Grower Summary

CP 158

Application and Management of Biopesticides for Efficacy and Reliability (AMBER)

Annual report 2020

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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Dr D Chandler

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GROWER SUMMARY

Headlines

- Controlled environment experiments showed that the mycoparasitic fungus *Ampelomyces quisqualis* declined markedly by 7 days after application to tomato as a representative crop plant.
- A pest control model has been developed to identify optimal biopesticide control strategies, using glasshouse whitefly and entomopathogenic fungi as a model pest and biopesticide.
- For spray applications to small plants with a horizontal boom sprayer, and where biopesticide products are used at a constant dose, the maximum active substance will be applied using the lowest water volume, providing that the maximum label concentration is not exceeded. Where the biopesticide is applied at a constant concentration, the maximum volume that should be used is 1000 L/ha, but there are likely to be benefits for smaller plants of reducing this down to around 500 L/ha.
- For tall plants such as tomato that are sprayed with a vertical boom, the quantity of active substance deposited on the plant appears to be relatively insensitive to volume. Thus, for biopesticide products applied at a constant dose, water volume can be chosen to suit other needs (e.g., use a low water volume to reduce the time needed to spray the crop). Where products are to be applied to tall crops at a fixed concentration, our studies suggest that the maximum volume that should be used is 1000 - 1500 L/ha applied to the crop.

Background

Pests (including invertebrates, plant pathogens and weeds) have a major impact on crop production, reducing yield and quality (it is estimated that about a third of the potential global crop yield is destroyed by pests before it is harvested). The standard method for pest control has been to use synthetic chemical pesticides. However excessive use is associated with a range of problems including harm to the environment, and concerns have also been expressed about safety to pesticide spray operators. Overuse has also resulted in the evolution of resistance in many pests, which has rendered some pesticides ineffective. In recent years, environmental legislation has resulted in a lot of these pesticides being removed from the market. Alternative pest controls are needed therefore. Many growers already use Integrated Pest and Disease Management (IPDM), in which different crop protection tools are combined, including chemical, biological and cultural methods. IPM is now a required practice under the EU Sustainable Use Directive on pesticides. In order to make IPM successful, it is vital that growers have access to a full range of control agents that can be

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used as part of an integrated approach. One group of alternatives are 'biopesticides'. These are pest control products based on natural agents, and there are three types; living microbes, insect semiochemicals and botanical biopesticides. These types of pest control agent are based on living organisms and so it takes more knowledge and understanding to use them successfully compared to traditional pesticides.

AMBER (Application and Management of Biopesticides for Efficacy and Reliability) is a 5-year project with the aim of identifying management practices that growers can use to improve the performance of biopesticide products within IPM. The project has three main parts: (i) to understand the reasons why some biopesticides are giving sub-optimal results in current commercial practice; (ii) to develop and demonstrate new management practices that can improve biopesticide performance; (iii) to exchange information and ideas between growers, biopesticide companies and others in order to provide improved best-practice guidelines for biopesticides.

Summary

Understanding the biology of biofungicides on crop foliage.

A small number of biofungicides are being used more widely in plant disease management programmes, but there has been a lack of independent information for growers about the length of time for which these control agents remain viable after they have been sprayed onto crop plants, which in turn will affect the optimum timing and frequency of application. In this part of AMBER, experiments were set up to investigate whether the persistence of the mycoparasitic fungus *Ampelomyces quisqualis*, which is used against powdery mildew, would depend on its application timing in relation to arrival of powdery mildew inoculum. This was based on findings from previous work in the project suggesting that the efficacy of this biofungicides is responsive to the population density of its powdery mildew host. Experiments were done in a controlled environment chamber, in which *A. quisqualis* was applied to tomato plants at different timings prior to, and after, the plants were inoculated with powdery mildew.

In overall terms, there was a marked decline in the presence of *A. quisqualis* on the leaves over 7 days, which is in keeping with previous observations. There was evidence that more *A. quisqualis* was present on leaves in which the mycoparasite was applied 2 or 7 days after inoculation with powdery mildew, compared to application 1 day before powdery mildew application, but this may also be related to initial differences in the amount of biofungicide applied to leaves.

