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Editorial

Nutrient management in tropical agroecosystems

This special issue deals with 'Nutrient Management in Tropical Agroecosystems'. Interest in this subject has greatly increased over the last decades, because of its immense social, economic and environmental dimensions. Nutrient management in agroecosystems is usually defined as the process of allocating and utilising nutrient resources to achieve specific agronomic, social and environmental goals simultaneously. The goals of nutrient management are to some extent mutually conflicting, and implications can be large when the focus is on a single goal while ignoring others. Tropical agroecosystems are in general poor in nutrient resources and there are often serious constraints to increasing nutrient resources. As a consequence, crop yields and quality are low, and soils depleted. The complexity of nutrient management is furthered by the fact that there are at least 13 nutrient elements known to be essential for plants and 18 for animals, whereas the difference between nutrient deficiency and toxicity levels can be very small. Currently, billions of people suffer from shortage of food, malnutrition and/or a nutrient deficiency, especially in the (sub)tropics (e.g., Welch and Graham, 1999).

Nutrient management literally is a key component for achieving sustainable agriculture. Global population will increase to about 9 billion during the next decades. Most of the additional people will live in the (sub)tropics. To enhance their food security, additional food will have to be produced there (Bruinsma, 2003; Smil, 2000). Already nowadays about 1.4 billion people live in risk-prone areas in the (sub)tropics, especially in Africa, where farming systems as yet have not much benefited from mainstream agricultural technologies. They are usually located in areas too marginal for intensive agriculture and remote from markets. Food insecurity is often directly related to insufficient food production. Depletion of soil fertility is a major cause of low food production in these areas, especially in Africa (Sanchez, 2002).

Traditional practices of shifting cultivation become less feasible with increasing population density. Fallow periods are shortened and farmers encroach forests. Alternatives have been sought in improved fallows and other forms of agroforestry, as well as in application of local natural nutrient sources such as rock phosphate, animal manure and green manures. Investigations of these alternatives have given diverse results, with both promising and disappointing messages. The alternative sources have a limited availability, are labour and knowledge intensive, and nutrient use efficiency is often low. In principle application of chemical fertilizers would solve these problems, but the high prices, compared to the prices of agricultural produces, make farmers have limited access to fertilizers, especially in Africa. Often, fertilizers are simply not available at local markets. In regions such as south-east Asia where fertilizers are available and their use often supported by governments, application of single element fertilizers (mostly nitrogen) has contributed to accelerated exhaustion of other nutrient elements, with low fertilizer use efficiency and large losses to the environment as consequences.

On the other hand, there are successes emerging also in African agriculture, notably in the breeding of maize and cassava, in the combat of its diseases and pests, in horticulture and cotton production (e.g., Gabre-Medhin and Haggblade, 2004). There are also success stories from Kenya, based on public–private partnership for input provision and regional upscaling (Blackie and Albright, 2005), and all these successes need to be studied carefully and explored further. But current experience says that private investments in soil fertility and soil conservation are made only when the revenues from crop production allow doing so, suggesting that support from governmental agencies and donors is deemed necessary for the subsistence agriculture in large parts of Africa.

Low nutrient use efficiency is a serious drawback for crop cultivation in many (sub)tropical agroecosystems. Increasing the nutrient use efficiency is key to securing food production, human health, protecting the wider environment, saving scarce natural resources, and keeping the remaining forests and natural areas intact. It has been reported that an efficiency gain by a factor 2–4 is needed worldwide to avoid large-scale eutrophication and ecosystem degradation (Tilman et al., 2001, 2002).

In the past much research directed at improving soil fertility and nutrient management has focused on individual nutrients, single crops, or on single component technologies or approaches. Although this is convenient for researchers in

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terms of simplifying and focusing research questions, farmers are often offered 'baskets of options' for soil fertility improvement. Even in the simplest farms the number of potential combinations of crops and soil fertility management options can be bewildering when the different land qualities and different cropping options are considered. Such complexity is often considered too great for scientists to address, yet smallholder farmers are continually faced with such situations as well as with additional problems. The decisions farmers make under such circumstances are crucial in determining the food security and the future of their households. The choice to invest in a particular technology or combination of technologies by a farmer results in significant trade-offs with other activities within, or beyond, the farm boundaries (e.g., Sanginga et al., 2003). There are also major trade-offs between crop yields in the short-term, and investments in long-term soil fertility improvement. Apart from the constraints resulting from poor soils, labour and cash and failing input and output markets are key constraints. An overriding conclusion from the many studies in various countries is that optimizing nutrient management must be seen within the broader socio-economic policy context (e.g., IAC, 2003). Evidently, optimizing nutrient management is highly complex. We are still in the infancy as regards developing effective policies and measures for sound nutrient management in practice.

