



**PROGRAMME OF RESEARCH AND  
GROWER SUPPORT FUNDED BY THE  
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## **FOREWORD**

This compilation of project synopses provides brief outlines of the aims of all projects current in the BBRO research and technology transfer programme. Projects are grouped in general categories. The compilation is intended to be a convenient *aide memoire* and will be updated annually.

Suggestions for improvement of the document would be welcomed by the Secretariat.

**J. E. King**

Programme Manager  
April 2010

## **GENETIC TECHNOLOGIES, CROP IMPROVEMENT, VARIETIES**

### **07/14 Physiology-based selection methods for improving sugar beet productivity under water-limited conditions – Broom's Barn Research Centre**

Limited soil moisture is the single most important factor that prevents the UK sugar beet crop from realising its full potential productivity, costing the industry approximately £30M annually in lost revenue. Climate change models predict that the situation will worsen. Furthermore, consolidation of the major growing area in the East means that a greater proportion of the crop could be grown on farms receiving less rainfall. The goals of this research are to enable breeders to develop varieties that can 1) maintain a greater proportion of their yield potential when water becomes limiting; 2) recover faster from drought as stress is relieved. A key element of this research is the development of screening tools and know-how to identify superior germplasm in breeding programmes. However, breeding companies have committed only half the support needed to make a research programme viable, and partnership with the BBRO is required. The proposed work focuses on areas that are most likely to result in practical selection criteria. Instrumental in this work is a core set of genotypes that show consistent contrasts for drought tolerance, yield potential, leaf morphology, water use efficiency (WUE) and wilting. Carbon isotope discrimination ratio has been used with success to breed wheat varieties with improved WUE; one objective is to implement this technique in sugar beet. Also, leaf morphological characters are related to drought tolerance and WUE, but further work is needed to refine protocols so that breeders can begin to cull inferior breeding lines on the basis of these traits. Drought susceptible varieties show a greater tendency to wilt, but wilted types are difficult to identify in large scale rainfed breeding trials. Identification of limiting plant processes that cause wilting will lead to the development of more specific selection criteria. The ability to recover quickly following a dry period may be an important trait of superior varieties, but there is little information on this response. Experiments are in progress to gauge the relative importance of recovery, and to identify genotypes that contrast in the rate of post-stress yield formation. New, more drought tolerant varieties will give UK growers the ability to compete with competitors who have deep, water retentive soils and wetter summers. Also, varieties that are less sensitive to the prevailing moisture supply should exhibit greater site-to-site and year-to-year yield stability, improving ability to plan production with greater accuracy. This has important economic benefits for both grower and processor.

### **08/01 Sugar Beet Variety Trials 2008-2012 – NIAB, British Sugar plc and Broom's Barn Research Centre**

The research programme will provide data for the preparation and selection of a Recommended List (RL) of Sugar Beet Varieties. The research is designed to monitor the development and improvement of sugar beet varieties made by breeding companies. A comprehensive set of field trials designed to assess agronomic performance, disease resistance and bolting levels is in place. Carried out in collaboration with British Sugar and Broom's Barn, they will provide information for all sectors of the sugar industry for efficient variety selection and utilisation. Yield trials are located within commercial crops and receive inputs appropriate to their locations and soil type. Additional early sown trials are carried out to measure levels of bolters. Special plots are grown by Broom's Barn to assess variety response to inoculated levels of powdery mildew and rust.

## **08/01(b) Logistic Regression analysis of sugar beet bolting trials - NIAB**

A small project has begun to re-analyse bolting data from sugar beet trials using logistic regression and compare with the original. This will also extend to review methods, not just logistic regression, of summarising data from the early sown bolter trials and incorporating data from early and late sown trials to provide more meaningful and easier to interpret summaries to growers.

## **09/22 Varietal differences in crown size and greater recovery of crown material at harvest – British Sugar plc**

The project has three components:

- (i) To update the varietal database for biological crown size to include a large number of new varieties on the current recommended lists.

There has been a downward trend in the crown size of recently-introduced varieties which introduces a greater risk of yield loss through overtopping. An updating of information on biological crown size is needed to allow the potential commercial risk to the industry to be assessed and to make growers aware of it.

