British Beet BBRO Research Organisation

Annual Report 2016 - 2017



INTRODUCTION

Colm McKay
Agricultural Director
British Sugar

Dr James Northen
Head of NFU Sugar
NFU

The UK sugar beet industry invests over £2 million each year in research, industry development and education. This is further supported by funds leveraged from external bodies, such as Innovate UK, and through collaborative partnerships, for example BBRO work with AHDB on soil health and with The Morley Foundation, to investigate intra-field variation.

BBRO aims to develop innovative supply chain solutions, through independent and robust scientific research to address the issues faced by growers and the processor. This enables the industry to respond quickly and efficiently to market, environmental and political changes.

This year's Annual Report gives a flavour of ongoing and new projects being delivered on behalf of the beet industry through BBRO's in-house research and development team and external parties. A snap shot of the progress the individual projects are given, in an easy to read format. These will be discussed in more depth at the Winter Technical events but if you are interested in seeing the details, please contact the BBRO office directly.

BBRO continues to strengthen its team in order to enhance delivery. We would like to express our particular thanks to Colin MacEwan for his leadership of BBRO over the past few years. He leaves BBRO in a healthy state and we wish him well for the future. The search for his successor is well underway.

Finally, we would like to recognise and thank BBRO staff who continue their work on behalf of our industry to deliver the world class research and knowledge exchange that is essential to help our industry meet the challenges of a more open, competitive market place.



INDEX OF CONTENTS

BBRO BOARDS

STAKEHOLDER BOARD

Alison Lawson
BBRO Stakeholder Board Chair
alisonorfordpartners@live.co.uk

It has been a pleasure to chair the BBRO Stakeholder Board and watch how our collective thoughts and decisions are embedded into practice and ultimately delivery for the UK sugar beet industry.

The Board has now completed two full years, during which time it has reviewed all the current and some of the previous projects, and agreed a great many new ones, which you will find within this document. Our role is to ensure that BBRO R&D funding is used to support a portfolio of projects to improve and enhance the sustainability of the UK sugar beet industry including its profitability and competitiveness, as well as environmental protection and product safety. We evaluate projects against 13 differing criteria to ensure they meet industry needs and are of good quality and value, but our remit is much wider. We also ensure that BBRO work to clear measureable objectives. This is particularly important with our investment in the area of knowledge exchange and the Demonstration Farm Network. Setting up the network has been quite a challenge for our small team, and we now need to ensure that industry utilises this amazing resource of early test bed research on a commercial scale. I would urge all growers to take a look at the programme via the BBRO website and visit one of the sites in the forthcoming year.

One of the major changes in 2016-17 has been to fully integrate the seconded trials team to BBRO. Our thanks to Colin Walters who oversaw the team for many years whilst at British Sugar. The trials team have now settled into our new premises at Bexwell and we look forward to hosting events on the site in future.

The strength of the current Stakeholder Board is due to the mix and depth of knowledge of the members, but there is always more to learn and we are sure that there are pockets of innovation, problems and best practice out there that we have yet to capitalize. Please do get in touch.

Lastly I would like to say a big thank you to my fellow Stakeholder Board members, the Technical Board and wider BBRO team for all their hard work, and of course a special mention for Colin MacEwan who we all wish well in his new role at SRUC.

Stakeholder Board Members

Alison Lawson (Chair) *Agricultural contractor and grower*

Susie Emmett *Green Shoots Productions*

Mark Fletcher *Grower*

Nick Morris *British Sugar*

Simon Smith *Grower*

Andrew Dear *British Sugar*

Prof Debbie Sparkes *University of Nottingham*

TECHNICAL BOARD

Technical Board Members

Prof Debbie Sparkes	*University of Nottingham (Chair)*
Dr Ian Bedford	*John Innes Centre*
Dr Jim Monaghan	*Harper Adams University*
Dr Tim Hess	*Cranfield University*
Dr Jon Knight	*AHDB*
Dr Mark Stevens	*BBRO*

The role of the Technical Board is to ensure that the quality and output of BBRO research is robust and of a high scientific standard. The Technical Board works closely with the Stakeholder Board, whose primary role is to prioritise new areas of research. Membership of the Technical Board comprises of the Head of BBRO and scientific lead (Dr Mark Stevens), alongside five other members who have been appointed to reflect the three pillars of BBRO research. In addition, if expertise in a specific area is required, which is not adequately covered by Technical Board members, then this will be brought in, as needed.

BBRO COMMUNICATIONS



At the BBRO we believe that applied research is fundamental to the attainment of growth in the sugar beet crop, however, research alone does not translate well into farm practice so it is important to ensure that our work is relayed to growers in the form of key messages. We are aware that growers want practical advice on a timely basis to support their decision making process.

In 2016-17 we engaged with a number of growers and advisors using different mediums:

- BBRO Reference Book - a practical guide to growing beet.
- Advisory Bulletin – a regular update during the growing season issued by email.
- British Sugar Beet Review – regular updates in every edition.
- Summer Open Days – 4 events (Summer 2016). A chance to view the crop and the RL varieties in person and meet the BBRO staff.
- Winter Technical Events – 2 events held in February 2017 with a plethora of knowledge being shared by our PhD students and research partners.
- Bespoke events for agronomists across the growing area – in-field and out.
- Student events – speaking to students in colleges and universities across the Country.
- Drill Operator Training – 2 events with over 40 people attending.
- Demonstration Farm Network – a new venture for 2017 offering growers the opportunity to see varieties and differing practices in a commercial environment.
- BBRO Website (www.bbro.co.uk) this has developed over the year with the addition of a new 'On-Farm' section. The website is the first port of call for updates, and access to BBRO publications.

Working directly within the beet industry provides a unique platform for the BBRO. Our research portfolio is shaped by industry and the results relayed directly back, allowing us to be flexible and responsive to growers needs. With this in mind we have produced a growers idea form called 'What if…'. The form is available on our website www.bbro.co.uk/research. We would love to hear from you.

CONTACT

Website: www.bbro.co.uk | Phone: 01603 672169 | Email: Info@bbro.co.uk

Twitter: Dr Beet@bbro_research (for discussions) | BBRO@BBRO_Beet (for news items)

CROP PROGRESSION

Project Lead
Dr Simon Bowen

Agronomy based KE role:
Soils, Water, Nutrition

In 2016, we had a stark reminder of the importance of soil health on crop yields. Following the 'monsoon'-like rain the UK received, many crops just simply stopped growing for a period, some turning pale with red-tinged leaves; classic symptoms of water-logging and 'slumped' soils.

This occurred at a critical stage of the season when crops needed to reach maximum canopy cover by the longest day of the year in June. There was a clear impact of this on the 2016 crop yields which were lower by some 5-10% although the impact of the poor June weather was to a degree compensated for by a warm and sunny autumn when many crops, especially those with healthy canopies, were able to continue to grow well into the harvest campaign, achieving a lot of late season sugar production.

If we accept the future predictions of climate change scientists, we are likely to see more intense weather events, the likes of those we had in June 2016 and we need to understand how we can ensure our soils and crops have greater resilience to these in the future.

In 2016, BBRO started a new programme of work on soil health. Funded by AHDB and BBRO, this five-year Soil Biology and Soil Health Partnership is a cross-sector programme of research and knowledge exchange. The programme is designed to help farmers and growers maintain and improve the productivity of UK agricultural and horticultural systems, through better understanding of soil biology and soil health.

Soil physics, chemistry and biology are interlinked and all play a role in maintaining productive agricultural and horticultural systems. While physical and chemical properties of soil are relatively well understood, the same is not necessarily true for soil biology. In recent years, a range of indicators for soil biology has been developed. These indicators, however, often have not been produced in parallel with the necessary guidance and tools to allow them to be exploited on farm. This project will link with many of our other on-going research programmes in the Crop Progression pillar such as the plant & soil interaction and PhD work on cover crops at the University of Nottingham, the Knowledge Transfer



Partnership (KTP) yield benchmarking project, as well as more specific agronomy projects addressing crop nutrition, irrigation and variety testing and development.

It is vital that we ensure the application and transfer of the knowledge from these research programmes is effective and the establishment of the BBRO Demonstration Farm Network in 2016-17 has focused on applying innovation at a commercial level. Understanding the interactions between factors such as varieties, cultivation and nutrition across different soil types is key if we are to progress yields further. Additionally, how we more effectively target the use of farm data to support the research data remains a key approach. The Beet Yield Competition and the KTP yield benchmarking project are all designed to deliver a commercial spotlight on the work.

The following reports will give you a good insight into the work we deliver, but please do pop along to our events and pose your own questions for us to consider.

NITROGEN PREDICTION RESPONSE EVALUATION (NPRE)

REPORT (Final year)

Project Lead:
Dr Simon Bowen
Project Sponsor:
BBRO

PROJECT SUMMARY

This was the final year of the project which aimed to assess the nitrogen requirements of sugar beet across a range of sites and to compare the requirements to the recommendations.

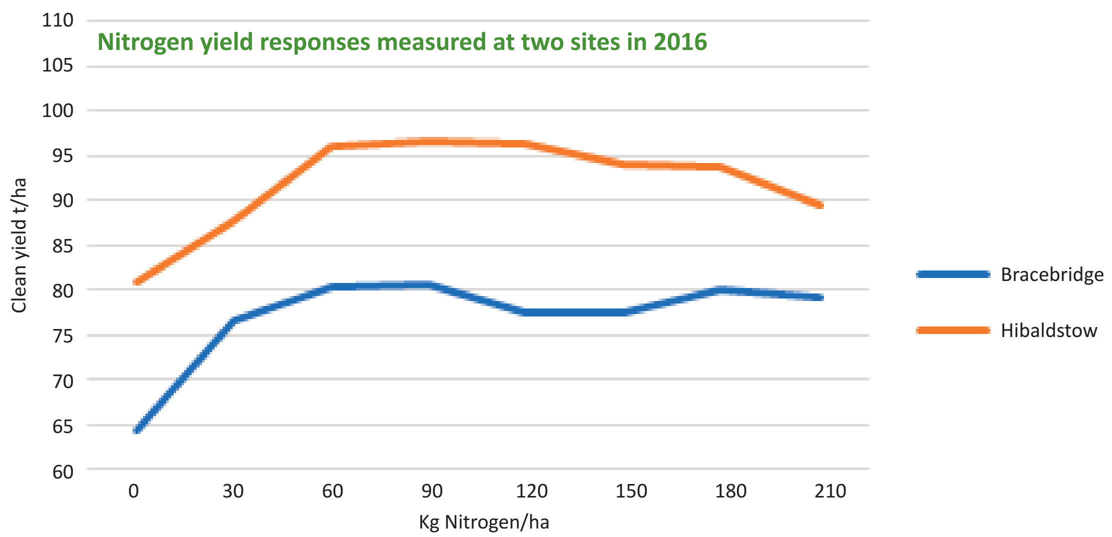
A series of trials were undertaken to assess the response of sugar beet crops to different rates of nitrogen fertilisers (0-210 kg N/ha). This work is to support and make any adjustments to the current nitrogen recommendations in the Nutrient Management Guide (RB 209). There was no evidence in the data collected from these 2016 trials that the existing sugar beet nitrogen recommendations required any adjustments. The trials did indicate a decrease in sugar content at higher nitrogen rate (illustrated in graphs A and B).

Sites were found to have higher SMN levels than expected and the range of soils tested were narrower than planned due to the loss of one site due severe weed beet problem. Any further work will focus on assessing the need for additional nitrogen in soils with low soil nitrogen levels and in crops grown for different harvest dates. A comparison of graphs A and C highlights the shallow response curve of index 1 soils, compared to that typical of an index 0 soil over the range 0-120 kg/ha.

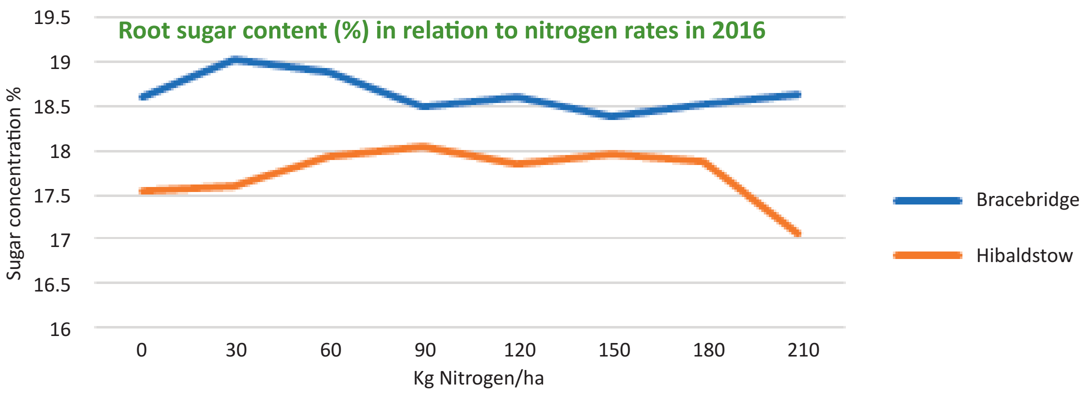
MAIN OBJECTIVES (2014-16)

- Establish three sites on a range of soil types in each of three years with fully randomised and replicated small plot trials in which a range of nitrogen levels can be assessed for impact on yield.
- To facilitate a comparison of the results to the current nitrogen recommendations made in The Nutrient Management Guide.
- To identify new areas of crop nitrogen nutrition which may lead to the more efficient use of nitrogen fertiliser and to improvement of yields.

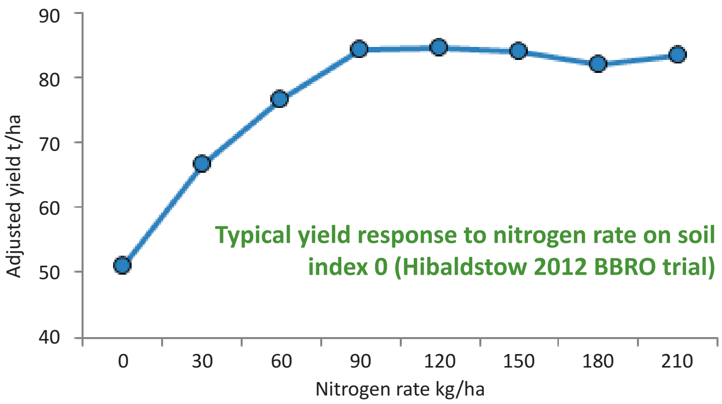
Graph A



Graph B



Graph C



OUTCOMES/ KEY MESSAGES FOR GROWERS AND INDUSTRY

- The results indicate that across the range of soil types tested that there is no evidence of the need to increase the rates of nitrogen applied.
- The trials support the existing nitrogen recommendations.
- Further testing of nitrogen rates in soils especially with low soil mineral nitrogen levels is warranted to assess the need to any adjustment in these situations.
- This series of trials did not test nitrogen requirements at different harvest dates (length of growing season) and this may warrant assessment.
- There were data which highlighted the potential depression of root sugar content at higher fertiliser nitrogen rates. This may also apply in situations where organic manure/amendments are applied and/or cover crops, especially legume cover crops, are grown over winter prior to sugar beet.
- The higher than expected soil nitrogen levels on the sites reinforce the need for careful assessment when deciding on nitrogen rates. Using the Field Assessment method which relies on soil type, previous cropping and rainfall can be inaccurate and should be supplemented with SMN testing.

OPTIMISING PLANT POPULATIONS AND NITROGEN RATES

REPORT (Final year)

Project Lead:
Colin Walters
Dr Simon Bowen
(from May 2016)

Project Sponsor:
BBRO

PROJECT SUMMARY

There is circumstantial evidence to suggest that some UK high-yielding sugar beet crops grown under modern conditions would benefit from higher than recommended plant populations and more nitrogen (N). An extensive 3-year programme of experiments has been testing factorial combinations of seven rates of N (0-200 kg/ha) and six plant population densities (50,000–150,000/ha) on three different soil types.

Of the three 2016 trials sites, the Garboldisham site was abandoned and not taken to yield due to high population of weed beet. SMN tests which were undertaken post-drilling revealed higher than expected soil N levels. This placed both the Bracebridge and Hibaldstow sites in Soil N Index 2. The recommended N rate for these soils is 100 kg N/ha.

The recommended plant population is 100,000/ha but this was not selected as one of the population densities treatments and 90,000 & 110,000 plants/ha were the nearest comparative treatments to this.

