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Access and excess problems in plant nutrition

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Abstract

As plant nutrition issues are redefined by society, new applications emerge for a basic understanding of nutrient use efficiency in soil-plant processes to avoid excess on rich soils as commonly found in the temperate zone and make the best of it under access-limited conditions common in the tropics. The main challenge of plant nutrition may be to increase the width of the domain between the access and excess frontiers, rather than to define a single 'economic optimum' point. Two approaches are discussed to widen this domain: the technical paradigm of precision farming and the ecological analogue approach based on filter functions and complementarity of components in mixed plant systems. Current understanding of plant nutrition, largely focused on monocultural situations, needs to be augmented by the interactions that occur in more complex systems, including agroforestry and intercropping as these may form part of the answer in both the excess and shortage type of situation. Simulations with the WaNuLCAS model to explore the concepts of a 'safety-net' for mobile nutrients by deep rooted plants suggested a limited but real opportunity to intercept nutrients on their way out of the system and thus increase nutrient use-efficiency at the system level. The impacts of rhizosphere modification to mobilize nutrients in mixed-species systems were shown to depend on the degree of synlocation of roots of the various plant components, as well as on the long-term replenishment of the nutrient resources accessed. In conclusion, the concepts and tools to help farmers navigate between the scylla of access and the charibdis of excess problems in plant nutrition certainly exist, but their use requires an appreciation of the site-specific interactions and various levels of internal regulation, rather than a reliance alone on genetic modification of plants aimed at transferring specific mechanisms out of context.

Introduction: threats to sustainability

Sustainability of farming and thus of agro-ecosystems depends on the ability of farmers to overcome current and future threats to a continuation of their enterprise in some form or other. These threats can derive from loss of on-site productivity, from 'angry neighbours' who no longer accept the lateral flows through air or water of elements and pesticides coming from the farm, from 'worried customers' who do not trust the quality of the products or don't agree with the production conditions, or from 'regulatory bureaucrats' in a policy frame that tries to control the activity of farmers. Plant nutrition research has traditionally focused on the first of these threats, and has helped to develop plant and soil management schemes that provide for adequate nutrient supply to the current crop without unduly mining soil resources. A build-up of soil nutrient stocks, some not directly available to common crops, was seen as an unavoidable side-effect of improved crop nutrition and use efficiencies of 30–40% for fertilizer N characterize the main grain production systems of the world (Doberman and Cassman, 2001). The apparent success of this type of plant nutrition in the intensively used agricultural lands of the temperate zone, as well as in specific areas in the tropics, has given rise to increased fluxes into the environment and thus to the *angry neighbour*, *worried customer* and *regulatory bureaucrat* type of threat to sustainability of current farming styles. In the Netherlands, the country with the highest nitrogen surplus per ha (Smaling et al., 1999), new legislation requires farmers to keep

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