

Germplasms from previous study may thwart new aphid biotype

Russian wheat
aphids in different
nymphal stages.
The aphids cause
leafrolling, as
shown on these
susceptible wheat
plants.

Scientists in ARS's Wheat, Peanut, and Other Field Crops Research Unit have played a major role in controlling Russian wheat aphid before. Now, it seems this group from Stillwater, Oklahoma, may have done it again.

Starting in the late 1980s, entomologist James Webster (now retired) spent a decade sorting through thousands of wheat and barley germplasm samples, seeking accessions that showed resistance to the aphid, *Diuraphis noxia*. Geneticists Cheryl Baker and Dolores Mornhinweg then used these accessions to develop germplasm breeding lines that resisted the pest. These breeding lines led to aphid-resistant wheats, some of which have already been released, and barleys that are due out over the next few years.

"The initial work against the Russian wheat aphid was landmark research," says the unit's research leader, David Porter. "The best evidence at the time showed that this threat was under control, thanks in large part to ARS research."

Unfortunately, it wasn't. In spring 2003, a new biotype of the pest was found in Colorado and was later identified in several other plains states. This variant was able to overcome many of the resistant wheat and barley lines, as well as all five of the released resistant wheat varieties.

Confronted with seeing their earlier work rendered obsolete, Baker and Mornhinweg turned to an invaluable safety net: the large collection of wheat and barley breeding lines they had developed while fighting the original aphid biotype. They may have hit pay dirt there in the form of advanced germplasm breeding lines also resistant to the new menace.

"If this hadn't been the case, we'd be back at square one," says Baker, whose expertise lies in protecting wheat crops from insect pests. "Hopefully, our discoveries will save us 4 to 6 years of new research."

Readiness Was Deliberate

"This was not by accident," says Mornhinweg, who focuses on protecting barley from pests. "We purposely sought genetic diversity in our resistant breeding lines for just such a possibility."

Mornhinweg says the development may save time in another way. "Usually, once a source of resistance is found, it takes about 10 years to incorporate the resistance into agronomic types appropriate for U.S. farmers," she says.

The discoveries may help thousands of wheat and barley growers envisioning a repeat of the original aphid's damage. That biotype has cost North American producers billions of dollars since its appearance in Texas in 1986.

The Russian wheat aphid is a major pest worldwide of winter wheat, barley, and other cereal crops. This tiny, green bug—about the size of a sesame seed—was first spotted in this hemisphere during the early 1980s, in Mexico.

It feeds on crop plants, causing leaves to curl while producing distinctive white, yellow, and purple longitudinal lines along them. These curled leaves provide shelter for the aphid and make them hard to detect until their damage is apparent. Aphids will still feed on resistant cultivars, but the plants' resistance



Plant geneticist Cheryl Baker infests greenhouse colonies with the newly found biotype of Russian wheat aphid. These colonies will be used to infest plants that will be screened for resistance to this aphid.

prevents leafrolling; this can significantly lower aphid numbers and reduce plant damage.

Prolific—In Certain Environments

Few farmers were as hard-hit by the pest as those in Colorado. That state's 14,000 wheat growers have suffered through more than \$130 million in crop losses and insecticidal control efforts since the original aphid arrived, and its barley industry was brought to a standstill.



Geneticist Dolores Mornhinweg transfers resistance to adapted U.S. barley by using traditional crossing techniques.

Entomologist John D. Burd of the Stillwater lab says biological, climatological, and ecological factors combine to make Colorado “the economic center of Russian wheat aphid problems in North America.

“This aphid—including the new biotype—reproduces asexually, year-round.” Females give birth to live females, and no eggs are involved. “This allows the pests to reproduce quickly and in large numbers. They will give birth every 4 to 6 hours under optimum conditions.”

This aphid is very particular about its environment. Conditions cannot be too hot or too cold, and there has to be an abundance of volunteer wheat—from spillage, wind, or harvesting—for overwintering. “The grasslands of eastern Colorado provide all these,” says Burd.

The Stillwater lab was among many research institutions that responded to the original Russian wheat aphid threat. In collecting as many wheat and barley germplasm samples as possible to test for aphid resistance, its scientists found their greatest resource to be the vast National Small Grains Collection (NSGC), managed by the ARS Small Grains and Potato Germplasm Research Unit in Aberdeen, Idaho.

NSGC personnel provided accessions for testing and collected and made available test data to barley and wheat researchers worldwide. Overall, scientists from the two labs tested 30,000 wheat accessions and all the available 24,000 barley accessions.

Baker also contacted germplasm collectors overseas—a move that may prove vital in the struggle against the new aphid biotype.

Years of greenhouse testing against millions of aphids led to identification of more than 300 resistant wheat germplasm lines. Mornhinweg developed 40 barley germplasm lines she terms highly resistant to the pest, as well as some lines with intermediate resistance.

