Wisconsin Vegetable
Insect Pest Management Research
Summer Field Trials

2016

Russell Groves
Professor, Entomology

Scott Chapman
Researcher, Entomology

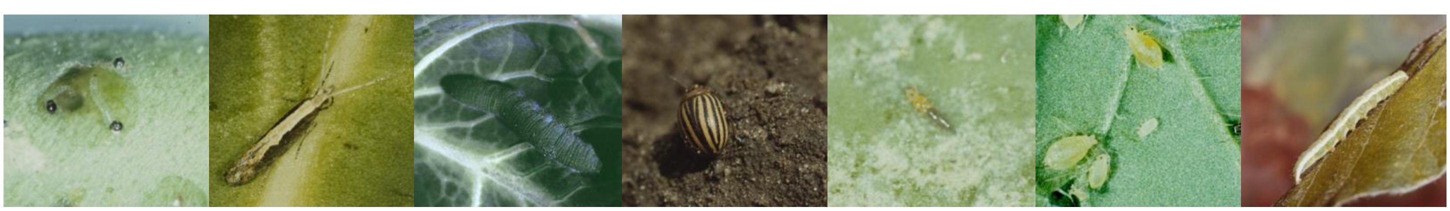
Ben Bradford

Linda Crubaugh

Emily Duerr

University of Wisconsin, Madison
Department of Entomology
1630 Linden Drive
Madison, WI 53706

(608) 262-3229
groves@entomology.wisc.edu
www.entomology.wisc.edu/vegento



Principle Investigators

Russell Groves and Scott A. Chapman

Additional Foliar PVY Management Principle Investigators

Stephanie Plaster, Langlade County Agricultural Extension Agent
Rick Hafner and Kevin Bula, Senior Field Inspectors, Wisconsin Seed Potato Certification Program, Antigo, WI
Alex Crockford, Jolene Spurgeon, and Trudy Bula. Wisconsin Seed Certification Program, Antigo, WI

Acknowledgements

The following organizations and representatives partially supported the research summarized in this report:

SyngentaCropProtection	*Tim Trower,Tony Burd*
Nichino America	*James Adams*
Lab Services	*James Steffel*
Pest Pros Inc	*Randy Van Haren, Linda Kotolski*
AgriPhar	*Jay Angel*
Marrone Bio	*Tim Johnson*
Vestaron Corperation	*Robert Venable*
Certis USA	*Brett Highland*
ISK BioSciences	*Sean Whipple*
Monsanto	*Ruohan Liu*

The following University of Wisconsin faculty and staff have contributed time and expertise to these projects:

Paul Bethke, Jed Colquhoun – Department of Horticulture
Amy Charkowski and Amanda Gevens – Department of Plant Pathology
Matthew Ruark – Department of Soil Science

The following graduate students and students assisted with implementing and evaluating the projects this summer:

Ben Bradford, Kathryn Prince, Justin Clements, Tabatha Davis, Claire Rebman, Anthony Rittmeyer and Nick Sorensen

The following people provided land and resources for this research:

Steve and Andy Dierks, Coloma Farms, Coloma, WI
John Bobeck, Trembling Prairie Farms
Richard and Roderick Gumz, Gumz Muck Farms, Endeavor, WI
Dennis Zeloski, Ron Krueger, Felix Zeloski Farms, Eagle River, WI
Mike Copas, William Wysocki, Russet Potato Exchange

The staff at the following research stations helped maintain the projects and assisted in evaluation of research results:

Arlington, Hancock, and Antigo Agricultural Research Stations

Thank you

Table of Contents

Onion

1) Evaluation of foliar insecticides for the control of onion thrips on dry-bulb onion (Markesan, WI) 5
Foliar. *Onion thrips*

Potatoes

2) Registered and experimental foliar insecticides to control Colorado potato beetle and potato leafhopper on potato (HARS) 9
Foliar. *Colorado potato beetle, potato leafhopper, aphids*

3) Foliar insecticide treatments for the control of Colorado potato beetle in Wisconsin potato production (AARS) 24
Foliar. *Colorado potato beetle*

4) Foliar insecticide treatments to limit the spread of Potato virus Y in Wisconsin seed potato production (Antigo, WI) 33
Foliar. *Potato virus Y*

5) Evaluation of systemic insecticides for the control of the Colorado potato beetle, potato leafhopper, and aphids in potato (HARS) 41
Systemic. *Colorado potato beetle, potato leafhopper, aphids*

6) Large plot demonstration experiments of Colorado potato beetle in Wisconsin potatoes (HARS) 55
Full season management. *Colorado potato beetle, potato leafhopper, aphids*

Snap bean

7) Foliar insecticide treatments for the control of European corn borer in Wisconsin snap bean production (Plover, WI) 70
Foliar. *European corn borer*

8) In-furrow treatments for the control of seedcorn maggot in Wisconsin snap bean production (Plover, WI) 72
In-furrow. *Seedcorn maggot*

Pepper

9) Foliar insecticide treatments for the control of European corn borer in Wisconsin pepper production (AARS) 74
Foliar. *European corn borer*

Cabbage

10) Evaluation of at plant insecticides for the control of cabbage maggot on cabbage (Randolph, WI) 80
In-furrow. *Cabbage maggot*

Cucurbit

11) Evaluation of at plant insecticides for the control of seedcorn maggot on cucurbits (Cashton, WI)....................83
In-furrow. *Seedcorn maggot*

Trial 1

Evaluation of foliar insecticides for the control of onion thrips on dry-bulb onion (Markesan, WI)

Purpose

The objective of this experiment was to assess the efficacy of foliar insecticides applied at-threshold to control immature stages of onion thrips (OT), *Thrips tabaci*, on dry-bulb onion.