- (ii) To examine whether flail-only approaches to harvesting can be adapted to profitably recover the entire sugar-beet crown without unacceptably high levels of green material.
- (iii) To assess the processability of such beet in the factory.

More efficient factory processes and new opportunities of using low-value molasses now make the processing of the crown material less of a problem and financially attractive. This, together with the compelling need for the UK sugar-beet industry to raise average yields above 70 t/ha in order to remain viable and competitive with the rest of Europe, provides a case for re-appraising UK harvesting practices to seek ways of delivering more of the previously-discarded crown material to the factory.

## **09/26 Early-sown bolting trials to characterise varietal bolting – British Sugar plc**

Increasingly mild spring temperatures during the past decade have meant that BBRO early-sown bolting trials that relied on early-March sowings no longer provide sufficient or consistent intensities of vernalisation for the bolting behaviour of new varieties to be fully characterised. A revised protocol for British Sugar's early-sown bolter trials is therefore under test, with two much earlier sowing windows - one in the second or third week of February and a second in late February, with each trial having three replicates of 1000 plants instead of two. For 2010 one trial, on a black peat soil at Holme Fen, will involve a wider range of over-winter sowing dates. Six weekly sowings of each variety on the Recommended and Provisional Lists will be made, as conditions allow, between mid February and late March. The aim is to establish two replicates with minimum stands of 1000 plants of each variety. Information from these trials will be supplemented with bolting data from the eight main variety trials sown in early to mid March. Hopefully, the combined dataset will provide a sufficient range of vernalisation to characterise varietal bolting in terms of specific *vernalisation requirements* and *bolting sensitivities*.

Definition of these two attributes for current varieties in conjunction with the new BBRO vernalisation-intensity bolting model should help growers better assess the bolting risk arising from their choice of variety and sowing windows in particular locations. It will also enable the modelling of bolting progress in these crops and so provide prior warnings of the need and cost of removing bolters to prevent future problems with weed-beet.

#### **10/08 Bolting Mechanisms: Molecular genetic basis of vernalisation & devernalisation responses in beet – Broom's Barn Research Centre**

Vernalisation-induced bolting and flowering is a major problem in sugar beet crops because it gives rise to weed beet which compromises yields and is expensive and difficult to control. Bolting resistant varieties do not yet exist because the genetic control of vernalisation in sugar beet is poorly understood; although it is widely recognised to be a complex trait that is linked to the dominant bolting gene B. Selection against the B-gene has resulted in obligate requirements for vernalisation but not in complete tolerance to vernalising temperatures. Thus, the B-gene is unlikely to directly regulate vernalisation responses. By contrast, we now have good evidence suggesting a dominant role for the gibberellin plant hormones (GA). Our data shows that vernalisation activates GA signalling and also that, without vernalisation, GA is unable to promote stem elongation. We believe that vernalisation facilitates full GA responses by de-repression of GA-signal transduction, most likely through the DELLA protein mediated pathway, thus, allowing elongation of the primary shoot axis. Studies in model species have established GA as an important factor in flowering pathways through which temperature and light-dependent signals are transmitted to floral integrators in the shoot meristem. We have identified and cloned sugar beet genes in the DELLA signalling pathway and now wish to characterise their activity in vernalised plants in order to determine correlation with “the vernalised state” as defined by the onset of cell elongation and/or cell division in the shoot apex. Devernalisation in sugar beet is marked by reversion of reproductive growth which, at the molecular level, we believe may be associated with the repression of floral transition genes in the shoot meristem. Candidate GA-responsive floral transition genes from sugar beet have been identified in our lab and will be used to develop expression assays to help define floral transition in sugar beet. Genes critical for sensitivity to vernalising temperatures and floral transition thus established will then be used to generate gene expression data sets that can be incorporated into existing bolt development and sugar beet growth models. These will immediately provide breeders with tools to evaluate physiological responses to vernalisation, without the need for lengthy field trials. In the longer term, marker assisted breeding protocols could be developed based on allelic differences in the genes discovered in this project.

