Focus on Insects: A Review of the Top 5 Research Articles in Agricultural Entomology

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Focus on insects: A review of the top 5 research articles in agricultural entomology
Marlin E. Rice, Professor, Entomology, Iowa State University

The scientific literature contains a wealth of new information on insect biology, ecology, behavior and management, but seldom does this research directly reach the crop advisor or agri-business professional. During the last 12 months, numerous research papers have been published that may have relevance to crop production and management in Iowa. Five of these scientific papers were selected from the scientific journals *Environmental Entomology*, *Journal of Economic Entomology* or *Nature Biotechnology* and the published abstracts are presented. Free PDFs of all but the Bt theory paper can be accessed at http://www.entsoc.org/Pubs/Overview/index.htm.

The objective of this presentation is to create awareness of this newly published research by briefly presenting an overview of the significant findings and the implications for agriculture in Iowa.

Is preventative, concurrent management of the soybean aphid (*Hemiptera: Aphididae*) and bean leaf beetle (*Coleoptera: Chrysomelidae*) possible?

Abstract
In Iowa, the management of insect pests in soybean, *Glycine max* (L.) Merr., has been complicated by the arrival of the invasive species soybean aphid, *Aphis glycines* Matsumura (*Hemiptera: Aphididae*), and occasional outbreaks of bean leaf beetle, *Cerotoma trifurcata* (Forster) (*Coleoptera: Chrysomelidae*), populations leading to economic losses. Several insecticide programs designed to reduce abundance of the overwintered and first generation *C. trifurcata* and the incidence of bean pod mottle virus were evaluated over 3 yr (2004-2006) for their impacts on *A. glycines* populations, at three locations in Iowa (Floyd, Lucas, and Story counties). There was no significant overlap of either overwintered (early May) or the first (early July) generations of *C. trifurcata* with *A. glycines*, because aphids were first detected in June and they did not reach economically damaging levels until August, if at all. During this study, insecticides targeting the overwintered population or the first generation of *C. trifurcata* provided a limited impact on *A. glycines* populations compared with untreated controls, and they did not prevent economic populations from occurring. Furthermore, the highest populations of *A. glycines* were frequently observed when a low rate of lambda-cyhalothrin (178 ml/ha) was applied targeting the overwintered population of *C. trifurcata*. Soybean yields were not protected by any of the insecticide treatments. Our results indicate that the use of either early season foliar or seed-applied insecticides for *C. trifurcata* management is of limited value for *A. glycines* management.
**Bottom line**

Insecticides applied against overwintered and first generation (early July) bean leaf beetles had little effect on soybean exposure to soybean aphid. No treatment during the three-year study had any effect on yield. Management of overwintered and first generation bean leaf beetles, and soybean aphids is not currently possible with a single or multiple early season insecticide treatments.

**Evaluation of management strategies for bean leaf beetles (Coleoptera: Chrysomelidae) and bean pod mottle virus (Comoviridae) in soybean.**


**Abstract**

*Cerotoma trifurcata* Förster (Coleoptera: Chrysomelidae) and Bean pod mottle virus (Comoviridae) (BPMV) both can reduce yield and seed quality of soybean, *Glycine max* (L.) Merr. Field experiments were conducted to evaluate the effects of systemic, seed-applied, and foliar-applied insecticides for the management of this pest complex at three locations in central, northeastern, and northwestern Iowa during 2002-2004. Seed-applied insecticide was evaluated according to a currently recommended management program for Iowa (i.e., insecticide applications that target emerging overwintered beetles, F₀, and the first seasonal generation, F₁). The experimental treatments included seed-applied (thiamethoxam, 0.3-0.5 g [AI] kg⁻¹ or clothianidin, 47.32 ml [AI] kg⁻¹) and foliar-applied (λ-cyhalothrin, 16.83-28.05 g [AI] ha⁻¹) or esfenvalerate (43.74-54.69 g [AI] ha⁻¹) insecticides. Applications of the foliar insecticides were timed to target F₀, F₁ or both F₀ and F₁ populations of *C. trifurcata*. Our results confirm that insecticides timed at F₀ and F₁ populations of *C. trifurcata* can reduce vector populations throughout the growing season, provide limited reduction in virus incidence, and improve both yield and seed coat color. Furthermore, seed-applied insecticides may be the more reliable option for an F₀-targeted insecticide if used within this management strategy. An F₀-targeted insecticide by itself only gave a yield improvement in one out of eight location-years. However, by adding an F₁-targeted insecticide, there was a yield gain of 1.42-1.67 quintal ha⁻¹, based on contrast comparisons at three location-years.

**Bottom line**

Management of both bean leaf beetle and Bean pod mottle virus with either a seed treatment, first generation targeted insecticide, or a combination of both is challenging and often produces inconsistent results. Seed treatments can be effective in reducing overwintered beetle populations during “low population” years but are ineffective during outbreak years. A seed treatment plus an insecticide applied against the first generation beetles (mid summer population) produced yields statistically greater (2.1-2.5 bu/acre) than the untreated check in only 3 out of 8 location-years.
Insect resistance to Bt crops: Evidence versus theory.


