Iowa State University
Extension and Outreach

2017 REPORT OF INSECTICIDE EVALUATION

Department of Entomology

Ames, Iowa 50011-3140

Sue Blodgett, Chair

Soybean Pest Investigated: Soybean Aphid

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To see a digital copy of the Iowa State University Soybean Insecticide Evaluation Reports from 2009-2017, visit our website:

www.ent.iastate.edu/soybeanresearch/content/extension

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BASF

Dow AgroSciences

FMC

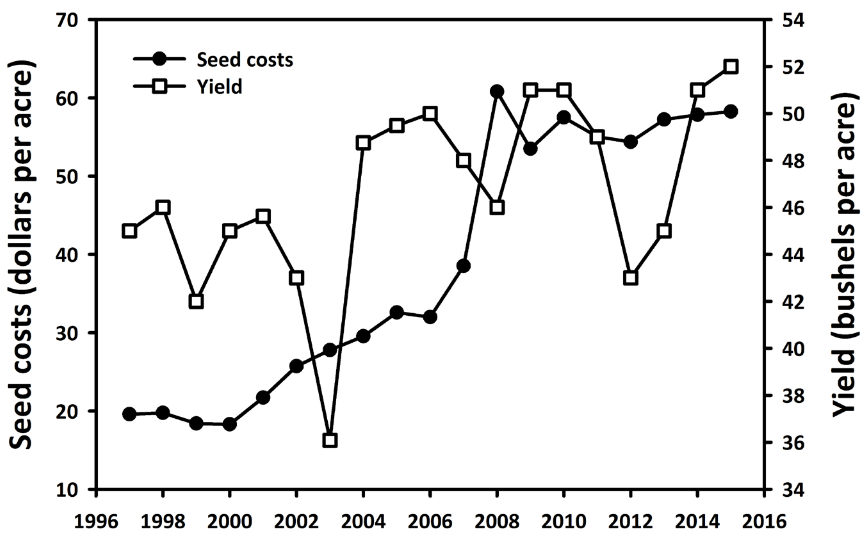
Syngenta Crop Protection

Soybean Aphid

Soybean aphid is Iowa's primary soybean insect pest. Photo by Matt Kaiser.

SOYBEAN APHID, ***Aphis glycines*** Matsumura (Hemiptera: Aphididae), is an invasive insect from eastern Asia first confirmed on soybean, ***Glycine max*** L., in the U.S. in 2000 (Ragsdale et al. 2004). Widespread soybean aphid outbreaks in Iowa and the northcentral region were observed in 2003 and 2005, with populations exceeding 1,000 aphids per plant. At this infestation level, 40% yield loss resulted in significantly reduced seed size, seed coat quality, pod number, and plant height (Ragsdale et al. 2007). Soybean aphid proved to be economically important and is now the primary soybean insect pest in Iowa and the northcentral region (Hodgson et al. 2012, Krupke et al. 2017).

There were only occasional insect pest issues in midwestern soybean before 2000, which resulted in less than 1% of fields being treated with insecticides (USDA-NASS). The injury potential of soybean aphid resulted in a 130-fold increase of insecticide applications in less than ten years (Ragsdale et al. 2011). Since 1996, the average soybean seed costs (not including pesticidal seed treatments) for the U.S. Heartland have increased from \$20 to \$58 per acre, while yield is more slowly increasing from 45 to 52 bushels per acre (USDA-NASS). Seed treatments are also becoming more widely adopted and increasing in costs annually. Fifteen years after the discovery of soybean aphid on soybean, farmers have drastically changed management practices to protect yield.

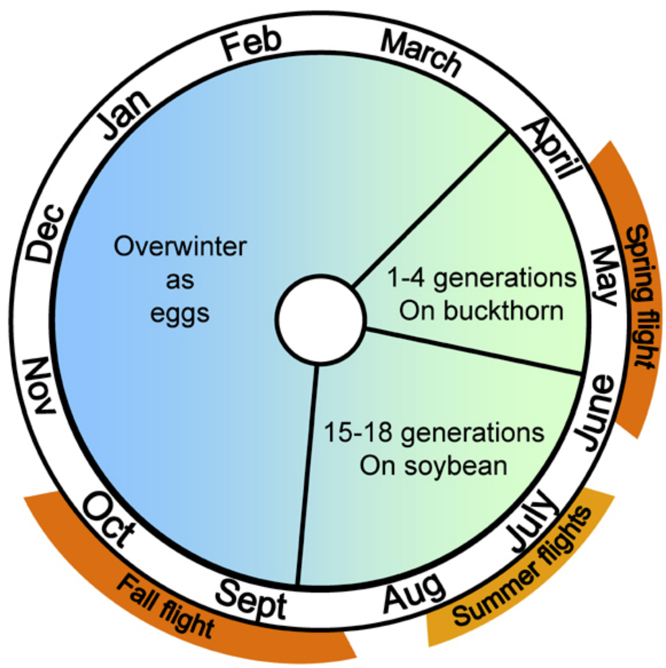


Seed costs for soybean has increased dramatically compared to yield increases since 1996 (USDA NASS ERS).

Description. Wingless soybean aphid adults have a typical pear-shaped body and are 1/16 inches long (Voegtlin et al. 2004). The body is bright yellow-green with red eyes and black cornicles (i.e., "tailpipes" at the end of the abdomen). They have pale legs and antennae, and a dusky-colored cauda (i.e., small appendage on the tip of the abdomen). Soybean aphid nymphs look similar to adults except smaller in size and a reduced cauda. Winged soybean aphids have a dark head and thorax, and two pairs of clear wings that extend well past the end of the abdomen.

Wingless soybean aphid (left photo by Claudio Gratton) and winged soybean aphid (right photo by Rob Venette).

Life Cycle. Soybean aphid has a complex life cycle similar to other host-alternating aphid species (Ragsdale et al. 2004). In the fall, eggs are laid on buckthorn, *Rhamnus* spp., to overwinter. Buckthorn is a woody shrub found in shelter belts throughout the north central region. Egg hatch is synchronized with buckthorn bud burst in the spring. A few asexual wingless generations are produced before winged adults are formed on buckthorn. Spring migrants move to emerging soybean during May and June. There can be 15–18 asexual generations on soybean depending on the temperature (McCornack et al. 2004). During the summer, there is a mixture of



Soybean aphid has a host-alternating life cycle that includes soybean and buckthorn.

wingless and winged adults formed. Aphid crowding, plant quality and the presence of natural enemies may prompt winged aphids to develop in the summer. Long distance migration can occur because the aphids move with jet streams. As soybean matures, and temperatures and day length decreases, winged soybean aphids move back to buckthorn, where mating and egg deposition occurs.

