



Grower Summary

CP 158

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

Annual 2016

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The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

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Previous report:

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GROWER SUMMARY

Headline

Different biopesticides were evaluated on commercial nurseries against a range of pests and diseases of protected edible and ornamental crops. Opportunities to improve biopesticide performance by altering local management practice have been identified. These include modification to spray applications, and improved understanding of how biopesticide efficacy is affected by P&D population size.

Background

Pests and diseases (P&D) are a major constraint on the production of protected edible, and protected and outdoor ornamental crops. Chemical pesticides can no longer be relied upon as the sole method of P&D control, as significant losses of pesticide actives are occurring as a result of government legislation and the evolution of pesticide resistance in target P&D populations. 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 used as part of an integrated approach.

Biopesticides are plant protection products based on living microorganisms, plant or microbial extracts, or semiochemicals (behavior-modifying substances). A small number of biopesticides have been available to UK growers for some time, and an increasing number will be entering the market in the next few years. Within 10 – 20 years, the number of biopesticide products available is likely to exceed the number of conventional chemical pesticides. Biopesticides have a range of attractive properties, in particular they are low risk products for human and environmental safety and many are residue-exempt, meaning they are not required to be routinely monitored by regulatory authorities or retailers. While some biopesticides work well in IPM, UK growers have found others to give inconsistent or poor results, and the reasons for this are often not immediately obvious. Clearly, growers need to get the best out of biopesticide products in order to support their IPM programmes.

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 identify gaps in our knowledge about biopesticides that are causing them to be used sub-optimally 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

In the first year of the project, the research team obtained baseline information on the use and performance of some representative biopesticide products on protected crops. Most of this work focused on benchmarking the performance of five different biopesticide products against five different plant P&D.

A meeting of the Industry Steering Group identified eight priority P&D. These infest a wide range of PE, PO and HNS crops, can be difficult to manage with conventional chemical pesticides, and cause significant financial losses if not controlled. The priority P&D are: (1) western flower thrips; (2) aphids; (3) glasshouse whitefly; (4) two-spotted spider mite; (5) Botrytis; (6) powdery mildew; (7) root rots (*Pythium* / *Phytophthora*); (8) downy mildew. Note that a separate work package is being done on mushroom disease management and does not form part of this report. Six different P&D were selected for study in biopesticide benchmarking experiments using crops that represent different types of plant architecture and growing conditions (Table 1). Experiments on glasshouse whitefly had to be postponed until year 2 to fit in with the host grower, but benchmarking at the five other nurseries was done successfully.

Table 1. Combinations of pest / disease, crop and biopesticides selected for benchmarking in year 1

P/D	Crop	Biopesticides tested	MAPP number
Powdery mildew	cucumber	AQ10 (CBC / Fargro)	17102
Botrytis	cyclamen	Prestop (Lallemand Plant Care)	15103
Root rots	Choisya & Dianthus	T34 Biocontrol (Biocontrol Technologies / Fargro);	17290
		Trianum G (Koppert);	16740
		Prestop (Lallemand Plant care)	15103
Aphids	sweet pepper	Botanigard WP (Certis);	17054
		Majestik (Certis)	17240
Western flower thrips	pot chrysanthemum	Botanigard WP tank mixed with Majestik (Certis)	17054; 17240
Glasshouse whitefly	mint	Naturalis L (CBC / Fargro) (tbc before start of trial)	17526

For all benchmarking experiments, the biopesticides were applied by the host grower to naturally occurring populations of P/D and done according to the best practice guidance supplied with the product. The products were incorporated into the existing IPM systems used by the grower. The intention of this work was to observe the performance of the selected biopesticides under 'real world' commercial production conditions. As expected when working on commercial crops, in the majority of cases it was not possible to include untreated controls. The research team observed how the grower used the biopesticide product(s), and data were obtained on the following: product storage conditions; application (spraying equipment, pressure, water volume, product concentration); deposition on the crop; persistence; amount of P/D control; environmental conditions in the crop.

