

Diamondback Moth



Diamondback moth (*Plutella xylostella*) was introduced into North America from Europe about 150 years ago. It now occurs throughout North America, wherever its host plants are grown. Although the diamondback moth occurs each year throughout the Canadian prairies and north central United States, the severity of the infestation varies considerably from year to year.

Host Crops

Diamondback moth larvae feed only on plants in the mustard family (Brassicaceae). This includes canola, mustard, and cruciferous vegetables (such as broccoli, cauliflower, cabbage, kale, radish and turnip). Larvae will also feed on some wild cruciferous plants, such as wild mustard.

Lifecycle

Diamondback moth has four life stages: egg, larva, pupa and adult. Crop damage is caused by the larval stage.

Normally, the diamondback moth takes about 32 days to develop from egg to adult. However, the time to complete a generation may vary from 21 to 51 days depending on weather and food conditions. There may be several generations per growing season. Generations usually overlap and all four life stages may be present in the field at the same time.

Adults

The adult moth is approximately 8 to 9 mm (1/3 inch) long with a wing span of 12 to 15 mm (1/2 inch).

At rest, the moth folds its wings over the abdomen in a tent-like manner. The folded wings flare upwards and outward at the tips. The wing tips are fringed with long hairs.

In the male, the inner margins of the forewings have a series of white wavy markings. When the wings are folded while the moth is at rest, these markings come together to form three white diamond-shaped patterns, hence the name diamondback.

Adult females lay an average of 160 eggs during their life span of about 16 days. Egg-laying occurs at night. The greatest number of eggs are laid the first night after emergence and egg-laying continues for about ten days.

In the field, moths will flutter up out of the canopy as the canopy is disturbed.

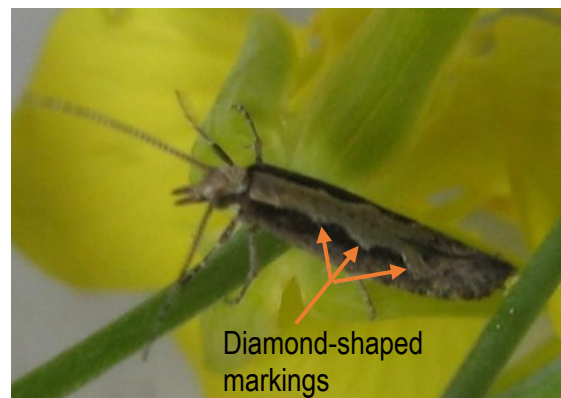


Figure 1. Adult of diamondback moth

Eggs

Eggs are oval, yellowish white and tiny. They are glued to the upper and lower leaf surfaces singly or in groups of two or three, usually along the veins or where the leaf surface is uneven. The eggs hatch in about five or six days.

Larvae

Immediately after hatching from the egg, larvae burrow into the leaf and begin mining the leaf tissue internally. After feeding within the leaf for about a week, the larvae exit from the underside of the leaf and begin feeding externally.

The larvae are pale yellowish green to green caterpillars covered with fine, scattered, erect hairs. The posterior end of the caterpillar is forked.

Larvae moult three times during the larval stage which lasts about ten to 21 days, depending upon temperature and the availability of food. At maturity the larvae are cigar-shaped and about 12 mm ($\frac{1}{2}$ inch) long.

The diamondback moth larva is easily identified by its peculiar reaction to being disturbed. It will wriggle backward violently and may drop from the plant, suspended by a silken thread. After several seconds, the larva will climb back onto the leaf and continue feeding.



Figure 2. Pupa (left) and larva (right) of diamondback moth

Pupae

Larvae pupate in delicate, white, open-mesh cocoons attached to the leaves, stems or seed pods of the host plant. Initially, the pupae are light green but as they mature, they become brown as the adult moth becomes visible through the cocoon. The pupal stage lasts from five to 15 days, depending on environmental conditions.

Damage

An infestation of diamondback moths cannot be predicted based on the previous year's population because very few, if any, survive the long, cold Canadian winters. Instead, the severity of the infestation in any given year depends on a few factors: overwintering populations to the south, strong south winds to transport the moths north into the Canadian prairies in the spring, and weather conditions and natural enemy populations after they arrive.

In years when conditions are right for the moths - that is, when moths arrive on the wind in large numbers in May and summer temperatures are hot - diamondback moth infestations can cause millions of dollars of damage.

Diamondback moth larvae feed on leaves, buds, flowers, seed pods, the green outer layer of the stems and occasionally the developing seeds within the older seed pods of canola and mustard. The amount of damage varies greatly, depending on plant growth stage, larval densities and size.

When larvae are small, damage is evident as small irregular holes or "shot holes" in the leaves. If larvae are numerous, they may eat the entire leaf, leaving only the veins.

When plants begin to flower, larger larvae often feed on the flower buds, flowers and young seed pods. Feeding damage during the early flowering stage can be extensive. Extensive feeding on the flowers will delay plant maturity, causing the crop to develop unevenly and significantly reduce seed yields.

When plants are fully podded and leaves begin to wilt or die in late July or early August, larvae will remove the surface tissue from the stems and seed pods. The seeds within a damaged pod will not fill completely and pods may shatter. Larvae may also chew into seed pods and eat the developing seeds.

Monitoring

Adult

The presence and relative abundance of the diamondback moth can be determined by using pheromone-baited traps. These traps cannot predict the potential for crop damage, but trap counts can provide an early warning if high levels of the adult moths blow in, and indicate regions that may be at higher risk. Environmental conditions will determine how many eggs are laid, and weather and natural enemies will determine how many larvae emerge and survive.