Materials and Methods

This experiment was conducted in a cooperating producer's onion field located near Markesan, WI on a muck soil. Onion, *Allium cepa* cv. 'Focus', was direct seeded on 19 April, 2016. Plants were spaced 2.6 inches apart within rows. Rows were 9.4 inches apart. The six-row plots were 60 inches wide by 25 ft long on raised formed beds, for a total of 0.003 acres, and were separated by planted guard beds of the same dimensions between plots. All plots were maintained by the grower according to standard commercial practices.

Four replicates of 7 experimental treatments and 1 untreated control were arranged in a randomized complete block design. Applications were initiated when mean immature thrips populations had exceeded established thresholds of 3 immature thrips/ leaf. All foliar treatments were applied on 18 and 25 July. Treatments were applied with a CO_2 backpack sprayer with a 6 ft. boom operating at 30 psi delivering 22.1 gpa through four flat-fan nozzles (Tee Jet XR8002XR) spaced 18" apart while traveling at 3.5 ft / sec.

Immature life stages of onion thrips (OT) were assessed by counting the number of larvae per plant on 10 randomly selected plants in the central 2 rows of each plot. Larval counts occurred four times, on 20 and 29 July (2 and 11 DAT), after the first application and again on 2 and 8 August (8 and 14 DAT) after the second application. Count data were Log10 transformed prior to data analysis using ANOVA and means were compared using a Tukey's HSD means separation test (P=0.05). Data are presented in **graphs** by date and a summary in **Table 1**.

No signs of phototoxicity were observed among treatments.

Table 1. Mean count of immature onion thrips per plant

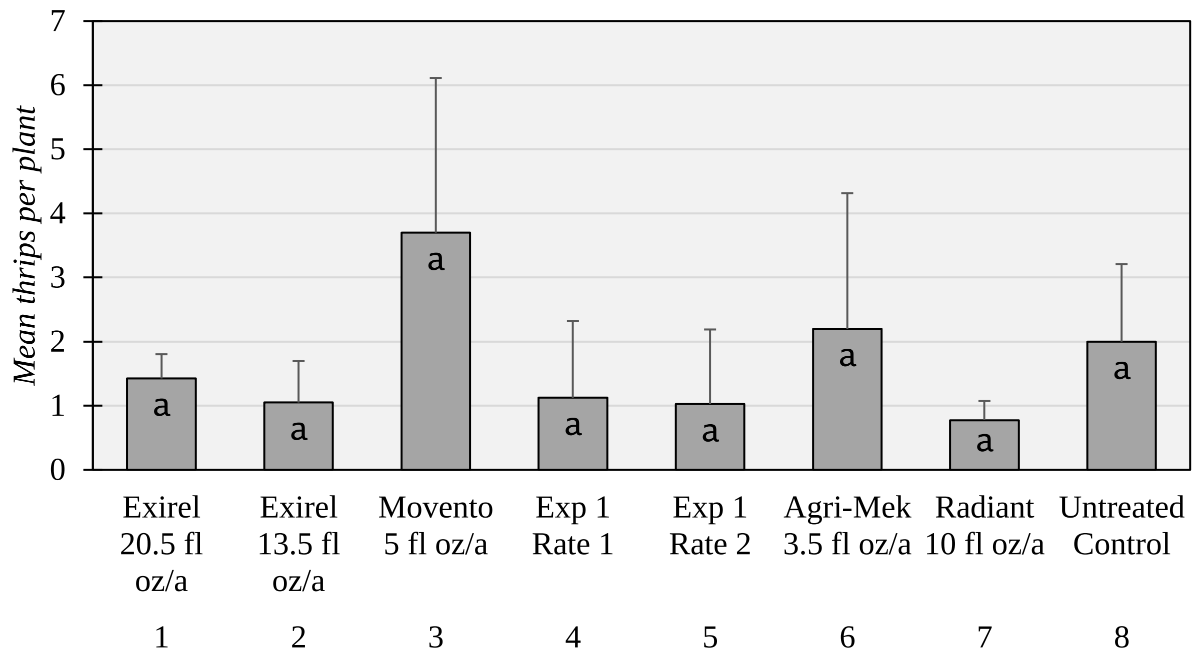
Trt	Product	Form	Rate		20-Jul (2 DAT)		29-Jul (11 DAT)		2-Aug (8 DAT)		8-Aug (14 DAT)	
1	Exirel	100 SE	20.5	fl oz/a	1.425	a	0.350	ab	0.425	ab	3.100	a
2	Exirel	100 SE	13.5	fl oz/a	1.050	a	0.500	ab	0.125	a	4.400	a
3	Movento	2 SC	5	fl oz/a	3.700	a	1.025	bc	1.525	b	6.500	a
4	Exp 1		Low		1.125	a	0.225	ab	0.275	ab	3.400	a
5	Exp 1		High		1.025	a	0.425	ab	0.225	ab	3.650	a
6	Agri-Mek	0.7 SC	3.5	fl oz/a	2.200	a	0.325	ab	0.375	ab	1.750	a
7	Radiant	1 SC	10	fl oz/a	0.775	a	0.075	a	0.550	ab	2.025	a
8	Untreated				2.000	a	1.950	c	5.075	c	7.900	a
				P	0.107		< .0001		< .0001		0.22	
				HSD	0.437		0.209		0.319		0.674	

