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| **Project Title:**  **Interactions between beet cyst nematode, sugar beet and brassica hatch crops** | |
| **BBRO project no:** |  |
| **Project Sponsor:** | **BBRO & UoN** |
| **~~Interim Report~~ / Final Report** (delete as appropriate) | |
| **PhD student** | **Alistair Wright** |
| **Supervisors** | **Debbie Sparkes**  **Mark Stevens**  **Matthew Back (Harper Adams University)** |
| **Report Date:** | **20/3/18** |
| **Reporting period covered:**  **(e.g. 1/1/16 - 31/12/16)** | **1/5/17-30/4/18** |
| **Timeline (e.g. Year 1 of 4)** | **Year 4 of 4** |

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| Date assessed: |  |
| Comments: |  |
| Action required: |  |

**Project summary**

BCN poses a serious threat to growers who cultivate sugar beet on infested fields. BCN may be more widespread than expected with infestations only being noticed in the crop when significant yield losses occur and is likely to become a greater problem in the future. 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. Research has also been undertaken to assess the ability of BCN resistant brassica species to reduce nematode populations prior to planting sugar beet.

**Main Objectives**

* To understand how susceptible, tolerant and resistant sugar beet varieties respond to infestation of BCN, particularly BCN reproduction levels on the varieties and yield quality differences.
* 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 sugar yield differences were found but infested susceptible plants had higher impurities and soil tare.
* Resistant brassicas may be a useful option for control of BCN in the future. The results produced so far do not show a clear response to all varieties.

**Key messages for growers and industry.**

Rotation length remains key to reducing BCN infestation levels. Cysts can retain viable eggs and juveniles that infest beet crops for over ten years following a suitable host crop (such as beet or OSR). A break of five or more years without a host allows for natural decline of nematode populations to less harmful levels, but there will still be losses in a susceptible beet crop.

The use of BCN tolerant varieties has become a popular option for control since their introduction in 2009 but their mechanisms of tolerance have been largely unknown. This PhD research has found that the tolerant varieties lead to significantly lower BCN populations than susceptible varieties but they cannot control BCN to the same extent as a resistant variety.

Resistant varieties have a smaller canopy per plant and take longer to reach canopy closure which explains their lower yields when previously tested in the UK. Increasing the seed rate of the resistant variety tested overcame the lower vigour shown and produced a similar yield to susceptible and tolerant varieties. Resistant varieties would be the best form of control for BCN and further investigations to their introduction to the UK might be beneficial for growers with high BCN populations.

Brassica hatch crops, planted in late summer, did not all produce significant reductions in BCN populations. Work is ongoing to understand the benefits of these brassicas and their interactions with BCN and is likely to require further trials in the future. Only some of the varieties currently available may be of benefit to use in the UK.

**Section 1: To be completed by Project Lead:**

**Other project objectives (not listed on page one)**

Understand how the exudates produced by the brassica hatch crops may causes differences in stimulating the hatch of BCN juveniles

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| **Milestones for current period (N.B. Milestones added retrospectively)** | | |
| Milestones | Comments + Any Action required | Status R/A/G |
| 1.1 | Complete Experimental work (only one repeat of exudate work to finish) | G |
| 1.2 | Write papers for publication (one submitted, one drafted and remaining two planned) | G |
| 1.3 | Write thesis to include papers and other unpublished work  (Thesis planned and due to be completed by mid July in time for review and submission by 31st August 2018). | G |

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| **Status** | |
| 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 |

