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

Welcome to the EU-Rotate-N project. This is the first of four newsletters which will be published during the life of the project. This newsletter introduces both our project and our ambitions. We hope that you will find it interesting and informative. The EU-Rotate_N project is co-ordinated by Dr Clive Rahn at HRI Wellesbourne. EU-Rotate_N is a four year project, funded by the European Commission within the Fifth Framework Programme.

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. The project has seven participants and three sub-contractors representing seven countries. 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

The aim of this project is to develop, and then evaluate, a model-based decision support system to optimise nitrogen use in both conventional and organic vegetable rotations across Europe. This will help Member States to:

- minimise hazards to the environment by adopting consistent approaches to improved efficiency of nitrogen use for different production systems and climatic regions of Europe

- optimise production of quality horticultural crops while enhancing the economic sustainability of horticultural production within the EU

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 this can cause 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 improved the design of rotations and by more closely matching nitrogen supply to the demands of individual crops. This project will exploit these new techniques to develop a flexible integrated decision support tool, based on models and databases, for nitrogen management and rotational planning in conventional, organic and other low input production systems. This support tool will then be used to compare the effects of different crop sequences and fertiliser rates and other cultural practices on the cycling of nitrogen within rotations, for widely different production systems and climatic conditions across Europe. It will be used to :

- Recommend protocols of Good Agricultural Practice, including nitrogen use in vegetable and mixed vegetable and arable crop rotations throughout Europe
- To provide a basis for choices between economic and environmental constraints to production.

The participants at the first meeting HRI Wellesbourne in February 2003.

The decision support system will be used to identify crop management strategies which lead to both reductions in nitrate leaching. These will be tested together with existing Codes of Good Agricultural Practice developed in accordance with the EU Nitrate Directive (91/676/EEC). The results will be used to develop ‘rules’ that will allow crops to be grown using environmentally sound practices as required in the

This project has been funded by the European Commission Fair Programme. The objectives of this pogramme are to promote and harmonise research in the major European primary production food and non-food sectors of agriculture, horticulture, forestry, fisheries and aquaculture and its links with the processing industries, together with rural activities and the consumer; however the information contained within these pages in no way reflects the views of the European Commission or its services.

reformed Fruit and Vegetable regime EC 2200/96, as part of the Common Agricultural Policy. Such work will help Member States satisfy the Community need for quality field vegetables while minimising the risk of nitrate leaching into ground, surface and coastal waters.

Current recommendation systems

Vegetables, particularly Brassicas, receive large quantities of fertiliser nitrogen, sometimes more than 250 kg/ha N. The economic penalties for failing to meet market criteria are so high relative to the cost of fertiliser nitrogen that growers can be tempted to apply insurance dressings of nitrogen above the optimum. On the other hand excessive amounts of fertiliser can cause cereal crops to lodge, bitterness and lodging in Brussels sprouts, reduce storability of produce as well as increase the risk of nitrate leaching. In order to allow environmental sustainability of both arable and horticultural crops there is a great need to maximise the efficiency of nitrogen use and match it to nitrogen demand. The methods for predicting fertiliser requirement include:

1. Experience
2. Applying the same amount of N to all fields
3. A simple table system
4. Using measurements of soil mineral nitrogen.
5. Computer Models

Experience is subjective and may not always lead to sound decision making. If growth is poor there is always the temptation of adding additional bags of nitrogen, but the limiting factors may be poor soil structure, pests, soil moisture, or disease problems rather than nitrogen.

Systems based on one rate of fertiliser for all crops may provide satisfactory yields for crops, but may give rise to nitrate leaching and could increase the risk of variable quality produce. An improvement is to use simple tables such as provided by Reference Book 209 (Fertiliser Recommendations) published by MAFF in the UK in 2000 to provide fertiliser recommendations for UK use, with previous cropping history being taken account of as a soil nitrogen index.

