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REPORT OF INSECTICIDE EVALUATION

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Insect Investigated
Soybean Aphid

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Iowa State University
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Table of Contents

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Introduction to Soybean Aphid

SOYBEAN, *Glycine max* (L.), grown in Iowa and most of the north central region of the United States has historically used low amounts of insecticide. However, an invasive insect has threatened soybean production in Iowa, with the arrival of the soybean aphid (*Aphis glycines* Matsumura). The soybean aphid causes yield losses from direct plant feeding, and has been shown to transmit several plant viruses. In Iowa, soybean aphid can colonize soybean fields in June and has developed into outbreaks in July and August capable of reducing yields by nearly 25% (Johnson 2006).

Since the arrival of the soybean aphid in Iowa, we have added considerably to our knowledge and understanding of this new pest. We know that just the presence of the aphid is not enough to warrant the application of an insecticide; populations above 650 aphids per plant are needed before economic injury will occur. Based on several years' worth of replicated field trials, we have developed a recommendation that incorporates an economic threshold (ET) of 250 aphids per plant (Ragsdale et al. 2007). This threshold should be used from flowering through seed set (R1-R5). In 2009, Iowa once again experienced economically significant populations of soybean aphid. Yield reductions as high as 8.5 bushels per acre were experienced in untreated control plots, and therefore there is a continued need for research on soybean aphid management in Iowa.

Materials and Methods

Northeast Research Farm plots and treatments. We established plots at the Iowa State University Northeast Research Farm in Floyd County, Iowa. The treatments were arranged in a randomized complete block design with six replications, and soybean (PB2636N RR) was planted in 30-inch rows using no-till production practices on 5 May. All of the seed had an fungicide seed treatment (Apron Maxx, mefenoxam + fludioxonil) except for the Cruiser Maxx treatment which contained an insecticide and fungicide (thiamethoxam + fludioxonil). Each plot was six rows wide and 50 feet long. In total for 2009, we evaluated 25 treatments with products alone or in combination (Table 1). The experiment included two controls: an untreated control, and a "zero aphid" treatment in which a tank-mix of two foliar insecticides (λ-cyhalothrin and chlorpyrifos) was applied every time aphids were detected. The two control treatments allowed for comparisons of yield protection against soybean aphid. Although seed treatments included a fungicide, we did not evaluate for plant diseases.

Johnson Research Farm plots and treatments. We established plots at the Iowa State University Johnson Research Farm in Story County, Iowa. The treatments were arranged in a randomized complete block design with four replications, and soybean (PB2494) was planted in 30-inch rows using no-till production practices on 13 May. Each plot was six rows wide and 50 feet long. In total for 2009, we evaluated 6 treatments with products alone or in combination (Table 2). The experiment included one untreated control.

Plant stand. Plant stands were taken at V2 at the Northeast Research Farm only on 9 June. Two 10-foot sections were randomly selected within each plot, and the number of emerged plants was counted. An average of the plant stand for each treatment is reported (Table 1). The reported stand is the number of plants per 10 ft of row.

Application techniques. For both locations, foliar treatments were applied using a backpack sprayer and TeeJet (Springfield, IL) twinjet nozzles (TJ 11002) with 20 gallons of water per acre at 40 pounds of pressure per square inch. Seed treatments were applied to the seed in a slurry before planting.

Estimation of soybean aphid populations and cumulative aphid days. Soybean aphids were counted on consecutive plants at randomly selected locations within each plot. The number of plants counted ranged from 20 to 5. The number of plants sampled was determined by the percentage of plants infested with aphids. When 0% to 80% of plants were infested with aphids, twenty plants were counted; when 81% to 99% of plants were infested, ten plants were counted; at 100% infestation, five plants were counted. All aphids (adults, nymphs and winged aphids) were counted on each plant. Summing aphid days accumulated during the growing season provides a measure of the seasonal aphid exposure that a soybean plant experiences. To estimate the total exposure of soybean plants to soybean aphid, we calculated 'cumulative aphid days' based on the number of aphids per plant counted on each sampling date. Cumulative aphid days are calculated with the following equation:

$$\sum_{n=1}^{\infty} = \left(\frac{x_{i-1} + x_i}{2} \right) \times t \qquad \text{equation [1]}$$

where x is the mean number of aphids on sample day i, x_{i-1} is the mean number of aphids on the previous sample day, and t is the number of days between samples i - 1 and i.