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| **Summary of results (including figures and tables)**  *For annual reports please provide a 2 page summary of key findings from the reporting year*  *For final reports please provide a summary of project findings and outcomes with relevant supporting data.*   1. Field trials to monitor canopy expansion of varieties of sugar beet which are tolerant, susceptible or resistant to BCN   Field trials in 2016 and 2017 have devised a method to monitor canopy development of varieties in the field. Four varieties were grown in both years and their canopy expansion photographed weekly. One variety was susceptible to BCN, one was resistant, one was tolerant and the final variety was light tolerant. The varieties were sown at 119,000, 153,000 and 211,000 seeds per hectare.  Figure 1 shows canopy expansion of two varieties measured in the trial when sown at the same seed rate. The more vigorous canopy was from the susceptible variety and the less vigorous canopy was the resistant variety. The graph shows that there is a nine day difference from when the varieties reach 50% of their maximum size. This delay in expansion of the resistant variety would lead to less assimilation of sugar and results in the lower yields found. The increased PPD was able to decrease this delay in canopy closure and yields were improved.    Fig 1 – Canopy expansion graphs fitted from the canopy data obtained using the camera rig. The more vigorous canopy (**-**) of the susceptible variety reached canopy closure faster than the less vigorous canopy of the resistant variety (---) and resulted in a higher yield of sugar.  The experiments have shown that the resistant variety has a less vigorous canopy in terms of its expansion. Sowing it at 153,000 seed ha-1 significantly increased the yield of the variety to levels similar to the susceptible variety at 119,000 seeds ha-1. Other findings from these experiments have shown a very strong relationship between canopy cover and NDVI (R2=0.96, P<0.001, Fig 2) which may be very useful in the future for rapid in-field phenotyping of varieties and measuring their canopy development throughout the season.    Figure 2- Relationship between observed canopy cover measured by image analysis and NDVI measured across all plots and times of measurements in the field trial in 2017.   1. Screening varieties of sugar beet for tolerance and resistance to BCN   Developed from the box technique established at Brooms Barn, box experiments were set up at Sutton Bonington in 2016 and 2017. They tested six varieties of beet, three tolerant, one light tolerant, one susceptible and one resistant. The beet were planted in the April of each year and harvested in November. Half of the boxes were infested with hatched juveniles of BCN. The results showed significant variation between the varieties tested (Fig 3). The light tolerant and susceptible varieties consistently produced the greatest populations, with the light tolerant producing the highest in 2016 and the susceptible highest in 2017. In both years the tolerant varieties produced populations which were consistently higher than the resistant variety but were not significantly different. There were also significant interactions between some varieties and the quality of the roots produced in parameters such as the alkalinity ratio of impurities (Data not shown) and the soil tare (Fig 4) of the infested plants. However, no significant differences in sugar yield were found which was surprising given the large differences in BCN infestation. Further work is needed to refine this method, such as changes to the soil type, irrigation method and inoculation of BCN.  Figure 3– Final populations of BCN from the soil in the infested boxes in 2016 and 2017 . Error bars show LSD at 5% (P<0.001 for both years).  Figure 4– Mean Soil Tare in 2017. Significant increases can be seen on some varieties infested with BCN. Not infested plants- Infested plants - .  Error bar shows LSD at 5% (P<0.001)  This technique shows promise of being a very useful tool to screen new and existing BCN tolerant varieties which are entered into variety trials. This would give sugar beet growers a better understanding of population increases they can expect in their fields and any subsequent impact on yield from growing the different varieties.   1. Brassica Hatch Crops   Field experiments were sown in September 2016 and September 2017, on fields infested with BCN, using a range of commercially available BCN resistant brassicas which claim to reduce BCN populations in the soil and are often used to control populations prior to growing sugar beet the following spring. These brassicas are marketed as class 1 (>90% BCN control) or class 2 (70-90% control) varieties and their levels of resistance are tested using a bioassay under controlled conditions. The results from the field show a clear reduction in BCN populations (calculated from Pf/Pi) across both years of trials in response to the Class 1 treatments, although when analysed separately only 2017 produced significantly different results. The class 2 treatments do not show a significant reduction in populations. The sowing time may be too late in the season to stimulate the required hatch from these varieties as BCN becomes dormant below 10°C. The lower temperatures in autumn may not be sufficient, or sustained for long enough, to lead to significant BCN hatch. Further research into this area is required to evaluate whether brassica hatch crops are a useful tool in managing BCN populations and whether their use is justified when BCN tolerant varieties are available.  BCN Reproductive Factor  (Pf/Pi)  Figure 5 – Mean BCN reproductive factor (Pf/Pi) from multi-year ANOVA analysis. Significant (P=0.01) responses were found when the data sets from both years were analysed. Error Bar shows LSD at 5%. A Pf/Pi of 1 = No change in population. Pf/Pi<1= population decline and >1 = population increase.  Sugar beet yield data from the trials planted immediately after the brassica cover crops have not shown any benefit of growing the brassicas, nor any residual impact of reduced BCN populations. However, as these data are only from one site and one year and the fact the trial was redrilled very late due to pest damage, the results may not accurately reflect any benefit of the brassicas above BCN population control.   1. Root exudates stimulating BCN hatch and emergence.   This is the final section of research to be completed in this PhD. Experiments looking at the exudates produced by sugar beet varieties has shown variation in their ability to stimulate BCN hatch (Fig 6). In both replicates of the experiment the light tolerant variety has shown a significantly greater level of hatch than the resistant variety. The remaining varieties produced levels of hatch which were higher than the resistant variety but not significantly so.  When the same method has been used on the brassicas, conflicting results have been produced. Whilst the same varieties were grown under the same conditions in the growth room for the same length of time, one replicate has shown the brassicas to stimulate BCN hatch and the other replicate of the experiment has shown inhibition of hatch. One final repeat of the experiment is now underway. This final experiment will use plants which are five, six or seven weeks old to investigate whether the developmental stage of the plants changes the ability of the brassicas to stimulate or inhibit hatch and may help to understand the results from the field trials.  Figure 6 – Mean percentage hatch of BCN juveniles in response to exudates collected from different varieties of sugar beet grown in a growth room. Error bars show LSD at 5% significance. (P<0.001 for exp 1,P=0.002 for exp 2). |

**Key issues to be addressed next year:**

N/A - Project to complete in August 2018.

**Publication of results to date/planned publications**:

* Alistair gave a poster presentation at the BBRO open days in July.
* Alistair gave an overview of the project at the BBRO winter technical meetings.
* An article was published in the British Sugar Beet Review (Spring 2017) outlining the progress of the project so far
* Alistair attended ‘Advances in Nematology’ in London in December 2017 to present findings from the Box trial. Subsequently awarded the Brian Kerry prize for best student presentation at the conference.
* Submitted paper on the field variety work at Sutton Bonington to European Journal of Agronomy.
* Drafted paper on Box experiments for Crop Protection Journal
* Papers on BCN hatch crop work and exudate experiments also planned
* Thesis writing is also underway ahead of hand-in during late August 2018.

**Section 2: To be completed by project mentor**

**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:

**Are conclusions scientifically robust? (please comment on data analysis/interpretation)**

**Please comment on any proposed changes to milestones.**