Feeding Injury. As with all aphids, soybean aphids have a piercing-sucking mouthpart. Nymphs and adults feed on plant sap in the phloem of all leaves and stems. Heavily infested plants may become discolored or wilted. Prolonged aphid feeding results in large amounts of cast skins and excreted honeydew on all aboveground plant parts. Honeydew is sugar-rich and sticky, and can promote black sooty mold growth. Severe aphid infestations can cause flower and small pods to abort. The combination of aphids removing plant nutrients and mold-covered leaves can result in up to 40% yield reduction (Ragsdale et al. 2007).

Sooty mold (top) on leaves can negatively impact soybean yield. Photo by Brian McCornack.

Seasonal Exposure. Estimating soybean aphid pressure over the entire growing season provides a measure of the seasonal aphid exposure that a soybean field experiences, similar to calculating area under the curve or heat units for plant development. To estimate the total exposure of soybean plants to soybean aphid, we calculate cumulative aphid days (CAD) based on the number of aphids per plant counted on each sampling date. We estimated CAD 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. We would expect to see economic injury around 5,000–6,000 CAD (Ragsdale et al. 2007). Fluctuating market values and control costs will influence the actual economic injury level each year.

Management. A multi-state research effort showed that over a wide range of growing conditions, 650 aphids per plant are needed before economic injury (i.e., bushels per acre being reduced) will occur (Ragsdale et al. 2007). A conservative economic threshold of 250 aphids per plant was developed and adopted throughout the north central region to minimize yield loss (Ragsdale et al. 2007, Hodgson et al. 2012). The economic threshold should be used from R1–R5.5 (i.e., flowering through seed set) to protect yield, reduce control costs, and preserve insecticide efficacy (Hodgson et al. 2012). This threshold remains consistent regardless of fluctuating input costs and market values (Koch et al. 2016). Our program validates the economic threshold annually (See 2009-2017 reports; *www.ent.iastate.edu/soybeanresearch/content/extension*) and showed spraying at R6 (i.e., full seed set) did not produce a yield response (Hodgson and VanNostrand 2013).

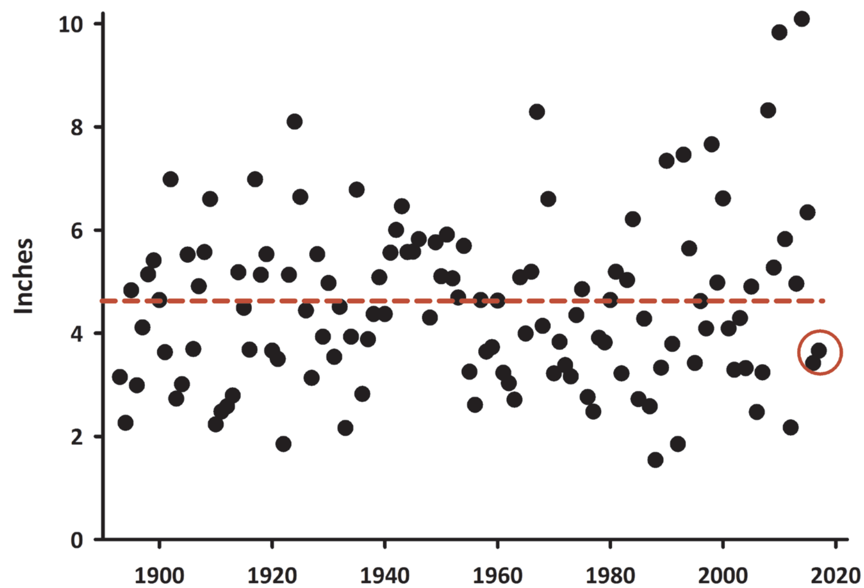
Most IPM (integrated pest management) programs involve regular sampling of the pest. This can be especially important for a multigenerational insect with a complex life cycle like soybean aphid (Hodgson et al. 2012). Regular scouting for soybean aphid in July and August, or at least from R1–R5.5 (i.e., bloom through seed set), is recommended (Hodgson et al. 2004) even if the plants have an insecticidal seed treatment and/or host plant resistance. Winged aphids are more prevalent and likely to migrate within and between fields during the reproductive soybean period (Hodgson et al. 2005). Regular sampling will help farmers and crop consultants track population trends and improve foliar application timing.

The severity and abundance of soybean aphid in Iowa fluctuates. Although colonies can be initially patchy, populations can quickly spread throughout the field under favorable weather conditions. Soybean aphid prefers the newest soybean foliage. Plants covered with honeydew or sooty mold indicate soybean aphids have been there for a long time and yield loss has likely occurred. Count aphids on 40 plants for every 50 acres of soybean, and be sure to look at different areas of the field. Alternatively, use a binomial sequential sampling plan, *Speed Scouting for Soybean Aphid,* to make faster treatment decisions (Hodgson et al. 2007; blank forms can be found here: *http://bit.ly/2fJbbdr*).

Host plant resistance is a new tool to manage soybean aphid and complementary to foliar insecticides. Aphid-resistant varieties have the potential to simultaneously reduce insecticide usage and associated production costs, and preserve natural enemies in soybean (Tilmon et al. 2011). To date, host plant resistant genes for soybean aphid are prefixed with "*Rag*" which is an abbreviation for "Resistant to *Aphis glycines*." The *Rag1* gene expresses antibiosis, a type of resistance where exposed insects do not live as long or produce as many offspring as they could on susceptible plants.

The *Rag1* gene does not cause yield drag but it is not always included into high-yielding seed genetics (Kim and Diers 2009). Additional *Rag* genes have been discovered and pyramids with two or more *Rag* genes have been developed. McCarville et al. (2014) showed *Rag1* or *Rag2* varieties significantly reduced the seasonal exposure of soybean aphid, and a pyramid of *Rag1+2* offered nearly full yield protection without the need for foliar insecticides in a wide geographic region. Recently, data showing 3-gene pyramids also provided excellent suppression of soybean aphid against multiple biotypes (Varenhorst et al. 2017).

2017 Statewide Summary. Spring planting conditions throughout Iowa were cold and wet, and most soybean fields were planted later to accommodate corn planting. June turned exceptionally dry, particularly in southern Iowa. The average monthly precipitation for the state of Iowa in June from 1893–2016 is 4.58 inches, but Iowa received an average of 3.6 inches in June 2017. Conditions remained dry until mid-August.



