Role of Symbiotic Nitrogen Fixation in the Improvement of Legume Productivity under Stressed Environments

R. Serraj[1]* and J. Adu-Gyamfi[2]
[1]ICRISAT-Patancheru, India. E-mail r.serraj@cgiar.org
[2]ICRISAT-Kano, Nigeria.

*Corresponding author

Abstract

The inclusion of a legume in a cropping system does not always ensure the attainment of optimal levels of symbiotic nitrogen fixation (SNF) in the field. Several environmental factors including drought, temperature, and soil nutrient status are known to dramatically affect the process at molecular/functional level and thus play a part in determining the actual amount of nitrogen fixed by a given legume in the field. This paper reviews the status of SNF in response to most significant environmental constraints, and focuses on specific cases of harnessing SNF by improving its tolerance to stress factors with the aim of enhancing system productivity. Several examples are discussed, including selecting legume crops tolerant to drought and salinity and/or allowing high biomass production and solubilization of phosphorus, identifying high nitrogen-fixing and nitrate-N tolerant genotypes and including them in relevant cropping systems, and making changes in agronomical management practices for the better integration of legumes in cropping systems. Finally, a general framework is discussed for agro-physiological contributions that can help overcome SNF limitation where this is caused by environmental constraints. The on-farm application of these knowledge-based SNF technologies will strengthen the role of N-fixing legumes in cropping systems.

Introduction

Symbiotic nitrogen fixation by legumes plays an important role in sustaining crop productivity and maintaining the fertility of marginal lands and in the smallholder systems of the semi-arid tropics. It is anticipated that the importance of legumes and SNF will continue to expand with the increasing development of sustainable agricultural practices. The first step toward maximizing SNF technologies is to increase the land area under legumes and enhance their grain and fodder yields through overcoming environmental limitations of SNF and legume productivity.

Substantial qualitative information is available on the net benefits of SNF and its residual effects on grain, herbaceous, and tree legumes. However, SNF by legumes is particularly sensitive to various environmental stresses such as drought, waterlogging, soil salinity or acidity, temperature, insect pests, diseases, and low phosphorus (P) and other nutrient limitations (see Zahram, 1999 for a review). Consequently, legume productivity can be greatly depressed if subjected to these environmental constraints. For instance, the sensitivity to drought and salt stress of both establishment and activity of the legume-*Rhizobium* symbiosis has long been recognized (Wilson, 1931; Bernstein and Ogata, 1966). Although drought and salinity effects on N_2 fixation have been extensively studied in several legume species, the physiological mechanisms involved in the inhibition are still poorly