Factsheet 02/10

Protected Edibles

PC 240

Horticultural Development Company

Stoneleigh Park
Kenilworth
Warwickshire CV8 2TL
T: 0247 669 2051
E: hdc@hdc.org.uk

Boosting Biocontrols Within IPM Programmes

Dr. Rob Jacobson, RJC Ltd

This factsheet describes how tomato growers can use novel methods of collecting biological control agents from areas of surplus, for distribution in areas of need.

Background

Integrated pest management (IPM) is highly advanced in UK tomato crops. The programmes have been developed over thirty years and include control measures that may be employed against over ten pest species. However, there are still some weak links in the IPM programme which must be strengthened. This could be achieved by releasing much greater numbers of biological control agents but that is rarely a financially viable option.

The use of the parasitoid, *Diglyphus isaea*, against tomato leafminer provides one such example. Leafminer damage on a tomato crop is shown in Figure 1. A crop monitoring procedure and a successful *Diglyphus* release strategy were developed for classic round tomato cultivars in the late 1990s (HDC factsheet 08/00). However, the technique proved inadequate for many of the new speciality cultivars, resulting in unacceptable foliar damage before the pest was controlled. There remains little doubt that this level of damage could be reduced if many more parasitoids were released, but numbers are restricted by the cost of the product.

The use of *Phytoseiulus persimilis*, a predatory mite for the control of spider mites, provides another excellent example. The predator is slow to establish on tomato plants. Attempts to improve its performance have met with only limited success. The use of tomato-reared *Phytoseiulus* would help to improve the situation. However, this involves a costly production system, which would make the product prohibitively expensive.

This document describes the development of novel methods that growers may adopt to obtain added value from their biocontrol agents. The techniques can help overcome the financial constraints associated with purchasing additional beneficials and will have a positive impact on the success of IPM programmes.

1 Leafminer damage to cv Nectar prior to obtaining control with *Diglyphus*

The Theory

The use of inundative biological control in single season crops, such as glasshouse-grown tomato, leads to distinct peaks in pest and natural enemy population development.

Graph 1 shows a hypothetical but typical scenario. The pest arrives in the crop and numbers rapidly increase in the absence of any natural constraint. There is usually a short delay before natural enemies are released and begin to feed on the pest. The natural enemies then start to produce offspring but there is a further delay before the population growth of the pest becomes constrained (Point A in Graph 1). The pest numbers then crash leaving a substantial population of natural enemies without any prey (Point B in Graph 1).

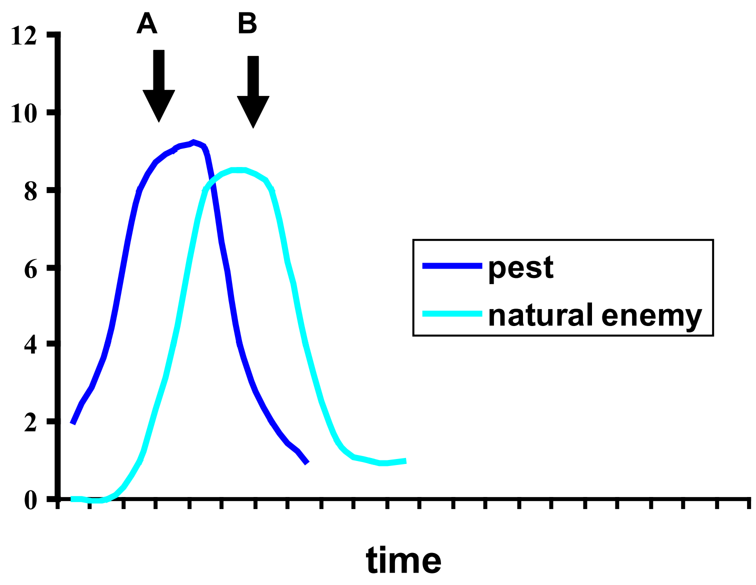
These natural enemies remain in the crop for a short time before dying or dispersing in search of prey elsewhere. A test case based on leafminers on speciality tomatoes (cv Elegance) can be used to explore the financial implications of the population trends shown in Graph 1. The leafminers were first recorded in the crop in February. A total of two *Diglyphus* parasitoids were released per m^2 by mid-March, which cost the grower approximately £140 per 1,000m^2. At the point equivalent to B in Graph 1, there was an average of 3-4 immature parasitoids per leaflet throughout the lower third of the crop canopy. With seven leaflets per leaf and allowing for only three affected leaves, this equated to over 75 immature parasitoids per plant or 300 per m^2. Given the same value as those originally purchased, this would have been equivalent to £21,000 per 1,000m^2!