Benchmark 1: Powdery Mildew on Cucumbers (17 August - 7 September 2016)

The objective of this experiment was to compare preventative application of AQ 10 (based on the mycoparasitic fungus *Ampelomyces quisqualis* strain AQ10) for management of cucumber powdery mildew (*Podosphaera xanthii*) compared to grower current practice (curative spray applications of the chemical fungicide isopyrazam once mildew was observed). AQ10 was applied to a three week old cucumber crop (two varieties were used, var Bonbon, which has intermediate levels of mildew resistance, and Bonifacio, which has mildew susceptibility) on two occasions using a hand-pushed trolley with a vertical boom with five pairs of nozzles (FF80 02) angled 45 degrees upwards, (3620 L/ha), with a hose attached to a 1000 L static water tank with agitation. The trolley was pulled backwards over a pair of rails along the space between the crop rows, with the operator setting his pace based on his own experience. Assessments (% powdery mildew and phytotoxicity) were undertaken before spraying and four days after the second spray (21 days from first spray). Samples from the spray tank, nozzles and leaf canopy were taken back to the laboratory for further assessment.

The water volume selected by the grower was done on the basis of his general knowledge and experience, and it is likely that the grower underestimated the volume that was applied. The AQ10 label guidance on water volumes was not found to be informative. The mixing of the product for this particular experiment was problematic: Granules (possibly the carrier) were visible as brown clumps in the water in the spray tank after leaving the AQ10 the recommended 30 minutes to hydrate. The same problem did not occur in follow up laboratory tests done with a different batch of the product, and further investigation is needed to find out the reason for poor mixing in this particular case. Some other biopesticide manufacturers are now posting YouTube videos for growers on how to mix and prepare their products and it would be worth having something similar for AQ10. The spray operator aimed to deliver visually wet plants and adjusted his walking speed accordingly between rows. Speed was

therefore slow. Viable spores of *A. quisqualis* were not recovered from spray or leaf samples taken on the first spray application. Despite this, AQ10 sprayed rows had lower powdery mildew infection than untreated plants. There was evidence that AQ10 worked more effectively when used as part of an IPM approach with the mildew resistant variety BonBon, with only trace levels of mildew seen on AQ10 treated plants compared to average levels of 4.5% on untreated plants.

Benchmark 2: Botrytis on cyclamen (12th July – 8th September 2016)

The objective of this experiment was to evaluate the effect of Prestop (based on the antagonistic fungus *Gliocladium catenulatum* strain J1446) on a natural infection of botrytis on cyclamen under commercial production. Two treatments were compared, consisting of (i) Prestop and (ii) an alternating fungicide programme of Rovral WG (Iprodione) and Amistar (azoxystrobin). Both treatments were applied to a six week old cyclamen (var. Picasso Verandi – Mixed) crop on two occasions at three week intervals. Application was made using a RIPA nozzle on the end of a hose from a Brinkman 200 L tank sprayer. Assessments (% *Botrytis* sp. sporulation, phytotoxicity) were undertaken before each Prestop application and samples from the spray tank, nozzles and leaf canopy were taken back to the laboratory for further assessment. Application of Prestop reduced the incidence and severity of botrytis on the leaves compared with an alternating spray programme of Amistar and Rovral WG at the same application interval. Neither treatment programme provided total control of the disease, with botrytis being recorded on over half of the plants in both treatments: at the final assessment, 56% of Prestop treated plants and 84% of the chemical fungicide programmes had botrytis sporulation, with a mean of 1.4 and 2.44 leaves per plant affected, respectively. Only 16% of the affected plants treated with Prestop had botrytis rot progressing back from the leaves into the petioles, whereas 52% of the affected chemically-treated plants had softened petioles. Leaf imprints showed that most of the Prestop product was applied to the upper surface of leaves. The finding that Prestop appeared to give superior control compared to the conventional chemical fungicide programme is worth noting. However, adequate mixing of the product required supplementary diagrams provided by the product supplier and could be improved by more detailed label guidance. The manufacturer, Lallemand, has since put up videos on YouTube instructing growers how to prepare the product, and has also developed a tool that enables growers to detect the presence of *Gliocladium* on plants after spraying. The experiment highlighted a number of areas where application of both the biopesticide and the conventional chemical fungicides needs to be improved. In particular, there is a requirement to deliver spray to the older leaves at the base of the plant and deep within the crown, which could be addressed with improved application technique, while the very high

water volumes used for the product combined with wide plant spacing used for this particular crop meant significant spray waste.

