Aboveground–belowground trophic linkages

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Plants are attacked by an array of pests and pathogens at the same time, so little wonder that many of these organisms affect each other by inducing physiological changes in their shared host plant. Plant and insect physiologists now recognise that these interactions could have important consequences for sustainable pest management in crop production. For example, simply targeting one pest could inadvertently lead to unanticipated surges in others. This is likely to be particularly true for pests that target different parts of the same plant, and root-feeding and foliar-feeding insect pests are known to affect each other through plant-mediated mechanisms even though these insects never physically meet (Wardle *et al.*, 2004). Root-feeding insects are frequently overlooked because they live in the soil and are less visible, so large populations can develop before growers spot the problem. We have begun to characterise the linkages between aboveground and belowground insect pests in several systems, ranging from barley to red raspberry, focusing on the changes in plant chemistry which underpin these interactions.

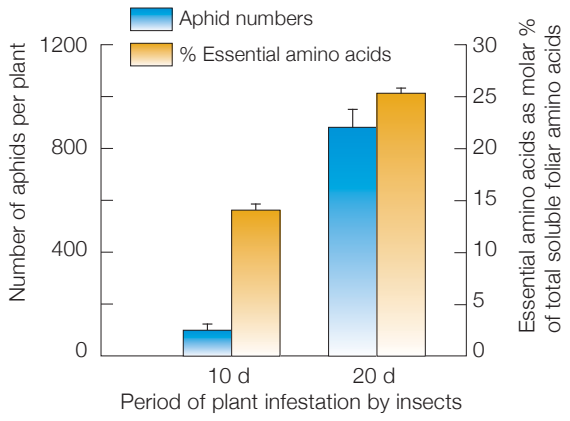
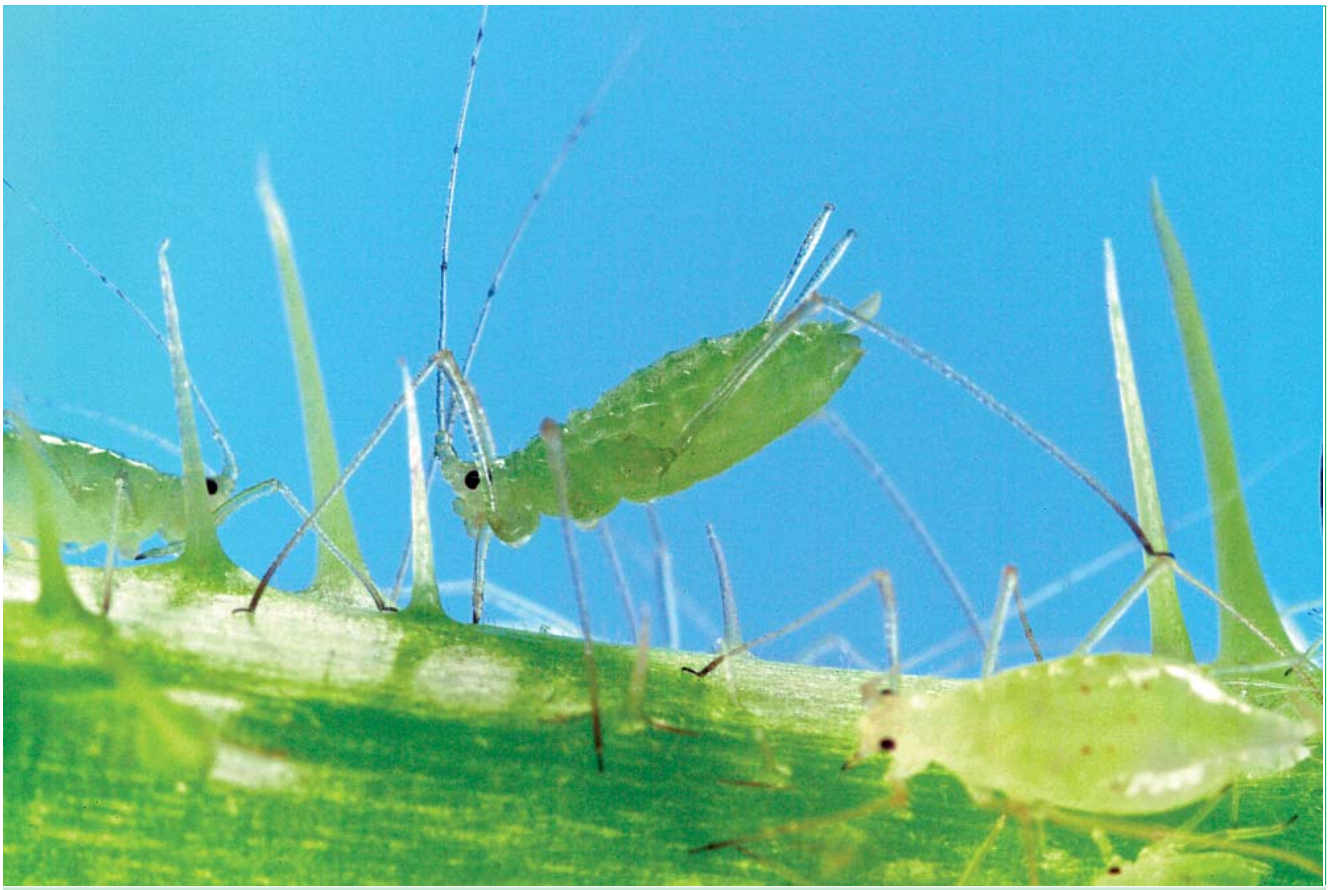


