**BBRO PROJECT REPORT FORM**

**Please note the details on page 2 will be used to formulate our Annual Report.**

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| **Project Title: A novel pre-breeding strategy to reduce dependence on insecticides for virus yellows control in sugar beet** | |
| **BBRO project no:** |  |
| **Project sponsor:** | **BBRO/Innovate UK (102098)** |
| **Final report** | |
| **Project lead or student name:** | **Dr Mark Stevens** |
| **Project mentor or supervisors:** |  |
| **Report Date:** | **28/03/20** |
| **Reporting period covered:**  **(e.g. 1/1/16 - 31/12/16)** | **01/04/19 – 31/03/20** |
| **Timeline (e.g. Year 1 of 4)** | **Year 5 of 5** |
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| BBRO use only | Date assessed: |
| Assessors comments |  |
| Action required |  |

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| **Project summary (no more than 300 words)** |
| Virus yellows is a major economic disease affecting sugar beet. Its impact is particularly significant in the UK due to our maritime climate, and is being exacerbated by restrictions passed in 2018 on the use of neonicotinoids. The production of resistant and tolerant varieties will be an essential form of protection against the threat of virus yellows. 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 and tolerance traits, and to identify genes which protect against foliar damage and yield loss. Several novel genetic regions on the sugar beet genome have been identified which mitigate the damaging effects of virus yellows on the canopy and molecular markers have been developed for future marker assisted breeding. Quantitative trait loci (QTL) controlling tolerance to virus yellows have also been crossed into modern breeding material, and hybrids assessed in 2018 and 2019 field trials for both foliar health and yield. A number of tolerant hybrid lines were found to perform significantly better in terms of canopy damage and yield in comparison to susceptible elite lines in the 2018 trials. This Innovate funded and industry-led project has proven to be successful in terms of genetic outputs, significantly accelerating understanding and development of virus yellows resistant/tolerant material which will become an important IPM tool for managing Virus Yellows in the UK into the future. |
| **Main Objectives** |
| * To identify and cross ‘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.   **Innovate UK: A novel pre** **eding strategy to** |
| **Main outcomes and achievements** |
| * **Stream I:** Six wild beet accessions were identified as significantly more tolerant/resistant to beet yellow virus (BYV) during field screening in year 1 and 2, when compared to current commercial varieties. Tolerant/resistant plants have been crossed with elite sugar beet material and four mapping populations were subsequently phenotyped in the field during the 2018 and 2019 field seasons. Data from field assessments and marker information have been used to carry out QTL analysis and several loci have been identified which protect beet plants from virus damage. The QTL identified can now be used by the plant breeders to aid development of resistant and tolerant sugar beet hybrids. * **Stream II:** Several tolerance QTL were validated in years 1 and 2 and subsequently crossed into elite breeding material to develop new hybrid sugar beet lines. Resulting hybrids carrying tolerance QTL were drilled during the 2018 and 2019 seasons. Canopies were tested for virus yellows tolerance and root yields were measured. Hybrids carrying three different tolerance QTL exhibited increases in yield in comparison to lines carrying the elite allele in the presence of virus. They also showed significantly lower canopy yellowing in the presence of virus. 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 play an important role in future ‘Integrated Pest Management’ strategies aimed at reducing the damaging effects of virus yellows on sugar beet crops with few pesticides available to control aphid vectors. * Virus yellows tolerance QTL have been identified by our research group, which exhibit a significant decrease in canopy yellowing and a yield benefit in the presence of virus. * Virus yellows resistant and tolerant sugar beet material has been generated which has high potential for development in future breeding programmes. * This project has significantly accelerated the development of virus yellows resistant and/or tolerant sugar beet varieties for the future. |