Abstract

Evolution of insect resistance threatens the continued success of transgenic crops producing Bacillus thuringiensis (Bt) toxins that kill pests. The approach used most widely to delay insect resistance to Bt crops is the refuge strategy, which requires refuges of host plants without Bt toxins near Bt crops to promote survival of susceptible pests. However, large-scale tests of the refuge strategy have been problematic. Analysis of more than a decade of global monitoring data reveals that the frequency of resistance alleles has increased substantially in some field populations of Helicoverpa zea, but not in five other major pests in Australia, China, Spain and the United States. The resistance of H. zea to Bt toxin Cry1ac in transgenic cotton has not caused widespread crop failures, in part because other tactics augment control of this pest. The field outcomes documented with monitoring data are consistent with the theory underlying the refuge strategy, suggesting that refuges have helped to delay resistance.

Bottom line

Cotton bollworm (=corn earworm) has developed resistance to Cry1ac in cotton, but widespread crop failure has not been observed. European corn borer resistance to Cry1Ab has not been detected in 933 field populations. A model simulating percent refuge abundance on European corn borer resistance to Bt corn suggests a 5 percent refuge will delay the development of resistance by more than 20 years.

Frequency and severity of western bean cutworm (Lepidoptera: Noctuidae) ear damage in transgenic corn hybrids expressing different Bacillus thuringiensis Cry toxins.


Abstract

The frequency and severity of corn ear damage caused by western bean cutworm, Striacosta albicosta (Smith), were measured on transgenic corn, Zea mays L., hybrids expressing two different insecticidal Bacillus thuringiensis (Bt) (Berliner) Cry toxins (Bt) selected to protect against damage caused by larval European corn borer, Ostrinia nubilalis (Hübner). A field cage experiment deliberately infested with western bean cutworm egg masses resulted in less damage in the hybrid expressing the Cry1F protein and supported fewer western bean cutworm larvae than its non-Bt isolate. Corn hybrids expressing Cry1F, grown in small plot field experiments at three locations over two separate years and exposed to natural western bean cutworm infestations suffered less damage than non-Bt or Bt-hybrids expressing a Cry1Ab protein. Later maturing hybrids suffered more damage than shorter-season hybrids. Finally, corn ears observed in strip trials for several years in diverse agronomic conditions in farmer-cooperator fields corroborated the in-plant protection conferred by corn hybrids expressing the Cry1F protein in small plot field trials.
**Bottom line**

Herculex hybrids (event TC1507, Cry1F) had significantly fewer ears with western bean cutworm damage, significantly lower ear damage scores, and occasionally fewer moldy kernels than YieldGard hybrids (event MON810, Cry1Ab) and non-Bt hybrids. Across all hybrids, damage was greater in late maturing hybrids than early and mid-season maturing hybrids.

**Prairie grasses as hosts of the northern corn rootworm (Coleoptera: Chrysomelidae).**


**Abstract**

We evaluated 27 prairie grass species thought to be among those dominant 200 yr ago in the northern midwest as larval hosts of the northern corn rootworm, *Diabrotica barberi* Smith and Lawrence. Maize (*Zea mays* L.), spring wheat (*Triticum aestivum* L.), and grain sorghum (*Sorghum bicolor* L.) were included as controls for a total of 30 species. Twenty pots of each species were planted in a randomized complete block design. Each pot was infested 5 wk later with 20 neonate northern corn rootworm larvae. Two pots within each species and block were assigned an extraction date of 7 or 14 d after infestation. The remaining two pots from each block were used to monitor adult emergence. The percentage of larvae recovered, change in larval head capsule width, and change in average dry weights varied significantly among the grass species. The highest percentage of larvae was recovered from slender wheatgrass, *Elymus trachycaulus* (Link), and this was significantly greater than the percentage recovered from all other species including maize for the 14-d sample date. Several additional species were also relatively good hosts, in that the percentage of larvae recovered from these species was not significantly different from maize. The average dry weight of larvæ recovered was significantly greater for larvæ recovered from maize than for larvæ recovered from all other species except slender wheatgrass, when the two samples dates were combined. Overall, adults were produced from only 6 of the 28 species evaluated, and no analysis was performed because of the low numbers. The results of this study are discussed in relation to the potential of alternate hosts of northern corn rootworm to serve as a bridge to survival on transgenic maize.

