Biology and Management of Bean Leaf Beetle in Soybean

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Introduction

The bean leaf beetle, *Cerotoma trifurcata* (Forster), is a widespread pest of soybean in the major crop production areas of the U.S. It has been a significant problem in the South but, until the last decade, was an infrequent problem in the Midwest. During earlier times, the major concern was early season invasion of soybean fields and localized problems of seedling defoliation. In the 1980's, however, grower reports of pod feeding were received, and these have increased significantly until the present. Indeed, today the bean leaf beetle has become the most consistently important insect problem on soybean in our region. The purpose of this presentation is to update specialists on the soybean and outline a basic integrated pest management (IPM) system for the species in Iowa. To accomplish this, we will discuss foundation elements of IPM, including identification and biology, sampling for adults and pod injury, and economic thresholds. We will conclude by describing both preventive and curative tactics that can be employed to reduce losses from this growing pest problem.

Identification and Biology

Bean leaf beetle (BLB) adults are small, measuring about 5 mm long and are variable in color. The most common wing cover coloration is light yellow, with 4 black spots and marginal stripes. Alternate colorations include crimson wing covers with spots present and light yellow wing covers without spots and stripes. A black triangle is always present behind the head. BLB eggs are orange and spindle shaped, but larvae are white and cylindrical, with a black head and anal shield. Pupae are white.

The BLB life cycle begins in the spring as adults leave their overwintering habitats. These habitats include woodlots, clumps of grass, leaf litter (Kogan et al. 1980) and, possibly,
soybean fields of the previous season. In Iowa, overwintered adults become active in mid to late April, moving into alfalfa fields and other suitable habitats. Once in the alfalfa, beetles feed and lay some eggs. Upon soybean emergence and first cutting of alfalfa, there is mass emigration from the alfalfa into the soybean, with very few beetles being found in alfalfa during most of the summer. When females enter the soybean, they have mated, and most have a full complement of eggs. Each female lays between 130 and 200 eggs in the upper 3.8 cm (1.5 in.) of soil near plant stems. Eggs hatch in about 5 to 7 days, and larvae feed on roots and nodules as the plants mature. During growth, the larvae molt 3 times and reach the pupal stage in about 15 to 30 days, depending on soil temperatures. Mature larvae build an earthen cell in which they pupate. The pupal stage requires about 7 days at 26.2 degrees C for adult emergence.

In Iowa, the BLB seasonal cycle comprises two generations (Smelser and Pedigo 1991a). Overwintered adults lay eggs in soybean from May until late June. First generation larvae develop in the soil. Beginning in July, adults emerge, mate, and lay eggs for a second generation. Second-generation larvae that develop from these eggs potentially have the greatest impact on soybean nodules. Second-generation adults begin emerging in early to mid August, depending on summer temperatures, and peak from late August to mid September. Unusually warm weather, as occurred in 1988, can produce a second-generation peak as early as the first week of August. Second-generation adults do not mate, and there is no development of the female ovaries. Nevertheless, adults feed on leaves and pods. As soybeans mature, tissue becomes less palatable, and adults feed on any remaining green tissue, including stems and late-maturing pods. As food availability in soybean diminishes, the beetles move back into alfalfa, if accessible. Here, they maintain themselves from late September to mid October, when they move to overwintering habitats and assume a dormant state for winter.

In addition to alfalfa and soybean, BLB will feed on other legume hosts, such as cowpea, species and varieties of Phaseolus, and red clover. Additionally, BLB has been observed feeding on nonleguminous hosts such as stinging nettle, wood nettle, and Euonymous when preferred hosts are unavailable (Helm et al. 1983).

**Nature of Injury to Soybean**

Both BLB larvae and adults possess chewing mouthparts, and they injure soybean by consuming tissue. Plant parts eaten by larvae include roots, root hairs, and nodules, with a preference for nodules. Nodule feeding is of particular interest because of the importance of nitrogen fixation to soybean yield. Although BLB reduces the number and size of nodules and, consequently,
nitrogen fixation, actual effect on yield has not been demonstrated (Newsom et al. 1978, Layton 1983). Currently, research on nodule feeding is an active field.

