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Targeting physiological traits for drought tolerance: water conservation and nitrogen fixation

*Thomas Sinclair*, Crop and Soil Sciences, North Carolina State University, North Carolina, USA

Simulations studies have shown three physiological plant traits that can consistently result in a high probability of yield increase and mean yield increase: early partial stomata closure with soil drying, partial stomata closure at elevated atmospheric vapor pressure deficit (VPD), and tolerance of nitrogen fixation (N2-fix) to soil drying. Unlike most crop species, very little variation in the onset of stomata closure with soil drying has been identified in Glycine max, although it has been observed in Glycine soja. Partial stomata closure at elevated VPD varies substantially among soybean genotypes, with PI 416937 having a particularly early response to soil drying. PI 416937 has a usually low hydraulic conductance in the water pathway in leaves from the xylem to the guard cells that can hinder replenishment of their water loss, resulting in decreased stomata conductance under high VPD. As a result of the decreased stomata conductance water is conserved and PI 416937 expresses a “slow wilting” phenotype in the field when subjected to water deficit. This water conservation trait from PI 416937 is in the pedigree of the recently released, drought tolerant ‘USDA-N8002’. Research to overcome the sensitivity of N2-fix in soybean traces to the discovery of the tolerance found in cultivar ‘Jackson’. Its N2-fix tolerance to soil drying was associated with both a low accumulation of ureide and nitrogen in its leaves, although the specific physiological mechanism conferring tolerance is not yet resolved. Two germplasm releases have been made for progeny of Jackson. More recently, it was discovered that N2-fix in genotype PI 471938 is especially drought tolerant. The pedigree of USDA-8002 also includes PI 4719938, as does the pedigree of additional lines being advanced for germplasm release.