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Growth, nitrogen fixation and ammonium assimilation in common bean (*Phaseolus vulgaris*): effect of phosphorus

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The impact of phosphorous nutrition on plant growth, symbiotic N_2 fixation, ammonium assimilation, carbohydrate and amino-acid accumulation, as well as on nitrogen, phosphorus and ATP content in tissues in common bean (*Phaseolus vulgaris*) plants was investigated. Plants inoculated with *Rhizobium tropici* CIAT899 were grown in Leonard jars under controlled conditions, with P-deficient (0 and 0.1 m*M*), P-medium (0.5, 1 and 1.5 m*M*) and P-high (2 m*M*) conditions in a N-free nutrient solution. The P application, increased leaf area, whole plant DW (67%), nodule biomass (4-fold), and shoot and root P content (4- and 6-fold, respectively) in plant harvested at the onset of flowering (28-days-old). However, P treatments decreased the total soluble sugar and amino acid content in vegetative organs (leaf, root and nodules). The root growth proved less sensitive to P deficiency than did shoot growth, and the leaf area was significantly reduced at low P-application. The absence of a relationship between shoot N content, and P levels in the growth medium could indicate that nitrogen fixation requires more P than does plant growth. The optimal amount for the *P. vulgaris–R. tropici* CIAT899 symbiosis was 1.5 m*M* P, this treatment augmented nodule-ARA 20-fold, and ARA per plant 70-fold compared with plants without P application.

Introduction

The common bean *Phaseolus vulgaris* is the most important food legume for human consumption worldwide, especially in Latin America and Africa (CIAT 1992), where its cultivation as a staple food extends into marginal areas. Symbiotic nitrogen-fixation (SNF) potential in common bean is considered to be low (Pereira and Bliss 1987) in comparison with other legumes. In studies on mineral requirements of the symbiosis (reviewed in Robson 1983), phosphate has received considerable attention due to the dramatic effects observed when P fertilizer is applied to nodulated legumes in low-phosphate soils. This element is frequently one of the most limiting nutrients for plant growth in the tropics, and it is estimated that over 50% of common bean production in tropical soils is limited by phosphate deficiency (CIAT 1992).

Studies with several legumes have consistently shown a positive response to P application; whole-plant N concentration and plant dry matter were found to increase in response to phosphate in the growth media (Pereira and Bliss 1987). Moreover, nitrogen fixation in common bean is more affected by P deficiency (Vadez et al. 1996) than in other legume crops such as soybean (Israel 1987). Nodules are a strong sink for P, reaching concentrations 3-fold higher than in other organs, with little effect from P deficiency (Vadez et al. 1999), although nodule DW is greatly reduced by such deficiency (Ribet and Drevon 1995). Nodule number, as well as total and specific nitrogenase activity, increases with the addition of P, implying more efficient nitrogen fixation (Israel 1987). Mechanisms accounting for the increased activity have not been elucidated, given that some studies report

Abbreviations – ARA, acetylene reduction activity; GS, glutamine synthetase; NADH-GOGAT, NADH-dependent glutamate synthase; XDH, xanthine dehydrogenase; URIC, uricase; APA, acid phosphatase activity; AAT, aspartate aminotransferase; TSS, total soluble sugars; NN, nodule number; NNW, normalized nodule weight; NDW, nodule dry weight; SDW, shoot dry weight; RDW, root dry weight; PDW, plant dry weight; RSR, root: shoot ratio; LA, leaf area; TP, total pigments.