Iowa average monthly liquid precipitation in inches for June from 1893 to 2017. The red line represents the average (4.58 inches) and the red circle indicates 2017 (3.6 inches). Data courtesy of the Mesonet, ISU Department of Agronomy, https://mesonet.agron.iastate.edu/.

Soybean aphids arrived on soybean in mid-June, as they normally do in the northeastern Iowa. Hot and dry conditions in June favored twospotted spider mite colonization, particularly in southern counties. But as moisture stress subsided throughout Iowa, spider mite populations faded and soybean aphid colonization expanded. Some commercial fields experienced exponential growth of soybean aphid after bloom, especially in northern Iowa. In August, some fields in northwestern and northcentral counties had soybean aphid exceed the economic threshold. Some populations did persist until after seed set (R5–R6), but very quickly crashed at most locations by mid-September. When applications had sufficient coverage and applied at the labeled rate, efficacy for soybean was good (i.e., >95% knockdown within three days after application) throughout most of Iowa. In some research trials near Sutherland, Iowa, poor knockdown with lambda-cyhalothrin was noted.

Treatment Recommendations. Population fluctuations between locations and years is typical soybean aphid dynamics for Iowa. Our recommendation for soybean aphid management in Iowa is to:

• Strongly consider using host plant resistance if soybean aphid populations are persistent and the seed agronomic traits are appropriate for the area. The use of a pyramided gene will result in lower CAD and reduce the need for foliar insecticides.

• Plant early if the field is in an area with persistent soybean aphid populations.

• Scout for soybean aphid, especially during R1–R5, and use a foliar insecticide if aphids exceed the economic threshold of 250 per plant.

• Use a product labeled for soybean aphid; most well-timed applications of foliar insecticides will provide yield protection if applied at the economic threshold and coverage is sufficient.

• Evaluate foliar insecticide efficacy three days after application to ensure soybean aphid populations were sufficiently reduced.

Use high volume and pressure to create small droplets that make contact with soybean aphids in the lower canopy. Photo by Erin Hodgson.

Look for surviving aphids 3-4 days after an application to assess insecticide efficacy. Photo by Thelma Heidel-Baker.

• Understand that late-season accumulation of CAD (i.e., after R5) may not impact yield like it does in early reproductive growth; a foliar insecticide applied after seed set may not be an economically profitable choice.

Methods and Materials

We established plots at two locations in 2017. Syngenta NK S24-K2 brand soybean was used for all the treatments. Seeds did not have a pesticidal seed treatment unless specifically stated. At both locations, soybean aphid arrived in mid-June and populations peaked in early September. In the untreated control treatments, aphid populations reached 132.17 per plant ± 39.08 (± SEM) at the ISU Northeast Research Farm on 12 September (Figure 1A), and reached 650.67 per plant ± 129.00 at the ISU Northwest Research Farm on 9 September (Figure 1B).

Plot Establishment. The first location was at the ISU Northeast Research Farm in Floyd County, Iowa. The treatments were arranged in a randomized complete block design with four replications, and soybean was planted in 30-inch rows using standard production practices on 14 May 2017. Each plot was six rows wide and 50 feet long. In total, we evaluated 19 treatments that included products alone or in combination (Table 1). The second location was at the ISU Northwest Research Farm in O'Brien County, Iowa. The treatments were arranged in a randomized complete block design with four replications, and soybean was planted in 30-inch rows using standard production practices on 30 May 2017. Each plot was six rows wide and 44 feet long. In total, we evaluated 19 treatments including products alone or in combination (Table 3).

Plant Stand. Plant populations were estimated at the V2 growth stage at the ISU Northeast and Northwest Research Farms on 20 June and 27 June, respectively. Two 10-foot sections were randomly selected within each plot, and the number of emerged plants were counted. The average plant stand per 10 linear feet was 81.41 ± 0.47 (± SEM) plants at the ISU Northeast Research Farm and 73.84 ± 0.32 plants at the ISU Northwest Research Farm.

Soybean Aphid Populations. Soybean aphids were counted on randomly selected plants within each plot. All aphids (adults, nymphs, and winged adults) were counted on whole plants from early vegetative stages through maturity. The number of plants counted per plot ranged from 20 to 3, and was determined by plant growth stage and by the severity of aphid infestation (Hodgson et al. 2005). Twenty plants were counted in each plot during the vegetative growth. At R1 (i.e., beginning bloom), ten plants were sampled in each plot. The number of plants sampled further decreased to 5 and then to 3 per plot as plants matured from R3–R5 (i.e., pod fill to seed fill). The CAD for each treatment was estimated for each location (Tables 2, 4).

Insecticide Applications. Most of the seed used in 2017 did not have a pesticidal seed treatment, except for those treatments with Cruiser 5FS. All seed treatments were applied by Syngenta. For the ISU Northeast Research Farm, 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. For the ISU Northwest Research Farm, foliar treatments were applied using a custom sprayer and TeeJet flat fan nozzles (TJ 8002) with 14 gallons of water per acre at 40 pounds of pressure per square inch. Our target spray application is made at the economic threshold or at R5.5 if the threshold is not met. The threshold was not met at the ISU Northeast Farm and sprayed on 18 August (Table 1); however, the threshold was met at the ISU Northwest Research Farm and was also sprayed on 18 August (Table 3).

Yield. Each plot was harvested using a small plot combine. The plots at the Northeast Research Farm were harvested on 3 October and the plots at the Northwest Research Farm were harvested on 20 October. Yields were determined by weighing grain with a hopper which rested on a digital scale sensor custom designed for each of the combines. Yields were corrected to 13% moisture and reported in bushels per acre (Tables 2, 4; Figures 3, 5).

Statistical Analysis. A one-way analysis of variance (ANOVA) was used to determine CAD and yield treatment effects within each experiment. Mean separation for all treatments were achieved using a least significant differences (LSD) test (alpha = 0.10). All statistical analyses were performed using SAS® software (SAS 9.4).

Results and Conclusions

The plots at each farm were initially colonized by soybean aphid in June, but populations remained low until after full bloom. Uniform aphid colonization was established in late July and continued to build throughout August (Figure 1). There were a few other soybean insect pests present (e.g., Japanese beetle, caterpillars and stink bugs), but economic populations were not evident. Natural enemies, such as beetles, flies, lacewings and wasps, were present and sometimes abundant throughout the reproductive stages, but did not significantly impact soybean aphid populations at either location.

