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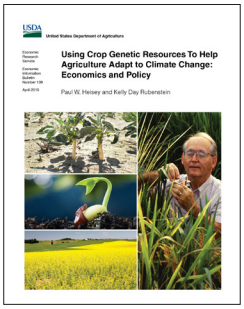

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Using Crop Genetic Resources To Help Agriculture Adapt to Climate Change: Economics and Policy

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What Is the Issue?

Climate change poses likely risks to future crop productivity as temperatures rise, rainfall patterns become more variable, and heat waves, drought, pests, and diseases increase. One strategy for helping farmers adapt to these changes is the development of crop varieties with better tolerance for increased stresses. Traits to boost crop adaptation, which may be found in genetic resources such as landraces (local varieties developed by farmers over many years) or in wild relatives of domestic crops, may be incorporated into varieties that gain wide commercial production. In light of their potential social and economic benefits, such resources have probably been underused. This report reviews the types of genetic resources, the ways they have been used, and how they might be used in the future. The report also discusses economic, scientific, and institutional factors that will determine the extent of genetic resource use and the benefits it might bring to climate change adaptation.

What Did the Study Find?

The authors first evaluated past and current use of crop genetic resources for stress adaptation and potential future demands on these resources. Their research led to the following conclusions:

- Empirical evidence from genetic resource use suggests that substantial economic benefits can follow from the collection, characterization, and use of genetic resources to improve crop resistance and adaptability.
- While the economic returns to genetic improvements in some U.S. crops have been substantial, contributions of the various stages of development—genetic resource discovery, conservation and use, biological research, and breeding of new commercial cultivars—are not always easy to differentiate and assess.
- Climate change is likely to increase demand for new crop varieties with better resilience to stresses such as heat, drought, pests, and diseases. In recent years, demand for crop genetic resources from the U.S. National Plant Germplasm System (NPGS) has increased rapidly, even as the NPGS budget has fallen in real dollars.

- The use of new genetic traits in crops has concentrated more on tolerance to pests and diseases than to stresses like heat and drought that are also expected to increase with climate change.
- Recent scientific literature suggests genetically controlled traits responding to heat and drought may need to be considered together to have the greatest impact.
- Direct or easily traceable use of new genetic traits from sources such as landraces and wild relatives has been relatively rare for some crops but more common for others (e.g., potatoes and tomatoes).

Next, the study focused on technical, economic, and institutional and political factors that help explain the current pattern of genetic resource use and that are likely to affect future use. A summary follows of the results.

- Two kinds of technical change could reduce the costs of using genetic resources and thus increase their use for climate-change adaptation:
  - — Improvements in genetic resource collection, conservation, characterization, and evaluation methods (e.g., through geographic information systems for predicting adaptation based on spatial information and DNA genetic marker analysis), and
  - — Increased efficiency in incorporating valuable genetic traits into commercial crop varieties (e.g., through genetic markers linked to genes and gene segments that govern desired traits).
- Private firms may find it difficult to market and profit from the largely social benefits of genetic resource collection, conservation, and prebreeding activities. With insufficient private-sector incentives, the public sector is left to play a major role in optimal development of genetic traits to aid climate-change adaptation.
- Institutional factors such as international agreements and intellectual property rules can promote or hinder increased use of crop genetic resources to adapt to climate change, meaning that access to genetic resources will be determined not only by supply and demand, but also by legal and political factors. This suggests the importance of considering unintended as well as intended consequences of such policies and agreements.

How Was the Study Conducted?

The authors reviewed the relevant scientific literature to determine how climate change may affect agricultural production, and thus the kinds of genetic traits that might be important for adaptation to climate change. They examined data from multiple sources to characterize past and current patterns of genetic resource use, including:

- Case studies of the use of particular genetic resources;
- Studies of the use of crop wild relatives for genetic improvement;
- Budget and distribution data for the National Plant Germplasm System (NPGS); and
- ERS analyses of data from USDA's Current Research Information System on U.S. public agricultural research, NPGS holdings from the Germplasm Resources Information Network, and information on traits used by the Germplasm Enhancement of Maize Project, a public-private collaborative effort.

The authors also reviewed the literature on the economics of genetic resource use and combined their observations into a supply/demand framework to analyze how genetic resource use for climate-change adaptation might increase over time. They also assessed existing intellectual property institutions and international agreements related to genetic resources.