The Future of Soybean Aphid Management?

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Since its arrival in 2000, soybean growers have a limited number of weapons to use against the soybean aphid. Although several insecticides are labeled for use against the soybean aphid, this is just one of the many tools that pest managers can use against any insect pest. I will describe efforts to improve upon this limited arsenal with brief summaries of research to develop biological control and host plant resistance against the soybean aphid.

Biological Control

Biological control is the intentional manipulation of predators, parasitoids, and pathogens to suppress the population of a specific pest, making it less abundant or less damaging. This trio — predator, parasitoids, and pathogens — are commonly referred to as natural enemies. There are three approaches to biological control: conservation, augmentation, and importation. Below is a very brief review of the three methods and their relevance for soybean aphid management. For a fuller summary of biological control for soybean aphid management, visit http://www.entomology.wisc.edu/sabc/resources.htm.

Conservation biological control is the use of conservation techniques to enhance the impact of the currently occurring natural enemies. Field research from across the Midwest has shown that predators, specifically the multicolored lady bird beetle and the insidious flower bug, can suppress soybean aphids. These predators prevent aphid populations from building and, under certain conditions, can suppress populations from reaching the economic threshold (Costamagna and Landis, 2006; Schmidt et al., 2007). Research addressing why predators fail to provide consistent protection is on-going. We have observed that predation on soybean aphids is affected by the landscape surrounding a soybean field. Soybeans grown in an area that is dominated by corn and soybean production is more likely to have soybean aphid outbreaks. Such an area likely lacks habitat for these predators to survive during inclement weather and periods of low food (aphid) availability. Providing greater habitat around soybean fields may increase the number and diversity of these predators. Visit the following Web site for plants that can serve as a suitable habitat for beneficial insects like the predators that feed on soybean aphids: Enhancing Beneficial Insects with Native Plants at http://nativeplants.msu.edu/.

However, recommendations are not yet in place to specifically increase soybean aphid predators by improving the habitat around soybean fields. If growers, especially organic growers, are interested in improving within-field habitat for greater biological control then consider the use of cover crops. At ISU, we (Schmidt et al., 2007) have observed that a living mulch of alfalfa can prevent soybean aphid populations from reaching economic levels (i.e., rising above the 250 per plant threshold). A more conventional approach is a fall seeded cover crop of rye. Entomologists at the University of Minnesota

(G. Heimpel, personal communication) are investigating this approach, which has produced favorable preliminary results for preventing soybean aphid outbreaks.

A more interactive approach to biological control is the release of commercially raised insect predators- often called **Augmentation, or inoculation, biological control**. Although there are several commercial sources of ladybeetles, lacewings, and other insect predators that will feed on aphids, there is no evidence that purchasing these predators for release in soybean fields has any impact on soybean aphids. This approach is not currently recommended. Extensive research from other cropping systems, like cotton, has shown that it is very difficult to release enough predators to increase the background population of predators. Furthermore, one popular predator for hire, the green lacewing, has limited value as a source of aphid mortality (Rosenheim et al. 1993). Research has shown that most of the lacewings released end up being fed upon by other predators.

The third approach is **Importation biological control** in which an exotic (i.e., non-native) natural enemy is released against an invasive pest. This is sometimes called **Classical biological control** because one of the first successes using biological control occurred through this approach in 1888. Since 2001, a multi-state program has been employing this approach for soybean aphid management. Several Midwest entomologists have explored the native range of the soybean aphid to discover what natural enemies prevent it from being a pest. Observations during these trips revealed a great degree (as much as 40%) of aphid parasitism, more so than what has been observed since the aphid has been in the United States. In Iowa, we have observed less than 1% of soybean aphids parasitized, even in outbreaks with several hundred aphids per plant (Schmidt et al. *in press*). Based on these observations, several species of parasitoid wasps have been brought to the United States in quarantine facilities and evaluated for use against soybean aphids (Heimpel et al., 2004). During my presentation I will provide an update, like efforts to release the species *Binodoxys communis*.

The Next Weapon — Host Plant Resistance

A soon-to-be released weapon in the soybean growers' arsenal against soybean aphid is host plant resistance (HPR). Like biological control, HPR comes in three different forms: antixenosis, antibiosis, and tolerance. The first, **antixenosis**, is the inability for an insect pest to find and feed on the plant. This can involve greater pubescence. This approach resulted in a successful reduction in leafhopper injury to soybeans 40 years ago. Antixenosis for soybean aphids has been observed in some forms of resistance currently being investigated by soybean breeders (Hesler et al., 2007; Diaz-Montano et al., 2006).

