EU-Rotate_N

European Community network to develop a model based decision support system to optimise nitrogen use in horticultural crop rotations across Europe

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Welcome

This second newsletter of four contains reports on project activities over the last year. EU-Rotate_N is a four year project, funded by the European Commission within the Fifth Framework Programme project and is co-ordinated by Dr Clive Rahn at Warwick HRI.

The project aims to develop a model based support system to optimise nitrogen use in conventional and organic field vegetable rotations across Europe. The project started in January 2003. EU-Rotate_N will build on work completed by a previous European project, ENVEG. The project website is www.hri.ac.uk/eurotate.

Aims and Objectives

Most vegetables within Europe are produced in intensive rotations, which rely heavily on large inputs of nitrogen from fertiliser or organic sources to maintain the yield and quality of produce. Unfortunately, many field vegetable crops use nitrogen inefficiently and often leave large amounts of nitrogen (either as unused fertiliser or crop debris) in the soil after harvest, potentially causing pollution to soil, water and aerial environments.

Recent research has shown that the environmental impact can be reduced without loss of yield or quality by improving the design of rotations and by more closely matching nitrogen supply to the demands of individual crops. The main project deliverable is a decision support system that can be used to compare the effects of different crop sequences, fertiliser rates and other management practices on the cycling of nitrogen within rotations, for widely different production systems and climatic conditions across Europe.

The decision support system

EU-Rotate_N is based on the N_ABLE model (Greenwood, 2001) which consisted of 20,000 lines of code. Un-necessary or duplicated parts of the code have been removed and the remaining code has been rebuilt into nine discrete modules. These modules have been incorporated into a database framework designed by Tessella in conjunction with HRI to allow easier upgrading in the future. Tessella have recently built a modern windows based Graphical User Interface which will make use of the decision support system easier.

New sub-models are in the process of being added, some of which are described below. A large experimental dataset is now being assembled by the participants that will be used to assess the new decision support system for fitness of purpose across cropping rotations in Europe. The new decision support system will be able to evaluate agricultural strategies with respect to N losses and economics. IGZ have reviewed the concept of optimising management practices and are co-ordinating the

The participants attending the 3rd meeting at IVIA in Spain in 2004.

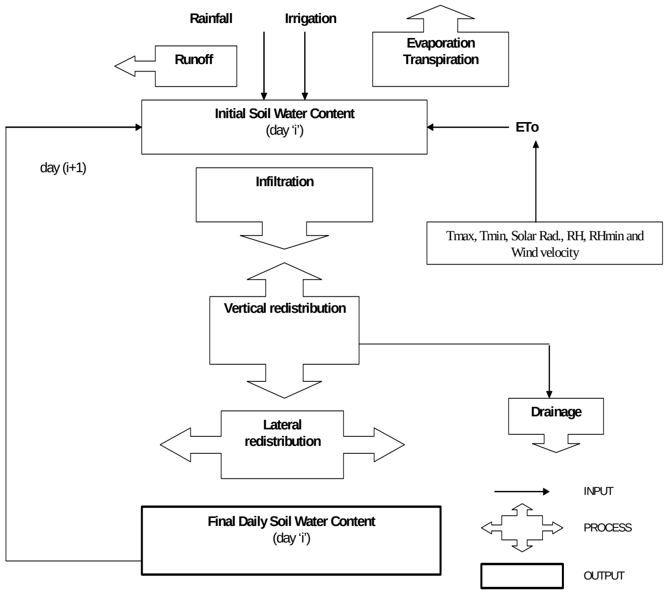
collection of data for representative 'model' farms in each participanting country.

References: Greenwood DJ. 2001. Modelling N-response of field vegetable crops grown under diverse conditions with N_ABLE: a review. Journal of Plant Nutrition, 24, 1799-1815.

This is a EU project, number QLK5-2002-01110, which is funded under the Quality of Life Programme, Key Action 5 – Sustainable agriculture. However, the information contained within these pages in no way reflects the views of the European Commission or its services.

New sub-model: Water movement by Carlos Ramos and Jordi Doltra

Water plays a key role in plant growth and nitrate transport through soil so a good water sub-model is important. In the N_ABLE model, no account for runoff was taken. In our new model, a runoff sub-routine will be included to predict how much of the applied water in rainfall will infiltrate into the soil. This is based on the former Soil Conservation Service (USDA) procedure that has been used in many soil water models.



Evaporative demand will be calculated from commonly available weather data, using the reference evapotranspiration approach based on the Penman-Monteith equation. In cases where data is not available empirical equations developed for USA climates will be used. These equations will be tested using European weather data bases to be sure they work well under the different climates in the European Union.

