Bean Leaf Beetle (Coleoptera: Chrysomelidae) and Bean Pod Mottle Virus in Soybean: Biology, Ecology, and Management

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Bean Leaf Beetle (Coleoptera: Chrysomelidae) and Bean Pod Mottle Virus in Soybean: Biology, ecology, and management

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ABSTRACT. Bean leaf beetle, Cerotoma trifurcata ( Förster ), is a pest of soybean found in many production areas in the United States. The bean leaf beetle larvae feed on soybean root nodules, whereas the adults feed on the above ground parts of soybean such as cotyledon, leaves, and pods. Bean leaf beetle is also a very efficient vector of Bean pod mottle virus, a widespread virus of soybean in the south and southeastern United States with recent expansion into the north central region of the country. This article summarizes bean leaf beetle biology, ecology, and its impact on soybean production in the United States. The management of this insect and Bean pod mottle virus as recommended in the north central states is also presented.

Key Words: bean leaf beetle, Cerotoma trifurcata, bean pod mottle virus, soybean

The bean leaf beetle, Cerotoma trifurcata ( Förster ), is a pest of soybeans, Glycines max ( L. ) in most soybean growing regions of the United States. Adults feed on cotyledons, leaves, and pods, whereas larvae feed on soybean nodules attached to the roots. Furthermore, bean leaf beetles also transmit Bean pod mottle virus, a widespread virus of soybean. Bean leaf beetles can be found in major soybean production areas in the United States (Turnipseed and Kogan 1976, Pedigo 1994). The biology of bean leaf beetle, both as a pest of soybean and a vector of Bean pod mottle virus will be discussed, followed by a section of management of bean leaf beetle and Bean pod mottle virus with emphasis on recommendations for the north central states.

Identification. The bean leaf beetle is a member of the family Chrysomelidae in the order Coleoptera. Adults are variable in color, ranging from red to orange to light yellow (Fig. 1). When adults first emerge from the soil, their elytra (wing covers) are soft and the body is often beige in color (Fig. 2). Four squarish black markings are common on the elytra; however, these markings can be as few as two or none. The elytra are usually rimmed by a black margin. A black triangle, termed the scutellum, is always present immediately behind the pronotum (Pedigo 1994) (Fig. 3) regardless of whether the insect has four, two, or no black “squares” on the elytra. Female beetles often have black frons (face), whereas the male beetles usually have tan frons (Kogan et al. 1980). In addition, the base of a male beetle’s first tarsal segment has a patch of dense setae (hairs) thought to be involved in the mating process (Hammack and French 2007). Female beetles lack this morphological feature.

Bean leaf beetle eggs are lemon-shaped and orange in color, and they are found in soil around the base of soybean plants (Pedigo 1994). The subterranean larva is elongate, white in color with dark brown plates on both ends of the body (Fig. 4). The dark brown color comes from sclerotization of the larva’s head and last abdominal segment. Larvae can grow to 0.4 inch (10 mm) long, are cylindrical in shape, and similar looking to corn rootworm (Diabrotica spp.) larvae. The pupae are white, ~0.2 inch (5 mm) long, and enclosed within earthen cells.

Host Plant. Bean leaf beetles have a large host range, mostly on leguminous plants including clover ( Trifolium spp.) and soybean (Bradshaw et al. 2007); however, they also have been reported to feed on nonleguminous hosts such as cucurbits (Koch et al. 2004), stinging nettle (Urtica dioica L.), and Canadian woodnettle [Laportea canadensis (L. )] (Helm et al. 1983).

Life Cycle and Seasonal History. Bean leaf beetles overwinter as adults and are able to withstand temperatures below the water freezing point. In a laboratory study, Lam and Pedigo (2000a) found that exposing winter-acclimated adult beetles for 12 minutes below 14°F (−10°C) resulted in 50% mortality, yet it took 400 hours at temperatures between 23° and 14°F (−5 and −10°C) to kill the same proportion of beetles. Carillo et al. (2005) reported that bean leaf beetles collected in different months in a year had varying degrees of cold hardiness. Most beetles collected between September to March were able to survive lower temperatures than beetles collected during the rest of the year. Bean leaf beetle adults survive winter under leaf debris in woodlots and crop residue in soybean fields. Survival rate of overwintering bean leaf beetles is higher in sheltered habitats (e.g., woodlands) compared with exposed habitats (e.g., soybean fields) (Lam and Pedigo 2000b). A measurement of daily temperature during winter in Iowa showed that woodland leaf litter can maintain temperatures above 23°F (−5°C), which contributes to higher survival rate of overwintering bean leaf beetles in this habitat (Lam and Pedigo 2000a). In the extreme southern United States, the beetles may not even hibernate at all (McConnel 1915).