Yield analysis. Yields were determined by weighing grain with a grain hopper which rested on a digital scale sensor custom designed for each of the three harvesters. Yields were corrected to 13% moisture and reported as bushels per acre.

Statistical analysis. One way analysis of variance (ANOVA) was used to determine treatment effects within each experiment. The impact of treatments applied within each experiment on accumulation of aphid days was determined using log-transformed data to meet the assumptions of ANOVA. Means separation for all studies was achieved using a least significant difference test ($P \leq 0.05$). Treatment impacts on yield were determined using untransformed data. All statistical analysis was performed using SAS® software (SAS 2009).

Results

Northeast Research Farm. During the 2009 growing season, foliar insecticides were applied to the zero aphid plots three times (23 July, 6 August, 1 September) while other treatments were sprayed on 6 August (Table 1). Soybean aphid populations averaged 10 per plant two days prior to the 6 August application. In general, soybean aphid populations in the untreated control plots peaked on 11 September at 787 aphids per plant (Figure 1). The zero aphid control did significantly reduce cumulative aphid days compared to the other insecticide treatments; however, the yield was not significantly higher than most single application treatments (Table 2; Figure 2). The foliar applied insecticides we tested provided similar levels of soybean aphid control and yield protection (Table 2; Figure 2). Overall, a single application of a foliar insecticide provided as much yield protection as three applications applied in the zero aphid treatment. Soybean aphid reached over 10,100 cumulative aphid days in the untreated control treatment.

Johnson Research Farm. In 2009, foliar insecticides were applied on 12 August (Table 3). Soybean aphid populations averaged 412 per plant one day prior to the 12 August application. Populations in the untreated control plots peaked on 8 September at 1,480 aphids per plant (Figure 1). The untreated control treatment had significantly more cumulative aphid days and significantly lower yield compared to all other insecticide treatments (Table 4; Figure 3). Soybean aphid reached over 20,600 cumulative aphid days in the untreated control treatment.

Discussion

In 2009, aphid populations measured in untreated control plots reached 10,000 and 20,000 cumulative aphid days at the Northeast Research Farm and Johnson Farm, respectively. This is considered very significant pressure and is approximately three to six times greater exposure than in 2008. As with previous soybean aphid efficacy evaluations, there are few significant differences in performance amongst most of the foliar insecticides.

Our recommendation for soybean aphid management continues to scout your fields and to apply foliar insecticides when populations exceed 250 aphids per plant (see Ragsdale et al. 2007 for a more detailed description). One well-timed foliar application applied after aphids exceed the ET will protect yield and increase profits in most situations. Rarely is the ET exceeded twice in a single season and would require multiple applications. We are not recommending seed-applied insecticides (i.e., seed treatments) for aphid management, and we are not recommending one insecticide over another. Most foliar insecticides are very effective at reducing soybean aphid populations if the coverage is sufficient. At this time, achieving small droplet size to penetrate a closed canopy may be the biggest challenge to manage soybean aphid.

References

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Table 1. 2009 treatments and rates at Floyd County, IA