## PEST, DISEASES & WEEDS

### **07/12 Monitoring and control of sugar beet pathogens – Broom's Barn Research Centre, British Sugar plc**

This new integrated project aims to achieve durable control of the major sugar beet diseases in the UK by monitoring pathogen populations to predict breakdown of resistance and advise on the need for chemical control, and to develop novel sources of genetic resistance where this is currently unavailable, inadequate or vulnerable to erosion.

Virus yellows forecasts are issued each year and aphid numbers monitored via the network of water pans in collaboration with British Sugar and other industry representatives; the infectivity of the individual sugar beet aphids are determined. Annual surveys of the yellowing viruses are undertaken to determine the distribution, significance and biological properties of BMV, BChV and BYV along with any new strains or viruses. The yield impact of these viruses on current and future varieties (standard and rhizomania resistant) are monitored in glasshouse and field studies.

The incidence, distribution and strain variation in the rhizomania virus, BNYVV is monitored by testing samples from surveys or individual growers. Results inform growers of the need to use resistant varieties and provide early detection of any resistance-breaking strains. Previously developed *Polymyxa* resistant lines are tested for their ability to slow inoculum multiplication – of particular value in UK soils. Variation in the pathogen is being examined to assess the likely durability of this form of resistance.

To date, no single major resistance genes to the yellowing viruses have been identified from *Beta* germplasm collections. Therefore, there are no prospects for conventionally bred resistance to the yellowing viruses. However, pathogen-derived resistance offers the potential to provide long term durable resistance to the yellowing viruses. This concept is being developed, exploiting the findings of previous studies and using new approaches to develop plant immunity to BMV, BChV and BYV.

A glasshouse screening test for violet root rot is being developed and resistant sources selected, in order to kick-start breeding programmes for this disease, primarily to the benefit of UK growers.

### **09/01 Optimising virus yellows control by monitoring population dynamics, virus content and insecticide resistance of aphids – Rothamsted Research**

The objective is to optimise and sustain the use of insecticides against aphid pests of beet through monitoring and forecasting aphid dynamics, monitoring the insecticide resistance status of aphids, evaluating virus yellows risk, and transferring relevant information to the industry.

Regional forecasts of the timing and abundance of vector aphids, based on aphid data from the national suction trap network and on meteorological data from the BBSRC ARCMET network, are updated annually and used to warn the industry of the likely level of virus yellows in crops grown from both neonicotinoid-treated and untreated seed.

Aphids are monitored using suction traps throughout the growing season and the status of the following three resistance mechanisms in individual *Myzus persicae* in relevant traps is determined:

- Enhanced esterase production (S+R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>), based on measurements of total esterase activity;
- Insensitive acetylcholinesterase (MACE), based on a PCR-based assay;
- Knockdown resistance (kdr and super-kdr), based on a PCR allelic discrimination assay.

The presence of beet mild yellowing virus in aphids is also tested in order to alert us to any change in the usual low level of occurrence (1-2% of tested aphids).

All results feed directly and immediately through to growers via the BBRO/Broom's Barn advisory Fax bulletins and complements results from the more localised monitoring programme of Broom's Barn project 07/12 – 'Monitoring and control of sugar beet pathogens', which uses yellow water traps.

The project complements and feeds into (as 'in-kind' contributions) an SA-Link project that commenced in 2009 for three years. This is monitoring several aphid species, including *M. persicae*, collected directly from field and glasshouse crops, for signs of resistance to neonicotinoids and any changes in the frequency of MACE and kdr.

### **09/09 Exploitation of fungicides for foliar disease control – Broom's Barn Research Centre, British Sugar plc**

Powdery mildew continues to be the major foliar disease of UK sugar beet, requiring fungicidal control every year in East Anglia. The majority (over 75%) of varieties sown in 2008 tend to have poor resistance to this disease. Triazoles or triazole mixtures now predominate in the fungicide market and offer varying levels of disease control along with physiological benefits, as demonstrated in the recent BBRO project 04/01 (Optimizing yield benefits from triazole and strobilurin fungicides). New active ingredients (e.g. trifloxystrobin, azoxystrobin, tetraconazole) continue to be introduced whilst some existing products (e.g. Punch C) may well be withdrawn in the near future. There is, therefore, a continuing need to test the available fungicides for their efficacy (against both mildew and rust), their yield boosting properties, the optimum sequences and their relative cost-effectiveness under different scenarios in order to provide growers with sound unbiased advice. This is especially important as most of the readily available remaining products will be more expensive than the cheaper but efficient options that have been available for some time.

