A Survey of Indiana Soybean Producers Following the Introduction of a New Invasive Pest, the Soybean Aphid

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In 2000, the soybean aphid, *Aphis glycines* Matsumura, invaded North American soybean production and quickly spread to 22 U.S. states and 3 Canadian provinces (Ragsdale et al. 2004). Since its introduction, periodic outbreaks of the soybean aphid have occurred, the most recent in 2005. During outbreaks, millions of acres of soybeans have been treated with insecticides (mostly in the Midwest), and tens of millions of dollars in lost yield have been reported (DiFonzo and Hines 2002, Landis et al. 2003). The soybean aphid has become the most devastating insect pest of soybeans in the United States.

The aphid challenges soybean insect management and has stimulated research on its ecology and management (Heimpel et al. 2004, Hill et al. 2004, Ragsdale et al. 2004, Rutledge et al. 2004, Venette and Ragsdale 2004, Voeglin et al. 2005). An undocumented area is what farmers know about the soybean aphid, and how their experience with it has influenced their management approach. We surveyed soybean farmers in Indiana to assess their knowledge and practices related to soybean aphid ecology and management. We took advantage of the relative densities of soybean aphid in the state to investigate how farmers’ experience with the aphid affected their survey responses. Our goal was to provide baseline information on farmers’ understanding of soybean aphid biology and management so as to better inform soybean aphid management programs.

**Methods**

In February 2005, 2,000 surveys were sent to farmers in 37 counties of Indiana. Two areas of the state were identified based on their relative soybean aphid densities as determined by previous sampling (RJO, unpublished data.). Counties \(n = 19\) where soybean aphid densities had not exceeded 100 individuals per plant in any year before the survey were designated as “low counties” or collectively as the “low aphid area.” In contrast, counties \(n = 18\) where soybean aphid densities had reached at least 500 per plant were designated as “high counties” or collectively as the “high aphid area” (Fig. 1). Equal numbers of surveys were sent to each area. Between 30 and 86 surveys were sent to randomly selected producers in each county, depending on the number of soybean producers in the county (NASS 2004).

The survey consisted of 35 questions divided into five sections (see box, “Survey Structure”). In the first section, farmers were asked about their soybean production experience and the frequency and reasons for visits to their fields. The second section focused on pest management and asked about the identity of soybean insect pests and insecticide use. Section three related specifically to soybean aphid management and included questions on the occurrence of soybean aphid, damage in farmers’ fields, and management approaches. A fourth section on information sources asked where farmers learned about soybean aphid and whom they trusted for advice on management options. The final section was designed as a “quiz” with questions about soybean aphid biology and ecology, including the origin of the aphid, its host plants and natural enemies, and where it can be found in a soybean field.

We compiled the frequencies and percentages of each response to every question. The statistical significance of responses between the low and high aphid areas was determined by using analysis of variance (ANOVA) for continuous numerical data. Nominal or ordinal discrete data were analyzed using cross-tabulation (Pearson chi-square). All comparisons were made using an \(\alpha = 0.05\) with SPSS statistical software (version 12) for Windows.

**Results**

Of the 2,000 surveys sent, 301 (15.1\%) were returned. There was a significantly higher response rate \(\chi^2 = 5.053, \text{df} = 1, P = 0.025\) from the high aphid area \(n = 170; 17\%\) than from the low aphid area \(n = 131; 13.1\%). Surveys with little or no information were considered “missing” (4.7\%) and were not included in analyses.

**Farm and Pest Management.** On average, farmers had about 29 years of production experience with soybeans. Average field size was ~134 ha. Farmers visited their fields an average of 11 times per season. Farmers in both areas indicated that the primary reason they visited their fields was to check for pests.

No significant difference was found in the reasons farmers gave for visiting fields in the two areas \(\chi^2 = 2.117, \text{df} = 4, P > 0.05\).

