Evaluation of Bean Classes for Root Traits Differences Associated with Root Rot Resistance

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Introduction. Detecting differences in root architecture and growth patterns among common bean (*Phaseolus vulgaris* L.) genotypes may provide unique selection criteria for genetic resistance to root rot caused by *Fusarium solani* (Mart) Sacc. f.sp. *phaseoli* (Burk.) W.C. Snyder & H.M. Hans. The pathogen infection acts to reduce root density by killing roots and may attenuate the functional efficiency of the remaining infected roots, leading to yield loss. When the primary root dies due to infection, promoting lateral and adventitious roots may contribute to plant survival in the presence of root rot organisms (Snapp et al., 2003). Understanding mechanisms of *Fusarium* root rot resistance in common bean, especially kidney beans, is a major goal of breeding programs. Quantitative information on root system traits associated with root rot resistance would improve selection criteria. Moreover knowledge of the genetic determinants of root traits and how they influence yield would allow for a more targeted breeding approach utilizing technologies such as QTL analysis. The objectives of this study were to: 1) characterize genetic variation of root architecture in contrasting bean classes expected to vary in reaction to *Fusarium* root rot and root system traits, under field and greenhouse conditions; and 2) identify root system characteristics that may be associated to root rot resistance in common bean.

Materials and Methods. Ten genotypes representing, four bean seed classes (kidney, cranberry, blacks, and snap beans), were evaluated for reaction to *Fusarium* root rot (Schneider and Kelly, 2000) and root system traits during the summer 2002 and summer 2003. The field study was conducted at the Montcalm Research Farm located near Entrican, MI, with an alfisol soil, series name Montcalm/ McBride loamy sand, arrange in a lattice design. The greenhouse study was conducted at Michigan State University using Treepots™ (a mixture of coconut coir and perlite (1:2) was used), arranged in a RCBD with two replications of the study each summer. Temperature in the containers for the greenhouse was monitored using a Watchdog™ and it ranged from 25° C at day and 20° C at night. Temperature for the field trial varied from 20° C to 26° C. The field environment was heavily and naturally infested with root rot while the greenhouse was disease free. A total of 180 roots were excised from the shoot and placed in ice to prevent dehydration while harvesting and preparing samples for analysis. Root architectural traits were analyzed by scanning the root samples into a digital image using the image analysis system WinRHIZO™ , following the procedure of Yabba and Foster (2003) and Frahm et al. (2003). Root were divided in ten root length classes based on diameter and classified as A-J respectively ranging from 0.1 to >4.5 mm, these were grouped in three root diameter classes: fine roots or secondary roots (A-C), intermediate roots or laterals (D-G), and taproots (H-J). One way analysis of variance using SAS was performed, evaluating genotype effect (SAS Inst., Inc., Cary, N.C.).

Results and Discussion. Genetic variation existed in root architecture among common bean classes and was highly significant under field environment at 30 days after planting (DAP) (Fig. 1). Plant breeders interested in enhancing root rot resistance and over all root health could focus on evaluating adventitious roots, root dry weight, and lateral roots in a breeding population since these traits are relatively easy to quantify under field conditions. Selection for root dry weight would appear to be useful in the greenhouse (Fig. 2), but should be delayed to flowering around 45 DAP to allow greater expression of root trait differences as plants mature. In the field, by contrast, edaphic stress may have enhanced differences earlier as shown by the markedly greater number of adventitious roots. The potential for improving root characteristics in common bean exist, and it appears that breeders have been effective in introgressing desirable rooting traits from black bean into kidney and snap bean as is the case of Chinook 2000 and FR266 which could serve as valuable parental lines to further enhance the root rot resistance of susceptible commercial kidney and snap bean varieties.

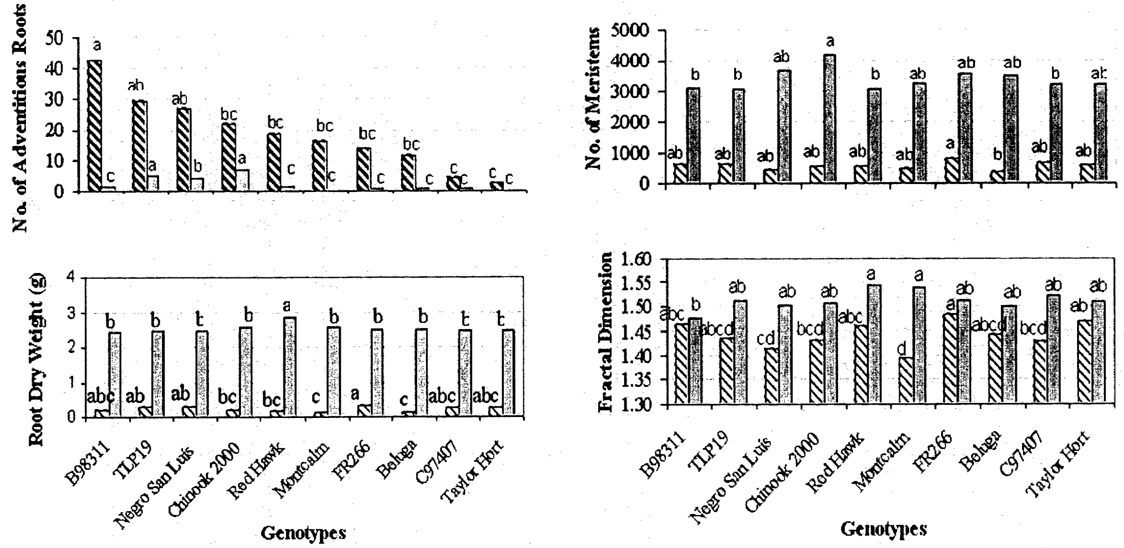

Figure 1. Illustration of differences between genotypes 30 days after planting under field (hatched boxes) and greenhouse conditions (solid boxes) for root traits such as adventitious rooting (A), number of meristems (B), root dry weight (C), and fractal dimension (D). (Different letters on columns represent statistical differences at $P < 0.05$)

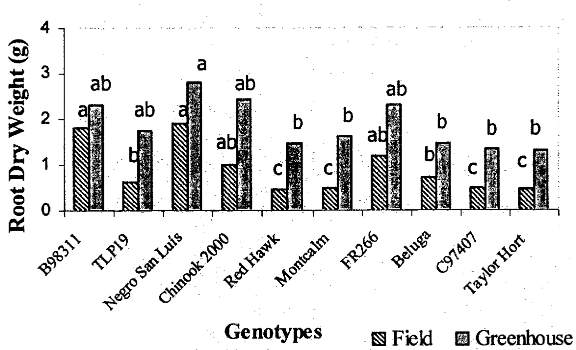

Figure 2. Differences between genotypes 45 days after planting under field and greenhouse conditions for root dry weight. (Different letters on columns represent statistical differences at $P<0.05$)

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