The NIAB/BBRO sponsored variety trials show that some varieties exhibit a strong resistance to powdery mildew and may require new fungicide strategies. Growers need advice on the fungicide programmes required by these compared to the very susceptible varieties.

This project, underpinned by BBRO funding and strengthened by company sponsorship from both fungicide manufacturers and sugar beet breeders, addresses the above issues in a series of field trials.

## **10/02 Ecology and control of beet cyst nematodes – British sugar plc, Broom’s Barn Research Centre and NIAB**

There are indications that beet cyst nematode (BCN) damage has increased in UK sugar-beet fields since the last UK surveys were completed in 1988. This joint project, involving British Sugar plc, Broom’s Barn Research Station and the National Institute of Agricultural Botany - with support from KWS UK - provides an up-to-date survey of the extent and intensity of BCN infestation in UK sugar-beet fields, examines the range tolerance in the new BCN-tolerant varieties now coming to market, defines the economic thresholds justifying their use, and determines their effectiveness in preventing the build up of nematode populations in the soil.

## **10/18 Reducing herbicide use in beet crops with targeted application methods treating detected weeds – Silsoe Spray Applications Unit (TAG), Tillett and Hague Technology Ltd**

An existing LINK project has successfully demonstrated the feasibility of using image analysis techniques to identify weeds (volunteer potatoes) in crops of onions, carrots and parsnips and to treat these with a targeted spray of a total herbicide. Key components of this work have involved the development of detection algorithms that identify weeds both within and between the rows and an application system capable of a rapid response so that spray can be delivered uniformly across an area down to 50 x 50 mm with the minimum of contamination outside of this treated area and when travelling at speeds of up to 5.0 km/h. An experimental machine capable of meeting this specification was designed, constructed and successfully used in full-scale field trials in the 2009 growing season.

The BBRO work has the objective of extending this approach to a wider range of weed/crop targets, including those relevant to the beet crop, and producing a system that will facilitate operation with a wider range of formulation types including selective herbicides. This involves the further development of:

- Spot spray and intra-row crop/weed detection techniques. This work by Tillett and Hague Technology Ltd builds on earlier work concerned with the detection of both weed patches and individual weeds to provide weed/crop/soil classifications that can be used as a basis for spray decisions.
- Nozzle systems for delivering spray to the target in a way that will give a good response when used to apply selective herbicides as well as minimising off-target contamination particularly when used to apply total herbicides. This work is led by Silsoe Spray Applications Unit with input from Tillett and Hague Technology Ltd.

The LINK project of which this study forms a part addresses the above issues. In the first year of the project, the existing experimental machine will be used in at least two beet crops to examine the ability of the system to adequately control weeds that will include weed beet and, if possible, volunteer potatoes. Results from these experiments will provide feedback into the main project particularly relating to parameters relevant to achieving high levels of weed control in the beet crop. In the second and third year of the project modified experimental equipment will be used in field trials and the results assessed in terms of weed control and crop damage.

