Component II: Protection of Agricultural and Horticultural Crops

2n. Small Grains (Barley, Oats, Rice, Rye, Sorghum, and Wheat) (U.S. Value 2007: $19 billion)

Problem Statement: Production of small grains is reduced by pest insects and weeds. The most widespread and economically significant insect and weed problems are:

- Cereal Aphids (Russian wheat aphid, greenbug, barley yellow dwarf virus and its very efficient vector the bird cherry-oat aphid) in Wheat, Barley, and Sorghum.
- Hessian Fly in Wheat. *(This is addressed in National Program 301)*
- Wheat Stem Sawfly in Wheat.
- Other Insect Pests* include: Cereal Leaf Beetle, Lepidoptera (such as Army Cutworm, Western Pale Cutworm, True Armyworm, Fall Armyworm), and Wheat Streak Mosaic Virus and its vector the Wheat Curl Mite.
- Weeds include: Crop Mimics or Weedy Relatives with similar growth periods and/or genetics to grain crops such as Red Rice, Wild Oats, Johnsongrass, Jointed Goatgrass, and Downy Brome; and weeds of grains in conventional, organic or biofuels systems such as Ryegrass, Wild Oats, Barnyardgrass, Common Crupina, Field Bindweed, Himalaya Blackberry, Knapweeds, Medusahead, Mile-a-Minute, Milk Thistle, Musk Thistle, Russian Thistle, Teasel, Swallowworts, White Top (Hoary Cress), Horseweed, Pigweeds, and Sedges, Canada Thistle, Leafy Spurge, Quackgrass, Sweet Sorghum, Bermudagrass, Yellow and Purple Nutsedge, Kudzu, Hemp Sesbania, Sicklepod, Redvine, and Trumpetcreeper. *(Weeds of interest to growers of grains are also addressed in other subcomponents especially Rangeland/Pasture and Arid Land Crops, Citrus Nut Crops, Vegetables, Cotton, and Weeds in Natural Ecosystems as well as in National Programs 202, 211, 301, 302, 305, and 308).*

*No actionable item due to resources

Research Needs:

1. **Cereal Aphids**

   Importance: Cereal aphids are key insect pests of wheat, barley, and sorghum throughout much of the United States due to their capability of explosive population growth and ability to cause severe damage to grains by their feeding. The Russian wheat aphid (RWA), for example, is an invasive pest of wheat and barley in the western United States that is especially important in the semi-arid High Plains region. RWA outbreaks occur somewhere in the High Plains almost every year with widespread outbreaks occurring periodically, resulting in heavy insecticide use and/or greatly reduced wheat and barley yields. Average losses to the wheat and barley industries from the RWA exceed $50 million annually. Similar statements can be made for the greenbug, which is an economic pest of sorghum in addition to wheat and barley, and has a more eastern

range. Losses caused by cereal aphids present an impediment to the economic viability of grain production. Both the RWA and greenbug have overcome genetic resistance conferred by resistance genes bred into wheat varieties. Varieties are currently being bred that contain other resistance genes, but the potential for these insects to adapt to overcome new resistance sources is high, and our ability to stop or slow this process is limited due to lack of fundamental knowledge on insect and plant biology, genetics, and ecology.

Research Gaps: Solutions are needed to mitigate the economic losses caused by cereal aphids. The underlying basis for development of RWA and greenbug biotypes needs to be determined to guide breeding programs to develop new, durable, resistant wheat, barley, and sorghum varieties. Tools for more effective pest management decision-making are needed, as are techniques to quickly and inexpensively detect RWA infested grain fields. Regional monitoring programs to detect new and emerging biotypes and potential new invasive insect pests are also needed. In addition, methods to enhance the role of naturally occurring biological control are important in the long term for sustainable pest management.

Actions: ARS will:

Monitoring and Decision-Making

- Determine the potential for airborne remote sensing to detect RWA infested grain fields.
- Develop a computer based pest management decision support system for the RWA.

Biology, Genetics, and Ecology

- Determine the genetic and biochemical basis for biotype formation in the RWA and greenbug.
- Monitor cereals for biotypic diversity in aphids and new invasive insect species.
- Determine the ecology of RWA and greenbug on native hosts and the relationship to biotype formation and pest status in cereals.
- Design, produce and utilize molecular markers to answer pertinent questions about ecology and evolution of aphid biotypes and populations.

Control, Biological

- Assess the effectiveness of key biological control agents in traditional and emerging small grain crop production systems.
- Conduct foreign exploration in Eurasia for new biological control agents. Screen introduce, and evaluate the impact of candidates for biological control introductions, based on host specificity and climate tolerances.
- Conduct research on behavior and genetic determinants of host specificity in parasitoids of cereal aphids.

Control, Host Plant Resistance

- Identify new sources of resistance to cereal aphids and incorporate them into resistant wheat, sorghum, and barley germplasm. *This is addressed in National Program 301 Action Plan.*

2. Wheat Stem Sawfly

Importance: The wheat stem sawfly (WSS) is an important pest of wheat and other grain crops in the northern Great Plains. Damage to wheat occurs primarily in Montana, the Dakotas, western Nebraska, eastern Wyoming, and the Canadian Prairie Provinces. Field infestation levels of greater than 80 percent have been reported with yield losses of as much as 20 percent in some years and locations. Damage caused to wheat in Montana alone has been estimated at $25-30 million annually with regional losses in the United States greater than $100 million. Current management practices for WSS, including resistant wheat cultivars and various cultural practices, have not been effective in minimizing losses. Biological control, including natural, classical, conservation and augmentation approaches, may have potential for effective control of the pest.