Treatment	Rate[1]	Active Ingredient	Target Application[2]	Stand[3]
Untreated	-------	----------	----------	85.8
Zero Aphid[4]	3.2 fl oz	λ-cyhalothrin	<5 aphids / plant	83.8
	8 fl oz	chlorpyrifos		
Cruiser Maxx	56 g	thiamethoxam	ST	83.1
+ Warrior II[5]	1.6 fl oz	λ-cyhalothrin		
Endigo	3.5 fl oz	thiamethoxam + λ-cyhalothrin	6 Aug	86.5
Warrior II	1.6 fl oz	λ-cyhalothrin	6 Aug	84.3
CMT 560[6]	5 fl oz	spirotetramat + imidacloprid	6 Aug	91.6
CMT 560[6]	6 fl oz	spirotetramat + imidacloprid	6 Aug	93.1
Trilex 6000[6]		trifloxystrobin + metalaxyl	ST	87.0
+ CMT 560	6 fl oz	spirotetramat + imidacloprid	23 July	
Trilex 6000[6]		trifloxystrobin + metalaxyl	ST	83.2
+ CMT 560	6 fl oz	spirotetramat + imidacloprid	6 Aug	
Trilex 6000[6]		trifloxystrobin + metalaxyl	ST	85.9
+ CMT 560	6 fl oz	spirotetramat + imidacloprid	6 Aug	
+ USF0731[7]	2 lb	N/A	6 Aug	
Trilex 6000[6]		trifloxystrobin + metalaxyl	ST	85.9
+ Temprid	3 fl oz	imidacloprid + β-cyfluthrin	6 Aug	
Trilex 6000[6]		trifloxystrobin + metalaxyl	ST	86.0
+ Temprid	3 fl oz	imidacloprid + β-cyfluthrin	6 Aug	
+ USF0731[7]	4 fl oz	N/A	6 Aug	
Asana XL	9.6 fl oz	esfenvalerate	6 Aug	82.8
Hero	5 fl oz	ζ-cypermethrin + bifenthrin	6 Aug	82.8
Nufos	24 fl oz	chlorpyrifos	6 Aug	89.3
Dimethoate	8 fl oz	dimethoate	6 Aug	87.7
Declare	1.02 fl oz	γ-cyhaolothrin	6 Aug	85.1
Declare	1.28 fl oz	γ-cyhaolothrin	6 Aug	84.3
Declare	1.5 fl oz	γ-cyhaolothrin	6 Aug	77.9
Declare	1.28 fl oz	γ-cyhaolothrin	6 Aug	82.9
+ Nufos	24 fl oz	chlorpyrifos	6 Aug	
Tombstone Helios	2.6 fl oz	cyfluthrin	6 Aug	86.3
Belay	3 fl oz	clothianidin	6 Aug	81.3
Belay	6 fl oz	clothianidin	6 Aug	84.3
Lorsban 4E	16 fl oz	chlorpyrifos	6 Aug	86.9
Lorsban Advanced	16 fl oz	chlorpyrifos	6 Aug	83.0

[1] Foliar product rates are given as formulated product per acre, and seed treatments are given as grams active ingredient per 100kg seed.
[2] ST = Seed Treatment.
[3] Reported stand number is given as the number of plants per 10ft of row.
[4] Treated with insecticides three times (23 July, 6 August, 1 September).
[5] Treated 1 September (7 aphids per plant).
[6] Crop oil and Ammonium Sulfate were included as adjuvants and formulated at a rate of 1qt per acre and 2lbs per acre respectively.
[7] Pesticide unlabeled at the time of this publication.

