CROP ADAPTATION TO HIGH SOIL-WATER CONDITIONS

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THE OXYGEN required by plants for respiration usually reaches the root system from the open atmosphere by diffusing through the air spaces in the soil, and by then dissolving in the water surrounding the root and diffusing into the root. However, rice and some other plants can grow very well under completely flooded conditions. When the soil is flooded, the air space is eliminated in the soil. Oxygen, therefore, cannot move through the soil system to the roots.

For some time it was thought that perhaps the reason the rice was able to grow was that the roots did not require as much oxygen as the roots of other plants, or that they were able to extract enough oxygen from some other source. It is now generally concluded that the oxygen for rice roots is supplied internally within the plant. The roots have air spaces within them through which the oxygen moves from the atmosphere to the root tips. Thus, the rice plant and other plants which grow in flooded conditions have an internal "wind pipe" for their oxygen supply.

Green house studies

In a greenhouse experiment at U.C. Riverside, rice was grown under drained conditions and under flooded conditions. After the rice was established and growing well under drained conditions, the soil was flooded and became saturated. During the first two or three days after the soil was saturated, the rice plant turned chlorotic and tended to wilt. After this period, however, new roots developed at the base of the plant and grew into the soil. Shortly after the development of the new roots, the plant started to recover and then grew very well. It appeared that these new adventitious roots were vital to the continued growth and vitality of the rice plants. It was suspected that these new roots differed somehow from the roots developed under drained conditions.

Solution culture

In some preliminary studies rice was grown in solution culture and the oxygen in the solution was varied by bubbling air or nitrogen gas through the solution; it was found that there was very little difference in the percentage of air porosity of the roots developed under the two systems. It therefore appeared that oxygen supply itself did not cause a different type of root system to develop in the rice plant.

It was decided therefore to set up another experiment in the greenhouse where plants would be grown under both drained and flooded conditions and then to examine the roots for air porosity.

Each of the treatments was replicated eight times. In one treatment, the soil columns with rice were continuously flooded while in another treatment soil columns were never saturated. The water was allowed to drain out and was resupplied each day for transpirational losses. In a third treatment, the soil was flooded for 10 days and allowed to be drained for 10 days. This cycle was repeated three times. After the plants had grown for 60 days, they were harvested and the amount of air space in the roots was measured.

The effect of the watering treatments on the percentage of root porosity is shown in the table:

TREATMENT	ROOT POROSITY
	%
Continuous flooding	21.5
Alternate flooding	10.9
No flooding	7.1

The data show there was a large effect of treatment on the percentage of air porosity of the root. These differences were statistically significant at the 1 percent level. Continuous flooding produced by far the highest percentage of root porosity. The plant had adapted to this environment by supplying its own internal route for oxygen movement. In unsaturated soil, the lowest amount of root porosity developed. When rice is grown in unsaturated soil, it does not depend upon oxygen movement through the root but can rely upon oxygen movement through the soil. The rice plant has the ability to adapt itself to accommodate the environment in which it is growing.

There was the question of whether other crops could partially adapt to high soil-water conditions. In other studies conducted in the greenhouse, it was found that corn, sunflower, wheat and tomato all had higher root porosity when grown under flooded conditions than when grown under non-flooded conditions. However, even though these crops are able to produce higher root porosity under flooded conditions and thus partially compensate for the different environment, these plants are not completely adapted to growing in these conditions and will produce very poorly or die, if prolonged flooding occurs. Nevertheless, it is interesting to note that crops do have ways of adapting themselves to the environment in which they grow.

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