It will never be possible to harvest all these natural enemies without sacrificing the crop. However, it is clearly of benefit to collect some of this windfall for use in other crops, where control has not yet been achieved.

HDC project PC 240 explored various means of collecting from this surplus of natural enemies in organic tomato crops. It was important that biosecurity, particularly relating to the spread of Pepino mosaic virus, was not compromised. The methods had to therefore separate natural enemies from plant material.

Further success of this work was achieved in all year round tomato crops (HDC projects PC 251/251a). The methods have since been validated in commercial tomato crops in many different situations.

The following techniques have now been developed to collect and redistribute three species of natural enemies with very different biological characteristics and life styles.



The vertical scale indicates population size in arbitrary units

Graph 1. Hypothetical representation of pest and natural enemy population trends in a single season crop

Collecting *Diglyphus isaea*

Diglyphus isaea is a small wasp which parasitises *Liriomyza* leafminers. When attacking a leafminer, the female *Diglyphus* first probes into the mine with her ovipositor to paralyse the larva (Figure 2), then lays an egg next to the host. The parasitoid larva feeds externally on the paralysed leafminer and eventually pupates within the mine, as shown in Figure 3. It is the pupae that we aim to collect from the crop.

A large proportion of the *Diglyphus* population pupate in the lower crop canopy, within leaves which are removed as part of routine crop husbandry. This means that they can be collected with no additional labour and very little additional cost to the grower.

The *Diglyphus* has to be separated from collected plant material. In preliminary tests, leaves containing immature *Diglyphus* were placed in a sealed cardboard box with a hole cut in the top, leading to a plastic collection bottle. Adult *Diglyphus* emerged from the pupae, and were attracted to the light. They were collected in the plastic bottle. Unfortunately, adult leafminers were also found in the bottle. The original tests were repeated with Agralan Enviromesh Ultra Fine screening material (code MC260), with 0.8mm x 0.8mm holes, positioned between the cardboard box and the collection bottle, as illustrated in Figure 4. This retained the adult leafminers while allowing the majority of *Diglyphus* to escape into the bottle.

The system was then scaled up for use in commercial crops. Leafminers had recently been controlled in the donor crop and the *Diglyphus* population was equivalent to point B in Graph 1. Leaves which had been routinely removed were placed in a plastic crate (approx 1m x 1m x 0.7m). A cardboard lid with a 200mm x 200mm window covered with Agralan Enviromesh Ultra Fine screening material was constructed and sealed in place as shown in Figure 5. The crate was moved to another tomato crop and kept under observation. Very large numbers of adult *Diglyphus* were seen passing through the mesh during the following five days. The leafminer population was controlled in the recipient crop without using any purchased material.

The two prototypes shown in Figures 4 and 5 illustrate the simplicity and the flexibility of the harvesting system. A wide range of recycled containers can be utilised to operate on almost any scale. Furthermore, it can be adapted to collect the adult wasps in bottles, as in Figure 4, or to allow them to emerge directly in the glasshouse, as in Figure 5.

For best results, the containers should only be loosely packed with leaves as this aids *Diglyphus* emergence. It is also important to take care when fitting the screening material because if it is stretched the holes become distorted and their dimensions change. A summary of how to harvest *Diglyphus isaeae* is given in Table 1.