**Bottom line**

The best host for northern corn rootworm larvæ was slender wheatgrass (number of larvæ recovered 14 days after infestation). Fewer larvæ, but statistically equal numbers, developed on corn, Canada wildrye, big bluestem, Indian grass, and prairie cord grass. Little bluestem produced even fewer larvæ and no larvæ survived on sorghum.
Aphid resistant soybeans: Will they prevent soybean aphid outbreaks?
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Since the invasion of the soybean aphid to the US, aphid resistance has been discovered in soybean germplasm. At least three different sources of resistance have been located, constituting mostly antixenosis and antibiosis. Host plant resistance against the soybean aphid has been incorporated into commercially available varieties that can be grown within the North Central region of the US. In 2009, these commercially sources will include the RAG1 gene. Soybean-checkoff funded research has revealed that this gene will reduce aphid populations and reduce yield loss during aphid outbreaks, compared to a related susceptible variety. However, RAG1-containing soybeans will not be aphid free, nor will yields be optimized without an insecticide application. In this brief summary, we discuss the performance of RAG1-soybean in Iowa during 2007 and 2008. During the presentation at the ICM conference, we discuss the utility of aphid-resistance soybeans in light of increasing commodity and input costs.

In 2007 we examined soybeans containing the RAG1 gene in replicated field plots in Story Co. Iowa. We compared a soybean variety containing RAG1 to a parental line that did not have this resistance-henceforth referred to as susceptible. The RAG1 gene confers a degree of antibiosis against soybean aphids (Hill et al. 2004). Antibiosis is a form of resistance in which the insect fails to reproduce, and in certain situations dies on the plant. As we have seen during our two years of study, soybean aphids in Iowa can survive on RAG1-containing soybeans. Therefore we wanted to determine if RAG1 provided some level of tolerance to aphids. Tolerance is an uncommon form of resistance in which the pest can survive and build large populations on the plant, but yield is not affected. To test for tolerance we split each plot in half, leaving one half unprotected from aphids and repeatedly spraying the other with an insecticide (lambda-cyhalothrin). We observed a significant difference in the number of aphids on resistant versus susceptible soybeans. By comparing the aphid-free to the untreated plots we can account for the yield impact of aphids on resistant and susceptible plants.

Populations peaked at 3,404 aphids per plant on 31 July, 2007 on susceptible plants while the resistant plants reached 497 aphids per plant. Throughout the season susceptible plants experienced 5 times the exposure of resistant plants. Although a significant reduction, previous research on soybean aphids (Ragsdale et al. 2007) indicates yield loss can occur when 10,000 aphid days are accumulated. Aphids had significantly reduced yield in the susceptible but not the resistant soybeans (Fig. 1). Our experiment does not indicate the presence of tolerance. Note that the difference between the aphid free and infested plots for the resistant line was 8 bushels and the same comparison for the susceptible line was 32 bushels; a 4-fold level of yield protection due to host plant resistance. This is very close to the difference in aphid exposure between the resistant (11,396 average CAD) and susceptible lines (59,513 average CAD); approximately a 5-fold difference. So the benefit of RAG1 appears to be antibiosis alone.

That soybean aphids can survive on RAG1-containing soybeans is not limited to Iowa (Kim et al. 2008). The discovery of biotypes that can survive on RAG1-soybeans with no detrimental
effect to their longevity or reproduction has been reported for aphids collected in Ohio. When we repeated this experiment we saw even larger populations on RAG1-soybeans in 2008 (Fig. 2) as in 2007. This is likely due to a larger numbers of aphids immigrating into Iowa and not the spread of the biotype. If it had been the biotype, as described by Kim et al. (2008) I would not have expected the population size to be different between the resistant and susceptible lines. Although, RAG1 does not keep the plant aphid-free, we observed significantly fewer aphids on the resistant susceptible lines in both 2007 and 2008. Aphid populations will develop and build slowly on resistant plants, reaching the economic threshold after such populations are reached on an adjacent susceptible plants. Since the current recommendation is based on applying an insecticide within 7 days of aphid populations exceeding the economic threshold, this slowing of aphid population growth may be a significant buffer for growers trying to manage an aphid outbreak.

Host plant resistance as an insect pest management tool has produce remarkable reductions in pest pressure, especially regarding genetically modified corn that is resistant to European cornborer or corn rootworms. However, as demonstrated above, conventionally developed host plant resistance for soybeans aphids has yet to produce a variety that is free of aphids, to the same degree as Bt-corn. As soybean aphid resistance becomes commercially available, it will likely require additional pest management tools for the optimal yield to be produced. For growers who scout and employ the 250 aphid per plant threshold, the RAG1-soybeans can be a useful supplement but not a replacement management tactic. Growers who want their fields aphid-free will be disappointed. However, the good news is that growers do not need aphid-free soybeans to reach optimal yields, as will be discussed by Kevin Johnson and Dr. Eileen Cullen later today during sessions C, D, E, and F.

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References.


**Figure 1.** Comparison of resistant and susceptible soybeans kept free from aphids using a foliage-applied insecticide or left untreated. Different letters indicate statistically significant differences in yield (P=0.05). Source of the resistant is the RAG1 gene.

**Figure 2.** Soybean aphid populations on a susceptible (empty boxes) and resistant soybean line (grey diamonds) that contains the RAG1 gene. Aphid populations were calculated based on an average (+SEM) for 10 plants from 4 replicated plots in Story County IA during the 2008 growing season.