Iowa State University
2007 Soybean aphid insecticide trials

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Introduction to Soybean Aphids

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 pest 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 colonize soybean fields beginning in June and has produced outbreaks in July and August capable of reducing yields by nearly 25% (Johnson 2006).

Over the last seven years 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 below 600 aphids per plant are typically needed before measurable yield lose will occur. Based on several years' worth of replicated field trials, we have developed a recommendation that incorporates an economic threshold of 250 aphids/plant (Ragsdale et al. 2007). We also know that natural enemies, like ladybeetles, can have a significant impact on aphid populations (Schmidt et al. 2007). In 2007, Iowa once again experienced damaging populations of soybean aphids. Yield reductions in excess of ten bushels per acre were experienced in university test plots in Iowa. The 2007 growing season has illustrated the need for continued research on soybean aphid management in Iowa.

Materials and Methods

Plots and treatments. We established experiments at the Iowa State University Northeast research farm in Floyd County, Iowa. In total, we evaluated 32 products alone or in combination in 2007 (Table 1). The experiment included an untreated control and a "zero aphid" treatment in which a tank-mix of two foliar insecticides (λ-cyhalothrin, chlopyrifos) were applied every time aphids were detected. The combination of these two treatments allow for estimation of total yield loss due to soybean aphids. The treatments were arranged in a randomized complete block design with six replications, and soybeans (NK2251 RR) were planted in 30 inch rows using no-till production practices on 15 May.

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 counted 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. To estimate the total exposure of soybean plants to soybean aphids we calculated 'cumulative aphid days' based on the number of aphids per plant counted on each sampling date. The exposure of soybean plants to aphids between two sampling dates (the 'aphid days') is 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. Summing aphid days accumulated during the growing season or cumulative aphid days provide a measure of the seasonal aphid exposure that a soybean plant experiences.

Plant stand and herbivore damage. Plant stands were taken at V2 in the seed treated treatments. The reported stand is the number of plants per 10 ft of row. At the same time plants showing herbivore damage due to chewing insects were counted and are reported as a percentage of plants in the stand count.

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 2001).

Results

During the 2007 growing season aphid populations peaked on 13 August at 915 aphids per plant at this research farm. Foliar insecticides were applied on 28 July and aphid populations averaged 240 aphids per plant 3 days prior to insecticide application. Table 2 shows mean aphid populations prior, 3, 10, 16, and 20 days after insecticide application. In general, all the insecticides applied reduced the exposure of plants to aphids compared to the untreated control, with the greatest reduction observed when a foliar insecticide was used. Note that the aphid free control did not reduce the exposure anymore than a single foliar application of any of the products tested (Table 3). This lack of a significant difference occurred despite applying insecticides on four different occasions starting a month before the single application at ~250 aphids per plant.

We observed the lowest yields when soybeans were left untreated (Table 4, Fig.1). The foliar applied insecticides we tested provided similar levels of soybean aphid control and yield protection (Fig. 1). Overall a single application of a foliar insecticide provided as much yield protection as four applications applied from 15 June to 13 August. The seed treatments we tested provided a lower level of soybean aphid control and lower yields as compared to all foliar applied insecticides (Fig. 2). Additionally, plant stands and % herbivore damage appeared to be unaffected by the addition of seed treatments, however late-spring storms at the location made it difficult to separate leaf damage and stand loss associated with herbivore damage and storm damage (Table 5).

Discussion

Although 2007 was the highest aphid population that we have experienced since beginning our insecticide evaluation program, the trends observed in this year's data are consistent with our past results. Again we observed little difference in performance amongst most of the foliar insecticides. The efficacy of the organophosphate (Dimethoate, Lorsban, and Penncap-M) and pyrethroid (Baythroid, and Warrior) was indistinguishable from each other. Combining pyrethroid and organophosphate insecticides did not improve aphid control or soybean yield. This was true even for a pre-mixed product like Cobalt. Rather, the most important issue for effective soybean aphid management is the timing of a foliar-applied insecticide (250 aphids per plant) and not the product selected. This is truly remarkable given the comparison to the aphid-free control, which would represent an economic threshold of 10 aphids per plant.

Compared to the foliar insecticides, the seed-applied insecticides did not provide as great a level of protection. Although we did observe some evidence of control between the untreated soybeans and the seed-treated soybeans, the variability among these treatments was great. Soybean aphid control from seed applied insecticides is not sufficient to protect plants from aphid outbreaks that occur in July or August, especially for soybeans planted in May. McCornack and Ragsdale (2006) showed that seed-applied insecticides are effective on soybean aphid, however this efficacy only lasts for the first month after planting.

