NEW THRESHOLDS AND STRATEGIES FOR MANAGEMENT OF BEAN LEAF BEETLES IN IOWA SOYBEAN

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The bean leaf beetle is an annual pest of soybean in midwestern states. Adult beetles feed on any aboveground plant part and are especially fond of soybean pods late in the growing season. Larvae, which are similar in appearance to corn rootworm larvae, feed below the soil surface on soybean nodules, but their impact on yield or plant health is not known. In addition to the physical injury that bean leaf beetle adults cause to soybean plants, this insect also transmits bean pod mottle virus—a potentially yield-robbing plant disease that makes proper management of this insect even more critical. This report focuses on a new concept for managing second-generation bean leaf beetle adults, the performance of insecticides in controlling this pest, and the problems related to bean pod mottle virus and transmission by adult beetles.

There are two generations of bean leaf beetle in Iowa (Table 1). Bean leaf beetle adults are commonly found on alfalfa after emerging from overwintering habitat. These overwintered populations, which are actually adults from the second generation of the previous growing season, move quickly into soybean, sometimes as soon as the plants crack the ground. This colonization of soybean is typical in Iowa, but because the overwintering bean leaf beetle population is usually small, adults often are not obvious on young soybean plants. The first generation typically occurs on late-vegetative- and early-reproductive-stage soybean. The second generation occurs mostly on soybean in all stages of pod development. It is common for adults from the end of the first generation and the beginning of the second generation to occur at the same time in a field, thereby making the two populations indistinguishable from each other.

Table 1. Seasonal occurrence of bean leaf beetles in central Iowa.[1]

Cycle	Begin	Peak	End
Overwintered population	Mid-May	Late May	Late June
First generation	Late June	Mid-to-late July	Mid-to-late August
Second generation	Early August	Late Aug/mid-Sept	Late September

[1]From Smelser and Pedigo (1991).

A 12-year population study conducted at Iowa State University shows that the bean leaf beetle population has steadily increased during the past 4 years (Fig. 1). It is believed that the relatively mild winters of the past 3 years have allowed above-average survival of overwintering beetles. This situation, coupled with an increase in the acres of early-planted (April) soybean, has contributed to damaging populations of bean leaf beetles throughout most of Iowa. Bean leaf beetle management requires that each of the three population cycles be scouted and considered separately.