Surviving adults begin to emerge from their overwintering sites at 50–55°F (10–12.7°C) (Boiteau et al. 1979a, Jeffords et al. 1983, Loughran and Ragsdale 1986). The beetles mate and disperse to various hosts such as alfalfa ( Medicago sativa L. ) and other legumes such as tick trefoil ( Desmodium spp. ) and clover (Smelser and Pedigo 1991, Bradshaw et al. 2007). Bean leaf beetle adults move to soybean, their apparent preferred host, as the soybean seedlings emerge (Figs. 5 and 6).

Female bean leaf beetles enter soybean fields gravid (i.e., mated and carrying eggs) and lay small clusters of eggs within 1.5 inches (3.8 cm) of the soil surface and within a 2-inch (5.1 cm) radius of the soybean plant (Waldbauer and Kogan 1975). Each female lays 130–200 eggs throughout its lifetime (Pedigo 1994). When given a choice, female beetles preferred to lay their eggs in an organic soil rather than in sandy clay loam or loamy sand (Marrone and Stinner 1983a). In addition, Marrone and Stinner (1983a) also found more eggs in wet or moist soils than in dry soils. Bean leaf beetle eggs take a week to hatch at 82.4°F (28°C). Both very wet and very dry soils are detrimental to the eggs. Coincidental with oviposition preference, egg survival was the greatest when kept in saturated organic soil as compared with loamy sand and sandy clay loam (Marrone and Stinner 1983b).
Bean leaf beetle larvae feed in the soil on soybean roots and root nodules (Pedigo 1994, Lundgren and Riedell 2008). Larvae develop through three stages before pupating in the soil. The larvae are capable of moving in the soil and under dry soil conditions can move up to 11.8 inches (30 cm) per hour in search of moisture (Marrone and Stinner 1983c). The type of soil in which the larvae forage for food affects the larval survivorship. Cuticle abrasion associated with the soil’s sand content is detrimental to larvae. Under moist soil conditions, larvae survived best in organic soil (0–4% mortality) compared with loamy sand (87–100% mortality) and sandy clay loam (0–20% mortality) (Marrone and Stinner 1983c).

Development from egg to adult requires 674–740 DD in °F (374–411 DD in °C), with the lower development threshold at 46°F (7.8°C) (Zeiss et al. 1996). Beetles emerging from the soil form the first generation of adults for a given year. Depending on the timing of emergence in relation to the stage of soybean development, adult beetles may mate again and deposit eggs or they may overwinter until the subsequent year. Bean leaf beetles produce three generations per year in the southern United States (Pedigo 1994), two generations in the central states of Illinois (Waldbauer and Kogan 1976), Iowa (Smelser and Pedigo 1991), and Nebraska (Danielson et al. 2000), and only one generation in Minnesota (Loughran and Ragsdale 1986).

Adults readily disperse by flight. In a laboratory study characterizing the beetle’s flight capacity, the majority of sampled beetles showed short distant flight of <167 feet (<51 m) in a 24-hour period. A little over 11% of the beetles showed medium range flight capacity >987 feet (>301 m) and one beetle flew 3 miles (4.9 km) in a 24-h period (Krell et al. 2003b).

In the field, bean leaf beetle populations are often highly aggregated along field edges (Kogan et al. 1974, Boiteau et al. 1979b, Smelser and Pedigo 1992a). It is not known whether the aggregated spatial pattern of bean leaf beetle in the field is maintained under very high population levels as observed in outbreak years.

**Plant Injury and Damage.** Bean leaf beetle larvae feed on soybean root nodules. Soybean compensates for larval feeding by producing additional nodules. However, high larval infestation (19 larvae per plant) may cause smaller root nodules and reduce leaf and pod...
The nitrogen content (Lundgren and Riedell 2008). The potential economic damage because of root feeding by larvae is not clearly understood.

Adults feed on the above ground parts of soybean such as cotyledons, leaves and pods (Figs. 7-9). Beetle feeding may commence at the leaflet edge or in the middle of the leaflet producing round holes in the tissues between leaf veins. The round holes produced by adult feeding are generally distinct from more jagged-edged feeding holes produced by grasshoppers and caterpillars (Smelser and Pedigo 1992b).