Our recommendation for soybean aphid management continues to be to scout your fields and to apply foliar insecticides when populations are 250 aphids per plant and increasing (see Ragsdale et al. 2007 for a more detailed description). We are not recommending seed-applied insecticides (seed treatments) for aphid management, and we are not recommending one insecticide over another. Over the four years we have been assessing insecticide efficacy Warrior, Baythroid, and Lorsban have performed equally well and the seed treatments have not prevented the need for a foliar insecticide in high aphid years. Multiple insecticide treatments have not protected yields compared to a single foliar insecticide application at 250 aphids per plant.

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Table 1. Insecticide treatments used and rates at Floyd County, IA.

Treatment	Rate[1]	Active ingredient	Target application
Untreated	---	---	---
zero aphid[2]	3.2 oz	λ-cyhalothrin	
	4 oz	Chlorpyrifos	0
Cruiser	100 g	Thiamethoxam	ST
Cruiser	50 g	Thiamethoxam	ST
Cruiser + Warrior	50 g	Thiamethoxam	ST
	3.2 oz	λ-cyhalothrin	250
Warrior	3.2 oz	λ-cyhalothrin	250
Gaucho	62.5 g	Imidacloprid	ST
Gaucho + Baythroid	62.5 g	Imidacloprid	ST
	2.4 oz	Cyfluthrin	250
Gaucho + Baythroid	62.5 g	Imidacloprid	ST
	2.4 oz	Cyfluthrin	250
Baythroid	2.4 oz	Cyfluthrin	250
Trimax + NIS	1.35 oz	Imidacloprid	250
Trimax + COC + UAN	1.35 oz	Imidacloprid	250
Trimax + Baythroid + COC	1.35 oz	Imidacloprid	250
	2.4 oz	Cyfluthrin	250
Spirotetramat + COC	4 oz	Spirotetramat	250
Spirotetramat + COC	6 oz	Spirotetramat	250
Trimax + Spirotetramat + COC	1.35 oz	Imidacloprid	250
	4 oz	Spirotetramat	250
Trimax + Spirotetramat + COC	1.35 oz	Imidacloprid	250
	6 oz	Spirotetramat	250
Spirotetramat + COC	4 oz	Spirotetramat	400
Spirotetramat + COC	6 oz	Spirotetramat	400
Cobalt	13 oz	γ-cyhalothrin + Chlorpyrifos	250
Lorsban 4E	16 oz	Chlorpyrifos	250
LAF-1	17 oz	Chlorpyrifos	250
GF-2020	19 oz	Chlorpyrifos	250
V10170	100 g	NA	ST
LI 6191-12	2.4 oz	NA	250
Imidacloprid	62.5 g	Imidacloprid	ST
Hero	5 oz	ζ-Cypermethrin	250
potassium silicate	0.5% v/v	K_2SiO_3	250
potassium silicate	1% v/v	K_2SiO_3	250
NuFos	8 oz	Chlorpyrifos	250
Dimethoate	8 oz	Dimethoate	250
Penncap-M	2 pt	Parathion	250

[1] Foliar product rates are given a formulated product per acre, seed treatments are given a grams active ingredient per 100 kg seed, and potassium silicate is given as a percent volume. All foliar products were applied using 20 GPA and 1002 twin jet nozzles.

[2] Treated with insecticides 4 times (15 June, 6, 22 July, and 13 August).

Table 2. Mean aphids per plant ± standard error of the mean (SEM) at 3 days prior to application, 10, 16, and 20 days post application.

