARS. He began his service in 1964 with USDA-ARS in Lincoln, Nebraska. In 1987, Dean transferred to the Stillwater Unit. He contributed greatly to Stillwater’s research effort in cereal aphid management, as well as the overall mission of the ARS. Some of his notable contributions were in forage entomology, greenbug biotypes, Russian wheat aphid host ecology, cereal aphid management, and the rice root aphid biology and economic impact. We wish him a long and happy life after retirement. Thank you, Dean. It has been an honor and pleasure to have worked with you.

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Washington State 2004 State Report -- WCC66
Prepared by Keith S. Pike, Washington State University

*Small Grain Insect Projects in Washington directed by
Washington State University Scientists*

1. Title: BIOLOGY, DAMAGE, AND MANAGEMENT OF INSECT AND VIRUS PESTS IN WHEAT: AN INTERDISCIPLINARY APPROACH.

Scientists: K. S. Pike, Entomologist; Hanu Pappu, Plant Pathologist

Problem: Wheat in the Northwest is subject to variable levels of aphid infestation and barley yellow dwarf virus (BYDV) infection, particularly fall-planted wheat. BYDV infection in fields will range from negligible to 100%; with severe infection, losses can exceed 50% of expected yield.

Project Goals: Determine (1) the source of aphid-transmitted BYDV serotypes in grassy hosts impacting wheat, (2) the aphid populations vectoring viruses, (3) the state of aphid biocontrol in Washington, and (4) ways to improve IPM measures minimizing aphid-virus damage in wheat.

Progress (brief statements only): In 2003, 274 field sites were assessed in Washington: 126 from wild grasses, 147 from wheat (Fig. 1). Aphid infestations were encountered in 89% of the wheat fields and 69% of the grasses; BYDV was encountered in 11.5% of the wheats and 8% of the grasses. There were five cereal aphids present. Table 1 shows the composition of aphids in the wheat and grasses sampled. Bird cherry-oat aphid was the predominant species, comprising 84-85% of the aphid populations assessed. In total, 31



Fig. 1. Wheat and grass sites evaluated for aphids, aphid-parasites, and BYDV in Washington, 2003.

Table 1. Mean composition of aphids in wheat and grasses, Wash., 2003.

Host Plant	No. of sites evaluated	Species ¹ % of aphid population				
		BC	CL	EG	RG	RW
Wheat	132	83.6	0	2.6	1.4	12.4
Grasses	87	85.3	9	1.9	1.4	2.4

¹Abbreviations: BC, bird cherry-oat aphid (*Rhopalosiphum padi*); CL, corn leaf aphid (*Rhopalosiphum maidis*); EG, English grain aphid (*Sitobion avenae*); RG, rose grass aphid (*Metopolophium dirhodum*); RW, Russian wheat aphid (*Diuraphis noxia*)

different grains and grasses were fed-upon by aphids, with bird cherry-oat aphid having the widest host range. *Aphid-attacking parasites* – Of 132 wheat fields that were aphid-infested, 77 (58.3% of the fields) contained aphid-attacking parasites; of 87 grasses that were aphid-infested, 14 (16.1%) contained parasites. *State of Aphid Biocontrol in Wheat in Washington* – In the early 1990's, several million Old World aphid-parasites were released in eastern Washington to broaden and strengthen the pool of parasitic species attacking Russian wheat aphid. In the last 6-7 years, neither Russian wheat aphid nor any of the other cereal aphid species have been much of a threat to wheat in Washington. One of the contributing factors to the decline in cereal aphids is the expanded aphid-attacking parasite pool. The benefits of aphid biocontrol to the industry are several – fewer aphids, less BYDV, less aphid-virus caused yield losses, less pesticide in the environment, less out-of-pocket expense for treatment, and higher profit margins. Two of the more important parasites are *Lysiphlebus testaceipes* and *Diaeretiella rapae*.

Research In-Progress: *Research is continuing on the hosts and host-habitats that sustain and enhance grain aphid parasite presence, particularly parasites of high merit. Biomolecular research is also being used to address differences in species and species strains relative to pest potential (aphid) and host utilization.*

2. Title: CEREAL LEAF BEETLE (CLB) DETECTION AND BIOCONTROL

Scientists: Diana Roberts, Extension Agronomist; K. S. Pike, Entomologist; Terry Miller, Insectary Manage. *Cooperators:* Steve Miller and Mike Klaus, USDA-APHIS.