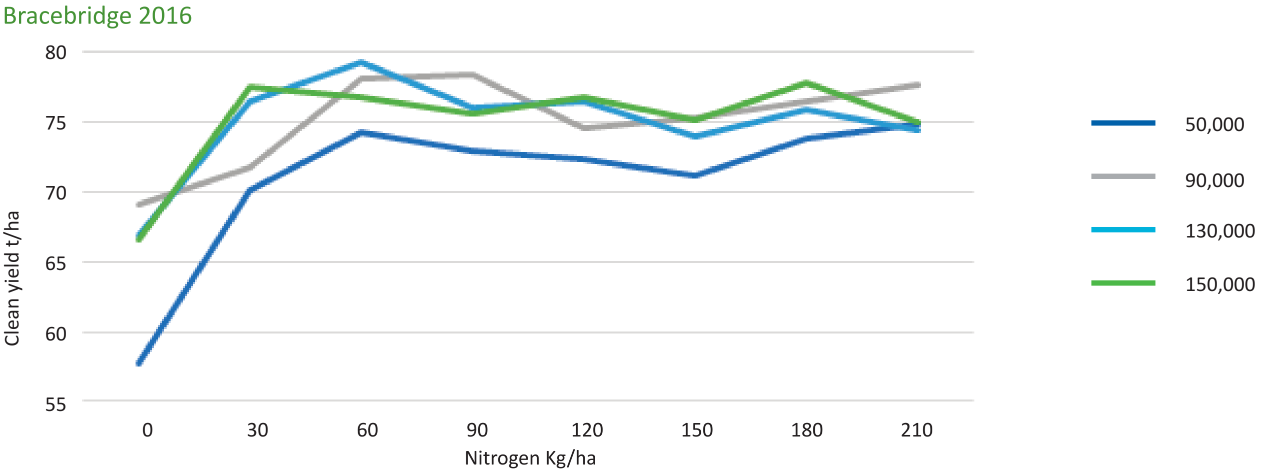
The 2016 data shows very little interaction between N rates and plant population and provides little evidence that higher plant populations require higher N rates. At both sites, the 50,000 population density was clearly, as expected, sub-optimal. At Bracebridge, there were few significant differences between the 90,000 and higher (110,000, 130,000 & 150,000) population densities whereas as at the Hibaldstow site the 90,000 population density was poorer than the higher population densities. There was a consistent reduction in root sugar content (%) above 90 kg N/ha at both sites albeit this effect was more variable at Hibaldstow. This effect was not significantly influenced by plant population.

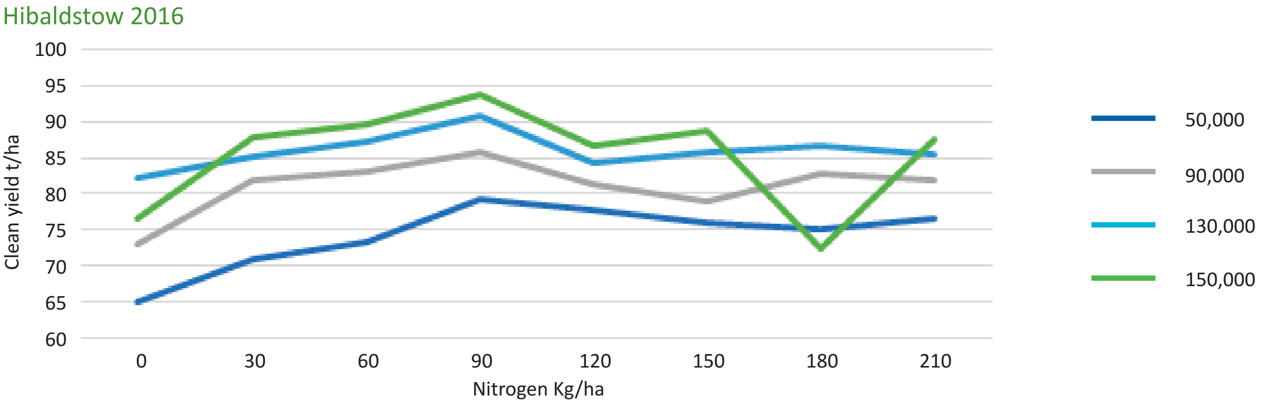
It is not possible to conclude from the 2016 trials that different soil types have different optimal plant population densities and N rates. Unfortunately, this is in part due to the small number of sites tested and the high soil N levels experienced.

MAIN OBJECTIVES

- To assess the interactions of N rates and plant populations on crop performance.
- To assess this interaction across different sites (soil types).
- To understand the basis for any interaction in terms of crop partitioning of dry matter.

THE EFFECT OF NITROGEN RATE AND PLANT POPULATION ON CROP YIELD





OUTCOMES/ KEY MESSAGES FOR GROWERS AND INDUSTRY

- The 2016 data shows very little interaction between N rates and plant population and provides little evidence that higher plant population require higher N rates.
- At both sites, the 50,000 population density was clearly sub optimal and this was expected given the current recommended population density of 100,000 /ha. At Bracebridge, there were few significant differences between the 90,000 and higher (110,000, 130,000 & 150,000) population densities.
- At the Hibaldstow site, the 90,000 population density resulted in lower yields than at the higher population densities. This was the higher yielding of the two sites and reinforces the need to establish the recommended population densities, especially to realise the potential of higher yielding sites.
- There was a consistent reduction in root sugar content (%) above 90 kg N/ha at both sites albeit this effect was more variable at Hibaldstow. This effect was not significantly influenced by plant population.
- The two sites in 2016 had higher than expected soil N levels at drilling and the recommended rate of N was 100kg N/ha. This is reflected in the relatively shallow response curve that reinforced the current recommendations.

SEQUENTIAL HARVEST TRIAL

FINAL REPORT (Final year)

Project Lead:
Colin Walters
Dr Simon Bowen
(from May 2016)

Project Sponsor:
BBRO

PROJECT SUMMARY

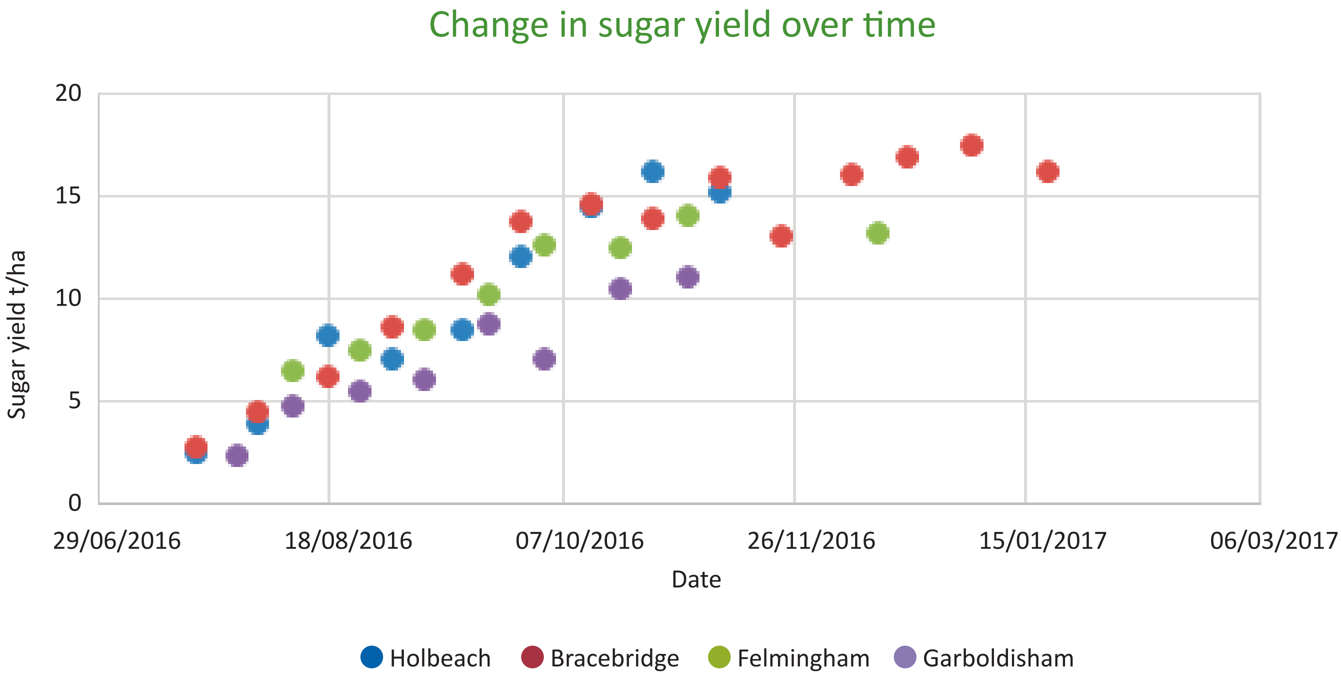
Sequential harvest data

This was a long term project to monitor crop yields sequentially (2m x 4 rows) every 2 weeks from mid-July until harvest across 4 sites.

The graph on the right shows the increase in sugar yield for the 4 sites over the 2016/17 campaign.

The Bracebridge site was the last to be harvested in January 2017.

These data from the four sites monitored, clearly identifies the potential of crops to continue to produce yield up to the middle of January. The 2016/17 was a short campaign so there was no opportunity to look at any later dates for further yield increases. The autumn of 2016 was also a relatively warm period which would have assisted with crops to realise yield potential. Comparison of sugar yield in the middle of September to those measured in the middle of November showed an increase of more than 50%. Crops were generally free of significant levels of disease and leaf miner, and reinforces the importance of maintaining healthy canopies to ensure crops can produce this later season yield.



KEY MESSAGES FOR GROWERS AND INDUSTRY

There is now a good series of data which can be used to estimate the increase in yields as the growing season progresses. These data can also be used to inform and update the BeetGro model if appropriate. This series of trials is now complete.

However, BBRO can see some benefit in monitoring yield potential of different varieties for later harvest and on-going work is assessing the potential for a new project in this area.

UNDERSTANDING SOIL PLANT INTERACTIONS TO IMPROVE SUGAR BEET PRODUCTIVITY

INTERIM REPORT (Year 3 of 5)

Project Lead:
Prof Debbie Sparkes &
Dr Jenny Bussell

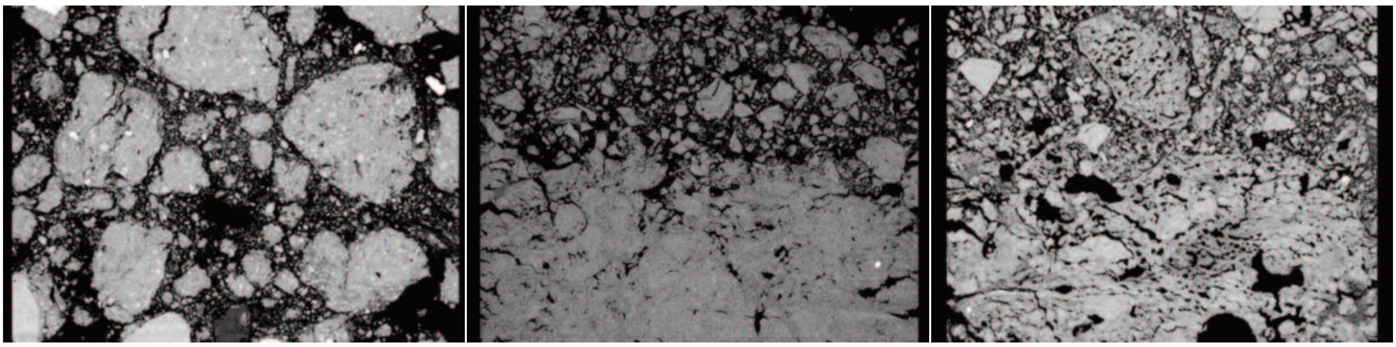
Project Sponsor:
BBRO
University of Nottingham

PROJECT SUMMARY

This project is divided into three work packages. The first focuses on limitations to water uptake by the sugar beet crop and how these might be overcome. Ongoing research into rooting constraints include glasshouse experiments, large box trials and field experiments; alongside wider field surveys. The second work package aims to identify rooting traits linked to enhanced nutrient uptake, and thereby yield, with the long-term aim to provide a screen for use by breeders. The final work package focuses on sugar beet establishment: by surveying seedbeds over the past two years we have identified seedbed properties that influence establishment. Further surveys will strengthen these results and inform recommendations on optimum seedbed and cultivation techniques.

MAIN OBJECTIVES

- Identify limitations to water uptake for sugar beet in the field and find potential solutions.
- Link rooting traits to nutrient uptake to develop a screen for use by breeders.
- Identify the optimum seedbed conditions for sugar beet establishment.



(a) (b) (c)

Xray CT images of seedbeds: (a) a sandy loam soil with high proportion of large aggregates and high shear strength, 47% establishment; (b) a clay loam soil with good aggregate size in upper 3cm but a strong layer immediately below (high shear strength), 68% establishment; (c) a silty loam with good aggregate size distribution and low shear strength, 90% establishment.



OUTCOMES AND ACHIEVEMENTS

- Soil penetration resistance was measured in sugar beet fields over two years, soil cores to one metre depth were taken, and X-ray CT scanned to identify rooting constraints at depth.

- We have identified a relationship between lateral root number in the phenotyping screen and nitrogen uptake in the glasshouse. Root phenotyping of commercial varieties is being linked with nitrogen uptake in field variety trials; root phenotyping is being extended to 172 breeding lines.

- The sugar beet establishment survey was extended from 16 fields in 2015, to 35 fields in 2016. Links between cultivation techniques and seedbed properties measured are being investigated (Photos left).

KEY MESSAGES FOR GROWERS AND INDUSTRY

Compaction at depth has been identified in a number of sugar beet fields surveyed. Scans of soil cores taken from fields will be analysed to visualise the impact of compaction on sugar beet root growth at depth.

A relationship has been identified between early rooting traits and nitrogen uptake in commercial varieties. The relationship is being tested on breeding lines, and tested on field grown commercial varieties.

The 2015 seedbed survey found a good relationship between soil physical properties and establishment. In 2016, cultivation methods were also recorded for each field, and the relationship between cultivation methods and seedbed properties is being analysed. Further data will be collected in 2017 to make a robust model of optimum seedbed conditions for sugar beet establishment, and cultivation techniques needed to achieve this.

VARIETY TRIALS PROGRAMME

REPORT (On-going)

Project Lead:
Dr Simon Bowen

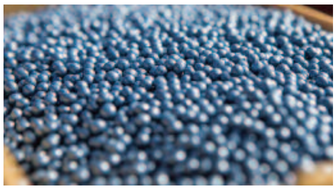
Project Sponsor:
BBRO
BSPB

PROJECT SUMMARY

The research programme, jointly funded by BBRO and the British Society of Plant Breeders (BSPB), provides 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 assess agronomic performance, disease resistance and bolting levels. Carried out by BBRO, KWS, NIAB and SESVanderHave, the programme provides information for all sectors of the sugar industry for efficient variety selection, utilisation and development. Yield trials are located within commercial crops and receive inputs appropriate to their location and soil type. Additional trials are early sown to measure levels of bolters. Special plots are grown to assess variety response to inoculated levels of powdery mildew and rust.

The Recommended List Trials Programme sown in 2016 involved 18 sites of which 13 could have been taken to full yield assessments. The programme included three trials for early sown bolting and two for disease assessment. The target is to select at least 8 out of 13 trials for harvest, with the results being used to prepare the Recommended List. The yield assessment sites involve up to 120 varieties (115 in the trials sown in 2016 and 120 for 2017), with four replications of each. In 2015 only seven trials were suitable for harvest so in 2016 the decision was taken to harvest 10 trials to assure that sufficient data was available for decision making for the RL list. This resulted in a total of 4600 plots taken from seed to harvest and ultimately processed through the BBRO plot trial processing unit with the sugar analysis being done in the commercial tare house at Wissington.

These data were reviewed by the RL Crop Committee in January 2017 and six new varieties were added to the 2018 RL list, one of which was tolerant to BCN. Four varieties were removed from the list owing to poorer yields than the control set. The best yielding new variety had an adjusted yield 106.9% of the controls and had tolerance to BCN. The 2018 RL (which is formed using data from the 2014, 2015 and 2016 trials) was published in a new landscape format with an additional, supplementary table presenting data from individual years.



