DIAMONDBACK MOTH
BEST MANAGEMENT PRACTICE GUIDE

SOUTHERN

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BACKGROUND

The diamondback moth (DBM), *Plutella xylostella*, is a destructive pest of Brassica oilseed, vegetable and forage crops, which has developed resistance to more than 80 insecticides globally.

Within Australia, moderate to high-level resistance to synthetic pyrethroid (SP, Group 3A), organophosphate (OP, Group 1B) and carbamate (Group 1A) insecticides is widespread. In addition to this, increasing tolerance to emamectin benzoate (Group 6), spinetoram (Group 5) and diamides (Group 28) has been detected. At present, emamectin (e.g., Affirm®), spinetoram (e.g., Success Neo®) and biological insecticide *Bacillus thuringiensis* (BtK) (e.g., Dipel®) still provide effective control of DBM in canola.

Insecticide resistance in DBM evolves through repeated use of insecticides in local areas, creating selection pressure. In some regions, summer-active brassicaceous plants provide a refuge habitat for DBM, which allows insecticide-resistant populations to persist locally. Resistance levels are similar in DBM populations across canola-growing areas due to the insect's widespread dispersal. This poses a threat to production. The more frequently growers use a certain type of insecticide, the more likely resistance will occur. Additionally, migration of resistant DBM from intensively sprayed brassica vegetable crops poses a threat to canola production.

HOW TO USE THIS GUIDE

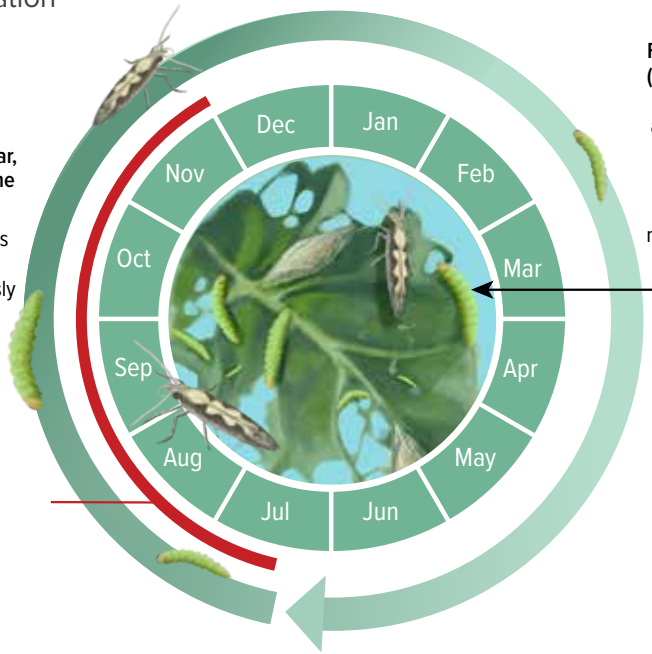
1. Become familiar with DBM biology and identification
2. Determine your risk for the season and follow recommendations
3. Consider seasonally based best management practices and actions
4. Note key considerations for each season

In southern Australia, canola crops are seasonally colonised by DBM soon after crop emergence and populations peak in spring. DBM densities in canola vary widely between regions and seasons. Between canola growing seasons, DBM survives on alternative brassicaceous plants before recolonising winter canola. DBM is highly mobile; it disperses efficiently between crops and other host plants in the landscape and is capable of long-distance migration over hundreds of kilometres.

In most years, canola tolerates DBM feeding without yield loss. In some years, DBM outbreaks in canola occur during spring, when larval populations increase rapidly to extremely high densities, causing extensive plant defoliation, flower-head and pod destruction and yield loss.

The impact of DBM on canola depends on crop growth stage and vigour:

- Pre-flowering larval feeding on terminal buds can cause yield loss.
- At later stages of crop development (late flowering onwards), canola can tolerate higher DBM densities than at earlier stages (pre or early flowering).
- Moisture-stressed crops are more heavily affected.



Breeding occurs all year, peaking in the spring

All life stages occur simultaneously

Critical monitoring period

mid-July to late spring

Four larval stages (instars), followed by pupation and adult emergence

Eggs are laid on leaves. Young larvae (1st instar) mine leaves. Older larvae surface graze on leaves, stems, flower heads and pods.

