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Development of Salt Tolerant Crops by Enhancing Signal Cross-Talk between Reactive Oxygen Species (ROS) and Phytohormones

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Summary

The halophyte *Mesembryanthemum crystallinum* (ice plant) has been focused as a model halotolerant crop which can adapt to salinity environments. Ice plant accumulate D-pinitol and changes its carbon fixation system from C3 photosynthesis type to Crassulacean acid metabolism (CAM) type in response to salinity stress. Our previous studies have revealed that a reactive oxygen species (ROS) signal is involved in phytohormonal signaling for adaptation to osmotic stress. Thus, molecular mechanisms of cross talk between ROS signal and phytohomones such as ethylene and ABA were studied using leaves and stems of ice plant. We analyzed the expression profiles of D-pinitol synthesis-related genes and protein levels involved in phytohormonal and salinity signals. Salt stress and ROS such as H_2O_2 significantly induced genes coding myo-inositol O-methyltransferase (IMT) and myo-inositol-phosphate synthase (MIPS) in ice plant. IMT catalyzes the first step in the biosynthesis of the cyclic sugar alcohol D-pinitol from myo-inositol, and MIPS is a limiting enzyme for myo-inositol synthesis. Interestingly, immunoblot indicated that salt stress and ROS both up-regulate protein levels of SOS3 and Ein3, which are involved in Na^+ ion-efflux system and ethylene perception signals, respectively. In addition, ROS treatment induced *ATG8i* encoding autophagy related protein as well as ethylene synthesis and ethylene responsive genes. We have compared the effects of various treatments, low temperature, ABA, ROS and NaCl, on the expression of the genes of D-pinitol synthesis. The induction profiles of D-pinitol synthesis-related genes in ice plant under those treatments exhibited different pattern between *IMT* and *MIPS*. We conclude that the molecular mechanisms that trigger induction of *IMT* and *MIPS* in response to salt stress in ice plant were possibly accompanied with ROS and ethylene signals and autophagy mechanism. It is suggested that the ROS treatment is a potentially more effective reagent for improvement of D-pinitol production and salinity tolerance in ice plant. There may be multiple signals or pathways that regulate D-pinitol synthesis pathway and Na^+ ion efflux in salinity tolerance of ice plant.