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The Soybean Aphid: What We Know and What We Don’t Know

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Compared to the past, 2000 certainly has been the year of soybean insects. The bean leaf beetle received most of the attention. With unprecedented numbers, several thousands of soybean acres were sprayed. But late in the season, another insect surprise occurred with the discovery of the soybean aphid, *Aphis glycines* Matsumura.

**History of the Problem**

The soybean aphid, is native to Asia and has been of concern in China, at least since the late 1940's. It was first detected in North America in Wisconsin. Wisconsin researchers reported finding widespread and high within-field incidence of aphids with unprecedented numbers on July 20, 2000. The aphid was first identified as a native species, *Aphis gossypii*, the cotton/melon aphid. The researchers witnessed large numbers on the underside of leaves with accompanying leaf curl, leaf chlorosis, and patches of stunted plants within fields. They reported densities so high that long trousers were needed because of sticky honey dew on the leaves from the aphids. In subsequent surveys, they found aphids across southern Wisconsin (in Grant county, across Iowa border) and as far north and east as Wausharara and Sheboygan counties.

About the middle of August, aphids were counted on a few whole plants from an infested field near Janesville, Wisconsin by T. Klubertanz, from the University of Wisconsin, Rock County. He reported that the plants were not stunted and looked normal when viewed a few feet away. But on two plants, he found over 1000 aphids per plant! He found them colonizing the whole plant, including leaves, stems, and pods. A single pod at stage R3.5 had 50 aphids present.

On August 15, Wisconsin researchers sent samples of the insect to aphid experts in Illinois (David Voegtlin of Illinois Nat. Hist. Surv.) and to the USDA (Manya Stoetzel of the USDA Systematic Entomology Laboratory, Beltsville, MD). The insects were identified by both experts as the soybean aphid, an introduced pest, not the native cotton/melon aphid as previously believed.

By August 18, aphid populations had begun to subside in Wisconsin. Many had been killed by fungus disease and perhaps insect predators (C. Grau, personal
communication). Little seems to be known about losses from this aphid in the Wisconsin discovery area.

**Subsequent Reports and Current Known Distribution**

After the Wisconsin discovery was advertised, subsequent reports began to be received. Early on, these were from Michigan and Illinois. Continued reports of aphid presence surfaced after focused searches for the species in soybeans. Currently, the pest has been confirmed in the following states: Kentucky, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.

Iowa surveys for the aphid were conducted by Iowa State Entomologist personnel (IDALS) from August 22 through September 1, 2000. Plants in representative fields were inspected and counts made by direct observation. Usual numbers were very low, with no expected effect on soybean yield. A map showing the results of this survey is given in Figure 1. About half of the Iowa counties, occurring east of a diagonal from Hancock to Lee County, seems to have been infested.

It seems that the soybean aphid was not a new arrival this season. Based on numbers and distribution, Wisconsin entomologists believe it has been here for several years. Manya Stoetzel, a USDA aphid specialist, believes that an introduced aphid species has to be present for three to four years before they can be detected at all (personal communication). This would seem so for the soybean aphid because of its U.S. distribution from Wisconsin to Kentucky and Iowa to Ohio.

It is only speculation on how the soybean aphid was introduced. A thought is that it may have been brought into the Great Lakes states with shipping. It would seem that the only stage that could survive transfer from Asia would be the egg stage. The egg, found on buckthorn plants where it overwinters, would likely be the most resilient and least detectable in shipments. This speculation is supported by reports of importation of buckthorn cultivars for breeding purposes in the U.S. However, there is no direct proof that these speculations are true.

What we know about the soybean aphid is mostly based on research done in China and other Asian countries. To find out about the species, much of the literature had to be translated from Chinese. What follows is mostly based on Asian work with this insect. A useful website on appearance, biology, and literature of this pest is www.agric.nsw.gov.au/Hort/ascu/insects/aglycin.htm.

**Aphid Biology and Distribution**

**World Distribution**

The literature on the soybean aphid reflects where it has been found and has caused problems. In addition to the U.S., the soybean aphid is distributed in China,
Japan, far eastern Russia, Korea, Thailand, Borneo, Malaya, Philippines, Indonesia, and, more recently, Australia (Blackman and Eastop 2000).