Table 2. 2009 cumulative aphid day exposure and yield at Floyd County, IA

Treatment	CAD ± SEM	CAD - LSD	Yield ± SEM	Yield – LSD[1]
Untreated	10150.5 ± 1534.7	k	57.2 ± 1.8	ef
Zero Aphid[2]	51.1 ± 10.0	a	62.9 ± 1.4	abcd
Cruiser Maxx + Warrior II[3]	5713.7 ± 538.7	jk	58.5 ± 1.2	def
Endigo	392.7 ± 90.6	b	61.1 ± 1.1	abcdef
Warrior II	820.8 ± 252.8	cdefg	64.1 ± 2.2	abc
CMT 560[4]	2849.0 ± 622.7	c	59.2 ± 1.8	cdef
CMT 560[4]	2223.5 ± 508.1	hi	56.7 ± 1.8	f
Trilex 6000[4] + CMT 560	3800.1 ± 1034.3	ij	64.0 ± 2.2	ab
Trilex 6000[4] + CMT 560	1130.5 ± 248.7	g	63.0 ± 0.8	abcd
Trilex 6000[4] + CMT 560 + USF0731[5]	1005.9 ± 339.8	efg	65.8 ± 1.8	a
Trilex 6000[4] + Temprid	917.6 ± 136.3	fg	58.9 ± 2.4	def
Trilex 6000[4] + Temprid + USF0731[5]	539.0 ± 129.9	bcde	65.3 ± 1.9	ab
Asana XL	396.0 ± 48.5	bc	63.5 ± 2.0	abcd
Hero	439.0 ± 64.1	bcd	64.5 ± 2.8	ab
Nufos	433.2 ± 24.0	bcd	62.1 ± 1.2	abcde
Dimethoate	3922.9 ± 836.6	ij	57.5 ± 2.7	ef
Declare	665.2 ± 92.3	cdefg	62.8 ± 2.2	abcd
Declare	479.4 ± 68.9	bcde	63.5 ± 2.0	abcd
Declare	410.0 ± 113.4	b	60.3 ± 2.3	bcdef
Declare + Nufos	495.8 ± 102.7	bcde	62.1 ± 2.0	abcde
Tombstone Helios	517.9 ± 49.9	bcdef	62.5 ± 2.6	abcd
Belay	4843.5 ± 826.9	j	58.5 ± 2.7	def
Belay	3750.7 ± 731.3	ij	58.7 ± 2.7	def
Lorsban 4E	756.7 ± 59.4	defg	61.3 ± 2.1	abcdef
Lorsban Advanced	1345.8 ± 337.8	gh	61.2 ± 1.2	abcdef

[1] Least significant difference (LSD). Means labeled with a unique letter were significantly different (P = 0.05).
[2] Treated with insecticides three times (23 July, 6 August, 1 September).
[3] Treated 1 September (7 aphids per plant).
[4] Crop oil and Ammonium Sulfate were included as adjuvants.
[5] Pesticide unlabeled at the time of this publication.

Table 3. 2009 treatments and rates at Story County, IA

Treatment	Rate[1]	Active Ingredient	Target Application
Untreated	-------	----------	----------
Discipline	5.12 fl oz	bifenthrin	12 Aug
Belay[2]	3 fl oz	clothianidin	12 Aug
Belay[2]	4 fl oz	clothianidin	12 Aug
Belay[2]	6 fl oz	clothianidin	12 Aug
Belay[2]	3 fl oz	clothianidin	12 Aug
+ Lorsban	1 fl oz	chlorpyrifos	12 Aug

[1] Product rates are given as formulated product per acre.
[2] Crop oil and Ammonium Sulfate were included as adjuvants and formulated at a rate of 1qt per acre and 2lbs per acre, respectively.

Table 4. 2009 cumulative aphid day exposure and yield at Story County, IA

Treatment	CAD ± SEM	CAD - LSD	Yield ± SEM	Yield – LSD[1]
Untreated	20648.2 ± 2759.8	d	48.2 ± 2.9	b
Discipline	1739.0 ± 841.2	a	60.7 ± 0.9	a
Belay[2]	4101.6 ± 754.0	bc	56.5 ± 2.3	a
Belay[2]	8054.4 ± 1455.1	c	56.2 ± 1.6	a
Belay[2]	4818.8 ± 1652.7	bc	57.9 ± 1.3	a
Belay[2] + Lorsban	1875.1 ± 305.7	ab	56.5 ± 1.7	a

[1] Least significant difference (LSD). Means labeled with a unique letter were significantly different (P = 0.05).
[2] Crop oil and Ammonium Sulfate were included as adjuvants.

