

Studentship Project: Annual Progress Report 11/2021 to 11/2022

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Project Title:	Resistance and susceptibility in interactions between apple and woolly aphid		
Lead Partner:	NIAB East Malling		
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Start Date:	23.09.19	End Date:	22.09.23

1. Project aims and objectives

This project aims to better understand the woolly apple aphid (*Eriosoma lanigerum*; WAA), a sap-feeding pest of worldwide apple production, with the long-term aim of increasing availability of apple rootstocks which are resistant to WAA feeding. The key aims include:

- To determine the genetic diversity of WAA populations in Britain to infer the likelihood that they are sexually reproducing. Understanding the lifecycle of WAA in Britain can help to inform pest monitoring, and control, in an orchard context;
- To understand the effect(s) of feeding on resistant rootstocks on WAA growth and reproduction. It is important to quantify whether population growth is halted or severely slowed to inform how to best utilise resistant rootstocks in an IPM strategy for WAA control;
- Identify genetic markers closely associated with WAA resistance genes. Markers located close to a gene of interest are useful for molecular breeding techniques which remove time consuming phenotyping steps involved in traditional breeding. This has the long-term aim of speeding up the commercial introduction of WAA resistant rootstocks.

2. Key messages emerging from the project

From analysis of the genetic diversity of WAA populations in the UK, and a small number of other countries, there is evidence that genetic variation between and within populations indicating that sexual reproduction is occurring in some populations. Originally, WAA was thought to reproduce exclusively asexually (no males produced) within the UK, compared to outside of its host range in America where it reproduces sexually. This finding raises the concern that with sexual reproduction there is the ability to spread virulence genotypes. For

The results described in this summary report are interim and relate to one year. In all cases, the reports refer to projects that extend over a number of years.

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example the ability to feed on resistant rootstocks is already observed and similar traits may arise in the future e.g. insecticide resistance.

Screening of forty-one crab-apple species and domesticated apple accessions for WAA resistance found twelve to be WAA susceptible, eighteen resistant and eleven as intermediate between susceptible and resistant with further testing required. Many -apple species are used as pollen sources in single variety commercial orchards and, if highly susceptible, can become a reservoir of WAA. Identifying resistant crab-apples can reduce pest numbers within the orchard and may also be novel source(s) of WAA resistance genes.

3. Summary of results from the reporting year

One of the main work packages of this reporting year was to carry out detailed genetic analysis on WAA samples collected from South East England. Two main genetic populations were identified with the presence of up to nine sub-populations, which is not necessarily evidence of sexual reproduction in the region but is indicative of gene flow between populations (mean F_{ST} value = 0.205). The areas with the largest genetic diversity were research facilities with many apple genotypes which may have acted as a selective pressure to drive variation.

Understanding how feeding on WAA-resistant rootstocks affects aphid growth and reproduction is key for modelling how populations are affected by resistant rootstocks: are they able to survive for long enough and produce enough offspring to damage rootstocks?

4. Key issues to be addressed in the next year

One of the key aims of the project is to locate WAA resistance genes in apple with the goal of developing molecular techniques for rootstock breeding. The WAA resistance gene Er1 is derived from Northern Spy and present in the rootstocks M.116 and MM106. We have refined the genetic position of Er1 using genetic markers which are associated with the gene and for use in future screening of seedling selections. In this next year the project aims to identify higher quality genetic markers which are more closely associated with the target gene. This will be carried out by screening existing genetic maps for potential markers in the approximate location of the target gene, these can then be tested using the breeding families we have. Having genetic markers which are very closely linked to the gene of interest is beneficial to molecular breeding as potential crosses can be screened for the presence of these markers and it can be reasonably assumed that the gene is present.

As with the genetic mapping of the first WAA resistance gene, a similar genetic map will be generated for the second WAA resistance gene, Er2, found in some rootstocks in the Geneva rootstock line e.g. G.41, G.222, G.202. We aim to locate the genetic position of this gene to develop molecular breeding techniques to speed up commercial rootstock breeding.

In the reporting year the genetic diversity of WAA in South East England was investigated (see section 3). In the coming year this work will be expanded to include many more samples from around the UK and from other key apple-growing regions including New Zealand, Chile and the USA. Many more of these samples

were collected from commercial orchards than for the English subset previously analysed and are hoped to give a broader image of WAA genetic diversity within the UK and in comparison to other countries.

2022-2023 is the final year of this project and therefore most planned work is completing datasets for all of the work packages addressed so far, including completing the data set for the WAA growth and reproduction studies.

5. Outputs relating to the project

(events, press articles, conference posters or presentations, scientific papers):

Output	Detail
Conference poster presentation IHC	WAA genetic diversity work was presented as a poster with a flash oral presentation at the International Horticultural Congress. Identification of genetic variation within populations of woolly apple aphid (Hemiptera: Aphididae) in South East England.
Conference paper	The work presented at the IHC was also submitted as a conference paper to be published in Acta Horticulture. Identification of genetic variation within populations of woolly apple aphid (Hemiptera: Aphididae) in South East England.
Conference oral presentation AAB	Oral presentation made at the Association of Applied Biologists 'Advances in Biocontrol and IPM' conference which that year had the focus of "Improving Global and Local IPM". Identification of potential woolly apple aphid biotypes in Kent, UK
TFD 22 Presentation	An oral presentation of project updates was given to industry members at the Tree Fruit Technical Day run by NIAB
BCPC congress poster	Summary of research progress was presented as a poster to the BCPC Congress 2021

6. Partners (if applicable)

Scientific partners	Harper Adams University, NIAB East Malling
Industry partners	WorldWide Fruits Ltd National Association of Cider Makers
Government sponsor	