Identification

The soybean aphid is a small insect, adults being about one-sixteenth inch long (Blackman and Eastop 2000). They are pale yellow and have dark-tipped tubes, called cornicles (siphunculi), on the back of the abdomen. A projection on the lower tip of the abdomen, called the cauda, is pale and contrasts with the color of the cornicles. These aphids feed though piecing sucking mouthparts and have both wingless and winged forms.

Colonization of Soybeans

Unlike other native aphids, the soybean aphid colonizes soybeans. Females of this species feed and stay on soybeans to produce offspring though several generations. Previous Iowa studies identified six native aphid species in soybeans. Only two, the corn leaf aphid and the potato aphid, occurred at densities large enough to study their population fluctuations (Hammond and Pedigo 1982). Neither of these species reproduce in soybeans, but they do probe the plants with their mouthparts. Along with that of other aphid species, such probing is largely responsible for the transmission of soybean mosaic virus (Hill et al. 1980).

Seasonal Insect Cycle

The seasonal cycle of soybean aphids is complex, showing alternation of hosts and reproductive mode. The Chinese literature (Wang et al. 1962) indicates that the primary host there is a buckthorn, Rhamnus daverica (as davuricus) Pallas. Eggs are produced on this buckthorn in fall and overwinter there. The eggs hatch in spring, giving rise to wingless females. These wingless females are parthenogenetic (reproduce without mating) and produce winged females that migrate to soybeans. Those founding females produce wingless females that also reproduce without mating and give rise to active young (viviparous reproduction) on soybean plants in late May and June.

The species is reported to pass through about 15 generations in soybean during the growing season, producing both winged and wingless forms. In China, two seasonal peaks occur, one in July and the other in September (Fig. 2). The greatest damage has been reported from the first peak, about the time of flowering. Near soybean maturity, winged aphid males are produced, as well as winged parthenogenetic females, both of which migrate back to buckthorn. The winged parthenogenetic females then produce wingless sexual females that mate with the winged males. These mated females subsequently lay eggs, beginning a new seasonal cycle.

The flight of aphids to buckthorn seems a critical link to success of this pest. Iowa has records of six buckthorn (Rhamnus) species, including the R. davurica host reported by the Chinese. However, common buckthorn (R. canthartica), is the most
prevalent in northern Iowa and lance-leaved buckthorn (*R. lanceolata*) in southern Iowa. Researchers in Michigan and Wisconsin have observed soybean aphids on common buckthorn at the edge of soybean fields, presumably colonizing it as a host (personal communication C. DiFonzo and C. Grau). A late September and early October 2000 survey of common buckthorn in Blackhawk, Clayton, Dubuque, and Johnson counties by R. Pope (I.S.U. Cooperative Extension) yielded no aphid records on this host.

**Aphid Ecology**

As with other aphids, soybean aphid populations have been strongly influenced by environmental conditions. Studies by Hirano et al. (1996) showed that developmental time decreased with increasing temperature up to 81°F. Developmental time increased after that. Reproduction decreased 25% from 72°F to 81°F, seemingly because females do not live as long at the higher temperatures. Therefore, the pest seems to do better in cooler environments (72°F to 77°F, with relative humidity below 78%, optimum), and this is supported by the fact that it is more of a problem during winter in some subtropical areas (Talekar and Chen 1983).

Soybean aphid survival and population dynamics also are affected by many natural enemies, including insect predators, parasites, and disease. Lady beetles seem to have a suppressive influence at low population levels but not early in the season (up to soybean flowering) when aphids are having their strongest impact. Other notable predators include lacewing and flower fly larvae. Effective parasitism was found in Korean parasitoids of the wasp genera *Aphidius* and *Ephedrus* (Chang et al. 1994). In the Philippines, other wasps of the family Braconidae were noted (Quimio and Calilung 1993), but their buildup lagged the increase in aphid populations, resulting in poor correlation with aphid numbers. Also, fungus epidemics have been observed in aphid populations. Such an epidemic was observed in Wisconsin the middle of August 2000, which was believed partly responsible for the decline in late-season aphid densities (D. Hogg personal communication).