2017 RECOMMENDED LIST TRIALS PROGRAMME LOCATIONS

CROP PROGRESSION NEW FOR 2017

ECONOMICS OF SUGAR BEET IRRIGATION IN ENGLAND

COMMENCEMENT OF ONE YEAR STUDY

Project Lead: Dr Tim Hess (Cranfield)

Project Sponsor: BBROm

PROJECT INTRODUCTION

The overall aim of this desk-based research study is to review and assess the costs and benefits of irrigating sugar beet in England and its sensitivity to changing agroclimate (rainfall), management (labour, energy) and market (price) conditions. The study will use a combination methodology integrating simulated estimates of yield and water use (from biophysical crop modelling) for each year since 1900, with spreadsheet analyses to assess the financial benefits (and sensitivity) of irrigation in the main beet growing areas of England under different weather conditions. The rationale for the work is driven by increasing concerns regarding the long-term viability of rainfed production in England and the potential impacts of increased rainfall uncertainty and drought risk on current beet management strategies.

New for 2017

MAIN OBJECTIVES

- To quantify the response of sugar beet to irrigation and the economics of irrigating sugar beet through an extensive literature review.
- To define future plausible agroclimatic scenarios based on historical data analysis.
- To assess sugar beet irrigation needs and yield response to irrigation based on biophysical crop modelling techniques using grower information and historical climatic data.
- To estimate the financial net benefits of irrigation including sensitivity analysis to assess the effects of changes in sugar prices and irrigation costs (considering different irrigation methods and energy sources) on production benefits.
- To transfer and disseminate the outputs through factsheet/guidelines and materials and technical presentations at key grower events.

EVALUATION OF USE OF PLACED NITROGEN (N) AND PHOSPHATE (P) FERTILISER

COMMENCEMENT OF TWO YEAR STUDY (2017-2019)

Project Lead:
Dr Simon Bowen

Project Sponsor:
BBRO

PROJECT INTRODUCTION

This project will show whether, by placing N, we can improve N uptake efficiency and crop performance. Also, to what extent it may be possible to reduce N inputs. It will also show whether this is further influenced by placing P with N.

Nitrogen application technologies that minimise losses and maximise N uptake have been linked to improved fresh weight and sugar yields, via earlier canopy establishment and improved N use efficiency. Work by the Nordic Beet Research (NBR) Institute has also indicated small but consistent responses in terms of crop yield and sugar content to the use of placed N and P fertiliser. Between 1979 & 1994, the average yield response to placed fertiliser was +4%.

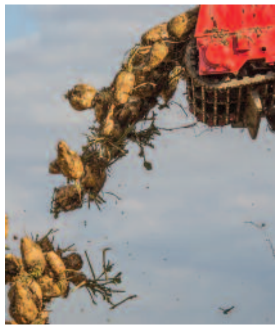
In the USA, the use of placed N fertilisers and placed P as a starter fertiliser to encourage early plant establishment is widely recommended by advisors and practiced by growers. Pilot work has been undertaken in plots at Nottingham University and commercial farms trials in Norfolk 2016. Interestingly, this work showed some improvement in early season canopy development but the effects diminished over time and by final harvest there were no significant effects on yield.

However, the published data indicates placement of N fertiliser and the use of starter P is worthy of further investigation. For the UK, it will be important to understand in more detail the interaction between fertiliser placement, soil texture, soil mineral N content, emergence and canopy expansion.

It is proposed to extend the work started in 2016 to more sites over a further two years, allowing us to make a full assessment of both the efficiency of nutrient utilisation and the practical and financial aspects of fertiliser placement. This will provide a total of 3 years of data (including 2016 trials) on which to base informed advice to growers. It will also support any specific recommendations in the next planned edition of RB209 (The Nutrient Management Guide) in 2019.

INSPiRE
(INTERPRETING & MANAGING SPATIAL PERFORMANCE IN REALITY)





FIVE YEAR STUDY (Commencing 2017)

Project Lead:
Dr Simon Bowen

Project Sponsor:
The Morley Agricultural Foundation

PROJECT INTRODUCTION

This is a joint project working alongside The Morley Agricultural Foundation to develop long-term monitoring of agricultural systems over 5 years.

The partnership will monitor spatial field variation in sugar beet crop performance to understand how key factors interact both spatially and temporally and how practical farming techniques can intervene to reduce intra -field variation and improve the overall yield performance on units of land. This can be seen clearly in the aerial shots taken by our very own drone 'pilot'.

This project will provide a key platform and resource for areas of more specific research activity and links with other research teams in disciplines such as pests, weeds, diseases, soil biology and nutrient management.

The approach will be applied to an agreed number of fields on the farm and whilst sugar beet crops will be the primary target, a cross rotational perspective would be followed.

The project will also link to the existing AHDB/BBRO project on measuring and managing soil biology.

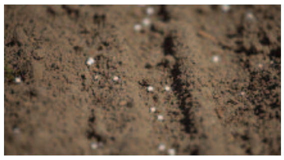
A recent publication has quantified the impact of intra-field variation in sugar beet crops and the correlation with some environmental variables showing positive correlations with soil organic matter, plant population & soil moisture (Mahmood & Murdock, 2017). This study however, only investigated the sugar beet crop in isolation from other crops and in a limited number of seasons/crop years. The BBRO/TMAF proposes to assess intra-field variation across a long term rotational study to understand where correlations may exist between different crops to identify and provide the basis for longer term soil and agronomic management and economic justification.

New for 2017

MAIN OBJECTIVES

- To monitor intra-field variation across the rotation of a number of fields to assess correlations between crop performance and environmental variables.
- To establish detailed baseline measurement as sub-field level of key soil chemical, physical and biological properties.
- To measure and monitor key crop development stages and yield using a range of remote sensing, field/crop-based measurements and yield mapping techniques.
- To statically analyse the date for positive and negative correlations between crop performance and environmental variables.
- To use this information to make decisions about long term management of soil and agronomic inputs.

SUGAR BEET RESPONSE TO ADDITIONAL APPLICATIONS OF SULPHUR FERTILISER


COMMENCEMENT OF THREE YEAR STUDY (2017 - 2020)

Project Lead:
Dr Simon Bowen

Project Sponsor:
BBRO

PROJECT INTRODUCTION

Work on other arable crops such as OSR and cereals has shown that crops frequently respond to additional sulphur fertilisers, especially on lighter land where the risk of sulphur deficiency is greatest. The depletion of atmospheric deposition of sulphur is well documented. The decline is expected to fall from 8-20 kg SO3/ha per year to around 5-10 kg SO3/ha per year by 2020 and for sulphur deficiencies to become more common place. The uptake of sulphur by sugar beet is around 50-70 kg/ha in average yielding beet crops and as much as 100 kg/ha in higher yielding crops. BBRO trials undertaken between 2003-5 indicated some responses to sulphur but the responses were inconsistent and gave no clear data about how much sulphur to add. The incremental increase in beet yields since this series of trials along with further declining atmospheric deposition is considered to increase the likelihood of sulphur responses in sugar beet and potentially impacting on further yield progression in the future.

Applications of between 25-50 kg SO3/ha (10-20 kg S/ha) are now routine in many cereal and potato crops with higher application rates being made on crops such as OSR. Soil analysis is not a reliable predictor of sulphur deficiency and tissue analysis using the malate: sulphate test is more reliable. The most recent revision of RB209 (The Nutrient Management Guide) has drawn attention to the need for wider use of sulphur applications. The Survey of Fertiliser Usage in the UK shows that many sugar beet crops are already receiving additional sulphur. However, there is no recent data to identify and recommend what rates of use are appropriate and it is not possible to give growers any recommendations based on recent trials. This project will provide a total of 3 years of data on which to base informed advice to growers and to also support any recommendations in the next planned edition of RB209 (The Nutrient Management Guide) in 2019.

The project will assess the response of beet crops to a range of sulphur application rates across a range of sites with contrasting soil types and cropping regimes. It will target soil types and regional weather trends (such as light textured soils with high winter rainfall >175mm) where the risk of sulphur deficiency is considered higher. The work will be undertaken on crops with later harvest dates (post November). The work will include an analysis of sulphur levels in plants to identify how any responses may relate to deficiency levels (previous work indicates this as >250ppm). A limited survey of sulphur levels in crops will be used to assist in identifying where responses may be most likely to occur. This information will be used in conjunction with sulphur deposition maps to further improve advice in this area.

CROP STABILITY

Project Lead
Dr Mark Stevens

Science based KE role:
Weeds, Pests and Diseases

Crop protection is essential to maximise yield and since their introduction, the neonicotinoid seed treatments have been widely adopted by the sugar beet industry as they provide an important, targeted approach for the control of up to 15 different UK pests (and associated insect-transmitted diseases). They are applied to the seed in low doses and protect the crop for up to 14 weeks from sowing, which often removes the need for regular follow-up sprays with other insecticides. For example, during the last 15 years these products have prevented the potential for 10 Virus Yellows epidemics, a disease that can decrease yield by up to 49% within infected plants. Also, they are currently protecting the crop from soil pests and the first generation of mangold fly larvae attack that is causing a number of grower's concern.

The BBRO are fully aware of the current debate surrounding the use of neonicotinoid insecticides, such as their potential impact on bee health, and are constantly reviewing the scientific literature and following developments across Europe and further afield. The BBRO encourage the use of integrated pest management strategies, and whenever possible, to avoid the use of prophylactic treatments. In addition, the BBRO have a diverse research portfolio investigating a range of alternative approaches for the control of these pests. The BBRO is also working closely with the sugar beet breeding companies to develop new and effective pest and virus resistant varieties for the future. However, these approaches take time to develop and currently there are few alternatives to the neonicotinoid seed treatments for pest control in sugar beet. Therefore, the BBRO supports the targeted use of these products until effective alternative solutions are found.

The following section provides an up-to-date summary of all the Crop Stability projects, their key outputs and findings.

COMBATING RESISTANCE TO APHICIDES IN UK APHID PESTS

REPORT (Year 4 of 4)

Project Lead:
Dr Stephen Foster
Rothamsted Research

Project Sponsor:
BBRO
in conjunction with:
CRD
Levy Boards
Agrochemical Companies

PROJECT SUMMARY

Supported by the Chemical Regulation Directorate (CRD), and a consortium of agrochemical companies and other levy boards, this project provides research on aphicide resistance management for the UK farming industries and up-to-date information for agronomic and regulatory procedures. This is heightened by the occurrence of control failures with neonicotinoids against *M. persicae* in southern Europe. The presence of resistant aphids in the UK would have very serious repercussions for neonicotinoid treatments of sugar beet. The project monitors the response of field-collected live samples of *M. persicae* to a range of novel aphicides, and also monitors for established forms of resistance. Vigilance is essential to safeguard the contribution of these compounds to aphid pest management in the UK, as resistant aphids that cannot be controlled will cause crop losses.

MAIN OBJECTIVES

- The over-riding objective of the project is to retain the availability of effective pesticides by developing appropriate aphid management strategies and provide robust scientific support to the regulatory decision-making process. Guidance is available to advisers, growers and the scientific community through the Insecticide Resistance Action Group (IRAG-UK). Other routes of communication for the scientific outcomes include articles in the trade press, along with presentations to growers and agronomists.

OUTCOMES AND ACHIEVEMENTS

- In 2016, 21 field and 5 protected crop samples of *M. persicae* were reared from sites in England.
- Screening bioassays applying diagnostic doses to these samples continued to show no resistance to neonicotinoids, pymetrozine, flonicamid, spiroteremat or cyantraniliprole.
- *M. persicae* carrying MACE resistance (to primicarb) and the new form (north European: ne) of super-kdr (conferring resistance to pyrethroids), continue to be relatively common and widespread in the UK.
- In the field samples, there continued to be a very low frequency of *M. persicae* with extreme (R3) esterase resistance to organophosphates (OPs). However, the 'O' and 'P' super-clones were found to carry resistance to OPs which maybe conferred by an unknown mechanism.
- A comparison of the *M. persicae* insecticide resistance profiles show that aphids with rarer combinations of resistance mechanisms/genotypes are being found more often at the protected sites. This could be due to aphids in these environments originating from more diverse populations, probably on imported plant material.
- The Nic-SR/RR or super-kdr (southern European) mutation, which currently appear to be mainly restricted to peach orchards in southern mainland Europe, have so far not been seen in UK samples.




KEY MESSAGES FOR GROWERS AND INDUSTRY

- Screening of *M. persicae* samples taken from the field and protected crops in 2016 showed that there continues to be no significant resistance (that may compromise control) to a range of newer compounds belonging to different chemical classes. Furthermore, there have been no significant shifts in response to diagnostic doses of these insecticides that are currently effective (un-resisted) in the UK.
- Strong pirimicarb resistance and pyrethroid resistance (conferred by MACE and super-kdr target site mechanisms respectively), remain prevalent in the *M. persicae* samples although there is evidence for a slight fall in their frequency over the past several years which reflects changes in the make-up of the population.
- Our findings continue to suggest that at least some aphids in our *M. persicae* samples collected from protected crops may have come from more genetically-diverse, sexual populations on imported plant material. Obtaining samples from these environments remains very important as they are more likely to harbour aphids with new resistance mechanisms (e.g to neonicotinoids) coming into the UK from abroad.
- The baseline work on important pests other than *M. persicae* continues to add data to the large database and will allow species that are involved in future reports of insecticide control problems to be quickly screened for potential resistance (that has not been seen before).
- Three *M. euphorbiae* samples (collected in England from lettuce and strawberry) were tested in response to reports of control problems. No evidence for insecticide resistance was found in the *M. euphoribae* samples.

DISCOVERING THE SOURCE OF SUGAR BEET INFECTION AND RE-INFECTION BY RUST AND POWDERY MILDEW

REPORT (Year 2 of 2)

Project Lead:
Dr Matthew Clarke
Earlham Institute

Project Sponsor:
BBRO

PROJECT SUMMARY

Powdery mildew and rust can cause sugar yield losses of up to 20% and 14% respectively. Little is known about (1) the level of diversity of these fungi, (2) the source of annual infection and (3) the races that re-infect after fungicidal treatment. Wild beet species could act as pathogen reservoirs, causing subsequent infection (and re-infection). In addition, these wild infections could be a source of novel virulence genes that overcome cultivar resistance. Therefore, it is important that a clearer understanding of mildew and rust population diversity is known to identify the causes of infection dynamics and improve future control strategies or resistance management.

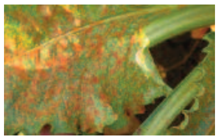
Wild plants may act as a reservoir for crop pathogens. Wild sea beet could harbour pathogens that attack sugar beet, if so wild and agricultural beets should share races of powdery mildew and rust.

In July 2015 – December 2016 we sampled (~600) across Yorkshire, Lincolnshire, Nottinghamshire, Cambridgeshire, Norfolk, Suffolk and Essex. We developed a new extraction and sequencing protocol designed to minimise the ratio of plant and pathogen DNA. We assembled a preliminary rust genome and re-sequenced twenty isolates from both the wild and agricultural samples in 2016.

Results from the preliminary sequencing highlighted that wild and agricultural rust isolates share large parts of their genomes. However, these two populations are different. The regions of differentiation may be particularly important for agricultural pathogen success. Preliminary sequencing also highlighted numerous other microorganisms present on the leaves of wild and agricultural beets. Importantly these preliminary data gave us insight into how best to improve the extraction protocol to increase the amount of DNA present for sequencing.

MAIN OBJECTIVES

- Quantify the diversity within UK rust and powdery mildew populations.
- Identify whether wild and agricultural plants share races of rust.



OUTCOMES AND ACHIEVEMENTS

- Powdery mildew prevalence was very low in the 2015/16 sampling season. Therefore, we adapted the project for rust which has a much larger and more complex genome

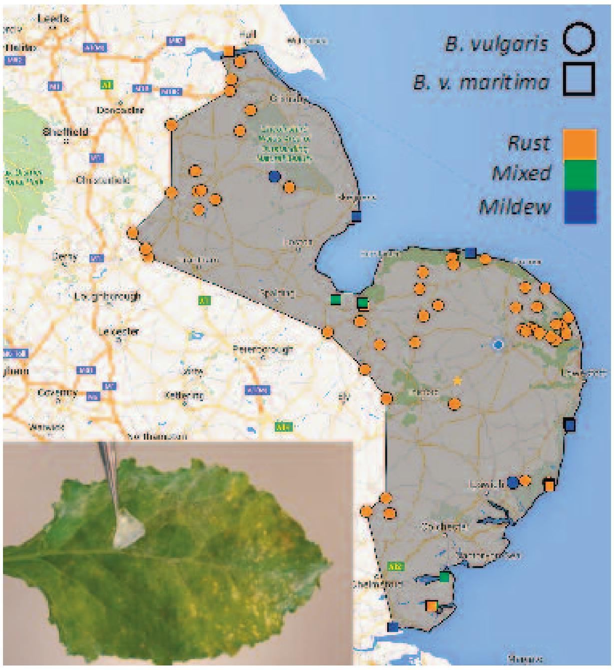


Figure 1. Sample sites and DNA peel extraction.

