Stress Perception and ABA Signaling in Rice Seed
Germination and Seedling Establishment

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A thesis submitted in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

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Aug 2011
Abstract

Stress perception and ABA signaling are pivotal processes in plant signaling network that enables plants to cope with the stresses. However, little is known about the mechanism of how these processes regulate seed germination and seedling establishment, especially with the non-dormant rice seeds. In this study, we first investigated how the equilibrium between ABA biosynthesis and catabolism is related to the regulation of seed germination by glucose in rice. Pharmacological experiments by manipulating endogenous ABA content show that ABA catabolism plays a key role during seed germination. Further QRT results indicate that it is OsABA8ox3, a key gene of ABA catabolism, was significantly induced during the first 6 h of imbibition, which was consistent with the decline of ABA contents in the imbibed seeds. The expressions of OsABA8ox genes, not OsNCED genes, were sensitively suppressed in the presence of exogenously supplied glucose. These results indicate that the glucose-induced delay of seed germination is rather a result from the suppression of ABA catabolism than any enhancement of ABA biosynthesis during the rice seed germination.

The antagonism between ABA and GA plays a key role in controlling seed germination but how ABA suppresses GA accumulation during this process is not known. We investigated the possible links among ABA, reactive oxygen species (ROS), ascorbic acid (ASC) and GA during rice seed germination. Unlike in non-seed tissues where ROS production is increased by ABA, ABA reduced ROS production in imbibed rice seeds, especially in the embryo region. Such reduced ROS also led to an inhibition of ASC production. Both ROS and ASC were required in enhanced levels to promote the germination processes. GA biosynthesis was also suppressed by ABA, possibly through the reduced level of ASC, which acts as a substrate in the biosynthesis. Applications of exogenous ABA, ROS scavengers and ASC biosynthesis inhibitors all proved such links.
These results indicate that ABA regulates seed germination in multiple dimensions. ROS and ASC are involved in its inhibition of GA biosynthesis and seed germination.

Both ABA and H$_2$O$_2$ productions are induced by drought and can act as signals under stress condition. In the present study, we have demonstrated that water stress inhibited the expressions of $CAT_{A}$ and $CAT_{C}$ but substantially enhanced the expression of $CAT_{B}$. The expression changes of $CAT$ gene families as well as the accumulation of H$_2$O$_2$ are arrested by suppressing the endogenous ABA content and show a correlation with the total activity of catalases in rice leaves under water stress. Our results suggest that water stress-induced ABA prevents the excessive accumulation of H$_2$O$_2$, through the induction of the expression of $CAT_{B}$ gene during water stress.

MAPK cascades are key modules in signaling network, but their functions in stress perception and seed germination are seldom investigated. In rice seedlings, we found that a 45kD MAPK is activated rapidly by water stress. The responses of this MAPK to exogenous ABA and NaCl are different with that to water stress. A comparison with the accumulation rate of ABA suggests that this MAPK might play a key role in mediating the accumulation of ABA in rice leaves under water stress. While in rice seeds, a MAPK with similar molecular weight is inactivated in 3h after the onset of imbibition. Western blot experiments reveal that the germination-related MAPK could be OsMAPK1. Further investigation is needed to discover its functions in seed germination.
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