Actual evaporation in N_ABLE is limited only by soil moisture deficit, which is calculated as the difference between field capacity and soil water content. This assumption leads to an over-estimation of evaporation under conditions of high evaporative demand and low soil water content, as occurs in the dry season. Substituting the current algorithm with the classical two stages evaporation approach of Ritchie (1972), later modified by Brisson and Perrier (1991), improves soil water evaporation prediction in the whole season and in semi-arid environments.

Infiltration and drainage processes are simulated in N_ABLE following a capacity (or cascade) based approach with no account for water redistribution once it has infiltrated after irrigation or rainfall. The introduction of algorithms related to water redistribution should allow a more realistic simulation of soil water movement. These modifications have been shown to improve soil water content prediction with data from different soil and climatic conditions while maintaining the original capacity-based structure and, therefore, a reasonable degree of model simplicity.

Drainage from a particular soil layer will use a function based on Ritchie (1998). In this approach, water content exceeding field capacity, in any soil layer, drains to the layer below provided that it is not saturated. The water actually draining is limited by a drainage coefficient (that depends on soil texture), which accounts for the effect of the soil hydraulic conductivity. In order to extend the model to temperate and semi-arid areas of the Mediterranean European countries, we will include a function to allow capillary water movement from a water table or from a wetter soil layer to a drier one. This diffusion-based concept approach has proved to be useful for predicting soil water in dry soils where evaporation and capillary movement are predominant.

References:

Brisson, N. and Perrier, A. (1991). A semi-empirical model of bare soil evaporation for crop simulation models. Water Resour. Res. 27: 719-727.

Ritchie, J.T. (1972). Model for predicting evaporation from a row crop with incomplete cover. Water Resour. Res. 8(5): 1204-1213.

Ritchie, J.T. (1998). Soil water balance and plant water stress.G.Y. Tsuji et al. (eds): Understanding options for agricultural production p. 41-54.

New sub-model: Nitrogen mineralisation by Claas Nendel

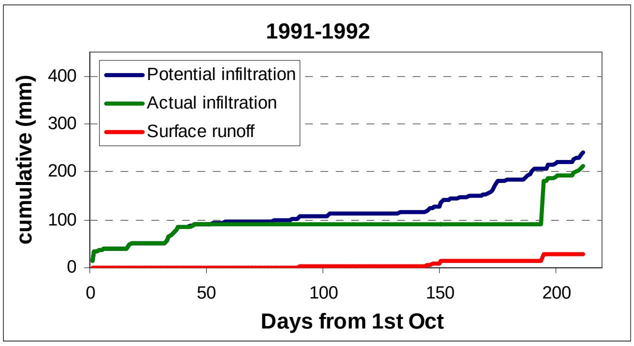
One of the main sources of nitrogen for crops is stored in the humic substances, the soil organic matter. In this form the nitrogen is not available to the plant roots, as they predominantly take up water soluble forms such as nitrates (NO_3^-) and ammonia (NH_4^+) to satisfy the needs of the crop. Soil micro organisms, which utilise organic matter as an energy source, leave mineral nitrogen compounds as a waste product, which can be taken up by plant roots. The soil micro organisms are an important part in the soil-crop nutrient cycle. This breakdown of organic nitrogen compounds into their mineral form is called nitrogen mineralisation.

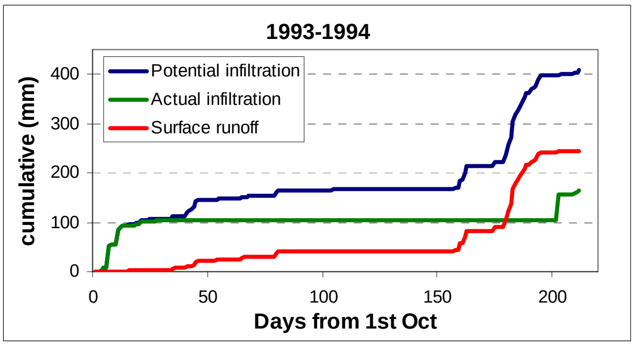
The current N mineralistion routine in the N_ABLE model is simple as it supplies a constant daily input of mineral N to the soil based solely on soil temperature. Since the amount of N which is mineralised from soil organic matter varies little from year to year this approach works well in a constant and un-changing environment. The values used for central England are 0.7 kg N/ha mineralised per day at a soil temperature of 15.9°C.

However, the new model is intended for use across many different climatic conditions and soils in Europe so requires a more sophisticated approach to describe mineralisation. We intend to use a modified routine from the DIASY model where mineralisation is calculated as a function of soil temperature, moisture content and of the amount of soil organic matter. Its concept of different organic matter fractions with specific decomposition rates allows not only the simulation of soil organic matter decay and the subsequent N release but also the ability to predict N mineralisation from different organic fertilisers and crop residues, which may be occasionally added to the soil during field vegetable production.