By far, the most obvious form of BLB injury to soybean is defoliation by adults. Defoliation is recognizable as small round holes between major leaflet veins. This injury differs markedly from the larger asymmetrical holes or jagged leaflet margins from caterpillar or grasshopper feeding. In feeding studies, Smelser and Pedigo (1991b) found that leaf consumption was 6.58 cm² per beetle. Most grower concern over defoliation arises early in the season when plants are in stages V1 to V2. During that time relatively great defoliation (more than 50%) may occur in field border rows. Because of soybean tolerance and/or compensation at this early stage, however, management activities are seldom needed. Indeed, in Ohio Hammond (1989) found no significant effect of leaf removal during stage V1 (unifoliolate stage) on yield, even with 100% defoliation. Although defoliation has its greatest impact during soybean reproductive stages (Pedigo et al. 1981), beetle numbers relative to leaf area are low, making leaf feeding of little concern except as it contributes to other insect defoliation.

Based on current knowledge, pod feeding by adults is the most important type of BLB injury to soybean. Pod injury occurs as leaves mature and beetles turn to feeding on younger tissues of the pod. They feed only on the pod surface, consuming tissue down to the endocarp, which directly encloses the seed. Often, the resulting pod lesion is similar in shape and size to a leaf-feeding hole and remains visible at harvest maturity. BLB pod lesions increase seed vulnerability to excess moisture and secondary pathogens, particularly *Alternaria tenuissima* (Fries) Wiltsh. Seeds beneath the lesion become shrunken, discolored, and sometime moldy (Shortt et al. 1982). The result is loss of grain weight and quality. In many instances, beetles have also been observed feeding on the pod peduncle and surrounding tissue, which can cause breakage and complete pod loss. This phenomenon, called pod clipping, can cause significant yield losses (Smelser and Pedigo 1991b).

Less obvious types of soybean injury from the BLB are stem feeding and vectoring of plant pathogens. Like peduncle feeding, stem feeding usually occurs as leaves mature. The impact of lesions from stem feeding is unknown but is believed minor. Vectoring of plant pathogens has been noteworthy but mainly in the southern U.S. Here, beetles are known to transmit bean pod mottle virus, cowpea mosaic virus, and southern bean mosaic virus (Walters 1969).

The impact of BLB injury to soybean yield and quality was quantified recently in Iowa (Smelser and Pedigo 1991c). From 1986 through 1988, soybean in field cages were infested with
field-collected adults at rates up to 18 beetles/plant. Regressing yield against beetle number showed a 3.06 kg/ha yield loss/beetle/m² (about 0.6 lb/a. loss/beetle/ft. row). Considering a plant stand of 25 plants/m row (about 8 plants/ft row) and 0.76 cm row spacing (30 in.), a 101 kg/ha (92.4 lb/a.) seed-yield decrease would be expected with a beetle on every plant. Additionally, damaged seed weight, as determined with data from official grain-grade reports, was regressed against the number of BLB-injured pods at harvest. Based on this analysis, over 40 percent of the pods would need to be injured to cause a price discount at market. In comparing losses of seed weight with those of seed quality, an economically important loss in seed weight would occur at a much lower BLB density than such a loss in seed quality. Therefore, BLB management decisions, first and foremost, should be made on the basis of potential yield loss. Later, we will discuss how to make management decisions based on the economics of loss.

**Sampling for Adults and Pod Injury**

Sampling for BLB adults and/or their injury to pods is the key to good management. From samples taken, estimates of population density and injury can be made, followed by projections of injury potentials and appropriate actions.

Adult sampling can be divided into early season and late season activities. Early season sampling allows estimates of the colonizing generation and provides forewarnings about potential problems with pod injury later in the season. Late-season sampling gives confirmation of early season predictions about the BLB second generation and provides information for management decision making.