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| **Section 1: To be completed by Project Lead:** | | |
| **Other project objectives (not listed on previous page)**   1. To identify and map QTL controlling resistance to the virus yellows complex in beet 2. To fine map and introgress tolerance QTL, generating hybrid elite material with host protection to virus yellows 3. Establish any yield benefit or penalty (in the presence or absence of virus yellows) from the introgression of tolerance into elite material | | |
| **Milestones for current period** | | |
| * **Stream I Milestone:** *Field (canopy yellowing) and glasshouse (viral titre) evaluation of F1S2 plants, genotyping and QTL analysis: SV populations 7430 and 8613* * **Stream II Milestone:** *Drilling, inoculating, phenotyping SV and MH yield trials and harvest/yield analysis.* | | |
| **Status - Mentor’s scoring system for interim reports.** | | |
| RED | “Major concern - escalate to the next level"  Slippage greater than 10% of remaining time or budget, or quality severely compromised. Corrective Action not in place, or not effective. Unlikely to deliver on time to budget or quality requirements. | |
| AMBER | "Minor concern – being actively managed”  Slippage less than 10% of remaining time or budget, or quality impact is minor. Remedial plan in place. | |
| GREEN | "Normal level of attention"  No material slippage. No additional attention needed | |
| Milestones | Comments + Any Action required | Status R/A/G |
| **Stream I:** To identify resistance QTL to virus yellows in beet | | |
| **Stream I Milestone 1/6 – 1/9:** *2019 field and glasshouse evaluation of F1S2 plants, genotyping and QTL analysis: SV populations 7430 and 8613* | **Completed tasks:**  **Field evaluation (ADAS, Boxworth):**   1. Trial site located and trial protocols and design finalised. 2. F1S2 lines successfully germinated and inoculated with beet yellows virus in the glasshouse 3. Inoculated plants were successfully transplanted into the field site and irrigated. 4. Yellowing assessment and chlorophyll measurements were taken on a monthly basis 5. QTL analysis of data completed on schedule.   **Glasshouse evaluation (BBRO, Norwich)**   1. Pilot ELISA experiments to measure BYV levels in leaf and root material of infected seedlings were successfully designed and completed by MH. 2. Trial design and protocols finalised 3. F1S2 lines successfully germinated and inoculated with beet yellows virus in the glasshouse 4. ELISAs carried out on both leaf and root material of BYV infected seedlings (5 plants/F1S2 line) 5. Statistical analysis of data completed on schedule | G |
| **Stream II:** To develop sugar beet hybrids tolerant to virus yellows and determine yield benefit for variety development | | |
| **Stream II Milestone 2/11 – 2/12:** *2019* d*rilling, inoculating, phenotyping yield trials and harvest/yield analysis.* | Hybrids from MH and SV were successfully sown at the Ramsey trial site. Both trials established well, but significant insect damage (e.g leaf miner) was recorded during the early weeks which led to some initial patchiness and weed development. All plants within the infected block were inoculated with BYV in early June. Visual symptoms of virus yellows were assessed monthly and chlorophyll measurements at a mid-canopy leaf were taken across all plots in Sept. An extremely wet autumn made harvesting the trial challenging, but the trial was successfully lifted on 31st Oct and yield analysis completed. Data was analysed on schedule. | G |

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| **Summary of results (including figures and tables)**  ***Annual report****: please provide a 2 page summary of key findings from the reporting year.*  ***Final report:*** *please provide a summary of project findings and outcomes with relevant supporting data.* |
