

Functional Plant Biology

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Research Front: Understanding Plant Responses to Acid Soils

Foreword: Understanding how plants cope with acid soils

Jian Feng Ma and Peter R. Ryan iii

Review: The convergent evolution of aluminium resistance in plants exploits a convenient currency
Peter R. Ryan and Emmanuel Delhaize 275–284

Many plants cope with Al^{3+} toxicity by releasing malate or citrate from their roots. The genes controlling this trait are members of two distinct families. This paper discusses why anion efflux became a favoured mechanism of Al^{3+} resistance in many different species and considers the mutations that may have occurred to drive its selection.

Mitochondrial enzymes and citrate transporter contribute to the aluminium-induced citrate secretion from soybean (*Glycine max*) roots
Muyun Xu, Jiangfeng You, Ningning Hou, Hongmei Zhang, Guang Chen and Zhenming Yang 285–295

Al-dependent changes in activities of mitochondrial citrate synthase, malate dehydrogenase and aconitase was found to be consistent with the sustained release of citrate from soybean roots induced by Al. Interestingly, it was also found that one putative citrate transporter gene was induced by Al in soybean roots.

Isolation and characterisation of two MATE genes in rye
Kengo Yokosho, Naoki Yamaji and Jian Feng Ma 296–303

Two MATE genes (*ScFRDL1* and *ScFRDL2*) expressed in the roots of rye were identified. They have different roles in metal stress tolerance; *ScFRDL1* was involved in efflux of citrate into the xylem for Fe translocation from the roots to the shoots, while *ScFRDL2* was involved in Al-activated citrate secretion in rye.

Genetic variability for root morph-architecture traits and root growth dynamics as related to phosphorus efficiency in soybean
Junhua Ao, Jiabing Fu, Jiang Tian, Xiaolong Yan and Hong Liao 304–312

This study showed that root morph-architecture traits are possibly controlled by quantitative trait loci and have a coordinating contribution to P efficiency. The root growth dynamics showed that the P efficient genotype established a longer and larger root system with preferred distribution in the surface layer, keeping more active roots.

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.

The utility of phenotypic plasticity of root hair length for phosphorus acquisition

**Jinming Zhu, Chaochun Zhang
and Jonathan P. Lynch**

313–322

Maize genotypes capable of responding to low phosphorus by extending their root hair length grew better under phosphorus stress than genotypes with long but unresponsive hairs. Root hair plasticity is a component of a broader suite of traits permitting greater root growth and phosphorus acquisition in low phosphorus soils.

Homeostasis of respiration under drought and its important consequences for foliar carbon balance in a drier climate: insights from two contrasting *Acacia* species

**Teresa E. Gimeno, Katy E. Sommerville,
Fernando Valladares and Owen K. Atkin**

323–333

This study examined the impact of drought on carbon balance on two contrasting *Acacia* species (*A. pycnantha* and *A. floribunda*). It was found that foliar respiration remained constant under drought in both species and, as a consequence, the rate of respiration/photosynthesis increased. This shows how drought can alter the whole plant, and potentially ecosystems and carbon balance.

Temperature effect on carbon partitioning in two commercial cultivars of sugarcane

**Christopher P. L. Grof, James A. Campbell,
Olena Kravchuk, Christopher J. Lambrides
and Peter L. Albertson**

334–341

The effect of temperature on plant growth and partitioning of dry matter in sugarcane (*Saccharum* spp.) was determined in two Australian commercial cultivars, Q117 and Q138. Clear cultivar differences were shown for total sucrose accumulation, stalk dry matter and sucrose/hexose ratio across the temperature treatments.

Similar irradiance-elicited plasticity of leaf traits in saplings of 12 tropical rainforest tree species with highly different leaf mass to area ratio

**Sabrina Coste, Jean-Christophe Roggy,
Gregory Sonnier and Erwin Dreyer**

342–355

The irradiance-elicited plasticity of photosynthetic traits is very large in saplings of a range of tropical forest tree species. It is related to changes in leaf mass to area ratio. Its amplitude was similar among species irrespective of leaf area to mass ratio, and of successional status.