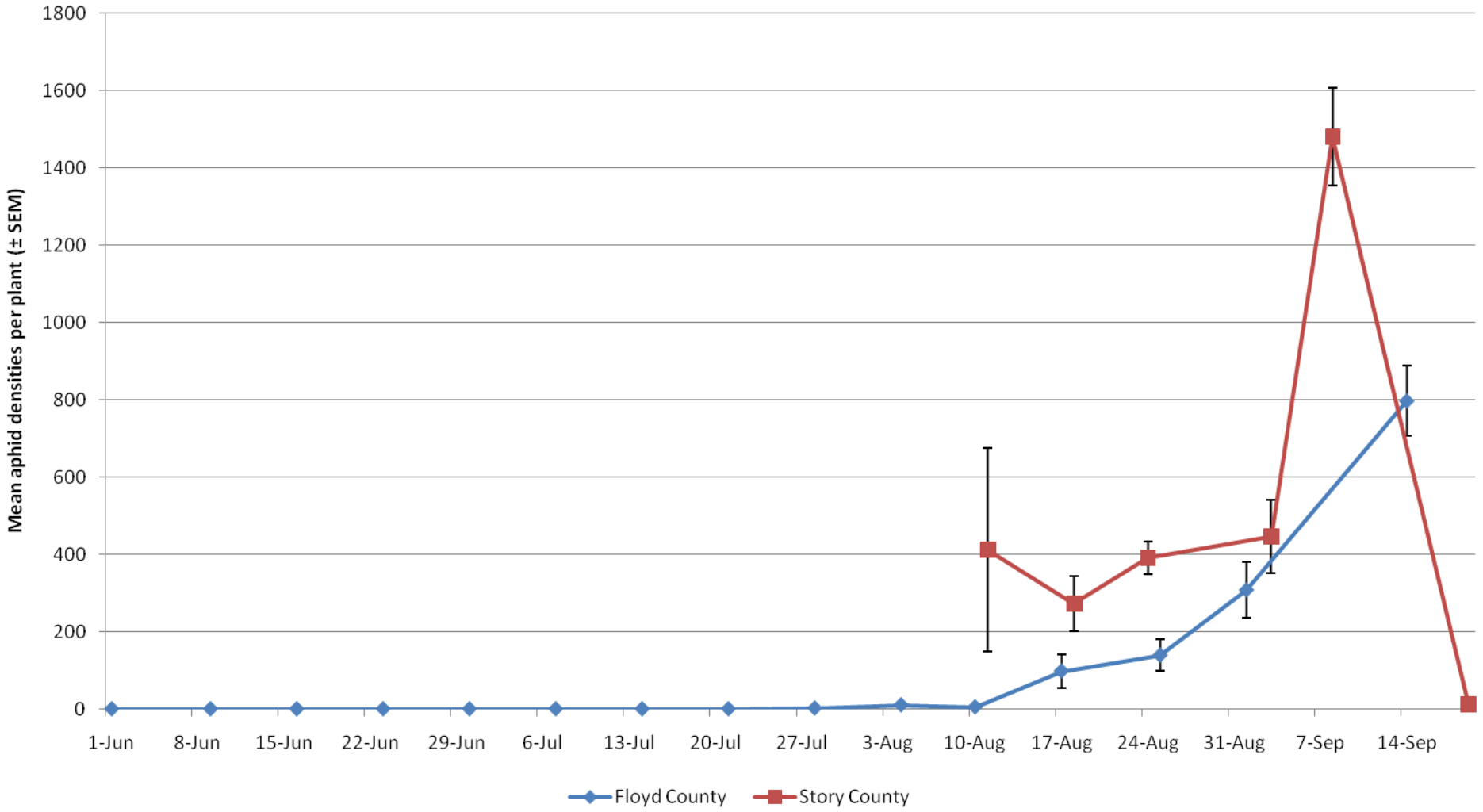

Figure 1. Mean number of soybean aphids in the untreated control plots at Floyd and Story Counties, IA.

