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Growth and Distribution of Irrigated Lowland Rice Roots in the United States

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In the United States, rice is either drill seeded into a non-flooded soil, with a permanent flood applied at the 4 to 5-leaf stage or pre-germinated seed is flown into standing flood. In both cases, the floodwater is drained from the soil approximately two weeks before mechanically harvesting the grain. Until recently, little research had been conducted in the United States to study the growth and development of field grown rice roots. This lack of research activity can partially be attributed to the difficulty of obtaining root samples from a flooded soil. Since 1985, the primary focus of our laboratory has been to conduct field studies to develop a rice root growth data base that would help us better understand root development and distribution of field-grown rice as affected by water and nitrogen management, soils, and cultivars.

Techniques for studying roots of field-grown rice

Depending on the nature of the data which we are interested in obtaining, we use a variety of techniques to study rice root growth in the field. Root growth and distribution is measured with a micro video camera inserted at pre-determined stages of plant development in clear tubes placed below the rice plants. This technique allows us to measure root length, rate of root growth, root diameter, and root turnover rates in a non-destructive manner, and make comparisons of treatment on a relative basis. For purposes of modeling nutrient uptake, we use the soil core technique which provides us a greater accuracy of absolute values of root length and biomass. A porous membrane has also been used to obtain an entire soil-free intact root system of field-grown rice under flooded soil conditions. Roots of rice are confined within a nylon fiber porous membrane envelope placed 0.20 m below the soil surface. This technique allows measurements of biomass and rhizosphere influences.

Root development of flooded irrigated rice

We have measured root length development on numerous rice cultivars on different soils and under different conditions of water and fertility management

in the United States. From these studies, a general description of root length development by the rice plant can be made: maximum rate of root growth occurs between maximum tillering and panicle initiation, while maximum root length are measured during early reproductive growth. A net decrease in root length occurs from heading to grain fill. These relationships governing carbohydrate translocation throughout the plant.

Greater than 70% of the total root length is found in the upper 15 cm of soil during vegetative growth and at lease 90% of the root system penetrates no deeper than 40 cm soil depth. The average root radius during vegetative growth ranges between 0.007 and 0.009 cm. Half-distance between rice root axes in the top 10 cm of roil rage between 0.5 to 1.5 cm possibly contributing to significant interplant competition for immobile nutrient such as P and K.

Modifications to the traditional floodwater management practiced by rice producers in the United States is currently being evaluated to reduce costs for energy and herbicide applications. Water management affects the development of the rice root system. Our studies has shown that rice grown in a flood that is maintained at least during reproductive growth produces considerably more root than rice grown without a flood but with adequate supplemental irrigation. The presence of the floodwater during vegetative growth and after two weeks after heading does not appear to be as critical for the growth and field of rice compared to flooding during reproductive growth. Pre-germinated rice seed planted in a standing flood produced more total root length by heading than rice that was initially drill seeded into a non-flooded soil in which a flood as applied 4-weeks later.

Cultivars also differ in their root development. Although the pattern of root length development is the same, early maturing cultivars produce less total length than late maturing cultivars.

Results from these studies have provided a better understanding of the factors that influence rice root growth in the field, resulting in our ability to better explain rice response to modifications in production practices and to refine management recommendations for farmer.