Research Gaps: Classical biological control using exotic parasitoids has promise for effective and sustainable control of WSS, however exploration is needed to identify new candidate biological control agents. Research is needed on prospective agents to determine the potential of classical biological control for WSS in the northern Great Plains.

Actions: ARS will:

Control, Biological

- Find, identify, and evaluate WSS parasitoids from Asia.
- Evaluate candidate biological control agents in the insect quarantine laboratory.
- Release and evaluate promising candidate biological control agents.

3. Hessian Fly

Importance: The Hessian fly is a pest of wheat over much of the United States. The primary method of control is through genetically resistant wheat. However, resistance resources in wheat and wheat relatives are expected to be finite. Within 8-10 years of the release of a new wheat cultivar, the Hessian fly is able to overcome the resistance gene and can survive on cultivars that were formerly resistant. Thus, new sources of resistance genes must constantly be identified to replace ones that are no longer effective. Since it takes roughly 8-10 years to identify a new source of resistance and incorporate it into a cultivar, the wheat crop is constantly under threat.

Research Gaps: Knowledge of how the insect overcomes resistance in wheat is essential to continued control with genetic resources from wheat. Molecular markers for analysis of the genetic structure of field populations of the insect, an understanding of the

molecular interaction between the insect and wheat, and identification of genes for resistance to transform into wheat will be important for continued effective and durable control of the Hessian fly.

Actions: ARS will:

Control, Resistance

- Devise deployment strategies that will lead to more durable resistance. *This is addressed in National Program 301 Action Plan.*
- Identify new sources of resistance and determine which genes will be effective in various parts of the United States. *This is addressed in National Program 301 Action Plan.*

4. Weed Management

Importance: Even with the array of herbicides available for producer use, weeds still remain a continuous problem for producers. Cost of weed management is often a major input for crop production, whereas resistance further increases difficulties with weed management in small grains.

Research Gaps: Producers are asking for alternatives to herbicide-centered weed management and for cropping systems that are not so dependent on herbicides. One approach is to expand weed management to include cultural tactics that disrupt weed population growth, and consequently, reduce weed community density in croplands. A key need is to identify cultural tactics that are effective in disrupting population growth of weeds and to integrate these tactics into production systems.

Actions: ARS will:

Control *This is addressed in National Program 202, 211 and 301 Action Plans.*

- Identify competitive crop cultivars that are also high yielding.
- Develop competitive crop canopies by combining several cultural practices together for crop management.
- Quantify the interaction between no-till and rotation design on long-term population dynamics of weeds.
- Measure the impact of crop rotations on weed seed survival in soil.
- Integrate cultural tactics that suppress weed population growth with the design of cropping systems to develop ecologically-based weed management.

Anticipated Products:

- Increased knowledge of pest biology, ecology, behavior, and genetics.
- More effective and durable grain varieties with resistance to insect pests.
- Improved pest early detection and monitoring at within field and regional scales.

- Improved pest management systems for insect pests of grains.
- Increased knowledge of the biology and ecology of key biological control agents and enhanced biological control of insect pests of grains.
- Increased knowledge of the biology, ecology, and genetics of problem weed species.
- New integrated weed management systems that include crop diversity.
- Increased knowledge of the interaction between crops and weeds.
- Information on weed seed survival in soil and weed density in following crops.

Potential Benefits (Outcomes):

- More effective strategies for managing insect pests of grain crops.
- Reduced crop losses to insect pests of grain crops.
- Reduced costs for managing insect pests of grain crops.
- Ecologically and economically sound (sustainable) pest management programs and systems for insect pests of grain crops.
- Strategies for improved IPM of pests in small grain crops.
- Reductions in crop losses to insect and weeds.
- Reductions in expenditures for pest management.
- IPM tactics that are ecologically sound.

USDA ARS Resources:

- Beneficial Insect Introduction Research Unit, Newark, Delaware
- Crop Production and Pest Control Research Unit, West Lafayette, Indiana
- Dale Bumpers National Rice Research Center, Stuttgart, Arizona (Weeds)
- Land Management and Conservation Unit, Pullman, Washington (Weeds)
- National Biological Control Laboratory, Southern Weed Science Research Unit, Stoneville, Mississippi (Weeds)
- Natural Products Utilization Research Unit, University, Mississippi (Weeds)
- Pest Management Research Unit, Sydney, Montana
- Plant Science and Entomology Research Unit, Manhattan, Kansas
- Subartic Agricultural Research Unit, Fairbanks, Alaska (Weeds)
- Sustainable Agricultural Systems Laboratory, Beltsville, Maryland (Weeds)
- Water Management Research Unit, Fort Collins, Colorado (Weeds)
- Wheat, Peanut, and Other Field Crops Research Unit, Stillwater, Oklahoma