Improved in-crop monitoring and use of trap-cropping as novel approaches to the integrated pest management of aphid BYDV vectors in winter cereals

Background

Barley yellow dwarf virus (BYDV) is one of the most widespread and economically damaging viral diseases of crops (Walls et al., 2019). BYDV infection is caused by viruses in the family Luteoviridae that result in yield reductions through chlorosis and reduced stress tolerance (Riedell et al., 2003). Losses vary but in wheat, AHDB estimate that in untreated crops they average 8%, but may be as high as 60%. It is estimated that without effective controls of BYDV vectors this disease could cost the industry on average £136 million a year in wheat alone. There are three distinct strains responsible for causing crop losses in UK cereals with the most common being BYDV-PAV (Harrington et al., 1999), vectored by *Rhopalosiphum padi* (bird cherry-oat aphid) and *Sitobian avenae* (English grain aphid). Susceptible crops may become infected with BYDV at any point of their development, but winter wheat is most susceptible up to growth stage 31 (Doodson and Saunders, 1970).

Host plant selection by aphids can be divided into: (1) habitat location, (2) host location, and (3) host acceptance (Ben-Issa et al., 2019). Olfactory cues dominate aphid behaviour during the first two stages of host plant selection. It is possible to manipulate aphid behaviour during host plant selection for the purpose of pest management by growing plants with behaviour modifying properties within or around a crop, something commonly referred to as trap cropping. The use of trap cropping has shown potential to be a highly effective method of pest management, particularly for lepidopteran pests in brassica crops (Ben-Issa et al., 2017). Trap cropping systems for aphid pests are relatively underdeveloped, but successful examples of this approach in crops such as pepper for the melon-cotton aphid (*Aphis gossypii*) (Hussein and Samad, 1993) potatoes for management of virus Y vectors (Difonzo et al., 1996). In cereal crops, even without the use of trap cropping, the majority of BYDV vectors land close to field magins (see AHDB Cereals & Oilseeds project 21120077), strongly indicating the potential of this approach.

The heritage wheat variety Maris Huntsman was the most widely grown winter wheat variety grown in the UK in much of the 1970s and 80s, a time characterised by repeated outbreaks of cereal aphids. As Maris Huntsman was replaced with other more modern semi-dwarf varieties these severe outbreaks of aphid pests became less common, although the reasons for this have never been studied. Recent work at Harper Adams University investigating the landing behaviour of English grain aphid, significantly more aphids landed on Maris Huntsman over AHDB Recommended Lists varieties. For example, numbers of alates landing on Maris Huntsman were 20 times higher than on KWS Lili or JB Diego.

Project outline

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Objective 1: Investigate the potential of using plants that are preferred hosts for BYDV vectors to reduce the numbers of aphids entering the crop.

Task 1.1. Record landing behaviour of winged grain aphids and winged bird cherry-oat aphids in response to Maris Huntsman – Project year 1

Complementing existing data held at Harper Adams University for the English grain aphid, aphid landing experiments will be completed using wheat seedlings of AHDB Recommended Lists for winter wheat as well as a selection of heritage varieties, landraces and grasses. The BYDV resistant variety Wolverine will also be included. Pots of wheat seedlings will be arranged in random order around the circumference of a circle within large mesh cages. In the centre of the circle of pots winged aphids will be released and numbers recorded on plants at regular intervals.

Task 1.2. Investigate the olfactory basis of host plant selection by winged aphids – Project years 1 and 2

'Pettersson-style' (four-arm) olfactometers developed for the study of aphids will be used to record the behavioural responses of the winged aphids to the odours associated with varieties, landraces and grasses studied in Task 1.1. Behavioural responses will be recorded using visual assessments as well as using Noldus EthoVision software to track the movement of each aphid within the olfactometer.

Task 1.3. Replicated plot experiments – Project years 1, 2 & 3

Year 1 will test the principle of trap cropping of BYDV vectors using Maris Huntsman – replicated plots of a selected AHDB Recommended Lists variety will be established at the Crop and Environment Research Centre (CERC). Around the perimeter of each plot a strip will be left: (1) uncultivated; (2) the same Recommended Lists variety as in the plot grown; (3) Maris Huntsman grown.