ISU Northeast Research Farm. Soybean aphid populations were steadily increasing in late July and early August; however, the economic threshold was never reached. Therefore, treatments 3-19 received a foliar application on 18 August when plants were at R5 (i.e., beginning seed set) and aphids averaged 11.58 ± 7.53 per plant four days prior (Table 1). There were some significant differences among CAD treatments, ranging from 391 to 1,872 (Table 2; Figure 2). Treatments 1-5 had significantly higher CAD than all other treatments, but all treatments were well below a level that would translate to measurable yield losses from soybean aphid (Table 2; Figure 2). Yield ranged from 57-61 bushels per acre with some significant differences among treatments (Table 2; Figure 3). Although there were yield differences, we do not believe it was due to soybean aphid seasonal exposure.

ISU Northwest Research Farm. Soybean aphid population had exponential growth in August, and plots exceeded the economic threshold on 26 August (Figure 1B). Treatments 3-19 received a foliar application on 18 August when plants were at R5 (i.e., beginning seed set) and aphids averaged 241.17 ± 94.19 (Table 3). The CAD for susceptible soybean treatments ranged from 648 to 14,004, and there were some significant differences among treatments (Table 4; Figure 4). The untreated control had significantly more CAD compared to all other treatments. Yield ranged from 55-62 bushels per acre with little significant difference among treatments (Table 4; Figure 5). Most of the CAD was accumulated in late August and early September, and did not effect yield among treatments.

Table 1. List of treatments and rates at the Northeast Research Farm in 2017

Treatment and Formulation	Group[a]	Active Ingredient(s)[b]	Rate[c]	Timing
1. Untreated Control	-----	-----	-----	-----
2. Cruiser 5FS	4A	thiamethoxam (ST)	1.28 oz/100 lb	-----
3. Cruiser 5FS and Warrior II CS	4A 3A	thiamethoxam (ST) lambda-cyhalothrin	1.28 oz/100 lb 1.6 fl oz	----- 18 Aug
4. Warrior II CS	3A	lambda-cyhalothrin	1.92 fl oz	18 Aug
5. Lorsban Advanced EC	1B	chlorpyrifos	16.0 fl oz	18 Aug
6. Warrior II CS and Lorsban Advanced EC	3A 1B	lambda-cyhalothrin chlorpyrifos	1.92 fl oz 16.0 fl oz	18 Aug
7. Dimethoate 4E	1B	dimethoate	16.0 fl oz	18 Aug
8. Hero EC and Dimethoate 4E	3A 1B	bifenthrin + zeta-cypermethrin dimethoate	5.0 fl oz 16.0 fl oz	18 Aug
9. Agri-Mek SC	6	abamectin	2.5 fl oz	18 Aug
10. Brigadier SC	3A + 4A	bifenthrin + imidacloprid	6.1 fl oz	18 Aug
11. Carbine 50 WG	29	flonicamid	2.8 oz	18 Aug
12. Cobalt Advanced EC	3A + 1B	lambda-cyhalothrin + chlorpyrifos	16.0 fl oz	18 Aug
13. Transform WG	4C	sulfoxaflor	1.0 oz	18 Aug
14. Seeker SE	4C + 3A	sulfoxaflor + lambda-cyhalothrin	2.1 fl oz	18 Aug
15. Sivanto 200 SL	4D	flupyradifurone	7.0 fl oz	18 Aug
16. Movento SC 100	23	spirotetramat	4.0 fl oz	18 Aug
17. Endigo ZC	3A + 4A	lambda-cyhalothrin + thiamethoxam	3.5 fl oz	18 Aug
18. Leverage 360 SC	4A + 3A	imidacloprid + beta-cyfluthrin	2.8 fl oz	18 Aug
19. Tundra EC	3A	bifenthrin	6.4 fl oz	18 Aug

[a] Insecticide group according to the Insecticide Resistance Action Committee (*http://www.irac-online.org/*);
[b] Does not contain a fungicidal/insecticidal seed treatment (ST) unless noted; [c] per acre unless noted.

Table 2. Soybean aphid density and yield for treatments at the Northeast Research Farm in 2017

Treatment and Formulation	CAD ± SEM[a]	CAD - LSD[b]	Yield ± SEM[c]	Yield - LSD[d]
1. Untreated Control	1,872.49 ± 423.71	E	60.21 ± 0.72	ABCD
2. Cruiser 5FS	703.09 ± 142.11	BCD	59.35 ± 1.03	ABCDE
3. Cruiser 5FS and Warrior II CS	321.53 ± 77.75	AB	60.10 ± 0.89	ABCD
4. Warrior II CS	960.78 ± 440.14	CD	58.77 ± 0.78	ABCDE
5. Lorsban Advanced EC	152.73 ± 25.49	A	58.09 ± 0.93	DE
6. Warrior II CS and Lorsban Advanced EC	134.20 ± 67.52	A	59.77 ± 1.25	ABCDE
7. Dimethoate 4E	177.66 ± 48.71	A	59.32 ± 0.65	ABCDE
8. Hero EC and Dimethoate 4E	193.72 ± 53.04	A	60.67 ± 0.60	ABC
9. Agri-Mek SC	982.96 ± 165.16	CD	58.29 ± 1.15	CDE
10. Brigadier SC	147.26 ± 48.62	A	59.67 ± 1.53	ABCDE
11. Carbine 50 WG	182.30 ± 40.19	A	60.76 ± 1.12	ABC
12. Cobalt Advanced EC	132.67 ± 9.96	A	60.63 ± 0.87	ABC
13. Transform WG	128.69 ± 20.20	A	60.96 ± 0.81	AB
14. Seeker SE	137.78 ± 28.25	A	61.13 ± 1.04	A
15. Sivanto 200 SL	207.07 ± 17.64	A	59.24 ± 1.27	ABCDE
16. Movento SC 100	615.03 ± 112.78	BC	57.41 ± 1.15	E
17. Endigo ZC	131.68 ± 30.41	A	60.33 ± 0.66	ABCD
18. Leverage 360 SC	1,067.80 ± 255.01	D	58.58 ± 1.48	BCDE
19. Tundra EC	391.21 ± 153.14	AB	58.05 ± 1.86	DE

[a] CAD (cumulative aphid days) is the estimated seasonal exposure of soybean aphid ± the standard error of the mean; [b] LSD (least significant difference) of CAD at alpha = 0.10 ($P<0.0001$; $F = 6.87$; df = 18, 3); [c] yield is reported in bushels per acre ± the standard error of the mean; [d] LSD of yield at alpha = 0.10 ($P=0.1950$; $F = 1.34$; df = 18, 3).