**Impact on Soybeans**

Winged soybean aphids reportedly colonize soybeans in stage V1, producing wingless females that feed especially on young and developing leaves. Aphids feed by sucking plant sap, which can cause leaf curling and plant stunting. As the plants grow, aphid populations expand to the middle of the plant and feed on the underside of leaves (Wang et al. 1962). Losses of up to 52% have been quantified from this injury with early season experimental infestations (Wang et al. 1994). At least in some locations studied, the impact of aphid feeding on soybean yield later in the season is minor, unless virus is present (van den Berg et al. 1997).

The soybean aphid has had the ability to transmit viruses wherever it occurs. These viruses include soybean mosaic virus (SMV) (Halbert and Goodman 1981), which is of primary concern in Iowa. SMV can cause significant yield loss, particularly
important when plants are also infected with other viruses such as bean pod mottle virus (transmitted by the bean leaf beetle).

Fifteen Philippine aphid species were studied for transmission efficiency in the greenhouse and field by Quimio and Calilung (1993). They found that the soybean aphid was the most efficient transmitter of the virus, requiring from 5 to 30 minutes of feeding time to efficiently transmit it. Cooperative studies between Iowa State University (J. Hill) and the University of Wisconsin (C. Grau) just recently showed that the aphid is capable of transmitting Iowa SMV strains to soybeans.

Soybean Aphid Management

Management activities for most soybean insect pests consist of scouting, use of thresholds, insecticide applications when necessary, and prevention through cultural activities.

Scouting

Scouting, by taking aphid counts on soybean leaves, probably is the most practical method for soybean producers. Direct observation of aphids on soybean leaves is the most useful method for pest detection and determining pest status (economic thresholds) when densities are low (Irwin 1980). Gross estimates based on infestation scales also may be useful for expressing aphid abundance. One scale used for soybean aphids per plant in the Philippines is as follows: 1 = no aphids, 3 = winged aphids to small colony, 5 = several colonies, 7 = many distinct colonies, and 9 = many indistinct colonies (Bandong and Litsinger 1976). Such scales are useful for comparing aphid densities among different locations or among different times at the same location.

Scouting methods for the soybean aphid in Iowa soybeans have not been investigated at this time. Therefore, any recommendation could have serious flaws. However, scouting must be conducted to determine aphid presence and abundance. Tentatively, we suggest a program of visiting five field locations per 20 acres, beginning at stage V2. At each site, five plants can be picked, then leaves turned over, and leaves searched for aphids. As plants grow, leaves can be picked from the top, middle and bottom of the five plants for aphid detection. It seems that observations should be made every one or two weeks until flowering. If aphids are present, estimates of aphid numbers per plant should be attempted. Numbers per leaf and numbers of leaves per plant might be useful in making large-plant estimates. Because these aphids are small, a hand lens or magnifying glass would be very helpful.

Economic Threshold

In pest management, scouting for pest presence and abundance is of little use without having appropriate decision guidelines. Such guidelines are usually given as economic thresholds. Economic thresholds have been developed by the Chinese from studies of soybean yield from infested field plots (Wang et al. 1994). In these studies,
plots were infested with soybean aphids at the two-leaf stage (V2), aphids were allowed to feed and reproduce, all plots were sprayed at flowering to eliminate late season infestations, and yields were taken.

To develop a tentative economic threshold for Iowa soybeans, we used the data from Wang et al. (1994) and fitted a logarithmic statistical model to it. The resultant yield loss curve and statistical model are shown in Figure 3. We used the model to determine the number of aphids per plant at the two-leaf stage (V2) required to produce a later damaging population for a 5 to 6 percent yield loss. With a production of 40 to 50 bushels per acre, we believe that this percentage would offset one insecticide application, i.e., this would be the gain threshold. At that gain threshold, the model predicts that 3.9 aphids per plant would produce a population to cause an economic loss. This would be the economic threshold. In other words, if action were taken against 4 aphids/plant at stage V2, we would not expect the aphid population to grow to a density capable of causing economic loss in yield. Quite likely, insecticide applications could be made within two or three weeks of the assessment and not result in significant loss.

