

Collectively facing an ugly rust

By Kim Kaplan, Agricultural Research Service, USDA

When the threat to a food staple like wheat is worldwide, the best way to counter it is to enlist the world's experts in a research coalition. That's just what has been done to answer the very real threat of Ug99, a new stem rust to which most of the world's wheat and barley has no resistance.

As part of that global response, the USDA Agricultural Research Service, Australia's CSIRO and other international organisations, have become partners in the Borlaug Global Rust Initiative (BGRI). The BGRI in an alliance with the International Maize and Wheat Improvement Centre (CIMMYT), the International Centre for Agricultural Research in the Dry Areas (ICARDA), the Food and Agriculture Organization of the United Nations, and Cornell University. The BGRI is chaired by Nobel Peace Prize winner Norman Borlaug.

"To reduce the vulnerability of global wheat crops to Ug99 requires an international partnership of scientists and institutions with diverse expertise and facilities," says Ravi Singh, BGRI's chief wheat scientist.

"Countries like the US and Australia have several of the world's small pool of experts in cereal rust research," explains Kay Simmons, ARS national program leader for plant genetics and grain crops.



Nobel Peace Prize winner Norman Borlaug (second from left) believes Ug99 is the most serious threat to wheat and barley in 50 years. He is shown here consulting with Kenyan and CIMMYT leaders near wheat plots in Kenya. (PHOTO: Kay Simmons)

"We have collaborative research projects under way that are feeding critical information into BGRI, and these partnerships are the best way to leverage everybody's resources to combat Ug99."

Kenya has had Ug99 since 2001, so having use of the nursery there provides

a way for breeders to find out which of their new varieties and lines may be able to stand up to the rust without bringing the pathogen into their country and without each wheat- or barley-breeding project trying to start its own nursery overseas.

"Everybody wins. Not only does the US benefit from this nursery, but ARS is also sharing all the information from these screenings with the other members of BGRI, and they are sharing their results with us," Kay says.

In fact, researchers from other BGRI members – such as CSIRO, Agriculture and Agri-Food Canada, KARI, and CIMMYT

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SOME UG99 FACTS

In 1999, a new strain of cereal stem rust was first reported in Uganda, hence the name "Ug99." It was found in Kenya in 2001 and in Ethiopia in 2003. Now it has spread to Yemen, Sudan, and Iran.

Stem rust is favoured by hot days and mild nights with adequate moisture for nighttime dews, and it is spread by the wind – conditions that can occur anywhere wheat grows. Historically, stem rust has been the most destructive disease of wheat and barley.



Close-up of stem rust on wheat. (PHOTO: Yue Jin)

– help score the wheats at various points in the growing season alongside ARS scientists such as plant pathologist/geneticist David Marshall, research leader of the ARS Plant Science Research Unit in Raleigh, North Carolina.

“Results from the 2005–07 screenings showed that Ug99 has overcome even more major resistance genes than previously believed,” David says. “This only emphasises how important it is to find new ways for wheat to deal with Ug99.”

ARS has also used the test nursery to screen a significant portion of the small-grains germplasm collection in search of new sources of resistance.

The information from this screening has helped jump-start a cooperative stem rust-resistance breeding program at Oklahoma State University. ARS geneticist Mike Pumphrey at the Plant Science and Entomology Research Unit, Manhattan, Kansas, transferred new resistance genes into germplasm that university professor Brett Carver is now incorporating into locally adapted breeding populations.

“What ARS accomplished in two years would have taken us about five years, assuming we would have enjoyed the same success in crossing with some of the more cantankerous wild wheat relatives used in this project,” Brett says. “This partnership allows me to remain focused on the locally specific breeding objectives that already have my attention.”

Opening a new window

Recently, the Bill & Melinda Gates Foundation provided a \$US26.8 million

AUSTRALIA JOINS THE BATTLE

World wheat production – and the food security of millions of the world’s poorest people – is gravely threatened by a new highly virulent stem rust population, known as Ug99, emerging from East Africa.

The Durable Rust Resistance in Wheat project (DRRW) – a collaborative effort begun in April 2008 by 17 research institutions around the world, including the CSIRO and the University of Sydney Plant Breeding Institute, is led by Cornell University in the US. The project seeks to mitigate the Ug99 threat through coordinated activities that will replace susceptible varieties with durably resistant varieties, created by accelerated multilateral plant breeding and delivered through optimised developing country seed sectors.

The project also aims to harness recent advances in genomics to introduce non-host resistance (immunity) into wheat.

Improved international collaboration in wheat research to meet growing world demand for food – an estimated 50 per cent production increase in wheat alone is needed by 2020 – is another major goal of this project.

Australia is making an important contribution to the global effort in tackling Ug99, both in terms of existing resources through the GRDC-funded Australian Cereal Rust Control Program as well as trained personnel. Four of the scientists appointed to work on the DRRW project are former graduates of the Plant Breeding Institute at Cobbitty, NSW.

grant to Cornell University to create the Durable Rust Resistance in Wheat (DRRW) project, which will help bolster Ug99 research. With this grant, Cornell University has brought together 15 partnering institutions from all over the world (see “Australia joins the battle” above), with the goal of systematically reducing wheat’s vulnerability to rust diseases through an international collaboration of unprecedented scale and scope, according to Ronnie Coffman, DRRW’s principal investigator.

ARS is most heavily involved in three of the project’s objectives:

- Tracking wheat rust pathogens;
- Exploring whether rice offers any immunity to rust that might be transferred to wheat; and,

- Discovering new sources of rust resistance in wild wheat and wild barley.

Because most of current Ug99-effective genes are derived from relatives of common and durum wheat, ARS is looking to wild relatives as a source of genes for new types of resistance. Preliminary studies led by plant pathologist Yue Jin at the ARS Cereal Disease Laboratory have found some resistance to Ug99 in einkorn, goat-grass, and sanduri wheat.

ARS will be joining with ICARDA and the University of Minnesota to screen other wild relatives of wheat and barley.

Efforts to find and characterise new sources of stem-rust resistance are also being undertaken by Ian Dundas at the University of Adelaide, in conjunction with Stephen Xu (North Dakota State University) and Mike Pumphrey (Kansas State University). This work is building on Ian’s successful efforts to improve the usefulness of stem-rust resistances derived from alien grass species by eliminating associated negative traits such as yield depression.

Scientists at CSIRO Plant Industry and Cornell University are also seeking molecular markers linked to stem-rust-resistance genes that will allow more efficient selection of the resistances in breeding programs.

“Wheat stem rust is borne by the wind across every political boundary where wheat is grown. To monitor it and defeat it, international partnerships have always been essential,” Ronnie Coffman says.

More information on DRRW can be found at www.wheatrust.cornell.edu

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International scientists are evaluating wheat lines for rust resistance in the hope of giving wheat and barley breeders around the world a head start towards protecting new varieties from Ug99, a deadly wheat stem rust in eastern Africa. (PHOTO: Jack Dykinga)