Problem: Cereal leaf beetle, *Oulema melanopus*, a new pest in Washington, is spreading rapidly in the region. Virtually all of the major small grain producing counties in Washington are now infested. It attacks and is injurious to wheat, barley, and oats, and some grasses. It is problematic in the first half of the growing season, especially on new plantings. It has been shown to cause yield reductions on the order of 25-30% in irrigated spring wheat in Washington. Federal, state, and university scientists are working together to establish affordable and environmentally sound management measures, with an emphasis on establishing effective parasitic biocontrols.

Project Goals and Progress: 1) *Maintain and expand on-farm biocontrol insectaries to establish parasitoids – Tetrastichus julis and Anaphes flavipes.* As of 2004, four on-farm insectaries are established, from which recoveries of *A. flavipes* within, and *T. julis* both within and beyond the insectaries have been made. Three additional insectaries are expected to be established in the state to expedite the spread of the new parasitoids. 2) *Continue detection surveys for CLB in (a) cereal grass and grass hay-producing counties of eastern Washington and (b) in hay-producing western Washington counties.* States and countries that import hay and grain from Washington expect that exporting counties be in compliance with quarantine regulations.

Expected Benefits: 1) CLB parasitoids will establish proactively alongside spreading CLB populations to reduce crop yield loss from the pest and reduce pesticide use, and 2) Washington State CLB information will be included in the NAPIS database to facilitate interstate commerce.

Some Key Papers Published on Grain Aphids, Aphid Parasitoids, Cereal Leaf Beetle

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New Book Released on Aphids of Western North America

- Pike, K. S., L. L. Boydston, and D. W. Allison. 2003. *Aphids of Western North America North of Mexico with Keys to Subfamilies and Genera for Female Alatae*. Washington State University, Cooperative Extension MISC0523, Pullman, Washington, pp. 282. [ISBN 0-9721994-3-8]

Scientists in Washington State presently involved in Research on –
Grain Aphids (GA), Biocontrol (BC), Cereal Leaf Beetle (CLB)

<i>Scientist</i>	<i>Agency-Location</i>	<i>Phone; email</i>	<i>Res. Area</i>
Mike Klaus	Wash St Dept Agric- Yakima	509-225-2609; mklaus@agr.wa.gov	BC, CLB
Steve Miller	APHIS- Spokane	509-353-2950; steven.m.miller@usda.gov	BC, CLB
Terry Miller	Washington State University- Pullman	509-335-5815; tdmiller@mail.wsu.edu	GA, BC, CLB
Keith Pike	Washington State University- Prosser	509-786-0269; kpike@tricity.wsu.edu	GA, BC, CLB
Diana Roberts	Wash St Univ.-Coop. Ext., Spokane	509-477-2167; robertsd@wsu.edu	BC, CLB

**CEREAL APHID RESEARCH
2004 STATE REPORT
IDAHO**

Representative

Juan Manuel Alvarez, Department of Plant, Soil & Entomological Sciences, University of Idaho, Aberdeen Research and Extension Center, P.O. Box 870, Aberdeen, Idaho 83210-0870, jalvarez@uidaho.edu

I. CURRENT RESEARCH AND ACCOMPLISHMENTS

Aphid population monitoring

A suction trap located in Rexburg, Idaho run for the second year during the summer of 2004. Overall, aphids were not abundant during the summer of 2004. The total collection count for the season was 2,202 aphids belonging to 25 species. However, 95.6% of the aphids collected belonged to three (*Rhopalosiphum padi*, *Metopolophium dirhodum*, *Capitophorous elaeagni*). Potato growers were specially concern about the aphid counts because the most important virus (PVY) vectors are actually aphid species that do not colonize potatoes, such as grain aphids. Twenty-three of the caught species in Rexburg do not colonize potatoes. The two colonizing species were the green peach aphid and the potato aphid. Potentially, all 23 species caught could vector non-persistently transmitted viruses into a potato crop.

