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Quantitative root ecology as element of soil fertility theory

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Abstract

Quantified hypotheses on the relation between root density, mobility of the nutrient concerned and possibilities for actual uptake have to be developed and tested as building stones of 'soil fertility theory'. Depending on the mobility of the nutrient concerned and the buffering capacity of the soil-root system, emphasis should be placed on a comparison of nutrient supply and demand in time ('synchronization') or in space ('synlocalization'). A model approach is outlined.

Introduction

Through a largely empirical approach farmers and agricultural scientists in the past have developed effective techniques for manipulating the root's environment to increase crop yields, despite their limited understanding of root growth and function. A system of fertilizer recommendations was developed on the basis of large numbers of field trials, with only qualitative concepts of underlying processes. As the economic and environmental demands on agriculture shift from 'maximum production' to 'high efficiency at high production levels', a finer attuning of fertilization to actual crop requirements is necessary, which demands a better, quantitative understanding of underlying processes, including root growth and function. In a strict economic sense it is no problem if through empirically based fertilization techniques only 50 % of nutrients applied as fertilizers are taken up by the crop. Present-day pressure on agriculture, however, requires maximization of nutrient use efficiency in agricultural systems, as nutrients not used by the crop generally lead to environmental problems (pollution of surface water, groundwater, soil or air) and fossil nutrient supplies and fossil energy used for making fertilizers are derived from limited resources. Recent development of soil analysis schemes to adjust N fertilization levels for potatoes to the amounts of mineral N in the soil may serve as an example: the method does not improve yields, but gives equal economical results to the farmer while saving, on average, 40 kg N per ha on the conventional advice of applying 245 kg ha regardless of soil N levels (Neeteson, 1985). Still, only about 60 % of the N fertilizer applied is taken up by the potato crop. The fine-tuning of fertilization schemes which is now required probably cannot be accomplished unless we have better quantified theories about the balance between nutrient demand by the crop and nutrient supply from the soil. The uncertainties and variation inherent in the purely experimental approach hinder the refinement required.