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Evaluation of Soybean Aphid-resistant Soybean Lines

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Abstract
The soybean aphid, Aphis glycines (Hemiptera: Aphididae), is a consistent pest of soybean in Iowa. Current management is heavily reliant on the use of insecticides, which can be expensive and time consuming to apply. Soybean varieties resistant to the aphid are available. These varieties primarily include one resistance gene (Rag1) for soybean aphid control. Varieties incorporating two genes (Rag1 + Rag2) have recently become available. We sought to compare soybean lines susceptible to the soybean aphid with lines carrying a single resistance gene (Rag1 or Rag2) and a line carrying two resistance genes (Rag1 + Rag2). We evaluated the lines based on aphid control and yield protection.

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Evaluation of Soybean Aphid-resistant Soybean Lines

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Introduction

The soybean aphid, *Aphis glycines* (Hemiptera: Aphididae), is a consistent pest of soybean in Iowa. Current management is heavily reliant on the use of insecticides, which can be expensive and time consuming to apply. Soybean varieties resistant to the aphid are available. These varieties primarily include one resistance gene (*Rag1*) for soybean aphid control. Varieties incorporating two genes (*Rag1* + *Rag2*) have recently become available. We sought to compare soybean lines susceptible to the soybean aphid with lines carrying a single resistance gene (*Rag1* **or** *Rag2*) and a line carrying two resistance genes (*Rag1* **+** *Rag2*). We evaluated the lines based on aphid control and yield protection.

Materials and Methods

Plots were established at the Iowa State University Northeast Research Farm in Floyd County, Iowa. The treatments were arranged in a split-plot design with four replicates. Soybean line was the whole-plot factor and insecticide was the split-plot factor. Four experimental soybean lines were used for the experiment. The lines were developed by the soybean breeding program at Iowa State University and were near-isogenic (BC_1, sharing 75% genetic identity) for the soybean aphid resistance genes *Rag1* and *Rag2*. The four lines were termed 'susceptible,' *Rag1*, *Rag2*, and *Rag1* + *Rag2*. Each line was grown free of insecticides to measure the aphid control provided by each line and with foliar insecticides in order to measure the yield potential of each line. We were able to measure yield loss due to aphid feeding for each line by comparing the yield of the insecticide-free treatment and insecticide treatment.

Soybeans were planted in 30-in. rows using conventional-tillage (fall chisel plow, spring field cultivate) production practices on June 19. Each split-plot was six rows wide and 50 ft long. A foliar application of Warrior II CS® was made to each insecticide treatment split-plot when aphid populations reached 50 aphids/plant.

Soybean aphid populations were counted on five plants/split-plot each week. Aphid populations are reported as cumulative aphid days (CAD), a summary statistic similar to growing degree-days. Cumulative aphid days measure the plant's exposure to aphids throughout the season and have a strong correlation to yield loss. Economic injury is expected to occur around 5,200 CAD.

Plots were harvested on October 22. Yields were determined by weighing grain from the middle four rows of each split-plot with a hopper that rested on a digital scale sensor custom designed for the combine. Yields were corrected to 13 percent moisture and reported in bushels/acre. An analysis of variance (ANOVA) was used to determine the effect of soybean line on CAD (aphid control) and the effects of soybean line and insecticide treatment on yield. Means were separated using a least significant difference test (alpha=0.05) for the CAD data. A t-test was used to test for yield differences between insecticide treatments for each line (alpha=0.05).

Results and Discussion

Soybean aphid populations were high in 2013. On the susceptible line, aphid populations exceeded the economic injury by the end of August and peaked in the second week of September at ≈ 1,500 aphids/plant (Figure 1). Aphid populations for the single gene lines were reduced compared with the susceptible line, but still supported substantial aphid populations. Populations on the *Rag1* + *Rag2* line never exceeded 10 aphids/plant.

Aphid populations varied significantly across the four soybean lines (soybean line $P<0.0001$). Cumulative aphid day data revealed significantly reduced aphid populations on the *Rag2* line compared with the susceptible line. The *Rag1* line, however, did not significantly reduce aphid populations. The *Rag1* + *Rag2* line provided the greatest aphid population suppression, reducing CAD by >98 percent compared with the susceptible line (Figure 2).

The average yield in the insecticide treatment was 47 bushels/acre across the four soybean lines. Yield loss to soybean aphid did not occur equally across the four soybean lines (line × treatment $P=0.05$). The susceptible line experienced 18 percent yield loss, while the single gene lines experienced 7 percent yield loss (Figure 3). As expected from the low aphid populations present, the *Rag1* + *Rag2* line did not lose any yield to aphids. Farmers who grow soybean aphid-resistant varieties still will need to scout for soybean aphid. We observed marginal protection against soybean aphid provided by single gene lines. These single gene lines still required an insecticide treatment to achieve optimal yield. Single gene resistance makes up the majority of commercially available soybean aphid-resistant varieties.