KEY MESSAGES FOR GROWERS AND INDUSTRY

- New DNA extraction protocol applicable to many plant pathogens developed.
- Preliminary data show that rust diversity in the UK appears to be low.
- Preliminary data show differences between wild and agricultural beet rust pathogens is also low, suggesting that a single isolate could survive on both hosts.
- Preliminary data show that we cannot rule out the potential for rust on wild hosts to invade the agricultural crop.
- Preliminary results show us that wild beets may harbour pathogens that are important to consider when trying to understand how crop pathogens evolve.
- We are still not clear about how wild and agricultural pathogens interact with each other but they appear to be closely related to one another.
- Of fundamental importance to continued reduction of pathogen levels on crops, is to better define the interaction between wild and agricultural pathogens.

IMPACT AND NOVEL CONTROL OF LEAF MINER

REPORT (Year 2 of 2)

Project Lead:
Dr Sacha White
(RSK ADAS Ltd)

Project Sponsor:
BBRO

PROJECT SUMMARY

Mangold fly (*Pegomya hyoscyami* species complex) is currently the most important mid- and late season insect pest of sugar beet. The larvae mine extensively within the leaves, producing characteristic blisters than reduce green leaf area and plant vigour. Mining also increases sensitivity to herbicides and susceptibility to frost. Infested crops that experience early frosts can lose considerable areas of canopy with consequent impact on the crop's autumn yield potential.

Control of mid- and late season infestations of mangold fly currently relies on targeting the larvae with foliar applications of contact action pyrethroid insecticides. However, the effectiveness of these is variable due to the difficulty in timing sprays. The larvae are only exposed in the time between egg-hatch and when they burrow into the leaf so contact insecticides must be applied to coincide with the hatching eggs.

Improved knowledge of temporal and regional patterns of adult emergence would provide the basis for developing decision support systems for growers, which would assist in monitoring and controlling the pest. Natural enemies contribute to pest control in a number of crops, and understanding their diversity and numbers in sugar beet would assist with integrating their activity into pest control programmes.

MAIN OBJECTIVES

- To identify effective alternatives to Hallmark Zeon and their optimal application timing.
- To improve understanding of mangold fly ecology, identify adult emergence patterns and regional variations in emergence.
- To provide preliminary data on the use of yellow water traps for monitoring natural enemies in sugar beet.

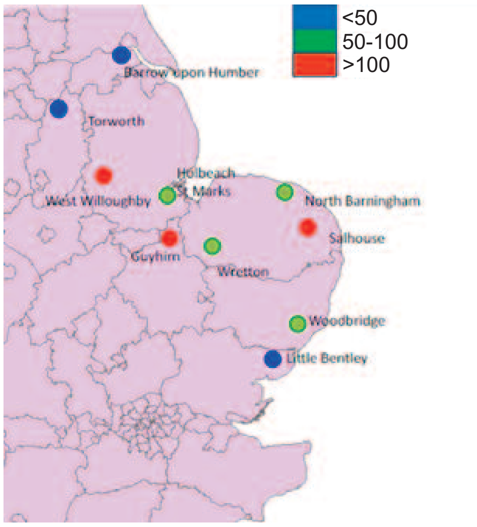


Figure 2. Number of mangold flies caught between May and July 2016.

OUTCOMES/ KEY MESSAGES FOR GROWERS AND INDUSTRY

- In 2015, Dursban WG was shown to provide the best control of mangold fly and a significant yield improvement compared to the untreated control plots. However, regulatory restrictions were introduced in 2016 that meant this insecticide could not be used in sugar beet. Hallmark Zeon was shown to be capable of providing significant reductions in pest damage.
- In 2016, three experimental products provided consistent control of mangold fly but no yield response was found, possibly due to low levels of pest infestation in the untreated control plots.
- Adult activity centred on the Wash in both years but was worst in south Lincolnshire and coastal north Norfolk in 2016.
- Patterns in the timing of adult activity differed widely between 2015 and 2016, likely due to differences in weather and environmental conditions.
- Large variation in natural enemy numbers were found between sites and across the season.
- Hallmark Zeon has been shown to be effective at reducing damage from mangold fly but sprays need to be timed accurately to target hatching larvae before they enter the leaf. This is difficult to achieve without close monitoring of the pest.
- A number of experimental products show good potential for providing better control of mangold fly other than Hallmark Zeon but further work is needed to confirm this.

INNOVATE UK: A NOVEL PRE-BREEDING STRATEGY FOR VIRUS YELLOWS CONTROL

REPORT (Year 2 of 5)

Project Lead:
Dr Mark Stevens

Project Sponsors:
BBRO
Innovate UK
SESVanderHave
Syngenta

PROJECT SUMMARY

Virus yellows is a major economic disease affecting sugar beet; its impact is particularly significant in the UK due to our maritime climate, and will be exacerbated by potential restrictions on neonicotinoid use and developing insecticide resistance in aphid vectors. Development of genetic resistance is therefore critical to maintain viral control. The consortium has explored the genetic diversity found in beet relatives, identifying candidates exhibiting resistance and tolerance to virus yellows. A novel phenotyping approach has been developed to quantify resistance/tolerance traits, and to identify genes which protect against foliar damage. Using this unique toolkit, tolerance quantitative trait loci (QTL) will be introgressed into modern breeding material, with hybrids assessed for foliar health and yield and new resistant candidates will be characterised, QTL identified, and molecular markers developed for future breeding, ultimately producing new virus-resistant commercial varieties.

MAIN OBJECTIVES

- To identify and introgress 'broad spectrum' resistance of the 'virus yellows' complex into elite sugar beet material for future breeding programmes.
- To develop sugar beet hybrids tolerant to virus yellows and determine yield benefit for variety development.


Stream I BYV tolerant accession


2016 stream II field trials

2016 stream I field trial

2016 stream II field trial

OUTCOMES AND ACHIEVEMENTS

- **Stream I**: Six wild beet accessions have been identified as significantly more tolerant/resistant to BYV when compared to current commercial varieties. Tolerant/resistant plants are currently being crossed with elite sugar beet material for testing in 2018.

- **Stream II**: Validation tests of virus yellows tolerance QTL have continued this year. Several tolerance QTL have been validated so far and crossed into elite breeding material to develop new varieties. Novel sugar beet varieties will be tested for virus yellows tolerance and yield in 2018. Molecular markers continue to be developed which can be used for marker assisted selection of tolerance/resistance traits in future breeding programmes.

KEY MESSAGES FOR GROWERS AND INDUSTRY

- Virus yellows resistant or tolerant varieties will provide an alternative to insecticides to combat this important virus.

- Ultimately, the validated tolerance/resistance will be crossed into elite commercial varieties during the project and the resulting hybrids tested for yield performance.

MAXIMISING SUGAR YIELD VIA FUNGICIDES

REPORT (Year 4 of 4)

Project Lead:
Dr Mark Stevens

Project Sponsor:
BBRO

PROJECT SUMMARY

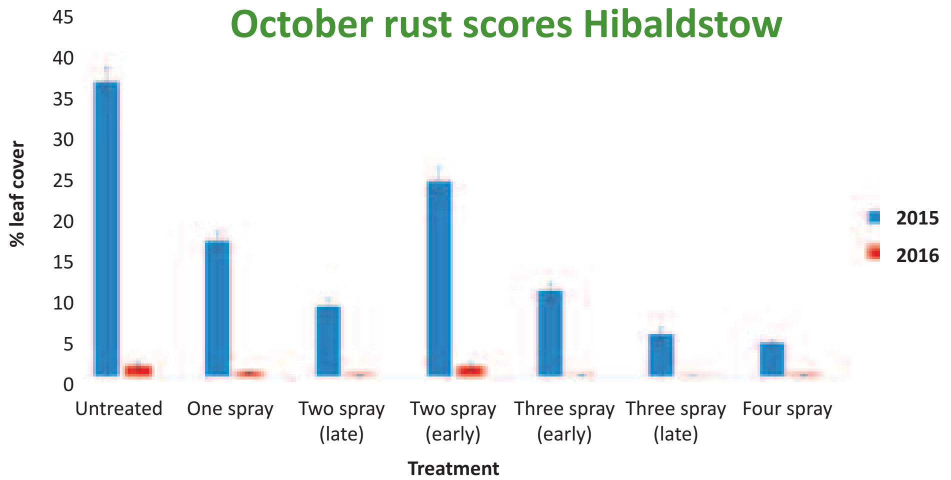
Previous BBRO trials since 2010 have shown that a two-spray programme on a typical crop harvested in November provides an average 6% yield increase from the first spray and an additional 7% from the second. Benefits of a third spray, applied in September, have been observed by growers when delivering their beet late in the campaign. BBRO trials have seen an increase in sugar content of harvested roots by up to one percent, when trial plots were lifted after Christmas. These fungicide trials have enabled the industry to optimise disease control, green-leaf cover and, ultimately, yield depending on harvest date. These studies continue to fine-tune advice regarding application timing and lifting date and provide a more robust advisory system for communicating when to apply products to maximise profitability of the crop.

MAIN OBJECTIVES

- Clarify the impact of drilling date together with crop developmental stage and first application of fungicide.
- Comparison of products to include an assessment of the current triazole/strobilurin fungicides as well as any potential chemistry on current and future sugar beet genetics.
- Assess fungicide timings, the number of applications and impact of harvest date.

OUTCOMES AND ACHIEVEMENTS

- In 2016, two trials (based in Norfolk and Lincolnshire) evaluated the impact of sowing date and seven different fungicide timing programmes on the yield of sugar beet; at both sites plots were harvested in either October/November or the following January.
- At both sites, only 2% of the leaf area of untreated plots was found to be infected with rust by mid-October. In contrast, in 2015, 24% was found to be infected at Garboldisham, Norfolk and 37% at Hibaldstow, Lincolnshire in mid-October at the equivalent time point.
- In 2016, yield responses to fungicide application were more varied compared to recent years. The lack of disease development, impacted by weather extremes during the season (e.g. very wet in June and hot and dry in September) will have influenced these overall yield responses.
- Cercospora leaf spot was seen more widely during the autumn, and although normally a disease of mainland Europe, isolates collected from the UK were found to be resistant to strobilurin fungicides.



KEY MESSAGES FOR GROWERS AND INDUSTRY

Fungicides remain key to protecting the crop from foliar diseases whilst maintaining canopy cover for autumn growth, early frost protection and maximising overall yield potential. The trials in 2015 and 2016 continue to show good rust control, the most abundant disease during these two years, although yield responses were more variable in 2016 and not all treatments provided significant yield increases as seen in previous years possibly reflecting the very variable weather and the impact this had on overall disease build-up.

MITIGATING NEW THREATS FROM VIRUS YELLOWS AND INSECTICIDE RESISTANCE

REPORT (Year 4 of 5)
1 year extention

Project Lead:
Dr James Bell
Prof Lin Field
(Rothamsted Research)

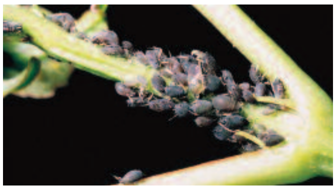
Project Sponsor:
BBRO

PROJECT SUMMARY

The objective of this project is to optimise the use of insecticides on beet by providing forecasts and up-to-date information on the timing and abundance of aphids, their virus content and the precise insecticide resistance mechanisms present. This project builds on previous projects centred on data provided by the Rothamsted Insect Survey's aphid monitoring network of suction traps, with two key components: 1) Molecular protocols were used to detect new insecticide resistance mechanisms (super-kdr, conferring strong resistance to pyrethroids, and nicR, conferring resistance to neonicotinoids), 2) Resistance testing of aphids, collected from the BBRO's network of yellow water pan traps, was employed to add information on local variability in sugar beet crops in the sugar beet growing region. The project also developed a new PCR-based assay for detecting individual *M.persicae* infected with the major beet yellowing virus, BMYV, that could be used alongside the resistance testing assays.

MAIN OBJECTIVES

- To monitor (on a regional basis using suction traps) winged aphid vectors of sugar beet viruses throughout the UK.
- To provide forecasts of the phenology and abundance of aphid vectors and the consequential potential levels of virus infections with and without control measures.
- To assess the status of four currently relevant insecticide resistance mechanisms: MACE (to pirimicarb), kdr and new super-kdr (to pyrethroids) and nicR (to neonicotinoids) in individual *M. persicae* from suction trap and yellow water pan trap (YWT) samples.
- To assess *M.persicae* from suction traps for beet mild yellowing virus (BMYV).
- To disseminate information to growers in a timely manner to aid decision on aphid control.


OUTCOMES AND ACHIEVEMENTS

- Annual virus yellows and aphid forecasts showed that whilst migrating aphids were able to exploit warmer winters, the sugar beet crop was exceptionally well protected by the use of neonicotinoid treated seed. Should seed treatments be withdrawn then the incidence of beet yellows could potentially exceed 50% of the crop.

- An RT-PCR molecular protocol was developed to replace ELISA techniques to rapidly test for virus yellows alongside the resistance mechanisms MACE (affecting pirimicarb), new super-kdr and kdr (pyrethroids) and nicR (neonicotinoids).

- A total of 2,070 *M. persicae* from suction traps and 577 from water traps were tested for insecticide resistance mechanisms over the four years of the project. The results from both suction and water traps confirmed extremely high levels of MACE (85-96%) and new super-kdr (88-94%) within the general *M. persicae* population. The level of kdr has continued to decline and was only found in 3-7% of the population. The nicR mutation, conferring strong resistance to neonicotinoids, was not found in any of the aphids tested (>700).

- A sub-sample of 1,135 *M. persicae* were tested for infection with BMYV, (by ELISA in 2013 and by the new RT-PCR method in 2015 and 2016). No aphids scored positive for this virus in any of the three years, providing further evidence of the low incidence of this important virus in recent years.

KEY MESSAGES FOR GROWERS AND INDUSTRY

- Infection with beet yellowing viruses has been shown to cause sugar beet yields to fall by up to 50% in outbreak years. Large scale infections are now rare largely due to the effectiveness of neonicotinoid insecticides that control the main aphid vector, *Myzus persicae*.

- In the UK *M. persicae* is currently susceptible to neonicotinoids but target site resistance (nicR) has been observed in Southern Europe and is expected to spread. Resistance evolution and the predicted loss of the once common UK clones suggest that there is additional uncertainty as to the future effectiveness of neonicotinoids generally.

- Should neonicotinoids be withdrawn or prove ineffective due to resistance, virus yellows could return to a situation not unlike the 1970s in which there were large-scale infections and consequently low yields.

MONITORING THE FUTURE RISK OF RHIZOMANIA

REPORT (Year 3 of 4)

Project Lead:
Dr Mark Stevens

Project Sponsor:
BBRO

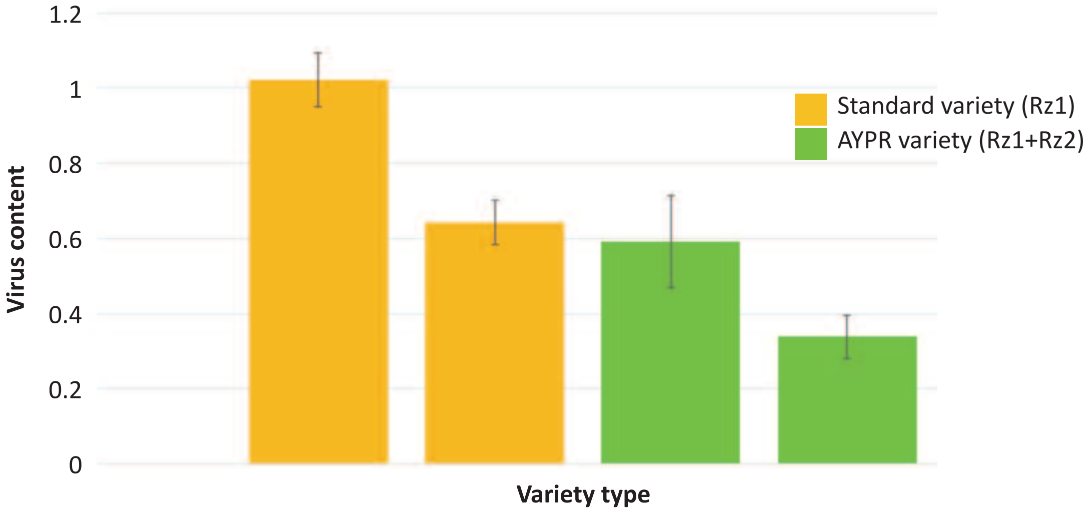
PROJECT SUMMARY

Previously, rhizomania had a major economic impact on the UK industry, potentially decreasing yields by up to 70%. The development of partially-resistant varieties by the breeders have made a major contribution to protect the yield potential of the UK crop. However, new strains of rhizomania, capable of overcoming varietal resistance, were identified in the UK (e.g. P-type [2001] and the AYPR [2007] strain). Such strains pose a serious threat to current 'resistant' varieties, although varieties with an additional resistance gene (Rz1 + Rz2) have been developed and released commercially that yield in the presence of these new strains (e.g. Sandra KWS). If no further sources of novel resistance genes are identified, the likelihood of a future breakdown in rhizomania resistance is high. The project monitors the incidence, distribution and strain variation of the rhizomania virus and assesses any future novel resistance to the virus.