a. MSO added at 0.5% v/v

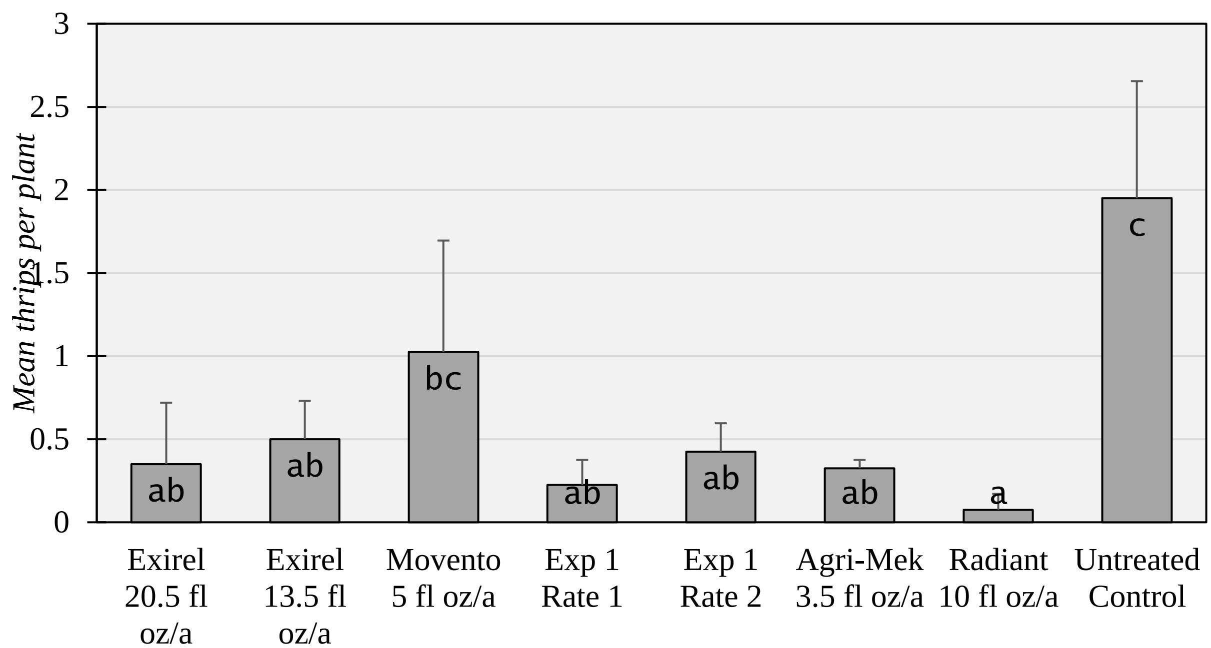
b. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)

