MODELLING SOIL NITROGEN DYNAMICS AND NITROGEN UPTAKE OF CAULIFLOWER CROPS

H. Kage, C. Alt & H. Stützel

Inst. for Vegetable & Fruit Crops, Univ. Hannover, Herrenhaeuser Str. 2, D-30419 Hannover, Germany, E-mail:kage@gem.uni-hannover.de

Introduction

Crops from intensive vegetable cropping systems like cauliflower often have high nitrogen uptake rates because of high nitrogen contents of their organs and high growth rates. However, often these crops also have comparable low total root lengths, especially when cultivated as transplants. This agronomic practice shortens their growing period on the field and thereby the time available for the root system to exploit the soil volume. High specific nutrient influx rates have therefore to be maintained throughout the crop's growing period in order to ensure maximum growth. Under similar conditions this is only possible with higher soil nitrogen contents than for crops with higher total root length. Higher residual soil nitrogen contents, however, may lead to leaching losses and therefore to a decrease of the nitrogen use efficiency of the cropping system and to environmental problems.

Methods

The two year field experiment used in this study is already described by (Alt *et al*., 1999). Within this experiment four nitrogen supply rates are combined with two light intensity regimes (shaded/not shaded) in a split-plot design. The N-supply rates were 450 (N3), 300 (N2) 150 (N1) kg N/ha including soil mineral nitrogen from 0-60 cm soil depth and zero nitrogen (N0) fertilisation.

The model used for analysing the data consists of an evapotranspiration module based on the Penman-Monteith approach, a soil water transport module based on a diffusion formulation of the soil water transport equation, a module based on the convection dispersion equation for vertical nitrogen transport, a simple carbon dynamics based mineralisation model, an empirical algorithm for root growth and a single root model (Baldwin *et al*., 1973) for potential nitrate uptake rates of the root system. For a description of an earlier version see Kage (1997). The model modules are integrated within the HUME modelling environment (Kage and Stützel, 1999).

Results

Actual nitrogen uptake rates of cauliflower crops are compared with potential, transport-limited uptake rates and calculations of apparent mass flow (Fig. 1). The unfertilised cauliflower crop from the N0 treatment, becomes N limited in growth shortly after day of year 220, which can be seen from the convergence of the calculated actual and maximum crop nitrogen uptake rates. Under these N limited conditions mass flow has only minor importance for N transport to roots. Also the N1 crop is N-limited in growth during the last third of the growing period, whereas the crops from the N2 and N3 treatment were not N limited throughout their growing period. Generally, with increasing supply rate of nitrogen, the contribution of mass flow to potential uptake rates increases and may even exceed the actual N demand of the crop. (Fig. 1).

Fig. 1: Calculated crop nitrogen uptake rates, apparent mass-flow and maximum nitrogen uptake rates of cauliflower crops under 4 different levels nitrogen fertilisation.

Conclusions

Mechanistic modelling of the crop's nitrogen demand and of nutrient transport and uptake processes in combination with appropriate experimental data may allow to define lower limits for soil nitrogen contents needed for optimal growth under changing environmental conditions.

References

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