Title
Identification of a novel QTL for shoot Cd accumulation in rice

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Introduction

Low Cd concentration in brown rice is a desirable trait for food safety, because rice is a staple food for nearly half of world's population, and thus is a large source of dietary intake of Cd. Several studies showed that there was a good correlation in Cd concentration between the shoot and brown rice (He et al., 2006; Liu et al., 2007), suggesting that controlling of root Cd uptake may ultimately suppress Cd accumulation in brown rice. Recently, we examined genotypic variations in shoot Cd concentration in 146 rice accessions from rice core-collection and found a large variation in the shoot Cd accumulation. Previously, we have characterized a high-Cd accumulating accession (Badari Dhan, *indica*) and found that this accession has a high ability to translocate Cd from the roots to the shoots (Ueno et al., 2009). By using a population derived from this accession and a low-Cd accumulating accession (Shwe War, *japonica*), we found that a major QTL for shoot Cd concentration is located on the chromosome 11 (Ueno et al., 2009). In the present study, we characterized another high-Cd accumulating accession (Nepal 555, *indica*) and performed QTL analysis for shoot Cd accumulation in a F_2 population derived from a cross with Shwe War. A novel QTL for shoot Cd accumulation was detected in this population.

Results and Discussion

Physiological characterization of a high Cd-accumulating accession

The Cd uptake and accumulation were compared between Nepal 555 and Shwe War. When they were exposed to 1 μM Cd for 10 days, Cd concentration in the shoot of Nepal 555 was 14-times higher than that of Shwe War. A short-term uptake experiment (20 min) showed that there was no difference in the Cd uptake by the roots between two accessions. However, the Cd concentrations in the xylem and shoots were much higher in Nepal 555 than that in Shwe War. These results suggest that the difference in the shoot Cd accumulation does not result from the root ability to take up Cd, but the ability of Cd translocation from the roots to the shoots. This trait is similar to Badari Dhan reported previously (Ueno et al., 2009).

Detection of QTLs for the shoot Cd concentration

We constructed a mapping population by crossing Nepal 555 with Shwe War. QTL analysis in the F_2 population lead to detection of two major QTLs for the shoot Cd accumulation, which are localized at the chromosome 6 and 11, respectively (Fig. 1). The QTL on chromosome 11 and 6 explained 47% and 12%, respectively, of phenotypic variation in the Cd accumulation. The QTL detected on the chromosome 11 was the same as the one detected in the progeny of Badari Dhan and Shwe War, indicating that Nepal 555 and Badari Dhan share the primary factor for shoot Cd accumulation. However, the QTL on the chromosome 6 has not been detected previously. Furthermore, an interaction between the QTLs on the chromosome 11 and 6 was found. These results suggest that Nepal 555 has additional function for Cd accumulation. In fact, when Nepal 555 and Badari Dhan were grown under the same conditions, Nepal 555 accumulated more Cd than Badari Dhan (Fig. 2), supporting that other factors in Nepal 555 are involved in the Cd accumulation. Cloning of QTL genes is being undertaken in our laboratory.

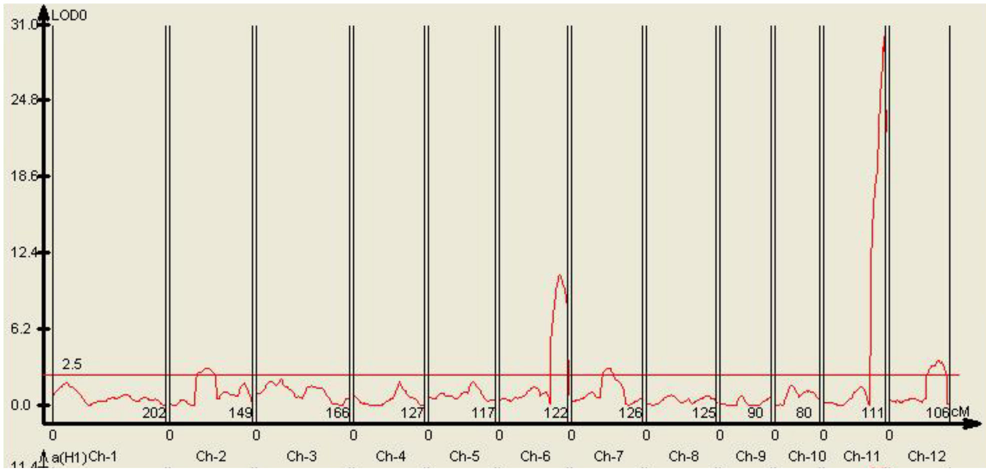

Figure 1 QTLs controlling shoot Cd concentration in the F_2 population of Nepal 555 × Shwe War. Horizontal axis shows genetic distance in the 12 chromosomes, vertical axis shows LOD score.

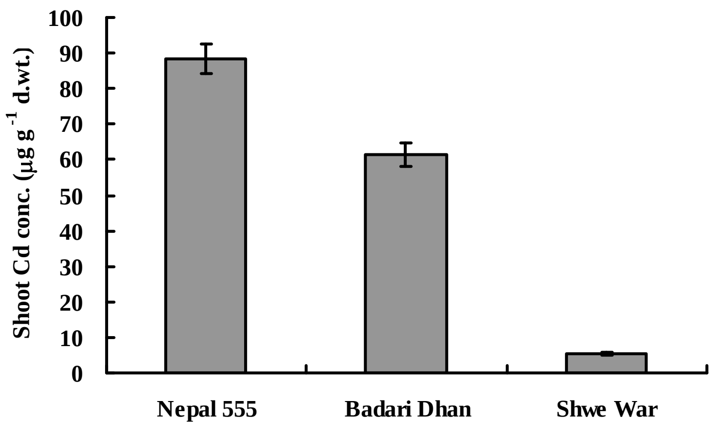

Figure 2 Shoot Cd concentrations in Nepal 555, Badari Dhan and Shwe War. Seedlings were exposed to 1 uM Cd for 10 days. Error bars represents ±SD (n=3).

References

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