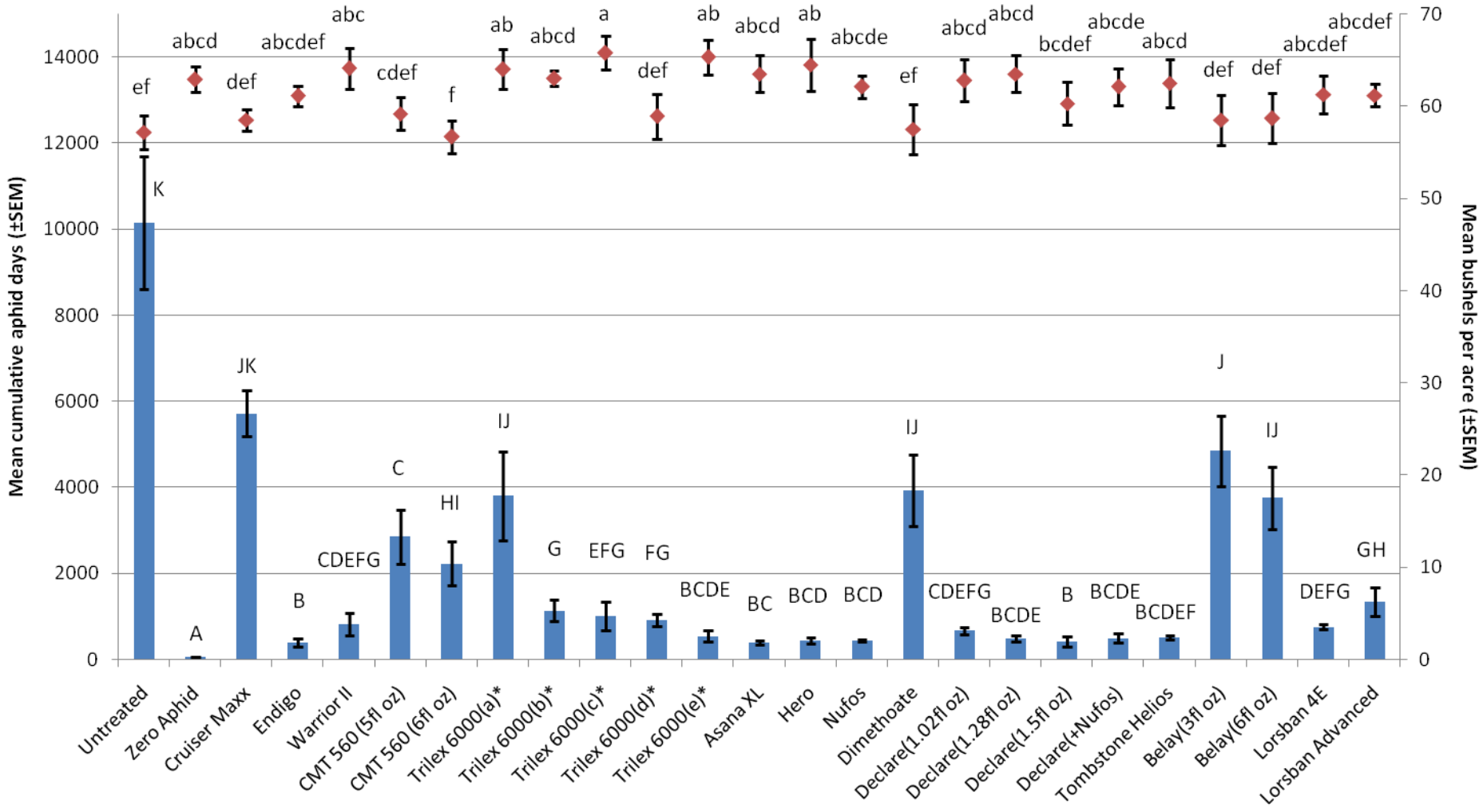

Figure 2. Impact of foliar-applied insecticides on soybean exposure to aphids and yield at Floyd County, IA. The zero aphid control was treated with insecticides 3 times (23 July, 6 August, 1 September), Trilex 6000 (a) foliar treatment was applied on 23 July, Warrior II treatment was applied on 1 September, Cruiser Maxx foliar treatment was applied 1 September, and all other foliar applications were made on 6 August. Rates are only given if the same product was applied at different rates, all other insecticide rates can be found in Table 1. Cumulative aphid days are represented by bars and capital letters (right axis). Yields are represented by triangles and lowercase letters (left axis). Means with a unique letter are significantly different (P≤0.05). *The Trilex 6000 seed treatments differed in several ways with foliar applications: (a) treated with CMT 560 on 23 July, (b) treated with CMT 560 on 6 August, (c) treated with CMT 560 and USF0731, (d) treated with Temprid, and (e) treated with Temprid and USF0731.

