LESSONS ON SOYBEAN APHID IN 2000 AND 2001

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Background

The soybean aphid *Aphis glycines* Matsumura, a serious pest of soybean in China, was first detected in the U.S. on 13 July 2000 in a research trial conducted by the authors on a private farm near Whitewater, WI. Although the aphids we collected appeared to be the cotton/melon aphid, an aphid already present in the U.S., we forwarded specimens to Dr. David Voegtlin at the Illinois Natural History Survey for additional examination. Dr. Voegtlin determined that the aphids were soybean aphid; the cotton/melon aphid and the soybean aphid closely resemble one another and separation of the of the identities of the two species is difficult. The cotton/melon aphid, *Aphis gossypii*, is reported to colonize on soybean in China. And there also are reports that the two species can hybridize when the overwinter on the same plant. By the fall of 2000, the presence of soybean aphid had been confirmed in nine states, but it appears that the heaviest infestations were present in Wisconsin, Michigan, and northern Illinois.

Life History

Most of our information is based on literature from China and a few other Asian countries (Takashi et al., 1993), where the optimal range of temperature and humidity for the aphid has been reported to be from 71-77 ^{o}F and less than 78%, respectively (Wang et al. 1962). During 2000 the soybean aphid's behavior in Wisconsin was very close to that reported by Wang et al. (1962). In China, the winter host is *Rhamnus davurica*, a species of buckthorn. The summer host range is limited to wild and cultivated soybean. Although *R. davurica* is not known to occur in Wisconsin, we have at least 5 other species of buckthorn and some of these have escaped cultivation as a landscape plant and can be found in wood lots, fence rows and similar areas. Additionally, winged forms of the soybean aphid have flown from soybean plants to cuttings of buckthorn in laboratory trials conducted at the University of Wisconsin Department of Entomology. Buckthorn is critical to survival of soybean aphid because it lays eggs on buckthorn in the fall. To survive winter in the upper Midwest, aphids must produce cold tolerant eggs.

Three periods of damage to soybean have been identified in China:

- From seedling stage to blooming stage of soybean, the aphid population reaches its highest peak. Its colonies concentrate on tender leaves and branches (i.e. new trifoliolate leaves).
- In late July, the top growing point of soybean stops growing, the aphids move from the top of the plant to middle or lower areas of the canopy and feed on the undersides of soybean leaves. At this time of the year, soybean aphids are much smaller, and more yellow than forms found earlier in the growing season.

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- From late-August to early-September the aphid colonies begin to multiple rapidly again. After this they migrate back to the overwintering host, where eggs are laid for winter.

The winged aphids that move from buckthorn to soybean early in the growing season are all females and they give birth to living young without fertilization, by an asexual process called parthenogenesis. They colonize stem apices and young leaves first. Winged and wingless females are present during the growing season, and the winged forms will leave plants to seek out new soybean plants when populations become crowded, or perhaps in response to a decline in plant quality.

The parthenogenetic females give birth to winged males that fly to buckthorn to mate with females during late summer to early fall. Reproduction is now sexual, rather than asexual, and the females lay eggs on the buckthorn plant. During 2000, we first detected winged sexual aphids in a late- planted soybean field on 29 September, which was a few weeks later than the timetable described for China.

Damage

The soybean aphid damages soybean by sucking plant sap and stressing the plant. They are also capable of transmitting plant viruses during the feeding process. Affected plant parts include the whole plant, leaves, stems and growing points while affected plant stages include seedling, vegetative, and flowering. Two of the viruses it is known to vector in China, soybean mosaic potyvirus and bean yellow mosaic virus, are already present in the U.S. It is not possible to control the spread of these viruses by controlling the aphids with insecticides.

Heavily infested plants are stunted and have distorted leaves; sooty mold grows on the honeydew excreted by the aphids and this results in charcoal-colored residue on stems, leaves and pods. In Wisconsin during 2000, many of the infested fields we visited also exhibited leaves with a yellow halo around the leaf edge that is also a symptom of potassium deficiency. Premature leaf drop can result when aphid infestations are heavy, but such leaf losses are also associated with potassium deficiency. Tissue testing and subsequent soil tests in fields expressing these symptoms during 2000 indicated the plants were potassium deficient. Perhaps the stress from aphid feeding exacerbated the effect of potassium deficiency.

Wang et al. (1994) inoculated soybean at the two-leaf stage with 5-220 soybean aphids per plant. The number of aphids per plant and plant infestation rate were closely related to yield losses, which were 2.7 - 51.8% at 5-220 aphids per plant. Aphid infestation at the seedling stage affected yield mainly by reducing plant height and numbers of pods and seeds.

Wang (1996) also reported that heavily infested plants (greater than 70,000 aphids per 100 soybean plants) had fewer pods per plant, lower test weight of seed, and reduced yield. Anecdotal information from China indicates that growers spray from two to five times during seasons with high aphid abundance.

Relationship between planting date and damage. Wisconsin fields that were double-cropped after a previous crop, such as succulent peas produced for processing, had higher aphid numbers and greater expression of injury symptoms than fields that were planted from late-April to mid-May. It is not know if the late-planted fields (after mid-June) were more attractive to colonizing aphids or if the nutritional quality of the younger plants provided for a more rapid build-up in aphid populations.

Variety Response

Results from University of Wisconsin and seed company variety trials indicate the aphids demonstrate varietal preferences that are distinct from maturity effects. Table 1 summarizes data for a variety trial conducted near Whitewater, Wisconsin in which we monitored aphid populations and leaf area index. Plots were planted on15 May and aphid populations were sampled on 16 August 2000 by taking 5 leaf core samples (3.9 cm in diameter) from the upper part of the plant canopy in each plot. In addition to significant differences in aphid numbers among varieties, the leaf area indices taken during the R2, R4, and R6 stages suggest a differential variety response to aphid feeding.