In the future, farmers may be able to purchase more varieties incorporating two soybean aphid-resistance genes. Two gene lines provide increased aphid population suppression and eliminated the need for foliar insecticides in our experiment. Iowa State University has produced the first commercially available varieties incorporating two soybean aphid resistance genes. We encourage farmers, especially organic farmers, interested in experimenting with soybean aphid-resistant varieties to try these varieties on their farm.

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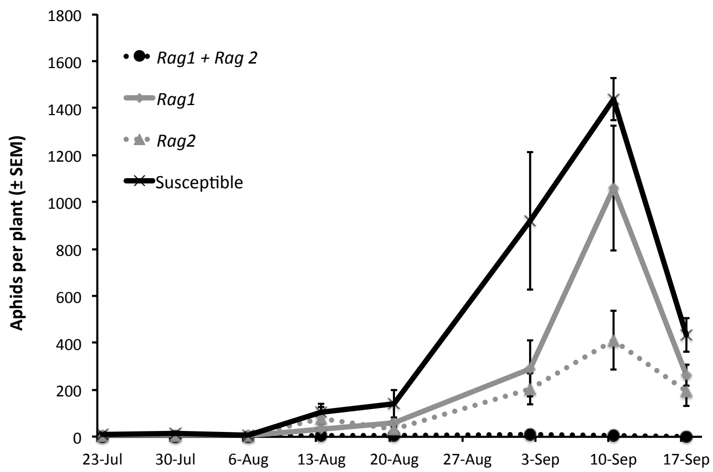

Figure 1. Soybean aphid populations throughout the 2013 experiment.

Figure 1. Soybean aphid populations exceeded the economic injury level (650 aphids/plant) on the susceptible and *Rag1* lines. Aphid populations remained below the economic injury level on the *Rag2* line, but still reached substantial populations. Aphid populations never exceeded 10 aphids/plant on the *Rag1* + *Rag2* line.

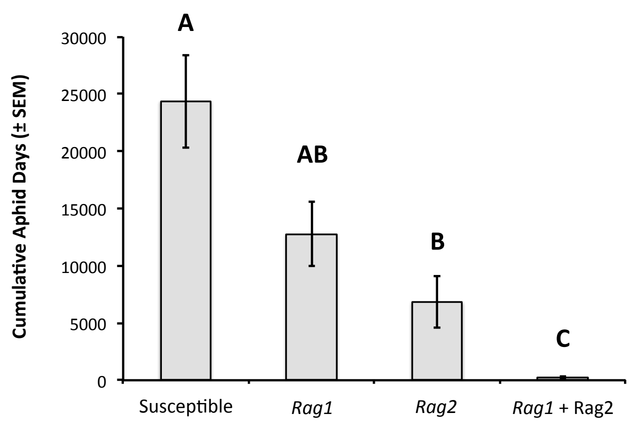

Figure 2. Cumulative aphid days across the four soybean lines.

Figure 2. Cumulative aphid days (CAD) are a measure of the plant's seasonal exposure to aphids and have a strong correlation to yield. We expect yield loss to occur around 5,200 CAD. Therefore, soybean lines are desired that maintain aphid populations below this level. Letters above bars represent significant differences among soybean lines at P<0.05.

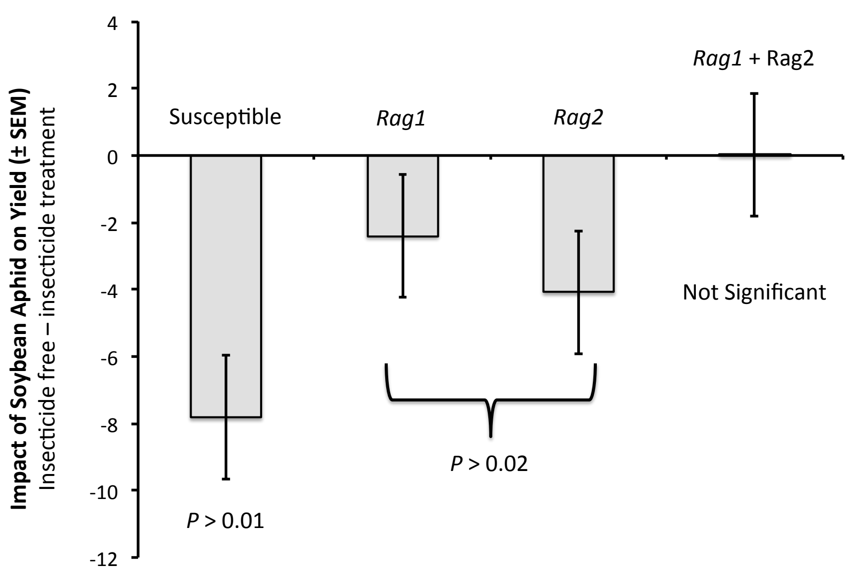

Figure 3. Impact of soybean aphid on yield of the four soybean lines.

Figure 3. The impact of soybean aphids on yield for each line was measured as the difference in yield between the insecticide-free and insecticide treatments. Yield of the insecticide treatment averaged 47 bu/acre across the four soybean lines. A *t*-test was used to determine differences among the insecticide free and insecticide treatment for each line. Only the *Rag1* + *Rag2* line did not lose yield to soybean aphids.