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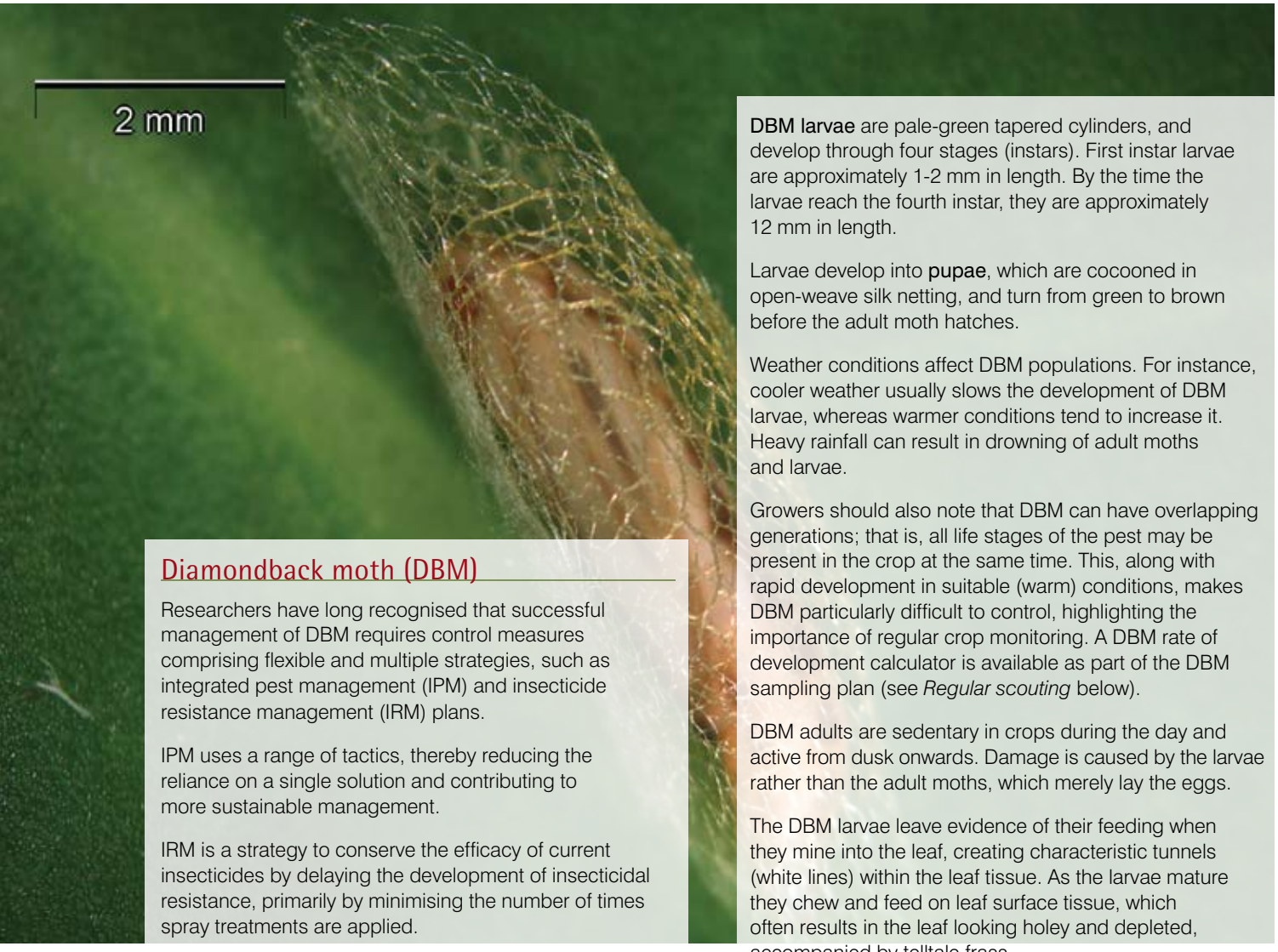
Diamondback Moth (DBM)

The key pest of Brassica crops, diamondback moth (DBM) (*Plutella xylostella*), is particularly hard to manage. It has been known to destroy Brassica and canola crops and cause economic damage to those industries in Australia and overseas. The annual cost of controlling DBM globally is estimated at $1 billion.

Suppressing DBM infestation has involved the widespread use of insecticides, which has exacerbated the problem for most growers as the pest has developed a decreased susceptibility to many chemicals over time.