Table 3. List of treatments and rates at the Northwest Research Farm in 2017

Treatment and Formulation	Group[a]	Active Ingredient(s)[b]	Rate[b]	Timing
1. Untreated Control	-----	-----	-----	-----
2. Cruiser 5FS	4A	thiamethoxam (ST)	1.28 oz/100 lb	-----
3. Cruiser 5FS and Warrior II CS	4A 3A	thiamethoxam (ST) lambda-cyhalothrin	1.28 oz/100 lb 1.6 fl oz	----- 18 Aug
4. Warrior II CS	3A	lambda-cyhalothrin	1.92 fl oz	18 Aug
5. Lorsban Advanced EC	1B	chlorpyrifos	16.0 fl oz	18 Aug
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12. Cobalt Advanced EC	3A + 1B	lambda-cyhalothrin + chlorpyrifos	16.0 fl oz	18 Aug
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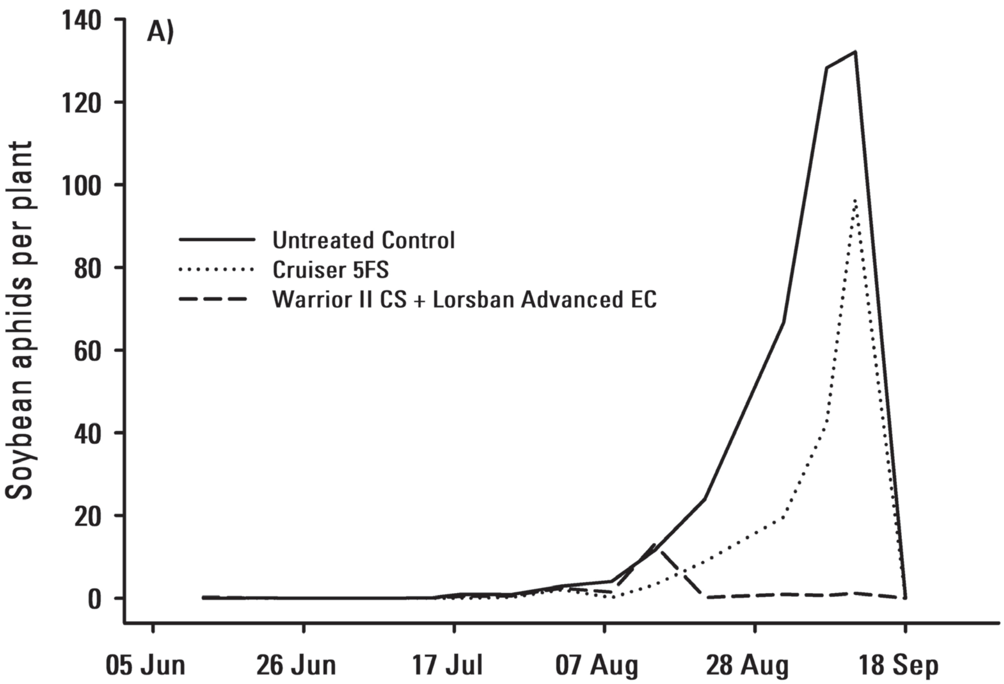
14. Seeker SE	4C + 3A	sulfoxaflor + lambda-cyhalothrin	2.1 fl oz	18 Aug
15. Sivanto 200 SL	4D	flupyradifurone	7.0 fl oz	18 Aug
16. Movento SC 100	23	spirotetramat	4.0 fl oz	18 Aug
17. Endigo ZC	3A + 4A	lambda-cyhalothrin + thiamethoxam	3.5 fl oz	18 Aug
18. Leverage 360 SC	4A + 3A	imidacloprid + beta-cyfluthrin	2.8 fl oz	18 Aug
19. Tundra EC	3A	bifenthrin	6.4 fl oz	18 Aug

[a] Insecticide group according to the Insecticide Resistance Action Committee (*http://www.irac-online.org/*);
[b] Does not contain a fungicidal/insecticidal seed treatment (ST) unless noted; [c] per acre unless noted.

Table 4. Soybean aphid density and yield for treatments at the Northwest Research Farm in 2017

Treatment and Formulation	CAD ± SEM[a]	CAD - LSD[b]	Yield ± SEM[c]	Yield - LSD[d]
1. Untreated Control	14,004.47 ± 3,576.81	F	57.46 ± 2.64	AB
2. Cruiser 5FS	6,601.77 ± 1,939.18	DE	60.35 ± 4.79	AB
3. Cruiser 5FS and Warrior II CS	1,344.30 ± 252.94	AB	58.14 ± 3.41	AB
4. Warrior II CS	2,657.48 ± 522.41	ABC	59.02 ± 3.49	AB
5. Lorsban Advanced EC	1,796.35 ± 666.76	ABC	62.28 ± 3.51	A
6. Warrior II CS and Lorsban Advanced EC	3,854.51 ± 2,520.41	BCD	58.42 ± 2.32	AB
7. Dimethoate 4E	1,718.64 ± 451.71	AB	58.47 ± 2.28	AB
8. Hero EC and Dimethoate 4E	1,070.83 ± 129.99	AB	59.07 ± 5.36	AB
9. Agri-Mek SC	8,442.74 ± 821.96	E	57.67 ± 3.83	AB
10. Brigadier SC	1,796.60 ± 320.17	ABC	55.35 ± 2.90	B
11. Carbine 50 WG	1,394.15 ± 586.51	AB	57.06 ± 3.83	AB
12. Cobalt Advanced EC	1,488.24 ± 391.94	AB	61.45 ± 2.15	AB
13. Transform WG	1,235.70 ± 185.39	AB	59.20 ± 1.93	AB
14. Seeker SE	658.33 ± 115.44	A	60.37 ± 4.42	AB
15. Sivanto 200 SL	2,467.79 ± 710.21	ABC	57.42 ± 1.55	AB
16. Movento SC 100	4,613.69 ± 930.32	CD	62.21 ± 6.32	A
17. Endigo ZC	2,369.28 ± 496.68	ABC	57.52 ± 3.68	AB
18. Leverage 360 SC	3,235.24 ± 809.45	ABC	55.74 ± 7.97	B
19. Tundra EC	1,466.81 ± 218.59	AB	62.24 ± 4.63	A

[a] CAD (cumulative aphid days) is the estimated seasonal exposure of soybean aphid ± the standard error of the mean; [b] LSD (least significant difference) of CAD at alpha = 0.10 ($P<0.0001$; $F = 6.47$; df = 18, 3); [c] yield is reported in bushels per acre ± the standard error of the mean; [d] LSD of yield at alpha = 0.10 ($P<0.0001$; $F = 3.79$; df = 18, 3).