The impact of adult feeding is dependent on the plant’s growth stage. A single adult feeding on soybean during vegetative stages (V1-V3, \(\approx 14\) days) is estimated to consume up to 5.48 inches\(^2\) (13.93 cm\(^2\)) of foliage (Hunt et al. 1995). Hunt et al. (1994) found that a reduction of cotyledon and seedling tissue delays canopy development and reduces yield. Sequential removal of 68% soybean seedling tissues between V1-V3 stages resulted in a 12% yield reduction (Hunt et al. 1994). It has been noted that soybean plants tolerate defoliation either by delayed leaf senescence or compensatory leaf regrowth. This compensatory response can offset foliage loss because of bean leaf beetle feeding (Haile et al. 1998). Defoliation tolerance seems to depend on an optimum growth environment, thus in drought years this tolerance may be limited. Turnipseed (1972) removed soybean leaves manually between blooming and pod set (R1-R4) to show that yield loss occurs at high levels of defoliation (above 50%). Adults feeding on later stage soybean plants may contribute additively to the overall impact of defoliation when they occur with other leaf feeding insects. It has been estimated that, on average, an adult beetle feeding on R6 soybean for two weeks may reduce as much as 0.0074 ounce (0.21 g) of seed weight (Smelser and Pedigo 1992c).

During seed filling, bean leaf beetles may feed on the pod surface. Although root-feeding larvae and leaf-feeding adults may affect seed yield and quality, pod feeding inflicts direct injury on the seeds. The feeding injury on the pod surface acts as an entry point for bacterial and fungal secondary infection, and the scarring of soybean pods exposes the seeds to excess moisture. The seeds on scarred pod may become shrunken, discolored, and moldy. Bean leaf beetles also feed on the soybean pod peduncle, sometimes clipping the pod in the process. Smelser and Pedigo (1992c) found no significant difference in seed weight, and number of seeds per plant between several levels of bean leaf beetle infestation. However, in a drought year of 1988, Smelser and Pedigo (1992b) documented that an average of 0.125 pod per beetle was lost each day because of beetle feeding on pod peduncles.

**Bean leaf beetle as Bean pod mottle virus vector.** Bean pod mottle virus is a member of the genus Comovirus in the family Secoviridae (Sanfacon et al. 2009). The first incidence of Bean pod mottle virus in
the United States was reported on common bean (*Phaseolus vulgaris* L.) in South Carolina (Zaumeyer and Thomas 1948) and the first reported incidence on soybean was from Arkansas (Walters 1958). The incidence of Bean pod mottle virus is widespread in major soybean growing regions in the south and southeastern United States; more recently increased incidence has been documented in soybean throughout the north central United States (Giesler et al. 2002).

Depending on the soybean variety and the virus strain, infected soybean may show symptoms ranging from chlorotic mottling, severe mosaic to leaf distortion (Fig. 10) and leaf necrosis. The most obvious symptoms occur in plants infected early in the season or during periods of rapid growth. Symptoms are more clearly shown in low ambient temperatures (Gergerich 1999). Bean pod mottle virus infection has been associated with a disorder known as “green stem”. The stems of plants showing green stem disorder stay green (Fig. 11) even as they bear normal mature pods. This condition may have an impact on soybean harvest as the green stems are more difficult for harvesting machinery to cut. Contradictory results have been reported on the relationship between Bean pod mottle virus infection and green stem disorder (e.g., Goh et al. 2004, Hobbs et al. 2006), and the precise cause of the green stem disorder remains unclear.

Soybean infected by Bean pod mottle virus produces 3–52% less yield depending on the soybean variety and the time of infection. Virus infection occurring in early vegetative stages (VC-V3) causes the highest yield reduction (Ziems et al. 2007). The seeds produced by Bean pod mottle virus-infected soybean may show mottled seed coats (Fig. 12), reducing the quality of the seed (Hobbs et al. 2003, Hill et al. 2007). Bean pod mottle virus infection on soybean also increases the risk of Phomopsis seed infection (Abney and Ploper 1994). Co-infection of Bean pod mottle virus and Soybean mosaic virus leads to synergistic infection where Soybean mosaic virus presence increases the titer of Bean pod mottle virus (Anjos et al. 1992), which translates into dramatic reduction of yield (Ross 1968) and root nodules (Tu et al. 1970) of co-infected soybean plants.