Benchmark 3: Root rots on Choisya and Dianthus (15 September 2016 to May 2017)

The objective of this ongoing work is to evaluate the effect of biopesticides in IPM programmes for root rot pathogens on both Dianthus and Choisya. The grower already uses three different biopesticides as preventative treatments have been applied. When older, the plants are potted into media with an incorporated biofungicide. The benchmarking experiment compares two different types of disease treatment that are incorporated into the growing medium when the plants are first grown and then potted on. Choisya are treated with T34 Biocontrol (*Trichoderma asperellum* strain T34), Prestop (*Gliocladium catenulatum* strain J1446) and Triatum G (*Trichoderma harzianum* strain T22), while Dianthus receive a preventative treatment of Triatum-G. The grower then supplements these biopesticide treatments with drenches of conventional chemical fungicides (Previcur Energy and Horti-Phyte) later in the year. For the benchmarking trial, the standard IPM programme is being compared against one in which the conventional fungicide drenches are replaced with drenches of T34 Biocontrol applied either two or three times from autumn to spring. The idea is that the *Trichoderma asperellum* strain T34 fungus in T34 works by growing and colonizing the root zone, and hence only one or two drench applications are needed to achieve this, in contrast to chemical fungicides that need to be applied more frequently. The drench treatments were applied at 10% of pot volume using a lance (2 x FF110 – 20 fan nozzles; 75-100 thousand L/ha) on a hose reel to a 300 L tank with pump. Assessments (foliage health, phytotoxicity) is being done over the winter of 2016 / 17 with assessment of roots for rots in March 2017. Initial points to note on the drench applications included an observation of significant waste of spray product running from the pot surface on to the bed. Viable T34 Biocontrol colonies were quantified from growth medium and observed at similar levels both in the spray tank and from the lance. The experiment has already highlighted a number of areas where application could be improved, including the need for clearer, more informative guidance in the product label, elimination of run-off to beds, and reducing the time required for drench applications through improved pressure control.

Benchmark 4: Western flower thrips in pot chrysanthemum (7 July – 28 July 2016)

The objective of this experiment was to assess the use of Botanigard WP (based on the insect pathogenic fungus *Beauveria bassiana* strain GHA) and Majestik (a product based on maltodextrin) at recommended rates against invertebrate pests in pot chrysanthemum, particularly western flower thrips (WFT), and *Frankliniella occidentalis*. Two treatments (Nemasys® *Steinernema feltiae*, BASF UK (current practice used by the grower) and Botanigard WP + Majestik tank mix) were applied, three times at weekly intervals from bud break to the week before open flower and dispatch, along two parallel rows of benches. The treatments were applied using an automated 16 nozzle spray boom, with 03 flat fan nozzles spraying vertically downwards, 1089 litres of water per hectare. Assessments (the number of WFT, the presence/absence of aphids, aphid mummies, leaf miners, presence/absence of WFT damage on the leaves and petals and phytotoxicity) were taken from bud break to the week before open flower and dispatch on two cultivars that varied in their susceptibility to thrips damage. Samples from the spray tank, nozzles and leaf canopy were taken back to the laboratory for further assessment.

WFT and damage were recorded during the experiment, but numbers were very low in both treatments, despite the experiment being done at a time of year when WFT normally increased to levels that could cause crop damage if left unchecked. During the trial the WFT population levels were lower than normal, also indicated by sticky traps placed within the glasshouse. Numbers of WFT in the Botanigard WP treatment were not different from those receiving the standard nematode treatment. Viable *Beauveria* sp. colonies were found in similar numbers both in the spray tank (foam and suspension) before and after spraying and from the nozzles. Viable *Beauveria* sp. colonies were observed on both upper and lower leaf surfaces, with the majority of spores being located on the upper surface of the leaves. The results suggest that at low WFT pest pressure, the Botanigard WP and Majestik treatment applied was as effective as the application of entomopathogenic nematodes. The spray equipment operated well and complied with the label requirement. Exploratory experiments at Silsoe investigating different spray application scenarios suggested that the label recommendations are not likely to result in the highest doses of Botanigard on the plant buds and flowers.

Benchmark 5: Aphids in organic sweet pepper (23 June – 11 July 2016)

The objective of this benchmark experiment was to assess the use of Botanigard WP and Majestik at recommended rates against invertebrate pests in organic pepper, particularly the peach-potato aphid, *Myzus persicae*, which had recently reached high numbers on the crop. Four treatments (Untreated control, Botanigard WP, Majestik, Botanigard WP + Majestik tank mix) were applied twice, six days apart along both sides of a 130m long x 2.5m high sweet pepper row. The treatments were compared along four parallel rows, with untreated buffer rows between each treatment. Applications were made using a trolley with a vertical boom consisting of four pairs of 80° hollow cone 03 size nozzles, angled at 45° upwards; average volume 1377 L/ha, 500 – 1500 L/ha target volume. Assessments (the number of aphids, aphid mummies, hyper-parasitised mummies, and aphid predators) were taken on 15 selected leaves at each of three heights within the crop canopy; this was done immediately before the first spray, and then at day 6 and day 12. Samples of Botanigard WP were collected from the spray tank and nozzles during spraying, while leaf samples were taken from the canopy after spraying. These were taken back to the laboratory to estimate the concentration of viable fungal spores in the spray and on leaves.