| **Stream I**  ***WP1a: Screen for ‘broad spectrum’ R to virus yellows in wild beet***  Fifteen wild beet accessions were tested for resistance to BYV during year 1. Plants were sown in the glass house at BBRO and inoculated with BYV alongside susceptible sugar beet varieties (Stingray and SY Muse). Infected plants were then transplanted into the field (three replicates) at ADAS, Boxworth. All plant canopies were assessed for visual yellowing (% of yellowing across canopy), chlorophyll content (as measured by a SPAD meter at the oldest leaf) and BYV viral titre measured from leaf samples collected from the trial using an ELISA technique carried out at BBRO. The six best performing wild beet accessions were then selected for further development within the project. Four red wild beet accessions (6223, 7430, 7454 and 3068) and two green wild beet accessions (8613 and 4012 (nb. red/green pigmentation was segregating in accession 4012) were selected. Accessions 6223, 7430 and 7454 showed lower canopy yellowing, higher chlorophyll content and lower BYV viral titre (see Figure 1 a and b) than the susceptible commercial controls, suggesting resistance or partial resistance to BYV. Red beet accession 3068 showed significantly lower canopy yellowing, however BYV viral titre was similar to that of the commercial controls, suggesting that the accession may be tolerant to BYV. Accessions 8613 and 4012 were the best performing green beet when compared to the commercial controls, with regards to canopy yellowing and viral titre, suggesting partial resistance to BYV.  2019  2018  **a.**  **b.**  ***Figure 1. a.*** *Correlation between whole canopy yellowing and viral damage at the oldest leaf (as measured by SPAD)* ***b.*** *Correlation between viral titre at oldest leaf and whole canopy yellowing. Mapping populations derived from accessions highlighted in blue were subsequently tested in 2018 and those highlighted in green in 2019.*  ***WP1b: Develop mapping populations segregating for virus yellows resistance***  F1 seed produced by each breeding company (R x elite, crossed as described in Figure 2) was assessed in the field during year 2. F1 plants were inoculated with BYV at BBRO as stated previously and plants transplanted into the field at ADAS, Boxworth. All F1 plants were assessed as carried out in the 2015 trial (reported previously). Twenty-six F1 plants with the healthiest canopy (low yellowing, high chlorophyll and low viral titre) were selected by each plant breeder for self-fertilisation as described below. The four most productive F1S1 seed lots were selected by the consortium and developed into F1S2 mapping populations during year 3 for testing in 2018 and 2019, as indicated in Figure 1.    ***Figure 2.*** *Stream I wild beet resistance testing (blue) and crossing programme (green) to produce F1S2 mapping populations segregating for virus yellows resistance or tolerance.*  ***WP1c: Mapping of R QTL in F1S2 populations 6223 and 4012***  Stream I trials were successfully completed in 2018 with no major issues, despite challenging weather conditions. Two mapping populations (seed provided by Maribo Hilleshog) were germinated and inoculated in the glasshouse with beet yellows virus. Inoculated plants were transplanted into the field in June and canopy assessments were taken at regular intervals during the season. Samples were also taken from the canopy to measure viral titre. It was evident that the viral titre measurements, taken from the oldest leaf and mid-canopy, did-not correlate well with the yellowing canopy symptoms. This could be due to variation of viral titre between plants and across leaf layers in the canopy during the season or alternatively due to the limited quantitative precision of ELISA. All canopy assessment data were compiled with molecular marker data. QTL analysis was carried out to identify chromosomal regions controlling beet yellows resistance and/or tolerance traits.  Significant QTL intervals were identified on Ch I and Ch IV from mapping population 6223 (population fixed for green pigmentation on Ch II), with plants carrying the wild alleles exhibiting significantly less yellowing than those carrying the elite allele. Quantitative yellowing data collected via visual assessments and via GIS analysis of RGB drone images throughout the season showed consistent QTL intervals on Ch IV, which also co-located to QTL intervals mapped using SPAD data (chlorophyll content of oldest leaves in canopy). Yellowing QTL of small effect were also identified on Ch III, using yellowing assessment data, drone imagery data and SPAD data. One significant QTL on Ch II was identified in mapping population 4012 (segregating for red pigmentation), with plants carrying the wild allele exhibiting significantly lower yellowing. This interval also co-localised with a red pigmentation QTL on Ch II, suggesting that the yellowing trait is closely linked to pigmentation and not of interest to the breeders.  ***WP1d: Mapping of R QTL in F1S2 populations 7430 and 8613***  In 2019, two mapping populations (8613 and 7430; seed provided by SV) were germinated and inoculated in the glasshouse with beet yellows virus. Population 7430 was segregating for red pigmentation; to ensure that red pigmentation did not mask the yellowing symptoms when assessed in the field, green plants were preferentially selected for inoculation. Inoculated plants were transplanted into the field in June and canopy assessments were taken at regular intervals during the season. Infected leaf material was not collected for ELISA testing during this season, due to the high variation of immunoassay data collected in previous years. Instead it was decided that a replica experiment should be set up in the glasshouse at BBRO, where an additional five seedlings of each line tested in the field were inoculated with BYV. Roots and leaves were then harvested at 14 days post inoculation and viral titre levels measured. All canopy assessment data (visual scoring, SPAD measurements and drone image analysis) from field trials and viral titre data from glasshouse ELISA experiments were compiled with molecular marker data generated by SV. QTL analysis was subsequently carried out to identify chromosomal regions controlling beet yellows resistance and/or tolerance traits.  A single, highly significant QTL interval was identified on Ch V from mapping population 7430 with plants carrying the wild allele exhibiting on average 15% less canopy yellowing than those carrying the elite allele (Figure 3). This QTL was also present when assessment data from green beet only were analysed, suggesting that this canopy yellowing trait was independent of red pigmentation in the canopy. An additional QTL located on Ch II was also identified where the wild allele exhibited significantly lower canopy yellowing within mapping population 7430. This interval also co-localised with a red pigmentation QTL on Ch II, suggesting that the yellowing trait is closely linked to pigmentation and not of interest to the breeders. Several minor QTL were identified that mapped to the 8613 genome, one of which (QTL mapping to Ch 8) was only identified when GIS drone data was analysed. As all 8613 QTL were of relatively small effect, it is unlikely that these QTL will pursued in future breeding programmes. Unfortunately, the viral titre data collected from both populations (seedling leaf and root tissue) was found to be too variable across plates and could not be used reliably within the QTL analysis.    **Figure 3.** *Bar chart comparing % canopy yellowing (Oct 2019) of 7430 parental lines and progeny w/wo the Ch V wild and elite allele.*  **Stream II**  ***WP2a: Fine mapping of Tol QTL intervals/ WP2b:* *Introgression of Tol QTL into elite material***  Previous studies carried out by the consortium on mapping populations 09-35-F1S1 and 09-45-F1S1 (BYV tolerant leaf beet x susceptible sugar beet), identified QTL intervals on Ch I, II, III, IV and VI which were associated with traits indicative of BYV resistance or tolerance. Large field trials in year 1 and 2 were carried out to test F1S2 families from populations 09-35 and 09-45 respectively, in order to validate and refine the QTL intervals. In parallel, lines carrying wild alleles controlling canopy health in the presence of BYV, were selected by both breeding companies for introgression into elite material. Both companies produced a set of 32 hybrids to be tested in replicated field trials for yield (sugar per hectare, white sugar yield, root weight (T/ha)), sugar impurities (potassium (mM\_K), amino N (mM\_Na) and N (mM\_N)) and canopy health (canopy Y %) in years 4 and 5. A summary of the crossing programme can be seen in Figure 4.    ***Figure 4.*** *Stream II crossing programme to produce BYV tolerant hybrids for yield and canopy health testing in year 4 and 5.