				25-Jul	prior	30-Jul	3 DPA	7-Aug	10 DPA	13-Aug	16 DPA	17-Aug	20 DPA
Treatment[1]	Rate	Active ingredient	Target application	Aphids / plant	SEM	Aphids / plant	SEM	Aphids / plant	SEM	Aphids / plant	SEM	Aphids / plant	SEM
Untreated[2]	------	----------	----------	195	83	211	41	384	59	915	267	545	90
zero aphid	3.2 oz	λ-cyhalothrin											
	4 oz	Chlorpyrifos	0	0	0	8	6	22	8	36	7	1	0
Cruiser	100 g	Thiamethoxam	ST	72	27	93	27	73	23	74	27	75	29
Cruiser	50 g	Thiamethoxam	ST	397	135	126	50	250	47	379	98	288	92
Cruiser + Warrior	50 g	Thiamethoxam	ST										
	3.2 oz	λ-cyhalothrin	250	572	413	48	17	10	5	12	4	4	1
Warrior	3.2 oz	λ-cyhalothrin	250	169	66	37	8	3	1	9	4	4	1
Gaucho	62.5 g	Imidacloprid	ST	119	34	171	45	273	91	367	139	514	292
Gaucho + Baythroid	62.5 g	Imidacloprid	ST										
	2.4 oz	Cyfluthrin	250	141	49	72	27	45	25	48	30	35	25
Gaucho + Baythroid	62.5 g	Imidacloprid	ST										
	2.4 oz	Cyfluthrin	250	177	67	156	80	29	10	24	7	12	3
Baythroid	2.4 oz	Cyfluthrin	250	474	366	222	70	122	94	43	13	37	24
Trimax	1.35 oz	Imidacloprid	250	171	48	64	26	35	9	29	10	58	39
Trimax	1.35 oz	Imidacloprid	250	197	42	47	21	79	60	23	4	27	7
Trimax + Baythroid	1.35 oz	Imidacloprid	250										
	2.4 oz	Cyfluthrin	250	126	46	61	27	25	8	14	3	24	7
Spirotetramat	4 oz	Spirotetramat	250	470	289	81	41	17	8	12	3	7	4
Spirotetramat	6 oz	Spirotetramat	250	258	148	125	44	8	1	9	3	4	1
Trimax + Spirotetramat	1.35 oz	Imidacloprid	250										
	4 oz	Spirotetramat	250	245	126	75	23	9	1	6	2	3	1

Trimax + Spirotetramat	1.35 oz	Imidacloprid	250										
	6 oz	Spirotetramat	250	155	63	129	66	5	1	4	1	3	2
Spirotetramat[3]	4 oz	Spirotetramat	400	121	41	226	64	400	152	85	35	38	9
Spirotetramat[3]	6 oz	Spirotetramat	400	203	96	196	44	450	134	70	26	42	18
Cobalt	13 oz	γ-cyhalothrin + Chlorpyrifos	250	194	80	9	3	14	4	21	4	14	7
Lorsban 4E	16 oz	Chlorpyrifos	250	156	77	3	1	14	6	16	3	10	2
LAF-1	17 oz	Chlorpyrifos	250	441	324	8	4	28	6	40	9	17	4
GF-2020	19 oz	Chlorpyrifos	250	191	53	7	2	36	5	32	4	31	13
V10170	100 g	NA	ST	153	59	193	31	335	80	1312	424	757	261
LI 6191-12	2.4 oz	NA	250	126	25	70	24	33	7	8	3	8	2
Imidacloprid	62.5 g	Imidacloprid	ST	94	21	148	33	549	147	938	273	326	56
Hero	5 oz	ζ-cypermethrin	250	118	41	22	11	4	2	7	2	12	4
potassium silicate	0.5% v/v	K_2SiO_3	250	482	343	364	170	492	178	775	288	351	68
potassium silicate	1% v/v	K_2SiO_3	250	223	112	195	40	532	99	652	304	449	108
NuFos	8 oz	Chlorpyrifos	250	219	46	9	3	28	4	25	4	40	14
Dimethoate	8 oz	Dimethoate	250	307	162	46	20	62	16	46	9	85	38
Penncap-M	2 pt	Parathion	250	228	75	94	40	6	1	13	4	14	2

[1]Foliar treatments were applied 28 July 2007 mean aphid populations were 240 aphids per plant 3 days prior to insecticide application..
[2] Treated with insecticides 4 times (15 June, 6, 22 July, and 13 August).
[3] These treatments of Spirotetramat at 4 and 6 oz were applied 6 Aug when mean aphid populations were 425 aphids per plant.

Table 3. Mean cumulative aphid days (CAD) ± standard error of the mean (SEM) for the full season, and post application.

