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

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. This, the third newsletter reports on the progress of the EU-Rotate_N project during 2004/5.

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 has its own website at www.hri.ac.uk/eurotate.

Aims and Objectives

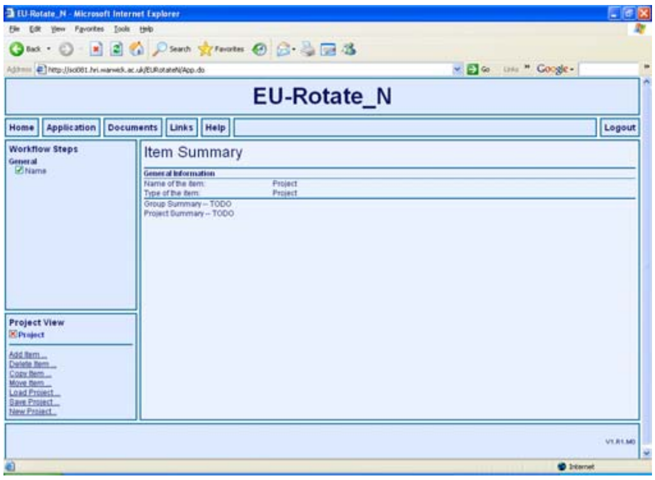
Most vegetables within Europe are produced in intensive rotations, which rely heavily on large inputs of nitrogen from fertilizer or organic sources to maintain the yield and quality of produce. Unfortunately, many field vegetable crops use nitrogen inefficiently and often leave large amounts of nitrogen (either as unused fertilizer 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, fertilizer rates and other management practices on the cycling of nitrogen within rotations, for widely different production systems and climatic conditions across Europe.

Progress so far

The new EU-Rotate_N model is based on the original N_ABLE model but includes new routines for nitrogen mineralisation from soil organic matter, animal manures, plant residues and green manures, immobilisation due to snow and frost, water movement within the soil environment and root growth. The way in which these different modules interact has also changed. A new approach has been developed which sub-divides the soil, horizontally and vertically, into ‘cells’. This enables more sophisticated calculations to be made of soil and water dynamics and root growth.

A MS Access databases is an integral part of the model. This contains all the crop, soil, weather and economic data required to ‘grow’ the crop in the model. The new model also boasts a new user interface which runs within a web browser. It uses the standard Microsoft approach to tasks and menus and is designed to be easier to use than previous versions of N_ABLE and MORPH. The entry screen is divided into three boxes which show different areas of the simulation: the main data entry area where the day to day crop management options can be entered or chosen from a default list, a project view box which allows the user to open, edit and save individual simulations and a scenario navigation box where individual simulations can be aggregated to form scenarios and where ‘what if’ type questions can be answered.



This model can simulate the growth of both conventional and organic crops, this has been achieved by adding the ability to ‘grow’ fertility building crops in any simulation. The one area, where we hope that the new model will prove useful is the inclusion of an economics output and the ability to answer ‘what if?’ type questions.

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The effects of varying nitrogen supply on the economics of vegetable production by Ulrich Schmutz

The EU-Rotate_N model contains a database of standardised prices, variable costs and gross margins for all of the major field vegetables grown across Europe. This database extends to both conventional and organic systems and includes information on non-vegetable crops which are commonly used within rotations, e.g. cover and fertility building crops and the major cereals.

Like N_ABLE, upon which it is based, the normal output from the agronomic part of the model is total plant dry weight, however, in order to calculate a gross margin, this has to be converted to marketable fresh weight. Even at the optimum nitrogen rate this is not straight forward since the ratio of total dry weight to marketable fresh weight varies greatly with plant species. At sub-optimum nitrogen rates and/or in organic systems with a limited nitrogen supply, this conversion ratio can vary greatly. Since this ratio is the major factor in deciding whether a crop is economic to grow or not, it is essential that this relationship is correctly established. In order to overcome these inherent crop variability's, three types of relationship have been used:

1. Crops with a simple linear relationship at all available nitrogen levels
2. Crops with a simple linear relationship at the optimum nitrogen level
3. Crops which are generally non-linear, more complex or with multiple harvests

Two different approaches have been developed to calculate the marketable yield at varying nitrogen supply. The first is direct conversion using empirical data from field experiments from across Europe. The second is more evolved and uses plant spacing and average plant weight distribution in combination with distinct quality classes to predict gradeouts and hence marketable yield and crop residues (Figure 1). Both approaches are used within the model depending on the type of crop and it's relationship between fresh marketable yield and nitrogen supply.