*  ***WP2c: Tolerance hybrid yield trials***  BYV tolerant hybrid varieties from both MH and SV were tested in 2018 and 2019 (year 4 & 5) in replicated field trials at two Cambridgeshire sites, Dry Drayton and Ramsey respectively. All hybrid lines from both companies were assessed for yield and canopy health in the presence and absence of BYV. Both trial years saw challenging weather conditions. In 2018 drilling of the Dry Drayton trial was hampered by an unseasonably wet spring followed by an unprecedented heat wave and prolonged drought. The abiotic stress observed in the 2018 season affected development of BYV symptoms after inoculation, with extreme yellowing symptoms being observed in the canopies of inoculated plots just 7 days after inoculation, suggesting a significant biotic/abiotic interaction which may have impacted and enhanced 2018 data. The 2019 season also saw periods of extremely hot and dry weather, however extreme weather events were not as prolonged as in 2018 and did-not appear to accelerate the onset of canopy yellowing. 2019 also saw prolonged rainfall during the autumn making harvesting of the trial challenging.  *Yield & canopy testing of the Ch I BYV tolerance QTL*  In 2018, SV hybrids carrying the Ch I wild allele (+ QTL) exhibited significant increases in root yield (t/ha), sugar per hectare (S/Ha), white sugar yield (WSY) and potassium (mM K) in the presence of BYV compared to hybrids carrying the Ch I elite allele (- QTL) (see Figure 5). No negative impacts on yield were associated with the wild Ch I allele in the absence of disease. They also exhibited significantly lower canopy yellowing in the presence of BYV (see Figure 6). No significant differences in terms of yield, sugar impurities or canopy health were identified in MH hybrids carrying the elite and wild Ch I alleles in 2018 trials. In 2019, SV hybrids carrying the Ch I wild allele exhibited significantly lower canopy yellowing in the presence of BYV in July (as seen in 2018), but later in the season (Sept & Oct) the opposite was observed with the elite allele exhibiting lower canopy yellowing. No significant differences in Yield were observed for Ch I hybrids from either company.    **Figure 5.** *Bar graphs showing 2018 mean root weight (T/ha), sugar per hectare (S/ha), white sugar yield (WSY) and potassium (mM K) from SV hybrids fixed for the Ch I wild allele (+ QTL)) compared to those carrying the elite allele (- QTL) in the presence and absence of BYV. An asterisk indicates that the mean values are statistically different.*    **Figure 6.** *Bar graphs showing 2018 mean % plot yellowing of SV hybrids fixed for the Ch I wild allele (+ QTL)) compared to those carrying the elite allele (- QTL) in the presence and absence of BYV. An asterisk indicates that the mean values are statistically different.*  *Yield and canopy testing of the Ch II BYV tolerance QTL*  In 2018, SV and MH hybrids carrying the wild Ch II (+ QTL) exhibited ~5% and 8% lower canopy yellowing respectively in the presence of BYV, when compared to infected lines carrying the elite allele (Figure 7). This data supports findings collected in year 1 & 2 and the preceding project. No significant differences in yield or sugar impurities were identified between SV or MH lines carrying the Ch II wild and elite alleles in the presence of disease in 2018 trials, although the average yield of plots carrying the wild Ch II allele were higher in both trials. There appeared to be a negative yield effect associated with the wild Ch II allele in the absence of disease. In trials conducted in 2019, no significant differences in canopy or yellowing were identified in SV material carrying the Ch II QTL interval (+/- QTL) in the presence or absence of BYV. In 2019, no significant differences were observed in terms of canopy yellowing or yield for hybrids carrying Ch II from either company.  September  August      \*  **Figure 7.** *Bar graphs showing 2018 mean % plot yellowing of MH hybrids fixed for the Ch II wild allele (+ QTL)) compared to those carrying the elite allele (- QTL) in the presence and absence of BYV. An asterisk indicates that the mean values are statistically different.*  *Yield and canopy testing of the Ch III BYV tolerance QTL*  In 2018, MH hybrids carrying the Ch III wild allele (+ QTL) exhibited significant increases in root yield (t/ha) and white sugar yield (WSY) in the presence of BYV compared to hybrids carrying the Ch I elite allele (- QTL) (see Figure 8). They also exhibited significantly lower canopy yellowing in the presence of BYV (See Figure 9). No significant changes in sugar impurities were identified. In addition, no negative impacts on yield were associated with the wild Ch I allele in the absence of disease. In 2019, no significant differences were observed in terms of canopy yellowing or yield for MH hybrids carrying Ch III. Hybrids carrying the Ch III QTL interval were not available from SV for testing within 2018 or 2019 field trials.    