The bottom line

- Control strategies that comprise IRM and IPM have been recommended as the best way to maintain the efficacy of insecticides, conserve natural enemies and ensure the sustainable management of DBM.
- To control DBM, it is essential that growers can accurately identify DBM in its various life stages and regularly monitor their crops.
- Researchers have developed various tools to assist growers in determining the most appropriate course of action against DBM.



Diamondback moth (DBM)

Researchers have long recognised that successful management of DBM requires control measures comprising flexible and multiple strategies, such as integrated pest management (IPM) and insecticide resistance management (IRM) plans.

IPM uses a range of tactics, thereby reducing the reliance on a single solution and contributing to more sustainable management.

IRM is a strategy to conserve the efficacy of current insecticides by delaying the development of insecticidal resistance, primarily by minimising the number of times spray treatments are applied.

The ability to recognise the various life stages of DBM and regular scouting for the pest and its natural enemies are essential in applying a strategy to maximise the management of DBM.

Recognising the various life stages and development of DBM

In order to control the pest, it is crucial that growers know and recognise the various stages of the DBM life cycle.

DBM adults are greyish-brown, approximately 10 mm in length and have a characteristic diamond shape on their back when at rest; the pattern is less distinct on female DBM.

DBM eggs are pale-yellow, approximately 0.5 mm in length and can be extremely hard to see. They are laid on all parts of the plant, including the stems and both sides of the leaves. The development time of DBM from egg through larval stages (instars) is strongly influenced by temperature. In warm weather (20-30 °C), development from egg to first instar larvae can take two to four days, but in cold conditions it can take seven to 10 days. Eggs will not hatch below 8 °C.

DBM larvae are pale-green tapered cylinders, and develop through four stages (instars). First instar larvae are approximately 1-2 mm in length. By the time the larvae reach the fourth instar, they are approximately 12 mm in length.

Larvae develop into **pupae**, which are cocooned in open-weave silk netting, and turn from green to brown before the adult moth hatches.

Weather conditions affect DBM populations. For instance, cooler weather usually slows the development of DBM larvae, whereas warmer conditions tend to increase it. Heavy rainfall can result in drowning of adult moths and larvae.

Growers should also note that DBM can have overlapping generations; that is, all life stages of the pest may be present in the crop at the same time. This, along with rapid development in suitable (warm) conditions, makes DBM particularly difficult to control, highlighting the importance of regular crop monitoring. A DBM rate of development calculator is available as part of the DBM sampling plan (see *Regular scouting* below).

DBM adults are sedentary in crops during the day and active from dusk onwards. Damage is caused by the larvae rather than the adult moths, which merely lay the eggs.

The DBM larvae leave evidence of their feeding when they mine into the leaf, creating characteristic tunnels (white lines) within the leaf tissue. As the larvae mature they chew and feed on leaf surface tissue, which often results in the leaf looking holey and depleted, accompanied by telltale frass.

Regular scouting

Success of an IPM program depends on knowing exactly what is happening in the crop by accurately identifying DBM and monitoring their numbers and developmental stages.

The South Australian Research and Development Institute (SARDI) and the Department of Primary Industries (DPI), Victoria, established a crop monitoring guide to enable growers to get a good indication of the extent of the DBM population within their crop and help determine the most effective course of action. Growers are encouraged to make use of the guide, *Diamondback Moth Sampling Plan*, to save costs, time and error in determining whether their crops have a DBM problem.

The sampling plan can be accessed at <www.dpi.vic.gov.au/dpi/index.htm> - click on 'Agriculture, Food and Forestry' followed by 'Horticulture', 'Plant Diseases & Pests', then 'Diamondback Moth Sampling Plan'. To determine the most efficacious time to target DBM, growers are encouraged to use this sampling plan in conjunction with the DBM development calculator.

The sampling plan recommends steps that growers can take, including:

- Inspecting plants throughout the entire crop. This can be achieved by taking a zigzag or a figure-of-eight path, while inspecting randomly chosen individual plants throughout the crop.
- Examining the entire plant, including both sides of leaves, using a magnifying glass or a head-mounted magnifier, known as an optivisor.
- Monitoring and keeping weekly records on changes in population densities. This enables growers to see if the population is increasing or decreasing and if sprays applied in the previous week have been effective.
- Looking vigilantly for and recording the presence of DBM, particularly eggs and small larvae and its natural enemies.
- Monitoring between five to seven days after spraying.

Control strategies

Although the use of broad-spectrum insecticides will remain a method of control of pests such as DBM, strategies that comprise IRM and IPM have been recommended as the best way to conserve the efficacy of insecticides and ensure the sustainable management of DBM.