However, in high residue situations where large quantities of manure have been applied or in intensive Brassica rotations, timely measurements of soil mineral nitrogen allow more balanced fertiliser predictions to be made. These measurements can be interpreted using tables but are more effectively interpreted using computer decision support systems such as WELL_N in the UK and 'N Expert' in Germany.

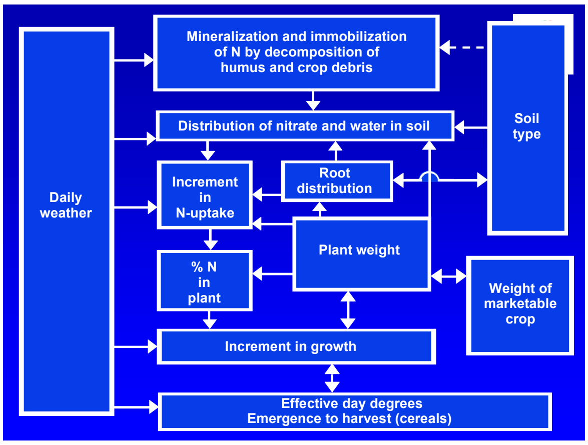
Getting the fertiliser application right involves understanding the contribution of many interacting factors such as previous crop residues, release of nitrogen from soil organic matter, rainfall, temperature, soil type, crop demand, rooting depth, planting and harvest times. Modelling provides a unique way of quantifying the effects of all these factors and the N_ABLE model was developed in the UK with such an aim in mind in order to be able to improve understanding and fertiliser prediction.

The existing model

The N_ABLE model has been developed at Wellesbourne over the last 20 years by a team led by Professor Duncan Greenwood and more recently by Dr Clive Rahn. The N_ABLE model is incorporated into WELL_N which has been used by growers in the UK to provide N fertiliser recommendations since 1994.Whilst the N_ABLE model has been used extensively in the UK its use more widely has been limited. Additionally it only operates for single crops and recent research has shown that N must be more effectively managed over whole crop rotations. This project will extend the usability of the model throughout Europe and will include tools to plan N use for crop rotations. Further details and access to an online version of N_ABLE will be provided via the EU-ROTATE-N website.

Structure of the Model

The model includes generalised relationships for growth and its dependence on plant size, nitrogen content and temperature, the development of roots, nitrogen uptake, release of nitrogen from soil organic matter, evapotranspiration, soil water content, leaching and the release of nitrogen from incorporated crop debris. The model operates on a daily timestep and provides simulations of growth and nitrogen requirement for 22 different crops including wheat, potatoes and sugar beet.



Structure of the N_ABLE Model

The future

In order to extend N_ABLE to cover the more contrasting climates of Scandinavia and the Mediterranean countries, as well as organic rotations, many new algorithms will be required. In the next two years, we intend to use existing datasets and dedicated field experiments to enable us to model many new aspects of crop-environment interactions, i.e. freeze thaw cycles, irrigation, fertigation, nitrogen mineralisation, nitrogen release from organic and green manures, and root growth in varying soils.

Extending the model to include the warmer climates of the Mediterranean countries will require the introduction of a number of new crops into the model, such as tomato, artichoke, eggplant, melon and squashes.

New sub-model: Economics

The new EU-Rotate_N model will include economic subroutines, which will be developed by Chris Firth and Ulrich Schmutz, based at HDRA in Warwickshire, UK.

The first step will be to create a database, containing economic data for all major field vegetables across the different European climate zones. This database will include price, variable cost and gross margin data for conventional and organic field vegetables. Other crops, often found in organic or conventional field vegetable rotations, like cereals or fertility-building legumes will also be included.

