Adaptation of upland and lowland rice to soil moisture deficits

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There is considerable variation in morphological and physiological characters among rice cultivars. Lowland rice materials typically have a smaller root system and leaf area and a higher potential for grain yield than upland rice types. This study examines the contribution of these characters to the adaptation of rice cultivars to varying moisture supply.

Methods

Two experiments were conducted at Redland Bay in 1985/86 under upland conditions. The first involved six cultivars (three each of lowland and upland adaptation) which were grown under treatments of differing moisture supply: - 1. Continuous irrigation (C), 2. an early stress period followed by a late irrigation period (L), and 3. a drought (D) consisting of both early and late stress periods. The second experiment involved forty rice lines (14 upland) which were either continuously irrigated (wet) or irrigated as L above (dry). Total dry matter and allocation of it to plant parts, including grain and leaf area index were measured on four occasions at 9, 13, 17 and 21 weeks in Experiment 1 and at anthesis and maturity only in Experiment 2. Leaf water potential was measured at the end of the first stress period in Experiment 1.

Results and discussion

In Experiment 1, grain yield of plants in Treatment C ranged from 4.1 to 7.0 t/ha and were approximately twice those in Treatment L (1.8 to 2.7 t/ha). Yields under rainfed conditions (D) ranged from 0.8 to 1.3 t/ha. Minimum leaf water potentials in Treatments D and L were -2.3 to -3.0 MPa and in Treatment C, -1.4 to -2.3 MPa. Panicle number was relatively constant across water environments while spikelet number per panicle was high in C and low in Treatments D and L indicating that stress during the early stage had a large effect on the latter component of grain yield. The percentage of unfilled grains was generally low in C and L (8 to 20%) but higher in D (40 to 70%). The mean weight of 100 grain was 2.3, 1.8 and 1.5 g in treatments C, L and D respectively. Thus reduced moisture supply during grain filling resulted in fewer and smaller grains at harvest. No increase in total dry matter occurred after the third harvest in D. Total dry matter increase was smaller in L than the increase in head dry weight, indicating retranslocation of assimilates for grain. Limited moisture in the early stage resulted in a sink limitation during grain filling since there was a smaller sink associated with fewer spikelets and a reduced potential grain size. There was no interaction of the cultivar by moisture treatment. However, the yields of the lowland cultivar were less than those of the upland cultivars in all treatments.

In the second experiment, anthesis and maturity dates were delayed in the dry treatment by 20 to 30 days depending on cultivar. Grain yields in the dry treatment were 10 to 200% of the control. Grain yield was related to change in total dry matter from anthesis to maturity for most cultivars, particularly under the wet conditions, but there were large genotypic differences in this relationship. After irrigation recommenced, a group of Japanese varieties diverted a large proportion of post-anthesis dry matter into tiller production at the expense of grain sink and hence grain yield. Others retranslocated up to 2.0 t/ha of pre-anthesis assimilate to the grain.