Generally, only one sampling technique is available for sampling in early season, viz., direct observation. Other techniques, such as sweep net sampling, are not practical at this time because of small plant size. Direct observation simply involves looking for beetles on the plants. By close inspection and turning over leaves, these can be observed and counted. Because beetles drop from the plants when disturbed, care must be taken to also look for them on the soil surface. For estimates from direct observation, the following program is suggested: (1) take samples at least weekly between plant stages V₁ and V₃ (unifoliolates to 2 trifoliolates), (2) sample between 11:00 a.m. and 3:00 p.m. when beetles are most abundant in the plant canopy, (3) each sample should consist of beetle counts along a 10-m (about 30 ft) section of soybean row, (4) take at least 5 samples in an average sized (40 a.) field, (5) compute an average. It is also wise to check field borders and note high concentrations of beetles as they enter the field from overwintering habitats.
The best late-season sampling programs for adults involve sweep-net or ground-cloth techniques. The sweep-net technique utilizes a 38-cm-dia (15-in.-dia) sweep net. Each sample consists of 20 sweeps taken along the row and up against the foliage. Beetles in the net are counted after each sample. Take at least 5 samples per average (40 a.) field. Ground-cloth samples are usually taken with a heavy muslin or canvas cloth, 1 m x 80 cm (about 36 in. x 30 in.). To sample, the cloth is laid between two adjacent rows, and plants on both sides are bent over the cloth and shaken for about 10 sec. Dislodged beetles that fall onto the cloth are counted to provide a 120 cm (about 4 ft) of row sample. Take at least 8 such samples for an average. The following sampling program may be used with these techniques: (1) take samples at least weekly from late July or when plants reach stage R4, until a decision is made or until pods yellow, (2) sample only when foliage is dry, (3) compute average number of adults per sweep (sweep net) or per foot of row (drop cloth).

Although both techniques are used widely, each has advantages over the other. The sweep net technique covers more habitat area and requires the least time for obtaining estimates. However, there may be more variability with this technique, and numbers must be converted when absolute estimates (beetles per unit of row) are desired. Also, sweep nets must be purchased initially, and replacement bags are needed at least once each season. Conversely, the ground cloth technique yields absolute estimates, and ground cloths are easily fabricated. They can be washed to retain a light-colored background. The greatest drawbacks with this technique are the time required to obtain samples and the relatively small row area sampled. Problems arise with both procedures when plants become badly lodged and vine together. If this occurs, the sweep-net technique is more practical than the ground-cloth method. Yet another approach to late-season BLB assessment is to estimate injury, rather than the insect population itself. Pod injury is determined through direct observation and is used to estimate damage potential of a pest population. Pod samples are taken beginning at stage R5 (beginning seed) and continued at least weekly until late R7 (beginning maturity). A pod sample consists of counting the total number of injured pods on 5 consecutive plants in a row. Five such 5-plant samples are taken in a field and a 5-plant average computed. The advantages of this technique are that no special equipment is required, good estimates can be made even when plants are lodged, and actual pod injury is estimated. The disadvantages are that the method is time consuming, and pod injury may exceed economic limits before action can be taken.

Because of both advantages and disadvantages for any BLB sampling technique, the particular program chosen is dictated by the circumstances. As a rule, managers and consultants seek the program that provides the most accurate assessment information.
for the least cost. Guidelines have been developed with each sampling method for making management decisions.