New sub-model: Snow and frost by Hugh Riley

The N-ABLE model contains a water balance sub-routine that simulates water percolation and associated nutrient leaching. These existing sub-routines do not make allowance for the cold winter conditions found in Scandinavia and in central Europe, where the incidence of snow and frost has important implications for leaching. Soil freezing acts as an effective barrier to water movement, and hence prevents leaching, whilst snow cover influences the depth of frost and consequently the amount of water that may infiltrate into the soil.





Many detailed models exist for both snow dynamics and soil freezing and thawing. Our challenge has been to find an approach with low levels of complexity and requirements for input data, suitable for incorporating into the existing water balance model. Elements from existing Scandinavian models have been used and tested on our own data. Snow dynamics are calculated using a development model from the Helsinki University of Technology (Tuomo Karvonen, www.water.hut.fi), soil freezing using an approach suggested by colleagues at the Agricultural University of Norway (Olsen & Haugen, 1997) and soil thawing using a routine from the ECOPMAG model developed at the University of Oslo (Motovilov et al., 1999).

The way in which winter conditions may affect water infiltration and associated leaching, is illustrated for two winters with contrasting weather conditions. The winter of 1991-1992 was relatively mild, with short periods of snow cover and intermittent snow thaw. The soil remained frozen at depth, but partial thawing allowed much of the thaw water to infiltrate, reducing surface runoff. Such conditions are likely to give high leaching.

The winter of 1993-1994, on the other hand, was uniformly cold with a large amount of snow. Although this gave a lower depth of frost penetration, there were fewer periods with partial soil thaw. This resulted in much of the snow meltwater being passed to surface runoff. The amount of leaching occurring under such conditions is thus limited, and this has important implications for the availability of residual soil nitrogen for following crops.

References:

Motovilov YG, Gottschalk L, Engeland K & Belokurov A. 1999. ECOMAG: Regional model of hydrological cycle. Application to the NOPEX region. University of Oslo, Department of Geophysics, Report Series No 105, 82 pp.

Olsen PA & Haugen LE. 1997. Jordas termiske egenskaper. Rapport nr. 8/97 Norges Landbrukshøgskole, Institutt for Jord- og vannfag, ISSN 0805 - 7214, 14pp.

Fertility building crops in organic systems by Francis Rayns

Effective nitrogen management is a major challenge in organic farming and is normally solved by the use of fertility building crops. The primary source of nitrogen is fixation from the atmosphere through the use of leguminous plants. Although there are a number of acceptable inputs which can also supply nitrogen – in particular animal manures – these are usually only of secondary importance. Non legume plants (especially grasses) may be grown with the legumes to help add organic matter to the soil and to modify the pattern of its mineralisation.

Organic crop rotations are often thought of as having two phases: fertility building and fertility depleting (ie the cash cropping phase). While this may be true for arable systems, the situation is more complicated in field vegetable production. Fertility building crops can be divided into a number of categories.

- **Leys**. These usually contain both grass and clover (sometimes just clover) and are grown for a period of one or two years. They may be grazed in mixed systems or maintained by cutting and mulching in stockless situations.

- **Summer green manures**. A wide range of species may be grown. Legumes may add a boost of nitrogen to the soil in mid-rotation while non legumes may be grown to add organic matter. They are more important in more intensive vegetable rotations.

- **Winter green manures** (often known as cover crops). These are often grown primarily to reduce nitrate leaching – a cereal such a rye is generally the most effective for this purpose.

- **Intercropping systems.** The most common situation here is a cereal crop undersown with clover but there has been some experimentation with growing fertility building crops and vegetables together. This practice can bring pest control benefits but there is a danger of competition with the crop if the understory becomes too vigorous.

Growing fertility building crops is expensive; there are direct costs of seed etc and no direct cash benefits while the land is out of production. This is particularly the case in stockless systems when leys cannot be used for grazing by animals. It is therefore important to make the best use of fertility building crops and this is an area where the EU_ROTATE_N project could be of help. It is important for a farmer to know both how much nitrogen a particular crop is likely to add to his soil and when this is likely to become available. Will there be enough fertility to grow the series of cash crops which he is planning? Does the planned rotation make the best use of the nitrogen available from fertility building crops or will it be lost by leaching?

Within the EU-Rotate_N project we are gathering information about a wide range of fertility building crops. We are also conducting validation trials under organic conditions with which to test the model when it has been developed. This should mean less guesswork when the farmer of the future is planning his rotations.

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