ECONOMIC IMPACT OF SOYBEAN APHIDS ON YIELDS
AND OPTIMAL INSECTICIDE TIMING EFFECTIVENESS

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Evaluating the Economic Impact of the Soybean Aphid

Widespread infestation of soybeans with soybean aphid across much of Wisconsin during the 2000 growing season prompted us to examine the economic impact this insect poses to the soybean crop in terms of direct yield losses (the potential yield losses due to virus transmission by the aphid are not addressed here).

The goal of this study is to examine the yield loss relationship of the soybean aphid to soybeans and attempt to quantify the damage caused by this insect. Furthermore, we would like to develop an economic threshold that will allow soybean producers to make intelligent decisions regarding aphid damage and control methods.

Methods

Small plot field experiments were established in two locations in 2001: at the Rock County Farm in Janesville, WI, and at the University of Wisconsin Agricultural Research Experiment Station at Arlington, WI. A single early planted (10 May) experiment was planted at Rock Co, while experiments were placed in both early planted (9 May) and late planted soybeans (11 June) at Arlington for a total of three experiments. The soybean varieties planted at Arlington were DSR215RR and NKS19-T9 for the early and late planted experiments respectively, and Jung 8226 was planted at Rock County. Both experiments at Arlington were planted in 30" row spacings while the experiment at Rock County was drilled into narrow rows. The seeding rate was 240,000 plants per acre for all three experiments.

Treatments were established as increasing rates of insecticides in an attempt to provide differential control of aphid populations, which would then allow us to relate aphid populations to yield losses. The five treatments used in 2001 were a multiple spray treatment which was sprayed on seven dates during the growing season, with alternating foliar applications of Warrior (?-cyhalothrin [0.030 lb aia]) and Lorsban (chlorpyrifos [0.50 lb aia]), a high (0.030 lb aia), medium (0.020 lb aia) and low rate (0.015 lb aia) of Warrior, and finally an unsprayed check treatment. Alternating insecticidal spray treatments of Warrior and Lorsban were used in the multiple spray treatment to attempt to avoid any potential insecticide resistance problems. The spray dates for the multiple spray treatments differed among the three experiments, and are listed in the attached tables. The other spray treatments were all sprayed on 26 July at the beginning of the peak of aphid populations.

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Aphid populations were sampled on a weekly basis beginning in the first part of July. We sampled 20 plants from the middle rows of each plot. A rating system was used to classify the number of aphids on a plant rather than count all of the individual aphids on each plant. Our ratings system is based on whole plant counts. The system assigns a rating of 1 for plants, which do not contain any aphids, a rating of 2 for plants with 1-10 aphids, 3 for plants with 11-25 aphids, 4 for plants with 25-50 aphids, 5 for plants with 51-100 aphids, 6 for plants with 101-200 aphids, and a rating of 7 for plants with greater than 200 aphids.

Results

In 2001, early populations of Soybean Aphids were first observed at the Rock County farm location during late June, and numbers were seen at Arlington approximately a week later. Weekly sampling data showed that early aphid populations initially grew at a slow rate during early to mid-July where they were primarily found on the early-planted experiments at both locations.

As plants in the late-planted (11 June) experiment reached the late vegetative stages toward mid to late July, aphid populations began to increase exponentially. This pattern was not seen in the early-planted experiments. Aphid counts in these earlier plantings showed aphid populations remained constant or only gradually increased in overall numbers as populations in the late planting rose rapidly. These data suggest that early-planted soybeans, while prone to initial attack may be less susceptible to soybean aphid attack when aphid numbers are large.

Sampling: Rock County

The unsprayed check never averaged more than a rating in the low 3's – in the range of 25 aphids per plant. Aphids in single spray plots rebounded to numbers similar to the unsprayed check despite a spray application that was timed to coincide with peak aphid numbers.

Sampling: Arlington Early Planting

The early-planted experiment at Arlington showed overall higher numbers of Aphids especially in the later part of the growing season. The low and medium rate spray treatments were not effective in reducing aphid numbers over the long term. However, it should be noted that the higher sample ratings, which were seen later in the season (mid- to late-August) may not accurately reflect plant damage equivalent to the early-season populations as a late season morphological form comprised the majority of the aphid populations at this time. This late season morphological form was significantly smaller in size, and field observations indicated that these aphids were not actively feeding or reproducing to the same extent as the earlier aphid populations.