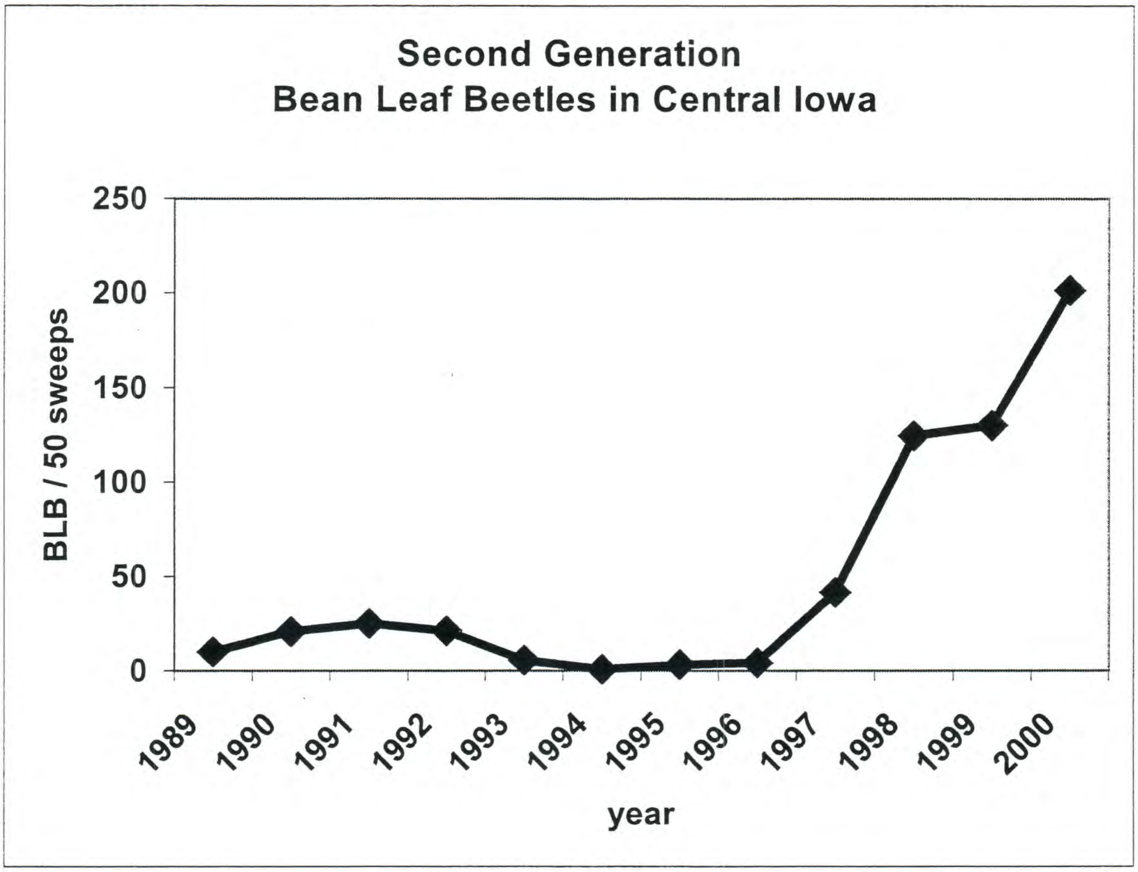

Fig 1. A 12-year population trend for second-generation bean leaf beetles in central Iowa soybean.

Economic Thresholds—Overwintered Beetle Population

Overwintered bean leaf beetles feed on new plant tissue and can quickly cause noticeable injury to seedlings in the form of defoliation and scarring of the stem, hypocotyl, and cotyledons. But noticeable injury does not necessarily translate into economically significant damage. Early-season damage does not gain economic significance until cotyledons are lost and regrowth is suppressed by feeding activity. Economic damage requires huge densities of feeding adults, and treatments are rarely justified. Table 2 shows the number of beetles per plant (or foot of row) needed to justify insecticide treatment. Three or more adults per plant are rare but may be possible in localized areas.

Table 2. Early-season (stage V1) bean leaf beetle economic thresholds in soybean.[1]

Crop value ($/bushel)	Treatment cost per acre (insecticide + application)						
	$7	$8	$9	$10	$11	$12	$13
	Beetles per plant						
$5.00	4.4	5.0	5.6	6.2	6.8	7.4	8.0
	Beetles per foot of row						
$5.00	33.4	38.0	42.6	47.1	51.7	56.2	60.8

[1]From Hunt et al. (1995) with economic thresholds calculated at 0.75 of economic injury levels

Economic Threshold—First-Generation Beetles

Soybean plants have a tremendous capacity to tolerate 30–40% defoliation during the vegetative stages of plant growth. Therefore, adult densities must be extremely large before an insecticide application is economically justified. Fields in Iowa are rarely treated for first-generation beetles because field sampling seldom detects economically damaging populations.

Economic Threshold—Second-Generation Beetles

Bean leaf beetles feeding on soybean pods can lead to significant reductions in seed quality and yield throughout Iowa. Management of bean leaf beetles on soybean during the pod setting and filling stages can be frustrating for farmers and crop advisers because adult beetles may feed on pods for several weeks before the density reaches the economic threshold. In this situation, some loss in seed quality and quantity occurs before an insecticide application is economically justified. The challenge is to try to prevent economic damage before it occurs.

During the past 15 years, entomologists at Iowa State University have been researching the biology and behavior of bean leaf beetles on soybean. We now have sufficient research-based information to make a management decision for second-generation bean leaf beetles based on the population size of the first generation. This concept is radically different from most other approaches to using economic thresholds in field crops.