Development rate depends on temperature

15 day lifecycle at 24°C

6-10 generations per year achieved in South Australia

Adult moths are slender, approximately 10mm in length, grey-brown in colour with a white stripe of an uneven width down the centre of the back when at rest. Larvae are pale green, up to 10mm in length with a body shape tapering at both ends. Characteristically, larvae wriggle violently when disturbed or suspend themselves on a silken thread.

PHOTO: GRDC

Adult diamondback moth.

PHOTO: ANDREW WEEKS

Diamondback moth pupae.

PHOTO: cesar

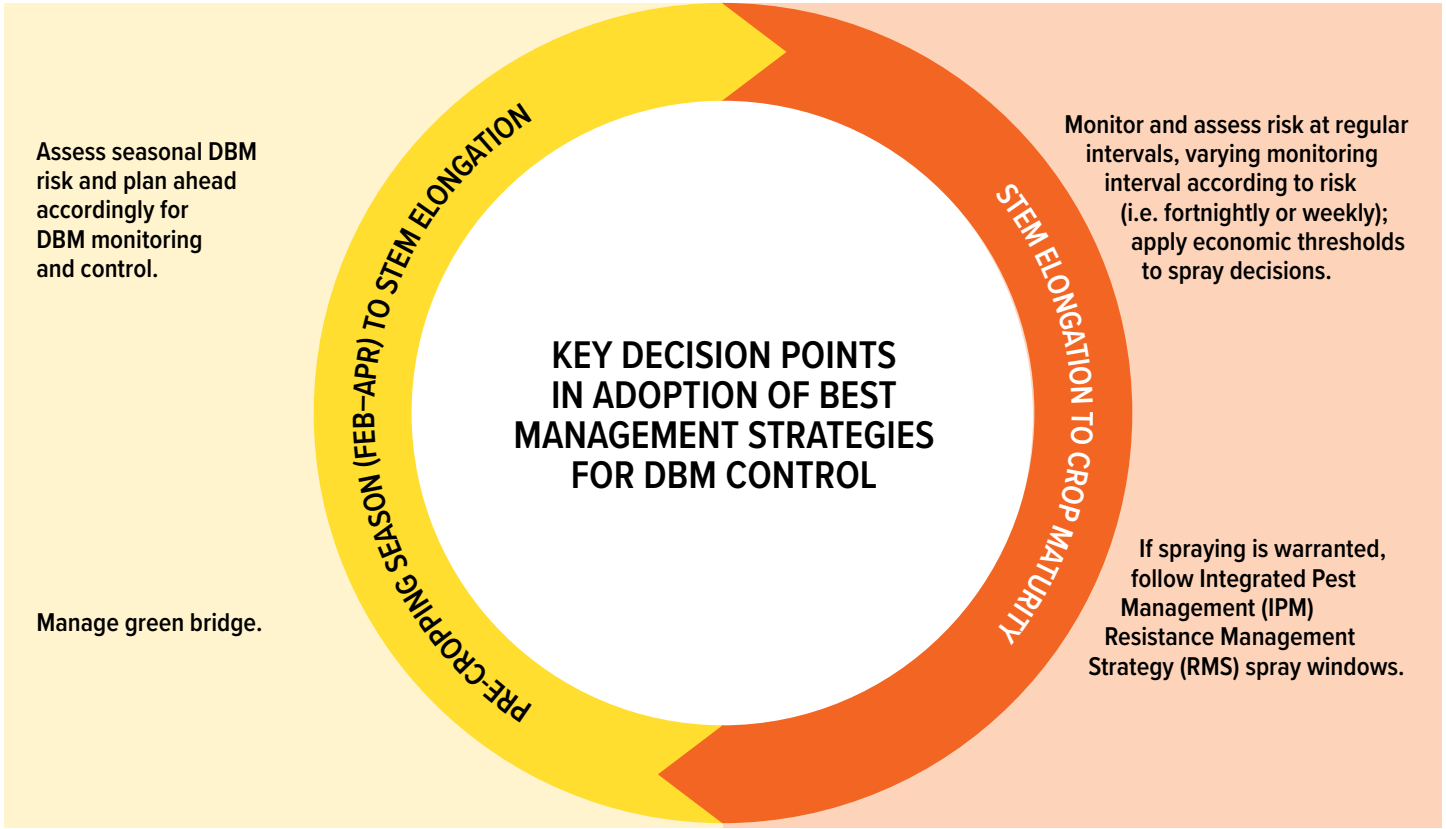
Diamondback moth larva.

