GENOTYPIC VARIATION IN ADVENTITIOUS ROOTING UNDER LOW PHOSPHORUS AVAILABILITY IN COMMON BEAN (*Phaseolus vulgaris* L.)

I.E. Ochoa[1], M.W. Blair[2], K.M. Brown[1], S. E. Beebe[2] and J.P. Lynch[1]
[1] Department of Horticulture, The Pennsylvania State University, University Park, PA 16802 USA,
[2]Centro Internacional de Agricultura Tropical (CIAT), AA 6713, Cali, Colombia.

Introduction

Since soil phosphorus content and availability are highly heterogeneous in most soils, generally being highest in surface horizons and decreasing with depth, root architectural traits have been proposed as an important adaptive mechanism for effectively and efficiently acquiring phosphorus under low-P input systems (Lynch and Brown 2001). Architectural traits like basal root angle have been correlated with low phosphorus adaptation (Bonser, Lynch *et al.* 1996). However, because adventitious roots are often the shallowest portions of a bean root system with an initial horizontal growth habit, they might explore topsoil horizons more efficiently than other root types (Miller, Ochoa *et al.* 2003). This study attempted to characterize the phenotypic variation and genetic regulation of adventitious rooting when phosphorus is limiting.

Materials and Methods

A $F_{5:8}$ recombinant inbred (RIL) population of 84 lines derived from the F_2 generation of the cross between G2333 and G19839, two parents contrasting for adventitious rooting and other root traits at the seedling stage, was used in this study. G2333 (Colorado de Teopisca) is a small seeded climbing type IV Mexican landrace of the Mesoamerican gene pool and G19839 is a large seeded bush type III Peruvian landrace of the Andean gene pool.

Both parents and the 84 RILs were planted in the field in an Andisol in Darien, Colombia and in nutrient solution under greenhouse conditions at University Park, PA. In both experiments genotypes were evaluated under high and low phosphorus conditions. The field experiment was amended with 45 kg P_2O_5 per hectare as triple super phosphate (TSP) in high P plots and 7.5 kg P_2O_5 per hectare as TSP for low P plots. For high and low P treatments in hydroponics a 1.5 % (w:v) of solid-phase-buffered alumina-P (Lynch, Epstein *et al.* 1990) providing a constant availability of 100 μM or 1 μM P in solution were added. The experimental design was a RCBD with split plot arrangement of treatments with phosphorus level as a main plot and genotypes as subplots with 3 replicates and 2 sub samples in the field and 5 replicates in the greenhouse.

Six weeks after sowing the upper 30 cm of the root system was carefully extracted from the soil in the field. All adventitious roots were counted and sub samples of adventitious and basal roots were collected for image analysis. For the hydroponics experiment the entire root system was harvested 14 days after germination. Adventitious roots were counted and both adventitious and a sub sample of basal roots were preserved in 25% ethanol for image analysis. In both experiments shoot and root biomass by root type were recorded. Total root length was obtained by scanning samples and analyzing them with WinRhizo Pro software (Regent Instrument Inc., Quebec City, Quebec, Canada) and used for calculating specific root length (SRL).

Results and Discussion

Except for the number of adventitious roots in the field, genotypic differences were observed between parents and among RILs for the ability to produce adventitious roots as well as the responsiveness of adventitious rooting under phosphorus stress (Table 1). G19839 had as many adventitious roots in the field as G2333, but not in the greenhouse, where G2333 produced twice as many adventitious roots as G19839. We interpret this as a phenological effect since the field data were collected at 6 weeks after planting whereas the seedling data were collected at two weeks after transplanting to the nutrient solution. Under controlled conditions all root parameters evaluated were significantly greater in G2333 than in G19839. Broad sense heritability values were moderate to high for all root traits evaluated (Table 1)

We observed significant phenotypic differences among RILs and also transgressive segregation for all adventitious root traits when comparing the ranges of the RIL population with the means of the parents, indicating useful genetic variation for the ability to produce adventitious roots as well as the responsiveness of adventitious rooting to phosphorus availability. Identifying contrasting genotypes for a particular root trait within a RIL population with a common genetic background will provide us with a valuable tool for investigating the mechanisms by which plants sense and respond to phosphorus stress.

A genetic linkage map using SSR, SCAR, and RAPD markers in this RIL population is in the final developmental stage at CIAT and will facilitate the identification of quantitative trait loci (QTL) or genetic factors conditioning adventitious and other root traits that might be important for low phosphorus adaptation in common bean.

Table 1. Phenotypic differences between parents and among RILs, and broad sense heritability (h^2) for some adventitious root traits in a RIL population of G2333 x G19839.

Adventitious root parameters	Phosphorus level	Parents			RILs		
		G19839	G2333	$Prob._P$	Range	$Prob._{RIL}$	h^2
Number / Field (n = 6)	High	34.4	32.5	ns	15.4 - 54.0	***	0.76
	Low	29.1	32.1	ns	18.3 - 50.5	***	0.68
Number / Greenhouse (n = 5)	High	7	14.1	***	2.6 - 20.8	***	0.57
	Low	8.4	14.9	***	0.4 - 21.4	***	0.66
Biomass (g) / Greenhouse	High	2.1	5.4	***	0.4 - 10.9	***	0.62
	Low	1.8	5.7	***	0.1 - 9.4	***	0.63
Root Length (m) / Greenhouse	High	39.8	131.7	***	10.6 - 274.5	***	0.70
	Low	30.4	139.3	***	1.3 - 289.7	***	0.66
SRL ($m\ g^{-1}$) / Greenhouse	High	105.2	275.7	***	42.1 - 287.0	***	0.52
	Low	123.4	243.0	***	152.4 - 277.0	ns	-

*** Significant differences between the two parents ($Prob._P$) or among RILs ($Prob._{RIL}$) at P=0.001.

References

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