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Erin W. Hodgson

Iowa State University, ewh@iastate.edu

Cody Kuntz

Iowa State University

Matt O'Neal

Iowa State University, oneal@iastate.edu

Greg VanNostrand

Iowa State University, gregvn@iastate.edu

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Japanese beetle biology and management in corn and soybean

Erin W. Hodgson, assistant professor and Extension entomologist, Entomology, Iowa State University; Cody Kuntz, graduate student, Entomology, Iowa State University; Matt O'Neal, associate professor, Entomology, Iowa State University; and Greg VanNostrand, research associate, Entomology, Iowa State University

The Japanese beetle (JB), *Popillia japonica* (Coleoptera: Scarabaeidae), is an introduced pest originating from Japan. It was first identified in New Jersey in 1916, and despite attempts at eradication and efforts to limit its spread, JB has quickly expanded across the continent. In the United States, JB populations have successfully established in all states east of the Mississippi River with the exception of Florida. This invasive species has also spread into Minnesota, Iowa (Fig. 1), and Nebraska, and north into Ontario and Quebec (Potter and Held 2002). According to a survey by Purdue University, the most recent distribution of JB in the United States now also shows detections in Missouri, Arkansas, Oklahoma, Kansas, and Montana (NAPIS 2011).

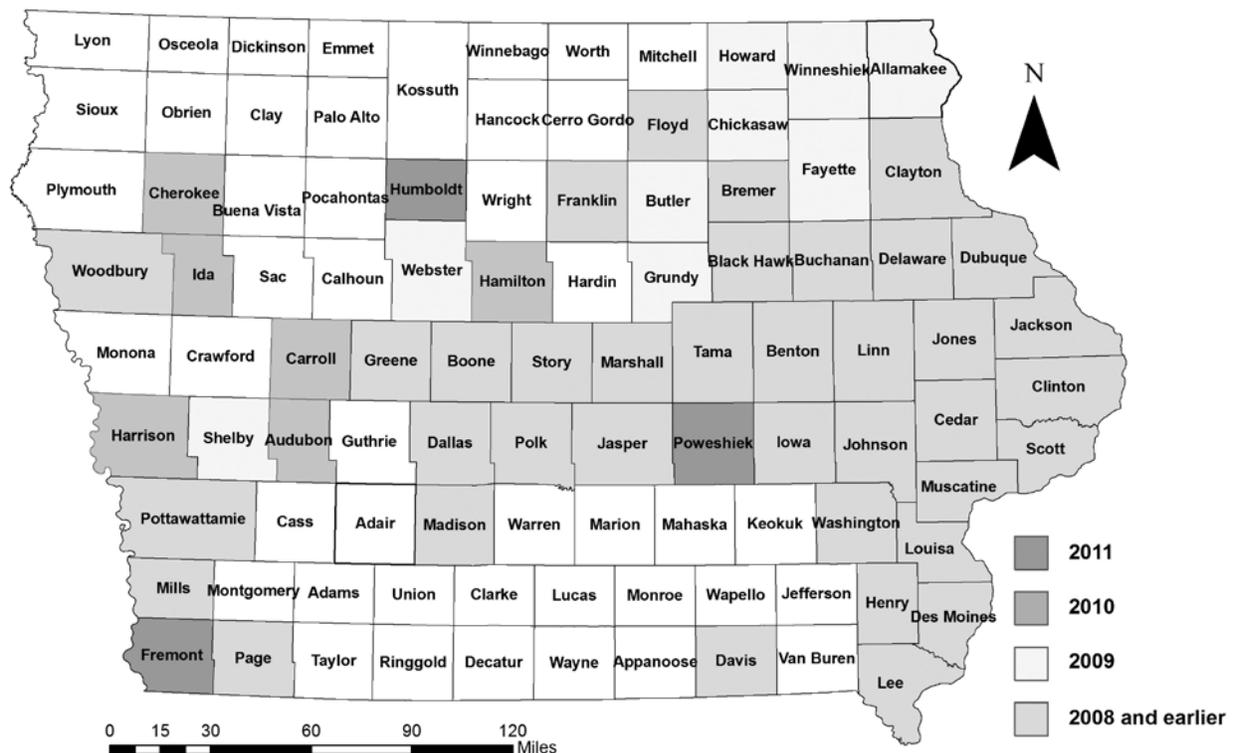


Figure 1. The first detection of JB in Iowa was in 1994. As of October 2011, 56 out of the 99 Iowa counties have confirmed JB.