			Season long[4]				After 28 July[4]			
Treatment[1]	Rate	Active ingredient	CAD	SEM	LSD	SNK	CAD	SEM	LSD	SNK
Untreated[2]	--------	----------	11270	1709	JK	H	9198	1342	MN	F
zero aphid	3.2 oz	λ-cyhalothrin								
	4 oz	Chlorpyrifos	387	101	A	A	366	87	ABCDEF	ABCD
Cruiser	100 g	Thiamethoxam	2235	468	BCDEF	BCDE	1404	327	IJ	DE
Cruiser	50 g	Thiamethoxam	6478	1336	IJK	GH	4725	711	KLMN	F
Cruiser + Warrior	50 g	Thiamethoxam								
	3.2 oz	λ-cyhalothrin	4696	3164	DEF	BCDE	334	114	ABCD	AB
Warrior	3.2 oz	λ-cyhalothrin	1894	654	BCD	BC	221	42	ABC	AB
Gaucho	62.5 g	Imidacloprid	6846	1730	HIJ	FGH	5463	1561	KLM	F
Gaucho + Baythroid	62.5 g	Imidacloprid								
	2.4 oz	Cyfluthrin	2219	366	CDEF	BCDE	909	348	FGHIJ	BCDE
Gaucho + Baythroid	62.5 g	Imidacloprid								
	2.4 oz	Cyfluthrin	2823	1048	CDEF	BCDE	973	382	HIJ	BCDE
Baythroid	2.4 oz	Cyfluthrin	6107	3477	FGH	CDEF	2030	863	J	E
Trimax	1.35 oz	Imidacloprid	2294	384	DEF	BCDE	761	171	FGHIJ	BCDE
Trimax	1.35 oz	Imidacloprid	2878	923	DEF	BCDEF	909	513	FGHI	BCDE
Trimax + Baythroid	1.35 oz	Imidacloprid	1787	363	CDE	BC	538	87	EFGH	BCDE
	2.4 oz	Cyfluthrin								
Spirotetramat	4 oz	Spirotetramat	4154	2326	DEF	BCDEF	516	209	CDEFG	ABCDE
Spirotetramat	6 oz	Spirotetramat	3079	1334	DEF	BCDE	607	176	EFGH	ABCDE
Trimax + Spirotetramat	1.35 oz	Imidacloprid								
	4 oz	Spirotetramat	2525	971	CDEF	BCDE	292	99	AB	AB
Trimax + Spirotetramat	1.35 oz	Imidacloprid								

	6 oz	Spirotetramat	2175	774	BCD		BC		574	261	BCDEFG		ABCDE		
Spirotetramat[3]	4 oz	Spirotetramat	5852	1644		GHI		DEFGH	4204	1323		K		F	
Spirotetramat[3]	6 oz	Spirotetramat	6384	1778		HI		EFGH	4372	1160		KL		F	
Cobalt	13 oz	γ-cyhalothrin Chlorpyrifos	1994	711	CDE		BC		263	30	ABCD		ABC		
Lorsban 4E	16 oz	Chlorpyrifos	1493	610	CDE		B		211	53	ABC		AB		
LAF-1	17 oz	Chlorpyrifos	3701	2295	CDE		BCD		462	65	DEFGH		ABCDE		
GF-2020	19 oz	Chlorpyrifos	1974	325	CDE		BCDE		501	54	EFGH		ABCDE		
V10170	100 g	NA	12946	2705		K		H	11191	2468		N		F	
LI 6191-12	2.4 oz	NA	1809	272	CDE		BCD		562	130	DEFGH		ABCDE		
Imidacloprid	62.5 g	Imidacloprid	10937	1856		JK		H	9779	2001		MN		F	
Hero	5 oz	ζ-cypermethrin	1310	319	BC		B		180	64	A		A		
potassium silicate	0.5% v/v	K_2SiO_3	13929	4538		JK		H	9478	2299		LMN		F	
potassium silicate	1% v/v	K_2SiO_3	10823	2003		JK		H	8661	1765		LMN		F	
NuFos	8 oz	Chlorpyrifos	2121	272	DEF		BCDE		437	60	DEFG		ABCDE		
Dimethoate	8 oz	Dimethoate	3477	1132	EFG		CDEF		1021	208	HIJ		CDE		
Penncap-M	2 pt	Parathion	2530	758	DEF		BCDE		514	151	DEFGH		ABCDE		

[1]Foliar treatments were applied 28 July 2007 mean aphid populations were 240 aphids per plant 3 days prior to insecticide application..
[2] Treated with insecticides 4 times (15 June, 6, 22 July, and 13 August).
[3] These treatments of Spirotetramat at 4 and 6 oz were applied 6 Aug when mean aphid populations were 425 aphids per plant.
[4] Two means separation test are shown least significant difference (LSD), and a more conservative Student-Newman-Keuls (SNK) test. Means labeled with a unique letter were significantly different (P = 0.05).

Table 4. Mean bushels per acre ± standard error of the mean (SEM).

