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Molecular Physiology of a Novel Signal-Transducing Protein and Vacuolar Function, which Are Related to Salt Tolerance of Plant

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Summary

In salinity soils, plant growth is severely suppressed due to reduction of water potential, cellular dehydration, and ion toxicity. However, many plants survive at high salt levels. Salt tolerant plants can synthesize compatible solutes, exclude salts, compartmentalization of excess ions in the cytoplasm into vacuoles, and suppress influx of salt ions. In the present study, we found that a novel signal transducing protein PCaP2 (plasma membrane cation^{+}-binding protein 2) is involved in response to salt stress. Our observations on PCaP2, vacuolar membrane zinc active transporter MTP1, and vacuolar membrane H^{+}-pyrophosphatase (H^{+}-PPase) are summerized.

(1) PCaP2 binds phosphatidylinositol phosphates (PtdInsPs) and Ca^{2+}/calmodulin (Ca^{2+}/CaM) complex. We revealed that PCaP2 is specifically expressed in root hair cells and is involved in normal tip growth of root hairs. We estimate that PCaP2 is involved in signal transduction from calcium signaling to PtdInsP signaling at the tip of root hairs (Kato *et al*. 2013, *Plant J.* 74: 690-700).

(2) *Arabidopsis* lines over-expressing PCaP2 were germinated and grew well even in 80 mM NaCl. Probably PCaP2 works as a suppressor element under salt stress to maintain the integrity of plants. Over-expression of PCaP2 may cause imbalance of the PCaP2 in cells and cancel this suppression.

(3) We got a unique line (NR23), which express the N-terminal part of PCaP2 and had no root hair, and characterized its physiological properties. NR23 had lower capacity of water absorption and became more sensitive to drought and salinity compared with wild type. High sensitivity of NR23 to salinity may be due to dysfunction of water absorption. Probably, salt entered into plant tissues must be diluted by a large amount of water.

(4) Salinity tolerance of plants partly depends on capacity of salt accumulation into vacuoles. Vacuolar accumulation of Na^{+} depends on the Na^{+}/H^{+} exchanger and vacuolar proton pumps, H^{+}-pyrophosphatase (H^{+}-PPase) and H^{+}-ATPase. We prepared several transgenic lines of H^{+}-PPase. At least the overexpressor of H^{+}-PPase grew well and showed higher salt tolerance.

(5) We investigated molecular structure and physiological roles of zinc transporter AtMTP1 (Kawachi *et al*. 2012, *FEBS J.* 279: 2339-2356; Tanaka *et al*. 2013, *FEBS Open Bio*, 3: 218-224), and are analyzing physiological effects of gene modification of AtMTP1.