A**ntibiosis** is the inability for the pest to grow and reproduce while feeding on a resistant plant. Evidence for antibiosis has been reported in the soybean germplasm by several groups of soybean breeders (Hesler et al., 2007; Hill et al., 2006; Mensah et al., 2005). When aphids are placed on these plants they produce fewer nymphs and in some cases die within a few days. The cause of this mortality is not yet known; it is not clear if resistant plants produce a toxin or are just less nutritious for aphids than susceptible soybeans. Breeders at the University of Illinois have identified a source of antibiosis in

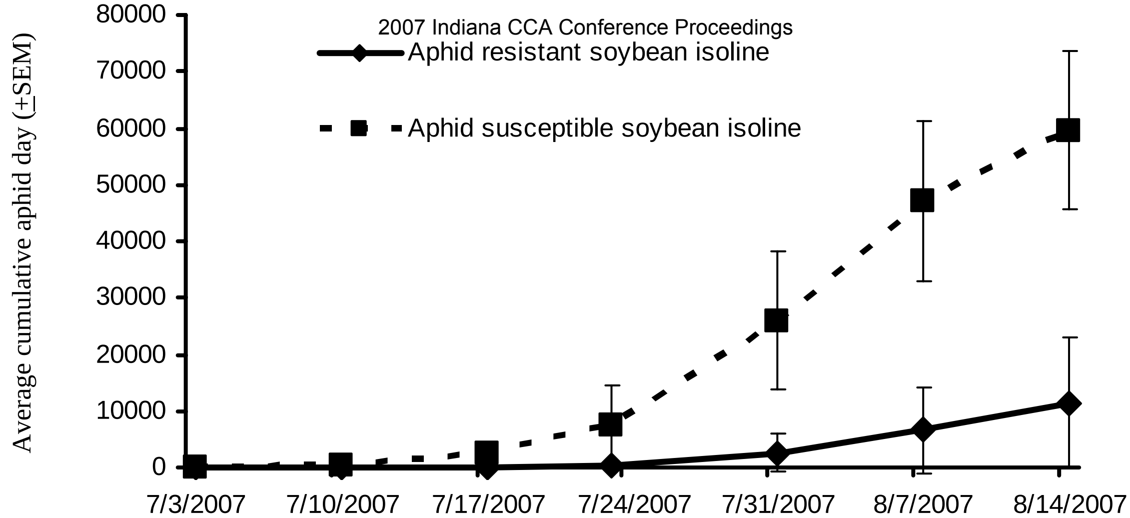

Figure 1. Impact of RAG1 on soybean exposure to soybean aphids. Aphid exposure is measured by the accumulation of "aphid days," calculated based on the average abundance of aphids between sampling dates. Populations peaked on 31 July and were less than 100 per plant after 31 August.

soybeans that is attributed to a single, dominant gene (Hill et al., 2006). This gene is called RAG1 and is expected to be available commercially by 2008.

The last form of resistance is **tolerance**, the ability of a plant to produce yields despite the feeding of an insect pest. This last form is difficult to test in the laboratory and may occur in addition to the other two forms. In 2007 we examined soybeans containing the RAG1 gene in replicated field plots in Story County, Iowa. We compared a soybean variety containing RAG1 to a parental line that did not have this resistance-henceforth referred to as susceptible. To determine if either variety contained some level of tolerance, we split each plot in half, leaving one half unprotected from aphids and repeatedly spraying the other, leaving it free of aphids. We observed a significant difference in the number of aphids on resistant versus susceptible soybeans. Populations peaked at 3,404 aphids per plant on 31 July on susceptible plants while the resistant plants reached 497 aphids per plant. Exposure of soybean plants to aphids is reported in Figure 1 as units of aphid days. 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 (Figure 2). 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 difference 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 (59513 average CAD): approximately a 5-fold difference. So the benefit of RAG1 appears to be antibiosis alone. Although not statistically significant, when kept aphid free the susceptible line had a higher yield than the resistant line. When conducted at three other locations within the Midwest (IL, MN, and MI), there was no difference in yield between resistant and susceptible lines when kept aphid free.