Figure 1 A-D. Mean thrips per plant by treatment/date

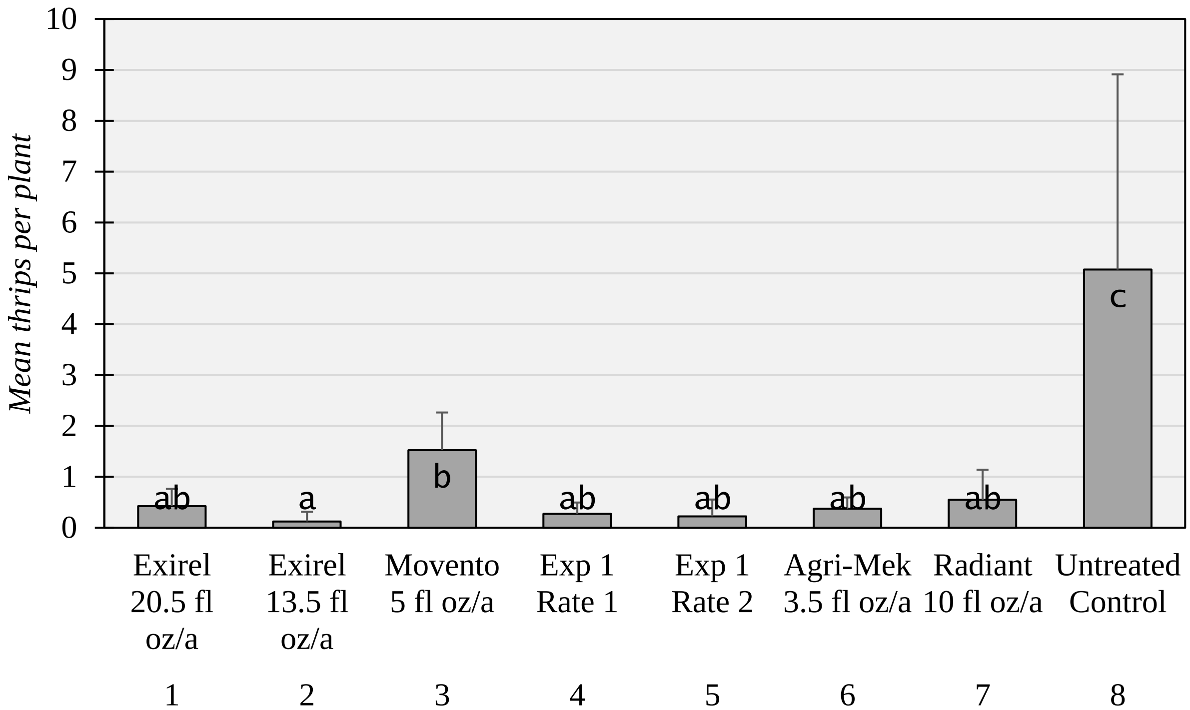
A) 20 July, 2016



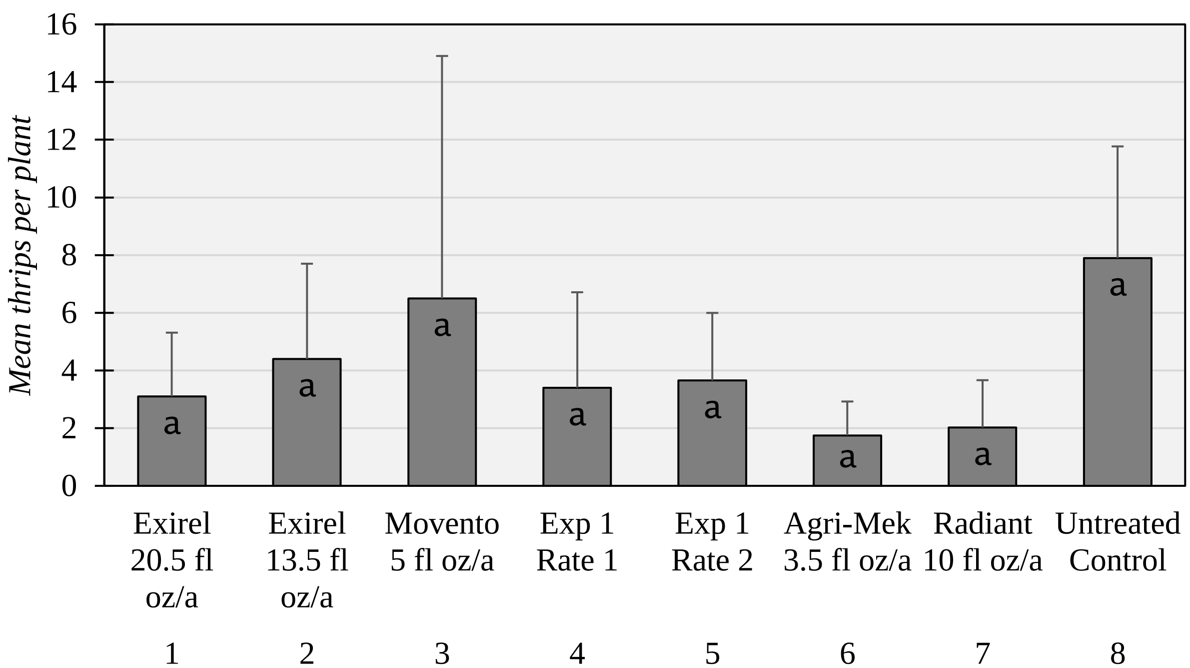
B) 29 July, 2016



C) 02 Aug, 2016



D) 08 Aug, 2016



Trial 2

Registered and experimental foliar insecticides to control Colorado potato beetle and potato leafhopper on potato (HARS)

Purpose

The objective of this experiment was to assess the efficacy of foliar insecticides applied to early instar larvae of the first generation of Colorado potato beetle (CPB), *Leptinotarsa decemlineata*, and potato leafhopper (PLH) adults, *Empoasca fabae*, on potato.

Materials and Methods

This experiment was conducted at Hancock Agricultural Research Station (HARS) located 1.1 mile (1.8 km) southwest of Hancock, Wisconsin on a loamy sand soil in 2016. Potato, *Solanum tuberosum* cv. 'Yukon Gold', seed pieces were planted on 21 April. Seed pieces were spaced 12 inches apart within rows. Rows were 3 ft apart. Two-row plots were 6 ft wide by 20 ft long, for a total of 0.003 acres. Two untreated rows separated plots while 12 ft tilled alleys separated replications. All plots were maintained according to standard commercial practices conducted by HARS staff.

Four replicates of 34 experimental foliar treatments and 2 untreated controls were arranged in a randomized complete block design. The foliar treatments were applied twice in succession when 75-90% of the first generation CPB was within the first and second instar larval stadia. Weather conditions and spray dates were noted (**Table 1 and 2**). The timing of foliar applications and insect scouting events are presented in **Table 3**. Treatments were applied with a CO_2 pressurized backpack sprayer with a 6 ft boom operating at 30 psi delivering 20 gpa through 4 flat-fan nozzles (Tee Jet XR8002) spaced 18" apart while travelling at 3.5 ft / sec.