Treatment[1]	Rate	Active ingredient	Yield	SEM	LSD[4]	SNK[4]
Untreated[2]	--------	----------	55.0	1.1	JK	E
zero aphid	3.2 oz	λ-cyhalothrin				
	4 oz	Chlorpyrifos	64.6	1.5	A	A
Cruiser	100 g	Thiamethoxam	59.3	1.5	GHI	BCD
Cruiser	50 g	Thiamethoxam	59.0	1.3	I	D
Cruiser + Warrior	50 g	Thiamethoxam				
	3.2 oz	λ-cyhalothrin	63.6	0.7	ABC	AB
Warrior	3.2 oz	λ-cyhalothrin	63.0	0.9	ABCDE	ABC
Gaucho	62.5 g	Imidacloprid	54.3	1.6	JKL	E
Gaucho + Baythroid	62.5 g	Imidacloprid				
	2.4 oz	Cyfluthrin	63.1	1.0	ABCDE	ABC
Gaucho + Baythroid	62.5 g	Imidacloprid				
	2.4 oz	Cyfluthrin	63.1	1.5	ABCDE	ABC
Baythroid	2.4 oz	Cyfluthrin	63.0	0.9	ABCDE	ABC
Trimax	1.35 oz	Imidacloprid	60.4	0.3	FGHI	ABCD
Trimax	1.35 oz	Imidacloprid	62.0	1.5	BCDEF	ABCD
Trimax + Baythroid	1.35 oz	Imidacloprid	63.9	1.3		
	2.4 oz	Cyfluthrin	63.9	1.3	AB	A
Spirotetramat	4 oz	Spirotetramat	63.1	1.2	ABCDE	ABC
Spirotetramat	6 oz	Spirotetramat	62.5	0.7	ABCDEF	ABC
Trimax + Spirotetramat	1.35 oz	Imidacloprid				
	4 oz	Spirotetramat	62.7	1.5	ABCDE	ABC
Trimax + Spirotetramat	1.35 oz	Imidacloprid				
	6 oz	Spirotetramat	61.4	1.5	CDEFG	ABCD
Spirotetramat[3]	4 oz	Spirotetramat	59.2	0.4	GHI	BCD
Spirotetramat[3]	6 oz	Spirotetramat	59.1	0.5	HI	CD
		γ-cyhalothrin				
Cobalt	13 oz	Chlorpyrifos	62.2	1.2	ABCDEF	ABC
Lorsban 4E	16 oz	Chlorpyrifos	61.5	0.9	CDEFGH	ABCD
LAF-1	17 oz	Chlorpyrifos	60.3	0.8	FGHI	ABCD
GF-2020	19 oz	Chlorpyrifos	61.3	0.4	DEFGH	ABCD
V10170	100 g	NA	52.0	1.4	L	E
LI 6191-12	2.4 oz	NA	62.8	1.3	ABCDE	ABC
Imidacloprid	62.5 g	Imidacloprid	55.3	1.2	J	E
Hero	5 oz	ζ -Cypermethrin	63.6	0.6	ABCD	ABC
	.5%					
potassium silicate	v/v	K_2SiO_3	52.2	1.5	L	E
potassium silicate	1% v/v	K_2SiO_3	53.0	1.2	KL	E
NuFos	8 oz	Chlorpyrifos	59.1	1.6	GHI	BCD
Dimethoate	8 oz	Dimethoate	60.4	1.2	FGHI	ABCD
Penncap-M	2 pt	Parathion	60.9	0.9	EFGH	ABCD

[1]Foliar treatments were applied 28 July 2007 mean aphid populations were 240 aphids per plant 3 days prior to insecticide application..

[2] Treated with insecticides 4 times (15 June, 6, 22 July, and 13 August).

[3] These treatments of Spirotetramat at 4 and 6 oz were applied 6 Aug when mean aphid populations were 425 aphids per plant.

[4] Two means separation test are shown least significant difference (LSD), and a more conservative Student-Newman-Keuls (SNK) test. Means labeled with a unique letter were significantly different (P = 0.05).

Table 5. Mean plant stand in 10 ft of row and percent of plants showing herbivore damage in the same 10 ft of row.

Treatment	Rate	Active ingredient	Stand	SNK[2]	% damaged	SNK[2]
Untreated	--------	----------	102	A	6 %	A
Cruiser	100 g	Thiamethoxam	103	A	4 %	A
Cruiser	50 g	Thiamethoxam	98	A	3 %	A
Gaucho	62.5 g	Imidacloprid	100	A	5 %	A
Gaucho[1]	62.5 g	Imidacloprid	104	A	3 %	A
V10170	100 g	NA	100	A	4 %	A
Imidacloprid	62.5 g	Imidacloprid	96	A	3 %	A

[1]All treatments received an equivalent fungicide seed treatment (Apron Maxx) with one exception (Allegiance).