2 *Diglyphus* attacking a leafminer larva

3 *Diglyphus* pupa within a leaf

4 Small scale prototype *Diglyphus* collection box

5 Large scale prototype *Diglyphus* collection box

Table 1: How to Harvest *Diglyphus*

- Monitor the crop for leafminer and *Diglyphus* activity:
  Act as soon as the pest population is controlled.
  Check the lower leaves for presence of *Diglyphus* pupae.
- Following routine deleafing:
  Collect leaves in a suitable box or crate.
  Fit an Agralan Enviromesh Ultra Fine screening material (code MC260) window to separate adult *Diglyphus* from adult leafminers.
  Do not pack the leaves too tightly as this impedes parasitoid emergence.
- The adult *Diglyphus* can be allowed to emerge into a collection bottle:
  It is ideal to use them immediately.
  They can be stored in the dark for 2-3 days at 10-12^{o}C.
  Take the collection bottle to another crop and release in the usual way.
- Alternatively:
  Take the box / crate to the other crop.
  Allow the parasitoids to emerge straight into the glasshouse.
- The whole procedure involves very little additional labour.

Collecting Phytoseiulus persimilis

Standard bean-reared *Phytoseiulus persimilis*, Figure 6, are notoriously slow to establish on tomato plants. This is partly due to the presence of glandular trichomes on the surface of the plant. The trichomes release exudates that are toxic to many species of insects and mites. In the 1990s, Dutch researchers demonstrated that *Phytoseiulus* could adapt their behaviour and eventually become acclimatised to this hostile environment. A research team at HRI subsequently showed that the population growth of *Phytoseiulus* reared on tomato plants for more than five generations was considerably greater than that of standard bean-reared predators. However, it was far more expensive to rear *Phytoseiulus* on tomatoes than on beans and this would have been reflected in the unit price of the products. As a compromise, some biocontrol producers supply 'tomato-conditioned' *Phytoseiulus*. Such predators may have been held as stock cultures on tomato plants and numbers boosted on bean plants before dispatch to the customer. Alternatively, they may have been held as stock cultures on beans and then passed through a single generation on tomato plants before sale.

It was clear that the *Phytoseiulus* already within the crop would be properly tomato-reared. They could therefore have considerable added value compared to both the standard bean-reared and tomato-conditioned *Phytoseiulus* products.

The *Phytoseiulus* collection system was based on two important factors in our knowledge of the interaction between this pest and predator. First, spider mites, and therefore Phytoseiulus, are attracted to young side shoots in the upper parts of the plants. Second, *Phytoseiulus* climb to the highest available point when in dispersal mode.

As with the *Diglyphus* collection method, the required parts of the plants were routinely removed during crop work minimising additional labour cost. The removed side shoots were stored in crates in the glasshouse. Small conical cups were then placed on the top of vertical canes within the plant debris as shown in Figures 7 and 8. The predators climbed the canes and were collected on / in the cups.

In a spin-off project from PC 240, Jade Taylor (Imperial College, London) compared the population growth of standard bean-reared *Phytoseiulus*, tomato-conditioned *Phytoseiulus* and harvested *Phytoseiulus*. The study was based on a series of laboratory bioassays which recorded three key factors in Phytoseiulus population growth; egg production, adult survival and offspring survival. The data were fed into a simple mathematical model, based on an original developed by Dr John Fenlon (Warwick University), which was used to predict the potential increase in *Phytoseiulus* numbers. It was calculated that, after two generations, the harvested *Phytoseiulus* would give rise to 70% more offspring than the tomato conditioned product. Table 2 is a summary of how to harvest *Phytoselulus.*

Table 2: How to Harvest *Phytoseiulus*

- Monitor the crop for spider mite and *Phytoseiulus* activity:
  Act as soon as the pest comes under control.
  Check side shoots for presence of *Phytoseiulus.*
- Following routine removal of side shoots:
  Collect in a suitable box or crate.
  Insert canes with an inverted collection container on the top.
  Allow *Phytoseiulus* to gather on / in the collection container.
- Remove collection container daily:
  It is ideal to transfer them to another crop immediately.
  Release in the normal way by tapping over spider mite infested leaves.
  It is not practical to store these predators unless they are repackaged, which can be wasteful.
- The whole procedure involves very little additional labour.

