USDA links gene flow between weedy and domesticated rice to rising carbon dioxide levels

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Higher levels of atmospheric carbon dioxide facilitate the flow of genes from wild or weedy rice plants to domesticated rice varieties, which could interfere with future rice production, according to new ARS research. Credit: David Nance

(Phys.org) -- New research at the U.S. Department of Agriculture (USDA) confirms that rising levels of atmospheric carbon dioxide facilitate the flow of genes from wild or weedy rice plants to domesticated rice varieties. As a result, domesticated plants could take on undesirable weedy characteristics that may interfere with future rice production.

This is the first study to demonstrate that the effects of increasing

atmospheric carbon dioxide concentrations include not only an influence on gene flow between closely related domesticated and wild plant genotypes, but that this gene flow is not the same in both directions. The investigation was conducted by researchers at the Agricultural Research Service (ARS), which is USDA's chief intramural scientific research agency.

"We know that global climate change will require some farmers to revise production strategies in response to shifting weather patterns and crop demands," said ARS Administrator Edward B. Knipling. "These new findings will help plant breeders design and interpret studies on how changes in climate may affect crop response."

ARS plant physiologist Lew Ziska led the investigation. Collaborators included David Gealy, Martha Tomecek, Aaron Jackson, and Howard Black. Ziska and Tomecek work at the ARS Crop Systems and Global Change Laboratory in Beltsville, Md., and the other scientists work at the ARS Dale Bumpers National Rice Research Center in Stuttgart, Ark.

Weedy wild rice, often called red rice, is the same species as domesticated rice and is very difficult to control in production settings. The team conducted a two-year combination growth chamber and field study to document how atmospheric carbon dioxide concentrations affect growth in weedy and domesticated rice and to observe the exchange of genetic material between the two plant types.

Twenty-four-hour carbon dioxide concentrations in the chambers were set at 300, 400 and 600 parts per million (ppm). These concentrations approximated the atmospheric carbon dioxide values present during the end of the 19th century, the current value, and values projected for the end of the 21st century, respectively.

When grown in carbon dioxide concentrations of 400 ppm and 600 ppm,

both types of rice put out more tillers and flowers and grew taller, compared to plants grown at carbon dioxide concentrations of 300 ppm. However, these changes in height, which scientists believe are an important factor in pollen sharing and therefore impact gene flow, were more pronounced in the wild rice.

The number of flowers produced by the wild rice grown in 600 ppm carbon dioxide was doubled compared to rice grown at 300 ppm, a significantly larger increase than the flowering increase in the domesticated rice. At the greatest concentration of carbon dioxide, wild rice also produced flowers an average of eight days earlier, a shift that apparently enhanced the likelihood of pollen transfer between the two rice types.

The researchers then conducted a genetic analysis of the hybrid seed offspring of the two rice varieties. The results of these tests indicated domesticated rice transferred only a small amount of genetic material to its weedy relative, even at the greatest concentration of carbon dioxide. But the weedy plants transferred a relatively greater amount of genetic material to their domesticated relatives, which differed from 0.22 percent at carbon dioxide concentrations of 300 ppm to 0.71 percent at carbon dioxide concentrations of 600 ppm.

The transfer of wild genetic material to the domesticated rice line resulted in the production of seed with significant weedy characteristics that would be undesirable in domesticated rice production.

Results from this study were published today in PloS One.

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- assess the nutritional needs of Americans;
- sustain a competitive agricultural economy;
- enhance the natural resource base and the environment, and
- provide economic opportunities for rural citizens, communities and society as a whole.

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