[2]The Student-Newman-Keuls (SNK) means separation test indicates no significant differences.

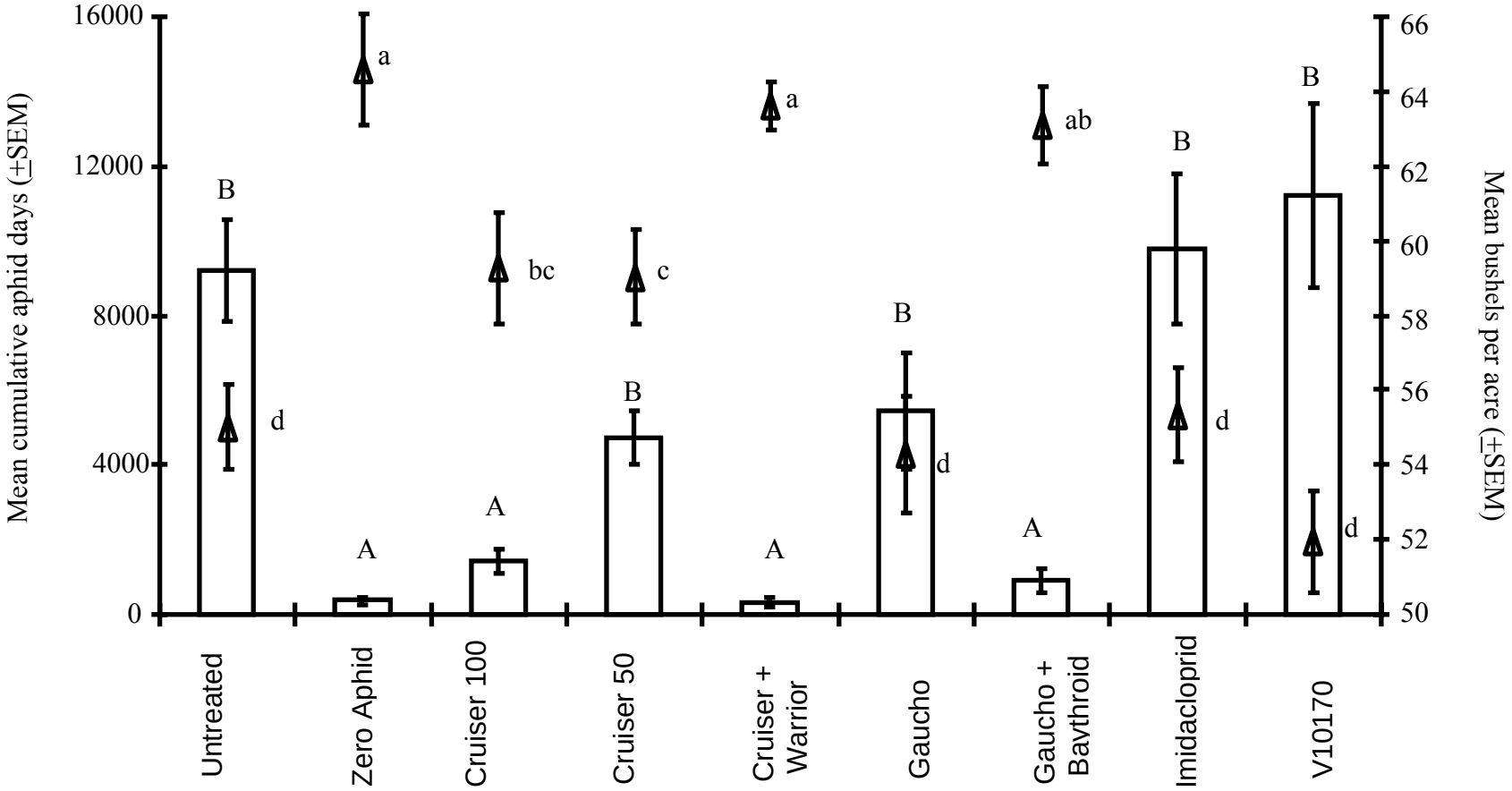

Figure 1. Impact of seed-applied insecticides on soybean exposure to aphids and yield. The aphid free control was treated with insecticides 4 times (15 June, 6, 22 July, and 13 August) all other foliar treatments were applied 28 July. Cumulative aphid days are represented by bars and capital letters (right axis). Yields are represented by triangles and lowercase letters (left axis). Means with a unique letter are significantly different ($P \leq 0.05$) using Student-Newman-Keuls (SNK) means separation test.