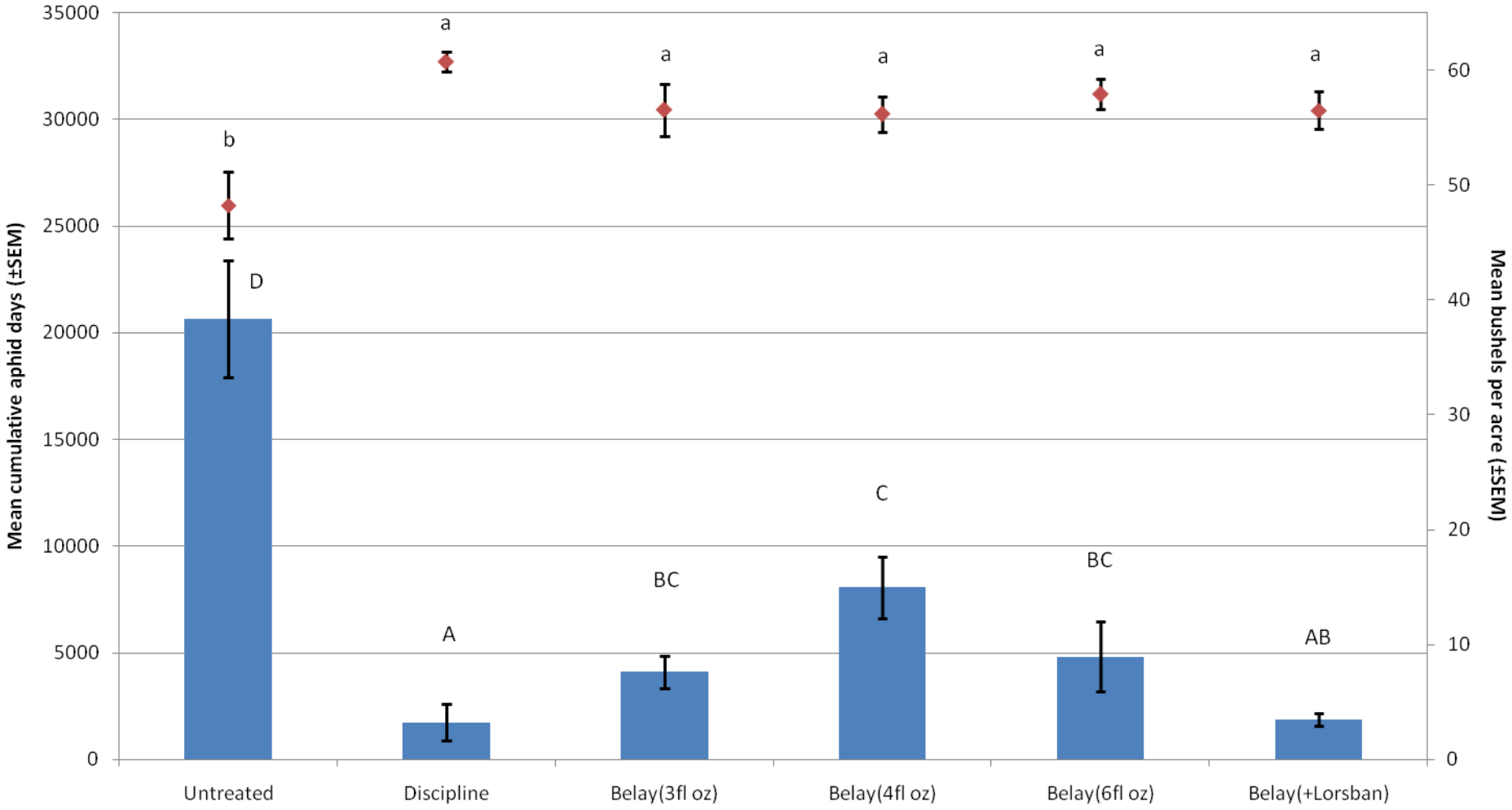

Figure 3. Impact of foliar-applied insecticides on soybean exposure to aphids and yield at Story County, IA. Rates are only given if the same product was applied at different rates, all other insecticide rates can be found in Table 3. Cumulative aphid days are represented by bars and capital letters (right axis). Yields are represented by triangles and lowercase letters (left axis). Means with a unique letter are significantly different (P≤0.05).