MAIN OBJECTIVES

- Glasshouse evaluation of rhizomania partially resistant varieties for the control of resistance breaking strains in the UK.
- Field evaluation of rhizomania resistance in future varieties.
- Monitoring the incidence, distribution and strain variation of rhizomania.

Evaluation of rhizomania for resistance to the AYPR strain



OUTCOMES AND ACHIEVEMENTS

- There were no new cases of aggressive rhizomania reported in 2016.
- Previous field trials evaluating existing and novel partially resistant rhizomania varieties in the presence of the AYPR virus strain near Orford, Suffolk showed that varieties with both Rz1 and Rz2 resistance genes performed well with no classic symptoms of rhizomania visible.
- Previous glasshouse tests confirmed that varieties with both resistance genes decreased

KEY MESSAGES FOR GROWERS AND INDUSTRY

The aggressive AYPR strain of rhizomania does not appear to be spreading from its current locations. Variety Sandra-KWS provides a good control option for growing sugar beet in the presence of this strain.

VIRUS YELLOWS: APHID MONITORING AND ALTERNATIVE CONTROL STRATEGIES USING EXISTING/NOVEL INSECTICIDES

REPORT (Year 2 of 4)

Project Lead:
Dr Mark Stevens

Project Sponsor:
BBRO

PROJECT SUMMARY

Virus yellows is a greater problem in the UK than anywhere else in Europe due to the influence of our maritime climate. Virus threats are accentuated by the ongoing development of insecticide resistance and climate change. An integrated disease management toolkit is required that utilises resistant varieties and accurate disease forecasts to enable timely and appropriate applications of insecticides. This system will slow the development of insecticide resistance in aphid populations, thus prolonging the life of active ingredients, whilst helping to reduce the amount used. This is crucial with the recent appearance of neonicotinoid resistance within mainland Europe. To achieve durable control of the viruses, aphid populations will be monitored and assessed for resistance and virus content in order to allow us to advise growers of risks to their crops. Existing and/or new insecticides will be assessed providing a potential novel approach for controlling these viruses.

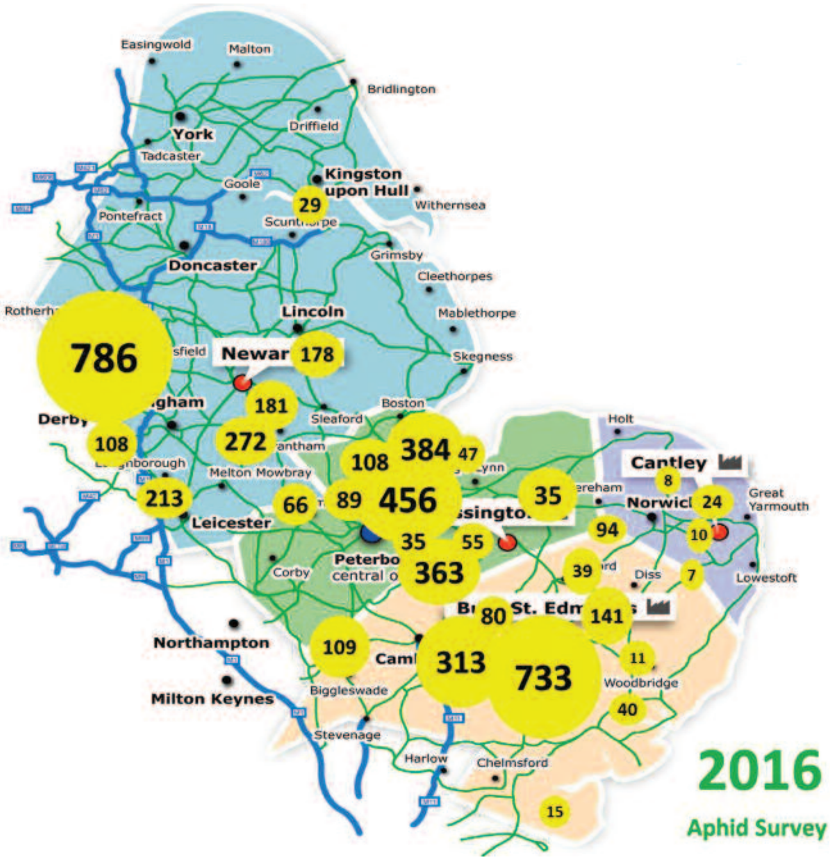
MAIN OBJECTIVES

- Annual aphid surveillance and distribution and impact of yellowing viruses.

- Efficacy of existing and novel insecticides for the control of *M. persicae*.

OUTCOMES AND ACHIEVEMENTS

- Aphids were caught from the beginning of May, and numbers peaked in early June, before numbers crashed due to predators and the unseasonably wet weather. A total of 4,888 were trapped at the 30 sites and there was significant regional variation in numbers, again influenced by neighbouring oilseed rape and other brassica crops harbouring populations.



- None of the 2,000 *M. persicae* tested were found to be carrying virus.

- Levels of virus in the commercial crop remained below one percent with neonicotinoid seed treatments providing good control of the aphid vectors.

- Although numbers of aphids were too low at field trial sites for insecticide trials, laboratory studies have continued to evaluate new insecticides for the control of *M. persicae*.

KEY MESSAGES FOR GROWERS AND INDUSTRY

The need for good on-farm hygiene remains critical to limit the range of pests and diseases encountered on farm and 2016 was no different, particularly after the very mild winter period, and when average December temperatures were 6.5ºC higher than normal. Destroying beet remnants and crown material on cleaner loader spoil heaps and maus loading sites is essential to reduce the threat from aphids and virus yellows. However, whilst most growers are using a neonicotinoid seed treatment to protect against virus-carrying aphids, the more that can be done to reduce infection levels the better for the long-term stewardship of these and future treatments.

CROP STABILITY NEW FOR 2017

IS RHIZOCTONIA A DEVELOPING THREAT TO UK SUGAR BEET PRODUCTION DUE TO DIGESTATE USE

NEW PROJECT

Project Lead:
Prof Neil Boonham
(Fera Science Ltd)

Project Sponsor:
BBRO

PROJECT SUMMARY

The project will re-evaluate the threat caused by rhizoctonia to sugar beet production in the UK in light of increasing maize production and anaerobic digestion facilities. A new diagnostic tool will be used to detect rhizoctonia and quantify the level of the fungus in high risk situations.

Rhizoctonia solani can cause a number of conditions in sugar beet: damping off in seedlings, foliar blight and root and crown rot. There are thirteen recognised anastomosis groups (AG) of *Rhizoctonia solani*, many of which have subgroups. In sugar beet, AG-4 and AG-2-2 can cause damping off and most isolates of crown and root are also AG-2-2. The rhizoctonia fungus survives as hyphae in organic debris in the soil, becoming active in warm temperatures, particularly above 17°C. Damping off may occur if beet are sown into warm soil and in the USA, seed treatment and disease tolerant varieties are exploited. Root and crown rot are important in the USA where up to 60% plant losses have been reported and this disease is also a significant problem in parts of Europe, where unlike the USA there are no fungicides registered for its control. Crop rotation can help to reduce disease prevalence but, as several species are susceptible to the same AG, this does not give complete control. For example, AG-2-2 affects sugar beet, barley, wheat and maize, the latter being a crop that has been increasing within the eastern regions of the UK as the main fuel stock for AD facilities.

New for 2017

MANAGING RESISTANCE EVOLVING CONCURRENTLY AGAINST TWO MODES OF ACTION, TO EXTEND EFFECTIVE LIFE OF FUNGICIDES



FOUR YEAR STUDY (2017-2020)

Project Lead:
Dr Neil Paveley
Dr Caroline Young
(RSK ADAS Ltd)

Project Sponsor:
BBRO

PROJECT SUMMARY

Most beet crops receive one or two fungicide applications, with 80% of treatments using a co-formulation of two modes of action (MOA) azole and strobilurin. Resistance to azole or strobilurin fungicides has been reported for cercospora leaf spot in recent years, but the resistance status of UK cercospora leaf spot, powdery mildew and rust is not known.

About 10% of yield is lost due to foliar disease. With a total value of the UK sugar beet crop averaging £247 M (Defra provisional statistics 2015), the current loss is significant. Good resistance management is needed to avoid losses and costs increasing.

This BBRO project will be part of a levy/industry collaborative project which will test new strategies for managing resistance developing concurrently against two or more MOA, using field experiments on Septoria as the test system, and mathematical modelling. A review of experimental evidence on resistance management shows that good anti-resistance strategies are effective across different pathogens on a range of crops. The results from the collaboration can therefore inform guidance to beet growers. The BBRO project will test the current resistance status of the major beet pathogens and run a pilot study using samples from beet field trials to test the effect of different fungicide treatment strategies on resistance build up.

Beet growers will benefit from revised resistance management guidelines to protect the future efficacy of fungicides.

New for 2017

MAIN OBJECTIVES

- Determine methods for in-vitro and in-planta fungicide sensitivity testing of beet pathogens.
- Quantify current levels of fungicide sensitivity in UK beet pathogens.
- Determine the effectiveness of strategies to reduce fungicide resistance in beet pathogens.

CONTROL AND MONITORING OF MANGOLD FLY 2017



ONE YEAR STUDY (2017-2018)

Project Lead:
Dr Sacha White
(RSK ADAS Ltd)

Project Sponsor:
BBRO

PROJECT SUMMARY

Mangold fly or beet leaf-miner (Pegomya hyoscyami species complex) can cause severe reductions in crop canopy (up to 70%) resulting in significant yield losses. While it affects approximately 1-2% of crops each year, incidence and severity of infestations are difficult to predict and treat. Mangold fly is currently the most important mid- and late season insect pest of sugar beet. The larvae mine extensively within the leaves, producing characteristic blisters, which reduce green leaf area and plant vigour. Mining also increases sensitivity to herbicides and susceptibility to frosts. Infested crops that experience early frosts can lose considerable areas of canopy with consequent impacts on the autumn potential.

In recent years, crop losses from the second and third generation of the pest have been significant. Currently, control of the second and third generation relies on foliar insecticides and only the pyrethroid Hallmark Zeon is registered for use against the pest. As a contact insecticide, sprays must be applied as close as possible to egg hatch to achieve effective control of the larvae. This means growers only have a small window of opportunity to treat the pest once eggs have been detected. For the last two years emergency authorisations for Biscaya have been granted. This product is a foliar-applied neonicotinoid with systemic activity, so larvae can still be controlled when inside the leaf, which provides growers with a wider spray window to treat the pest. However, there is uncertainty regarding the efficacy of this treatment and it is unknown whether further emergency authorisations will be granted. Furthermore, applying foliar neonicotinoids following neonicotinoid seed treatments increases the risk of development of pest resistance. For this reason the use of foliar neonicotinoids is not an advisable control method for mangold fly in the long-term.

New for 2017

MAIN OBJECTIVES

- Identifying effective chemical control methods and their optimal application timing.
- Improving understanding of mangold fly emergence patterns across the sugar beet growing region and throughout the summer.
- Improving the understanding of natural enemy activity across the sugar beet growing region and throughout the summer.

UNDERSTANDING VARIETY-FUNGICIDE INTERACTIONS: MAXIMISING FUTURE YIELD POTENTIAL

ONE YEAR STUDY (2017-2018)

Project Lead:
Dr Mark Stevens

Project Sponsor:
BBRO

PROJECT SUMMARY

This project will build on existing BBRO knowledge to determine whether specific RL varieties respond differently to fungicide application(s) particularly if fungicide options are restricted in the future following decisions concerning their endocrine disruption properties. These studies will also provide additional information to understand whether there are varieties that are more suited for early/late harvest following these applications or respond differently to different disease scenarios. These additional data will improve the fungicide element of the current BeetGro yield model as currently these are based on average yield responses and are not variety specific.

In the future if the availability of fungicides (or the number of applications) to UK growers is limited or restricted, then it will be important to have a greater understanding of the response of varieties to fungicides to be able to highlight the most appropriate variety types for specific on farm requirements.

New for 2017

MAIN OBJECTIVES

- to determine whether the yield potential of specific RL varieties differ with and without fungicide application(s).

CROP RECOVERY

Project Lead

Dr Simon Bowen

KE Role:
Harvest, storage and yield monitoring

As an industry, we have made great progress towards reducing previously high losses. Average yield losses of around 10% were the 'norm', but today these are below the 5% level. However, complacency is not an option and in the more competitive sugar market we now operate in, it's imperative that we continue to assess and understand the causes of beet damage to deliver even better efficiencies.

In the 2016/17 harvest campaign BBRO undertook 130 harvester tests across a range of soil types and with different operators and machines. On average, the physical loss of yield was 2.6t/ha representing 3.7% yield loss. Surface losses were, overall, very low accounting for 0.3% of the lost yield whilst root breakage accounted for most of the damage which ranged from 0.1 t/ha to 7t/ha.

The low incidence of damage in 2016 was not surprising considering the relatively dry harvest conditions that prevailed in what was a relatively short campaign. We can reasonably expect these levels to be higher in a longer campaign and with the impact of poorer weather conditions so it is important that we maintain a keen focus on this area.

Losses during harvest and storage can occur at all stages of the harvest process. We tend to focus on losses from the harvester operation and what we term mass or physical losses, which is yield loss due to whole beet left in the ground or shed from the harvester, and to root breakage. However, we should not forget that the physical loss of yield is not the only cause of sugar losses. The knock-on effect of damage can increase the respiration rate of roots, cause sugar leakage from bruised cells and increase susceptibility to root disease which can all accelerate the rate of further sugar loss.

During 2016 we initiated a strategic review of our Crop Recovery projects with key BBRO stakeholders. This has resulted in our programme now being based on four key workstreams:

1. Reducing sugar losses from root damage in the supply chain.
2. Reducing sugar losses from respiration during storage.
3. New tools and protocols for testing roots for sugar losses.
4. Investigating the physiology underlying crop differences in sugar losses in a harvested crop.

The BBRO commercial harvesting damage assessment testing work undertaking in 2016 and reported above is on-going with in-field assessments and in-clamp assessments during the campaign. This is now being supported with more detailed research investigations into understand the causes of damage to beet in the process of harvesting handling and storage and how we can apply this to reduce damage in practice.

We are also keen to ensure we can, where appropriate, transfer and adopt technology and knowledge from harvesting and storage operations in other crops such as

potatoes. There are some very relevant parallels to be found between the two crops which are worthy of consideration such as the use of an electronic beet/potato to detect areas of significant impacts during harvesting and handling and the use of thermal cameras to give advance warning of hotspots in clamps.

The importance of linking the growing crop to the crop recovery process is also an area we are looking to develop more. Successful crop recovery begins with uniform, weed-free crops, grown on level seedbeds with good foliar disease control. The difference between the approach of 'growing a crop for harvest & storage' as opposed to just 'harvesting a crop for storage' sounds subtle but one which we believe can deliver advantage. We are using the BBRO Demonstration Farm network to take a preliminary look at some of the aspects associated with this. For example, are there differences between varieties in terms of late season growth and their susceptibility to damage as well as their susceptibility to root diseases and sugar losses during storage.

