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Identification of the quantitative trait loci for breaking and bending types lodging resistance in rice, using recombinant inbred lines derived from Koshihikari and a strong culm variety, leaf star

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Abstract

To develop rice cultivars with increased biomass and grain yield, superior lodging resistance is an essential trait. The new breeding approach can be adopted for the improvement of stem lodging resistance by enhancing culm strength. The resistance to breaking type lodging is attributed to bending moment of basal culm (M), which is composed of the section modulus (SM) and bending stress (BS). The resistance to the bending type lodging is attributed to flexural rigidity (FR) of stem, which is composed of the secondary moment of inertia (SMI) and Young's modulus (YM). Starch and cell wall components such as cellulose, hemicellulose and lignin also play a significant role in physical strength of culm, and thus affect lodging. Leaf Star has a superior lodging resistance due to its thick and stiff culm because of its high M and FR compared with Koshihikari. Furthermore, Leaf Star contains high densities of hemicellulose, cellulose and low lignin density in culm compared with Koshihikari. In this study, we performed QTL analysis for these traits associated with culm strength, using 94 recombinant inbred lines (RILs, F_8), derived from a cross between Leaf Star and Koshihikari. The SM in the RILs showed a continuous distribution. QTLs for SM were detected on chrs.2, 3 and 10. Leaf Star alleles increased SM on chrs. 2 and 3, but Koshihikari allele increased on chr.10. These QTLs overlapped with those QTLs identified using backcrossed inbred line derived from a cross between Chugoku 117 and Koshihikari, the parents of Leaf Star. The FR in Leaf Star was higher than that in Koshihikari due to the larger SMI and YM. 3 QTLs for SMI were detected on chrs.2, 3 and 10. Leaf Star alleles increased SMI on chrs.2 and 3, and Koshihikari alleles increased on chr.10. One QTL on chr.3 and two QTLs on chr.5 for hollocelulose content were detected with Leaf Star alleles contribution. Moreover, two QTLs were detected for hemicellulose density on chrs.3 and 5. Leaf Star allele increased hemicellulose density on chr.5, and Koshihikari allele increased on chr.3. Furthermore, two QTLs for cellulose density were detected on chr.5, and one QTL on chr.2. For starch content, one QTL on chr.3 and two QTLs on chr.5 with Leaf Star alleles contribution were detected. TULK-6 carrying a chromosome segment of Leaf Star on chr.5 in the Koshihikari genetic background showed higher densities of starch and hemicellulose than those in Koshihikari. These results suggest that the detected QTLs for culm strength could be utilized for the improvement of lodging resistance in rice by marker-assisted selection.

Keywords: cell wall component, cellulose, hemicellulose, lodging resistance, QTL

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