RISK ASSESSMENT GUIDE FOR DIAMONDBACK MOTH IN AUTUMN-SOWN CANOLA : PRE-SEASON TO CROP MATURITY

NB: spring-sown canola and long-season autumn-sown canola varieties (harvested late in summer) can be heavily attacked by DBM. Due to differences in crop timing, the 'regional/geographic' and 'within-season' general risk factors can be considered similar to autumn-sown crops, but 'pre-season' risks do not apply.

RISK FACTOR	REDUCED RISK	ELEVATED RISK	EXPLANATORY NOTES
REGIONAL (GEOGRAPHIC) RISK FACTORS			
General climate (rainfall, temperature) in your cropping zone.	Cropping areas with relatively high annual rainfall (>550mm) and cool winter/spring temperatures.	Cropping areas with relatively low annual rainfall (<450mm) and warm winter/spring temperatures.	Relatively warm and dry conditions favour DBM survival and can promote rapid population growth in spring; the impact of DBM is greater in moisture-stressed crops.
Overall abundance of summer-active brassica plant species (wild or irrigated) within your cropping region (within 50–100km of property*).	Summer-active brassicas are relatively rare or restricted to isolated crop or non-crop areas.	High abundance of summer-active brassicas (widely distributed, in the order of thousands of hectares).	Weedy brassicas provide refuge habitat that supports DBM populations during non-cropping periods.
PRE-SEASON RISK FACTORS			
Pre-cropping season rainfall patterns during February–April across the region.	Below-average monthly rainfall (deciles <4) in at least two months during February–April.	Above-average monthly rainfall totals (deciles 8–10) in at least two months during February–April.	Pre-season rainfall proliferates growth of brassicaceous weeds; where and when rain falls is important; prolonged green bridge increases risk.
Pre-cropping season vegetation response during March–April across the region.	Relatively little or short-lived brassica green bridge.	Substantial brassica green bridge until at least mid-April.	
WITHIN-SEASON RISK FACTORS			
Rainfall and temperatures during winter–spring.	Prevailing relatively cool and wet conditions; intermittent heavy rainfall events.	Prolonged periods of relatively warm and dry conditions expected.	DBM development is more rapid at higher temperatures; heavy rainfall causes mortality; moisture-stressed crops are more susceptible to damage.
Level of biological control by natural enemies from early spring onwards.	DBM parasitoids and predators are moderately abundant in early spring; evidence of DBM infection with entomopathogenic fungi.	Broad-spectrum insecticides (e.g. SPs, OPs) were applied against any pest in the crop during winter or spring, causing destruction of beneficial insects.	Natural enemies regulate DBM populations; spread of DBM infection with naturally occurring entomopathogenic fungi, favoured by relatively warm humid conditions (e.g. *Zoophtora radicans*), can cause DBM populations to crash.

*Disclaimer: It is thought this is the likely dispersal range of this pest in most seasons; however, this has not been verified directly.


Assess seasonal DBM risk and plan ahead accordingly for DBM monitoring and control.
Manage green bridge.
PRE-CROPPING SEASON (FEB–APR) TO STEM ELONGATION
KEY DECISION POINTS IN ADOPTION OF BEST MANAGEMENT STRATEGIES FOR DBM CONTROL
STEM ELONGATION TO CROP MATURITY
Monitor and assess risk at regular intervals, varying monitoring interval according to risk (i.e. fortnightly or weekly); apply economic thresholds to spray decisions.
If spraying is warranted, follow Integrated Pest Management (IPM) Resistance Management Strategy (RMS) spray windows.