IPM

The adoption of IPM has become crucial with the impact of pesticides on the environment and health and safety of humans, as well as the unwanted effects that broad-spectrum insecticides have on natural enemies. IPM includes cultural, biological and chemical control strategies. Integrating these strategies can benefit growers by helping to provide cost-effective management methods; success is based on the early detection of pest populations by regular and rigorous crop monitoring and the conservation of natural enemies.

→ Cultural

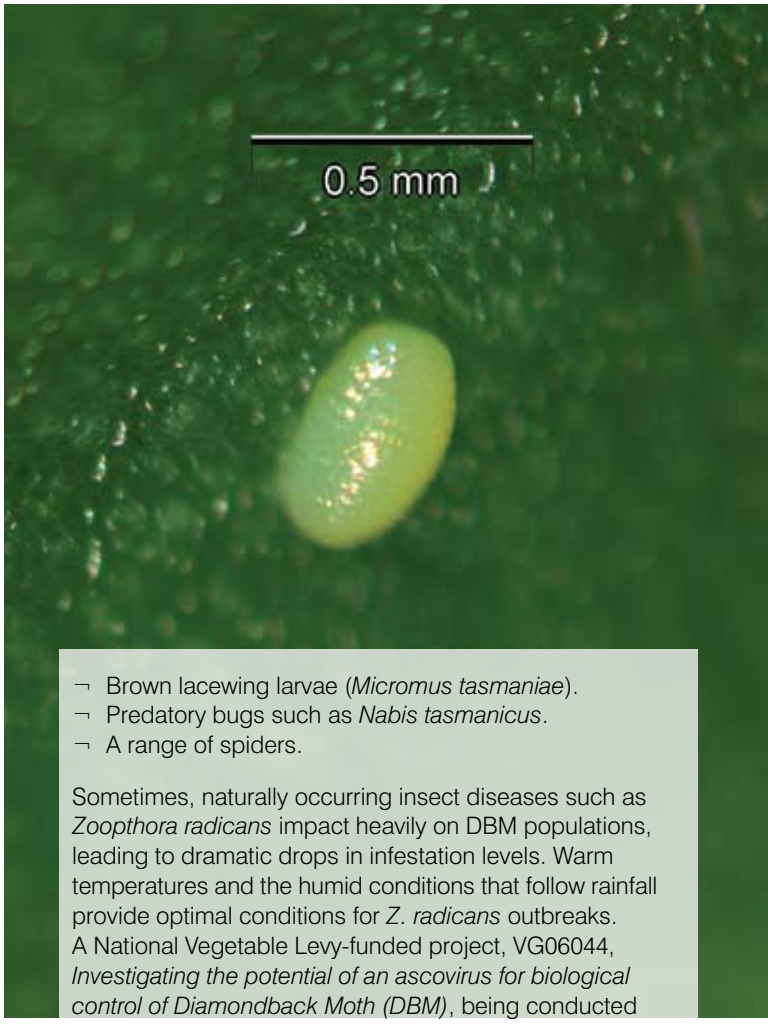
Growers should practise good farm hygiene, which entails the clearing of weeds and damaged or diseased crops from the property. This helps to prevent the survival of DBM populations. Trap crops and the cultivation of resistant varieties may also be advisable. Clean seedlings should be used and harvested crop areas should be cleared promptly.

→ Biological

An IPM program identifies and conserves the natural enemies of DBM, understands the role of insect diseases in the control of pests and understands how weather conditions can influence the development of DBM.

DBM has a number of natural enemies, that can cause significant mortality to pest populations, thereby aiding in their control. These include:

- Parasitic wasps including *Diadegma semiclausum, Diadromus collaris* and *Apanteles ippeus*. These wasps lay their eggs either externally on or internally in DBM larvae or pupae. The wasp egg hatches, feeds and develops inside the DBM host, resulting in its death.



- Brown lacewing larvae (*Micromus tasmaniae*).
- Predatory bugs such as *Nabis tasmanicus*.
- A range of spiders.

Sometimes, naturally occurring insect diseases such as *Zoopthora radicans* impact heavily on DBM populations, leading to dramatic drops in infestation levels. Warm temperatures and the humid conditions that follow rainfall provide optimal conditions for *Z. radicans* outbreaks. A National Vegetable Levy-funded project, VG06044, *Investigating the potential of an ascovirus for biological control of Diamondback Moth (DBM)*, being conducted by the University of Queensland, has revealed that DBM is susceptible to an ascovirus pathogen, which was isolated from the cotton bollworm *Helicoverpa armigera*. Ascoviruses can be transmitted between susceptible host insects by parasitoids; the transmission of an ascovirus pathogen (HaAV), between DBM hosts by *Diadegma semiclausum*, is currently being investigated.