CPB adults (CPB-A), egg masses (-EM), small larvae (-SL), large larvae (-LL) were assessed by counting the number of each life stage on 10 randomly selected plants from the center two rows in each plot. Potato leafhopper (PLH) control efficacy was assessed by counting the number of adults (PLH-A) in 20 canopy sweeps, and nymphs (-N) on 25 randomly selected leaves from the center two rows of each plot. Aphid control efficacy was assessed using the same method as for PLH nymphs. Defoliation ratings (DF) were determined by visual observation of the entire plot. CPB count data summaries can be found in **Table 4** and accompanying **graphs**.

Insect and larval counts on several dates throughout the summer and cumulative counts were generated for statistical analysis (**Tables 1-3).** Count data were Log10 transformed prior to data analysis using ANOVA and means were compared using a Tukey's HSD means separation test (P=0.05). No signs of phytotoxicity were observed among treatments.

Table 1. Spray dates and atmospheric conditions

Date	Appl Time	Wind Dir	Wind Speed	Temp.	RH%	Sky
8-Jun	10:00-11:00	N/NW	3 mph (4.8 kph)	71°F (22°C)	57	cloudy
16-Jun	9:30-11:00	N	5-8 mph (8-13 kph)	68°F (20°C)	55	cloudy
23-Jun	9:00-10:30	E	2 mph (3.2 kph)	70°F (21°C)	62	cloudy
6-Jul	9:00 - 10:00	W	2.5 mph (4.1 kph)	72°F (22°C)	79	cloudy

Table 2. Spray timing by treatment

Trt	Product, Rate, App. Freq.	Application Dates			
		8-Jun	16-Jun	23-Jun	6-Jul
1	Untreated				
2	Exirel 10.8 oz/a + NIS (2 app.)		X	X	
3	Agri-Mek 2.72 oz/a + NIS (2 app.)		X	X	
4	Exp1-1 + NIS (2 app.)		X	X	
5	Exp1-2 + NIS (2 app.)		X	X	
6	Exp1-3 + NIS (2 app.)		X	X	
7	Besiege 9 oz/a + NIS (2 app.)		X	X	
8	Blackhawk 3.3 oz/a + NIS (2 app.)		X	X	
9	Blackhawk 3.0 oz/a + NIS (2 app.)		X	X	
10	Blackhawk 2.75 oz/a + NIS (2 app.)		X	X	
11	Exp2 + LI-700 (2 app.)		X	X	
12	Exp3-4 + LI-700 (2 app.)		X	X	
13	Exp2 + Exp3-4 + LI-700 (2 app.)		X	X	
14	Exp2 + Exp3-2 + LI-700 (2 app.)		X	X	
15	Exp3-5 + LI-700 (2 app.)		X	X	
16	Exp3-3 + LI-700 (2 app.)		X	X	
17	Exp3-1 + LI-700 (2 app.)		X	X	
18	Gladiator 19 oz/a + NIS (2 app.)		X	X	
19	Athena 17 oz/a + NIS (2 app.)		X	X	
20	Exp4-2 + NIS (2 app.)		X	X	
21	Exp4-1 + NIS (2 app.)		X	X	
22	Exp5-2 (3 app. 14 day)	X		X	X
23	Exp6-2 (3 app. 14 day)	X		X	X
24	Exp5-1 (3 app. 14 day)	X		X	X
25	Exp6-1 (3 app. 14 day)			X	X
26	Exp5-2 (3 app. 7 day)	X	X	X	
27	Exp6-1 (3 app. 7 day)	X	X	X	
28	Rimon 9, 8, 7 oz/a (3 app.)	X	X	X	
29	Grandevo 3 lb/a (3 app.)	X	X	X	
30	Venerate 8 qt/a (3 app.)	X	X	X	
31	Untreated				
32	Belay 3 oz/a + MSO (2 app.)		X	X	
33	Entrust 10 oz/a (2 app.)		X	X	
34	Radiant 8 oz/a (2 app.)		X	X	
35	Sivanto 14 oz/a (2 app.)		X	X	
36	Coragen 5 oz/a (2 app.)		X	X	

Table 3. Timing of insecticide sprays and pest scouting events

Count type	8-Jun	16-Jun	20-Jun	22-Jun	23-Jun	27-Jun	29-Jun	6-Jul	6-Jul	7-Jul	12-Jul	13-Jul	14-Jul
CPB-A	Insecticide application	Insecticide application	X		Insecticide application	X		X	Insecticide application		X		
CPB-EM			X			X		X			X		
CPB-SL			X			X		X			X		
CPB-LL			X			X		X			X		
PLH-A				X			X					X	
PLH-N							X			X			X
Aphid							X			X			X
Defoliation							X			X		X	
Days after last treatment			4	6	-	4	6	13	-	1	6	7	8

Table 4. Mean cumulative counts for each pest and life stage.

