DEFRA Project AR0714: A study of the scope for the application of crop genomics and breeding to increase nitrogen economy within cereal and rapeseed based food chains.

(Nov 2003 – Oct 2004)

UoN, NIAB & RR

Drivers

- Major UK crops ~ cereals (23 M t p.a) and OSR (1.4 M t p.a).
- Annual UK use 1.2 M t of N fertilizer → 0.65 M t cereals & 0.06 M t OSR.
- N fertilizers →
  - cost for the grower
  - nitrate leaching (bread-making wheats & OSR high risk)
  - emissions of N_20 and ammonia, → eutrophication/ acid rain/climate change
  - production by industrial fixation uses fossil fuels
- 42% of UK cereals are used in livestock diets. The low value proteins → high N excretion.
- Minimising environmental impacts of fertilizer N inputs requires resource-efficient crops.
- Minimising N emissions from livestock diets requires the development of varieties with increased energy: protein ratios.

Objectives

- **Objective 1. Review of genetic variation in N-use efficiency and protein content and composition (trait prioritisation)**
  - **a. Physiology review (UoN/RR)**
  - **b Analysis of variety/N data sets (NIAB)**
- **Objective 2. Review of genomics-based technologies (UoN/RR)**
- **Objective 3. Consultation with the breeding industry (UoN/NIAB)**
- **Objective 4. Environmental and economic potential-impact analysis (NIAB)**
  - **a. Environment: N emissions (leaching and denitrification), impact on groundwater , biodiversity**
  - **b. Farm incomes**
- **Objective 5. Guidance to DEFRA research policy (UoN/NIAB, RR)**
  - **a. Inform research strategies of the DEFRA GINs.**
  - **b. Inform DEFRA on the potential success of public investment to increase N economy in cereal and rapeseed-based food-chains.**

Objective 1a: Physiology review

- 1.1.Scope for improving N-uptake efficiency (Crop N uptake/available N, soil + fertilizer)
  - Root development, morphology and size
  - Cellular/molecular physiological processes influencing root functioning
  - N assimilation
- 1.2 Scope for improving N-utilization efficiency (seed DM/crop N uptake)
  - Leaf photosynthesis
  - Canopy photosynthesis
  - N remobilization to the seed
  - N/S interactions
- 1.3 Scope for modifying protein content/composition of quality varieties
- 1.4 Scope for modifying protein content/composition of feed varieties
  - In collaboration with DEFRA Project IS0208 A theoretical analysis of how the protein requirements of livestock in England and Wales might be best met (Reading University, ADAS, IGER)

Trait prioritisation

- **For each trait area: rooting, root functioning, N assimilation, leaf ps etc →**
  - **Define quantitatively target trait(s)**
  - **Review current knowledge from scientific literature**
  - **Suggest future research priorities**
- **Preliminary comments on OSR →**
  - **Few genetic comparisons of physiological traits affecting resource capture and utilization.**
    - ***Roots → OSR more root limited than winter cereals? Further studies to quantify the extent of available genetic diversity in root traits?***
    - ***Canopy → reduce over-dense pod canopies (shading of lower pods) and/or improve low photosynthetic efficiency of pods.***
    - ***Remobilization → N from leaves to stems/taproots, storage to supply pods/seeds. Further studies to identify genetic diversity in, and improve understanding of, remobilisation.***

Genetic improvement of establishment

- **Poor establishment →**
  - **Increased use of N in spring to hasten canopy establishment, lower NUE?**
- **Seed factors → high protein content, large seed size, maturity**
  - **Intra-varietal differences (site,season, husbandry, storage) greater than inter-varietal differences.**
  - **Resistance to soil-borne and post-emergence diseases?**
  - **Resistance to pests?**

Objective 1b: Analysis of variety/N data sets

- **Data sets**
  - **UK RL/NL trial series 1992 – 2003 (WW 237 trials (69 low N), OSR 237 trials)**
  - **Other wider organic data sets**

- **Soil N supply estimated from soil type, previous cropping and winter rainfall**

- **Calculation of N economy characters**
  - **1. Grain DM yield (t/ha 85% DM)**
  - **2. Grain N% (protein%/5.7)**
  - **3. Crop N offtake = [Grain DM (kg/ha @ 100% DM)/0.78] x [Grain N%/100]**
  - **4. N-uptake efficiency = Crop N offtake (kg N/ha) / [SNS kg N/ha + fert. N kg N/ha]**
  - **5. N-utilization efficiency = grain DM (kg/ha @ 100% DM) / Crop N offtake kg N/ha**
  - **6. N-use efficiency = grain DM (kg/ha @ 100% DM) / [SNS kg N/ha + fert N kgN/ha]**
  - **7. Fertilizer recovery = Crop N offtake (kg N/ha) / Fertilizer N kg N/ha**

- **Search for varietal differences in :**
  - **variables 1 - 7 in the sub-set of specialized low N fertilizer input trials.**
  - **variables 3 - 7 in standard N fertilizer rate trials.**
  - **Relative performance of characters 1 - 7 under contrasting total N availability (SNS + fertilizer N), using data from all trials.**

OSR variety x N data sets

- **Chalmers, A.G., (1989) *Aspects of Applied Biology*. 23 (Double low vs single low)**
- **Baer et al., (2003) . *Proceedings of 11th International Rapeseed Congress III*, pp 887-892 (Hybrids)**
- **Horst et al. (2003). In *Innovative soil-plant systems for sustainable agricultural production*. pp 75-92. (Genotypic differences in NUE).**
- **Soeparjono et al. (2003) *Proceedings of 11th International Rapeseed Congress III*, pp 993 (Hybrid vs semi-dwarf hybrid)**
- **EU project FACTT, *Familiarisation and Acceptance of Crops incorporating Transgenic Technology (Final report*, 2003) (5 varieties in 5 countries)**

Time-lines

- **Physiology and genomics reviews**

1st drafts sent out to scientific experts for feedback in April 2004

- **Breeders consultation**

2nd drafts of reviews sent out in June 2004 for feedback followed by visits to individual breeders

- **Stakeholders' Workshop at UoN**

October 2004

- **Report to DEFRA**

November 2004