Now that these relationships have been resolved, it is possible to see what effect the available soil nitrogen has on fresh marketable yield and gross margin. This will enable farmers and growers to experiment with reduced nitrogen inputs and judge the effect on their gross margin but without the real risk of crop failure or reduced crop quality.

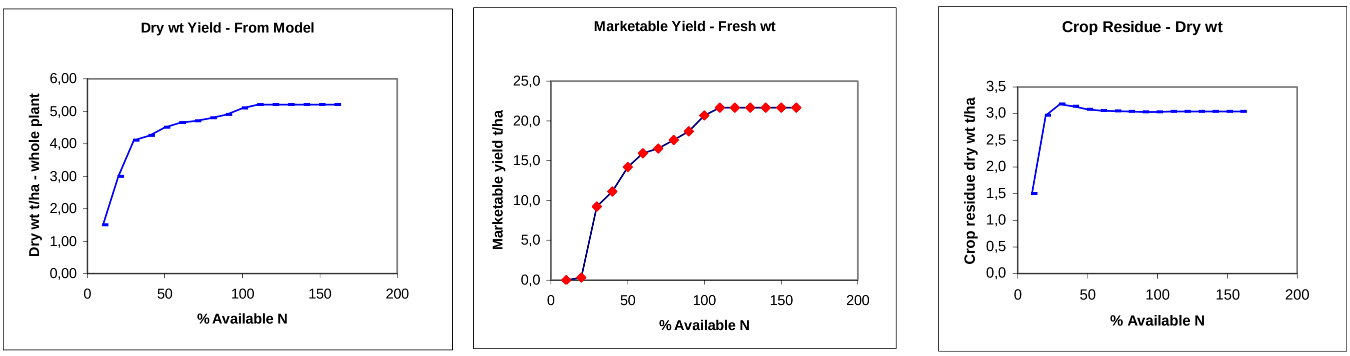

Figure 1. The relationship between total dry weight, marketable fresh weight and crop residue at varying nitrogen supply

Scenario testing by Claas Nendel

The new EU-Rotate_N model is more than just another decision support system for nitrogen fertilizer recommendations. A major advantage will be its ability to run simulations on a broader scale, up to regional, national and EU level. It will achieve this by aggregating hundreds of individual simulations and presenting them as a single result. The model includes a new database which contains information on hundreds of 'typical' crop rotations from across Europe which when combined with the new economics module will make it a very powerful tool for policy and decision making. The model will be able to answer 'what – if' type questions.

What is a scenario? For example: a policymaker would like to know what would happen to the average farmer's income in his region, if the use of nitrogen fertilizer was restricted to 80% of the current recommended rate. The approach is to run two scenarios and then compare the differences. Scenario one, using the normal nitrogen fertilizer rate, would produce an average per farm gross margin on a regional basis. Scenario two, using 80% of the normal rate, would produce the same output. At a glance, it would be possible to see any reduction in regional gross margins. In additional to an economic judgement, environmental concerns can also be assessed since the model outputs also include an estimate of nitrate leaching at this scale.

Complications can arise when using a point model for larger scale simulations. The model was originally designed to simulate an infinitively small area. So, in theory, one simulation tells you about the nitrogen dynamics in one soil type when one plant is grown under the influence of one set of site-specific weather conditions. In reality, the simulation area is field sized since in the majority of cases, data from field scale experiments was used to programme and validate the model (Figure 2).

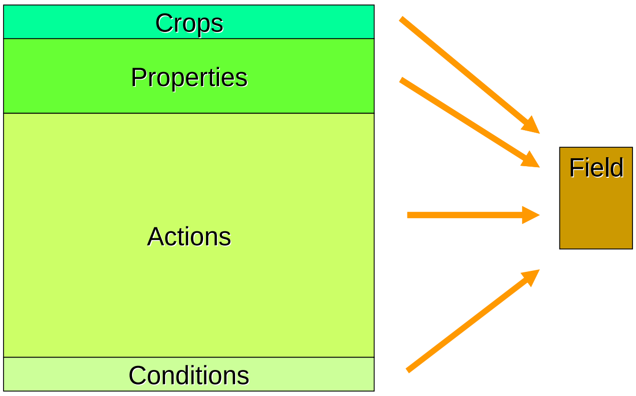

Figure 2. A single model run on a specific vegetable field (smallest spatial unit) under specific environmental conditions

Simulating field vegetable production on a larger scale requires the multiple simulations of single fields. These fields have to fulfil some requirements. Firstly, fields need to be representative of a typical farm, area or region. This requires data for soils, crop rotations and weather for typical farms across a region or country. The aggregated simulations that can then be produced are a representation for a larger area. Within the EU-Rotate_N model, various up scaling levels can be defined. A farm is defined by simulating several fields, a region by simulating several farms and a nation by simulating several regions (Figure 3).

