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Old tree root channels in acid soils in the humid tropics: Important for crop root penetration, water infiltration and nitrogen management

M. VAN NOORDWIJK[1], WIDIANTO[2], M. HEINEN[1] and KURNIATUN HAIRIAH[2]
[1]*Institute for Soil Fertility Research, P.O. Box 30003, 9750 RA Haren, The Netherlands and* [2]*Soil Science Department, Faculty of Agriculture, Brawijaya University, Malang 65145, Indonesia*

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Abstract

Under high rainfall conditions on acid soils with shallow crop root systems the rate of N leaching is high. A simple model predicts nitrogen uptake efficiency as a function of the amount of rainfall in excess of evapotranspiration, rooting depth and degree to which N leaching is retarded in comparison with water transport. Field observations on acid soils in S.E. Nigeria and S. Sumatera (Indonesia) showed that this model should be amended to include the role of old tree root channels. Crop roots can follow these channels, which are coated with partly decayed organic matter, into the acid subsoil. Measurements of water infiltration with a Guelph permeameter and a methylene blue dye showed that such channels form the major infiltration sites during rainstorms. Implications for nitrogen use efficiency and cropping pattern are discussed.

Introduction

In the humid tropics acid soils dominate. Efficient utilization of nitrogen by natural vegetation and/or crops under these conditions is hindered by high rates of leaching and by shallow rooting due to subsoil toxicity. The resulting low nitrogen supply is often a major constraint to plant production. Use of fertilizer N is limited by a low agronomic efficiency, unfavourable cost/benefit ratios, poor accessibility and increasing concern for environmental effects. To obtain a higher agronomic N use efficiency, basic soil and plant processes should be known.

Van Noordwijk (1989) presented a simple model for N leaching and uptake by crops under conditions of high rainfall. The model is based on one-dimensional flow of water, nitrogen and other nutrients in the profile, driven by the excess of rainfall over evapotranspiration. Recovery of nutrients is possible within an 'effective rooting depth', defined for each nutrient on the basis of a root length density (L_{rv}, cm cm^{-3}) nutrients at the rate required by the crop (De Willigen and Van Noordwijk, 1987). Various patterns of nutrient release in the topsoil during the growing season were compared to study the relative importance of *synchronization* of nutrient release and crop demand. As shown in Table 1, the rooting depth required to make a nutrient recovery of at least 80% possible, depends on the excess rainfall and the retardation factor, K_a.

Retardation of nutrient movement with respect to water flow can be based on three types of mechanism:

a) Interactions between solid phase and soil solution (adsorption or ion exchange). Adsorption constants are generally much higher for ammonium than for nitrate, so the rate of nitrification is important for potential N leaching. In a model incorporating pH-dependent nitrification, De Willigen (1985) showed that increasing the pH of acid soils may decrease N use efficiency by crops.

b) Microbiological immobilization/mineraliza-