Figure 3. Pheromone-baited delta trap, used to monitor diamondback moth

Larvae

Monitor diamondback moth larvae by selecting plants in an area measuring 0.1 square metre area (about 1 foot square), beating them on a clean surface, and counting the number of larvae dislodged from the plants. To obtain an accurate count, repeat this procedure in at least five locations in the field. Crops should be monitored at least once a week during the growing season, and more frequently if populations approach economic levels.

Action Threshold in Canola

Seedling stage: A nominal threshold of 25-33% defoliation, with larvae still present on plants, can be applied for canola at the seedling stage.

Immature to flowering plants: Control may be required in canola if larvae exceed 10-15 per ft² of plants (100-150/m²) in immature to flowering plants.

Plants with flowers and pods: Control may be required in canola if larvae exceed 20-30 per ft² (200-300/m²) in plants with flowers and pods.

Thresholds at all crop stages may be lower for Polish type canolas than for Argentine type canolas and higher for mustard.

Pest Management

Weather

Cool, windy weather reduces adult activity and females often die before they lay all their eggs. Heavy rainfall can drown small larvae and reduce numbers by more than half. Humid conditions within the crop following a rainfall can promote the spread of fatal fungal diseases throughout the diamondback moth population.

Natural Enemies

Diamondback moths are affected by diseases, parasites and predators.

Pathogens: Entomophthorales fungi cause natural disease outbreaks in diamondback moth populations. These outbreaks usually occur late in the growing season when populations are high. The rate of infection of diamondback moth larvae can be high enough to limit the development of additional generations late in the season.

Parasitoids: In Western Canada, several species of parasitic wasps attack the diamondback moth. The most important species are often *Diadegma insulare* (Ichneumonidae) and *Microplitis plutellae* (Braconidae) which attack the larval stages, and *Diadromus subtilicornis* (Ichneumonidae), which attacks the prepupal and pupal stages.

In some years parasitoids can have a big impact on populations of diamondback moth. For example, the diamondback moth outbreaks on the prairies in 2003 and 2005 were terminated primarily through the activity of *Diadegma insulare*.

Predators: Damsel bugs and some species of ground beetles will eat diamondback moth larvae. Green lacewings will feed on eggs, larvae and cocoons of diamondback moth.

Chemical Control

Despite the abundance of potential biological control agents, the only effective way of controlling a diamondback moth outbreak once the population exceeds the action threshold is to apply an insecticide.

Insecticide selection will depend on cost, environmental conditions, days to harvest, availability of product, the presence of other pests, and the presence of pollinating and other beneficial insects. The recommended insecticides are listed in the tables below.

Insecticides should always be applied with enough water to ensure adequate coverage. Use high water volumes and label rates when the crop canopy is dense.

Pollinator protection: Injury to honeybees and other pollinating insects can be minimized by not spraying flowering crops. If it is necessary to apply an insecticide to a flowering canola or mustard crop, Plutex does not harm beneficial and pollinating insects, and Coragen is not harmful to some beneficial insects, including bees. Apply insecticides in the evening to reduce risk to bees.

Table 1. Insecticides Registered for the Control of Diamondback Moth on Canola or Mustard in Canada.

Product	Rate of product per acre	Preharvest Intervals (days)	
		Canola	Mustard
Plutex	20 to 81 ml	0	Not registered
Coragen Max	17 ml	1	1
Coragen	51 ml		
Decis 100 EC	20-30 ml	7	7
Advantage Deltamethrin	40-60 ml		
Poleci	81-121 ml		
Matador, Silencer, Labamba, Zivata*	34 ml	7	7
Voliam Xpress	91 ml	7	7
Malathion 85E	109-168 ml	7	7

*Crops treated with lambda-cyhalothrin (Matador, Silencer, Labamba, Zivata) can't be used as animal feed.

Table 2. Insecticides registered for diamondback moth in Brassica cruciferous vegetable; cabbage (cab), broccoli (bro), cauliflower (cau), and kale.

Trade Name	Active ingredient	Crop	Notes
Plutex	<i>Plutella xylostella</i> granulovirus	cab, bro, cau	Can be used on organic crops
Dipel	<i>Bacillus thuringiensis</i> var. Kurstaki	cab, bro	Can be used on organic crops. Kills only larvae of Lepidoptera (moths and butterflies).
BTK, Bioprotec CAF, Bioprotec PLUS	<i>Bacillus thuringiensis</i> var. Kurstaki	cab, bro, cau, kale	Can be used on organic crops. Kills only larvae of Lepidoptera (moths and butterflies).
Entrust, Success	Spinosad	cab, bro, cau, kale	Entrust can be used on organic crops
Delegate	Spinetoram	cab, bro, cau, kale	
Intrepid (suppression)	Methoxyfenozide	cab, bro, cau, kale	Harmless to many beneficial insects
Rimon	Novaluron	cab, bro, cau, kale	Must be absorbed by eggs or ingested by larvae, does not kill adult insects.
Coragen, Coragen MaX	Chlorantraniliprole	cab, bro, cau, kale	Will not harm bees, low to moderate toxicity to many natural enemies,
Exirel	Cyantraniliprole	cab, bro, cau, kale	
Harvanta	Cyclaniliprole	cab, bro, cau, kale	
Poleci	Deltamethrin	cab, bro, cau	
Matador, Silencer, Labamba, Zivata	Lambda-cyhalothrin	cab, bro, cau	

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Revised: April 2024

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