We believe that as we improve our understanding in these areas we can develop a more effective integrated approach to crop recovery, especially by being pro-active in reducing sugar losses ahead of harvesting and storage as opposed to re-active to when problems occur during harvest. The need for a greater attention to detail and the assessment and measurement of crops is going to be required and use of simple digital mobile technology has a potential role which we need to embrace more fully.

INCREASE THE PROFITABILITY AND SUSTAINABILITY OF THE SUGAR BEET INDUSTRY THROUGH REDUCTION IN SOIL TARE

REPORT (2 OF 4)

Project Lead:
Colin Walters
Dr Simon Bowen
(May 2016)

Project Sponsor:
BBRO

PROJECT SUMMARY

Large quantities of soil adhering to beet are delivered to factories during the campaign at considerable cost to the industry in transportation, removal and disposal. Improvements in the design and operation of harvesters and cleaner-loaders that allow better removal of the soil on-farm have mitigated this to some extent. Even so, soil tares in recent campaigns have amounted to around 350,000 tonnes, at a cost in excess of circa £2.5 million to the industry.

Year 1 of the project looked at whether soil tares can be decreased further by changing on-farm storage practices to increase the rate of drying of the soil on lifted beet, thus making more of it removeable prior to delivery.

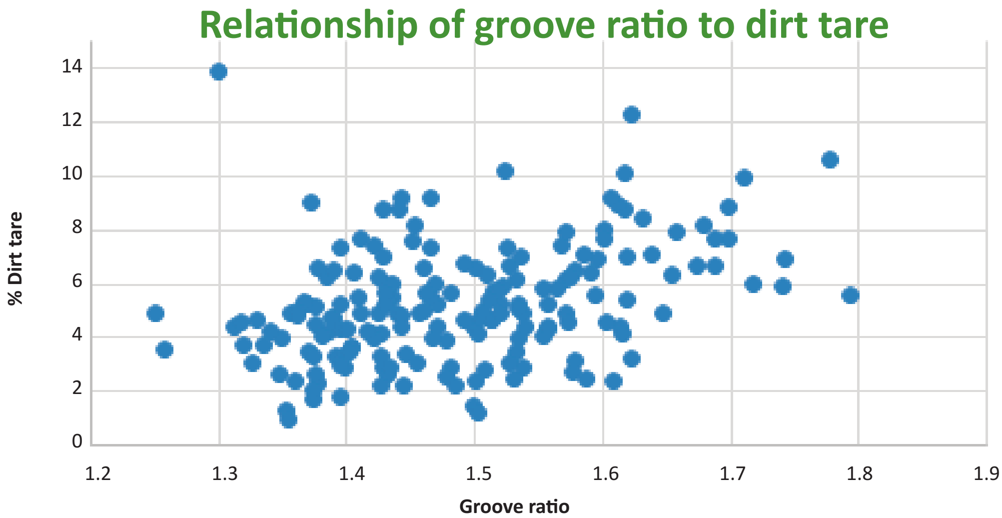
The short campaigns of 2015 and 2016 made it difficult to collect viable data. Therefore, a new element was added in 2016/17 campaign, assessing root shape and its effect on levels of dirt tare. The objectives set out below relate to this latest piece of work.

MAIN OBJECTIVES

- Determine the scale of differences in root shape both within and between commercially available varieties in the UK.
- Determine the scale of differences in dirt tare of commercially available varieties in the UK.
- Establish the strength of correlation between root shape and dirt tare.
- Produce a summary of the approaches taken to measuring root shape in other countries with a view to identifying a cost-effective and robust solution for use in the UK.

OUTCOMES AND ACHIEVEMENTS

- Variety demonstration strips at four demonstration sites around the country in 2016 were used to commercially harvest beet and to assess the roots for their shape characteristics and the level of dirt tare they carry.
- Root shape is described by determining a root groove ratio – the ratio of the narrowest part of the root and the widest part along a horizontal slice. Some previous research undertaken in Germany showed that slices between 7 and 10.5 cm from the crown gave the greatest discrimination. The objective was to establish the range of root groove depths that exists within and between the current varieties in the UK.
- A preliminary analysis of a subset of the data shows the relationship between root groove ratio and dirt tare, demonstrating that a higher root groove ration is associated with a higher dirt tare.
- The relationship between varieties and dirt tare and the root groove ratio is shown. This shows some minor differences between varieties but clearly shows when comparing across varieties, a high soil tare is not always associated with a high root groove ratio and other factors such as soil type and soil conditions may be more important.
- A review of the data will be undertaken before continuing with work addressing this aspect of soil tare reduction.



KEY MESSAGES FOR GROWERS AND INDUSTRY

With shortened campaigns and the fast changing pace of varieties, it has been concluded that this work, although of interest, holds no long-term benefit for the industry. Therefore, the BBRO Stakeholder Board has agreed to terminate this work and concentrate on other areas within crop recovery to achieve greater gains for both grower and processor.

CROP RECOVERY NEW FOR 2017

ASSESSMENT OF THE REDUCTION OF SUGAR LOSSES BY ADOPTING A ‘CHASER’ BASED HARVESTING SYSTEM

NEW (2017-2019)

Project Lead:
Dr Simon Bowen

Project Sponsor:
BBRO

PROJECT INTRODUCTION

The use of chaser bins (also known as transfer wagons) are not an entirely new concept and have been used widely in Australia and North America transferring grain from combine to road truck for many years. The potential benefits of using a chaser-based system will depend on whether the crop is being directly loaded for just in time delivery to the factory or whether it is being used simply as a more efficient indirect system i.e. to unload the harvester in-field and transfer crop to a temporary pile or clamp before loading to the factory. The use of chasers in sugar beet has not been widely adopted but producers are beginning to consider the benefits. There is little independent data available on the advantages this system may deliver.

- Reducing the need to have multiple tractor and trailer units working in the field.
- An ability to keep working in difficult conditions.
- Less mud on the roads and damage to tracks.
- Reduced ground compaction.
- Easier formation of temporary and longer-term storage clamps with less root damage.
- The more significant improvement is likely to be where the chaser-system is used for direct loading to the factory and leads to lower levels of damage and root losses as the crop does not get unloaded to a pile from where it then must be cleaned and transferred to the lorry for delivery.

These advantages may need to traded-off against ability to do less root cleaning prior to delivery or storage as chasers have a lower screen area to remove soil compared to a cleaner loader and will not benefit from having a short period for adhering soil to dry and separate as occurs in a conventional system. This will to an extent be soil type dependant although this has not been quantified.

The project is designed to assess the advantages in terms of better sugar recovery through the use a of chaser-based harvest system for direct loading situation and to examine the impact of soil type on operational advantage.

MAIN OBJECTIVES

- To measure a potential reduction in root damage and increase in sugar recovery per hectare by adopting a direct loading chaser-based harvesting system.
- To assess the effect of different soil types.
- To compare overall harvest efficiency of a chaser-based harvest system versus a conventional system in terms of machinery usage/operation and fuel costs/carbon footprint.
- To assess any reductions in soil compaction levels resulting from the use of a chaser-based system.

IDENTIFICATION, QUANTIFICATION AND REDUCTION OF THE KEY CAUSES OF SUGAR LOSSES ON BEET HARVESTERS

New for 2017

NEW (2017-2019)

Project Lead: Dr Simon Bowen

Project Sponsor: BBRO

PROJECT INTRODUCTION

Sugar losses during the harvest process are related to 1) unharvested roots left in the soil and 2) root damage. However, it is generally accepted that root damage is the most frequent cause of sugar loss. An AB Sugar Study in 2015 showed that 7% and 93% of the beet mass loss was due to unharvested beet and damaged root respectively and in 2016, the BBRO harvester testing study showed similar mass losses of 8% as unharvested roots and 92% as root damage. Olsson (2008) estimated that about 80-90% of the injuries to beet originate from the harvester as opposed to loading and unloading. The impact on actual sugar loss was not measured. A focus of the harvesting process is therefore justified.

The increase in respiration losses when roots are damaged have been reported as a three-fold increase compared to undamaged roots and has been shown to be related to the severity of damage, measured as the surface area of the root damaged (Huijbrregts, 2008). In addition to mechanical damage causing visible root breakage there is also sugar loss that arises from the root being internally bruised, usually as consequence of large impact. This type of damage causes internal cell damage within the root and may not exhibit actual root breakage. Bruising damage also results in increases to sugar respiration and sugar loss and the relationship between impact energy (drop height) and resulting sugar loss has been established (Hopkinson & Houghton, 1998).

There are several studies that have shown that the operating conditions of a harvester can have a significant impact on the sugar loss. Ingelsson (2002) showed that aggressive harvesting injured two-three-fold more beet compared to more gentle harvesting. After aggressive harvesting (higher forward & turbine cleaning speed) the temperature of the beet was higher and the beet was more susceptible to disease infection compared to the more gently harvested beet. Huijbregts (2008, 2010) showed how different harvester designs (manufacturers & models) can influence the amount of root breakage, root rot (disease ingress) and sugar losses. Work by Brown (1998) also identified differences in harvester design but highlighted in the harvester maintenance levels and the operator skill level were also significant factors and often more important than other factors.

Many assessments on harvesting losses tend to focus on the mass losses of beet. However, this underestimates the actual sugar loss as it does not consider the consequential sugar loss arising from 1) increased respiration rates that result from root breakage damage and 2) arising from internal bruising damage not associated with root breakage.

It is proposed that this project identifies and quantifies the key causes of root losses and damage associated sugar loss during the harvesting stage. The project will seek to identify the key components and processes within the harvester that causes root damage and the associated sugar loss.

MAIN OBJECTIVES

- To identify and quantify sugar losses associated with root damage during the harvest process and how harvest efficiency can be improved.
- To map out the key stages and processes within harvesters that cause root damage and quantify the associated sugar loss.
- To understand how the extent of root damage during harvesting is influenced by key field and crop parameters such as crop uniformity (root distribution, depth soil type and soil moisture conditions).
- To understand how the extent of root damage during harvest is influenced by harvester set-up and operation and how the harvesting system can be optimised.
- To develop clear best-practice advice for reducing sugar losses during harvesting.

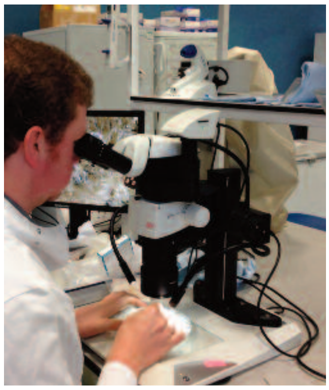
INVESTING IN THE FUTURE

Developing the next generation of enthusiastic, applied crop scientists is crucial for the future success of UK agriculture. The training and exposure of these students to the latest thinking and technologies will ensure that the most appropriate skill sets are encouraged, whilst evaluating and testing ideas and theories for the continued success of the UK sugar beet sector.

Without the next crop of bright new minds the industry will be at risk from not keeping up with the rapidly developing technological revolution. Consequently, and as part of its ongoing review of priorities, the BBRO has invested your levy with several of the key UK Universities to develop these future scientists and currently supports five PhD students with plans to recruit two new ones for 2017-18. The following gives you a brief insight into the projects the current students are working on.

PhD students studying at the University of Nottingham. (left to right) Georgina Barratt, Alistair Wright, Tamara Fitters, Jake Richards





GENETIC INFLUENCES OF SUGAR BEET CELL WALL COMPOSITION ON BIO-REFINING

REPORT (4 OF 4)

PhD Student:
Rachel O'Neill

Project Lead:
Dr Belinda Townsend
Professor Paul Knox

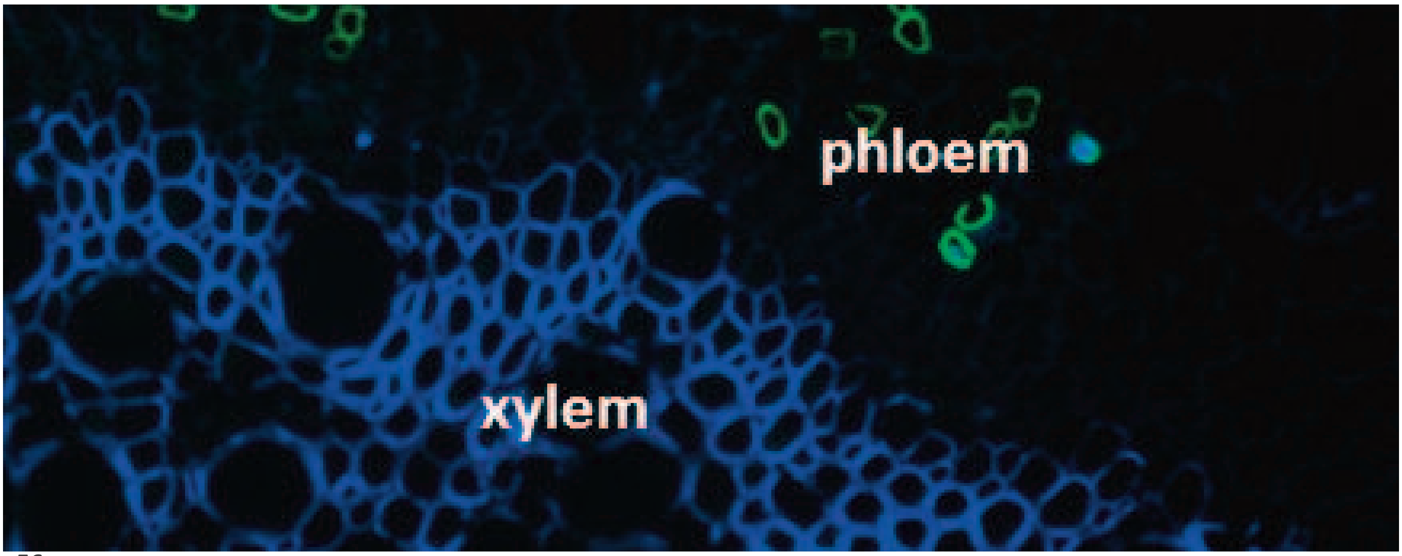
Project Sponsor:
BBRO
University of Leeds
Rothamsted Research

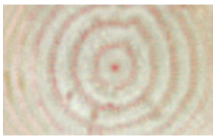
PROJECT SUMMARY

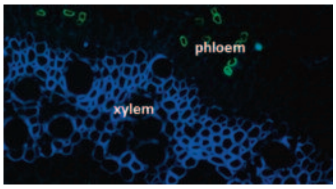
This project investigates the complex anatomy of sugar beet roots and cell wall development and the abstraction of high energy values such as sucrose, fibre and biofuels from the pulp. Sugar (sucrose) in plants is a product of photosynthesis, the process where plants use light energy from the sun and convert it into sugar. Specialised transport tissues called xylem and phloem form the plants vascular system and are required to allow movement throughout a plant. Xylem transports water from the roots to the leaves and phloem transports the products of photosynthesis (sugar) from the leaves to the rest of the plant, including the roots. The structure of these transport tissues is very specialised, and this project aims to understand the cell wall structure and the impact of varietal differences and the decomposition of sugar beet pulp.

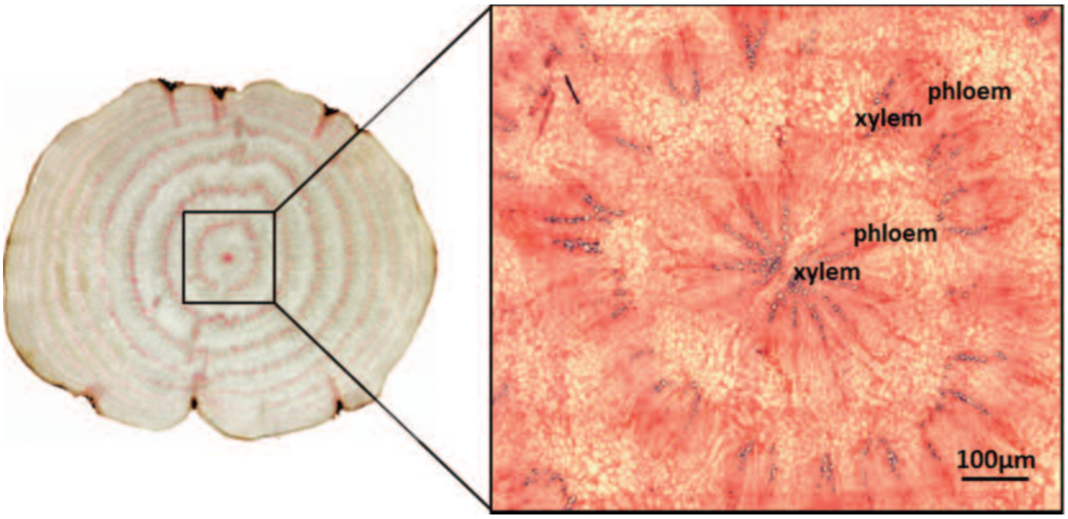
MAIN OBJECTIVES

- Identify key cells within the root using biological markers.
- To increase dry matter content and tailor dry matter composition for industry needs.
- Identify characteristics that have an effect on the structural properties of sugar beet cells.