Caution needs to be applied to this recommendation, however. First and foremost, it is based on data from Chinese soybeans. Iowa soybeans may not respond similarly. Secondly, the aphid population may not have the same growth potential in Iowa as it does in China, producing error in the threshold estimate. Furthermore, the pest may transmit SMV in Iowa, probably resulting in much lower thresholds and different management strategies for preventing loss. Therefore, our economic threshold is submitted as a tentative estimate, one that needs to be validated with thorough field and laboratory research.

Insecticides

If soybean aphids produce potentially economic populations, there probably are insecticides available to suppress populations. Some of the insecticides investigated in other countries include disulfoton (Disyston®) and carbofuran (Furadan®) granules at planting, which reduced aphids until July (Kobayashi et al. 1976, Hwang et al. 1981). Other insecticides, effective as early season sprays, included fenvalerate (related to esfenvalerate, Asana®) (Qu et al. 1987) and pirimicarb (Pirimor®, Rapid®) (Wang et al. 1993), an effective aphicide used in alfalfa, lettuce, cereals, and vegetables.

Likely candidates for early testing against soybean aphid in the Midwest include esfenvalerate (Asana®) and lambda-cyhalothrin (Warrior®). Both of these advanced pyrethroid insecticides are labeled for use on soybeans. Although still being evaluated, research in Wisconsin using lambda-cyhalothrin in small plots this past season showed a yield increase believed, in part, from having reduced aphid numbers (C. Grau, personal communication).
Preventive Tactics

In addition to insecticides, some preventives may help. Certainly, eliminating overwintering hosts would seem to reduce soybean aphids populations. Therefore, when possible, buckthorn should be removed from field edges and other locations, making the host less accessible for overwintering. Moreover, early planting may allow soybeans to escape aphid population buildup and virus disease. This proposition is based on work by Irwin and Schultz (1981) who found highest aphid numbers (not soybean aphid) on the younger plants present in the later plantings. However, early planting also encourages bean leaf beetle colonization, so such should be considered carefully before implementation.

Planting seed of resistant plants may also be an option for future management programs. Currently, there are no commerical soybean cultivars resistant to soybean aphid. However, Zhuang et al. (1996) found several species of wild perennial soybeans highly resistant to both the soybean aphid and SMV. The germplasm from these highly resistant accessions could be used in soybean breeding and especially in biotechnology. Indeed, two lines of transgenic soybeans have already been developed at Iowa State University with tolerance to SMV (Wang et al. 1998). Further development may allow adapted varieties for use in management of disease and perhaps management of the aphid, as well.

Prognosis for Iowa

What the pest will do in Iowa regarding continued establishment and spread is anyone’s guess. We can speculate that our summers may be too hot and humid for the large populations that developed in Wisconsin in 2000. Another factor that may limit soybean aphid population growth is adequate buckthorn occurrence for overwintering. It can only be hoped that most Iowa environments are not conducive to pest buildup.

With its widespread occurrence, the soybean aphid seems well established in the U.S. Therefore, eradication is likely not feasible. Probably, the Iowa farmer’s best bet is to not over exaggerate the problem and to be vigilant. Looking for aphid populations in fields early in the 2001 growing season and reporting findings to county extension personnel and area crop production specialists seems the best path to follow. Farmer observations will be supplemented by an IDALS and Iowa State University cooperative soybean aphid surveillance program, allowing us to be forewarned and forearmed when and if serious problems occur.

Literature Cited


Figure 1. Soybean aphid distribution in Iowa.
Figure 2. Seasonal cycle of the soybean aphid in China.
Figure 3. Percentage soybean yield loss resulting from infestations of different levels of the soybean aphid in China. Data from Wang et al. (1994).

\[ y = 13.324 \ln(x) - 18.075 \]

\[ R^2 = 0.991 \]