Life cycle and biology

JB has one generation per year in the United States, with the exception of the northernmost regions of the country, where the cold temperature may extend development to two years (Potter and Held 2002). Variations in the first appearance of adults, timing of reproduction, and rate of larval development are mostly attributable to latitude and local climatic fluctuations between years (Potter and Held 2002).

Male JB adults emerge a few days before females in late May or early June (Cook and Gray 2004). Adults are most abundant from mid-July through August (Fleming 1972). Females go through several mating and egg-laying cycles. In 4-6 weeks, a female can enter the soil more than a dozen times and deposit 40-60 solitary eggs (Potter and Held 2002). To be a suitable egg-laying site, an area must have moderate to high soil moisture, moderate soil texture, sunlight, and short grass cover (Potter and Held 2002). Females prefer to lay eggs in grasses, however, they may also lay eggs within field crops with sufficient soil moisture. Cultivation may also be an important factor in determining a site's suitability for JB females. Higher adult JB densities are found in no-till or reduced-till soybean and JB larvae have been found to be 10-fold more abundant in weedy nursery fields compared with cultivated fields (Szendrei and Isaacs 2006). Eggs hatch in about 10-14 days, and larvae will feed for several weeks. Larvae move downward in the soil as temperatures cool and overwinter as third instars. As the weather warms in spring, the larvae move upward in the soil and continue feeding for several more weeks until pupating in early spring. Mature adults emerge from the soil a few weeks later.

Host range and feeding behavior

The host range of JB is quite broad. Larvae are able to feed on the roots of a wide variety of grasses, weeds, garden or nursery crops, and ornamental plants. As adults, they are able to eat leaves and consume the fruits and flowers of more than 300 plant species in at least 79 families (Potter and Held 2002). Although the focus here will be on JB in corn and soybean, some other economically important hosts of adults include grapes, and fruit trees such as apples, cherries, peaches, and plums.

JB larvae are not mobile and are generally restricted in movement (other than their accidental relocation through movement of soil). Adults can fly several miles to colonize new areas; however, they typically make short flights to feed or lay eggs (Potter et al. 2010). Adult JB tend to aggregate on host plants, with the males attracted to sex hormones released by females (Ladd 1970). Both sexes are attracted to volatile compounds released by the plants when fed upon by JB (Potter and Held 2002). Adult aggregations produce the greatest damage to plants, skeletonizing the leaf tissue between the veins and leaving a lacy appearance (Fleming 1972). They also may be able to consume entire flower petals or leaves of species with delicate veins (Potter et al. 2010). On corn, in addition to consuming leaf tissue, adult JB feed on the silks and can interfere with pollination. Significant silk clipping can lead to incomplete ear fill and yield loss (Cook and Gray 2004).

Scouting and management

JB larvae can be somewhat difficult to identify, as they resemble several other white grubs, but they are C-shaped with a white body and a brown head, and about one inch in length when fully developed. They can be distinguished from other white grubs by the V-shaped pattern of hairs on the tip of the abdomen (Cook and Gray 2004). Identification of adult JB, on the other hand, is relatively easy. They are generally about half an inch long and somewhat oval in shape (Cook and Gray 2004). Adults have a metallic green head and bronze forewings. They also have five white tufts of hair projecting from under the wings on both sides of the abdomen and two more tufts on the end of the abdomen.

Because adults tend to aggregate and are highly mobile, economic thresholds are not typically based on beetle abundance (e.g. through sweep netting or density of beetles per plant). It is therefore necessary to scout a representative area of the entire field in order to determine the extent of JB defoliation. For soybean, foliar insecticides are recommended if scouting shows that defoliation has reached or exceeded 30% before bloom or 20% between bloom and pod fill (Cook and Gray 2004). In corn, foliar insecticides are recommended when silks are present and an average of three or more JB adults per ear are present (Cook and Gray 2004). Other insects also feed on silks and insecticides are recommended if silks have been clipped to less than half an inch in length and pollination is less than 50 percent complete (Cook and Gray 2004). There are many currently available insecticides that are labeled for use against JB in both corn and soybean. These products encompass several modes of action and pre-harvest intervals.

An efficacy evaluation for Japanese beetle

In 2011, we established plots at the Iowa State University Johnson Research Farm in Story County, Iowa. The treatments were arranged in a randomized complete block design with four replications. Soybean was planted in 30-inch rows using no-till production practices and each plot was six rows wide and 30 feet long. We evaluated five foliar insecticide treatments and an untreated control (Table 1). Treatments included three modes of action (e.g., pyrethroid, organophosphate, neonicotinoid) alone or in combination. Foliar treatments were applied using a backpack sprayer and TeeJet (Springfield, IL) twinjet nozzles (TJ 11002) with 20 gallons of water per acre at 40 pounds of pressure per square inch.