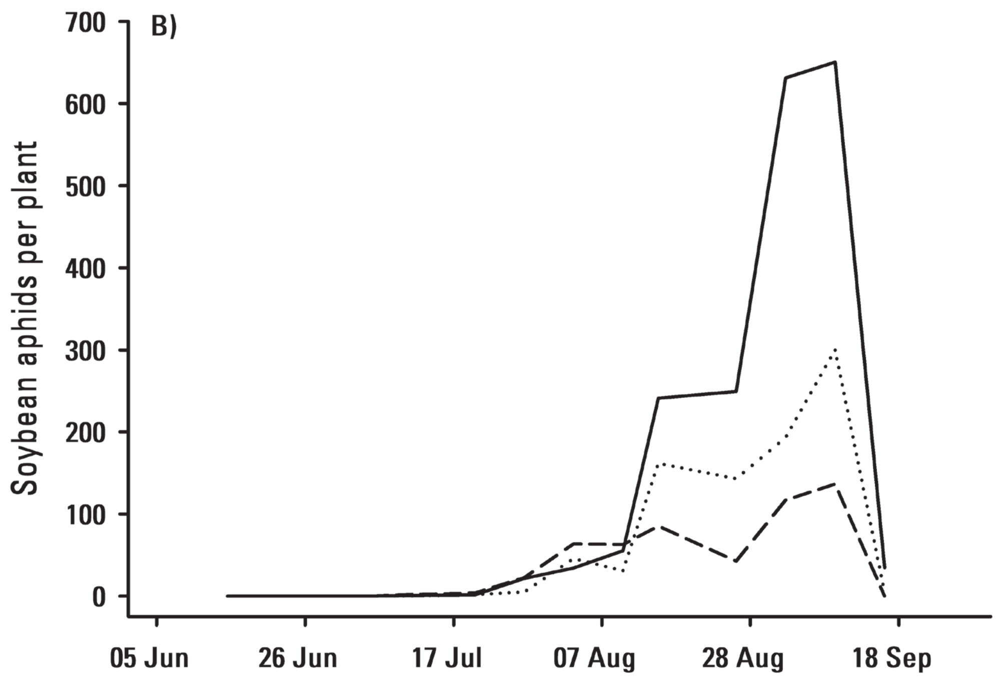


Figure 1. Mean number of aphids per plant in 2017 at the A) Northeast Research Farm and B) Northwest Research Farm.

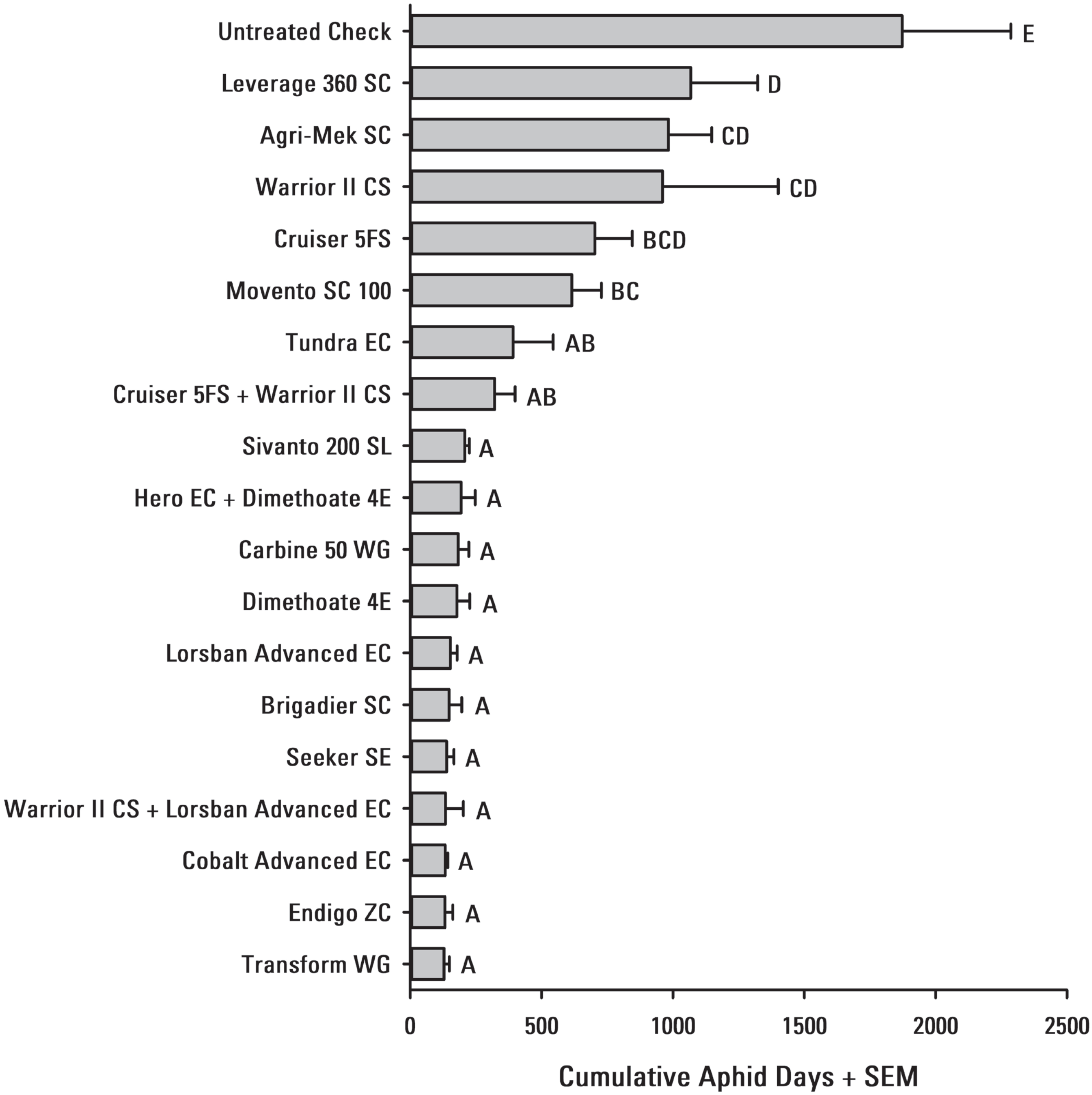


Figure 2. Mean separation of cumulative aphid days + standard error of the mean treatments at the Northeast Research Farm in 2017. See Table 1 for a full list of treatments and rates. Means with a unique letter are significantly different at alpha = 0.10 (P<0.0001; F = 6.87; df = 18, 3).