Key actions

1 Manage green bridge.

2 Assess regional and seasonal risk.

- Observe pre-season rainfall patterns and brassica vegetation response across the region during February–April (see risk assessment guide)
- Plan ahead accordingly for (winter/spring) DBM monitoring and control.

LOW RISK DBM

- Continue to monitor and use risk assessment to inform actions.

HIGH RISK DBM

- Discuss/plan sourcing appropriate insecticide stocks with chemical resellers. NB: refer to resistance management strategy (RMS) guidelines when selecting effective chemistries (refer to References/Further resources).
- Where possible, reduce green bridge – especially those containing brassicaceous weed populations – area-wide in cooperation with neighbours to gain best results.
- Plan to start monitoring from mid-winter (stem elongation).

Considerations

- Use risk assessment guide to understand management actions advised.
- As DBM are a high dispersal pest, large areas of management are the best way of reducing incursions.

Green bridge management reduces DBM risk.

PHOTO: BRAD COLLIS

Key actions

1. Monitor, assess risk and apply economic thresholds (ETs).
   - Monitor at fortnightly intervals from stem elongation onwards.
   - If larval numbers approach ETs, or if risk factors are high (see risk assessment guide), increase monitoring frequency to weekly.
2. If spraying is warranted, follow recommended IPM/RMS spray windows.
   - Refer to the RMS guidelines (and Figure on pg3) and adhere to all label directions and harvest withholding periods.
   - Look to use selective chemistries to preserve natural enemies.
   - Ensure correct spray application; use droplet sizes to penetrate crop canopy; ensure good coverage.

LOW RISK DBM

- Continue monitoring – do not spray.

HIGH RISK DBM

- Consider a two-spray approach seven days apart following the RMS windows.

Considerations

- Spray penetration and coverage is critical; DBM larvae are distributed vertically throughout the canopy.
- The two-spray strategy is designed to control susceptible DBM life stages (larvae) in two steps, allowing (non-susceptible) eggs and pupae to emerge between applications.

The parasitoid wasp, *Diadegma semiclausum*, lays its eggs into the developing larvae of the diamondback moth.

PHOTO: cesar

HOW TO MONITOR

- Using a sweep net, take 10 sweeps at five locations in the crop. Calculate average number of larvae per 10 sweeps.
- Avoid sampling in wet and/or windy weather.

THRESHOLDS

Economic thresholds
(in units of larvae per 10 sweeps):

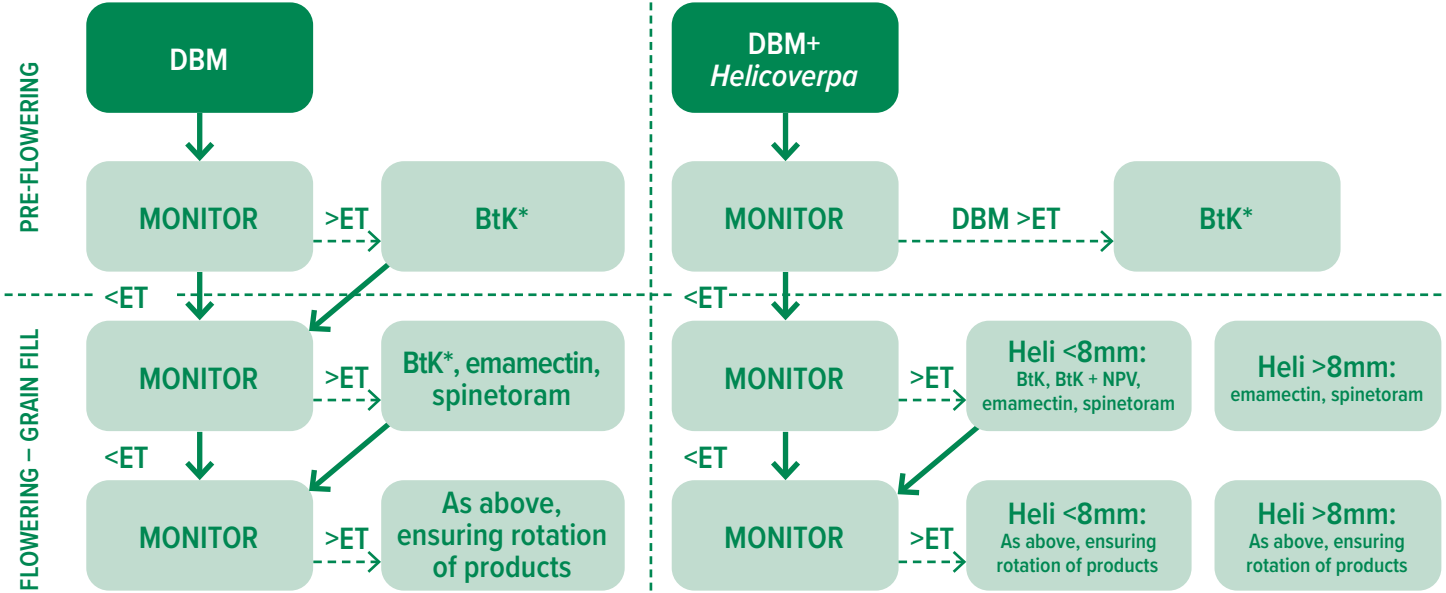
- **Rosette stage** >50 per cent leaf area damaged
- **Pre-flowering crops** (stressed) >30
- **Pre-flowering crops** (unstressed) >50
- **Early-mid flowering** >50
- **Mid-late flowering** >100
- **Pod maturation** >200