Bean pod mottle virus is transmitted by several leaf feeding beetles in North America, including bean leaf beetle, grape colaspis [*Colaspis brunnea* (F.)], banded cucumber beetle (*Diabrotica balteata* Le Conte), spotted cucumber beetle (*Diabrotica undecimpunctata howardi* Barber), striped blister beetle [*Epicauda vittata* (F.)], and Mexican bean beetle (*Eiplachna varivestis* Mulsant) (Gergerich 1999). Bean leaf beetle is an extremely efficient Bean pod mottle virus vector; up to 80% of beetles feeding on Bean pod mottle virus-infected soybean for three days were able to transmit the virus to healthy plants (Giesler et al. 2002). In addition, bean leaf beetle transmits Cowpea mosaic virus and Southern bean mosaic virus (Boethel 2004). Of all the soybean viruses transmitted by bean leaf beetle, Bean pod mottle virus is considered to be the most prevalent and widespread in the U.S. soybean producing regions (Tolin and Lacy 2004).

Theoretically, there are at least three sources of primary Bean pod mottle virus inoculum in summer soybean introduction: soybean seeds infected with the virus, virus from previous year’s epidemic retained in overwintering bean leaf beetles, and virus-infected leguminous weeds. Seed infection of Bean pod mottle virus occurs at a very low rate and seed coat mottling is not a good indicator of seed infection as mottling may still occur without virus presence within the seed (Krell et al. 2003a). Overwintering bean leaf beetles have been shown to retain Bean pod mottle virus from the previous year albeit in a very low frequency (Krell et al. 2003a). Bean pod mottle virus infects a range of mostly leguminous hosts including soybean and dry bean. Tick trefoil, a perennial leguminous weed, was found to host Bean pod mottle virus in nature (Krell et al. 2003a, Bradshaw et al. 2007). Beetles emerging from overwintering habitats and feeding on infected perennial tick trefoil may acquire the virus. When soybean seedlings emerge, the beetles move to these plants, transmitting the virus. The subsequent generation(s) of bean leaf beetle may continue to spread the virus within and between soybean fields during the growing season.

Management Approaches. The first part of this section describes management approaches of bean leaf beetle in the absence of Bean pod mottle virus. If a particular field’s history included incidences of Bean pod mottle virus and virus-related loss of yield quantity and quality, a different management approach is recommended. Bean leaf beetle management in the presence of Bean pod mottle virus history is discussed under the heading “Management of Bean Leaf Beetle in the Presence of Bean Pod Mottle Virus.”
Scouting and Threshold. Scouting for bean leaf beetle can be done by direct observation, sweep net, or ground cloth. The description of scouting techniques described here is drawn largely from Kogan et al. (1980). Some thresholds are based on the field estimation of percent defoliation or pods injured from beetle feeding activity while other thresholds are directly based on the sampling of bean leaf beetle population in the field.

Direct observation may accurately estimate early-season (VC–V4 stage) bean leaf beetle populations. This observation estimates the abundance of overwintering beetles from the previous year. Randomly select five 16–32 feet (5–10 m) row-lengths from across the entire field. At each sampling site, walk slowly and carefully count all beetles. Make sure that beetles on the underside of the leaves are counted by gently turning the leaves over. Cool early-morning hours are probably the best time to conduct the observation as the beetles are relatively inactive. At the end of sampling, the average number of beetles per row-foot or, given a fixed inter-row spacing, the number of beetles per plant can be calculated.

In conventional soybean cropping system (the rows are ~30 inches [76 cm] apart), the ground cloth technique is reliable in moderate to high beetle population levels (defined as the number of beetles per row-3 feet [1 m] >10) while the sweep net is reliable at all population levels. Both techniques are used when the soybean plants are too large for direct observation. These techniques are essential in estimating the first and subsequent generations of bean leaf beetles in soybean fields. Deighan et al. (1985) noted that ground cloth sampling produced better estimates of bean leaf beetle population in conventional cropping system than in drill-planted soybean.

Five to eight sampling sites should be chosen randomly across the field for sweep net scouting. On each site, walk between two rows and swing a sweep net upward and downward on a row (not across rows) with successive steps (Video Clip 1: Sweep net sampling technique on soybean [video-Marlin E. Rice]). Count each stroke of the net as a sweep and 10–20 sweeps per sampling site should be conducted. Bean leaf beetles are counted after each sampling unit. At the end of sampling, the average count of bean leaf beetles per sample site can be calculated.

