Regulation of Chilling Tolerance in Rice Seedling by Plant Hormones

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Abstract

The major important factors limiting plant growth and crop productivity are environmental stresses, of which low temperature is the most serious. It has been well known that many physiological processes are alterant in response to the environmental stress. With regard to the relationship between plant hormones and the regulation of chilling tolerance in rice seedlings, the major physiological roles of plant hormones: abscisic acid, ethylene and ploy amines are evaluated and discussed in this paper. Rice seedlings were grown in culture solution to examine the effect of such plant hormones on physiological characters related to chilling tolerance and also to compare the different responses among tested cultivars. Intact seedlings about 14 day-old were chilled at conditions of 5°C and 80% relative humidity for various period. Cis-(+)-ABA content was measured by the indirect ELISA technique. Polyamine content and ethylene production in leaves were determined by means of HPLC and GC respectively. Chilling damage of seedlings was evaluated by electrolyte leakage, TTC viability assay or servival test.

Our experiment results described here demonstrated the physiological functions of ABA, ethylene, and polyamines related to the regulation of chilling tolerance in rice seedlings.

Levels of cis-(+)-ABA in leaves or xylem sap of rice seedlings increased rapidly in response to 5°C treatment. The tolerant cultivars had significant higher level of endogenous ABA than the sensitive ones. The (±)-ABA pretreatment for 48h increased the chilling tolerance of the sensitive indica cultivar. One possible function of abscisic acid is the adjustment of plants to avoid chilling-induced water stress. Accumulation of proline and other compatible solutes is assumed to be another factor in the prevention of chilling injuies by abscisic acid. In addition, the expression of ABA-responsive gene is reported in some plants and may be involving in the acclimation to low temperature.

Ethylene and its immediate precusor, 1-amincyclopropane-1-carboxylic acid (ACC) increased significantly after 5°C treatment. The activity of ACC synthase which converts S-adenosylmethionine (SAM) to ACC enhanced earlier than the increase of ethylene and ACC. Low temperature increased ACC synthase activity, whereas prolonged chilling treatment damage the conversion of ACC to ethylene. It was shown that application of Ethphon was beneficial to recovering from chilling injury in rice seedlings. However, the physiological functions of chilling-induced ethylene are still unclear.

Polyamines are thought to be a potential plant hormone and may be involving in the regulation of chilling response. Results indicated that chilling treatment induced a remarkable increase of polyamines, especially putrescine content in rice seedlings. The relative higher putrescine content was found in chilling-tolerant cultivar and the maximal level of enhanced putrescine in shoot of chilling cultivar (TNG. 67) was about 8 folds of controls at two days after chilling. The accumulation of polyamines may protect membrane structure or buffer ionic imbalance from chilling damage.

Stress physiology is a rapidly expanding field. Plant growth regulators that improve tolerance to low temperature may affect stress protein production. The molecular or gene approaches will help us to elucidate the functions of plant hormones related to the regulation of chilling tolerance in plants in the near future.