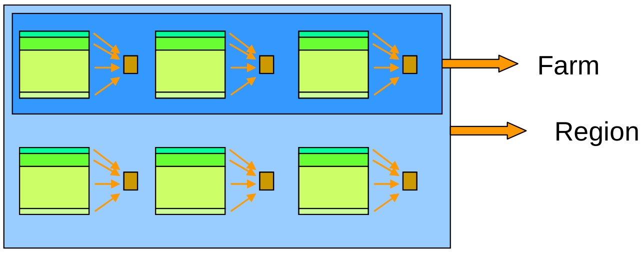

Figure 3. A group of simulations but on different fields make up a scenario

Inbuilt into the model are statistical routines and local expert knowledge which define the best set-up for the desired scaling levels (target level) and a distribution key for later calculation of the model output.

Once the target levels are defined by the number and type of fields to be simulated, the model is ready to tell "what happens, if…"

The 5th meeting in February 2005

The participants gathered at CRA-ISOR in Salerno, Italy in February to discuss the progress of the new model and to map out the final two years of the project. Two years of field experiments have been completed on time and the data stored in a newly designed database. All the new modules have now been delivered from the participants although model programming has proved more time consuming than anticipated, as has designing and constructing the databases. The project is currently two to three months behind schedule although the new model is expected to be delivered on time in 2007.

Field experiments in 2003/4 by Hugh Riley

The main purpose of the field trials was to generate data for model validation. Although a large amount of data was available to us, there were certain crops and rotations where more was required. The field trials addressed these concerns. All the data collected is now stored in an especially designed MS Access database.

In England, HDRA have concentrated on organic rotations using a combination of five vegetable crops: carrots, beetroot, French beans, calabrese and leek. Treatments included different previous cropping history (duration of fertility building crops) and the use of farm manures. Total and marketable yields and nitrogen uptakes were measured and soil mineral nitrogen was sampled on several occasions. Additional data has been collected on soils and crops on a soil with greater inherent fertility.

In Norway, NCRI have grown two crops with deep and shallow rooting (white cabbage and onions) at both an inland site (cold winter, retentive soil) and a coastal site (milder winter, leaching-prone soil) at which different levels of crop residues and soil nitrogen had been established in 2003. Responses to three levels of N in 2004 were studied, as well as residual effects from the previous year. Soil mineral N was also monitored.

In Germany, IGZ has monitored soil mineral nitrogen, as well as yields and nitrogen uptake of crops in 19 intensive vegetable rotations in SW Germany and in 8 more extensive rotations in NE Germany. Frequent measurements of soil mineral nitrogen have been made and the dataset includes a large range of crops and growing regimes.

In Spain, IVIA have monitored trials on three farmer fields. One is a two-year nitrogen fertilizer trial with artichokes with harvesting from November 2003 to May 2005. At the other two sites, lettuce and onion have been grown in rotation under different irrigation regimes (drip irrigation and furrow irrigation) to study their effects on nitrogen use efficiency (furrow irrigation being the traditional method). Soil mineral nitrogen has been measured at all sites and nitrate leaching by means of suction cups at selected sites. The sites have also provided data on soil moisture dynamics under drip irrigation.

In Denmark, DIAS has studied the carry-over of nitrogen from early and late cauliflower grown in 2003 at different levels of fertilizer input. Three crops with different rooting depth (lettuce, sweet corn and white cabbage) have been grown at two levels of nitrogen input (zero and optimum fertilizer) and their root growth, nitrogen uptake and soil nitrogen depletion has been measured.

In Italy, ISOR have used a rotation of four vegetable crops (brassicas, fennel, lettuce and spinach), grown using three levels of nitrogen fertilizer. Frequent measurements have been made of crop dry matter development and nitrogen uptake. Soil mineral nitrogen has been measured at planting and harvest of each crop. Additionally, root depth has been measured at harvest and crop growth has been expressed in relation to available nitrogen.

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