Trt	Product / Rate	CPB-AD 1		CPB-AD 2		CPB-EM		CPB-SL		CPB-LL		PLHA		PLHN		Aphid		DF	
1	Untreated	1.25	a-e	172.75	d-g	5.75	a	407.25	hi	277.00	j	5.75	a-g	25	ef	4.75	a	3.83	kl
2	Exirel 10.8 oz/a + NIS (2 app.)	6	c-g	30	ab	5.25	a	38.25	a-d	5.50	ab	28.00	ij	19.5	ef	2.5	a	1.08	ab
3	Agri-Mek 2.72 oz/a + NIS (2 app.)	2.5	a-g	31	a-e	8.00	a	81.75	c-g	7.50	a-e	26.75	hij	25.5	ef	6.5	a	1.08	ab
4	Exp1-1 + NIS (2 app.)	10.25	g	77.5	a-g	9.00	a	51.25	a-e	7.00	a-d	21.25	g-j	22.5	ef	4	a	1.33	a-d
5	Exp1-2 + NIS (2 app.)	8.75	fg	31.5	a-d	10.00	a	45.25	a-d	3.25	a	28.00	hij	21.75	ef	3	a	1.08	ab
6	Exp1-3 + NIS (2 app.)	4.75	a-g	12.5	a	11.50	a	32.00	abc	1.50	a	20.50	f-j	16.25	c-f	2	a	1.00	a
7	Besiege 9 oz/a + NIS (2 app.)	5	b-g	39	a-f	8.75	a	186.75	e-i	24.75	e-h	12.00	c-j	2.5	a-e	3.5	a	1.00	a
8	Blackhawk 3.3 oz/a + NIS (2 app.)	6.75	c-g	52.25	abc	11.25	a	46.50	a-d	24.25	d-g	21.50	g-j	34.25	f	5.5	a	1.25	abc
9	Blackhawk 3.0 oz/a + NIS (2 app.)	6.75	d-g	93.5	a-g	12.50	a	49.50	a-e	14.00	b-f	29.25	ij	43	f	8.5	a	1.42	a-e
10	Blackhawk 2.75 oz/a + NIS (2 app.)	5.75	c-g	30.75	a-e	10.75	a	54.00	bcdef	20.00	c-f	23.00	g-j	23.5	ef	4	a	1.00	a
11	Exp2 + LI-700 (2 app.)	1.75	a-g	210	efg	4.00	a	571.75	i	286.25	j	1.75	a	9.75	a-f	2.75	a	3.92	l
12	Exp3-4 + LI-700 (2 app.)	0.75	abc	123.75	c-g	2.75	a	555.50	i	287.50	j	2.25	ab	8.5	a-f	4.5	a	3.83	kl
13	Exp2 + Exp3-4 + LI-700 (2 app.)	1.75	a-g	181.75	d-g	4.25	a	371.75	hi	246.00	ij	3.25	abc	11.75	a-f	5.5	a	3.33	jkl
14	Exp2 + Exp3-2 + LI-700 (2 app.)	1.25	a-f	159.25	d-g	1.50	a	483.50	i	267.25	j	3.75	a-d	11	a-f	2.25	a	3.50	jkl
15	Exp3-5 + LI-700 (2 app.)	0.25	a	146.75	d-g	3.25	a	568.50	i	239.75	ij	1.50	a	6.25	a-f	3.25	a	3.58	jkl
16	Exp3-3 + LI-700 (2 app.)	1.5	a-g	199.5	efg	4.25	a	522.75	i	180.50	ij	3.75	abc	14	a-f	1.5	a	3.08	hij
17	Exp3-1 + LI-700 (2 app.)	2.25	a-g	142	d-g	4.00	a	490.75	i	231.50	ij	4.00	a-d	9.25	a-f	0.75	a	3.42	jkl
18	Gladiator 19 oz/a + NIS (2 app.)	4.5	a-g	219.75	d-g	7.50	a	266.25	ghi	112.00	ij	4.75	a-e	0.75	abc	9.5	a	1.75	b-f
19	Athena 17 oz/a + NIS (2 app.)	0.75	abc	278.75	g	7.25	a	236.25	f-i	79.75	hi	1.75	a	0.25	a	7	a	1.92	c-g
20	Exp4-2 + NIS (2 app.)	0.75	abc	220.5	d-g	7.00	a	394.25	hi	25.75	e-h	5.00	a-f	9.25	a-f	5.25	a	2.08	efg
21	Exp4-1 + NIS (2 app.)	8.5	efg	155.25	d-g	8.75	a	48.00	a-e	4.00	a	20.50	e-j	41.25	ef	12.25	a	1.58	a-e
22	Exp5-2 (3 app. 14 day)	2.5	a-g	129.5	d-g	5.00	a	482.25	i	217.75	ij	8.75	b-j	30.75	ef	2.75	a	3.08	hij

