Enhancing biological nitrogen fixation (BNF) of leguminous crops grown on degraded soils in Uganda, Rwanda, and Tanzania

III. Genetic Studies

Issues Being Addressed

An aim of our ISU-2 BNF-CRSP program is to develop germplasm that benefits most from symbiotic inoculation.

We are conducting studies to characterize genetic diversity for BNF capacity, develop bi parental recombinant inbred line populations, assemble a panel of genotypes for association mapping and test BNF related candidate gene expression.

Strategic Objective

II. Examine inheritance of genetic and environmental variation for BNF in common bean, and to identify molecular markers associated with QTL conditioning for enhanced BNF:  

- 2a. Identify parental materials for inheritance studies of BNF.  
- 2b. Phenotype existing mapping populations for BNF response, populate with molecular markers, and conduct QTL analysis

Progress to date

Germplasm evaluation: Tested select genotypes, many from existing mapping populations, for BNF response under low N conditions in the GH (Fig. 1), and under low N in the field (Fig. 2).

Andean Diversity Panel: Increase seed of 300+ Andean lines from Africa, North and South America. Andean beans predominate in Africa and there has been less breeding progress in large-seeded market classes worldwide. The lines were selected based on their importance to major Andean bean breeding programs and to consumers. The panel will be used for association mapping of traits related to BNF. Each line will be SNP genotyped. The panel will be a useful resource for other CRSP projects, international programs (FTF), and the bean research community at large.

Progress to date (cont.)

RIL population development: To compliment the Andean diversity panel, Andean x Andean RIL populations are being developed. Parents for the populations were chosen based on their BNF capacity and agronomic/quality characteristics of importance. Currently the populations are in the F2 generation.

Gene expression: P. vulgaris exports fixed N2 from the nodules in the roots to the shoots mostly as ureides. These ureides are translocated in the xylem and provide the major supply of nitrogen for the plant. To accommodate this flux of fixed nitrogen in nodules, activities of enzymes involved in the de novo purine and ureide synthesis are enhanced (Figure 3). We hypothesise that the expression of genes coding for these enzymes is enhanced in genotypes that are high in BNF and could be good candidates for marker-assisted breeding.

We have sequence information in beans on ten de novo purine synthesis genes and four genes for ureide biosynthesis (courtesy of Carol Vance, USDA-ARS). Analyses of the expression of these genes in four selected bean genotypes inoculated with rhizobium strain 899 will be conducted. These four bean genotypes are 'Majesty', 'Solwezi', 'Sanilac' and 'Jaguar'. Results from our greenhouse study where we evaluated a wide range of genotypes for nitrogen fixation showed 'Majesty' and 'Solwezi' to have had the highest amounts of total nitrogen fixed whereas 'Sanilac' and 'Jaguar' fixed significantly lower amounts of nitrogen. Total RNA will be isolated from these genotypes at 10, 21 and 30 days post inoculation with Rhizobium strain CIAT899. Transcript abundance of fourteen genes would then be determined using both RT-PCR and qRT-PCR.

Opportunities for Future Collaboration

We are collaborating with Carol Vance, USDA-ARS on the gene expression work. The development of the Andean Diversity Panel is a collaborative effort with many groups including: BeanCAP, CIAT, and FTF.