Developments in Biological Control for Nursery Stock

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INTRODUCTION

Biological control has been used commercially on protected edible crops for more than 25 years in most Northern European countries. Many pests are similar for most horticultural crops, whether grown outside or under protection. Nursery stock plants however, are subject to some additional pest organisms not usually associated with edible crop production. These include vine weevil, many aphid and caterpillar species, plus transient minor pests such as psylids, gall midges, etc.

The basic technology behind biological control is independent of the crop, so the lessons learned in one branch of horticulture can usually be modified to suit another. For non-edibles, programmes which integrate biological and chemical controls, are more usual because of the wider range of selective pesticides available. The U.K. is fortunate that any pesticide approved for use on an edible crop can automatically be used on a non-edible crop grown under similar conditions. An example is the recently approved Luxan Dichlorvos 600 and Dichlorvos Aerosol 15 which only carry label approval for thrip control on protected cucumber. However both products can also be used as a rapid knockdown of many adult pest organisms on any non-edible crop. However, as with all ornamental off-label uses, the liability for phytotoxic damage on crops, other than protected cucumber, falls to the grower.

Integrated pest management (IPM) is a method of harmonising several control strategies. Principally biological and cultural control methods are used for the major pests: aphids, spider mites, thrips, vine weevil, and whitefly. Cultural control includes the use of sticky traps for flying insects and covered floors to help prevent spread of soil borne diseases and weeds. Certain chemicals may also be integrated with biological agents to control diseases and other pests. The pesticides mentioned in the text are known to have negligible effects on beneficial organisms and can therefore be used in an IPM programme. Most other pesticides are harmful to beneficial organisms — for example synthetic pyrethroids such as bifenthrin, cypermethrin, and deltamethrin are broad-spectrum insecticides capable of killing most insects and are active for several weeks.

You can use an IPM strategy for most crops grown under protection for several months of the growing season. This paper will concentrate on the two pest organisms for which recent developments have occurred: aphids (the development of new species of parasites) and vine weevil (the development of new control strategies).

APHIDS

Aphids feed on plant sap causing leaf yellowing and distortion, they also excrete a sugary honeydew onto leaves on which sooty moulds develop. These moulds reduce the photosynthetic area, thereby reducing crop growth. Aphids can also transmit several plant viruses. Several species of aphid may be found on protected crops. *Myzus persicae* (the peach-potato aphid) is extremely common and variable in colour, ranging from shades of pink and yellow to grey-green. Other species include *Aphis gossypii* (the melon or cotton aphid), which is usually found on cucumbers, chrysanthemum, and other ornamentals. Recently several other aphid species have become more prominent and invariably more difficult to control. These include *Aulacorthum circumflexum* (the mottled arum aphid), *A. solani* (the potato aphid), *Brachycaudes helichrysi* (the leaf-curling plum aphid), and *Macrosiphum euphorbiae* (the glasshouse potato aphid). Biological control using parasites, predators, and pathogens is now well established.

Parasitic Wasps. *Aphidius colemani* can be purchased as a mix of adults and "mummies" (the papery bodies of dead aphids in which the wasp has pupated). Adult parasites lay single eggs in up to 150 individual aphids, the egg hatches into a larva, which eats the internal body tissues. When the parasite pupates inside the aphid body it forms the characteristic papery mummy which remains stuck to the leaf. The complete life cycle (adult to adult) takes around 3 weeks. Parasite mummies are well protected from most pesticides allowing short-persistence and selective chemicals to be safely integrated. Aphid parasites tend to be fairly specific against the aphids they will attack. *Aphidius colemani* is mainly active against *Aphis gossypii, Myzus persicae* and several cereal aphids. This has forced the development of other aphid parasites, most of which are equally specific but to different aphids.

Aphidius ervi attacks the pea aphid (*Acyrthosiphon pisum*) as its principle host, along with several cereal aphids. However, within a biological programme we use it against *Myzus euphorbiae, M. persicae*, and *Aulacorthum solani*. Perhaps the most useful second-line aphid parasite is *Aphelinus abdominalis*. This parasite can be used to control *M. euphorbiae, M. persicae* (plus other *Myzus* species), *A. solani*, and others. Trials, by Novartis BCM, have shown that, at 20C, each female is capable of parasitising 200 aphids, over a period of between 15 and 27 days. Fecundity is low during the first few days of adult life, but by day four has risen. Daily fecundity rates are between 10 and 15 eggs per female per day after this, and do not decline with age. In addition, host feeding kills approximately two young aphids per day. A black mummy forms 7 days after parasitism at 20C. The adult parasitoid emerges from this mummy 14 days later. At 25C the daily average fecundity drops slightly to 11 eggs per female per day, but the total number of aphids parasitised continues to increase. Mortality of aphids as a result of host feeding rises to approximately three per day.

Aphid Midge. The aphid midge, *Aphidoletes aphidimyza*, will attack almost all species of aphids. They are distributed around the crop as cocoons from which the nocturnal adult fly emerges. Adults lay between 100 to 200 small orange/red eggs close to aphid colonies, these hatch after 3 to 4 days and the larvae attack the nearest aphid, injecting a paralysing toxin. Larvae hide beneath the aphids, where they suck out the body fluids. After 4 to 5 days of feeding, the orange-coloured larva will have killed between 5 and 50 aphids and be 2.5 to 3 mm long. At this stage the larvae drop from the leaf and produce a cocoon in which they pupate. If the predators receive less than 15.5 h of light per day they may enter diapause — a form of hibernation. However under longer periods of light adults will emerge after about 10 days.