Cross section of sugar beet

Enlarged view of beet centre showing cell structure

OUTCOMES AND KEY MESSAGES FOR GROWERS AND INDUSTRY

In sugar beet roots the vascular system is in a novel arrangement of repeating vascular rings starting from the centre of the root, and each ring contains an additional set of phloem and xylem tissues. This arrangement of the transportation tissue is one explanation for the amazing ability of sugar beet to store sugar at such high concentrations. Having the phloem arranged in repeating rings ensures sugar is being delivered and can be stored throughout the root, which would not be the case if the phloem were located in one vascular ring as is the case with most other plant species.

Combining the ability to pin point the stage where all phloem rings have developed with genetic knowledge allows for breeding targets to be identified. These breeding targets would aim to increase the number of phloem cells and/or vascular rings containing them.

The overall strength of the sugar beet root arises from each individual cell within the root. The cell walls are the skeleton of plants and dictate the overall structure and strength as well as protection and defence from environmental pressures like harvesting or pests and diseases. The composition of cell walls differs between different plant parts depending on their function.

Cell walls also make up the majority of sugar beet pulp, produced after sugar extraction. Assessing its content can lead to improved and additional uses of this resource. If improvements can be made to the composition of the pulp this can lead to enhanced animal feed with higher nutritional value too.

INTERACTIONS BETWEEN BEET CYST NEMATODE, SUGAR BEET AND BRASSICA TRAP CROPS

Report Year (3 OF 4)

PhD Student:
Alistair Wright

Project Supervisors:
Dr Debbie Sparkes
Dr Mark Stevens
Dr Matt Black
(Harper Adams University)

Project Sponsor:
BBRO
University of Nottingham

PROJECT SUMMARY

BCN poses a serious threat to growers who cultivate sugar beet on infested fields. In order to tackle this problem a greater understanding of how the various types of sugar beet varieties yield under infestation is required to allow growers to make informed decisions on variety choice and more importantly how this will influence BCN populations in the future.

Inoculation of beet with BCN juveniles

Beet harvested from the boxes with white cysts visible on the roots

BCN second stage juvenile

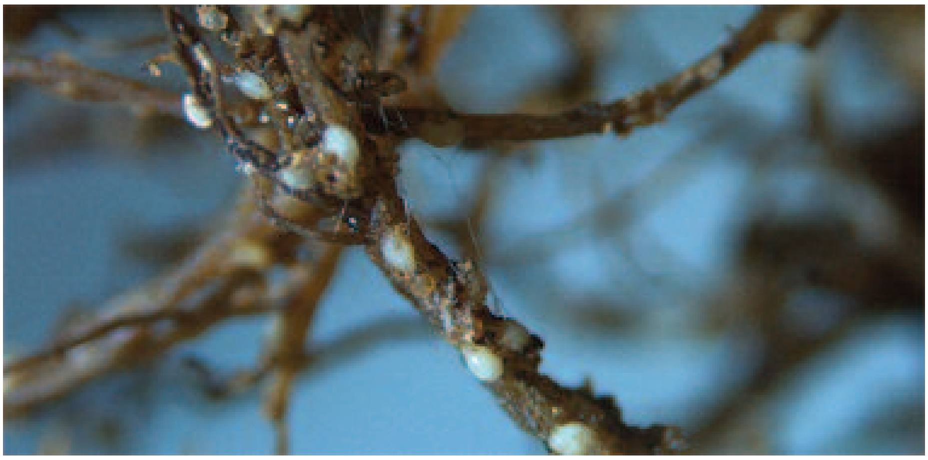
MAIN OBJECTIVES

- To understand how the tolerance and resistance mechanisms operate in the presence of BCN.
- To investigate whether planting BCN resistant mustard and radish cultivars, prior to beet, encourages BCN hatch, hence reducing infestation of the following crop.
- To investigate the impact of planting BCN resistant brassicas on the yield of the following sugar beet crop.

OUTCOMES AND ACHIEVEMENTS

- The BCN infested boxes have allowed differences in the reproductive capabilities of the varieties to be seen, however no significant yield differences were found. This may be due to insufficient initial infestation, the infestation occurring too late or watering not being sufficient throughout the summer.

- The exudate hatch experiments show some interesting results regarding the brassica species tested. The experiment needs to be repeated to strengthen the results and then compare the response in the laboratory with the field results as the brassica hatch crops may be more effective on older field cysts than freshly cultured.



Heavily infested BCN root sample from BBRO plant clinic

Canopy photography rig

KEY MESSAGES FOR GROWERS AND INDUSTRY

Rotation length remains key to reducing infestation levels. Cysts can retain viable eggs and juveniles, that can infest beet crops, for over ten years following a suitable host crop (such as beet or OSR). However, after five years less than 5% of the eggs remain inside the cyst and at this point populations usually do not pose a serious threat to the crop but populations will still increase again in the presence of the host. This project has found major differences between sugar beet varieties in their ability to host BCN and has also indicated differences between brassica hatch crops. Over the next year, further experiments will be conducted to confirm the results, which will provide new guidance for growers.

THE EFFECT OF COVER CROPS ON SOIL STRUCTURE AND THE SUBSEQUENT SUGAR BEET YIELD

Report Year (2 OF 4)

PhD Student: Jake Richards

Project Supervisors:
Prof Debbie Sparkes
Prof Sacha Mooney
Dr Mark Stevens

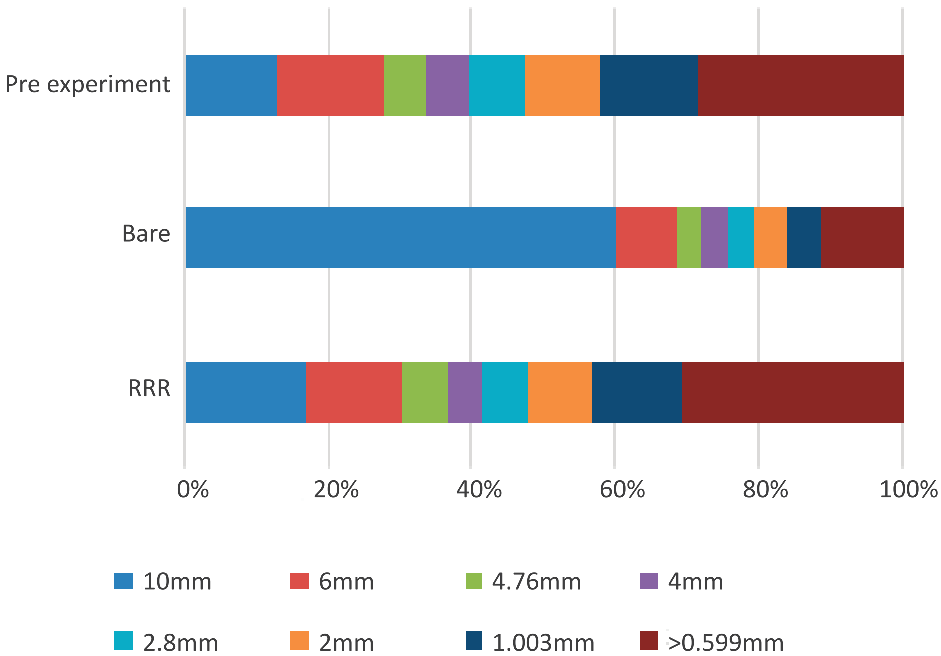
Project Sponsor: BBRO
University of Nottingham

PROJECT SUMMARY

The project is investigating the effect of autumn/winter cover crops on the physical structure of soil before and throughout the sugar beet crop and how this may influence growth and yield. We will be looking at the growth of cover crops in the UK and how they change soil structure in controlled environments, small-scale trials and also in commercial beet growing situations.

MAIN OBJECTIVES

- To understand how cover crop species can influence soil structure.
- To determine whether the potential changes to soil structure persist into the sugar beet crop.
- To investigate whether changes in soil structure, as a result of growing cover crops, affects the growth and yield of the subsequent beet crop.



After growing cover crops in a glasshouse for 700°C days the soil aggregate distribution had changed depending on the treatment. Bare soil resulted in larger aggregates which may be compared to clods in an agricultural setting.

OUTCOMES AND ACHIEVEMENTS

- Soil aggregation appears to be closely linked to soil moisture and rooting structure.
- In the glasshouse, there were differences in soil aggregate distribution that related to the different species grown (radish, rye and phacelia).
- Radish roots should not be thought of as only useful for their tap root; the large number of lateral roots contributed greatly to the water uptake from the soil.

KEY MESSAGES FOR GROWERS AND INDUSTRY

Cover crops do seem to have some impact on the soil structure. However, there are a great number of factors, which may contribute to the possible effects that the cover crop may have on the soil structure. The glasshouse experiment also showed some differences because of different species and how they were combined. Mixes with a high proportion of radish tended to dry the soil out and produce large proportions of small soil aggregates.

Over the next year we'll be carrying out glasshouse experiments to find out what cover crops are capable of at depth and will be scanning 1m tall soil columns with the X-ray CT scanning technology at the University of Nottingham.

We also have a fully replicated field trial at Nottingham looking at the effect of 8 different species of cover crops on soil structure and sugar beet yield. Alongside this we are working with the University of Lancaster to look at soil moisture deep in the profile to see the effect of the cover crops on water availability for the sugar beet crop.

We intend to continue our partnership with the commercial farms in Norfolk and Suffolk to monitor how effective cover crops are in these situations.

UNDERSTANDING WATER USE EFFICIENCY OF SUGAR BEET

Report Year (1 OF 4)

PhD Student:
Georgina Barratt

Project Supervisors:
Prof Debbie Sparkes
Dr Erik Murchie
Dr Mark Stevens

Project Sponsor:
BBRO
University of Nottingham

PROJECT SUMMARY

This project focuses on water use efficiency (WUE) in sugar beet, which examines the crop's water use and the associated yields achieved. Sugar beet is often observed to wilt in the field even when soil water is freely available, resulting in lost yield potential. Sugar beet stomata, leaf pores through which water is controlled, are slow to respond to water stress. This response and other traits related to water regulation often inherited from its wild ancestor, *Beta vulgaris* ssp. *Maritima*, are of interest. The aim is to understand the behaviour of sugar beet under water stress, with a focus on the crop's canopy, and the impact of a range of factors on WUE and whether they can be manipulated through management practices and breeding.

MAIN OBJECTIVES

- To identify sugar beet traits linked to water conservation with a focus on leaf and canopy traits.
- To understand if the traits identified can be explored to increase WUE.
- To understand the impact management practices have on WUE.

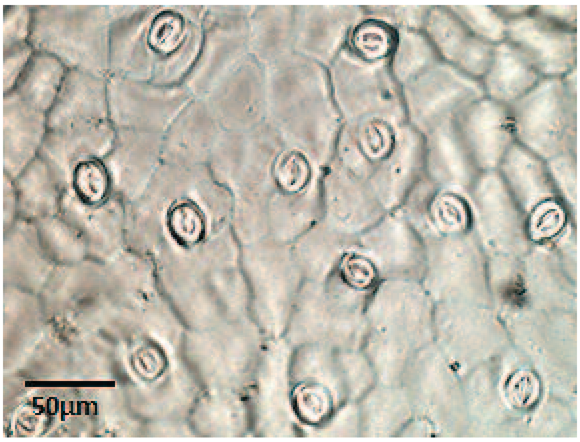


Figure 1 *– Stomata on the upper surface of a sugar beet leaf at 400x magnification*

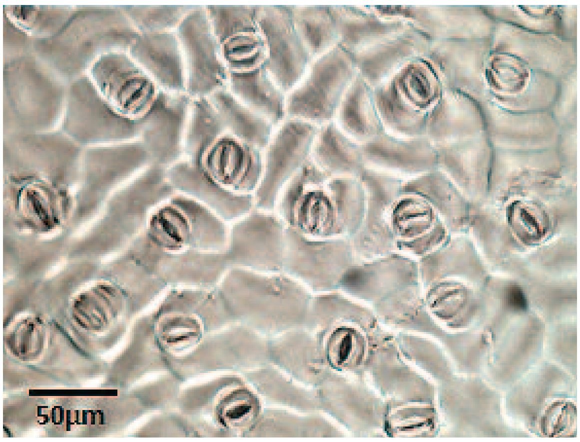


Figure 2 *- Stomata on the bottom surface of a sugar beet leaf at 400x magnification, notice the increase in density compared to the upper surface*

OUTCOMES AND ACHIEVEMENTS

- Reviewed available information on past research into sugar beet WUE.
- First year experimental plan developed based on this review.
- Carried out Initial measurements of stomatal density in different sugar beet varieties to develop technique (Figure 1 and 2).

KEY MESSAGES FOR GROWERS AND INDUSTRY

Glasshouse, large boxes and field experiments will be utilised to explore factors which affect WUE in sugar beet. This work will be undertaken with the UK climate in mind and will therefore include the assessment of sugar beet WUE under drought stress. The influence of management practices on sugar beet WUE such as variety selection, irrigation and tillage, which may affect the factors identified as influencing WUE, can then be assessed.

UNDERSTANDING WATER UPTAKE IN SUGAR BEET

Report Year (3 of 4)

PhD Student:
Tamara Fitters

Project Supervisors:
Prof Debbie Sparkes
Prof Sacha Mooney

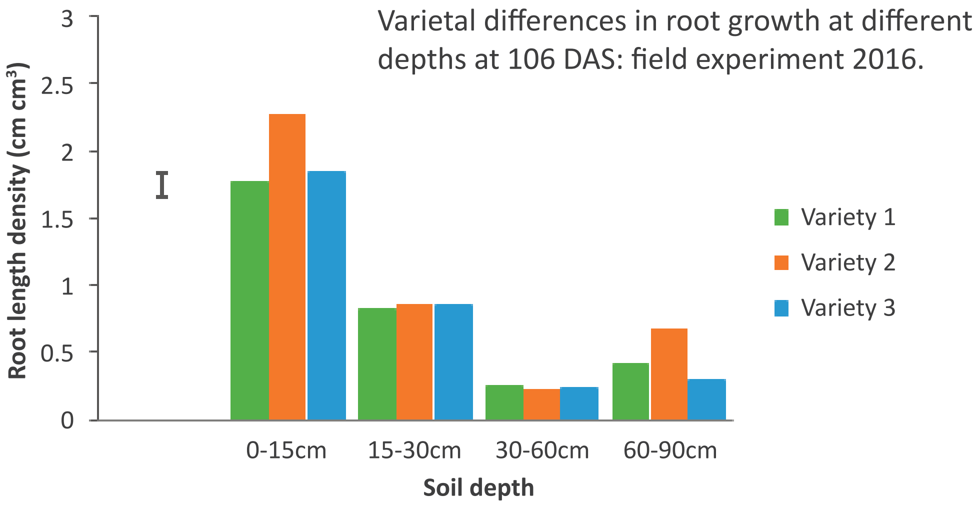
Project Sponsor:
BBRO
University of Nottingham

PROJECT SUMMARY

This project focuses on understanding water uptake in sugar beet. Drought is a serious threat to sugar beet yield in the UK and therefore more insight is needed. In this project we will look at the constraints to water uptake with a focus mainly on roots. The aim is to identify the main constraints and possibly find ways of resolving these limitations. This project links closely with the project: Understanding plant/soil interactions to improve sugar beet productivity.

MAIN OBJECTIVES

- To understand why sugar beet take up very little water from depth.
- To identify the main limitations to water uptake by the sugar beet crop focussing on 1) root physiology and 2) soil constraints.



OUTCOMES AND ACHIEVEMENTS

- Watering regime had a major impact on sugar beet root distribution with depth.
- While sugar beet roots reached deep soil layers early in the experiment, no water was taken up from depth until the upper layers had been exhausted.
- Compaction had a major impact on sugar beet root growth and water uptake in 1m columns.
- In a field experiment, different varieties show slightly different root growth at depth (Figure above).
- From the box trial we confirmed earlier findings that sugar beet grow deep roots and take up water from depth when top soil layers have been depleted of water.