WSY  T/Ha  **Figure 8.** *Bar graphs showing 2018 mean root weight (T/ha) and white sugar yield (WSY) from MH hybrids fixed for the Ch III wild allele (+ QTL)) compared to those carrying the elite allele (- QTL) in the presence and absence of BYV. An asterisk indicates that the mean values are statistically different.*    **Figure 9***. Bar graphs showing 2018 mean % plot yellowing of MH hybrids fixed for the Ch III wild allele (+ QTL)) compared to those carrying the elite allele (- QTL) in the presence and absence of BYV. An asterisk indicates that the mean values are statistically different.*  *Yield and canopy testing of the Ch IV BYV tolerance QTL*  In 2018, SV and MH hybrids carrying the elite Ch IV (+ QTL) exhibited ~5% lower canopy yellowing in the presence of BYV, when compared to infected lines carrying the wild allele (data not shown). This data supports findings collected in year 1 & 2 and the preceding project. No significant differences in yield or sugar impurities were identified between SV or MH lines carrying the Ch IV wild and elite alleles in the presence of disease in 2018 trials. In trials conducted in 2019, no significant differences in terms of yield or yellowing were identified in SV or MH material carrying the Ch IV QTL interval (+/- QTL) in the presence or absence of BYV.  *Yield and canopy testing of the Ch VI BYV tolerance QTL*  No significant differences were identified between hybrid lines carrying elite and wild Ch VI alleles in 2018 or 2019 from either company’s trials, in terms of yield, sugar impurities or canopy yellowing (data not shown).  **Company Project Impact Statements**  *Maribo Hilleshog impact statement*  With the current restrictions on neonic applications, the population of *Mysus persicae* is forecasted to increase and contribute to a more rapid spread of virus yellow in sugar beets. The aim of the project has been to develop a host protection against the virus yellows complex and thereby maintain a healthy a sugar beet crop.  The project has enhanced the understanding and accelerated development of virus yellows resistant and/or tolerant sugar beet varieties for the future. In the presence of the virus, a significant decrease in canopy yellowing and as well a yield benefit have been expressed in sugar beet germplasms identified carrying resistance and tolerance QTLs. Such identified virus yellows resistant and tolerant materials can be incorporated into commercial breeding programs.  The estimated success in terms of the the investment made by the partners/Innovate is 60 %. Further, the chance of success based on the material produced within the project is 20-40 % based on the fact that it included two parallel workstreams. There are positive results from one of the workstreams, the experiments in the other workstream needs to be repeated and evaluated further.  *SESVanderHave impact statement*  The project started at a time when neonicotinoids were freely accessible and there was no threat from virus yellows (VY).   Almost immediately upon commencing the project it became apparent that the timescale for the loss of neonicotinoids would accelerate through legislation, leaving sugar beet growers vulnerable to the 25 to 50% yield loss that VY cause.  The project therefore took on far greater importance and additional investments were made by SV in and surrounding the project above budget.  In terms of success we estimate the overall figure is approximately 60% across the two streams;  Stream 1 – early stage resistance screening delivered the highest level of success, whilst Stream 2 – screening for tolerance in more advanced material was less successful in absolute terms, but provided valuable knowledge to further our breeding strategy.  However the wider success was the knowledge gained by our team from working with this vector borne disease, it proved invaluable and timely in shaping strategy going forward; both in laboratory, UK field trials and ultimately how improved products can be effectively deployed into this new landscape, where VY is a significant risk across northern Europe and the UK in particular.  This has resulted in further investments in research and development and inward investment into the UK.  