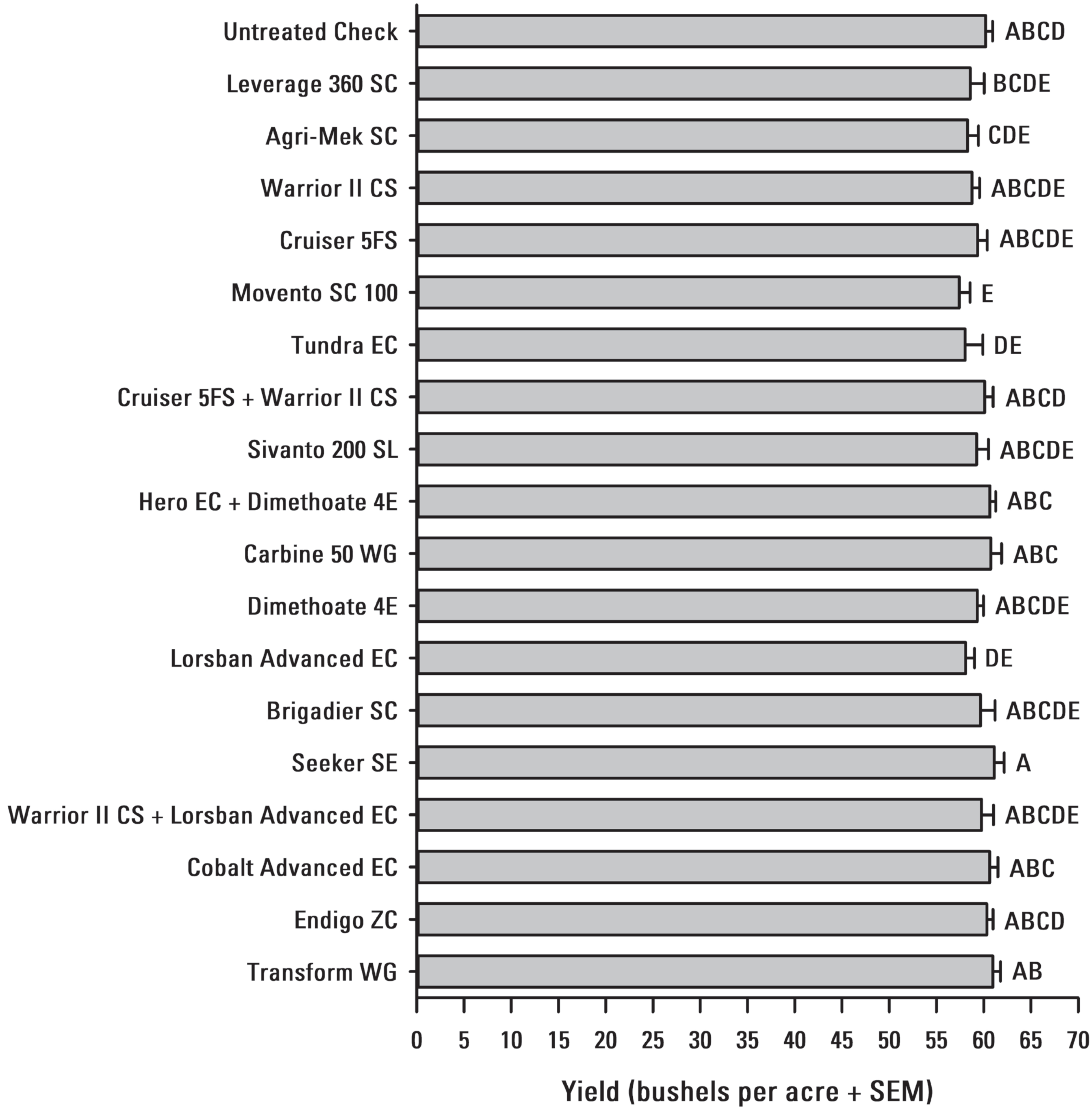


Figure 3. Mean separation of yield + standard error the mean for treatments at the Northeast Research Farm in 2017. See Table 1 for a full list of treatments and rates. Means with a unique letter are significantly different at alpha = 0.10 (P=0.1950; F = 1.34; df = 18, 3).

