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Aluminium activates a citrate-permeable anion channel in the Al-sensitive zone of the maize root apex: a comparison between an Al-sensitive and an Al-resistant cultivar

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Abstract

In search for the cellular and molecular basis for differences in Al resistance between maize cultivars, we applied the patch-clamp technique to protoplasts isolated from the apical root cortex of two maize cultivars differing in Al resistance. Measurements were performed on protoplasts from two apical root zones: The 1-2 mm zone (DTZ), described as most Al-sensitive, and the main elongation zone (3-5 mm; EZ), the site of Al-induced inhibition of cell elongation.
Aluminum stimulated citrate and malate efflux from intact root apices revealing cultivar differences. In the EZ anion channels were neither observed in the absence nor presence of Al. Preincubation of intact roots with 90 µM Al for 1 h induced a citrate and malate-permeable, large conductance anion channel in 80 % of the DTZ protoplasts from the resistant but only in 30 % from the sensitive cultivar. When Al was applied to the protoplasts in the whole-cell configuration, anion currents were elicited within 10 minutes in the resistant cultivar only. La^{3+} was not able to replace or counteract with Al^{3+} in the activation of this channel. In the presence of the anion-channel blockers niflumic acid and DIDS anion currents as well as exudation rates were strongly inhibited. Application of cycloheximide did not affect the Al response suggesting that the channel is activated through posttranslational modifications. We propose that the Al-activated large anion channel described here contributes to enhanced genotypical Al resistance by facilitating the exudation of organic acid anions from the DTZ of the maize root apex.