This special issue is based on presentations and discussions at the symposium 'Nutrient Management in Tropical Agroecosystems' held at the occasion of the retirement of Dr. Bert Janssen from Wageningen University, on 18–19 February 2004. The 13 papers were prepared by colleagues and former PhD students of Bert Janssen and are meant as state-of-the art overviews as well as a tribute to his contribution to nutrient management in tropical agroecosystems. He has been working in a broad range of agroecosystems in Africa, Latin America and Southeast Asia. He is well-known for his methodological contributions to accurate assessing soil nutrient supply using the double-pot technique, modelling organic matter dynamics in soil and the model QUEFTS for quantitative evaluation of the fertility of tropical soils (e.g., Janssen et al., 1990; Smaling and Janssen, 1993).

The papers is this volume present both background and options for increasing use efficiency of indigenous nutrients and of nutrients contained in organic and chemical fertilizers. The presented visions have been derived from desk studies, inventories, field and laboratory experimentation and simulation modelling. Results obtained in the field originate from participatory research with farmers and from trials designed and managed by scientists. The first paper outlines the needs for optimizing nitrogen use efficiency and minimizing nitrogen losses to the environment from a global perspective. The next 10 papers deal with various nutrient management issues at continental, regional, farm and field scales. The final two papers deal with the framework of ideal soil fertility in tropical agroecosystems and its implications for nutrient use efficiency from a theoretic point of view. These papers have been written by Bert Janssen and Peter de Willigen, and basically are a synthesis of the technical knowledge about soil fertility evaluation and nutrient management in tropical agroecosystems.

Important messages arising from the studies presented in this special issue are:

- Soil organic matter content is a key proxy for the soil fertility level of tropical soils, and mixed cropping systems with nitrogen fixing leguminous trees and crops are important attributes of proper soil organic matter management. These mixed systems contribute to increasing crop yields and to sequestering organic matter in the soil. The increased crops yields, however, increase the rate of depletion of nutrients other than nitrogen from the soil. In the longer term, mixed cropping systems with nitrogen fixing leguminous trees and crops thereby run the risk of increased soil degradation, unless the soils are supplied with targeted amounts of phosphorus, potassium and other essential nutrients.
- Farmers' indigenous knowledge is an important social asset for soil fertility evaluation. But this knowledge must be augmented with results of targeted soil analysis and model calculations so as to identify the crop yield limiting factors precisely, and hence the best remediation strategy.
- The concepts of ideal soil fertility and saturated soil fertility provide simple, robust and cost-effective attributes for sustainable soil fertility and nutrient management. Application of these concepts will be useful especially in regions with a limited soil fertility data infrastructure. Yet, the concepts apply equally well to affluent countries coping with nutrient surpluses, eutrophication of the environment and degradation of natural ecosystems.
- Nutrient balances indicate the degree of nutrient depletion or enrichment of systems and subsystems, provided all inputs and outputs are assessed accurately. Additional soil chemical analyses and model calculations, however, are required for assessing the availability of the nutrients to crops, while the kinetics of the nutrient transfer from one pool to another pool ultimately defines whether the supply of nutrients meets the demand by the growing crop. The kinetics of the potassium transfer from the 'stable soil reserve' to the 'labile soil pool' appears to be a critical factor in the intensification of rice cropping from two to three rice crops per year in the Mekong delta in Vietnam.
- The management of soil fertility and nutrients resources for sustainable crop production is highly complex, and becomes even more difficult with the current trends of liberalization of markets, urbanization and decoupling of crop and animal production systems. Evidently, there is a great need for integration of sound environmental policies with agricultural and socio-economic policies, at global, continental, regional and local levels. There is also need for increased capacity building so as to let farmers

practice nutrient management for sustainable agricultural production in tropical agroecosystems.

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