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# Functional Plant Biology

## Contents

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**Research Front: Understanding Plant Responses to Acid Soils**



*Cover illustration*: The image illustrates a widespread mechanism of $Al^{3+}$-resistance controlled by members of the ALMT and MATE protein families. Root growth of $Al^{3+}$-sensitive plants is inhibited by the toxic $Al^{3+}$ ions present in acid soils. Root growth of $Al^{3+}$-resistant plants is maintained due to the efflux of organic anions ($OA^-$) such as malate and citrate, which bind and detoxify the $Al^{3+}$ ions. The cartoons provide models for the $Al^{3+}$-activated efflux of organic anions from different species. The upper cartoon depicts the $Al^{3+}$-activated malate efflux via TaALMT1 in wheat. In this case the transport proteins are expressed constitutively in root apices with $Al^{3+}$-resistant genotypes showing greater expression than $Al^{3+}$-sensitive genotypes. The $Al^{3+}$ ions (red circles) activate organic anion efflux by interacting directly with the pre-existing proteins in the plasma membrane (blue proteins; arrow 1). The lower panel depicts the $Al^{3+}$-activated efflux of malate via AtALMT1 in *Arabidopsis* as well as $Al^{3+}$-activated efflux of citrate via $Alt_{SB}$ in sorghum or via AtMATE1 in *Arabidopsis*. In this case $Al^{3+}$ first induces the expression of the transport proteins through a signal transduction pathway possibly involving a specific receptor (brown object) or non-specific stress responses (arrows 1, 2 and 3). The $Al^{3+}$ ions then activate organic anion efflux by interacting with the newly synthesized proteins in the plasma membrane (arrow 4). Photograph by Carl Davies and cartoons drawn by Peter Ryan. The cartoon is reproduced, with permission, from an article that first appeared in Delhaize *et al*. (2007) *FEBS Letters* **581**, 2251–2267.