For a select number of additional plots, winged aphids will be carefully marked with a fluorescent powder (using techniques developed at Harper Adams University) to allow subsequent assessments of secondary movement of winged aphids from trap crop to main crop or vice versa. This will be achieved through night-time assessments of plots using ultra violet (UV) lighting.

Year 2 will test a wider range of potential trap crops identified through Tasks 1.1. and 1.2. These trap crops will be tested under replicated field conditions and may include the BYDV resistant variety Wolverine.

Year 3 will test if plant density and width of the trap crop can be increased to create a more effective trap – replicated plots of a selected AHDB Recommended Lists variety will be established at CERC. Around the perimeter of each plot a range of widths of trap crop will be grown of the most effective trap variety identified in Years 1 and 2. The seed rate in each strip will be adjusted from a low rate of 200 seeds/m^2 to higher rates such as 600 seeds/m^2.

Objective 2: Record the responses of natural enemies of BYDV vectors to trap crop and AHDB Recommended Lists varieties to determine the potential of conservation biological control being used in conjunction with trap cropping.

Task 2.1. Investigate the olfactory basis of host plant selection by natural enemies of BYDV vectors – Project years 2 & 3

Olfacometer, wind tunnel and cage experiments will be used to record the behavioural responses of a range of natural enemies to the odours of aphid infested heritage varieties as well as AHDB Recommended Lists varieties. This work will also include the BYDV resistant variety Wolverine. The behavioural responses of parasitoids (e.g. *Aphidius rhopalosiphi* and *A. ervi*) and predators (e.g. *Episyrphus balteatus* and *Coccinella septempunctata*).

Task 2.2. Investigate the potential of integrating use of trap crops with flowering field margins as a means of enhancing biological control of BYDV vectors – Project years 2 & 3

Where appropriate the link between trap crop and flowering strips at AHDB Strategic Cereal Farms will be investigated in order to demonstrate the potential of conservation biological as a means of managing BYDV vectors.

Objective 3: Identify and exploit the volatile chemicals produced by the highly susceptible heritage winter wheat varieties such as Maris Huntsman and those associated with BYDV infection to improve reliability of in-field monitoring of cereal aphids.

Task 3.1. Headspace sampling of Maris Huntsman and selected other varieties – Project year 1 & 2

Air entrainments will be completed on winter wheat plants of the same variety and growth stage. This will be done by trapping volatiles on the porous polymer adsorbent Porapak Q. Entrained volatiles will be analysed using gas chromatography coupled mass spectrometry (GC-MS) to identify the compounds present. Where appropriate headspace sampling of BYDV infected wheat varieties will also be done to identify any differences in the plant volatile composition between uninfected and infected plants.

Task 3.2. Identify electrophysiologically active plant volatiles using gas chromatography coupled electroantennography (GC-EAG) – Project year 1 & 2

Electrophysiological responses of adult winged aphids to the headspace samples collected in Task 3.1 will be recorded (completed in Prof. Toby Bruce's lab, Keele University). This will be done by injecting a sample, which will be equally split between the aphid preparation and the GC flame ionization detector (FID). This will allow the electrophysiological response of an aphid to each chemical component of the wheat headspace to be characterised.

Task 3.3. Record responses of winged aphids of each species to electrophysiologically active plant volatiles – Project years 2

Synthetic standards of electrophysiologically active plant volatiles will be prepared in a range of concentrations. The behavioural response of winged aphids toward these standards will then be tested in olfactometer assays. EthoVision software will record the aphid's movements within the olfactometer.

Task 3.4. Determine efficacy of behaviourally active plant volatiles in improving sensitivity and specificity of trap catches – Project years 2 & 3

Field trapping will be carried out within crops at Harper Adams University and where possible at AHDB Strategic Cereal Farms West and/or East. Novel traps releasing a known rate of behaviourally active plant volatiles will be compared against standard general purpose yellow stick traps. Traps will be laid out in a randomised complete block design with trap positions re-randomised regularly. Results from Year 2 will inform work to be completed in Year 3t, which may include experiments to investigate trap height and distance from field margins.

Starting dates

The studentship would commence in September 2020 at Harper Adams University.