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Acclimation of tomato plants to salinity stress after a salicylic acid pre-treatment

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ABSTRACT Long-term incubation of tomato plants in low concentration of salicylic acid enabled plants to tolerate salt stress caused by 100 mM NaCl. Na^+ ions accumulated in the leaf tissues of treated plants and functioned as osmolytes without the well-known detrimental effects of the excess sodium.
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Crosstalk between transduction pathways of external or/and internal signals in plant cells results in new possibilities for unusual hardening techniques in order to increase plant resistance to abiotic or biotic stress factors. It has already been established that a relatively new plant growth regulator, salicylic acid (SA) improved the chilling resistance of maize (Janda et al. 1999) by activating a new isoenzyme of ascorbate peroxidase, a H_2O_2 scavenging enzyme and by decreasing ethylene production and accumulation of its precursor, 1-aminocyclopropane-1-carboxylic acid (ACC) in non-acclimated plants during chilling (Szalai et al. 2000). SA has been identified as a key signal for the expression of pathogenesis-related proteins and it has also been implicated in the hypersensitive response. Moreover, its synthesis can be induced by H_2O_2 derived from the reactive oxygen species during abiotic stress (Yalpani et al. 1994). It is a fundamental requirement of a successful acclimation to control the oxidative chain-reactions and/or maintain effective repair and detoxifying mechanisms. The role of ethylene in these acclimation processes is effectively investigated but not fully understood. In the present work acclimation to salinity stress of tomato plants, which had previously been grown for a long time in a relatively low concentration of SA, was investigated. We tried to reveal those biochemical and physiological effects of SA pre-treatment which led to improved fitness of plants exposed to salt stress.

Materials and Methods

Tomato plants (*Lycopersicon esculentum* Mill. L. cv. Rio Fuego) were grown in hydroponic culture both in the presence or in the absence of SA applied at 10^{-7}-$5x10^{-4}$ M concentration range. Six-week-old plants were treated with 100 mM NaCl and were exposed to salinity stress for a week. Water potential of plants was estimated using pressure chamber (PMS Instruments) and osmotic potential was determined in the expressed cell sap by digital automatic osmometer. Ion contents of plants were determined by AAS (Hitachi-Z8200). Chlorophyll fluorescence measurements were made by a pulse amplitude modulated fluorometer (PAM-2000, Walz) and ethylene production was determined by GC (Hewlett-Packard, 5890 Series II). Total soluble sugar contents were estimated by the method of Dubois et al. (1956). Isoenzymes of aldehyde oxidase were separated with native PAGE and activity staining was performed as described by Zdunek and Lips (2001).

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Results and Discussion

Growth of tomato plants in a broad concentration range of SA exhibited an optimum curve. After six weeks of incubation in SA, the quantum efficiency of PS2 open centers in the treated leaves in dark adapted (Fv/Fm) and light adapted state (F_M'-F_s/F_m') were not significantly different from that of the control. There were no significant differences in the thiobarbiturate (TBA) reactive lipid peroxidation products of the samples, too. SA however, increased water potential of leaves, which was at least partly a result of an increased ion accumulation. A 7-day incubation in 100 mM NaCl effectively reduced the relative growth rate and decreased relative water content of control plants. However, as compared to the control, Na^+ concentration increased signifi-cantly in SA-pretreated leaves under salt stress, which led to an increased water potential of the leaf tissues. Excess of sodium ions did not cause the well-known symptoms of salt stress in SA-treated plants. SA reduced the salt stress-induced loss in Chl *a* and carotenoid contents and significantly decreased the concentration of TBA-reactive compounds in the presence of 100 mM Na^+. Salt stress resulted in a considerable decrease in total and reducing sugar contents both in leaves and roots of tomato plants. These reductions were partially reversed by SA providing a pool of compatible osmolyts in the presence of sodium. This is important not only in osmotic adjustment but also in the maintenance of carbohydrate intermedier pool in the chloroplasts. Moreover, SA increased the rate of photosynthetic electron transport above the control level and increased the photochemical quenching parameter in the presence of Na^+. SA concentrations used in our experiments did not inhibit significantly or slightly increased the ethylene production by the young leaflets of salt-stressed plants.

Application of exogenous ACC, an ethylene precursor to the culture solution of tomato plants in 10^{-8}-10^{-4} M concentration range resulted in small increases in ethylene emanation and ACC treatment increased the photosynthetic electron transport rate and photochemical quenching parameter of photosynthesizing leaves in a concentration-dependent manner. The role of stress ethylene in the acclimation process to salt stress needs further elucidation. Activities of three aldehyde oxidase isoenzymes increased significantly in the root tissues in the presence of 100 mM Na^+ in SA-treated plants. These enzymes seem to be involved in indole-acetic acid catabolism and the last step of abscisic acid biosynthesis is also catalysed by an aldehyde oxidase. So they are intimately involved in the stress-coupled acclimation processes and changes in their activities may balance the hormonal levels during stress.

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