Blended Refuge Approach for Sustainable Management of Virulent Soybean Aphids

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Introduction

Soybean aphid (*Aphis glycines,* Hemiptera: Aphididae) is the most economically important insect pest of soybean in the North Central United States. While on soybean, aphids rapidly reproduce and can result in exponential population growth. An unmanaged aphid outbreak has the potential to reduce yield by 40 percent.

Foliar-applied insecticides are the most widely used management strategy for protecting yield loss from soybean aphid. Using varieties with aphid resistance genes (*Rag*) also is an effective strategy to suppress aphids. However, the emergence of virulent soybean aphid biotypes that persist on *Rag* soybeans has raised questions on the durability of this strategy. Inclusion of a susceptible refuge may be an effective strategy to preserve the efficacy of *Rag* genes. Blended seed mixtures (i.e., "refuge-in-a-bag") is an approach used in corn, but is not yet used in soybean.

We conducted a field experiment to test whether the blended refuge approach can protect yield while maintaining a population of soybean aphids.

Materials and Methods

We evaluated the effects of (a) host plant resistance (*Rag*), (b) inclusion of a susceptible refuge, and (c) foliar insecticide treatment on aphid population and yield. Insecticide treatment was included to estimate yield loss from aphids and genetic differences between resistant and susceptible plants. The experiment was designed as a split-plot randomized complete block design with four replicate blocks and four refuge mixes (main plot) that were treated or left untreated with a foliar insecticide (split plot).

Aphid-resistant variety LD12-15805Ra (*Rag1* + *Rag2*) and its susceptible isoline LD12-15838R were used. Both varieties were glyphosate-tolerant. Aphid-susceptible (S) and aphid-resistant (R) mixes were prepared before planting as follows: 100 percent S/0 percent R; 25 percent S/75 percent R; 10 percent S/90 percent R; and 0 percent S/100 percent R (hereafter mixes are referred to by susceptible percentage only). Mixes were planted in plots 100 ft x 80 ft (~ 0.18 acres) at 140,000 seeds per acre May 29.

Aphids were scouted in July and August. When aphid-free split plots exceeded 10 aphids/plant, they were sprayed with Cobalt® Advanced August 15. The number of aphids/plant was converted to cumulative aphid days (CAD) as a way to estimate the seasonal exposure of plants to aphids. Soybean seeds were harvested October 19. Yields were compared among all treatments.

Results and Discussion

Seasonal aphid exposure. Aphid populations were low in 2018. Despite low aphid populations, seasonal aphid exposure was significantly affected by refuge treatment ($F_{3,9}$ = 19.27, P = 0.0003) and insecticide treatment ($F_{1,12}$ = 7.98, P = 0.0153) (Figure 1A). CAD decreased as the amount of susceptible seeds in the mixture decreased. 100 percent S plots had the highest average CAD at 1,326.5 ± 407.8 (± SEM, standard error of the mean)

and 0 percent S plots had the lowest average CAD at 75.9 ± 16.1. In plots not treated with insecticide, the 25 percent S treatment (CAD: 383.4 ± 93) was the only blended refuge treatment showing significantly higher seasonal aphid exposure compared with 0 percent S. These results indicate that inclusion of a susceptible refuge did not affect the capacity of *Rag* genes to limit aphid outbreaks, but did maintain an aphid population consistent with refuge requirements.

Yield. There was no effect of refuge ($F_{3,9}$ = 0.78, P = 0.5367) or insecticide ($F_{1,12}$ = 1.05, P = 0.0.3263) on yield (Figure 1B). The average yield for all treatments was 62.6 ± 0.3 bushels/acre. Since aphid populations were far below the economic injury level (~5,500 CAD), the lack of yield difference was not surprising as these aphid pressures are not expected to cause yield loss. Additionally, aphid-free (insecticide) treatments provide evidence that aphid resistance genes *Rag1* and *Rag2* genes are not associated with yield drag.

Overall, the data suggests aphid-resistant soybeans blended with a minimum of 25 percent aphid-susceptible plants could serve as a refuge while still being effective for suppressing aphids in the field. Thus, blended refuge could be a viable resistance management strategy for soybean aphid.

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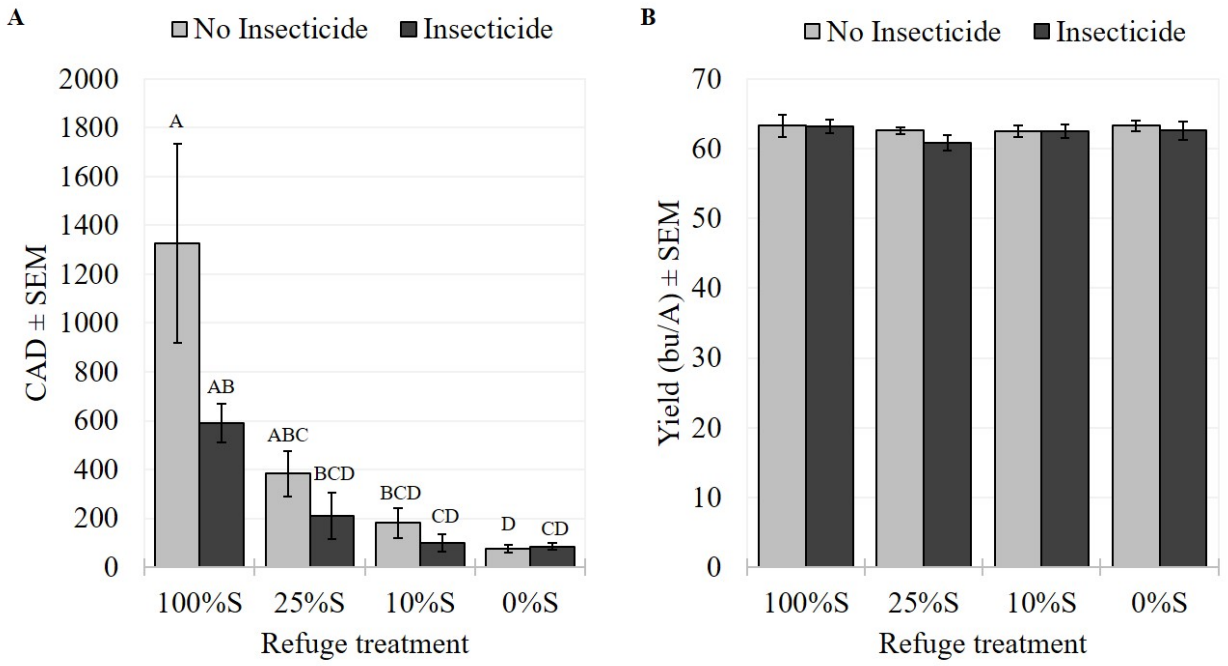

Figure 1. Season-long exposure of plants to soybean aphids (A) and yield (B) for each of four seed mixes based on amount of aphid-susceptible soybean (i.e. refuge) in the mix. Refuge and insecticide had a significant effect on aphids (CAD). No significant yield differences were detected.