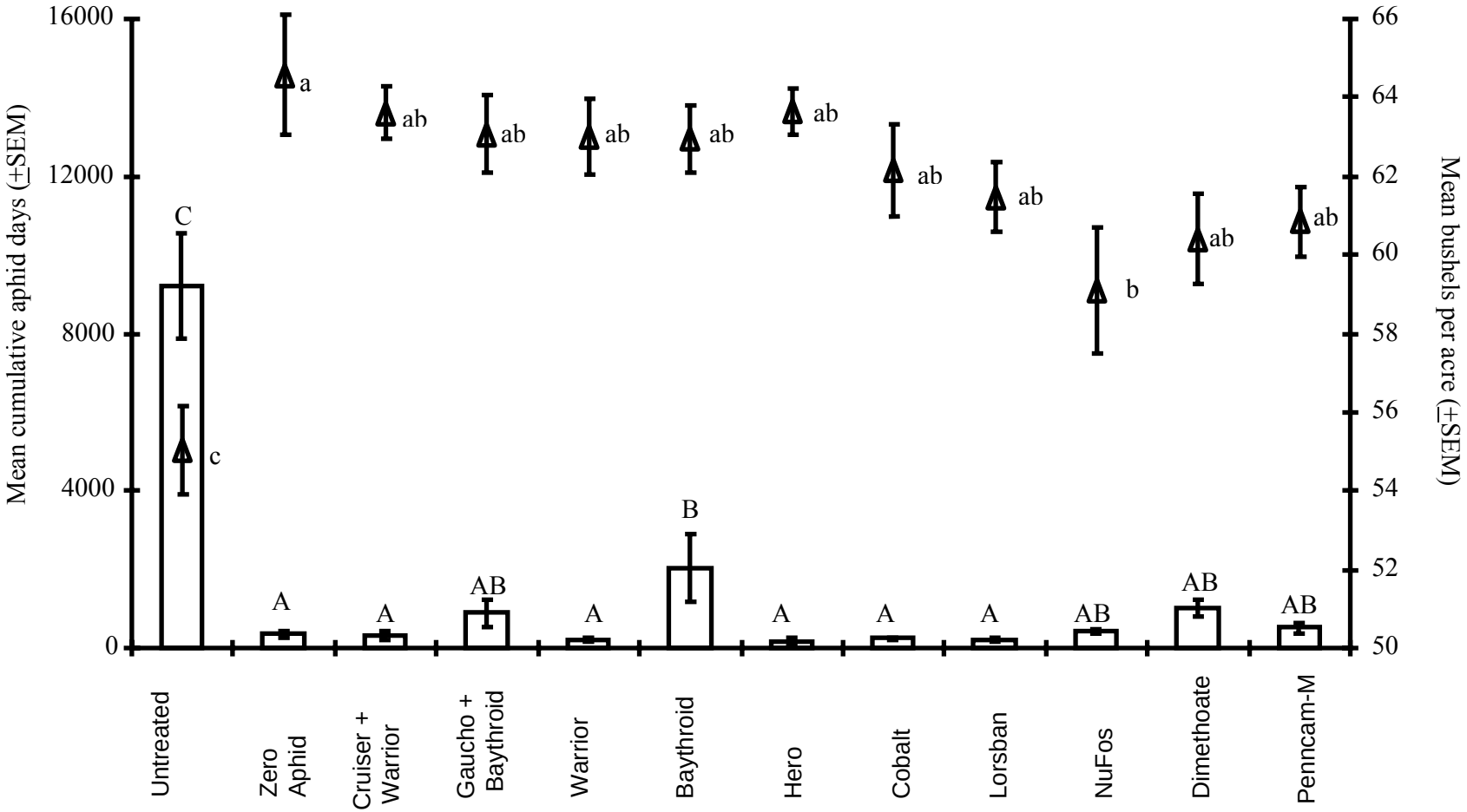

Figure 2. Impact of available foliar-applied insecticides on soybean exposure to aphids and yield. The aphid free control was treated with insecticides 4 times (15 June, 6, 22 July, and 13 August) all other foliar treatments were applied 28 July. Cumulative aphid days are represented by bars and capital letters (right axis). Yields are represented by triangles and lowercase letters (left axis). Means with a unique letter are significantly different ($P \leq 0.05$) using Student-Newman-Keuls (SNK) means separation test.