The original studies had a huge impact. Baker says the effort has helped many state and private wheat breeders screen their material. “We’ve also done extensive crossing to incorporate

resistance into wheat lines that have agronomic characteristics suitable for U.S. farmers.” She says that virtually all the identified unimproved plant introductions she encountered had characteristics that made them unattractive to American farmers. “They’re usually very tall and weak-strawed, and they mature at the wrong time,” she says. “But we’ve bred out the undesirable characteristics and put the aphid resistance into plants with desirable agronomic backgrounds.”

Meanwhile, Mornhinweg’s work may rejuvenate eastern Colorado’s barley industry. She says 62 adapted barley germplasm breeding lines have been developed from her work against the original aphid. ARS geneticists Phil Bregitzer and Don Obert at Aberdeen conducted field testing and selection of advanced breeding lines, and Bregitzer made a few crosses that may be released as germplasm.

Then, Along Came Trouble

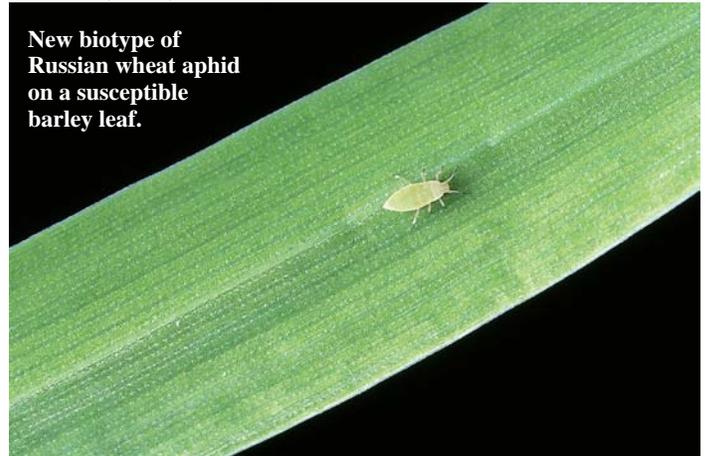
The new aphid biotype threatened much of this work. “The discovery of the new biotype was alarming at first,” says Baker. “You can’t breed for resistance to a biotype until it arises. But we did our best to prepare for something like this.”

The barley germplasm is showing strong promise against the new aphid biotype. “We’ve tested about one-third of the lines resistant to the original aphid against the new biotype and found all of them to be resistant,” says Mornhinweg. She adds that four breeding lines of winter barley and three feed barleys set to be released within the next few years show resistance to both biotypes. These co-releases will occur in conjunction with the Aberdeen lab, University of Idaho, Colorado State University, the University of Nebraska, and New Mexico State University.

Results are still up in the air with most of the wheat germplasm breeding lines. Baker says most sources of resistance to the first biotype have yet to be tested against the new biotype, but so far there are some strong candidates among the advanced breeding lines. Interestingly, the best ones are derived from a wheat-rye translocation line she received from G.F. Marais, a scientist from South Africa, a nation that has problems with the Russian wheat aphid similar to those experienced in Colorado. “It shows a lot of potential,” she says. “It looks like aphids don’t even want to feed on it.”

The Stillwater scientists emphasize that they have received plenty of help. Mornhinweg has been assisted by Bregitzer and Obert, entomologists Frank Peairs and Robert Hammon from Colorado State University, agronomist Dave Baltsenperger

PEGGY GREB (K11166-1)



New biotype of Russian wheat aphid on a susceptible barley leaf.

from the University of Nebraska, and New Mexico State University associate professor Mick O’Neill.

Baker has worked with wheat breeding and genetics professors Brett Carver of Oklahoma State University and Stephen Baenzinger of the University of Nebraska, and wheat breeders Kim Kidwell of the University of Washington and Cal Konzak, president and CEO of the Northwest Plant Breeding Company in Pullman, Washington.

Neither ARS scientist could say enough about how much the germplasm collection in Aberdeen helped. “People don’t realize how important these collections are,” says Baker. “As improved varieties gain popularity and more acreage is planted with fewer varieties, genetic diversity decreases. These gene banks are very important sources of potential genetic diversity, including plants tolerant of drought and other environmental conditions, as well as resistant to insects and disease.”—

By Luis Pons, ARS.

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Cheryl A. Baker and Dolores W. Mornhinweg are in the USDA-ARS Wheat, Peanut, and Other Field Crops Research Unit, 1301 N. Western Rd., Stillwater, OK 74075-2714; phone (405) 624-4141, fax (405) 624-4142, e-mail cbaker@pswcr.ars.usda.gov, dmornhinweg@pswcr.ars.usda.gov.

P. Phillip Bregitzer and Donald Obert are at the USDA-ARS Small Grains and Potato Germplasm Research Laboratory, 1691 S 2700 W, Aberdeen, ID 83210; phone (208) 397-4162, fax (208) 397-4165, e-mail pbregit@uidaho.edu, dobert@uidaho.edu. ★

PEGGY GREB (K11157-1)



Sarah Schultz, biological science aid, transplants winter barley into the greenhouse for seed increase.