A degree-day model was developed to estimate the occurrence of first-generation adults in the field (Zeiss et al. 1996) that we converted from Celsius to Fahrenheit. Degree-day estimates for the first generation of adults were 1212 degree days with a developmental threshold at 46°F. Overwintered female beetles usually begin to lay eggs after colonizing soybean fields. The degree-day estimation for first-generation adults is calculated by accumulating the temperature starting at the week of soybean emergence. Table 3 shows the accumulated degree days in 2000 for the first-generation adults from

May 1 through June 28 in five different areas of Iowa. Table 4 shows the dates predicted for the peak emergence of first-generation adults at these locations.

The new management concept is to sample the first-generation of beetles and use this information to manage the second generation of beetles in a field. Here's how it works:

1. Determine what week soybean plants emerged from the soil.
2. Consult Table 4 (left-hand column) and find the dates that match the soybean emergence date.
3. Determine which of the five Iowa locations is closest to your field.
4. Where the date (row) and location (column) intersect represents the predicted date for peak first-generation beetle emergence.
5. Sample the soybean fields 1 week after the predicted peak emergence. If the number of beetles reaches or exceeds the threshold (Table 5), stop sampling. If the sample is below the threshold, sample again the following week. If the sample remains below the threshold, sample a third and final week. If the threshold is not reached, then an economic infestation of bean leaf beetles should not occur in your pod-stage soybean.
6. If the first-generation population is above the threshold, scout the fields **again** in mid-August to monitor for the first emerging beetles of the second generation. If beetles are present, spray the field with an insecticide (45-day preharvest interval or less). Based upon the density of the first generation, it is expected that the second generation will exceed the economic threshold.

Table 3. Degree-day accumulations in 2000 for first-generation bean leaf beetle adults (1212 degree days with developmental threshold of 46°F) from the date of soybean emergence through June 28.

Date of soybean emergence	Degree-day accumulations				
	Decorah (Northeast)	Burlington (Southeast)	Des Moines (Central)	Omaha (Southwest)	Spencer (Northwest)
May 1–7	1039	1221	1240	1308	1158
May 8–14	884	1075	1088	1158	1002
May 15–21	788	960	980	1044	911
May 22–28	708	850	859	918	823

Table 4. Predicted dates in 2000 for peak emergence of first-generation bean leaf beetle adults.

Date of soybean emergence	Degree-day accumulations in 2000				
	Decorah (Northeast)	Burlington (Southeast)	Des Moines (Central)	Omaha (Southwest)	Spencer (Northwest)
May 1–7	July 7	June 28	June 27	June 24	July 1
May 8–14	July 15	July 5	July 4	July 1	July 7
May 15–21	July 20	July 10	July 9	July 6	July 11
May 22–28	July 24	July 15	July 14	July 11	July 15

Fields can be sampled for first-generation beetles by using either a drop cloth or a sweep net. Procedures for sampling are as follows:

Drop Cloth

- Walk 100 feet in from the field edge and scout each field and each variety separately.
- Place a 3-foot-wide strip of cloth on the ground between the rows.
- Bend the plants of one row over the cloth and shake them vigorously.
- Count the number of beetles on the cloth.
- Repeat the procedure four times for each 20 acres of the field.
- Determine the average number of beetles per 3 feet of row.
- Consult Table 6 for the number of beetles per 3 feet of row necessary to justify insecticide treatment for the second-generation adults in August.
- If the number of beetles is below the economic threshold, sample the fields again the following week, or a third week if necessary.

Sweep Net

- Walk 100 feet in from the field edge and scout each field and each variety separately.
- Sample the beetles for 20 sweeps by sweeping **down** the row, not across the row.
- Repeat the procedure four times for each 20 acres of the field.
- Determine the average number of beetles per 20 sweeps.
- Table 5 shows the number of first-generation beetles per 20 sweeps that justifies insecticide treatment for the second-generation beetles.

If the number of beetles is below the economic threshold, sample the fields again on following week, or a third week if necessary.

