Combating insecticide resistance in major UK pests

Despite substantial progress with developing non-chemical methods of crop protection, pesticides remain essential for effective suppression of invertebrate pests in many cropping systems, including the control of virus vectors and leaf miners in sugar beet. Reliance on pesticides introduces a number of risks, including the appearance of resistance in target organisms.

The overall aim of this project was to maintain chemical control of economically important pests of agriculture and horticulture, by identifying effective insecticide resistance management strategies and developing an objective method for resistance risk assessment. Work package 1 investigated the influence of biological, agronomic and insecticide-related traits on resistance risk. A data set of over 100 historical cases of resistance was used to test which traits were associated with faster or slower development of resistance. Multivariate statistical methods were used to identify the most influential traits and incorporate these into a resistance risk assessment. Work package 2 used mathematical modelling to simulate the evolution of resistance in crop pests with contrasting life-histories. Optimal resistance management tactics were explored for groups of pest species with contrasting life histories.

A resistance risk model was developed accounting for 46% of the variation in how rapidly resistance occurred after the introduction of a new mode of action to control a particular pest. The five most influential traits were: crop area, crop type, number of crop hosts, mode of reproduction and taxonomic Order. The model can be used to guide resistance risk assessment for novel pest/crop combinations since all the key traits are relatively easy to quantify without knowledge of prior resistance history. Considerable uncertainty still remains, and it is unlikely that we will ever be able to predict the number of years for resistance to evolve with complete accuracy. However, the model provides an objective means of ranking pest-crop combinations from high to low risk, allowing proportionate resistance management strategies to be put in place. Adoption of this risk assessment approach should prevent either overly stringent resistance management (which often constrains insecticide use) being put in place unnecessarily, or inadequate resistance management shortening the effective life of insecticides.

There were two key results from the modelling of resistance management strategies. Firstly, it found that in most realistic scenarios, a higher dose of insecticide leads to faster selection for resistance. Secondly, comparing optimal combinations of insecticides of different modes of action for resistance management showed that when two insecticides were mixed together at their label dose, resistance developed considerably faster than when the two insecticides were alternated. However, if the dose of each insecticide was reduced so that the mixture provided the same control of the insect population as a single label dose of either product alone, then mixtures were often the most effective resistance management tactic. Only when the resistance resulted in substantial fitness costs in the insect species did alternating two insecticides at their label dose lead to slower resistance development than reduced-dose mixtures. These results differ from current resistance management guidance for insecticides, but are in agreement with findings from modelling and experimental studies on fungicide resistance.