Sampling: Arlington Late Planting

Late planted field at Arlington received the highest overall numbers of aphids. Almost all of the treatments including the multiple sprayed treatment showed ratings indicating the majority of the plants contained more than 200 aphids/plant as early as 25 July. Spray applications while effective in controlling aphids over the short term did not

Yields

No significant difference in yield was observed among any of the treatments from the experiment at Rock County.

Yields from the early-planted experiment at Arlington showed, surprisingly, that the low rate spray treatment yielded the highest. However, other treatments decreased in yield in accordance to the amount of insecticide application that they received. There was about a 6- bushel difference between the unsprayed check treatment and the multiple spray treatment.

The late-planted experiment at Arlington sustained the greatest yield damage from aphid feeding. Yields loss was almost 9 bushels between the unsprayed check treatment and the multiple spray treatment. The high, medium, and low spray rate treatments showed yield decreases in order of their spray concentrations. However, the high spray rate did not differ significantly from the multiple spray treatment, which suggests that a well timed single spray application can be just as effective as multiple sprays in controlling yield losses.

Discussion

At Rock County aphid sample ratings peaked at 3.25 on 10 August with no reductions in yield. This gives us a good indication that aphid populations not exceeding 25-50 aphids per plant, will not reduce yields.

In the early planted experiment at Arlington aphid populations peaked at higher numbers than what we saw at Rock Co. especially later in the growing season. The medium, high and multiple spray rate treatments did the best job in controlling aphid numbers at the beginning of population peak. When comparing these to yield we were surprised to see that the low rate spray treatment showed the highest yield. However, it is important to note that the low rate spray treatment did not differ significantly from the multiple spray treatment or the high spray rate treatments. In this experiment only the unsprayed check treatment showed a significant yield loss, though it was a reduction of almost 6 bushels per acre.

In the late planted experiment at Arlington our results showed that sprays shortly after 25 July, when aphid populations were beginning to peak, that is when the majority of plants exhibited numbers of aphids exceeding 200 individuals per plant, were successful in preventing yield loss. The multiple spray and high rate spray treatments, which were the most effective in controlling aphid numbers also showed the highest yields, while the medium and low rate spray treatments were somewhat lower yielding. Contrasting to the early-planted experiment at Arlington the low rate spray treatment did not differ significantly for the unsprayed check.

The results from these experiments tell us that soybean aphid can cause significant yield losses, but the degree of damage varies among locations and planting dates. Early spray applications of sprays on low levels of aphids are not worthwhile for trying to prevent yield loss from aphid feeding. Early-season populations, i.e. the first appearance of aphids on early planted soybeans does not mean there will be yield loss in that field, and control applications should be avoided at this time. Planting later in the growing season has been proven to attract higher populations of aphids when these plants are still relatively young resulting in higher yield losses.

Considering a spray application cost of $15 per acre and a soybean value of $5 per bushel then any yield loss resulting from aphid infestation that exceeds 3 bushels per acre would warrant an insecticide application. Our yield data show that in many instances spray applications will warranted and effective in controlling yield losses from aphid feeding. However, spray appli-cation timing is crucial to preventing yield loss as aphid numbers can quickly rebound. The data from these experiments show that a well-timed spray at the beginning of the peak aphid popula-tion, as defined as when the majority plants show aphid numbers above 200 per plant, will pre-vent yield losses.

Finally, we need to refine our sampling methods to more accurately categorize higher aphid populations. The rating of "more than 200" aphids per plant does not accurately reflect the impact of plants that may have had thousands of aphids on them. Continuation of this work will involve improving the sampling methods used as well as evaluating the impact of the soybean aphid across multiple growing seasons.

Determining the Optimal Timing for Spray Treatments

One of the difficulties in controlling soybean aphids with traditional insecticides is that populations have the ability to quickly rebound from insecticide applications. Ideally one insecticide application made as aphid populations are nearing their peak would be applied to reduce populations to a level below the economic threshold.

The goal of this study is to determine the optimal timing for a single spray application of a broad spectrum insecticide applied soybeans to control soybean aphids.

Methods

Experiments were established similarly to the economic threshold study with an early and late planted experiment at the Arlington Agricultural Experiment Station at Arlington, WI, and a single early planted experiment at the Rock County Farm in Janesville, WI. Six treatments were established in each experiment. Treatments consisted of spray applications at four different plant growth stages during the season (V0-V1, V2-V3, R1-R2, and R3-R4), an unsprayed check, and a treatment which received multiple sprays on approximately 7-day intervals in attempt to keep it as free of aphids as possible. Spray timing studies were conducted in plots adjacent to the economic threshold experiments, so the general pattern of aphid population growth throughout the season was nearly identical.