Table 5. First-generation bean leaf beetle populations necessary to predict economically damaging second-generation bean leaf beetles.[1]

Crop value ($/bushel)	Treatment cost per acre (insecticide + application)								
	$7	$8	$9	$10	$11	$12	$13	$14	$15
	Beetles per 3 feet of row								
$5.00	5.6	6.4	7.2	7.9	8.7	9.5	10.3	11.0	11.8
	Beetles per 20 sweeps								
$5.00	23.0	26.2	29.4	32.6	35.8	39.0	42.2	45.4	48.6

[1]Economic thresholds are based on a row spacing of 30 inches and a plant population of eight plants per foot of row. For narrow-row soybeans (8-inch rows) and a plant population of three plants per foot of row, multiply the above-mentioned economic thresholds by 0.7.

Management with Insecticides

A variety of insecticides are labeled for management of bean leaf beetles. Insect control is always a prime consideration when selecting a product to use, but another consideration in choosing an insecticide is the length of the preharvest interval. Commonly available insecticides and their preharvest intervals are Ambush 2EC (60 days); Asana XL (21 days); Lorsban 4E (28 days); Penncap-M (20 days); Pounce 3.2EC (60 days); Sevin XLR Plus (Rhone-Poulenc label states "5 days," whereas the Aventis label states "within 21 days of harvest of dried beans or peas, seed, or hay"); and Warrior T (45 days). A 60-day preharvest interval may exclude some chemicals from being used, especially for late-season insect management.

There is little published information on the performance of insecticides labeled for control of bean leaf beetles on soybean. An exception is the work of Ron Hammond (1996), an entomologist at The Ohio State University. Hammond evaluated Sevin (carbaryl) and the new pyrethroid Warrior (lambda-cyhalothrin) during 1994 and 1995, to test the long-term efficacy against second-generation bean leaf beetles. Hammond stated "pyrethroids are excellent insecticides because of their low active ingredient rates, excellent efficacy against a wide range of insects, and long residual activity. The efficacy of pyrethroids is often extended beyond that of other insecticides because of their ability to repel insects."

Hammond found that even though bean leaf beetle populations were low during the experiments, there was a significant difference in the performance of the Sevin and Warrior treatments (Tables 6 and 7). In 1994, Warrior kept the beetles out of the plots for up to 4 weeks. Similar results were found in 1995 with both rates of Warrior providing better control than the Sevin treatment.

Table 6. Post-treatment counts of second-generation bean leaf beetles in soybean treated with insecticides, Ohio, 1994.[1]

Treatment	Rate/acre	Bean leaf beetles/20 sweeps (mean ± S.E.)[2,3] Week 1	Week 2	Week 3	Week 4
Warrior T	2.96 oz.	0.7 ± 0.7	0.3 ± 0.3b	0.0 ± 0.0c	1.3 ± 0.7b
Sevin XLR	0.75 pint	2.0 ± 1.2	10.7 ± 3.8a	13.0 ± 2.1b	27.0 ± 8.3a
Check	—	1.3 ± 0.7	10.0 ± 0.6a	21.0 ± 3.5a	27.0 ± 4.5a

[1]From Hammond (1996).

[2]Week 1, 2, 3, and 4 are August 23, 30, September 6, and 13, respectively.

[3]Numbers in the same column and followed by the same letter are not significantly different ($P > 0.05$, LSD).

Table 7. Post-treatment counts of second-generation bean leaf beetles in soybean treated with insecticides, Ohio, 1995.[1]

Treatment	Rate/acre	Bean leaf beetles/20 sweeps (mean ± S.E.)[2,3] Week 1	Week 2	Week 3	Week 4
Warrior T	1.92 oz.	0.0 ± 0.0	0.3 ± 0.3c	1.3 ± 0.3b	1.8 ± 0.8c
Warrior T	2.96 oz.	0.0 ± 0.0	0.5 ± 0.3c	0.5 ± 0.3b	1.3 ± 0.6c
Sevin XLR	0.75 pint	0.0 ± 0.0	3.4 ± 1.9b	10.5 ± 3.4a	10.8 ± 3.6b
Check	—	0.8 ± 0.5	7.5 ± 0.9a	17.5 ± 6.3a	23.2 ± 5.5a

[1]From Hammond (1996).

[2]Week 1, 2, 3, and 4 are August 23, 30, September 6, and 14, respectively.