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Studies were carried out on a nursery to investigate late season applications of *A. quisqualis* against powdery mildew on Hebe and Rosemary. Hebe plants were inoculated with powdery mildew in mid-October and AQ 10 applied with or without Silwet L-77 wetter a week later. The incidence and severity of powdery mildew was compared weekly until early December with that of water-sprayed and wetter-only treated plants. Treatment to Hebe plants was done using a knapsack sprayer with a flat fan nozzle at the recommended commercial rate on two occasions at a 7-day interval at the end of October 2019. Leaf discs were sampled from central plants in plots directly after and again a week after each of these applications. *A. quisqualis* spore viability was assessed by washing leaf discs and spreading aliquots onto agar plates containing antibiotics to stop the growth of bacterial contaminants from the leaves. Viable *A. quisqualis* was detected seven days after AQ 10 application. Although three leaves had the first signs of powdery mildew on the first biofungicides application date, the disease did not establish much further, so that only seven plots had developed mildew by the end of the experiment, each on only one Hebe branch. Consequently, it was not possible to compare treatment efficacy. A parallel experiment was also done in the same nursery with Rosemary in early November 2019. A group of 24 plants were divided equally into those with either high (mean of 32%), medium (mean of 10%) or low (mean of 1%) mildew coverage. A single application of AQ 10 was made using a knapsack sprayer with a flat fan nozzle at the recommended rate to half of the plants while the remainder were treated with water as controls. Coverage of plants by powdery mildew changed by 5% or less up to the final observations at the end of December. on 20 December, without any difference between the AQ 10 treated or untreated plants. No greying of the mildew attributable to *A. quisqualis* parasitism was seen on any of the plants. Application coincided with a slowing of powdery mildew colonisation, but new growing tips continued to develop powdery mildew whether or not treated with the single AQ 10 application.

A pest control model to help identify optimal biopesticide control strategies.

The optimal use of biopesticides can differ markedly to that for conventional pesticides. This is because biopesticides can often take longer to kill individual pests than a conventional pesticide, can have different effects on different pest life stages, or have specific requirements for environmental conditions in order to work properly. All these factors influence how often they need to be applied, as well as things like the best time of day to apply them, and how quickly they can bring a pest population under control. Because of the large number of variables involved, identifying optimal application programmes for biopesticides using crop scale experiments is very time consuming and expensive. A better alternative would be to use mathematical modelling to simulate how pest populations respond to biopesticides, and

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to computationally test out different biopesticide application scenarios to identify the ones that are likely to produce greatest improvements in control.

In this part of AMBER, a 'boxcar train' computer model was developed that simulates how pest populations grow over time. The model considers each individual in a pest population and mathematically describes their transition from one development stage to the next until they reach adulthood and reproduce. From this, the development of the whole population can be evaluated. The effect of biopesticide application on the pest population can also be simulated using data on the susceptibility of individual insects. A model was constructed for the glasshouse whitefly (*Trialeurodes vaporariorum*) and the tobacco whitefly (*Bemisia tabaci*) and control with the entomopathogenic fungi (EPF) *Lecanicillium* spp. and *Beauveria bassiana*. A literature review was carried out to identify model parameter values for each pest (e.g. time for completion of each developmental stage) and biopesticide (e.g. infection efficacy). Knowledge gaps were identified and filled using data from bioassays carried out in the project. The model developed here is a valuable research tool that allows different control programmes to be tested.

Making biopesticide spray application more efficient.

It has become increasingly apparent through AMBER that spray application of biopesticides to horticultural crops could be made significantly more effective than at present. The aim of this part of the project is to identify the optimum volume range to be used for biopesticides on representative crops, as this needs to be in place before appropriate spray equipment and other techniques for improving application can be explored. Growers are using relatively high volumes for biopesticides as set out by the product label recommendations, possibly because such labels need to cover a wide range of crop structures. Unfortunately, data is not available from biopesticide companies to support the volumes being recommended.