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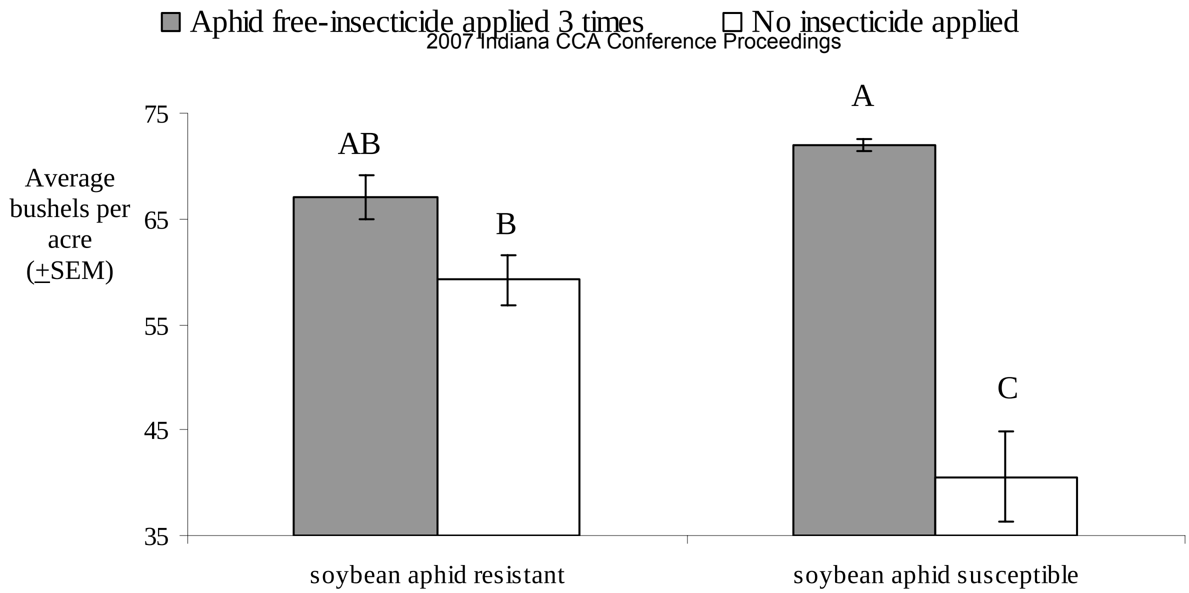

Figure 2. Comparison of resistant and susceptible soybeans kept free from aphids using a foliage-applied insecticide or left untreated. Different letters indicate statistically significant different in yield (P=0.05). Source of the resistant is the RAG1 gene.

Soybean aphids will continue to be a sporadic pest for soybean growers throughout the Midwest. Growers are recommended to consider multiple management strategies when dealing with soybean aphid outbreaks. Relying on a single practice or tool will result in the occurrence of resistance by the aphid to that practice. The current recommendation of scouting fields to determine if aphid populations exceed 250 aphids per plant allows predators to suppress populations when possible. When those predators fail then the use of a foliar insecticide is necessary. The release of exotic natural enemies like *Binodoxys communis* may result in more consistent biological control, but it may require several years before this new species can establish and have an impact, if at all. Growers who participate in this program will need to consider how to encourage the wasps establishment while still maintaining high yields when outbreaks occur, as almost all foliar insecticide are toxic to them.

The use of resistant varieties may play a role in reducing the risk of an aphid outbreak. As our data indicate, there will be fewer aphids on resistant plants, but these plants will not be aphid free. The most available source of HPR is unlikely to serve as a “silver bullet” that will completely remove the risk of soybean aphid outbreaks. We will continue to recommend that growers scout fields planted with aphid-resistant varieties of soybean.

This review should provide insight into the role HPR and biological control can play in preventing soybean aphid outbreaks. These alternatives have a great upside in terms of limited cost and environmental impacts, but they currently do not have the efficacy of foliar insecticides. This review should also highlight how powerful foliar insecticides are as a tool for soybean aphid management. It would be tragic if by their over-use we lose these tools to resistance. By judicially applying foliar insecticide growers decrease the risk of insecticide resistance developing in soybean aphids and preserving their use into the future.

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