UCCE & DPR Sponsored

California Department of Pesticide Regulation

Lompoc

Row Crop Pest Management

Project

No. 4 Diamondback Moth: A Key Pest of Cruciferous Crops

University of California Cooperative Extension

624 W. Foster Road, Suite A
Santa Maria, CA 93455

IPM Information Series

April, 1997

Diamondback Moth: A Key Pest of Cruciferous Crops

By Phil A. Phillips

Introduction

The diamondback moth, *Plutella xylostella* (Linnaeus), introduced before the mid-1800's into the United States from Europe, is a worldwide pest of cruciferous crops. The larvae attack a wide range of cole crops including: cabbage, cauliflower, rape, kale, turnip, and brussels sprouts. Other crucifers or mustard family plants are attacked as well, including sweet alyssum and the floriculture crop "stocks," which originated in Southern Europe.

Description of the Pest

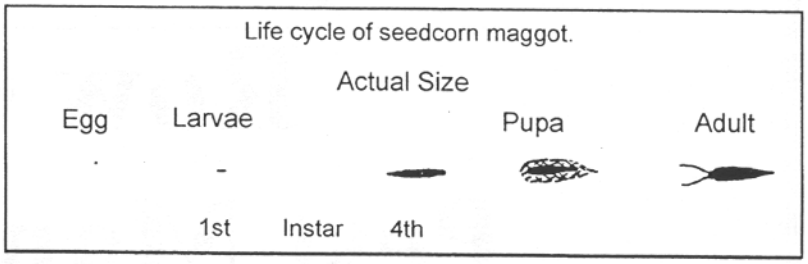


Figure 1

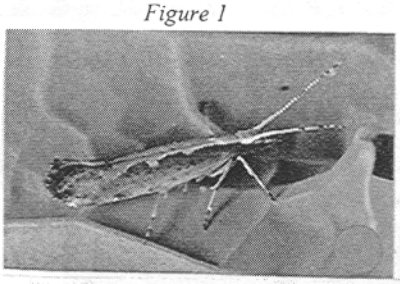
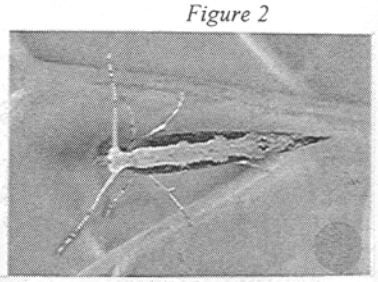


Figure 2



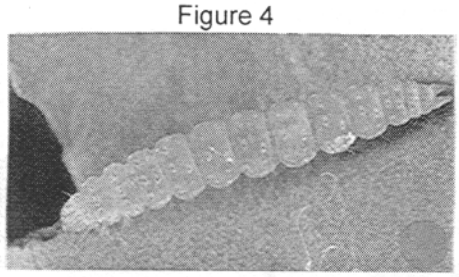
Diamondback moth adults overwinter either in wild or cultivated cruciferous plants. The adults are slender, very small, 1/3 inch (8 mm) long, greyish-brown moths with folded wings flaring outward and upward at their posterior ends (Fig. 1). They are distinguished by having three pale, triangular markings along the inner margin of the wings. When the moth is settled at rest, these join together to form a row of three diamond-shaped pale spots down the middle of the back (Fig. 2); hence, the name diamondback moth. Moths prefer to rest under the leaves and in protective plant structures. They move rapidly when disturbed, and flight is usually in the form of quick flutterings from plant to plant. Although this activity occurs during the day, moth activity is greatest at dusk and dawn. They fly around plants searching for a mate or a place to deposit eggs. Male moths are attracted to the pheromone produced by females. During the day, moths can be flushed out and easily noticed by merely walking down between the crop rows.

Figure 3

Diamondback moths lay their small (<1 mm), roundish, somewhat irregular shaped white eggs singly or in groups of two or three on the underside of lower leaves near the leaf veins or on the lower stalks (Fig. 3). Egg hatch occurs in 5 to 10 days depending on the prevailing temperatures.

Diamondback larvae pass through four instars (growth stages). First instars, upon hatching, begin mining within the leaf tissue, whereas later instars feed on heart leaves of young plants and/or the underside of the leaf surfaces of more mature plants. Compared to other caterpillars in cruciferous crops, mature diamondback larvae are small (1/3 inch or 8 mm). The larval body is wider in the middle and pointed at both ends (Fig. 4) with two prolegs on the last segment forming a distinctive V-shape at the rear end. Diamondback larvae can be distinguished from other young pest species by their habit of actively wriggling or dropping from the leaf on a silken thread when disturbed. They climb back on the leaf on this thread once the danger has passed. Caterpillars vary in coloration from a light brown at hatching to dark green when fully grown. Larval development occurs within 10 to 14 days depending on temperature.