## HARVEST, HANDLING & STORAGE

### **08/08 Gap – analysis of discrepancies between yield potential and delivered yield – British Sugar plc and Broom’s Barn Research Centre**

In England, sugar beet must compete with wheat and oilseed-rape for a place in the arable rotation. At today’s prices for wheat (c. £130/t) and beet (£20/t) the competition is stiff: the production costs per tonne of beet must decrease. There is little if any opportunity to reduce input costs, so yield must increase rapidly. There is a target to increase commercial beet yields above an average of 70t/ha. Where should the R & D effort be concentrated to achieve this yield increase? Large differences exist between yields measured in experiments or simulated in mathematical models and those delivered to factories. This difference was 30% when it was last examined in detail in the 1980s (Jaggard *et al.*, 1984) and much of it was ascribed to headland management and losses during harvesting. Despite improvements in harvesting (Brown, 2006) and headland management strategies, the differences between simulated or experiment yields and delivered yields remain close to 30% (Jaggard *et al.*, 2007). In this project, Broom’s Barn and British Sugar are quantifying, in selected commercial fields and contracts, the factors causing (a) the discrepancies between the potential yields (assessed from a model and from local experiments) and yields in the fields and (b) the discrepancies between yields in fields and delivered yields and how these relate to harvesting, storage and delivery practices. The findings will be conveyed to participating growers and will be used to inform the Grower Support Programme of those aspects of crop production where the greatest and fastest improvements in delivered yield might be made.

### **10/04 Seed rates and optimal spatial arrangement of seeds for maximum yield and profitability – British Sugar plc and Broom’s Barn Research Centre**

BBRO Project 06/05 ‘Seed rates for the new sugar regime’ showed that, in the majority of situations, maximum yield could be obtained with plant population densities of 80-100,000 plants/ha. There was, however, an indication that yield responses to plant populations above 100,000/ha might be achieved on the lighter, drought-prone soils that constitute approximately 10% of the UK sugar-beet acreage. There is little scope for achieving the full benefit of such dense plant populations on such soils with rows conventionally spaced 45-50 cm apart because the within-row spacings induce early and severe plant-to-plant competition which restricts shoot growth well before the leaf canopy meets between the rows, and results in inefficient radiation interception that limits yield. One way forward on such soils and might be to use the closer row spacing, spatial arrangements and harvesting practices of the bed systems used to grow root vegetables such as carrots and parsnips.

This joint 1-year project involving British Sugar plc and Broom’s Barn Research Centre is undertaking a desk-top review of past plant population/spatial arrangement work done on sugar beet in the UK and other countries, paying special attention to water usage and linking them to the bed technologies currently used to grow vegetables. The profitability of growing high density beet on beds is also being examined in an experiment in collaboration with a grower who is developing the bed approach on a droughty Bunter sandstone soil in Nottinghamshire. The experiment compares the profitability of standard vs high density plant populations established on beds or conventional 50 cm rows. If this proof of concept is successful, and depending on the outcome of the literature review, the study could be extended to a wider range of spatial arrangements and growing conditions at other sites.

## **GROWER SUPPORT**

### **10/01 A fully integrated programme of grower support to enhance the productivity of the UK sugar beet crop – British Sugar plc and Broom's Barn Research Centre**

The objective of the British Beet Research Organisation (BBRO) is to commission and implement research and technology transfer designed to promote a profitable, sustainable and environmentally sound beet sugar industry in which the competitiveness and profitability of UK growers and the processor may increase.

The overall aim of this Grower Support Programme is to provide an effective conduit to ensure rapid uptake of new technologies and best practices.

Moving on from previous technology transfer projects which have been driven by, and measured on, the number of activities conducted, this new programme builds on some very clear crop targets which will be agreed annually with the BBRO Board. The aim is to focus messaging in particular areas to achieve a specific result, and ensure that the impact of the programme can be objectively measured.

It has long been the view of the project co-ordinators that to consistently deliver co-ordinated and unambiguous messages about the sugar beet crop, up-front agreement of those messages is essential. The co-ordinators have presented their 'Growing together' plan for this new programme to both the BBRO board and the Scientific Advisory Committee and both received it well. In fact, this approach has received endorsement from British Sugar, Broom's Barn, NFU and the BBRO and this unified support from all stakeholders is seen as central to the success of the programme.

Co-ordinated by British Sugar plc and Broom's Barn Research Centre, and guided by an industry survey of growers' technical needs, the new Grower Support Programme includes technical meetings alongside decision-maker training, field demonstration days, attendance at Cereals and other major agricultural events, operator training courses, technical bulletins in a variety of hard and electronic formats as well as face-to-face advice to growers and a plant clinic.