P067

Estimation of the quantitative trait loci associated with breaking and bending types lodging resistance in rice using chromosome segment substitution lines derived from a cross between Takanari and Koshihikari

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Abstract

Lodging is one of the important constraints in rice production. The lodging destroys the canopy structure, and sharply reduces the capacity of photosynthetic rate and dry matter production. In cereal crops, stem lodging can be classified into two types: stem breaking type and stem bending type. To improve stem lodging resistance, it is important to reveal strong culm traits of superior lodging resistant varieties. There are large varietal differences in parameters associated with the bending moment at breaking (M) and flexural rigidity (FR). The *indica* variety Takanari possesses large M due to its large section modulus (SM) despite of its small bending stress (BS), while Takanari also has large FR due to its large secondary moment of inertia (SMI) and Young's modulus (YM). To identify quantitative trait loci (QTLs) and the corresponding genes associated with the parameters for M (=SM×BS) and FR (=SMI×YM) should enable to develop lodging resistant varieties, efficiently. In order to identify QTLs for cell wall materials such as cellulose, hemicellulose and lignin associated with BS and YM, a set of Chromosome Segment of Substitution Lines (CSSLs) consisted of 37 lines with chromosome segments of Koshihikari in the genetic background of Takanari were used. Takanari had large M and small BS as compared with Koshihikari. The QTLs for BS were estimated on chromosomes 3, 5, 6, 8, 9, 10, 11 and 12. Koshihikari alleles increased BS in these QTLs. Takanari had a large FR due to its large SMI and YM as compared with Koshihikari. The YM was increased by substitution of the Koshihikari chromosomal segments on chromosomes 2, 10 and 11. Other QTLs estimated on chromosomes 7 and 12 that Koshihikari alleles contributed to the decrease of YM. For lignin, only one major QTL for lignin density was detected on chromosome 11. Hollocellulose densities were increased by the substitution of Koshihikari segments on chromosomes 5 and 11. On the other hand, these were decreased on chromosomes 1 and 3 by substitution of Koshihikari segments. QTLs for cellulose density were estimated on chromosomes 1, 3 and 5 by substitution of Koshihikari segments. For hemicellulose, QTL on chromosome 3 showed that hemicellulose density decreased by the substitution of Koshihikari segment. However, hemicellulose densities on chromosomes 5, 8 and 11 showed the opposite effects. The QTLs for hemicellulose, cellulose, and hollocelulose densities identified on chromosome 5 overlapped with that for bending stress, indicating the positive effect of Koshihikari segment on increasing bending stress. These results suggest that some QTLs for the densities of cell wall materials contribute to increasing bending stress and Young's modulus, and could be utilized to improve the lodging resistance for both types of breaking and bending in rice varieties.

Keywords: bending type lodging, breaking type lodging, lodging resistance, QTL, rice

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