Green Lacewing and Other Parasites. Each green lacewing (*Chrysoperla carnea*) larva will kill more than 200 aphids and they can control several other pest organisms. Recent research has developed an artificial diet, which should result in a dramatic price reduction enabling further widespread availability of this predator. Other noncommercially available aphid predators include hoverflies and ladybirds, both of which can consume 300 aphids per developing larva. These often enter biologically controlled crops and provide additional, free, pest control.

Pathogenic Fungi. The insect pathogenic fungus *Verticillium lecanii* can control several aphid species, western flower thrips, and whitefly on a range of crops. The pathogen has strict environmental requirements, including a temperature of 15 to 25C and relative humidity of 95% or higher. Such humidity levels are rarely met in greenhouses using modern growing techniques. However, during spring, autumn and occasionally during muggy summer weather these conditions can be obtained and excellent control achieved. Propagation units however, by design, will provide high humidity and warmth, which will encourage the fungus to germinate and protect the crop against insect attack.

As *V. lecanii* is a fungus, great care must be taken with any fungicides used against plant disease. No fungicide should be tank mixed with *V. lecanii* and at least 3 days (longer is better) should elapse between applying *V. lecanii* and any fungicide. The following fungicides are known to be relatively safe to this biocontrol: bupirimate, iprodione, fenarimol, and triforine. Other pesticides may also be integrated but their full toxicity to *V. lecanii* has not been fully evaluated so a small-scale trial should be made before use on a commercial crop.

VINE WEEVIL

This pest evokes more emotion from growers than most other organisms mainly because it is hidden from view for most of its life cycle. Damage, in the form of leaf notching, occurs overnight when the adults feed, while plants can collapse because of larvae feeding on roots. Both adults and larvae can ring young shrubs at ground level, killing the plants. Adult weevils are all female (males are very rare) and can live for more than 1 year and produce about 1000 eggs each. These hatch into small C-shaped white larvae with brown heads, which feed on plant roots. Larvae develop into pupae, which form a small cell in the compost where they overwinter to emerge in the spring as soft bodied, white adults. These adults soon harden their skins and turn black, hiding during the day under leaf material to emerge at night and feed.

Biological Control. Biological control of larvae is possible using insect parasitic nematodes. The most commonly used and efficient ones being*Steinernema carpocapsae* and *Heterorhabditis megidis*. Nematodes are minute eelworms, which swim in a film of water surrounding soil or compost particles. Thus dry composts can reduce their mobility and eventually kill them, water-logged compost can drown them and gritty mediums allow them to be flushed through. The majority of peat or coir growing media are perfectly suitable for nematode use and good results are achieved.

Compost-Applied Pesticides. Although not biological, compost-applied pesticides such as Suscon Green are fully compatible with these biological control agents. When the granules are evenly incorporated into compost before potting they give a full 2 years of control in liners or small pots. ADAS trails have shown that the level of control can be reduced in composts containing more than 20% bark or wood-fibre-based materials. With these composts a rate of 1 kg of Suscon Green m^{-3} is necessary for acceptable weevil control. Suscon Green has also been evaluated for use in cutting modules with good results and cuttings have recently been added to the label approval. Efficacy is good with large modules but becomes more variable in module sizes below 75 ml. This is probably because it is not always possible to get sufficient granules into these very small volumes of compost, even with good mixing. Margaret Scott evaluated phytotoxicity at HRI Efford with little damage being recorded.

A recently approved addition to the soil-incorporated control agents is imidacloprid. This active ingredient has a persistence of about 1 year and is systemic through the plant. This gives activity against whitefly and aphids plus some other sucking insects but not against thrips or spidermites. Being systemic the product is also harmful to many beneficials, including *Aphidius, Aphidoletes, Chrysoperla, Encarsia,* and *Orius* (Novartis BCM data). Its lengthy persistence also allows insect pests to be exposed to sublethal doses as the product breaks down — giving rise to the potential for resistance problems.

Other Chemical Controls. The Agricultural Development and Advisory Service (ADAS) has conducted many trials against vine weevil under the guidance of Dr. John Buxton. These have included the development of an adult weevil attractant based on an aggregation pheromone and plant leaf extracts and the results are eagerly anticipated. Pesticide spray programmes, against adults, have shown that malathion and the pyrethroid insecticides, especially Talstar, are good contact insecticides (night sprays being most effective). The pyrethroids also have a strong repellent activity which reduces feeding by up to 14 days after application. Unfortunately these chemicals are very broad-spectrum insecticides which will kill beneficial organisms for several weeks after application.

PESTICIDE INTEGRATION

All producers of biological control agents produce tables showing how each agent is affected by different crop protection chemicals. In general most fungicides are safe to natural enemies (except for the fungus *V. lecanii*, as noted above). The following insecticides are relatively harmless, although some will kill everything they hit but persist for only a short period of time: Pirimor, Hostaquick (persistence of 4 to 5 days), Torq, Nemolt, Applaud, Nico Soap (persistence of 1 to 2 days), and Savona (persistence of 1 day).

The use of IPM reduces potentially harmful exposure to pesticides and will slow the development of resistance, and ultimately extend the useful life of the few pesticides we have available.