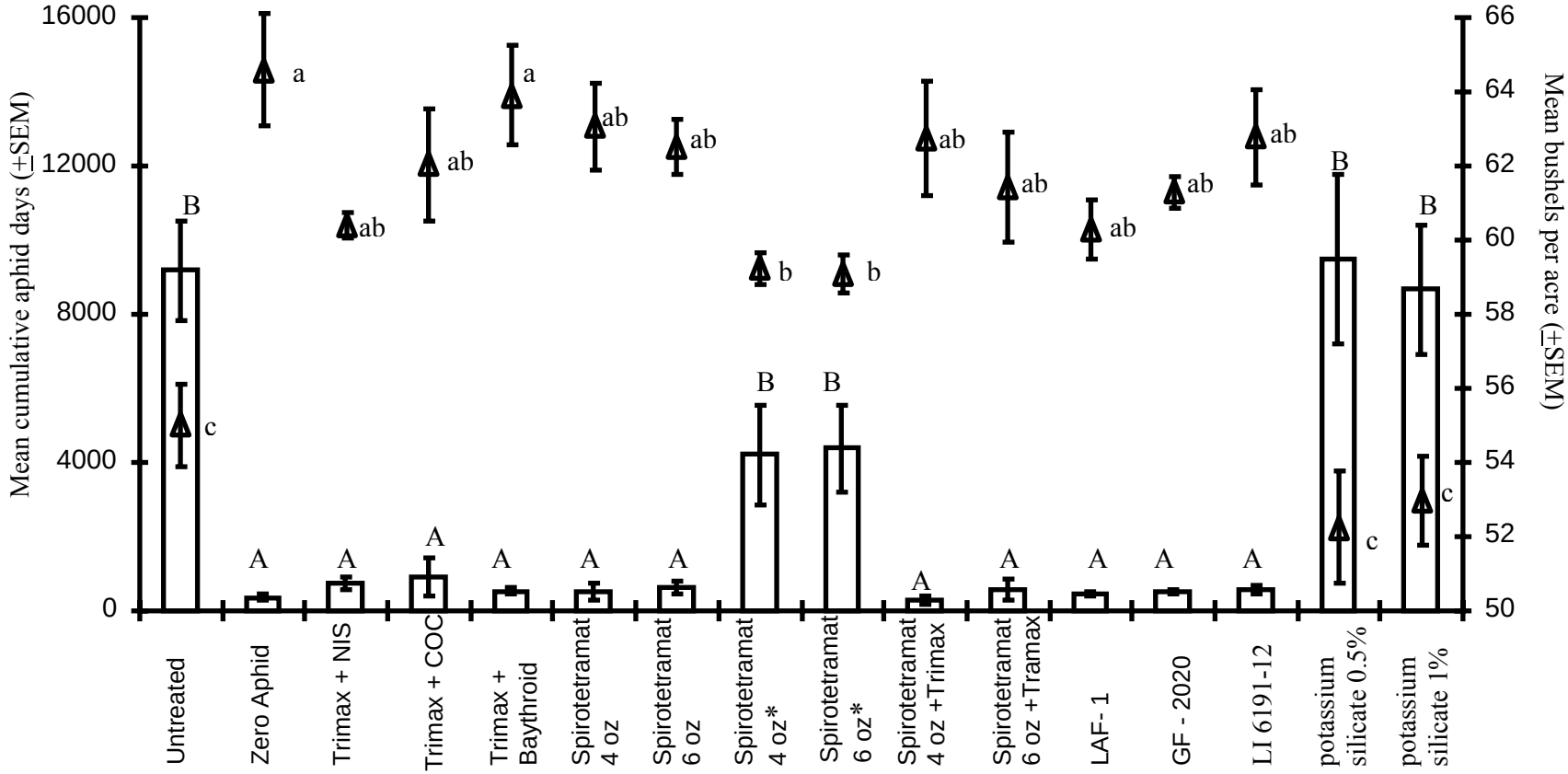

Figure 3. Impact of experimental foliar-applied insecticides on soybean exposure to aphids and yield. The aphid free control was treated with insecticides 4 times (15 June, 6, 22 July, and 13 August) all other foliar treatments were applied 28 July. Cumulative aphid days are represented by bars and capital letters (right axis). Yields are represented by triangles and lowercase letters (left axis). Means with a unique letter are significantly different ($P \leq 0.05$) using Student-Newman-Keuls (SNK) means separation test.