The chances of success of the material are hard to quantify, and will be determined by the approach individual countries take to derogations for neonicotinoids, emergency approvals, new chemistry registration or restrictions, or wider insecticide resistance. More significantly with reduction in sugar factory capacities across the EU due to the sugar price, lower yields and rising costs of beet production the challenge will be sustaining the industry whilst such material is integrated into elite lines for commercial release.  If the landscape is supportive of integrating genetics into the management of VY the material has a 40% chance of success given the evolving landscape of vector and virus. Ultimately the time frame for integrating material from this programme into a commercial product will depend on a multitude of factors, but we are grateful to the huge efforts put in by the consortium and the support of Innovate UK in facilitating such a pivotal project for the Beet industry and the UK. |
| **Annual report: Key issues to be addressed next year:** |
| N/A |
| **Publication of results to date/planned publications**: |
| **Year 1 (1/04/15 – 31/03/16)**   1. Article in British sugar beet review to highlight project (summer edition ‘15) 2. Article in ADAS’s technical update to highlight project (spring edition ‘15) 3. SESVanderHave virus yellows project launch/brochure to highlight project (Spring ’15) 4. Project highlighted at BBRO summer open days (May ’15) 5. Project highlighted in SV farmers article (Oct ‘15) 6. BBRO: Poster at REAP- AgriTech East Annual Conference to highlight project (Nov ’15)   **Year 2 (1/04/16 – 31/03/17)**   1. Project highlighted at BBRO summer open days (May ‘16) 2. Poster presentation at IIRB conference (winter ’16) to summarise project 3. Summary of project published in the BBRO annual report for 2016/2017   **Year 3 (1/04/17 – 31/03/18)**   1. BBRO grower meetings at demo sites at Morley and Bracebridge (Nov 2017) and Advanced BASIS course (Nov 2017). 2. ADAS summarised the project at the Advanced BASIS course in Dec ’17 (slides agreed with consortium)   **Year 4 (1/04/18 - 31/03/19)**   1. BBRO highlighted the project at the AICC Winter conference and NFU Sugar Board (Jan 2018) 2. ADAS presented a platform presentation at the IIRB congress in Normandy, in June 2018, summarising the project. 3. BBRO highlighted the project at the BCPC ‘Diseases of high value Crops’ talk (Oct ’18 NIAB), 4. BBRO highlighted the project at the AAB Crop protection conference in Southern Britain (Nov ‘18, Brighton). 5. BBRO highlighted the project at various grower/agronomist meetings and in the British Sugar Beet Review (Jan ’19) 6. ADAS presented a platform presentation at the BCPC Pests and Beneficial’s meeting in Jan 2019, summarising the project. 7. ADAS presented a project update at the ‘Growing sugar beet without neonicotinoid seed treatments’ IIRB workshop in Leuven, Belgium in March 2019.   **Year 5 (1/04/19 – 31/03/20)**   1. Field tour of the stream I and stream II sites by UKRI/political/scientific leaders (Sept 19) 2. The project featured in farmers weekly and on Twitter in Sept ’19 (<https://www.fwi.co.uk/arable/sugar-beet/breakthrough-in-sugar-beet-battle-against-virus-yellows>) 3. BBRO highlighted the project at the IIRB Genetics and Breeding study group in Norwich (Sept ’19) 4. ADAS and BBRO highlighted the Advanced sugar beet BASIS course in Dec 19 (slides agreed with consortium). 5. BBRO highlighted the project on the BBRO Northern Tour (growers and agronomists) (3 x events in Dec 19). 6. BBRO highlighted the project at an invited lecture on virus yellows to CRD/HAS/DEFRA in York Jan ’20. 7. ADAS presented the project highlights at the 77th IIRB congress (Feb ’20). 8. Presentation at the APPGSTA meeting at Westminster (TBC)     Posters presented by ADAS at the 77th IIRB Congress in 2020  Posters presented by BBRO at the IIRB in 2016 |
| **Section 2: To be completed by project mentor** |
| **Is the project on track to meet the stated objectives? (please comment in relation to milestones and the status score awarded in section 1).** |
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| **Please comment on any proposed changes to milestones.** |
|  |
| **Are conclusions scientifically robust? (please comment on data analysis/interpretation)** |
|  |
| **For final reports only:** |
| **How would you rate the project against the following criteria (please give a score out of 10, with 10 being highest)**  1 ) The project met its original objectives:  2) Contribution to scientific knowledge:  3) Direct relevance to growers: |