Almost half of the respondents (49.5\%) believed they had economically important insect pests in their soybean fields; there was no significant difference between aphid areas \(\chi^2 = 3.731, \text{df} = 3, P = 0.292\). Farmers mentioned 19 arthropods, including aphids (35.1\%), Japanese beetles (22.5\%), bean leaf beetles (9.8\%), spider mites (9.4\%), beetles (6.5\%), and grasshoppers (4.5\%). A higher percentage of farmers from the high aphid area (50.8\%) mentioned aphids as an economic pest than did farmers from the low aphid area (20\%\); \(\chi^2 = 12.998, \text{df} = 2, P < 0.05\).

Although half of the respondents reported pests, 70\% of them had not applied insecticides in their soybean fields in the previous 10 yr. On average, less than one insecticide application was made over the previous 10-yr period. No significant difference
was found in insecticide use between the two aphid areas (F = .431, df = 1, 282, P = 0.512). Of those farmers who used insecticides, 33% reported that the application was based on the use of an economic threshold. In comparison, 21.1% relied on the advice of pesticide providers and 10.8% on recommendations of Extension educators. In addition, 10.3% treated when they thought there were too many insects, and 9.7% treated based on the recommendation of someone they knew. About 5% of farmers reported they used scheduled (calendar spray) applications. There was no significant difference in farmers’ decisions for applying insecticides between the two areas (χ² = 2.830, df = 7, P = 0.900).

**Soybean Aphid Management.** Farmers strongly agreed (84.1%) that it is important to sample pests before deciding to apply a control method. However, when asked the economic threshold for soybean aphid, only 23.6% of the respondents knew the threshold guidelines of 250 aphids per plant. There was no significant difference between areas (χ² = 2.830, df = 1, P = 0.604).

Most respondents (76.4%) stated that they would be willing to try nonchemical methods for managing soybean aphids. Those who disagreed indicated that insecticides are the most effective method for controlling pest (39.6%), that they are easier to apply than other control tactics (20.8%), or that insecticides were what they used to using (10.4%). Between high and low aphid areas, no significant differences were detected in either the willingness of respondents to try insecticide alternatives (χ² = 0.318, df = 2, P = 0.853) or their reasons for using insecticides (χ² = 0.508, df = 4, P = 0.973).

Overall, 152 (50.5%) of the respondents reported having seen soybean aphids in their fields (high area, 99 respondents, 58.2%; low area, 53 respondents, 40.5%). When asked the level of soybean aphid damage from 2000 to 2004, more than half of the respondents left the question blank, except for 2003 when low (34.2% of respondents) to moderate (25.7% of respondents) damage was reported. When comparing the responses from the high and low aphid areas, there was a significant difference only for 2003 (χ² = 29.732, df = 4, P < 0.001). About half (54.5%) of the farmers from the high aphid area reported moderate to high aphid damage, whereas only 11.3% of the low aphid area respondents reported similar damage levels.

Insecticide use during the aphid outbreak of 2003 increased significantly in the high soybean aphid area. Twenty-three of the 170 respondents from this area reported using insecticides in 2003. In contrast, an average of about two farmers per year had applied insecticides during the 9 yr between 1994 and 2004. In the low aphid area, three farmers used insecticides in 2003, which is similar to the average of 3.4 farmers using insecticides yearly in the 9 yr between 1994 and 2004. Farmers in the low aphid area reported spraying 196 ha for soybean aphid, whereas farmers in the high aphid area sprayed 4,781 ha. Farmers in the high aphid area sprayed ~25.5% of their 18,724 ha, whereas farmers in the low aphid area sprayed ~1.1% of their 18,278 ha. Multiplying these proportions by the total acreage in the two areas (low aphid area, 596,761 ha; high aphid area, 466,640 ha; NASS 2004), we estimated that 6,564 ha were sprayed for soybean aphid in the low aphid area, whereas ~18 times that amount (118,993 ha) was sprayed in the high aphid area in 2003.

