Defying Climate Change: Stability of Maize Populations under Multiple Stress Conditions

Climate change threatens agriculture. Experts predict sudden and unexpected changes in climatic conditions, which in turn will bring about environmental stresses. A critical breeding goal when dealing with an unstable climate is the stability of varieties across environments.

Maize is one of the three main crops around the world, and slight changes in climatic conditions may cause substantial yield losses. Decreases in maize production due to variable climatic conditions can result in great economic losses. Consequently, numerous breeding programs are currently dealing with stability under stress conditions. When maize breeders think of breeding for environmental stress tolerance, they often design a breeding program for improving yield under one of the common climatic stresses, sometimes without conducting preliminary studies on which environmental factors actually limit the crop and which genetic parameters are essentially affected.

In the January–February 2010 issue of Crop Science, a group of scientists in northwestern Spain, belonging to the Spanish National Council (CSIC), investigate the effects of multiple stresses on maize grain yield. They evaluated 76 Spanish populations of maize, along with five checks (commercial hybrids), at three distinct locations during three years, i.e., in a total of nine environments. A statistical technique known as factorial regression was performed to obtain a biological explanation of the effect of genotype and environment as well as the magnitude of genotype × environment interaction. The existence of a significant genotype × environment interaction means that the differences among varieties are not constant when they are grown in different environments, and that indicates a lack of stability.

The evaluation was made under multiple stress conditions, mostly a shortage of water, cold temperature, and low nutrient availability. No pesticide treatments were applied during the growing cycle to let pests attack without restraint. Also, no herbicides were applied and weeding was limited in order to allow weed competition. On each plot, data were taken on several traits related to plant development and yield. Environmental variables were recorded for monitoring variations in temperature and rainfall during the growth season.

The commercial hybrids had more yield and stability than most populations; therefore, breeding programs focusing on yield have released hybrids with high yield and stability under stress conditions. There were some populations with a reasonable compromise between yield and stability. The researchers conclude that, if yield stability under stress conditions is a breeding goal, several climatic variables, especially those related to high temperatures and genotypic traits such as kernel depth and ear length should be considered.

“We can honestly say that presently, hybrids are more stable under diverse climatic conditions,” says co-author Amando Ordas. “We must not forget, however, that the old populations are the reservoirs of genes from which these hybrids have been developed, and so research with populations must be emphasized. However, the old populations need to be intensely improved for yield to be used in future breeding programs.”

Adapted from Romay, M.C., R.A. Malvar, L. Campo, A. Alvarez, J. Moreno-González, A. Ordas, and P. Revilla. 2010. Climatic and genotypic effects for grain yield in maize under stress conditions. Crop Sci. 50:51–58. View the full article online at http://crop.scijournals.org/content/vol50/issue1

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