Abstract

Plants regulate many physiological processes in response to adverse environmental stresses. This study focused on the seed germination and seedling establishment stage and investigated the molecular signaling events when abiotic stresses, such as osmotic, water and temperature, were applied. Seeds of Arabidopsis, mutants or wild type, were used to identify the signaling components.

Cold-pretreatment (stratification) is widely used to break seed dormancy and improve germination rate. Stratification at 4°C significantly broke the seed dormancy of Arabidopsis in wild-type, cyp707a2, sleepy1 and sleepy1/cyp707a2, but not in ga3ox1. Stratification and exogenous ABA treatment strongly enhanced the expression and the activity of α-amylase in the freshly harvested seeds among the wild-type and those mutants, which have relatively high ABA content. Similarly, the expression of RGL2 and ABI5 were also substantially suppressed by stratification. These results suggest that stratification firstly leads to GA biosynthesis and unlocks the inhibition of RGL2 on the expression of α-amylase. Stratification also relieves the inhibition of ABA on the germination process but the inhibition of ABA on seedling development is not affected.

We have isolated an Arabidopsis mutant, dsptp1, which is hyposensitive to osmotic stress during seed germination and seedling establishment, indicated by exhibiting higher seed germination rate, lower inhibition in root elongation under osmotic stress, and more tolerance to drought compared with the wild type (Col0) plants. Osmotic stress and drought enhanced AtDsPTP1 expression in seed coats, the bases of rosette leaves and roots. Compared with the wild type, the dsptp1 mutant increased proline accumulation, reduced MDA content and ion leakage,
and enhanced antioxidant enzyme activity under osmotic stress. AtDsPTP1 regulated the transcript levels of various dehydration responsive genes, ABA biosynthesis and metabolic enzyme gene under osmotic stress, resulting in reduced accumulation of ABA in dsptp1 mutant plants than wild type in response to osmotic stress. AtDsPTP1 also mediated the ABA signaling pathway under osmotic stress by suppressing the expression of ABI1 and enhancing the expression of the positive regulators ABI3 and ABI5 in ABA signaling. These data suggest that AtDsPTP1 positively regulates ABA accumulation and signaling during seed germination and seedling establishment in Arabidopsis under osmotic stress.

To further investigate the regulation mechanism of DsPTP1 in osmotic stress and drought signaling, we analyzed the water holding capacity between wild type and dsptp1 mutant. The dsptp1 mutant exhibited enhanced water holding capacity compared to wild type under osmotic stress resulting from reduced water loss and increased relative water content, which shall contribute the osmotic and drought tolerance. To identify the signaling components, we investigated the activity of MAPKs under osmotic and drought stress and found that the DsPTP1 differentially regulates the activities of MAPK6 and a p38 MAPK, which is inferred as MAPK12 according to its molecular weight in Arabidopsis under osmotic and salt stress. However, there is no direct interaction between DsPTP1 and 20 MAPKs indicated by the results of the of specific interaction test. These results suggest that the differential regulation of MAPK6 and MAPK12 by DsPTP1 is indirect. In addition, we screened the interaction proteins of DsPTP1 under abiotic stress. Seventeen positive clones were acquired from the sequencing results. More work need to be done to confirmed the positive interactions and the
signaling cascades.

In summary, seed germination and seedling growth are closely regulated by environmental cues. This should be the result of evolutionary selection since successful new growth from the seed embryo depends on the sensitive perception of environmental conditions and effective regulation of many physiological processes that are involved. We have demonstrated that plant hormones, especially ABA, play central regulative roles during such regulations. Many other signaling components, such as protein kinases and phosphatases, are also involved. Identifying the detailed signaling pathways should be the focus of further research.
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