**Economic Thresholds**

Some of the most basic elements in managing BLB adults are economic thresholds. An economic threshold (ET) is the level of insect density or injury when management action is recommended. Actually, it is a time to take action, based on the current status of a pest population and its future injurious potential. Economic thresholds are based on another concept, the economic injury level (EIL). An EIL is the number of insects required to cause an economic loss equal to the cost of managing the pest, in other words, it is the economic "break-even" point. The ET is usually fixed at a point lower than the EIL to prevent increasing injury from reaching the EIL. Although many EILs and their accompanying ETs are based on firm quantitative information, some are not. Rather, some are based on the experiences of growers and specialists and are quite subjective. So it is in soybean insect management, and both objective ETs and subjective ETs, which require development, are given in recommendations. ETs for adult BLB on soybean have been recommended since at least 1976 (Kogan 1976a). The first ETs were developed for early season invasion by overwintered beetles, representing the apparent damage from defoliation. Objective ETs have recently been developed (Smelser and Pedigo 1991d) for BLB pod injury.

Early season ETs (seedling stage) for BLB have been given as 0.5 beetles/plant (Kogan 1976a) and 20 beetles/m row, accompanied by 20% defoliation (Kogan 1976b). The latter recommendation considers that some injury has already occurred and that feeding beetles are present. In the past, insecticide application has been recommended if the BLB density is at or above these levels. Although growers may choose to implement one of these decision rules, recent evidence suggests that no action should be taken against the early season population. As mentioned, even complete removal of leaves during stage V1 cannot be shown to cause a significant loss in soybean yield. Thus, insecticide applications may not be profitable. An exception would be if early season-treatment could be applied to avoid late season losses. Although this approach is not beyond possibility, evidence does not exist presently to justify early season treatment for late-season suppression.

Currently, late-season ETs, based on regular sampling in late July and August, offer the best pest management approach to reducing losses from BLB pod feeding. Until recently, late-season ETs were set at 8% of the total pods injured (3 to 5 injured pods/plant). These levels were wholly subjective, being based on best guesses of specialists. After careful experimentation with caged beetles during three growing seasons, these existing recommendations were found too conservative. New,
objective levels, calculated from values of damage per beetle, cost of insecticide treatment, and market value of soybeans are presented in the accompanying tables. Each table is based on market values of soybean ($/bu) and management costs ($/a.). It can be noted in the tables that as market values increase, ETs decrease, and as management costs increase, so do the ETs. A table can be used by obtaining sampling information with the desired technique and comparing this estimate with ETs for a given soybean value and management cost. A range of ETs is given under each value/price comparison that reflects 67 percent and 80 percent of the EIL. Risk averse growers would tend to select the lower criterion for taking action. If field estimates reach or exceed these critical values, insecticide sprays are warranted.

Management Strategies

IPM is a comprehensive approach to pest control that employs multiple tactics. In practice, IPM can be divided into preventive strategies and therapeutic strategies. Preventive strategies aim to lower the carrying capacity of an agricultural environment for pests or to increase tolerance of crops to pest injury. For example, crop rotation may make the environment less inviting to the pest, or fertilizer applications may make crops less damage prone. Usually, tactics used with preventive strategies are employed as a matter of course, often without knowledge of pest status for the season. Some examples of preventive tactics are host resistance, most biological controls, crop rotations, changes in planting date, sanitation, and other cultural manipulations. In contrast to prevention, therapy is applied if preventive tactics fail to keep injury below economically tolerable levels. Therapeutics are necessary when a "correction" to the system is needed. In other words, therapy aims to dampen population peaks, rather than lower environmental carrying capacity. To employ a therapeutic strategy, sampling is conducted, population trends and future injury potentials are predicted, economic thresholds are consulted, and, if necessary, action is taken against the pest. The most significant therapeutic tactics involve the use of conventional pesticides.

