Nitrogen use efficiency in oilseed rape

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Introduction

Oilseed rape production impacts on and is impacted by a range of global environmental sustainability issues. These are primarily global warming and environmental pollution, but also include a sustainable rural economy.

The primary reason for global warming is the release of greenhouse gases (GHG) from ever increasing industrial, transportation and agricultural sources. The main GHG is CO_2 which has increased from pre-industrial levels of about 280 ppm to over 380 ppm today. For a graphic display of the trend in atmospheric CO_2 levels see the US National Oceanic and Atmospheric Administration measurements taken at Mauna Loa Observatory in Hawaii. Another potent GHG is NO_x (primarily N_2O) which has a global warming potential of more than 300 times that of CO_2.

The UK is a signatory to the Kyoto Protocol which imposes on us the need to reduce emissions of GHGs by about 5.2% below a baseline level set to that of 1990. In the UK, transport fuels represent about a quarter of the national CO_2 emissions. One approach to reduce GHG emissions from transport is to substitute fossil fuels with biofuels. The principle of this is that plants obtain their carbon from atmospheric CO_2, so by using them as a fuel the potential net result is a reduction in emissions. The European Biofuels Directive provided the direction for the UK government Renewable Transport Fuel Obligation (RTFO) legislation which sets out the process that requires transport fuels to incorporate a minimum of 5% biofuel component in fuel sold in UK forecourts by 2010. This is achievable either by blending bioethanol with petrol or biodiesel with diesel and can be used directly by most engines without modification. Achieving these targets could potentially save the equivalent of about 1 million tonnes of CO_2 emissions per year.

Currently in Europe the primary feedstock for home-grown biodiesel is oilseed rape (OSR). However, Life Cycle Analysis, the process of determining the energy requirement for each component of crop production, harvesting and transport, is leading to growing concern about the environmental credentials of using rapeseed oil as a biofuel. For the UK the GHG emissions associated with OSR production have been estimated at over 150,000 t CO_2 p.a. and 83% of these emissions are associated with the manufacture and application of Nitrogen fertiliser.

> **Did you know…?** The use of nitrogen fertiliser is so vital to global crop production that the Harber-Bosch process used to convert atmospheric nitrogen for fertiliser manufacture consumes 3-5% of world natural gas production. This equates to more than 1% of the world's annual energy supply! In addition, human-related N_2 fixation now exceeds that fixed by all natural processes combined (Vitousek et al, 1997).

Historically, OSR has been grown as the main break crop in cereal rotations. In order to maximise yields OSR receives a higher rate of N fertiliser than other arable crops, with a UK average of 207 kg/ha. This, combined with the recent increase in UK annual cropping area from 557,000 ha to 750,000 ha, means that OSR has a significant environmental N footprint in the UK. In comparison to the N supply, the N offtake is only 96 kg/ha. This benefits crops following it in rotation, but

associated with this the winter following an OSR crop is particularly prone to N leaching and pollution of river courses. Soil processes also result in the conversion of significant amount fertiliser to the GHG NO_x. The net result is that approximately 83% of the CO_2 equivalent emissions associated with growing and distributing OSR is from N fertilisers.

In order to realise the potential environmental benefits of rapeseed oil for biodiesel there is a pressing need to increase the nitrogen use efficiency (NUE) of the OSR crop. This may be via increasing the yield for current N inputs or maintaining current yields using lower quantities of N. An improved NUE will also provide economic benefits at the farm gate as availability of fertilisers is increasingly becoming an issue and prices have risen steeply so that they now make up 45% of the variable costs of OSR production.

Plant breeding is widely recognised as an effective approach for delivering improved crop traits. After all, this has been absolutely fundamental to the development of human civilisation throughout the ages. Both the Stern Report and the Defra-commissioned review of the economic potential of breeding (IF0101) concluded that the development of new cultivars is cost-effective in comparison with other approaches. A summary of the current state of knowledge in this area is given in Defra desk study (AR0714) and a set of recommendations is provided to guide the direction of future research.

Compared with wheat, OSR is a relatively new crop with a considerable potential for improvement through breeding. Most trialling has been performed under high input conditions so, until recently, there has been little pressure to optimise for production under low input systems. NUE is a complex trait covering uptake, incorporation into organic material, storage and remobilisation. Surprisingly, there has been relatively little research on these processes in OSR. To start to address this, a 5 year Defra-LINK project (LK0979; Breeding oilseed rape with a reduced requirement for nitrogen fertiliser) was initiated in 2006. This project aims to identify component traits associated with NUE by assessing a number of elite varieties for their performance at high and low N, and to genetically dissect these traits to search for segments of the genome controlling them by screening mapping populations.

A key aim of the OREGIN project is to develop underpinning resources for the benefit of the OSR research and breeding communities. One of these is the *Brassica napus* Diversity Fixed Foundation Set (BnaDFFS) which provides a usable window into the genetic diversity within this species. This is a potentially rich source of genetic variation for breeding oilseed rape with enhanced environmental sustainability.

A short overview of NUE and OSR prepared for the Fresh Produce Journal can be found here.

References

Vitousek, PM et al. (1997) Human alteration of the global nitrogen cycle: sources and consequences. Ecological Applications, 7:737-750

OREGIN work related to N use efficiency in OSR:

1) **To test the hypothesis that the BnaDFFS contains genetic variation for a putative component trait associated with NUE. (insert link to N uptake report)**

2) **To evaluate the issues with identification and characterisation of putative candidate genes.**