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"Competing pathways for equitable food systems transformation: Trade-offs and synergies"

Genotypic variation and associated loci for lateral root density and length in rice (*Oryza sativa* L.)

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Abstract

Many abiotic stresses associated with climate change will be most acutely perceived by the plant at the root-soil interface where fluctuations in soil moisture affect water and nutrient uptake. As rainfall patterns change water supply is becoming less predictable and that has caused shifts in rice production systems away from transplanting into flooded fields towards direct sowing into drier soil. The rice root system consists of two lateral root types, indeterminate larger L-types capable of further branching, and determinate, short, unbranched S-types. L-types correspond to the typical lateral roots of cereals whereas S-types are unique to rice. Both types contribute to nutrient and water uptake and our objectives were to assess whether genotypic variation for density and length of these laterals could be exploited in rice improvement to enhance adaptations to nutrient and water-limited environments. A QTL mapping population developed from parents contrasting for lateral root traits was grown in a non-flooded low-P field, roots were sampled, scanned and density and length of lateral roots measured. One QTL each was detected for L-type density (LDC), S-type density on crown root (SDC), S-type density on L-type (SDL), S-type length on L-type (SLL), and crown root number (RNO). The major-effect QTL for LDC on chromosome 5 accounted for 46 % of the phenotypic variation and additional field experiments confirmed that lines with the donor parent allele at qLDC5 had 50 % higher LDC. Simulating effects of allelic differences of main QTL in a P uptake model indicated that qLDC5 was most effective in improving P uptake followed by qRNO9 for RNO and qSDL9 for S-type lateral density on L-type laterals. Pyramiding qLDC5 with qRNO9 and qSDL9 is possible given that trade-offs between traits were not detected. Phenotypic selection for the RNO trait during variety development would be feasible, however, the costs of doing so reliably for lateral root density traits is prohibitive and markers identified here therefore provide the first opportunity to incorporate such traits into a breeding program. Breeding lines combining above QTL are currently being tested without supplementary irrigation in farmers' fields in Madagascar.

Keywords: Crown root, L-type lateral roots, P uptake simulation

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