Trt	Product / Rate	CPB-AD 1		CPB-AD 2		CPB-EM		CPB-SL		CPB-LL		PLHA		PLHN		Aphid		DF	
23	Exp6-2 (3 app. 14 day)	1.5	a-f	171.25	d-g	3.75	a	279.75	ghi	150.25	ij	11.25	b-j	26	ef	2	a	2.42	fgh
24	Exp5-1 (3 app. 14 day)	0.75	ab	180.5	d-g	5.50	a	450.50	hi	201.75	ij	8.75	a-i	27.5	def	4.25	a	3.33	jkl
25	Exp6-1 (3 app. 14 day)	1.5	a-f	156.5	d-g	3.25	a	463.25	i	229.75	ij	5.75	a-g	24.5	def	3	a	3.42	jkl
26	Exp5-2 (3 app. 7 day)	1.25	a-f	191.25	d-g	6.50	a	301.25	ghi	140.75	ij	9.50	b-j	32	ef	2.5	a	2.50	ghi
27	Exp6-1 (3 app. 7 day)	1	a-e	172.75	d-g	2.00	a	626.50	i	204.50	ij	5.50	a-f	33.5	ef	4.5	a	3.17	ijk
28	Rimon 9, 8, 7 oz/a (3 app.)	3	a-g	198	efg	7.75	a	226.50	ghi	75.25	ghi	19.50	e-j	60	f	11.5	a	2.08	efg
29	Grandevo 3 lb/a (3 app.)	1.25	a-f	114.5	b-g	4.00	a	474.00	hi	274.00	j	3.75	a-d	17.25	b-f	0.5	a	3.83	kl
30	Venerate 8 qt/a (3 app.)	1.25	a-d	112.75	b-g	6:00 AM	a	405.25	hi	220.50	ij	6.75	a-h	32.75	ef	3.5	a	3.75	jkl
31	Untreated	1.75	a-g	128.25	b-g	4.75	a	418	hi	226.50	ij	7.00	a-i	23.5	ef	2.75	a	3.92	l
32	Belay 3 oz/a + MSO (2 app.)	10.25	g	385.25	fg	14.25	a	56.5	a-e	34.25	fgh	11.50	c-j	2	a-d	0	a	2.00	d-g
33	Entrust 10 oz/a (2 app.)	3	a-g	144.5	d-g	5.25	a	15.5	a	6.00	abc	16.00	d-j	18.5	ef	2.75	a	1.92	c-g
34	Radiant 8 oz/a (2 app.)	7	d-g	148.5	b-g	13.00	a	17.75	ab	23.75	def	22.25	g-j	41.5	ef	6	a	1.83	c-g
35	Sivanto 14 oz/a (2 app.)	5.75	c-g	180.5	d-g	5.00	a	268	ghi	209.75	ij	7.00	a-i	0.5	ab	0.25	a	2.50	ghi
36	Coragen 5 oz/a (2 app.)	5.25	a-g	279.25	efg	7.25	a	121.75	d-h	24.75	c-f	33.75	j	31.5	ef	0.75	a	1.67	a-e
	P	< 0.0001		< 0.0001		0.0002		< 0.0001		< 0.0001		< 0.0001		< 0.0001		0.513		< 0.0001	
	HSD	0.663		0.8653		0.8114		0.5866		0.5125		0.565		1.022		1.1744		0.7438	

a. *NIS 100L added at 0.1%v/v, MSO added at 0.125 %v/v*

b. *Means in a column followed by the same letter are not significantly different (Tukey's HSD Test, α=0.05). Means transformed (square root X +1) prior to separation*