Using the database to link with yields generated from the main model, it will be possible to examine the effect of varying the supply of N on the economics of vegetable rotations. The effect of sub-optimal nitrogen supply on marketable yields and different costs like reduced amounts of nitrogen fertiliser or fertility building crops in organic rotations will also be accounted for. It will also be possible to examine the effect on the farm economics of using various strategies to optimise the use of N and to minimise nitrate leaching within the rotation, for example through the use of winter cover crops

Upon completion, the model could be used to scale up data for a particular vegetable producing region or country. This would allow the implications of adopting various N management strategies to be evaluated on a wider scale, at farm and the broader macro-economic level. This sub-model will therefore allow EU-Rotate_N to be used for the evaluation of nitrogen management strategies from an agronomic, environmental and economic point of view.

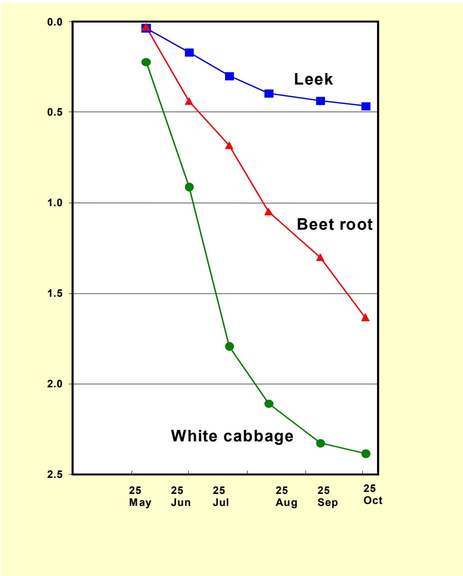
New sub-model: Root growth

The routines for simulating root growth in the existing model are very simple, here Dr Kristian Thorup-Kristensen explains why greater sophistication is required to understand how root growth is fundamental to crop growth and N uptake.

Simulation of root growth and distribution is a fundamental part of models used to simulate crop N uptake and fertiliser N demand. Models of root growth are especially critical when modelling vegetable crops, as vegetables crop species have widely different patterns of root growth. Further, vegetables are intensively fertilised and N is often left in the field, so in order to find out whether vegetable crops can utilise N leached to deeper soil layers, it is important to know their effective rooting depth. N leached to 75 cm depth may be lost to many shallow-rooted vegetables, like onion, lettuce, leek or celery, whereas N leached to 150 cm may still be available to deep-rooted crops such as cabbage.

Generally, models simulate plant processes to determine crop N demand, and soil processes to determine soil N availability. Simulations of root growth and root distribution constitute the link between the simulated plant and soil processes, and are necessary to calculate how much of the inorganic N present in the soil is actually available to the crop at any stage of growth.

At the Danish Institute of Agricultural Science we have studied root growth and its significance for utilisation of soil N by vegetable crops. Rooting depth at harvest ranged from only 25 cm for onions to more than 250 cm for white cabbage. Onions take a long time to germinate, and only increase their rooting depth at approximately 3 mm day^{-1}, while Brassica crops are very different, they establish quickly and increase their rooting depth between 15-20 mm per day; given a long enough growing season, and deep soils, they can reach very deep. We have accumulated new knowledge on root growth modelling, root growth of vegetable crops and the significance of root growth for N efficiency, which we will include in the model.



Rooting depth (m) versus time for three vegetable crops with very different root growth.

One of the main goals of the EU-Rotate_N project is to simulate cropping sequences, i.e. to simulate the effect of previous crops. The effects on N supply are determined by the retention of N in the soil from one year to the next. N may be retained in the soil in either organic form (crop residues) or as inorganic N. When organic N is retained, it will contribute to N mineralisation in the next year. This mineralisation will mainly occur in the uppermost soil layers, where even shallow-rooted crops can reach it.

However, when inorganic N is retained in the soil from one year to the next, it will generally be found in somewhat deeper soil layers due to leaching during the winter season. So, the pre-crop effect is strongly dependent on crop root growth as mainly deep-rooted crops can use such N. To simulate such pre-crop effects it is essential that the EU-Rotate_N model includes realistic models of vegetable root growth.

EU-Rotate_N. The Participants

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