[3]Numbers in the same column and followed by the same letter are not significantly different ($P > 0.05$, LSD).

Hammond suggested that it was unlikely that sufficient residues of Warrior capable of causing mortality persisted on the plants for the 4 weeks of the experiment, but that repellency was most likely the cause of lower insect densities near the end of the experiment.

In summer 2000, Ken Pecinovsky, Nashua Research Farm, Iowa State University, expanded on the work of Hammond. Soybean was planted on May 10 in 30-inch rows. On August 10, a large population of bean leaf beetles was found in R5 (beginning seed)-stage soybean; the beetle population averaged 132.8 beetles per 20 sweeps. Five treatments were established in the field: 1) Warrior T (3.2 oz/acre), 2) Lorsban 4E (2 pints/acre), 3) Sevin XLR (2 pints/acre), 4) Furadan 4F (0.5 pint/acre), and 5) an untreated check. All insecticide treatments were applied in 20 gallons of water per acre broadcast over the row. Plots were eight rows in width and 60 feet in length. Treatments were applied on August 10 and each was replicated four times in a randomized complete block design. Twenty sweeps were taken in each plot on August 16, 24, 31, and September 7 (approximately 1, 2, 3, and 4 weeks, respectively) after application. Beetles were counted at the end of each 20-sweep sample and released back into the plot from which they were collected. Soybean was machine harvested on September 30.

One week after application, the bean leaf beetle density was reduced significantly in all insecticide treatments with Warrior and Lorsban providing the best level of control (Table 8). Two weeks after application, bean leaf beetle densities increased in all plots but were substantially smaller in the Warrior and Lorsban treatments compared with Sevin and Furadan. Three and 4 weeks after the initial insecticide application, there was a natural decline in the insect population, but the Warrior and Lorsban treatments continued to suppress the beetle population to levels significantly lower than the other insecticides. The 4-week control of Warrior was similar to the findings of Hammond. The performance of Lorsban in our study was nearly identical to that of Warrior. In spite of the performance of the insecticides in reducing insect densities, a significant yield benefit was detected only in the Warrior treatment.

Table 8. Insect densities and soybean yields from insecticide plots treated for second-generation bean leaf beetles, Iowa, 2000.

		Bean leaf beetles/20 sweeps (mean ± S.E.)[1,2]				Bushels
Treatment	Rate/acre	Week 1	Week 2	Week 3	Week 4	per acre
Warrior T	3.2 oz.	0.5 ± 0.3c	24.5 ± 4.8d	40.5 ± 5.5b	3.3 ± 0.3b	61.8 ± 0.7a
Lorsban 4E	2 pints	5.3 ± 2.0c	45.3 ± 2.7d	22.8 ± 3.6c	11.5 ± 1.3b	58.3 ± 0.7b
Sevin XLR	2 pints	9.3 ± 2.5bc	127.3 ± 6.6c	63.5 ± 5.4a	40.0 ± 3.9a	59.4 ± 1.2b
Furadan 4F	0.5 pint	30.5 ± 3.6b	168.8 ± 13.1b	59.8 ± 10.1a	40.8 ± 10.0a	59.1 ± 0.8b
Check	—	94.8 ± 14.3a	206.3 ± 14.7a	61.3 ± 3.2a	44.5 ± 6.8a	58.8 ± 0.9b

[1]Week 1, 2, 3, and 4 are August 16, 24, 30, and September 7, respectively.
[2]Numbers in the same column and followed by the same letter are not significantly different ($P > 0.05$, LSD).

Bean Leaf Beetle and Virus Transmission

In 1999 many soybean producers from Iowa reported problems with soybean green stem, and mottled or discolored soybean seed. Many of these reports of poor soybean quality were suspected as caused by the spread of a soybean disease, bean pod mottle virus. This virus has been a problem in the southern United States since the 1950s. Bean pod mottle virus was identified in Iowa as early as 1968 (Quiniones and Dunleavy 1971) but it hadn't been widespread or implicated in causing significant yield losses. Bean pod mottle virus was confirmed in soybean during 1999 in several central and western Iowa counties (Dallas, Ida, Marshall, Polk, Story, and Woodbury). Unconfirmed reports suggest that it may be present in all but the northern two tiers of Iowa counties.

