The Diamondback Moth, *Plutella xylostella:* Resistance Management is Key for Sustainable Control

IRAC
Insecticide Resistance Action Committee

www.irac-online.org

Introduction and Biological Background

Diamondback moth (*Plutella xylostella* L.) is a highly migratory and cosmopolitan species, and is one of the most important insect pests of cruciferous crops worldwide. Its rapid life cycle, up to 15 generations per year, in warm climates also contributes to its year-round pest status and ability to rapid develop resistance to insecticides.

Adults are about 6 mm in length with pronounced antennae. They can live from 2 to 8 weeks laying as many as 350 eggs per female. Adults can be found resting on plants but are most active during dusk when mating and oviposition occur.

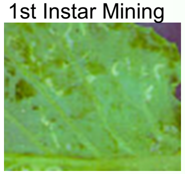
Eggs are oval, flattened, yellow, and about 0.25 mm in length. Eggs will hatch in about 2-6 days after laying depending on temperature.

The larval stage is unique since first-instar larvae mine leaf tissue while later instars consume leaf tissue from underside the leaves. Often the epidermal layer of the upper side of the leaf is left intact with a window-like appearance, called window-paneing. There are usually four larval instars with a development time of 20-28 days. Larvae aggressively wriggle when disturbed and spin down a strand of silk.

Prepupal larvae spin a loose silk cocoon usually on the host plant. Within a day the pupa develops within the cocoon turning from yellow to brown.

Plutella xylostella Damage in Cabbage

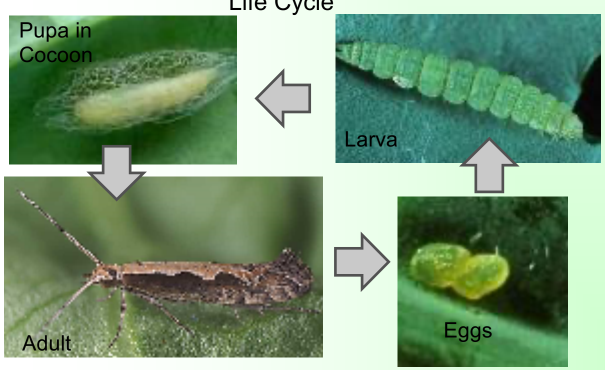
1st Instar Mining



Windowpaneing

Foliar Damage

Life Cycle



Resistance Mechanisms

Several biochemical mechanisms are described as conferring resistance to insecticides in diamondback moth populations. Many of these mechanisms listed below act in concert and can provide resistance factors of 1000-fold or greater. Updated information is available at www.irac-online.org/pests/

- Enhanced metabolic detoxification mechanisms
- Insensitive acetylcholinesterase
- Reduced Cry1C binding to target site in midgut membrane and reduced conversion of Cry1C protoxin to toxin
- Reduced penetration
- Target-site resistance

Insecticides and MoA For *Plutella xylostella*

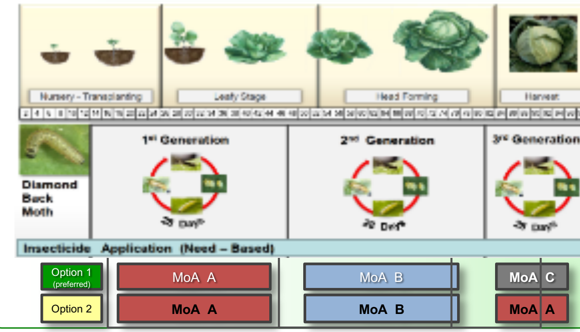
P. xylostella is one of the most difficult pests to control because of its ability to rapidly develop insecticidal resistance. Continuous insecticide applications in many regions are often needed to maintain adequate crop protection.

P. xylostella is resistant to most insecticide classes including newly introduced mode of action chemistry. The proliferation of generations combined with destructive feeding behaviour requiring numerous sprays contribute to the rapid development of insecticide resistance.

MoA	Primary Target Site	Chemical Class
1A	Acetylcholinesterase inhibitors	Carbamates
1B	Acetylcholinesterase inhibitors	Organophosphates
2B	GABA-gated Cl channel antagonists	Phenylpyrazoles (Fiproles)
3A	Sodium channel modulators	Pyrethroids, Pyrethrins
4	Nicotinic acetylcholine receptor competitive modulators	Neonicotinoids
5	Nicotinic acetylcholine receptor allosteric activators	Spinosyns
6	Chloride channel activators	Avermectins, Milbemycins
11	Microbial disruptors of insect midgut membranes and derived toxins	*Bacillus thuringiensis var. kurstaki*
13	Uncouplers of oxidative phosphorylation	Pyrrols
15	Inhibitors of chitin biosynthesis, type 0	Benzoylureas
18	Ecdysone receptor agonists	Diacylhydrazines
21A	Mitochondrial complex I electron transport inhibitors	Tolfenpyrad
22A	Voltage-dependent Na channel blockers	Indoxacarb
22B	Voltage-dependent Na channel blockers	Metaflumizone
28	Ryanodine receptor modulators	Diamides
30	GABA-gated chloride channel modulators	Meta-diamides, Isoxazolines
31	Baculoviruses – Host specific	
UN	Compounds of unknown/uncertain MoA	Azadirachtin, Pyridalyl

P. xylostella IRM Strategy Using Windows

Below is an example of a resistance management program using a spray window rotation strategy developed for Brassica crops in the Philippines.



Resistance Management Strategies

- To delay the development of insecticide resistance, use a combination of all available pest management and resistance management tools to decrease DBM exposure to insecticides such as biological control with natural enemies (Cotesia spp), and crop rotation.
- Always follow the "directions for use" on the label of each product.
- Consult product label or IRAC's website (www.irac-online.org) to determine the mode of action (MoA) of each product.
- Do not treat successive generations with products of the same MoA.
  - Follow the "treatment windows" approach (see example above)
  - A "treatment window" is the period of residual activity provided by single or sequential applications of products with the same mode of action. This "treatment window" should not exceed approximately 30 days (generally referred to as the length of one insect pest generation) but can be less and should not exceed two applications of products from the same MoA.
- Following this treatment period, rotate to an approximate 30 day "window" of effective insecticides with different MoAs if needed.
- Generally, the total exposure period of products representing a single MoA applied throughout the crop cycle (seedling to harvest) should not exceed approximately 50% of the crop cycle or exceed 50% of the total number of insecticide applications targeted at the same pest species.
- Apply insecticides only when needed based on economic thresholds.

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