To manage BLB adults, both prevention and therapeutics should be considered in the overall strategy. Current preventive practice involves possible modification in planting date, and therapeutic practice includes population evaluation and use of insecticides. The idea of modifying planting date to reduce insect pest problems is certainly not a new one. A well known example is the use of "fly-free" planting dates to allow winter wheat an escape from Hessian fly infestations (Pedigo 1989). Examples of altering planting dates to reduce insect problems in soybean include those for the stink bug and corn earworm in the southern U.S. In an attempt reduce insecticide use, our research group began investigations on the potential of planting-date modification for managing BLB. Here, we reasoned that altering
planting date might reduce either absolute pest numbers or damage per pest. As mentioned, female beetles begin searching for feeding and egg-laying habitats in late April or early May. By delaying planting until late May, we hypothesized that female beetles might be forced to lay a portion of their egg in non-crop areas, lay fewer total eggs, or both. Preliminary studies from 1989-90 used 'Corsoy 79' soybean planted during the early (10 May 1989, 3 May 1990) and the late (30 May both years) portions of the currently recommended planting period. Analysis of data from these studies has shown that beetles were significantly more abundant in the early planted plots, accompanied by a 73 percent (1989) and 50 percent reduction (1990) of injured pods in late-planted plots. These results suggest that late planting can substantially reduce BLB adult injury, and thus require less frequent insecticide applications, relative to early planting. Studies on this phenomenon are being continued to determine variability in results and define the mechanism involved.

The detail of therapeutic practice for BLB adults has already been discussed in the foregoing. Even if late planting is implemented, soybean should still be sampled weekly, beginning in late July, to detect the development of significant problems. Subsequently, ET tables can be consulted to define the need for insecticide treatment, and recommendations of the Iowa State Cooperative Extension Service (Holscher et al. 1990) may be followed. In selecting a treatment, compounds with greatest personal and environmental safety should be considered and lowest effective rates used.

References


1991b. Bean leaf beetle, Cerotoma trifurcata (Forster), herbivory on leaf, stem, and pod components of soybean. J. Econ. Entomol. (in press)

1991c. Soybean seed yield and quality reduction by bean leaf beetle, Cerotoma trifurcata (Forster), pod injury. J. Econ. Entomol. (in press)

1991d. Economic injury levels, population dispersion, and sequential count plans for bean leaf beetle, Cerotoma trifurcata (Forster) on soybeans during late season. J. Econ. Entomol. (in press)

## Bean Leaf Beetle Economic Thresholds for Soybeans

**Bean leaf beetle injured pods/5 plant sample**

<table>
<thead>
<tr>
<th>Market value</th>
<th>Management Costs $/acre</th>
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<tbody>
<tr>
<td>$/bu</td>
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<tr>
<td>5.00</td>
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</tr>
<tr>
<td>6.00</td>
<td>25.4 - 30.3</td>
</tr>
<tr>
<td>7.00</td>
<td>21.6 - 25.8</td>
</tr>
<tr>
<td>8.00</td>
<td>19.5 - 23.3</td>
</tr>
<tr>
<td>9.00</td>
<td>17.2 - 20.5</td>
</tr>
<tr>
<td>10.00</td>
<td>15.0 - 17.9</td>
</tr>
</tbody>
</table>

* ET range is set at 67 and 80 percent of the economic-injury level.

### Based on a row spacing of 30 inches and approximately 8 plants per foot of row.

## Bean leaf beetles per sweep

<table>
<thead>
<tr>
<th>Market value</th>
<th>Management Costs $/acre</th>
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<tbody>
<tr>
<td>$/bu</td>
<td>$ 7.00</td>
</tr>
<tr>
<td>5.00</td>
<td>2.9 - 3.5</td>
</tr>
<tr>
<td>6.00</td>
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</tr>
<tr>
<td>10.00</td>
<td>1.5 - 1.7</td>
</tr>
</tbody>
</table>

ET range is set at 67 and 80 percent of the economic-injury level.

## Bean leaf beetles per foot of row

<table>
<thead>
<tr>
<th>Market value</th>
<th>Management Costs $/acre</th>
</tr>
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<tbody>
<tr>
<td>$/bu</td>
<td>$ 7.00</td>
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<tr>
<td>5.00</td>
<td>4.6 - 5.5</td>
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<td>10.00</td>
<td>2.3 - 2.8</td>
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</table>

* ET range is set at 67 and 80 percent of the economic-injury level.

* Based on a row spacing of 30 inches.