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Exclusion of Na⁺ and Cl⁻ Ions by the central parenchyma in leaf sheaths of rice and the involvement of lamina joint

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Abstract

Rice is highly sensitive to salt stress especially in its early growth stage, which thus is one of the major constraints in rice production. In rice plants, salt sensitivity is associated with the accumulation of Na⁺ in the shoots, especially in the photosynthetic tissues. High salt concentrations in soil cause high Na⁺ and Cl⁻ transport to the shoot and preferential accumulation of those ions in older leaves, which decreases K⁺ in the shoot, photosynthetic activity and grain yield. Salt exclusion capacity at the leaf sheath is therefore considered to be one of the main mechanisms of salt tolerance. In addition, it is suspected that the lamina joint might be involved in the salt transport from leaf sheath to leaf blade. This research aims to determine if leaf sheaths of rice exclude a large amount of Na⁺ only or other ions such as K⁺, Ca²⁺, Mg²⁺, and Cl⁻ as well, to identify tissues in the leaf sheath, which accumulate Na⁺, and to examine if the lamina joint is involved in the salt exclusion by the leaf sheath. The rice seedlings of salt tolerant genotype FL478 and salt sensitive genotype IR29 were independently treated with NaCl, KCl, MgCl₂ and CaCl₂, and Taichung 65 and its near-isogenic liguleless line (T65lg) were treated with NaCl. Then, the content of Na⁺, K⁺, Ca²⁺, Mg²⁺, and Cl⁻ ions and their specific location were determined using Atomic Absorption Spectrometer, Ion Chromatograph, and Energy Dispersive X-ray Spectroscopy. Results showed that leaf sheaths of FL478 and IR29 accumulated a large amount of Na⁺, K⁺, Ca²⁺, Mg²⁺, and Cl⁻ ions, and thus excluded them from leaf blades when treated with high concentration of each salt. When treated with NaCl, the highest Na⁺ concentration was found in the basal part of leaf sheaths of both cultivars. Moreover, energy-dispersive X-ray spectroscopy revealed that the central parenchyma cells of the leaf sheath were the site where most Na, Cl, and K were retained under salinity in the salt tolerant genotype FL478. Also, the concentration of Na⁺, K⁺ and Cl⁻ ions in leaf sheaths and leaf blades was comparable between T65 and T65lg, indicating that the lamina joint may not be involved in the exclusion of Na⁺, Cl⁻ and K⁺ by the leaf sheath from the leaf blade under salinity. Therefore, we conclude that the central parenchyma cells of basal part of leaf sheath are the site that plays a physiological role to exclude Na⁺ in the shoots of rice without the involvement of the lamina joint.

Keywords: Salt stress, salt exclusion, leaf sheath, laminar joint

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