KEY MESSAGES FOR GROWERS AND INDUSTRY

Sugar beet roots are capable of growing deep roots but they hardly take up water from depth until drought stress occurs. This could be caused by limitations in the root, a slow stomatal response or both (and possibly other factors). This project focuses on understanding the reasons why roots are slow to take up water from depth, so that any limitations can be addressed.

Experiments so far have been 1m columns in the glasshouse, a large scale box experiment, and a first year field trial. This year another field trial will be held to look at water uptake and a box trial to look at the effects of early and late drought stress. Mainly focussing on root growth, and water uptake from depth.

On-farm

In 2016, we introduced some new initiatives as part of the BBRO's knowledge exchange programme. These are designed to support grower innovation, providing access to new technologies and ideas at a commercial field level and showcasing the results – warts and all.

The programme currently has three main workstreams:

1. Demonstration Farm Network
2. Benchmarking
3. Beet Yield Competition

The underpinning aim of these initiatives is to understand how we can make better use of data collected at a farm and whole crop level to provide greater insight to crop performance and how yields can be improved. To enable us to collate the various forms of on-farm data BBRO has been working with the KisanHub data platform. This enables us to bring together data all in one place and to facilitate analysis. The platform utilises a geographic information system (GIS) approach which lets us visualize at a field level and to interpret data to understand relationships, patterns & trends. This includes data sources such as soil maps and soil analysis, meteorological data, crop development (including aerial imagery), yield digs and estimates.

Demonstration Farm Network

The programme commenced in the autumn of 2016 with the selection of six farms that represented both a range of contrasting soil types and the beet growing area as a whole. The network is now well established and the range of demonstration work is highlighted below. Typically, these take the form of large commercial strips or blocks of crops within a field and are unreplicated. The programme of grower visits and meetings are targeting smaller groups of growers to allow plenty of time for discussion.

Common to all the sites is the eight key commercial variety strips (from the existing Recommended List). This allows us to assess any varietal interaction between soil type, pest and disease susceptibility, plus any advances in yield to be found through a later harvesting programme.

	N rates	Foliar feeds	Variety strips /sequential harvest date	Tillage systems	Cover crops	Seed treatment	Harvesting and storage	Pest and disease management
Rougham	✓	✓	✓	✓	✓	✓		✓
Newborough	✓	✓		✓		✓		✓
Leverington	✓	✓	✓				✓	✓
Morley	✓	✓	✓		✓	✓		✓
Bracebridge	✓	✓						✓
Snelland	✓	✓	✓			✓	✓	✓

We are also monitoring application programmes with different rates of nitrogen, fungicides and insecticides. Whilst all the sites have demonstrations on N rates, foliar feeds and pest & disease management, a few have specific projects such as; use of cover crops, seed treatments, varying harvest dates, harvest and storage and differing tillage systems. This programme is being used as an observation platform, to build the confidence of growers in the advice being shared and to provide some base data from which future replicated trials could be drawn.

cont/d.....

Benchmarking

There is plenty of data available to farmers, but not much in the way of help in understanding ‘good’ or relevant data. Our benchmarking programme is aimed at determining the data that is of value and incorporating it in on-farm decision making. In particular, we are looking to compare actual crop performance to potential performance based on a crop yield model. This model draws on data generated over many seasons and sites had been validated against commercial crops. We are using a range of data collection techniques including aerial sensing and digital soil mapping, working closely with the KisanHub platform, to provide data to the model. Identifying the yield gap between actual and potential yields and, how this gap can be bridged at an individual grower level, is a key objective. The benchmarking programme will be running behind many of our projects, to collect a large pool of comparable data which in turn will provide results in which growers can trust.

One of the challenges is to understand the impact and causes of spatial variation in our crop yields. Aerial imagery is a useful tool to identify and characterise this (see examples). BBRO is beginning to address this complex challenge but always with a view on how growers can use the information to take practical and profitable action.



BEET YIELD COMPETITION

In 2016, the Beet Yield Competition project was initiated. This is a unique partnership between growers (NFU), BBRO, British Sugar and Hutchinsons. The objective is to encourage growers to have a crop of their beet monitored and assessed in 'forensic' detail across a complete growing cycle, to understand the components of yield and to compare this to an estimate of yield using specific farm data to drive the beet yield model. Adopting some standard data collection approaches for measuring characteristics such as soils, crop canopy development, intra-field variation and harvest losses, it is anticipated that a broader analysis of crop performance can be undertaken as well as individual crop analysis.
Each entrant will receive a final field report and potential yield forecast, which includes aerial field shots such as those shown. This report will aim to identify the causes of the yield gap and any key actions that could be implemented to narrow this. We would expect most growers to attain between 50 - 70 % of full crop potential across the cohort of fields analysed. This will provide some vital insight as to why some crops attain different proportions of their potential. We currently have over 30 crops which have been entered into the competition and are being followed throughout the 2017 growing season.

Further details of the BBRO On-farm initiative are available on the BBRO website www.bbro.co.uk/on-farm

FIELD TEAM

Once projects have been approved by the Stakeholder Board and the Technical Board the delivery of the trials is largely passed on to the BBRO field team. Bringing trials together from their concept notes is always a challenging task to ensure the science is correctly balanced with the practicalities of delivery of in-field plot trials. The field team will take the trials protocol, find an appropriate trial site, and complete soil tests to ensure the field is suitable for the proposed trial.

Once the location is found plans are drawn up for the trial to be placed in the field. Wherever possible and where protocols allow, the aim is to maximise the amount of trials in individual fields, ensuring the most efficient use of area and Trials Officers time. If 10 trials can be checked in one location it is the most efficient and effective use of time. This enables the continued future expansion of the trials programme.

During the whole process of planning, through growing the crop, to harvesting the trials it is key that communication with host growers and their field operatives is good. This safeguards all elements of trial operations and that protocols are followed to generate results for analysis. For example, if there are untreated areas in a trial field that require pesticide or fertiliser applications to switched off, all parties need to know, as it only takes one mistake to fail a trial.



With 9 trial sites and 6 demonstration/open day sites in 2017 there is a lot of responsibility on the BBRO to deliver quality trials that can continue to drive yields up. The BBRO produces around 5,000 in-field trial plots. We also harvest and process through the BBRO plot processing unit around 10,000 plots every year, that can be from as many as 18 trial locations. Along with the plot trials, strip trials are replicated at various sites. The strip trials produce data following protocols that utilise machinery and larger areas to try and represent commercial practice. With field trials it is extremely important to forward plan but also to have the ability to react to a problem or evaluate an arising problem. For example in 2015 we abandoned a trial due to powdery mildew, however, the trial plots had been treated in such a way that we were able to incorporate into another project, adding value to the data collected from the existing powdery mildew trial.


The Farm Demonstration sites and Open Days are within the field teams remit and many hours are spent preparing areas to give visual information to back up the science. Having a fully qualified drone pilot on the team also assists with this as drone pictures always generate discussion and help back up scientific data.

As the BBRO project pillars grow, it is the job of the field team to diversify its approach to trials and knowledge exchange delivery, sticking with the core plot trials but always looking for different or novel ways of working, whilst, as ever, being meticulous and thorough.

Going forward the team are utilising more and more new technology for trial and data delivery. Computer field mapping to generate trial plans, RTK tractor operations, fertiliser placement systems, NDVI canopy assessments and aerial drone assessments to mention a few.

The BBRO Field team is pushing its “Mission statement”

TO BE A WORLD CLASS TRIALS TEAM IN ORDER TO MAXIMISE GROWERS AND BEET INDUSTRY RETURNS

PLANT CLINIC

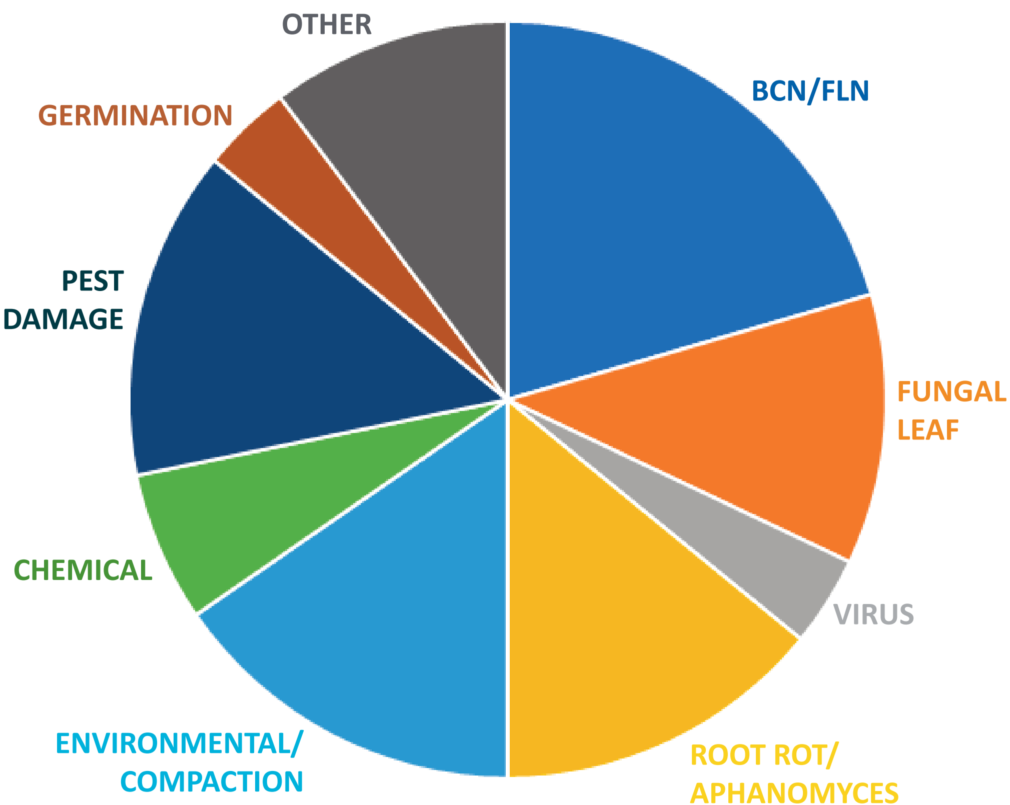
In 2016 the BBRO Plant Clinic received 81 physical samples ranging from seeds, soil, roots, leaves or a combination of these elements. In many cases the cause for concern was quickly identified, often helped by detailed notes of farming practice and cropping history supplied by the agronomist or grower. Unfortunately, for a small number of cases, the initial cause(s) of the problem in beet can be difficult to identify and a more in-depth analysis is required including growing seed in the affected soil to see if the symptoms can be re-created and confirmed. For example, a poor seed bed, variable drilling depths or the presence of soil pests are just some of the issues at plant establishment that can lead to plant stress that ultimately makes the beet more susceptible to other issues later in the season. Several of the cases seen in 2016 showed signs of multiple infections.

The weather also plays its part, and in 2016, there was an increase in the prevalence of free living nematodes when the water table was high in the early part of the season. Each year, there are usually several complicated cases relating to herbicide damage, where the damage may not be visible for a number of weeks and therefore hard to pinpoint or prove the original reason for the problem.

The plant clinic does provide a good insight into the general issues being faced within the crop, and also enables the BBRO to ensure that its research programme is targeted at relevant issues affecting the UK crop. Therefore, we encourage growers to submit samples or send photographs of any areas of concern with supporting information (plant clinic forms are available at BBRO website **bbro.co.uk/research/plant-clinic/**).

Contact: Plantclinic@bbro.co.uk

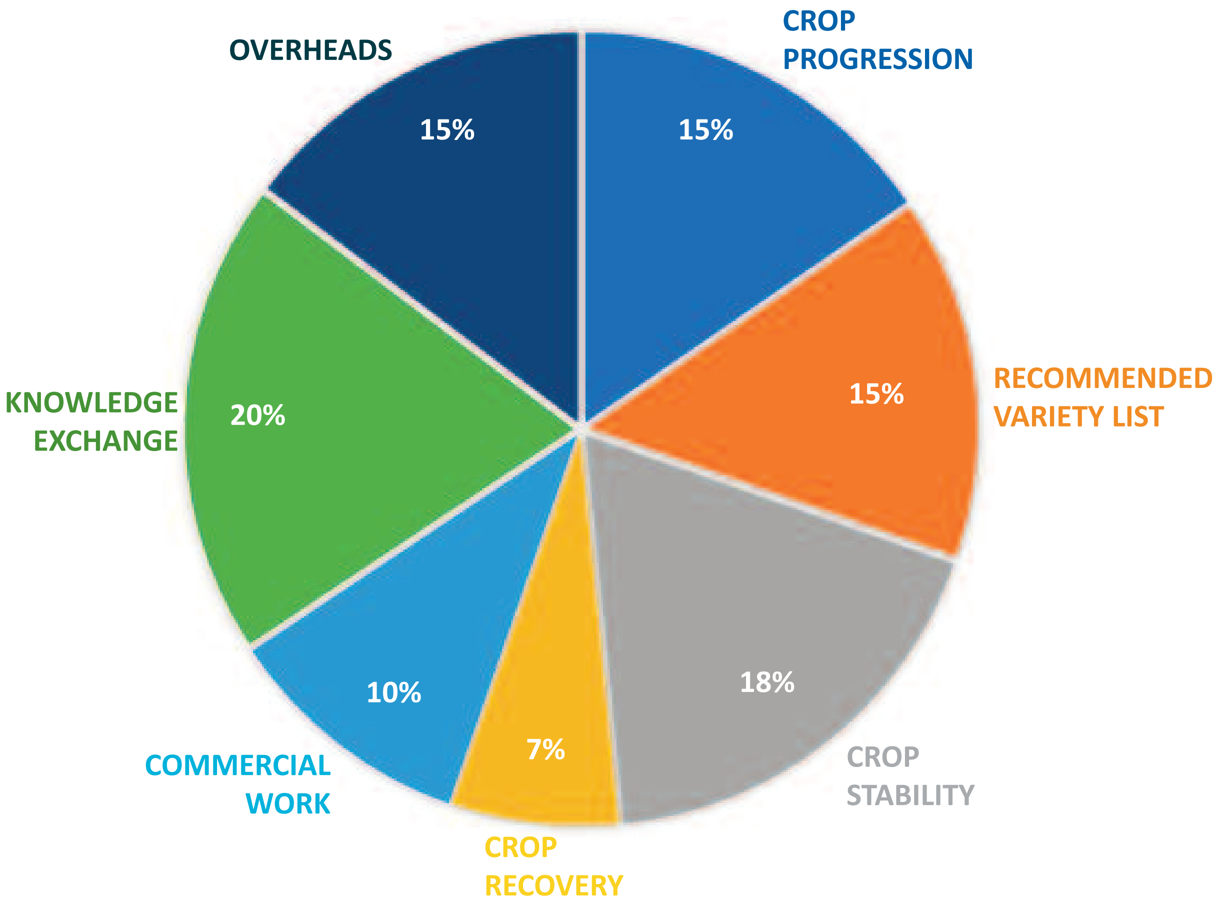
BBRO PLANT CLINIC 2016



FINANCE

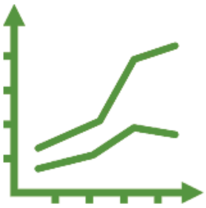
The BBRO implements and commissions work on behalf of the UK sugar beet industry. Funds to support this work are received from the growers levy, processor and external research bodies. The following chart shows the areas of spending for the 2017/18 crop.

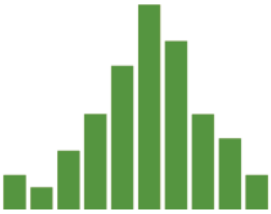
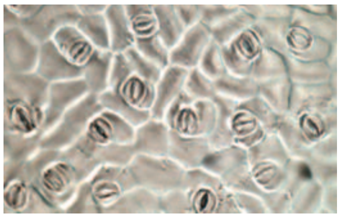
BBRO BUDGETED SPEND BY AREA 2017-2018

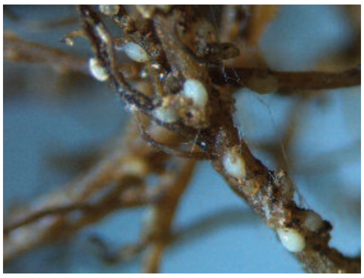









British Beet Research Organisation

Innovation Centre | Norwich Research Park | Colney Lane | Norwich | NR4 7GJ

01603 672169 | BBRO@bbro.co.uk | www.bbro.co.uk