Key discovered to cold tolerance in corn

August 29 2008

Demand for corn -- the world's number one feed grain and a staple food for many -- is outstripping supply, resulting in large price increases that are forecast to continue over the next several years. If corn's intolerance of low temperatures could be overcome, then the length of the growing season, and yield, could be increased at present sites of cultivation and its range extended into colder regions.

Drs. Dafu Wang, Archie Portis, Steve Moose, and Steve Long in the Department of Crop Sciences and the Institute of Genomic Biology at the University of Illinois may have made a breakthrough on this front, as reported in the September issue of the journal *Plant Physiology.*

Plants can be divided into two groups based on their strategy for harvesting light energy: C4 and C3. The C4 groups include many of the most agriculturally productive plants known, such as corn, sorghum, and sugar cane. All other major crops, including wheat and rice, are C3. C4 plants differ from C3 by the addition of four extra chemical steps, making these plants more efficient in converting sunlight energy into plant matter.

Until recently, the higher productivity achieved by C4 species was thought to be possible only in warm environments. So while wheat, a C3 plant, may be grown into northern Sweden and Alberta, the C4 grain corn cannot. Even within the Corn Belt and despite record yields, corn cannot be planted much before early May and as such is unable to utilize the high sunlight of spring.

Recently a wild C4 grass related to corn, Miscanthus x giganteus, has been found to be exceptionally productive in cold climates. The Illinois researchers set about trying to discover the basis of this difference, focusing on the four extra chemical reactions that separate C4 from C3 plants.

Each of these reactions is catalyzed by a protein or enzyme. The enzyme for one of these steps, Pyruvate Phosphate Dikinase, or PPDK for short, is made up of two parts. At low temperature these parts have been observed to fall apart, differing from the other three C4 specific enzymes. The researchers examined the DNA sequence of the gene coding for this enzyme in both plants, but could find no difference, nor could they see any difference in the behavior of the enzyme in the test tube. However, they noticed that when leaves of corn were placed in the cold, PPDK slowly disappeared in parallel with the decline in the ability of the leaf to take up carbon dioxide in photosynthesis. When Miscanthus leaves were placed in the cold, they made more PPDK and as they did so, the leaf became able to maintain photosynthesis in the cold conditions. Why?

The researchers cloned the gene for PPDK from both corn and Miscanthus into a bacterium, enabling the isolation of large quantities of this enzyme. The researchers discovered that as the enzyme was concentrated, it became resistant to the cold, thus the difference between the two plants was not the structure of the protein components but rather the amount of protein present.

The findings suggest that modifying corn to synthesize more PPDK during cold weather could allow corn, like Miscanthus, to be cultivated in colder climates and be productive for more months of the year in its current locations. The same approach might even be used with sugar cane, which may be crossed with Miscanthus, making improvement of cold-tolerance by breeding a possibility.

Source: American Society of Plant Biologists