Figure 1 Impacts of root-feeding wireworms on aboveground populations of *R. padi* and foliar amino acids.

Our most recent research has explored the interactions between root-feeding wireworms (not worms at all, but juvenile stages of the *Agriotes* spp. click beetle) and the foliar-feeding bird cherry oat aphid (*Rhopalosiphum padi*) on barley. These aphids are known to transmit several viruses to barley which can severely reduce crop yields. Wireworms, in contrast, are a relatively new pest of cereals (conventionally a problem in potatoes; Johnson *et al*., 2008) which have begun to affect many Scottish growers due to changes in management practices (e.g. declining residues of soil pesticides and increased irrigation). Our latest findings suggest that if barley plants are simultaneously attacked by both insects during certain stages in plant development, root-herbivory by wireworms can lead to increases in *R. padi* populations of more than 30% (Figure 1). Greater numbers of aphids in the presence of wireworms might be due to wireworm-induced changes in foliar amino acid composition, which reflects the food resource available to aphids, as aphid numbers correlated with the proportion of leaf essential amino acids (Figure 1). Moreover, simultaneous attack by both insects causes changes in important plant mineral nutrients such as phosphorus, sulphur and calcium. We aim to address how these changes affect plant health and the performance of insect pests.



In red raspberry we have discovered that even moderate root-herbivory by the vine weevil (*Otiorhynchus sulcatus*) compromises genetically inbuilt aphid resistance in some cultivars. For instance, when two vine weevils fed on the roots of Glen Clova plants, populations of the large raspberry aphid (*Amphorophora idaei*) increased by 80%. This is significant because the large raspberry aphid transmits at least four raspberry viruses and remains the most damaging aphid pest of commercial raspberry production in the UK.

It is clear from this research that aboveground–belowground trophic linkages could have important implications for how breeders and growers address pest control in the future. With greater understanding of the chemical and genetic mechanisms underpinning such aboveground–belowground interactions, it may become possible to control such interacting pests much more effectively in the future.

References

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Wardle, D.A., Bardgett, R.D., Klironomos, J.N., Setälä, H., van der Putten, W.H., & Wall, D.H. 2004, Ecological linkages between aboveground and belowground biota. Science, **304**, 1629–1633.