The experimental design was a randomized complete block with four replications. Soybean varieties used were the same as those in the economic threshold study with respect to location and date of planting, and again all plots were seeded at a rate of 240,000 plants per acre.

Results

Treatments that were sprayed shortly after aphids were observed in the field (early vegetative stages) initially provided good control with some plots remaining nearly aphid free up to two weeks after spray applications were made. This was especially true in the early-planted experiments where aphid numbers did not reach the same magnitude as those in the late planted experiment. Unfortunately, after this initial period of good control, aphid numbers rebounded.

Treatments in late planted soybean which were sprayed at the R1 growth stage, later in the season (16 July) when aphid numbers were rapidly increasing did not provide long-term control of aphids. In fact some of the sprayed treatments showed higher numbers of aphids than in the unsprayed treatment only 10 days after a spray application was made. This is possibly due to the elimination of natural enemies in these plots.

Yields from the Rock County experiment showed no significant difference among any of the treatments. This field did not receive sufficient aphid number to cause yield losses, and in this case a spray treatment was not warranted.

The early-planted experiment at Arlington exhibited yield losses in all treatments in com-parison to the multiple spray treatment. The average yield loss in comparison to the multiple spray treatment was 9.6 bushels.

The late-planted experiment at Arlington also showed significant yield differences among the treatments. The multiple spray treatment yielded the highest overall and was 17.3 bushels greater that the unsprayed check treatment. All of the single spray timed treatments were significantly greater than the untreated check with the application on 31 July showing the greatest yield difference (16 bushels).

Discussion

The results from these three experiments again indicate that aphid populations vary among locations and planting dates, although overall yield differences among the treatments at the experiments at Arlington were greater than those in the economic threshold study.

While none of the spray treatments showed an improvement in yields over the untreated check at the early-planted experiment in Arlington, the results from the late planted experiment showed that sprays later in the season were quite effective in preventing yield losses. These data suggest that a spray application timed to coincide with the beginning of peak numbers, the R1-R2 plant stage in the case of the late planting, can be just as effective in preventing yield losses as multiple sprays.

Correctly timing spray applications in accordance with aphid numbers in the field may be a more important consideration that basing insecticide applications on plant stage. During the 2001 growing season, aphid numbers began to peak during the end of July in most areas. Our data show that sprays made during this time period were the most effective in preventing yield loss. Continued studies will help to determine seasonal variations of aphid numbers over multiple years, and provide the information accurately predict optimal insecticide spray application timing.

Economic Threshold Study – Rock Countyt - Early Planting
Rock County, WI
Soybean Variety: Jung 8226
Planting Date: 10 May2001
Experimental Design: RCB w/ 6 Replications, Each Plot 21' x 10" (4 rows in a 30" row planting)

Treatment	Spray Dates	Aphid Samp ling 7/6	Aphid Sampling 7/13	Aphid Sampling 7/19	Aphid Sampling 7/27	Aphid Sampling 8/10	Aphid Sampling 8/20	Aphid Sampling 8/31	Yield Bu/A
Unsprayed Check	-	1.56 B	2.18 AB	2.85 A	2.61 A	3.23 AB	1.66 A	1.42 AB	75.3 A
Low Rate Spray (Warrior 0.015 lbs aia)	7/26	1.94 A	2.35 A	2.94 A	1.94 B	3.11 B	1.77 A	1.52 AB	75.7 A
Med Rate Spray (Warrior 0.025 lbs aia)	7/26	1.62 AB	2.30 AB	2.70 A	1.79 BC	3.25 A	1.87 A	1.62 A	75.5 A
High Rate Spray (Warrior 0.030 lbs aia)	7/26	1.50 BC	1.88 B	2.64 A	1.53 C	3.18 AB	1.65 A	1.57 AB	75.9 A
Multiple Spray (Lorsban 0.50 lbs aia Warrior 0.030 lbs aia)	6/26, 7/6, 7/10, 7/16, 7/26, 8/9	1.18 C	1.02 C	1.01 B	1.14 D	0.64 C	0.61 B	1.32 B	72.5 A
LSD		0.36	0.46	0.38	0.32	0.12	0.36	0.26	4.87

Aphid sampling based on whole plant counts of 20 plants per plot Yields are based on harvest of middle rows of each plot.