Bean pod mottle virus is a disease that can infect soybean and other legume species. Potential problems with bean pod mottle virus are twofold: reductions in soybean quality and yield. Symptoms of bean pod mottle virus can resemble injury from herbicide drift, or symptoms of soybean mosaic virus. Symptoms also may vary depending on the soybean variety and growing conditions. Infected soybean plants may have mottled or crinkled leaves and plants may be stunted. At maturity, infected plants are associated with mottled soybean seeds. The effect of bean pod mottle virus on soybean yield also may be variable, but losses of more than 50% were noted in some studies (Hopkins and Mueller 1984). Bean pod mottle virus also can occur in combination with soybean mosaic virus, resulting in even greater yield reductions. Seed transmission of bean pod mottle virus has been documented, but so far the percentage reported was less than 1%.

The main pathway for bean pod mottle virus entry into soybean plants is through insect feeding. The main known vector for this virus is the bean leaf beetle. When beetles feed on soybean leaves they produce a small amount of regurgitated plant material. If this regurgitant comes from a previous plant that was infected with virus, it can infect a healthy plant on which the beetle is feeding. Other vectors for this virus have been reported, including blister beetles and southern corn rootworm beetles; however, the bean leaf beetle is considered the most important vector in Iowa because of its abundance and statewide distribution.

There is some controversy over whether the virus overwinters in bean leaf beetle adults. One study found that the virus could overwinter in adult beetles that would create a mode for early infection of soybean. Beetles could obtain the virus from infected soybean plants in the fall and infect soybean as soon as they emerge from overwintering sites and enter soybean fields the next spring. However, other work has shown that bean pod mottle virus does not stay infective in adult beetles throughout the winter (S.A. Ghabrial, personal communication). It also is possible that adult beetles may obtain the virus by feeding on infected wild legumes in the early spring and then transmit the virus to soybean at plant emergence. Although we don't know exactly when beetles may be transmitting bean pod mottle virus, we do know that the earlier soybean is infected, the greater the potential reduction in yield (Hopkins and Mueller 1984).

The only way to determine whether a plant is infected with bean pod mottle virus is to test for virus presence. Soybean plants that have the above-mentioned symptoms would be good candidates for testing; however, disease symptoms are identical to soybean mosaic virus. Diseased plants should be sent to a reputable plant disease laboratory for confirmation.

If soybean is infected, the best way to manage the virus is to manage bean leaf beetle populations. If bean leaf beetle adults were abundant in your fields last year, you will likely have them again in 2001. Very cold winter temperatures reduce the population, but not necessarily below economically damaging levels. If bean pod mottle virus symptoms were observed in your fields, you may want to consider an early-season insecticide treatment when the adults first invade the field. This management strategy is being tested in Iowa for its ability to prevent viral infection of the crop and reductions in grain quality and quantity. The reason this strategy may be difficult to implement is that timing an insecticide application for early-season beetles is difficult because beetles leave overwintering sites and colonize soybean fields over several weeks. Because there is so much that we are still learning about the virus–beetle–soybean relationship, we cannot state confidently that an early insecticide treatment is the best management tactic. We will be evaluating this management strategy again in 2001.

Another option for managing early-season beetles is to plant soybean later in the season to deter colonization of fields by bean leaf beetles adults. Even delaying planting until mid-to-late May can reduce bean leaf beetle densities in a field and possibly reduce incidence of the disease in the crop.

There is still a tremendous amount to learn about bean pod mottle virus and its relationship with bean leaf beetles. A cooperative project between plant pathologists and entomologists at Iowa State University has begun exploring many of the basic questions about the disease and potential management strategies. The economic thresholds that we currently use do not consider the potential disease transmission role of adults and the impact of bean pod mottle virus, a glaring limitation in our understanding of these interacting and complex pest problems.

Additional information on bean leaf beetle management, including photographs of the insect and plant injury, can be found at **www.ipm.iastate.edu/ipm/icm/** Check this site for updates on bean leaf beetles during the growing season.

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