Research

Research Project: USING GENOMIC/PROTEOMIC TECHNOLOGIES TO IMPROVE QUALITY AND STRESS TOLERANCE OF CROP SPECIES **Title:** Aluminum Resistance in Maize Can Not Be Solely Explained by Root Organic Acid Exudation: a Comparative Physiological Study

Authors

- Pineros, Miguel - CORNELL UNIVERSITY
- Shaff, Jon - CORNELL UNIVERSITY
- Manslank, Holly - CORNELL UNIVERSITY
- Alves, Vera - EMBRAPA, BRAZIL
- Kochian, Leon

Submitted to: Plant Physiology
Publication Type: Peer Reviewed Journal
Publication Acceptance Date: January 20, 2005
Publication Date: January 31, 2005
Citation: Pineros, M., Shaff, J., Manslank, H., Alves, V., Kochian, L.V. 2005. Aluminum resistance in maize can not be solely explained by root organic acid exudation: a comparative physiological study. Plant Physiology. 137:231-241.

Interpretive Summary: Large areas of land within the U.S. and over 40% of the world's arable lands are acidic. In these acid soils, aluminum (Al) toxicity is the primary factor limiting crop production via Al-induced inhibition of root growth. The physiological and molecular basis for Al tolerance is still poorly understood. Thus, we need a more complete understanding of the mechanisms underlying Al tolerance if we are going to be able to develop more Al tolerant crop plants for improved cultivation on acid soils. In this paper, we used physiological methods to conduct a detailed characterization of a proposed Al tolerance mechanism in maize based on the Al-activated release of the Al detoxifying compound, citric acid, from the root tip (the site of Al toxicity. The study was conducted with 6 maize genotypes - 2 were Al tolerant and 4 Al sensitive. Root citrate release in response to Al is widely accepted as the main Al tolerance mechanism in maize and a number of other plant species. We found that both Al tolerant maize lines had high rates of Al-activated citrate release, but so did 3 of the four Al sensitive maize lines. These findings suggested that root organic acid release is not the only or even the main tolerance mechanism in maize. We also looked for differences in other possible Al tolerance mechanisms, including changes in internal organic acid content, and Al-induced changes in the pH at the root surface (as Al solubility increases at lower pH). We did not find evidence that these processes were involved in differential Al tolerance. These findings are important, as these indicate novel and currently undiscovered mechanisms of Al tolerance are functioning in this important crop species.

Technical Abstract: Root apical aluminum (Al) exclusion via Al-activated root citrate exudation is widely accepted as the main Al resistance mechanism operating in maize. Nonetheless, the correlation between Al resistance and this Al exclusion mechanism has only been tested in a very small number of maize lines. In this study, we conducted a comparative study of the physiology of Al resistance using six maize genotypes that capture the range of maize Al resistance and differ significantly in their genetic background (three Brazilian and three North American genotypes). We were able to establish a clear correlation between root tip Al-exclusion and Al resistance. Both Al resistant genotypes and three of the four Al sensitive lines exhibited a significant Al-activated citrate exudation, and there was a lack of correlation between differential Al resistance and root citrate exudation for the six maize genotypes. In fact, one of the Al sensitive lines, Mo17, had the largest Al-activated citrate exudation of all of the maize lines. Our results indicate that although root organic acid release may play a role in maize Al resistance, it is clearly not the only or the main resistance mechanism operating in these maize roots. A number of other potential Al resistance mechanisms were investigated, including release of other Al-chelating ligands, Al-induced alkalinization of rhizosphere pH, changes in internal levels of Al-chelating compounds in the root, and Al translocation to the shoot. However, we were unsuccessful in identifying additional Al resistance mechanisms in maize. It is likely that a purely physiological approach may not be sufficient to identify these novel Al resistance mechanisms in maize and this will require an interdisciplinary approach integrating genetic, molecular, and physiological investigations.

Last Modified: 02/15/2009