**Natural Enemies.** Respondents had a low awareness of practices that can be used to increase numbers of natural enemies in soybean fields. Only 20% were aware that cropping practices may influence natural enemies, whereas 16.6% knew about augmentative biological control methods, and 9.8% knew about introducing foreign natural enemies (difference between the areas was not significant; χ² = 6.602, df = 6, P = 0.359). When asked about the introduction of foreign natural enemies, almost half (46.1%) of the respondents were concerned about using exotic natural enemies. More than one-quarter of the respondents shared concerns on the safety of biological control agents (27.5%), and 7.3% believed that biological control is ineffective. Only 9.7% had no concerns at all. Overall, respondents from both areas had similar levels of concern about introducing exotic soybean aphid natural enemies (χ² = 2.009, df = 5, P = 0.849).

**Information Sources.** Most respondents had seen information about soybean aphids in print or electronic media (28.9%), or in Purdue Extension publications (19.4%). A smaller percentage of respondents learned about soybean aphids from extension presentations or field days (17.9%), from other farmers (16.3%), or the Internet
identified aphids in the field ($\chi^2 = 5, P = 0.389$).

Only about 25% of respondents knew that the soybean aphid originated in Asia.Farmers reported a higher likelihood of trying a new control method when recommended by researchers from Purdue (27.9%), followed by Extension educators (24.2%), other farmers (19.3%), pesticide sales representatives (13.8%), or the media (9.4%). There were no significant differences between responses from the two aphid areas ($\chi^2 = 1.876, df = 6, P = 0.931$).

Soybean Aphid Biology and Ecology.

Only about 25% of respondents knew that the soybean aphid originated in Asia. Regarding overwintering habitat, most respondents did not know (41.9%) or left the question unanswered (17.9%). Only 18.9% were aware that soybean aphids overwinter on a plant (buckthorn, *Rhamnus* spp.) found outside the soybean field. Many (29.8%) farmers did not know how to distinguish soybean aphids from other insects. Others reported that they could recognize them in colonies (24.6%), by their characteristic morphology (14.9%), or by their behavior (10.8%). There were no significant differences in the farmers’ knowledge of the origin of the aphid ($\chi^2 = 10.334, df = 6, P = 0.111$), its overwintering locale ($\chi^2 = 12.387, df = 6, P = 0.054$) and the ways in which they identified aphids in the field ($\chi^2 = 5.228, df = 5, P = 0.389$).

A higher percentage ($\chi^2 = 7.706, df = 2, P = 0.021$) of the respondents from the low aphid area did not know where soybean aphids are found on soybean plants (low = 16.8%, high = 8.1%). Half of the respondents did not know or did not respond (51.8%) about the soybean aphid’s within-field distribution. About one-fourth (26.9%) of the farmers believed they had an aggregated distribution, and 14.6% thought they were located on field edges. Only 6.3% reported that soybean aphids were usually distributed uniformly in the field. There was no significant difference in farmers’ knowledge of within-field distribution between the high and low aphid areas ($\chi^2 = 4.859, df = 5, P = 0.433$).

In general, respondents had a similar familiarity with symptoms of soybean aphid damage ($\chi^2 = 12.764, df = 8, P = 0.120$). Between 10 and 17% of the respondents knew that soybean aphids can cause plants to turn yellow, that plants can be stunted, have smaller and fewer pods and seeds, and that leaves may curl and wilt. Only a very small percentage (3.7%) knew about the sooty mold fungus that grows on the aphid’s honeydew.

