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Root metabolic cost analysis for root plasticity expression under mild drought stress

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Abstract

Drought is a major limiting factor that reduces rice production and occurs often especially under recent climate change. Plants have the ability to alter their developmental morphology in response to changing environment, which is known as phenotypic plasticity. In our previous studies, we found that one chromosome segment substitution line (CSSL50 derived from Nipponbare and Kasalath crosses) showed no differences in shoot and root growth as compared with the recurrent genotype, Nipponbare under non-stress condition but showed greater growth responses compared with Nipponbare under mild drought stress condition. We hypothesized that reducing root respiration as metabolic cost, which may be largely a consequence of aerenchyma formation would be one of the key mechanisms for root plasticity expression. This study aimed to evaluate the root respiration and aerenchyma formation under various soil moisture conditions among genotypes with different root plasticity. CSSL50 together with Nipponbare and Kasalath were grown under waterlogged conditions (Control) and mild drought stress conditions (20% of soil moisture content) in a plastic pot (11 cm × 14 cm, $\varphi \times H$) and PVC tube (3 cm × 30 cm, $\varphi \times H$). Root respiration rate was measured with infrared gas analyzer (IRGA, GMP343, Vaisala, Finland) with a closed static chamber system. There was no significant difference between genotypes in control for shoot and root growth as well as root respiration rate. In contrast, all the genotypes increased their root respiration rates in response to mild drought stress. However, CSSL50 showed lower root respiration rate than Nipponbare, which was associated by higher root aerenchyma formation that was estimated based on internal gas space (porosity) under mild drought stress conditions. Furthermore, there were significant negative correlations between root length and root respiration rate. These results imply that reducing the metabolic cost (= root respiration rate) is a key mechanism for root plasticity expression, which CSSL50 showed under mild drought.

Keywords: rice, aerenchyma, lateral root development, drought stress, root plasticity, root respiration

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