An example of equipment used for ground cloth sampling consists of a white cloth measuring 36 by 42 inches (0.91 by 1 m) with strips of wood, ~one-half by 1 inch (1.27 by 2.54 cm) wide, stapled to each long side of the cloth. Sample at least five randomly chosen sampling sites across the field. In each site, roll the cloth beneath the canopy from one row over to the next row without disturbing the foliage (Fig. 13). Vigorously shake the plants from both rows over the ground cloth by using both hands and forearms. Count the beetles collected on the cloth. This way, two 3-row-feet (0.91 row m) sections (a total of 6 feet, or 1.82 m) are sampled. If some insects can’t be identified on the field, collect several specimens for later identification. By the end of sampling, the average count of beetle per row-foot or row-meter can be calculated.

Table 1. Economic threshold of overwintered bean leaf beetle in 30-inch row early-stage soybean (beetles per plant) (Hunt et al. 1995, Rice et al. 2005)

<table>
<thead>
<tr>
<th>Market value $/bu ($/kg)</th>
<th>VC (14.8)</th>
<th>10 (24.7)</th>
<th>14 (34.6)</th>
<th>18 (44.5)</th>
<th>V1 (14.8)</th>
<th>10 (24.7)</th>
<th>14 (34.6)</th>
<th>18 (44.5)</th>
<th>V2 (14.8)</th>
<th>10 (24.7)</th>
<th>14 (34.6)</th>
<th>18 (44.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.00 (0.18)</td>
<td>2.5</td>
<td>4.1</td>
<td>5.8</td>
<td>7.4</td>
<td>3.8</td>
<td>6.3</td>
<td>8.9</td>
<td>11.4</td>
<td>6.0</td>
<td>9.9</td>
<td>13.9</td>
<td>17.9</td>
</tr>
<tr>
<td>10.00 (0.36)</td>
<td>1.2</td>
<td>2.1</td>
<td>2.9</td>
<td>3.7</td>
<td>1.9</td>
<td>3.2</td>
<td>4.4</td>
<td>5.7</td>
<td>3.0</td>
<td>5.0</td>
<td>7.0</td>
<td>9.0</td>
</tr>
<tr>
<td>15.00 (0.54)</td>
<td>0.8</td>
<td>1.4</td>
<td>1.9</td>
<td>2.5</td>
<td>1.3</td>
<td>2.1</td>
<td>3.0</td>
<td>3.8</td>
<td>2.0</td>
<td>3.3</td>
<td>4.6</td>
<td>6.0</td>
</tr>
</tbody>
</table>

These values are calculated by using the formula: ET = 0.75*(C/VIDK). Where ET is Economic threshold, C = cost of management per production unit, V = market value per production unit, I = injury units per insect per production unit, D = damage per production unit and K = proportionate reduction of the insect population. It is assumed that for VC growth stage, D = 1.33 (from regression based on an expected yield of 34.4 bu/acre), I = 18.79, and K = 1 (total control); for V1, D = 1.33, I = 12.20 and K = 1; for V2, D = 1.33, I = 7.78 and K = 1 (Hunt et al. 1995).
next (e.g., second) generation. If the threshold is exceeded in one of the three scouting efforts, Lam et al. (2000) recommends a control action; however, the timing of control action should correspond with the emergence of the later second generation population in the soybean field (Rice et al. 2005).

A more general approach to set an economic threshold for bean leaf beetle is by using the defoliation rate because of bean leaf beetle feeding activity. Overwintered beetles feed on seedling soybean and treatment is warranted if over 20–30% of the seedlings in the field are destroyed. Treatment is also warranted if defoliation exceeds 30–50% during other vegetative stages of soybean development. Adults from the first generation bean leaf beetles feed on soybean leaf around July in the north central United States and should be treated if defoliation rate exceeds 15–35% during bloom (R1-R2). During pod-set and pod-fill (R3-R6), a field should be treated if defoliation exceeds 25%. Because bean leaf beetles also feed on pods, damage to pods should also be monitored. Control is warranted if pod injury exceeds 10% during pod-fill (Zeiss and Klubertanz 1994, University of Minnesota Extension 2006, Knodel et al. 2009).

**Cultural Methods.** Delayed soybean planting date may reduce bean leaf beetle abundance (Pedigo and Zeiss 1996). Planting soybean as late as possible within the recommended planting period for a variety may reduce initial and subsequent beetle densities, although maintaining yield potential. A potential risk is of note when late-planted soybean fields were located next to early-planted fields. In this situation, beetles from early-planted fields may easily migrate to late-planted fields, rendering planting date strategy ineffective.

