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Root, shoot and soil parameters required for process-oriented models of crop growth limited by water or nutrients

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Abstract

A review is given of the prospects for using process-oriented models of water and nutrient uptake in improving 'integrated agriculture'. Government-imposed restrictions on the use of external inputs will increase the likelihood of (temporary) nutrient or water stress in crop production in NW Europe and thus a better understanding is required of shoot-root-soil interactions than presently available. In modelling nutrient and water uptake, three approaches are possible: 1) models-without-roots, based on empirically derived efficiency ratios for uptake of available resources, 2) models evaluating the uptake potential of root systems as actually found in the field and 3) models which also aim at a prediction of root development as influenced by interactions with environmental factors. For the second type of models the major underlying processes are known and research can concentrate on model refinement on the one hand and practical application on the other. The main parameters required for such models are discussed and examples are given of practical applications. For the third type of models quantification of processes known only qualitatively is urgently needed.

Introduction

The tradition of root ecological research in the Netherlands dates back to the beginning of the 20'th Century (Maschhaupt, 1915). Although concepts (Greenwood et al., 1985; Schuurman, 1983; Van Noordwijk and De Willigen, 1987; Wiersum, 1962) as well as methods (Schuurman and Goedewaagen, 1971; Van Noordwijk, 1987) of root research have shown considerable development since then, knowledge of root growth and function is not often applied directly to farm management. Farm operations such as choice of crops and cultivars, type and amount of fertilizer applied at a specific time and place, soil tillage, drainage and irrigation are still largely guided by empirical evidence of yield effects or by management models in which empirically derived water or nutrient uptake efficiencies (output/input ratios) are used. This category of models can be designated as 'models-without-roots'. Research aimed at avoiding nutrient and water limitations to crop production could progress without detailed description of the plant response to such limitations, as long as the environmental effects of excess applications were disregarded. Presently, a much sharper identification of the transition zone between insufficient and surplus is required as environmental problems are not restricted to situations of a real excess, but start within the range of soil nutrient levels required for near-maximum crop production (Neeteson et al., 1989; Van Noordwijk et al., 1990). This is certainly the case when the spatial heterogeneity of agricultural fields is taken into account (Van Noordwijk and Wadman, 1992). Instead of aiming at a complete avoidance of 'stress' conditions, farm management in 'integrated' agricultural systems will be directed at minimizing losses of yield and crop quality while keeping environmental side-effects at acceptable levels. The increasing concern

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