Numbers of aphids per leaf were highly variable in all four treatments, but mean numbers were very high; around 175 aphids per leaf on untreated plants. With this aphid population density, none of the treatments reduced aphid abundance compared with abundance on untreated leaves. Viable *Beauveria* sp. colonies were found at similar numbers both in the spray tank before and after spraying and from the nozzles. Viable *Beauveria* sp. colonies were also observed on both upper and lower leaf surfaces but were variable between samples. Immediately after the benchmarking experiment, laboratory experiments were done to measure the susceptibility of individual *M. persicae* reared from the population infesting the crop. This showed that Botanigard WP killed *M. persicae* within six days of application.

For this particular experiment, we found that the spray equipment operated well. Excessive foaming was observed when the product was mixed in the spray tank but did not appear to impede application of Botanigard WP to the crop. Calculating the optimum application volume for the biopesticide was not straightforward, as no information was given for how to adjust for the height of vertical crops. This highlights the need for growers to be able to adjust spray tank water volumes to cope with different crop heights and structures. It was also noted that the spray volume applied and therefore the dose, is likely to fluctuate along the crop because of changing trolley speed and pressure during spray runs. The spray boom was also in close proximity to crop which may result in poor distribution of spray.

Botanigard WP is recommended for control of whitefly on various protected crops, however, it is known from the scientific literature that it is also effective against aphids, and this was confirmed in our own laboratory bioassays with *M. persicae*. The main question raised is, if Botanigard WP is able to infect and kill aphids under laboratory conditions, why was there no significant reduction in the aphid population on the crop? Temperature and humidity conditions recorded within the crop were within the limits recommended by the supplier. There is some background evidence that the fungal spores of Botanigard WP are susceptible to damage by UVA and UVB radiation (which is not filtered out from sunlight by glass). It is also possible that the speed of kill of the biopesticide was not fast enough to reduce the net reproductive rate of the aphid population sufficiently. Aphid nymphs may also have been able to 'escape' infection by fungal spores through moulting. Both of these effects may be more apparent at high pest population densities.

Summary of biopesticide application assessments

For all benchmarking experiments, observations and evaluations were made of how the partner growers in the project were applying the biopesticides to their crops. Some general conclusions can be drawn from this. Product, dose and timing are crucial parameters in the performance of biopesticides. Observations at this early stage of the project showed that high spray volumes were being used across all crops which are unlikely to be consistent with optimum deposition of product on the crop and maximum efficiency of the application process. More knowledge is needed about the optimum conditions required for good performance of each biopesticide in order to identify potential improvements in application. This includes quantity of product, quantity of water, location within the crop that should be targeted, and other environmental parameters that could influence performance. The sites chosen for year 1 benchmarking studies had a wide range of equipment for application but encountered common problems: (i) Mixing and dispersion of biopesticide products; (ii) Calibration of equipment and accurate dosing; (iii) Interpretation of labels to comply with legal requirements and best practice; (iv) Achieving uniform distribution over the crop. As part of this, there is a question about whether current label requirements can be modified to make the application more efficient, more efficacious and easier to deliver in practical situations. The label is a regulated document and text changes cannot be made without the approval of the regulator, however it is possible for manufacturers to add advisory information to the label or issue technical notes.

Financial Benefits

It is difficult to comment on the financial benefits given the early nature of results. However any improvements to the performance of biopesticides - including issues such as improved efficiency of spray applications, and improved efficacy and reliability - would allow growers to use biopesticides more cost effectively and to reduce over reliance on synthetic chemical pesticides at a time when their availability is declining, and when growers generally are under increasing pressure to produce crops with zero detectable pesticide residues.

Action Points

No specific actions are being recommended at this stage until more research has been done, however we would highlight to growers the need to ensure that spray applications are done according to best practice guidelines in order to get the best out of biopesticides.