Figure 4



Larvae are generally found on the underside of leaves, between the veins or in the developing flower buds. They can burrow into the leaves when they are small, making small white tunnels. Later, the caterpillars feed on the underside of the leaves. They do not eat the veins and often

leave the upper skin of the leaf intact, which leaves a window-like appearance. They also feed on the growing tips of the young plants, preventing them from developing further. Once mature, the larvae spin a loose, open lacework white cocoon (Fig. 5) that is attached to the leaves or stems of the plant or spun under the plant for pupation. Adults emerge in 7 to 15 days. The lower developmental temperature for diamondback moth is 45 ^{0}F, which is rather cool compared to other lepidopterans. The full life cycle takes from 490 degree-days (^{0}D) for the females to 530 ^{0}D for the males. Using the daily maximum and minimum temperatures during a given crop cycle, the degree-days for diamondback development can be calculated and generation times established (Table 1). For more information, see Info. Series #1.

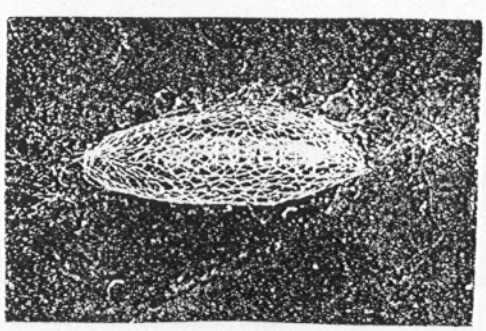
Table 1.
A degree-day table for diamondback moth based on its developmental threshold of 45 ^{0}F

Maximum Temperature	Minimum Temperature																									
	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
44	0																										
45	0	0																									
46	0	1	1																								
47	1	1	2	2																							
48	1	2	2	3	3																						
49	2	2	3	3	4	4																					
50	2	3	3	4	4	5	5																				
51	3	3	4	4	5	5	6	6																			
52	3	4	4	5	5	6	6	7	7																		
53	4	4	5	5	6	6	7	7	8	8																	
54	4	5	5	6	6	7	7	8	8	9	9																
55	5	5	6	6	7	7	8	8	9	9	10	10															
56	5	6	6	7	7	8	8	9	9	10	10	11	11														
57	6	6	7	7	8	8	9	9	10	10	11	11	12	12													
58	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13												
59	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14											
60	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15										
61	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16									
62	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17								
63	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18							
64	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19						
65	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20					
66	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21				
67	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22			
68	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23		
69	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	
70	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25
71	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26
72	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26
73	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27
74	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27
75	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28
76	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28
77	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29
78	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29
79	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30
80	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30
81	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31
82	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31
83	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32
84	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32
85	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33
86	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33
87	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34
88	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34	34
89	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34	34	35
90	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34	34	35	35

Damage

The diamondback moth larva can damage cruciferous plants by feeding and mining. Upon hatching, the first instar larva burrows into the cruciferous leaf and begins mining between the upper and lower leaf surfaces (Fig. 6). The leaf mining injury to the plant normally is negligible unless extremely high populations occur. The later instars feed on the leaf surface, generally on the underside of leaves, making small, irregular holes while leaving the upper leaf epidermis intact (Fig. 7) and giving a window-like appearance to the feeding site.

Figure 5



Diamondback moth is the most serious pest of cabbage and stocks. Infestations are most serious when they damage the crowns or growing points of young plants. This injury can severely stunt growth. Diamondback larvae may affect yield or flower production if feeding occurs in the heart leaves prior to heading. However, in cabbage, once the plant has headed, feeding is usually found on the outer frame leaves, which are discarded at harvest. Thus, larger larval populations are necessary at this stage to cause plant damage and necessitate control. In stocks, larval feeding up in the floral stalk may exacerbate botrytis bloom rot and the presence of larvae presents a contamination problem for the fresh cut flower market.

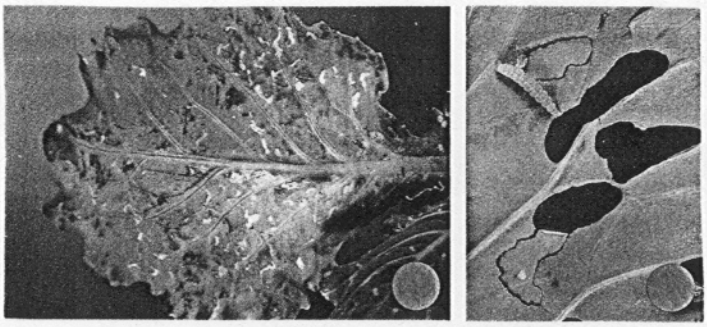
Monitoring

Larvae are detected by visual observations of the plant. Adults can be detected by the use of a pheromone trap.

Diamondback larval populations should be evaluated weekly in cabbage during the critical period from approximately the 8 leaf stage until head formation. Sampling cabbage from head formation until harvest is less critical and can be done less often. The whole plant should be examined. Pay special attention to look for

small caterpillars under the leaves in the basal part of the plant. Damage or holes in the leaves are not a good predictor of the caterpillar population. Larval counts should be acquired from at least 20 randomly selected plants per field. Larvae feeding on the heart leaves during the pre-heading stage are difficult to find. The outermost cupping leaves should be pulled back and examined for larvae and signs of feeding.