1=0 Aphids
2=1-10 Aphids
3=11-25 Aphids
4=26-50 Aphids
5=51-100 Aphids
6=101-200 Aphids
7=200+ Aphids

Economic Threshold Study – Early Planting
Arlington, WI
Soybean Variety: DSR215RR
Planting Date: 9 May2001
Experimental Design: RCB w/ 6 Replications, Each Plot 21' x 10" (4 rows in a 30" row planting)

Treatment	Spray Dates	Aphid Sampling 7/5	Aphid Sampling 7/11	Aphid Sampling 7/18	Aphid Sampling 7/25	Aphid Sampling 8/1	Aphid Sampling 8/8	Aphid Sampling 8/16	Aphid Sampling 8/28	Yield Bu/A
Unsprayed Check	-	2.37 A	3.15 A	2.90 A	3.38 A	2.92 A	6.58 A	6.52 A	0.83 B	56.5 C
Low Rate Spray (Warrior 0.015 lbs aia)	7/26	2.01 A	3.22 A	3.13 A	3.67 A	2.15 B	6.86 A	6.67 A	0.86 B	63.3 A
Med Rate Spray (Warrior 0.025 lbs aia)	7/26	2.37 A	3.38 A	2.83 A	3.25 A	1.66 C	6.81 A	6.55 A	0.84 B	57.9 BC
High Rate Spray (Warrior 0.030 lbs aia)	7/26	2.63 A	3.74 A	3.24 A	3.43 A	1.48 C	6.71 A	3.30 B	0.97 A	60.3 ABC
Multiple Spray (Lorsban 0.50 lbs aia Warrior 0.030 lbs aia)	6/26, 7/6, 7/10, 7/16, 7/26, 8/9	1.01 B	1.01 B	1.01 B	2.23 B	1.38 C	4.19 B	1.78 C	0.58 C	62.4 AB
LSD		0.78	0.73	0.63	0.78	0.45	0.51	0.74	0.11	4.83

Aphid sampling based on whole plant counts of 20 plants per plot Yields are based on harvest of middle rows of each plot.

1=0 Aphids
2=1-10 Aphids
3=11-25 Aphids
4=26-50 Aphids
5=51-100 Aphids
6=101-200 Aphids
7=200+ Aphids

Economic Threshold Study – Late Planting
Arlington, WI
Soybean Variety: NK S19-T9
Planting Date: 11 June 2001
Experimental Design: RCB w/ 6 Replications, Each Plot 21' x 10" (4 rows in a 30" row planting)

Treatment	Spray Dates	Aphid Sampling 7/11	Aphid Sampling 7/18	Aphid Sampling 7/25	Aphid Sampling 8/1	Aphid Sampling 8/8	Aphid Sampling 8/16	Aphid Sampling 8/28	Yield Bu/A
Unsprayed Check	-	1.57 AB	2.86 BC	5.53 AB	5.04 A	6.93 A	6.98 A	2.52 A	47.2 C
Low Rate Spray (Warrior 0.015 lbs aia)	7/26	1.65 A	3.88 AB	6.91 A	3.34 B	6.88 A	6.98 A	2.42 A	48.1 C
Med Rate Spray (Warrior 0.025 lbs aia)	7/26	1.59 AB	4.66 A	7.00 A	3.00 B	6.86 A	6.97 A	2.52 A	49.8 BC
High Rate Spray (Warrior 0.030 lbs aia)	7/26	1.71 A	4.11 AB	6.89 A	2.33 BC	6.88 A	4.37 B	2.08 B	52.6 AB
Multiple Spray (Lorsban 0.50 lbs aia Warrior 0.030 lbs aia)	6/26, 7/6, 7/10, 7/16, 7/26, 8/9	1.29 B	2.28 C	5.17 B	1.63 C	5.28 B	2.08 C	1.10 C	55.9 A
LSD		0.34	1.32	1.59	1.13	0.46	0.33	0.29	4.10

Aphid sampling based on whole plant counts of 20 plants per plot Yields are based on harvest of middle rows of each plot.

1=0 Aphids
2=1-10 Aphids
3=11-25 Aphids
4=26-50 Aphids
5=51-100 Aphids
6=101-200 Aphids
7=200+ Aphids