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CROP DEVELOPMENT
FOR THE COOL AND WET REGIONS
OF EUROPE

NITROGEN CYCLING AND LEACHING IN COOL AND WET REGIONS OF EUROPE

— WORKSHOP —

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A Simulation Model of Mineral Nitrogen in Soils

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Introduction

Nitrogen has been at the center of attention of agricultural scientists for several decades. Initially, most studies focused on increasing crop yields with fertilizer while maintaining reasonable production costs. Presently, much research is conducted primarily for environmental purposes because many aquifers are now or threaten to be contaminated by nitrate and other pollutants.

Research objectives as well as the tools available to lead them have changed. Among the new techniques are the use of the isotope ^{15}N that allow one to 'follow' an atom through its journey in the soil and the plant, and the development of comprehensive models.

In order to increase the level of understanding of the behavior of mineral nitrogen in loamy soils (bare and cropped to winter wheat) such a model has been developed at the Faculté des Sciences Agronomiques de Gembloux.

General description of the model

Comprehensive simulation models are formed from a set of equations that contain the hypotheses assumed by the modeler about the behavior of the system and the processes he tries to reproduce. The subject model uses a one day time step and a 15 cm depth step, meaning that it computes for every layer of 15 cm the daily intensity of all the processes modeled by solving the set of equations that describe the system.

Model input

The input data necessary to run this type of model are typically readily available. In the present case they include daily weather data (mean temperature, precipitation, evaporation and evapotranspiration), basic soil characteristics (humus content, drainage characteristic, bulk density, sand, silt and clay content), crop residue information (biomass, composition, date of incorporation), amount of fertilizer applied and date of application, and sowing date of the crop.

Processes modelled

Modelled processes include mineralization of stable and fresh organic matter, denitrification, nitrate leaching, root uptake and fertilizer reversion. In the model, nitrification occurs instantaneously after mineralization. The microbial processes are affected by temperature and soil water content whose effects are quantified through two response factors varying between 0 and 1. The responses represent the ratio of process intensity between actual and optimum conditions.

The model water routine is based on a cascading approach that computes the water content of each layer and water flows between them as a function of precipitation, evaporation and evapotranspiration, and soil characteristics[1].

Stabilized organic matter is quantified by zero order kinetics Those coefficient is estimated from an empirical regression on humus content and drainage quality of the soil.

Fresh organic matter decomposition is modeled by first order kinetics. Its constant is calculated as a function of the residue composition[2].

Denitrification is also assumed to follow first order kinetics as it depends largely on the amount of available nitrate. Its intensity is enhanced by the presence of soluble organic compounds derived from crop residues.

Leaching is quantified by the traditional product of water flow, nitrate concentration, and a leaching efficiency factor[3].

Root uptake is quantified by Michaëlis - Menten based kinetics[4] whose maximum varies daily as a function of crop demand. The latter is generally proportional to the crop growth rate.

The uptake is distributed in the different soil layers in proportion to root content. Root density is assumed to decrease exponentially with depth. In the present version of the model, crop growth is quantified by an empirical sigmoidal curve and the sum of temperature since sowing.

Mineral fertilizer immobilization is assumed to be a fraction of the amount applied, whatever the amount.

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