Research on Root Systems of Rice at IRRI

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Water stress is commonly considered the most severe limitation to productivity of rice in rainfed ecosystems. In the uplands, soil remain aerobic throughout the season, while in rainfed lowland and flood-prone ecosystems, ponding and submergence may occur. These changing soil conditions have enormous consequences for nutrient availability, and the adaptive strategies which the plant may require to perform successfully. Upland lines generally favor and enhanced capacity to extract soil water, while lines from other ecosystems have poorer root systems but may possess a capacity to tolerate partial tissue dehydration. Spatial heterogeneity and seasonal variability in the timing, duration and intensity of water stress, and its interactions with other factors, further complicate the characteristics likely to confer improved adaptation to the different ecosystems.

Drought resistance may be conferred by three strategies: escape, avoidance and tolerance. plant breeders have been successful in exploiting drought escape, by adjusting crop phenology to minimize coincidence of sensitive growth stages with expected periods of drought. Breeders have been less successful in utilizing the more complex strategies of drought avoidance and drought tolerance, however, and are seeking help from physiologists and biotechnologists. Plant may avoid drought by being able to extract more water from deeper layers of soil, or by reducing losses during periods of stress. Plants may tolerate drought by physico-chemical adjustments to offset the adverse effects of partial tissue dehydration. An avoidance strategy, by improving the root system of rice, seems promising for each of the rainfed ecosystems. Likely traits include ability to penetrate to deeper soil layers, a greater maximum rooting depth, a higher root length density at depth, and greater capacity to conduct water from depth (Fukai and Cooper, 1995).

Recently, IRRI has collaborated with the Rockfeller foundation, Texas Tech, CSIRO, the University of Bangor and ODA in efforts to develop molecular markers for traits likely to confer improved drought avoidance and improved drought tolerance. Parental lines were screened for hardpan penetration capacity, osmotic adjustment, dehydration tolerance, epidermal conductance, and root characteristics. Eight rainfed lowland lines were chosen for further research, and five diverse crosses were made for production of doubled haploids and development of molecular markers. Marker research is also proceeding for upland rice, using doubled haploids derived from a further three crosses.

Multi-disciplinary research commenced in the 1994 wet season, to quantify expression of root traits for drought avoidance and tolerance among the eight parental lines of rainfed lowland rice in the field, to examine conditions required for trait expression, the consistency of response, and the implications for selection (Samson et al., 1995). This work seeks to quantify and understand the responses of the parental lines, and to identify suitable conditions and appropriate methods for screening the doubled hapoloids, which are also suitable for detailed genetic and physiology research. Collaborative linkages are being formed with the University of Queensland, ACIAR, Rothamsted, ODA, Nagoya University and the Rockfeller Foundation.

A new research initiative commenced in the 1994 et season, to characterize the expected timing, duration and intensity of drought stress, and to understand genotype by environment interaction and its consequences for selection for drought resistance (Wade et al., 1995). This research involves multi-location experiments at Consortium sites with NARS collaborators. Pattern analysis is used to examine similarity of genotype response over, environments, and to group environments. Physiological measurements on reference or probe genotypes aid understanding of plant response, and of the conditions to which the crop has been exposed at each location. Crop models are then used to examine yield distributions over sites and years for the probe genotypes, to aid interpretation of risk. The capacity of putative traits to contribute effective drought resistance is examined directly, and by simulation modeling. Progress in such complex research topics require multi-disciplinary partnership, with related activity in plant breeding, crop physiology and biotechnology.

References

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