Does root architecture affect whole root respiration under low phosphorus ?

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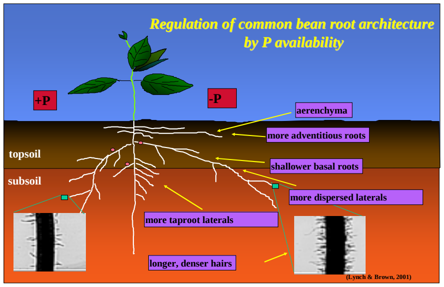
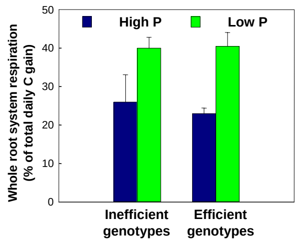
Introduction

Plant productivity is limited by phosphorus availability in natural and agricultural ecosystems throughout the world. Root system architecture plays an important role in soil resource acquisition (Lynch & Brown, 2001). Using common bean (*Phaseolus vulgaris* L.) as a model system, we have identified specific root architectural traits that are regulated by genetic and environmental factors, particularly phosphorus (P) availability. Low P availability can dramatically alter the growth angle of basal roots (Liao et al., 2001) and the production of adventitious roots (Miller et al., 2001), resulting in more shallow root systems. Low P availability has recently been shown to increase aerenchyma production, which likely reduces carbon costs and enhances P use efficiency (Fan et al., 2003). These traits have been associated with genotypic differences in adaptation to low-P soils.



The Problem

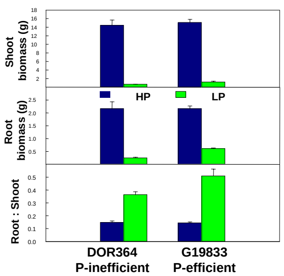
A common response to low phosphorus availability is increased biomass allocation to roots, which presumably enhances phosphorus acquisition. At the same time, an increased root:shoot ratio results in decreased growth rates due to a reduction in the carbon allocation to photosynthetic tissue. Hence, root carbon costs have been hypothesized to be a primary limitation to plant growth in low P environments. In fact, common bean plants grown in low P do utilize a larger fraction of net carbon assimilation for root respiration than plants grown in high P.

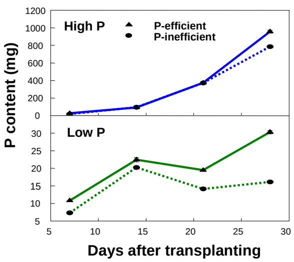


(adapted from Nielsen et al., 2001)

Working Hypothesis

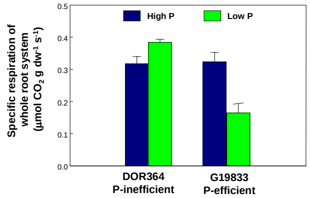
P-efficient genotypes are able to maintain a greater root biomass under low P because of differences in 1) root C allocation and 2) in root respiration costs, which results in increased P acquisition and biomass over time.





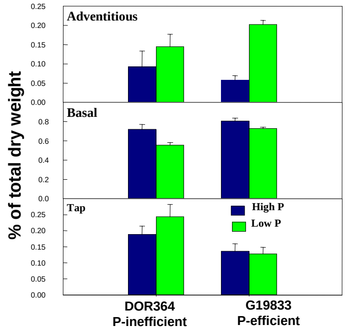
Results

Specific root respiration costs are lower for P-efficient genotype under low P. This enables the P-efficient genotype to increase the biomass allocation to root growth under low P, without increasing the whole root system respiration costs.

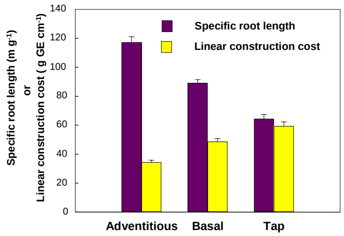


?? So how do P-efficient genotypes grow more roots more efficiently ??

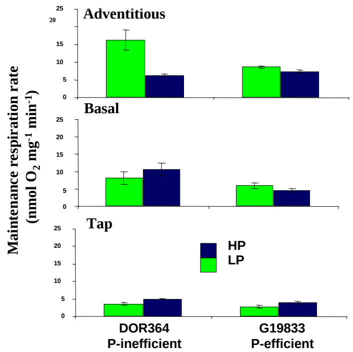
1). P-efficient genotype allocates more root C to adventitious and basal roots under low P.



2). Adventitious and basal roots have higher specific root length and lower construction costs, so they are more P-acquisition efficient root classes



3). P-efficient genotype has lower maintenance respiration costs for all root classes under low P.



Conclusions

Root carbon costs increase under low P. P-efficient genotypes are able to allocate more C to root biomass under low P, because of lower specific root respiration costs. This is achieved by allocation to more P-acquisition efficient root classes and lower maintenance respiration costs for all root classes under low P.

Acknowledgments

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References Cited

Fan et al., 2003. *Funct. Plant Bio*. (30, 493-506); Liao et al., 2001. *Plant and Soil*. 2001. **232**, 69-79; Lynch & Brown, 2001. *Plant and Soil*. **237**, 225-237; Miller et al., 2003. *Funct. Plant Bio*. (in press); Nielsen et al., 1998. *New Phytol*. **139**, 647-656; Nielsen et al., 2001. *J. Exp. Bot*. **52**, 329-339