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Researchers Identify Gene to Improve Wheat Frost Tolerance

by Stacy Kish, CSREES

The United States, the world's leading exporter of wheat, is struggling to keep pace with demand, and a decline in grain available is causing a world-wide crisis. Improving the performance of winter wheat is crucial to keeping pace with worldwide demand. With funding from USDA's Cooperative State Research, Education, and Extension Service (CSREES), scientists in California have identified the genes in wheat that are responsible for the plant's tolerance to freezing temperatures. This discovery may lead to improved crop production. >>

Winter wheat varieties tolerance to freezing temperatures ranges from 1 to 10 degrees Fahrenheit. When temperatures fall below this range, wheat is either injured or it dies. Reduced grain production presents serious economic implications.

Wheat breeders have long recognized the need to produce cultivars with greater resistance to freezing temperatures, but have had limited success at developing cultivars that exhibit improved freezing tolerance. This may be due in part to the regulation of temperature tolerance by multiple genes as well as the variable nature of freeze injury in fields where snow and sloped ground create microclimates.

"It has been difficult for wheat breeders to develop more winter-hardy varieties because frost tolerance in wheat is a complex trait that is regulated by many genes," said Jorge Dubcovsky, a wheat breeder and geneticist.

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Right: Winter wheat.
Credit: Scott Bauer

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Dubcovsky led an international team of scientists from the University of California–Davis (UCD) and European institutions to identify the genes that regulate temperature tolerance in wheat and to identify frost-susceptible varieties.

The research team had previously identified a compact group of 11 genes on wheat chromosome 5AL. These genes play key roles in regulating a large number of other genes that confer tolerance to cold temperatures.

The team demonstrated that the frost-tolerant variety activated two of these genes earlier than the frost-susceptible varieties when exposed to decreasing temperatures. This earlier response helped to better prepare the plants for freezing temperatures.

"This research has great potential to be directly incorporated into winter wheat breeding programs where improved winter survival is a goal," said project collaborator Dr. Kim Garland-Campbell. "Our next step is to further examine differences in freezing tolerance among winter wheat varieties to determine which genes are present and active in the hardiest varieties, such as from Russia, the Ukraine, Canada, western Nebraska, and other locations with extremely severe winters."

The project team will use these discoveries to screen wheat varieties for the best combinations of frost tolerance genes and then develop genetic markers to accelerate the selection of hardier wheat cultivars. The United States annually produces more than 50 million metric tons of wheat, which is used to make a broad spectrum of food products ranging from breads to pastas. The results of this research will enhance wheat sustainability and production.

This project is part of the CSREES National Research Initiative (NRI) Plant Genome program and included participants from UCD, USDA's Agriculture Research Service, Washington State University, the Ohio Plant Biotechnology Consortium, and the Hungarian Academy of Sciences.

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