6 Adult *Phytoseiulus*

7 *Phytoseiulus* collection box

8 Close up of *Phytoseiulus* on paper cups

Collecting *Macrolophus caliginosus*

Until 2006, *Macrolophus caliginous*, seen in Figure 9, was considered to be the most important pest of organic tomato crops in the UK. Numbers would rapidly build up on insect prey and then attack tomato trusses causing flowers and fruit to drop prematurely. Furthermore, the predators could survive on a vegetarian diet, so the populations didn't crash as rapidly as shown after point B in Graph 1.

There was little doubt that this predator could make a very important contribution to IPM in tomatoes if the populations could be manipulated to avoid the subsequent injury to plants and financial losses to growers. In 2006, a treatment based on natural pyrethrins, which are extracts of African chrysanthemums, was developed and used to successfully cull *Macrolophus* populations. This ability to manage *Macrolophus* populations opened new opportunities for the control of spider mites, leafminers and whiteflies in organic tomato crops. The predator could now be used as a primary biological control agent in the knowledge that numbers could be reduced when necessary. Furthermore, it was clear that the predator population had considerable value at the time that it was to be culled.

Initial attempts to collect *Macrolophus* from tomato crops involved shaking leaves over white plastic trays and sucking the insects into containers using small modified vacuum pumps. However, many of the insects evaded capture by flying or rapidly running off the tray. Others were damaged by the turbulence in the pipes and collection tubes. Both of these problems were overcome by shaking leaves into a large smooth sided plastic funnel, through which the insects tumbled into a collection bag attached to the spout (Figure 10). The funnel was a recycled item, being made from an empty water container with a convenient handle built into the side. *Macrolophus* can be harvested using the method given in Table 3.

9 *Macrolophus caliginosus*

10 *Macrolophus* collection system

11 *Macrolophus* in inflated collection bag

Table 3: How to Harvest *Macrolophus*

- Monitor crops for the point at which *Macrolophus* would normally be culled to avoid crop damage.
- Working from a trolley:
  Shake upper leaves into a large smooth-sided funnel with a collection bag attached to be spout.
- When there are 150-200 predators in the bag:
  Partially inflate the bag and fasten with an elastic band as shown in Figure 11.
  They should ideally be used immediately.
  They can be stored in the dark for 24 hours at 10-12^{o}C. If stored, it is advisable to place loosely crumpled tissue paper in the bag.
  Take to another crop and release in the normal way.
- At optimum population levels:
  Over £200 worth of *Macrolophus* has been collected with £8 expenditure on labour and without any investment in specialist equipment.

Financial Benefits of Harvesting BioControls:

***Diglyphus*:** The potential financial benefit to growers was illustrated in the test case on page 2. Thousands of pounds worth of *Diglyphus* can be collected and released with minimal expenditure by the grower.

***Phytoseiulus*:** The most obvious benefit from the *Phytoseiulus* collection technique is the ability to utilise very large numbers of home-grown predators which would otherwise have been wasted. The technique involves very little additional labour and so these predators are virtually free to the grower. Furthermore, these home-grown *Phytoseiulus* have considerable added value because they are already fully adapted to the tomato plant.

***Macrolophus*:** At optimum population levels, the technique allowed batches of about 250 *Macrolophus* to be collected in less than five minutes. Even allowing for the non-productive time involved in setting up equipment, over 2,500 *Macrolophus* were collected within an hour. Given a retail price of £80 per 1,000, *Macrolophus* valued at £200 could be collected with an £8 expenditure on labour without any investment in specialist equipment.

Further Implications

Harvesting large numbers of healthy natural enemies from commercial crops offers short term financial benefit to growers. However, the ramifications could go very much further in terms of our whole approach to IPM. For example, the first seasonal releases of natural enemies could have two functions. The first would be to control those specific pest infestations, while the second would be to establish cultures of biological control agents to be harvested at a later date.

On this basis, growers could greatly increase the numbers of natural enemies released at the start of the season in the knowledge that they could make larger financial savings at a later date.

Acknowledgements:

The author is grateful to Dr Phil Morley and colleagues at Wight Salads Group who assisted with the development of these techniques. In particular, Paul Howlett enthusiastically encouraged all new ideas and Brian Moralee was instrumental in developing the new *Phytoseiulus* collection system.

Additional information:

January 2010

Design and production: Kavernel Media