Further research, *VG07039, Enhancing the efficacy of fungal pathogens using a synergistic chemical, Imidacloprid*, is also being undertaken at the University of Queensland to evaluate the potential of Imidacloprid to enhance the effect of fungal pathogens against DBM.

→ Chemical

The widespread reliance on insecticides to manage DBM populations has resulted in resistance to many insecticides. The reliance on insecticides also adds to environmental pressures, including the disruption of on-farm biological control provided by the many natural enemies and the risk of unacceptable levels of pesticide residue on vegetable crops, and hinders attempts to mitigate damage to the environment (on farm and on a wider scale).

A levy-funded project headed by SARDI and DPI Victoria, VG97014, recommended that the industry adopt insect resistance management to target declining levels of DBM susceptibility to pesticides (as part of an IPM approach).

IRM

DBM populations across Australia have developed resistance to synthetic pyrethroids and organophosphates. Frequent, repeated use of insecticides, with a similar mode of action, to control DBM leads to an increase in less-genetically-susceptible insects within the DBM population.

Projects VG97014 and VG00055, in conjunction with CropLife Australia's Insecticide Resistance Management Review Group (IRMRG, formerly AIRAC), established and developed the DBM Two-window IRM Strategy to assist growers to control the development of DBM resistance. The system is region-specific and season-specific, and updated regularly. The strategy lists specific pesticides together with optimal times for their use for different states and is available at <www.sardi.sa.gov.au> - click 'Entomology', followed by 'Horticulture', then 'Diamondback moth'.

It is highly recommended that growers use the Insecticide Toxicity Chart (also available at <www.sardi.sa.gov.au>), the CropLife Australia's IRMRG Two-window strategy and the Diamondback Moth Sampling Plan together, to consolidate their IPM and IRM programs.

Growers should also follow these general IRM guidelines before using insecticides for the management of DBM:

- Use insecticides only when necessary or when indicated after using the electronic sampling chart and development calculator.
- Check the Two-window IRM chart to see which insecticides are able to be used. This will depend on the area of Australia and the time of year.
- Growers should strive to use insecticides that cause the least harm to beneficials, and should refer to the Insecticide Toxicity Chart for guidance.
- The biological insecticide Bt (*Bacillus thuringiensis*) has been found to be effective at suppressing young DBM larvae. Bt reduces the need for more toxic sprays, is non-toxic to humans and wildlife, and has no withholding period (WHP). However, its use should also be limited in order to avoid DBM developing resistance.
- Spray timing must be accurate; target second to third instar larvae rather than the moth, spray at dusk to avoid Bt and spinosad (Success™[2]) breaking down with UV exposure.
- Ensure good spray coverage by using the correct calibrated spraying equipment; use sprays within the rate range specified on the label, spray in suitable weather conditions and use the correct surfactant as specified on the label only.
- Do not mix insecticides.
- Target only the crop areas that need treatment.
- Monitor crops weekly and use the crop sampling tool to provide accurate readings.

Further reading

'The Field Guide to Pests, Diseases and Disorders of Vegetable Brassicas', *Integrated Pest Management for Brassicas* CD ROM, available from Crop Health Services Bookshop, Agriculture Victoria, phone 03 9210 9356

The Brassica IPM National Newsletter, available on the SARDI website

AUSVEG: www.ausveg.com.au

The South Australian Research and Development Institute: www.sardi.sa.gov.au

Department of Primary Industries, Victoria: www.dpi.vic.gov.au

Agriculture Western Australia: www.agric.wa.gov.au

Department of Primary Industries, Queensland: www.dpi.qld.gov.au

Cornell University: www.nysaes.cornell.edu.ent/dbm

Dr Greg Baker, Senior Entomologist, SARDI
Phone: 08 8303 9544, Email: baker.greg@saugov.sa.gov.au

Dr Cate Paull, Research Officer, SARDI
Phone: 08 8303 9543, Email: paull.cate@saugov.sa.gov.au

Dr Sassan Asgari, Senior Lecturer, School of Integrative Biology, University of Queensland, Phone: 07 3365 2043
Email: s.asgari@uq.edu.au

Dr Michael Furlong, Lecturer, School of Integrative Biology, University of Queensland, Phone: 07 3365 4822
Email: m.furlong@uq.edu.au

DBM larvae.
Cover image, Diamondback moth; p.2 DBM pupa; p.3 DBM eggs.

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PO Box 563, Mulgrave VIC 3170
T: 03 9544 8098 | F: 03 9558 6199

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