During 2004, peak collection dates for all aphid species were by the end of July. Bird cherry-oat aphid was the most abundant species in 2004 followed by the rose-grass aphid and the Russian olive aphid. The purpose of this project is to provide timely information to potato and cereal producers about risks of aphid pests and virus epidemics. Information was distributed throughout the growing season by means of the *Aphid Flyer*, email, a newsletter and the web. According to these preliminary results, adjusting in 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 potato transmitted viruses.

Biology of bird cherry-oat aphid

The response of the bird cherry-oat aphid, *Rhopalosiphum padi*, to wheat plants infected with *Barley yellow dwarf luteovirus* (BYDV) was evaluated in the laboratory. Significantly more aphids settled onto virus-infected than non-infected plants when aphids were able to contact the leaves of varieties Lambert and Caldwell. Additionally, more aphids congregated on screens above headspace of virus-infected plants than above non-infected ones of both varieties. The concentration of headspace volatiles was greater on virus-infected Lambert, than on non-infected plants of this variety.

The effects of different acquisition access periods (AAP) and inoculation access periods (IAP), on the transmission efficiency of BYDV by *R. padi* was examined in the laboratory. Three wheat entries were tested as sources of virus: the virus susceptible cultivar Lambert, and the transgenic lines 103.1J and 126.02, both derived from Lambert, and which express the BYDV

coat protein gene. Virus transmission efficiency increased with an increase in AAP for all genotypes. AAPs of 6-48 h on 103.1J resulted in significantly lower transmission efficiency than equal periods on Lambert. Transmission efficiency was not significantly different following varying IAPs, for any of the genotypes tested.

Haanchen barley mealybug found in Idaho

A new insect pest of malt barley, the Haanchen barley mealybug, *Trionymus haancheni* McKenzie, was discovered for the first time in Soda Springs during June 2003 from a commercial malt barley field. Surveys since then have detected this pest in nine eastern Idaho counties. Feeding of the Haanchen Mealybug reduces the amount of chlorophyll in the leaves causing the malt barley plants to become yellow or brown and heavy infestations in commercial fields eventually kill the plants. Additionally, the Haanchen barley mealybug indirectly can damage the crop by producing a sticky sap-like substance called honeydew, which reduces grain quality and clogs combines at harvest.

Insecticide trials for this insect were established in three Idaho counties to determine the efficacy of different insecticide treatments to control this new pest. No differences were detected in these trials because of the low densities of the insect this year. Despite of high overwintering densities found early in the spring, very low numbers were detected during the summer. A wet spring and mild summer temperatures perhaps explain low populations in 2004. One could also speculate that the low populations in 2004 are due to an increase use of seed treatment insecticides in malt barley [imidacloprid (Gaucho) and thiomethoxan (Cruiser)] and more intense soil preparation in the previously infested counties.

II. PERSONNEL

Juan Manuel Alvarez, Department of Plant, Soil & Entomological Sciences, University of Idaho, Aberdeen Research and Extension Center, P.O. Box 870, Aberdeen, Idaho 83210-0870, tel. 208 397-4181, fax 208 397-4311, jalvarez@uidaho.edu

Nilsa A. Bosque-Pérez, Department of Plant, Soil & Entomological Sciences, University of Idaho, Moscow, Idaho 83844-2339, tel. 208 885-7544, fax 208 885-7760, nbosque@uidaho.edu

Eric Dotseth, Department of Plant, Soil & Entomological Sciences, University of Idaho, Aberdeen Research and Extension Center, P.O. Box 870, Aberdeen, Idaho 83210-0870, tel. 208 397-4181, fax 208 397-4311, edotseth@uidaho.edu

James B. (Ding) Johnson, Department of Plant, Soil & Entomological Sciences, University of Idaho, Moscow, Idaho 83844-2339, tel. 208 885-7543, fax 208 885-7760, djohnson@uidaho.edu

Dennis J. Schotzko, Department of Plant, Soil & Entomological Sciences, University of Idaho, Moscow, Idaho 83844-2339, tel. 208 885-7740, fax 208 885-7760, schotzko@uidaho.edu

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