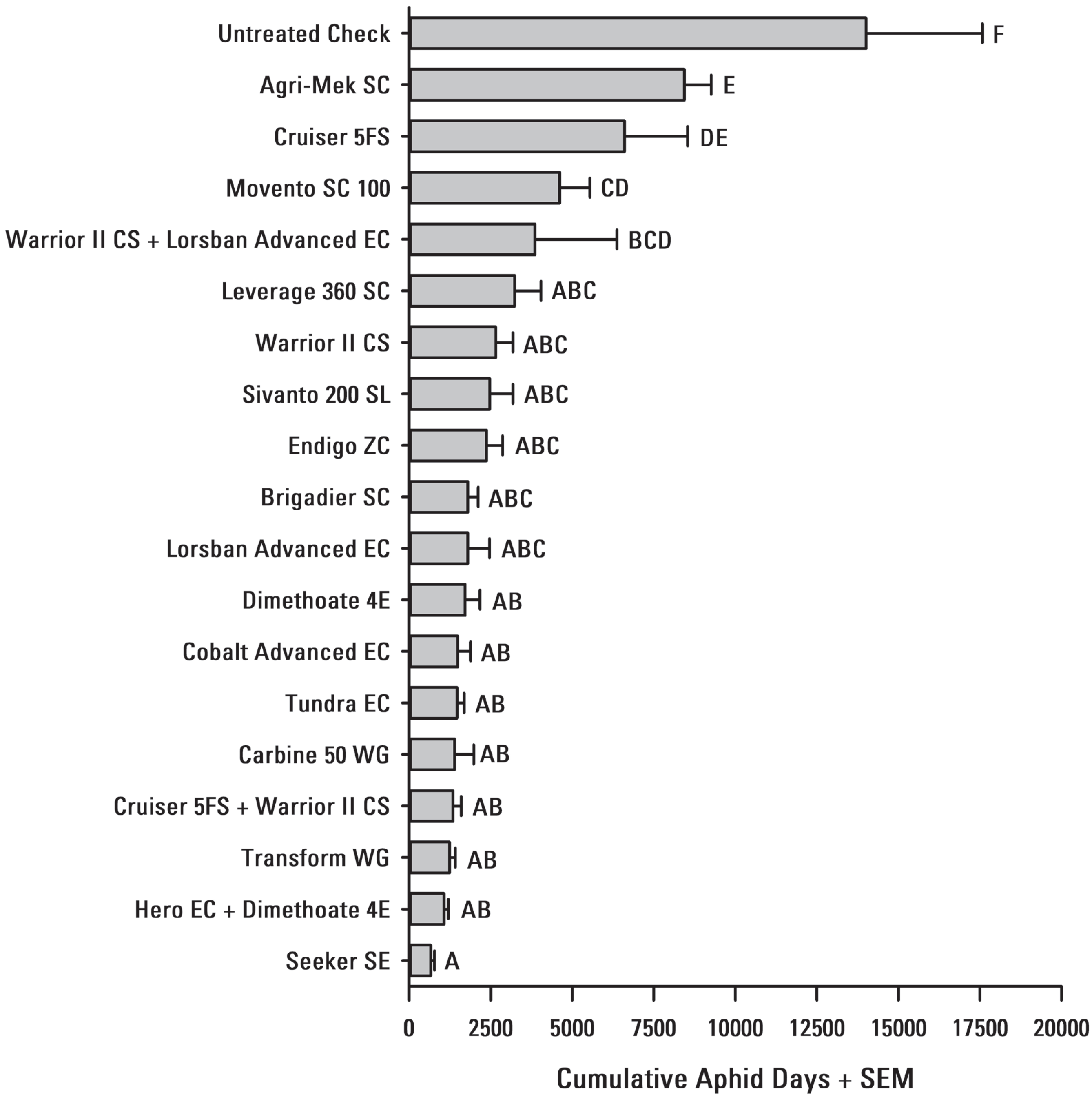


Figure 4. Mean separation of cumulative aphid days + standard error of the mean for treatments at the Northwest Research Farm in 2017. See Table 5 for a full list of treatments and rates. Means with a unique letter are significantly different at alpha = 0.10 (P<0.0001; F = 6.47; df = 18, 3).

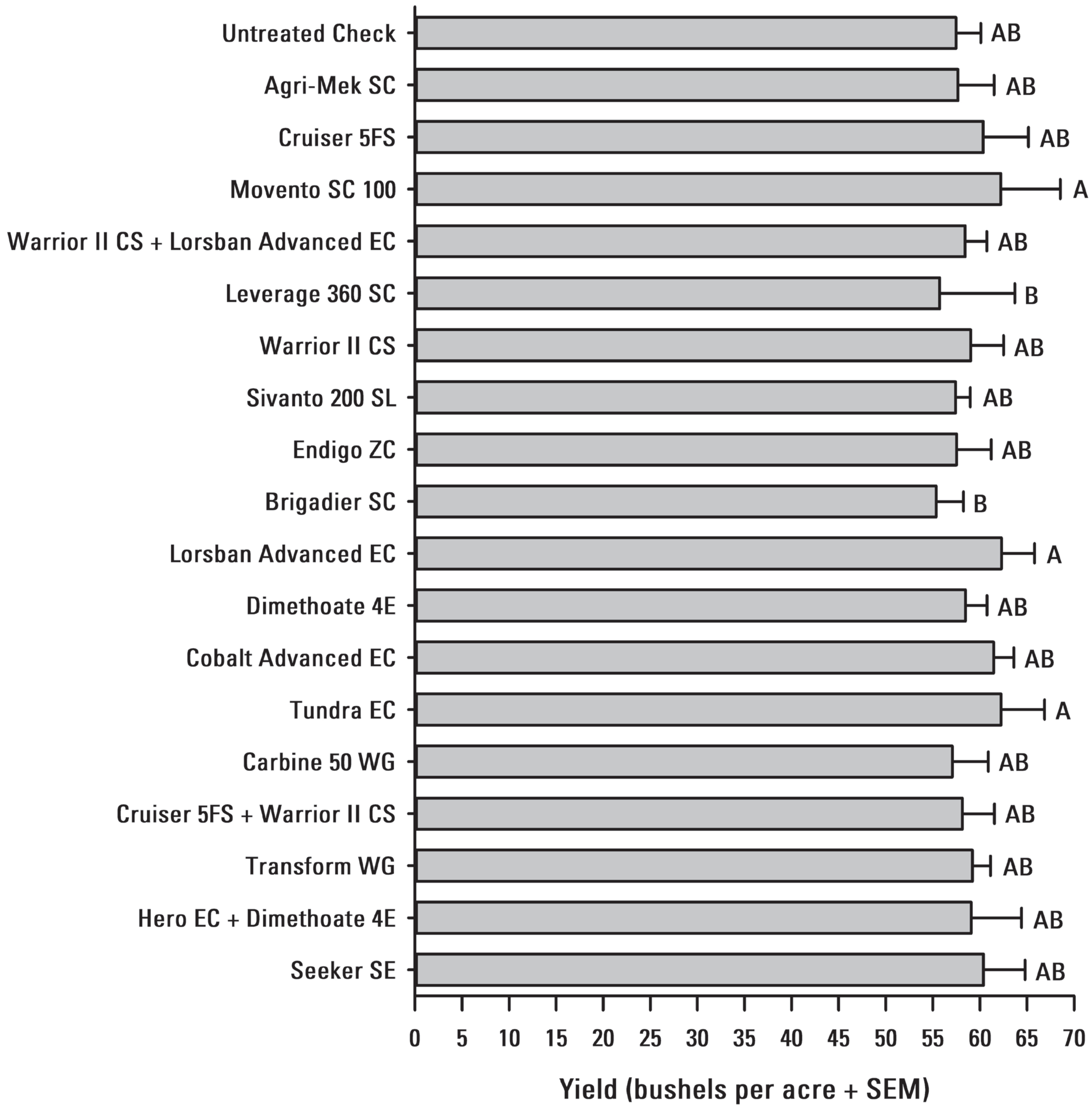


Figure 5. Mean separation of yield + standard error of the mean for treatments at the Northwest Research Farm in 2017. See Table 5 for a full list of treatments and rates. Means with a unique letter are significantly different at alpha = 0.10 (P<0.0001; F = 3.79; df = 18, 3).

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