Developing heat tolerant cotton in Arizona

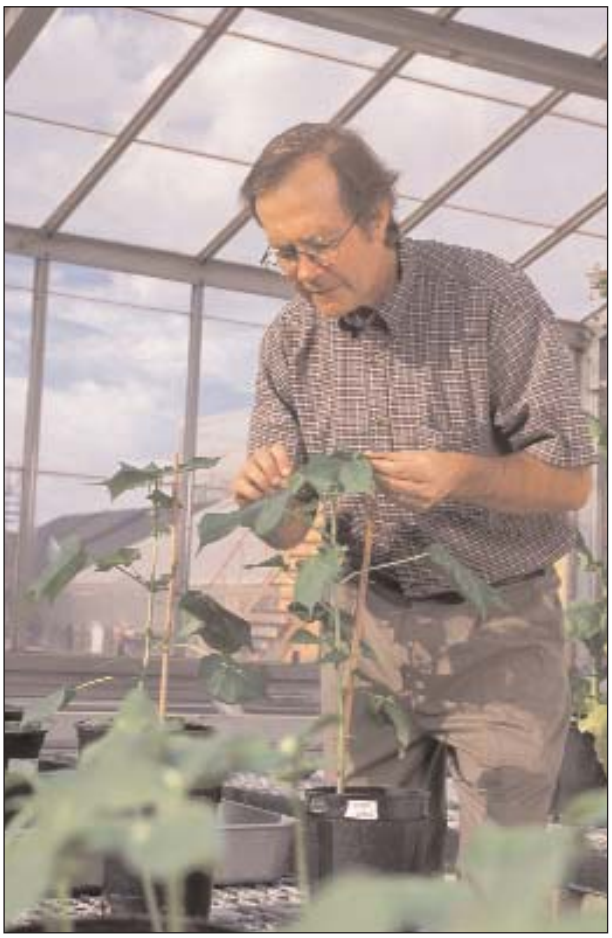
By David Elstein, USDA Agricultural Research Service Information Staff

Scientists in Phoenix are studying plants that thrive in extreme climates to help them produce better cotton in Arizona. These plant physiologists want to see what internal processes allow plants to grow in harsh climates and then apply the information to develop cotton — and perhaps some other crops — with improved ability to grow in very hot, dry places, like Arizona.

Several years ago Michael E. Salvucci and Steven J. Crafts-Brandner of the ARS Western Cotton Research Laboratory began studying the properties of rubisco activase, a plant enzyme that helps photosynthesis work properly. They found that the enzyme, and thus photosynthesis, does not operate effectively if the crop is grown out of its native environment and subjected to heat stress.

They have now taken this knowledge to the next step. They compared plants from various regions — desert shrubs, Antarctic grasses, temperate spinach, and subtropical cotton — to see how the enzyme works under a variety of conditions.

"We found that the enzyme from plants native to warmer regions is inherently more stable in high temperatures," Salvucci explains. They also found the opposite — rubisco activase in plants native to colder regions is more stable in lower temperatures.



Plant physiologist Steven J. Crafts-Brandner inspects a cotton plant that will be used in a heat-stress experiment. (Photo Peggy Greb)

Thanks to plant breeding and irrigation, commercially grown cotton produces very high yields. But yields could be even higher, particularly in the US Southwest, if photosynthesis did not shut down in the heat. With the knowledge obtained from their research, the scientists believe they may be able to manipulate the enzyme in cotton to improve heat tolerance and thus produce more bountiful yields in Arizona.

The Southwest is dry as well as hot, and water is valuable. Normally, cotton performs best when its leaves are at 28°C. When air temperature rises above that point, cotton leaves can be cooled by transpiration — evaporation of water from their surfaces.

The research conducted at the cotton lab may help cotton grow with less water, because tolerance of higher leaf temperatures means that less water needs to be used in cooling the leaves. The research could also apply to growers in other parts of the country who rely on rainfall and whose cotton can be wiped out by a severe drought.

The researchers are currently putting the gene for rubisco activase from a desert shrub into cotton. They want to test their hypothesis that the altered cotton will better tolerate Southwest heat, producing greater yields with less water. "We're developing a potential cure for the heat-stress problem by examining how desert plants cope with the temperatures of their native environment," Salvucci says.

In the future, other crops besides cotton may be grown successfully outside their traditional temperature and water-limited production areas.

This research is part of Plant Biological and Molecular Processes, an ARS National Program (#302) described on the World Wide Web at www.nps.ars.usda.gov.

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