When asked about the soybean aphid’s population growth, more than half of the respondents either did not know or did not respond (37.9%). Only 9.2% were aware that soybean aphids are capable of doubling their population in less than a week under favorable conditions (Ragsdale et al. 2004). When asked about the conditions that may favor population growth, the most common response was lack of natural enemies (27.3%), followed by drought (21.3%) and cool temperatures (14.5%). Even though some respondents were aware that natural enemies are important in determining the numbers of soybean aphid, only 30.6% of respondents reported natural enemies being present in their fields. Between the two areas, there was no significant difference in farmers’ appreciation of soybean aphid population growth rate ($\chi^2 = 0.154, df = 2, P = 0.926$) or their understanding of the factors that contribute to aphid population dynamics ($\chi^2 = 3.091, df = 3, P = 0.378$).

The farmers’ knowledge of identifying the natural enemies of soybean aphid was limited. When asked to list natural enemies, ~72% of respondents recognized lady beetles as predators of soybean aphid. No other organism was mentioned by more than 5% of respondents. Other soybean aphid natural enemies mentioned included parasitic wasps, assassin bugs, lacewings, spiders, predaceous flies, and pathogens. Farmers misidentified grasshoppers, Japanese beetle, and leaf beetles as natural enemies. They also mentioned birds and praying mantis whose predatory association with soybean aphids is not known, but doubtful.

**Discussion**

Differences in responses from farmers in the two areas appeared to be related to their direct experience with the aphid. Farmers in the high aphid area identified the aphid as a pest more often than farmers in the low aphid area, and they knew where it could be found on the plant. In the high aphid area, they significantly increased their insecticide use, compared with the historical pattern and with respect to farmers in the low aphid area. The 18-fold increase in applications in the high aphid area suggests that farmers were more likely to treat soybean plants with insecticides in face of the threat posed by the aphid. By using the percentage of area sprayed in the high aphid area, we can estimate the acreage sprayed during the 2003 soybean aphid outbreak in Indiana. In 2003, ~1.1M ha were economically infested with soybean aphids (RJO, unpublished data). If farmers in those 1.1M ha sprayed the same percentage acreage (25.6%) as was sprayed by surveyed farmers in the high aphid area, ~280,500 ha would have been sprayed during the 2003 outbreak. The application costs (assuming an average of $25/ha; Krupke et al. 2006)
would highlight the impact of the aphid on soybean production and present a challenge to find alternatives to reduce environmental and economic costs from such widespread application of insecticides.

Current recommendations for soybean aphid management suggest that farmers sample multiple times to estimate the size and growth rate of the aphid population in their fields (Krupke et al. 2005). Although farmers regularly visit their fields, they reported limited knowledge about aphid population growth. Extension materials that educate farmers about soybean aphid population dynamics would help farmers better implement recommendations and potentially reduce the inappropriate use of insecticides.

Although farmers trust the effectiveness of insecticides, more than two-thirds agreed that they would be willing to try nonchemical methods. Alternative methods may therefore find a receptive audience and gain widespread use if shown to be effective. When we asked about one alternative approach, the importation of Asian natural enemies, farmers expressed several concerns about their introduction. Implementing a classical biological control program for soybean aphid should therefore incorporate an educational component so farmers appreciate the benefits and risks of classical biological control in their production system.

Our survey reinforces the importance of involving farmers in management plans, particularly those that rely on methods and objectives that differ from the farmers’ common experience. In areas where the soybean aphid has caused economic damage (i.e., the U.S. Midwest and parts of Canada), extension specialists have developed a wide range of educational materials. The extension response to the threat caused by the soybean aphid is a clear example of how extension has an important role in managing invasive agricultural pests.

Acknowledgments
We thank the Indiana Soybean Board, the USDA Cooperative State Research, Education and Extension service, the North Central IPM Center, and the Department of Entomology, Purdue University for funding. We also thank the Indiana Agricultural Statistics Department, and Steve Wilson for assistance with survey questions, questionnaire design and logistics. Cliff Sadof, Rick Foster, and two anonymous reviewers provided helpful feedback with earlier drafts. Finally, we thank the Indiana soybean farmers for sharing their knowledge and experiences that made this study possible. This is Purdue University Agricultural Research Programs manuscript 2006-17871.

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