Breeding Aluminum Tolerance Into Wheat

To increase wheat yields at the present rate on the world's richest soils may not be enough to help provide adequate nourishment for countries whose populations are growing rapidly, muses ARS geneticist J. Perry Gustafson. The world's less-productive soils must also produce much higher wheat yields to feed the 9 billion people the United Nations projects will inhabit the globe in 2040.

"We'll have to depend increasingly on acidic, high-aluminum soils," Gustafson says. Aluminum, found mostly just below topsoil, impairs plant growth on nearly 2.5 billion of the world's 8 billion acres of cropland, including about 86 million acres in the United States.

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ARS technician Kathleen Ross and graduate students Miguel Rodriguez (left) and Miftahudin analyze an amplified fragment length polymorphism film as they search for molecular markers linked to genes controlling aluminum tolerance in wheat and rye.

When soils are acidic, more aluminum is available to restrict wheat growth. One of Gustafson's passions is to help plant breeders develop new wheat varieties with genes that enable the plant to yield abundantly on this type of soil.

Besides breeding, another way to increase yields is to add lime to deacidify the soil. But lime is expensive to transport long distances.

At ARS' Plant Genetics Research Unit, in Columbia, Missouri, Gustafson researches ways to tap into genetic resources for improving aluminum tolerance in wheat. He and his colleagues have mapped the location of a major wheat gene for aluminum tolerance found between two closely situated marker genes. Wheat breeders can now select breeding lines that have these markers in order to breed for aluminum tolerance. This process, called marker-assisted selection, may halve the 10 to 15 years it currently takes to develop a new variety.

The Brazilian wheat, called BH 1146, in which the marker was identified was developed more than 50 years ago and so far has no equal for aluminum tolerance.

Borrowing genes from another cereal—rye—may be wheat's best hope for surviving on acidic, high-aluminum soils, Gustafson says. His research on mapping genes in rye may help breeders make sure they place desirable rye genes into wheat-rye crosses without greatly sacrificing wheat's desirable agronomic and food qualities. He's found molecular markers in rye that closely linked to the aluminum-tolerance genes and can be used to help transfer desirable rye genes into wheat.

Thanks to research done on wheat-rye crosses many decades ago, most of the modern high-yielding bread wheats have rye genes that impart resistance to diseases like powdery mildew. Other rye genes are suppressed. Breeding for aluminum tolerance in the same fashion has until now been a more daunting task, because lurking somewhere in various wheat chromosomes are certain genes that suppress the expression of rye aluminum-tolerance genes.

Through further genetic sleuthing, Gustafson and his colleagues hope to locate the most important suppression genes and then figure out how to delete them.—By **Ben Hardin,** formerly with ARS.

The research is part of Plant, Microbial, and Insect Genetic Resources, Genomics, and Genetic Improvement, an ARS National Program (#301) described on the World Wide Web at http://www.nps.ars.usda.gov.

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