Role of Biological Control in 2000

Harmonia axyridis, the imported Asian lady beetle**,** was the most common predator associated with aphid infested fields during 2000. Although, along with green lacewing larvae; damsel bugs; minute pirate bugs; syrphid maggots and cecidomyid larvae, they took a tremendous toll on aphid numbers, predators will probably be unable to keep aphid numbers below damage thresholds during severe outbreaks. The aphids can produce young too rapidly for predators, alone, to bring populations under control. Additionally, we did not find high levels of parasitism of aphids. An as-yet unidentified fungal pathogen(s) was the major biological control factor and was the major component responsible for the crash in aphid populations during August. Aphids that are killed by this aphid are brown to reddish-brown and are usually found on the lower surface of the soybean leaf.

Insecticides

Farmers that decided to spray for soybean aphids during 2000 were faced with a situation in which there were no insecticides labeled for aphids in soybean, nor were there insecticide efficacy data available for soybean aphids. Applicators used insecticides labeled for soybean that were labeled for aphids on other crops. Results were mixed, but most insecticide application occurred when the plant canopy was closed and aphids had moved down the plant and located on the lower surface of leaves. Most of the aphids probably escaped insecticide contact.

Table 1. Comparison of soybean cultivars for aphid population density and leaf area index ratings (LAI), Whitewater, WI.

Company	Entry	8/16/00 Aphids per Sample‡	7/14/00 LAI† (R2 Stage)	8/14/00 LAI† (R4 Stage)	9/7/00 LAI† (R6 Stage)
Asgrow	AG 2201	39	1.93	4.45	3.31
Asgrow	AG2401	32	1.90	3.95	3.06
Asgrow	AG2301	37	2.02	4.21	3.59
Asgrow	AG2001	79	1.89	4.65	3.55
Dairyland	DSR218	76	1.99	4.04	2.69
Dairyland RR	DSR241	38	2.07	4.94	3.85
Dairyland	DSR277	20	1.91	4.38	3.39
Golden Harvest	H-2519	32	2.15	4.01	2.97
Hughes	Hughes225	50	1.87	3.87	2.28
Hughes RR	Hughes261	45	1.78	3.50	2.80
LG Seeds	LG6200	60	1.76	4.30	3.21
Mark	Mark9927	20	1.82	4.40	3.40
Midwest	G2380	24	2.16	3.88	3.39
Mycogen	MYC5261	27	1.79	4.31	3.23
Novartis	S24-92	63	2.04	4.52	3.29
Public	Sturdy	49	2.37	4.31	3.06
Public	Corsoy79	139	1.70	3.77	2.81
Public	Hardin	79	1.77	3.19	2.55
Public	BSR101	55	2.39	4.70	3.18
Public	Jack	27	1.61	3.70	3.29
Public	Dwight	27	1.82	4.09	3.52
Spansoy	Spansoy 250	50	2.02	4.47	3.24
Spansoy	Spansoy 201	68	1.89	3.98	2.52
Trelay	Trelay248	35	1.76	4.16	3.05
Probability %					
Entry		<0.01	1.80	0.10	0.14
LSD (0.10)					
Entry		30	0.32	0.59	0.55
CV %		42	14	12	15

† LAI expressed in m/m^2

‡ Aphids per 19.5 cm diameter sample (6 leaf core samples per plot and 3.9 cm in diameter)

Table 2 summarizes the results of an insecticide trial at the University of Wisconsin Arlington Agricultural Research Station. The experiment was planted on 16 May 2000, in 30 inch rows and was being used to study the potential role of transient insects as vectors of soybean viruses prior to our discover of soybean aphids in Wisconsin. Spansoy 201 and 250, with and without protection with Warrior T 1EC were monitored throughout the season. Warrior was applied at 0.02 lb ai/a on 22 June (V2 growth stage), 5 July (V5), 14 July (R2) and 2 August (R4) to suppress insect populations. Aphids were sampled in each plot by taking 24 leaf cores,1.6 cm in diameter, and counting all aphids on each core.

Although there were no leaf abnormalities from aphid feeding in the unsprayed plots, plants were significantly shorter than sprayed plots, and the plant canopy took longer to close. The plant height and canopy differences are reflected in the leaf area index ratings (LAI) taken on each sampling date.

Table 2. Effect of Warrior 1EC on soybean aphid population density and soybean plant height University of Wisconsin Arlington Agricultural Research Station.

Variety	Treatment	Aphids per sample† 8/03/00	Height 8/03/00	Height 8/11/00	Height 8/24/00	Yield
			------------- inch		--------------	bu/acre
Spansoy201		51.0	31.1	33.4	35.2	
Spansoy250		44.0	29.7	37.1	42.4	
	None	86.0	28.9	33.5	37.0	
	Warrior	9.0	31.6	37.1	40.6	
Spansoy201	None	88.0	29.7	31.4	33.3	52.4
Spansoy201	Warrior	13.0	32.6	35.4	37.1	60.3
Spansoy250	None	84.0	28.1	35.6	40.7	45.9
Spansoy250	Warrior	4.0	30.6	38.7	44.1	51.8
	Mean	47.0	30.3	34.2	38.8	
Probability%						
Variety (V)		>50	10.8	3.1	0.38	
Treatment (T)		2.20	5.60	8.5	4.80	
V x T		>50	48.9	>50	>50	
LSD (0.10)						
Variety		NS‡	NS	2.20	2.10	
Treatment		17.3	1.50	3.10	1.70	2.60
CV%		62	2	5	4	

†Aphids per 38.4 cm diameter sample (24 leaf core samples per plot and 1.6 cm in diameter).
‡NS, not significant.

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