Table 1. JB foliar insecticide treatments and rates in 2011

Treatment	Active Ingredient	Rate (oz/ac)
Warrior II	lambda-cyhalothrin	1.6
Lorsban Advanced	chlorpyrifos	16.0
Centric 40WG	thiamethoxam	2.5
Warrior II + Lorsban Advanced	lambda-cyhalothrin + chlorpyrifos	1.6 + 16.0
Endigo ZC	thiamethoxam + lambda-cyhalothrin	4.0
Untreated Control	-----	-----

Yields were determined by weighing grain with a grain hopper and adjusting the moisture to 13%. One way analysis of variance (ANOVA) was used to determine treatment effects within each experiment. Means separation for all studies was achieved using a general linear mixed model and a least significant difference (LSD) test ($\alpha \leq 0.10$) using SAS software (2011).

Evaluation results

Weekly sampling started on 27 July and continued until 26 August (Figure 2a). On the first sample, percent defoliation ranged from 5-15%, and beetle abundance ranged from 12-27 beetles per sweep. Although the treatment threshold of 20% after bloom was not reached, foliar insecticides were applied on 2 August. Foliar insecticides reduced JB densities to less than ten per sweep while the untreated control was over 18 per sweep. However, within seven days, there were no differences between any foliar treatment and the untreated control. Beetles continued to feed past pod fill, but percent defoliation never exceeded 20%.

Yield comparisons indicated a significant difference between treatments ($F=1.74$; $df=3,8$; $P<0.0001$) (Figure 2b). But the foliar insecticides did not significantly differ from the untreated control. These data support the currently established economic threshold for JB, and that applying a foliar insecticide was not cost-effective decision.

In this evaluation, JB was easily detected and plots had non-uniform defoliation. Some of the plants had extensive defoliation, but overall estimates were below 20%. The plots near the field edge had more obvious damage compared to interior plots. Therefore, we highly recommend scouting entire commercial fields to assess overall defoliation, as field edges will result in an over-estimate of damage. If only the field edges exceed treatment thresholds, consider making border application, if practical, to reduce application costs.

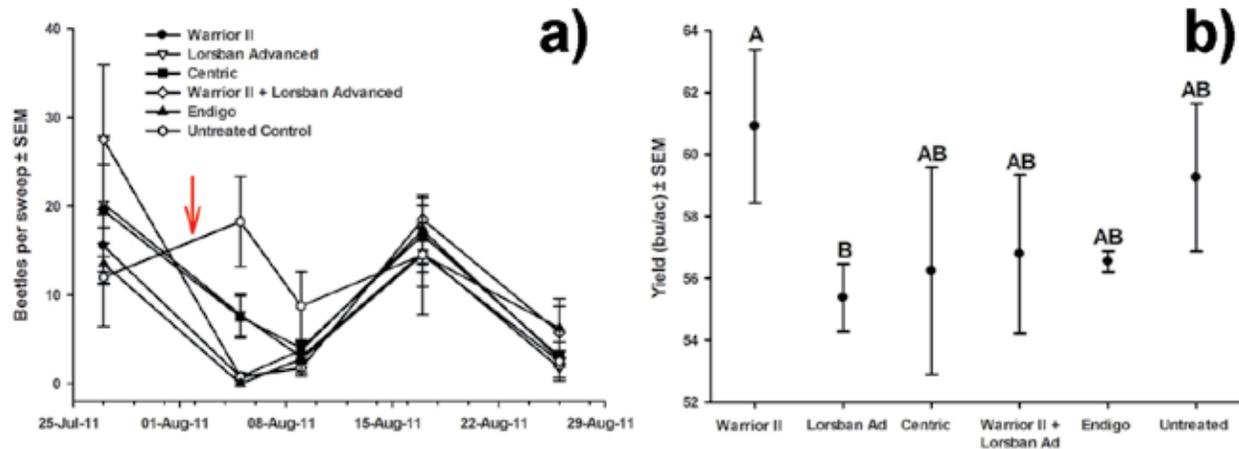


Figure 2. JB efficacy evaluation summary for 2011 showing a) comparison of treatments and JB density; arrow indicates timing of foliar applications, and b) comparison of treatments and soybean yield. Different letters represent a significant difference between treatments.

Acknowledgments

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