Figure 6 & 7



In cabbage and stocks, the economic threshold is one larva per plant. For broccoli and cauliflower at the vegetative stage, the plant can support 30% defoliation. At harvest time, an infestation level of one caterpillar per head is the action threshold.

Adult monitoring can be conducted through the use of pheromone traps. The pheromone lure attracts and traps males that occur in and near the field. These moth counts can be used to determine peak flight activity and indicate the occurrence of subsequent larval populations within the following two weeks. Control recommendations should be based on larval counts, other pest problems, and plant growth stage.

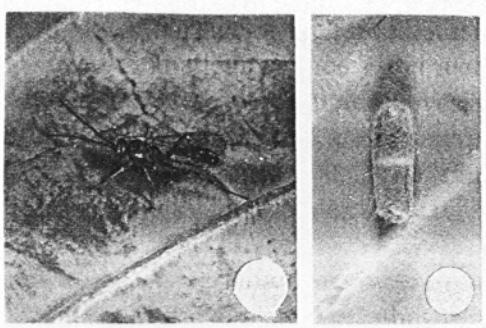
Control - Biological and Chemical

There are some naturally-occurring controls of the diamondback population in the field. Various predacious arthropods, namely ground beetles, true bugs, syrphid fly larvae, lacewing larvae, and spiders can be important factors in controlling populations. A parasitic wasp, *Diadegma insularis* (Fig. 8), has been found to parasitize greater than 25 percent of the diamondback larvae early in the season. The elliptical pupal case of the parasite can be seen within the gauzelike silken cocoon of the diamondback. The parasite's puparium is easily detectable due to the white stripe banded around the middle (Fig. 9). Other parasites also parasitize the larvae, but to a lesser extent.

Diamondback eggs may be parasitized by the egg parasite *Trichogramma pretiosum*. Microbial diseases are not known to be a significant mortality factor, even though several naturally occurring fungi, viruses, and bacteria, including *B. thuringiensis* var. *Kurstaki*, infect and kill diamondback larvae.

Diamondback larval and egg populations are also influenced by weather factors. It has been observed that heavy rainfalls cause significant reductions to early larval instar populations. Because of severe pesticide resistance problems with diamondback moth around the world, it is very important to use pesticides as little as possible in an IPM program. This insect has even developed resistance to the bacterial pesticide, *Bacillus thuringiensis*, var. *Kurstaki* in areas where it is in heavy use, leaving farmers without a useful pesticide. Since cole crops such as cabbage and broccoli contain large amounts of wax in the surface of the leaves, it is very difficult for pesticides to stay on the leaf surface. It is recommended to use spreader stickers to increase pesticide coverage and persistency. The majority of diamondback moth caterpillars live under the leaf surface. For this reason, it is very important to have excellent pesticide coverage under the leaves.

Figures 8 & 9



However, recent research has shown that when spreader stickers are used, they degrade the protective wax of cole crops which increases plant volatiles emitted into the air stream. This in turn increases the attractiveness of the plants to diamondback

moths flying in from outside the treated field, and can result in even heavier subsequent new infestations than prior to the initiation of treatments using spreader stickers.

When considering control strategies, it is important to remember that mustard and other crucifer weeds are alternate hosts and may contribute to the re-invasion of treated crops.

IPM Practices:

Planting season: It is preferable to plant in the rainy season when the population of diamondback moth is deterred by the rain. However, this is generally not economically feasible for coastal California row crop growers.

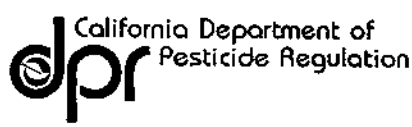
Irrigation: Sprinkle irrigation may reduce the number of caterpillars in the field. If it is applied at dusk, it may limit the activity of adults. However, sprinkler irrigation generally increases disease pressure.

Plot location: It is better not to have multiple planting dates in the same area because the older plots will serve as "inoculum" of diamondback moth for the new plantings. If you need to have several planting dates, plant the younger crop into the direction of the prevailing winds to make it harder for the moths to fly into new plantings.

Seedlings: Seedbeds should be distant from old plantings and new plots to be planted. It is very important that seedlings are clean of diamondback moth before transplanting to the field.

Remove unharvested plant parts: At harvest time, it is important to cut and, if possible, remove all plant materials that are not harvested. Diamondback moth can survive in plant residues and migrate to the next plot.

Intercropping: In some areas, especially in the eastern United States where small plots are the norm, it is recommended to plant small plots of crucifers between other crops that are not susceptible to the diamondback moth. The idea of intercropping is that diamondback moths will have more difficulty in finding new crops when they are camouflaged between other non-susceptible crops.



Questions or Comments?

(805) 645-1457 or (805) 934-6240
or e-mail paphillips@ucdavis.edu