- Stressed crops are more susceptible to damage. Use a lower economic threshold if an extended warm and dry period is expected.

Sweep-netting crops to determine pest presence and population numbers.

PHOTO: KYM PERRY, SARDI

FIGURE 1 Flowchart demonstrating the resistance management strategy (RMS) guidelines for diamondback moth in canola. Use this guide when controlling DBM alone (left panel) or DBM together with *Helicoverpa* (right panel). Read the chart from top to bottom.



In the second year, avoid using the same product as the previous year.

*If DBM are building rapidly (for example sweep net counts are near threshold and doubling approximately every 7-10 days), use emamectin or spinetoram.

ET = economic threshold; BTK = *Bacillus thuringiensis* (e.g.Dipel®); emamectin (e.g. Affirm®); spinetoram (e.g. Success Neo®); Heli = Helicoverpa; NPV = nucleopolyhedrosisvirus

Bacillus thuringiensis, var. *kurstaki* (BtK)–, a group of bacteria used as biological control agents against lepidopteran pests.

Economic injury level – pest density at which the cost of yield loss is equal to the cost of control

Economic threshold – thresholds help to rationalise insecticide use by indicating when control actions should be taken in order to prevent a population from reaching the economic injury level

Entomopathogenic fungi – fungi that can act as a parasite of insects and kills or seriously disables them

Green bridge – presence of green plant material in the non-cropping phase of broadacre farming that can host out-of-season pests and diseases

Instar – a phase between two periods of moulting in the development of an insect larva or other invertebrate animal

Mode of Action (MOA) – mode of action; how a chemical compound works within the target species and the biological pathway(s) it disrupts

Nucleopolyhedrosisvirus (NPV) – a virus affecting insects, predominantly moths and butterflies. It has been commercially manufactured into a an insecticide for the control of *Helicoverpa* spp. larvae

Parasitoid – an insect whose larvae live as parasites that eventually kill their host

Pupation – an intermediate stage of a metamorphic insect (such as a moth), which occurs between the larva and adult stage usually involving a cocoon or protective covering

Resistance Management Strategy (RMS) –a strategy which directs timing and type of integrated pest control approaches with the aim of limiting risk of insecticide resistance from evolving or persisting

Soft insecticide – an insecticide that has fewer impacts on non-target organisms. Also called ‘selective insecticide’

References / Further resources

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McDonald G, Umina P, Lye J, Maino J, Perry K and Baker G (2019) *Insecticide resistance in the southern region: current status, future risk and best management practices*, GRDC Research Report, Grains Research and Development Corporation, Canberra. Available from URL: https://grdc.com.au/insecticide-resistance-in-the-southern-region.

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Science behind the RMS – www.ipmguidelinesforgrains.com.au.

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