A set of experiments were done using a track sprayer and tracer dyes to investigate the effect of altering spray water volume on the amount of product applied per unit leaf area. By using this approach, a range of volumes can be applied to a crop through changing nozzle and forward speed. Because changing nozzle also changes droplet size, which influences the quantity retained on the plant, we chose to use the speed of the track sprayer to manipulate volume. The quantities of spray liquid deposited on different parts of plants were determined by washing detached, leaves in a known volume of water and then evaluating the rinsate using spectrophotometry. The weight of the plant material in each sample was determined so that results can be presented as quantity of spray liquid per unit mass of plant material. It is then also normalised for the applied volume, and presented as quantity of spray liquid per mass of plant material per 100 L/ha applied volume. This allows the quantity of active

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substance to be estimated on the assumption that concentration increases as volume reduces.

Experiments done using basil, as a representative short plant, sprayed with a three-nozzle horizontal boom, indicate that, where the biopesticide is applied at a constant dose, the maximum active substance will be applied using the lowest water volume providing that the maximum label concentration is not exceeded. Where biopesticide products are used at a constant concentration, the maximum volume that should be used is 1000 L/ha, but there are likely to be benefits for smaller plants of reducing this down to around 500 L/ha. This is considerably less than the upper water volume allowed for most biopesticides on the label (which is typically 1500 L/ha).

An experiment was then done using a vertical boom track sprayer erected within an experimental tomato crop, as a representative tall plant. In this case, the quantity of active substance deposited on the plant appears to be relatively insensitive to volume. Thus, for biopesticide products applied at a constant dose, water volume can be chosen to suit other needs (e.g. use a low water volume to reduce the time needed to spray the crop). Where products are to be applied to tall crops at a fixed concentration, our data indicates that the maximum volume that should be used is 1000 - 1500 L/ha applied to the crop.

Finally, a system was developed to investigate how control of water volume translates into effects on biopesticide efficacy. This was done using a fungal biopesticide sprayed against spider mite on tomato. The system allowed us to have precise control of water volume, quantify the number of fungal spores deposited per unit leaf area, and monitor mite mortality under controlled conditions. The data will be analysed in 2020 although the indications from the raw data are in keeping with our tracer dye experiments, i.e. that the best strategy for optimising control is to manipulate the water volume to achieve the highest concentration of biopesticide on the leaf surface (i.e amount of active substance per unit leaf area). The experiment shows significant promise as a cost-effective technique that can begin to explore the relationship between efficacy and application method without the need for costly field trials.

Financial Benefits

- Biopesticides can be more expensive and less forgiving of environmental conditions that conventional pesticides so understanding the optimal way to use them is crucial to maximising efficacy and minimising cost.
- Computers models are useful for understanding systems that involve complex biological interactions where there are multiple interacting factors. They can be used for rapidly

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testing a large number of hypotheses to identify those hypotheses that should be further investigated. The model developed here is a valuable research tool that allows different control programmes to be tested. Once optimal control programmes are identified a subset of these will be tested experimentally to assess the accuracy of the model. Attempting to investigate all components of a spray programme in laboratory or grower experiments would be prohibitively expensive and time-consuming.

- Similarly, the systems developed in AMBER on biopesticide spray application also enable different spray systems to be investigated faster and cheaper than using field trials.
- At present, most biopesticides are used according to a constant dose model. The upper water volume recommendations for biopesticides are typically 1500 L/ha, and growers might be tempted to use this on the assumption that higher water volumes give better coverage on the plant. However, on short plants, a better strategy would be to use the lowest water volume providing that the maximum label concentration is not exceeded. In principle this means that the maximum active substance will be applied, which will maximise efficacy. Lower water volumes also mean that the time to spray will be reduced, saving on labour costs. On tall plants (tomato, cucumber, pepper) the quantity of active substance deposited on the plant appears to be relatively insensitive to volume, in which case - for products applied at constant dose - spraying at a lower volume will save time and money without affecting product efficacy in a negative way.

Action Points

- Biopesticide efficacy depends on good management practice, with attention to detail being paid at all stages of their use (storage, handling, mixing, application, monitoring).
- When using biopesticides at a constant dose, a sensible strategy is to the lowest water volume within the label limits providing that the maximum label concentration is not exceeded.

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