Characterising secondary metabolite-based aphid resistance mechanisms from ancestral introgressions into modern wheat

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Submit applications to this project to University of Exeter

Project description: Aphids impact global cereal crop production, causing significant losses to both harvest yield quantity and quality via direct feeding damage alongside indirect transmission of devastative plant viruses. Cereal aphid management has historically relied upon broad-spectrum toxicants / synthetic insecticides, but the continued widespread use of such practices is a highly contentious topic. Alternative, reliable approaches to supplement current management practices are urgently required. Genetic resistance(s) may provide an environmentally friendly and sustainable option for mitigating aphid impacts if used within an effective integrated pest management (IPM) strategy.

Plants have evolved various anti-herbivory defence mechanisms; antixenosis (deterrence), antibiosis (negative effects on pests), and tolerance (ability to withstand damage). Volatile organic compounds (VOCs) mediate aphid host location and selection prior to colonisation, whilst aphid feeding-induced (or constant) VOCs from a resistant plant can deter aphid settlement and / or recruit aphid predators. Secondary metabolites (SMs) play a crucial role in many resistance mechanisms, and in wider plant-aphid / insect interactions. Various leaf SMs, such as phenolics, flavonoids and alkaloids, may also contribute to plant defence through aphid toxicity. Genetic regulation and biochemical pathways associated with SM-based resistance(s) are not comprehensively understood; the evaluation of known resistances in wheat could generate immense value, promoting effective breeding of elite varieties.

Previous work at Rothamsted Research has identified and characterised an ancestral wheat relative exhibiting muti-action aphid resistance, with both VOCs and leaf SMs implicated. Significant efforts have successfully generated relevant trait mapping populations for this resistance, and modern wheat lines with relevant ancestral genomic introgressions. This PhD will aim to comprehensively elucidate VOC and SM-based aphid resistance mechanism, build upon established germplasm resources, and involve exploration of this valuable trait through novel approaches.
The overall aim of pursuing valuable aphid resistance for future deployment underlying this PhD project will be achieved through the following objectives: 1) Characterise the bioactivity (aphid attraction/repellence) of pre- and post-herbivory VOCs from ancient, modern and introgressed wheat lines; 2) Screen introgressed wheat lines for known leaf SMs involved in aphid resistance; 3) identify candidate genes and biochemical pathways involved in the SM-based aphid resistance mechanisms of aphid resistant ancient wheat, and introgressed wheat lines, using bioinformatic, genomic and transcriptomic analysis. This highly multidisciplinary work scheme will equip the PhD student with a diverse skillset spanning entomology, chemical ecology, analytical chemistry, bioinformatics and genetics.

Our aim as the SWBio DTP is to support students from a range of backgrounds and circumstances. Where needed, we will work with you to take into consideration reasonable project adaptations (for example to support caring responsibilities, disabilities, other significant personal circumstances) as well as flexible working and part-time study requests, to enable greater access to a PhD. All our supervisors support us with this aim, so please feel comfortable in discussing further with the listed PhD project supervisor to see what is feasible.