**Management of Bean Leaf Beetle in the Presence of Bean Pod Mottle Virus.** Delayed soybean planting date has been suggested as a Bean pod mottle virus management tactic (Giesler et al. 2002), but 3-yr field data from Iowa showed that delayed planting did not consistently result in lower Bean pod mottle virus infection (Krell et al. 2005).

The use of soybean varieties with antixenosis (i.e., physical resistance) against bean leaf beetles does not sufficiently reduce Bean pod mottle virus incidence and spread in the field (Redinbaugh et al. 2010). No soybean varieties with resistance against Bean pod mottle virus have been reported although some varieties have some tolerance (Hill et al. 2007, Ziems et al. 2007).

Insecticide seed treatment by using neonicotinoid insecticides (Video Clip 2: The effect of seed treatment on soybean on overwintered bean leaf beetle [video-Marin E. Rice]) or foliar pyrethroid insecticides between emergence and first trifoliate reduces total Bean pod mottle virus incidence, likely by protecting soybean seedlings from early beetle populations (Krell et al. 2004, Bradshaw et al. 2008). Additional applications of foliar insecticides by using foliar pyrethroid insecticides in season (around blooming), aimed at controlling the first generation of bean leaf beetle, may further suppress virus incidence (Krell et al. 2004, Bradshaw et al. 2008).

**Summary.** The bean leaf beetle is an occasional pest of soybean but occurs in most soybean producing areas of the United States. Thus, the potential for economic injury exists in many soybean production systems, especially in the north central states. The biology, sampling, and management considerations described are intended to reduce the economic impact of this pest, including its role in transmitting Bean pod mottle virus. Effective management of the insect requires an understanding of pest ecology, timely scouting, and the application of appropriate control measures when economically warranted.

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### Table 2. Ground cloth economic threshold for 1st generation bean leaf beetles scouting in soybean (beetles per m²) (Smelser and Pedigo 1992, based on the work of Smelser and Pedigo (1992), where a beetle feeding on planted fields, rendering planting date strategy ineffective.

<table>
<thead>
<tr>
<th>Market value ($/Bu)</th>
<th>Cost of treatment/acre ($/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>5.8</td>
</tr>
<tr>
<td>8</td>
<td>6.7</td>
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<tr>
<td>10</td>
<td>8.3</td>
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<tr>
<td>12</td>
<td>10.0</td>
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<tr>
<td>15</td>
<td>12.5</td>
</tr>
<tr>
<td>18</td>
<td>15.0</td>
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</table>

These values were calculated by using the formula: ET = 0.75*EIL. Where EIL is Economic injury levels. The economic injury levels used here were based on the work of Smelser and Pedigo (1992), where a beetle feeding on late season soybean was found to cause an average seed yield reduction of 0.000306 kg.

### Table 3. Sweep net economic threshold for 1st generation bean leaf beetles in soybean (beetles per 20 sweeps) (Lam et al. 2000). If the beetle population is higher than the threshold value, control action should be conducted upon the emergence of the second generation bean leaf beetles

<table>
<thead>
<tr>
<th>Market value ($/bu)</th>
<th>Cost of treatment/acre ($/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>17.4</td>
</tr>
<tr>
<td>8</td>
<td>19.9</td>
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<tr>
<td>10</td>
<td>24.8</td>
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<tr>
<td>12</td>
<td>29.8</td>
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<tr>
<td>15</td>
<td>37.2</td>
</tr>
<tr>
<td>18</td>
<td>44.7</td>
</tr>
</tbody>
</table>

These values were calculated by using the formula: ET = 0.75*EIL. Where EIL is Economic injury levels. The economic injury levels used here were based on the work of Smelser and Pedigo (1992), where a beetle feeding on late season soybean was found to cause an average seed yield reduction of 0.000306 kg.

### Summary

The bean leaf beetle is an occasional pest of soybean but occurs in most soybean producing areas of the United States. Thus, the potential for economic injury exists in many soybean production systems, especially in the north central states. The biology, sampling, and management considerations described are intended to reduce the economic impact of this pest, including its role in transmitting Bean pod mottle virus. Effective management of the insect requires an understanding of pest ecology, timely scouting, and the application of appropriate control measures when economically warranted.