c. *Defoliation scored as follows: 1: 0- 2%; 2: 2-5%; 3: 5-10%; 4: >10%*

Fig. 1. Cumulative 1st generation CPB adults

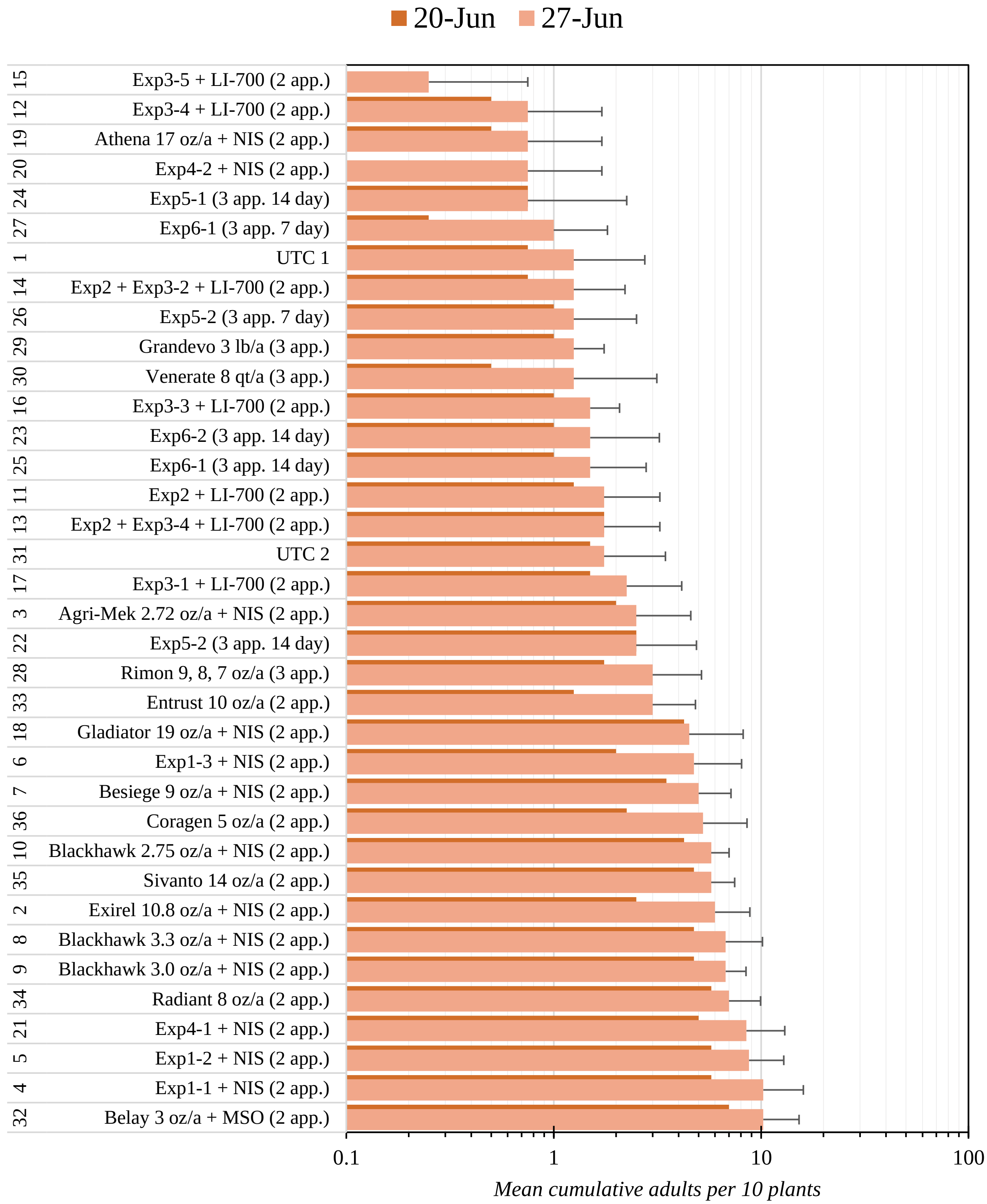


Fig. 2. Cumulative 2nd generation CPB adults

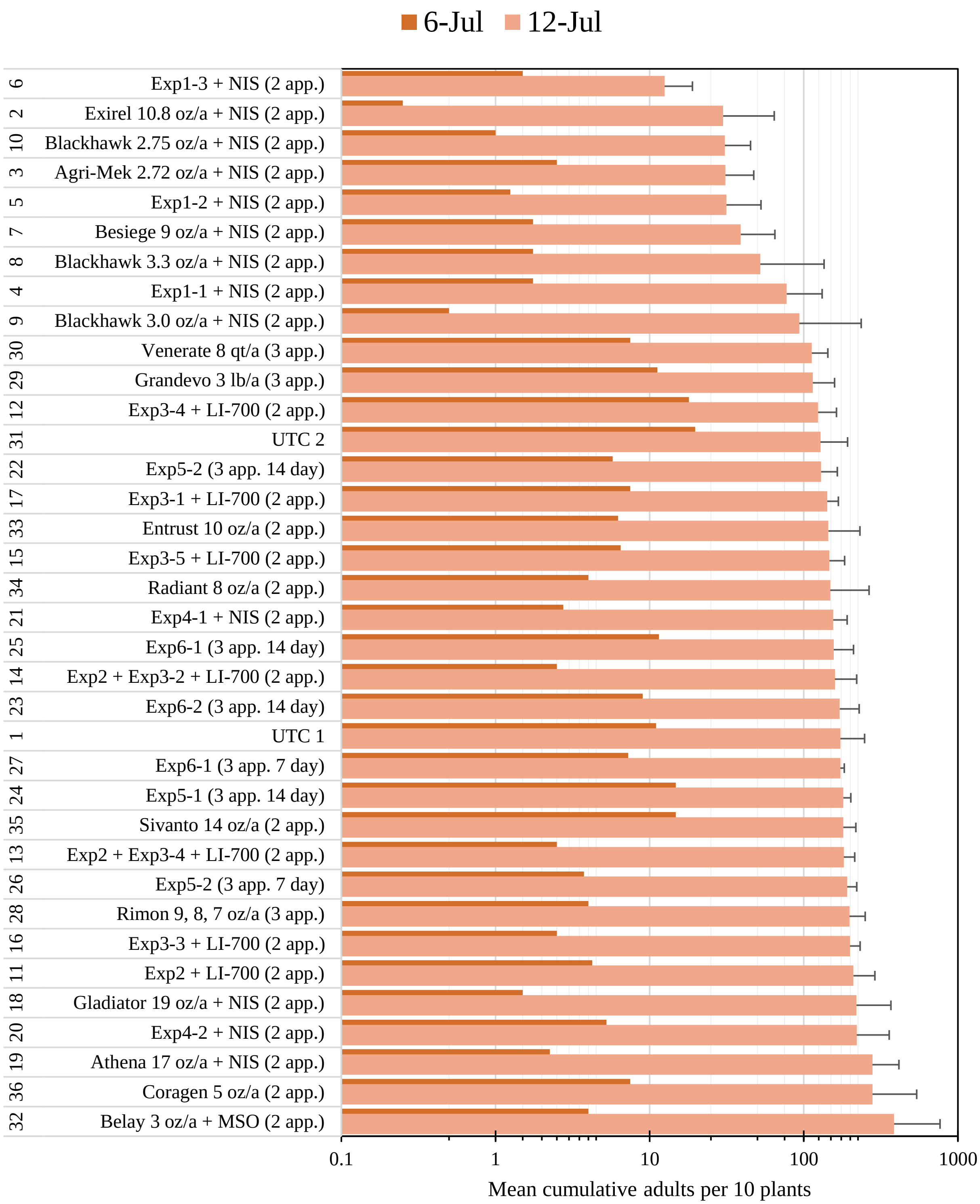


Fig. 3. Cumulative CPB egg masses

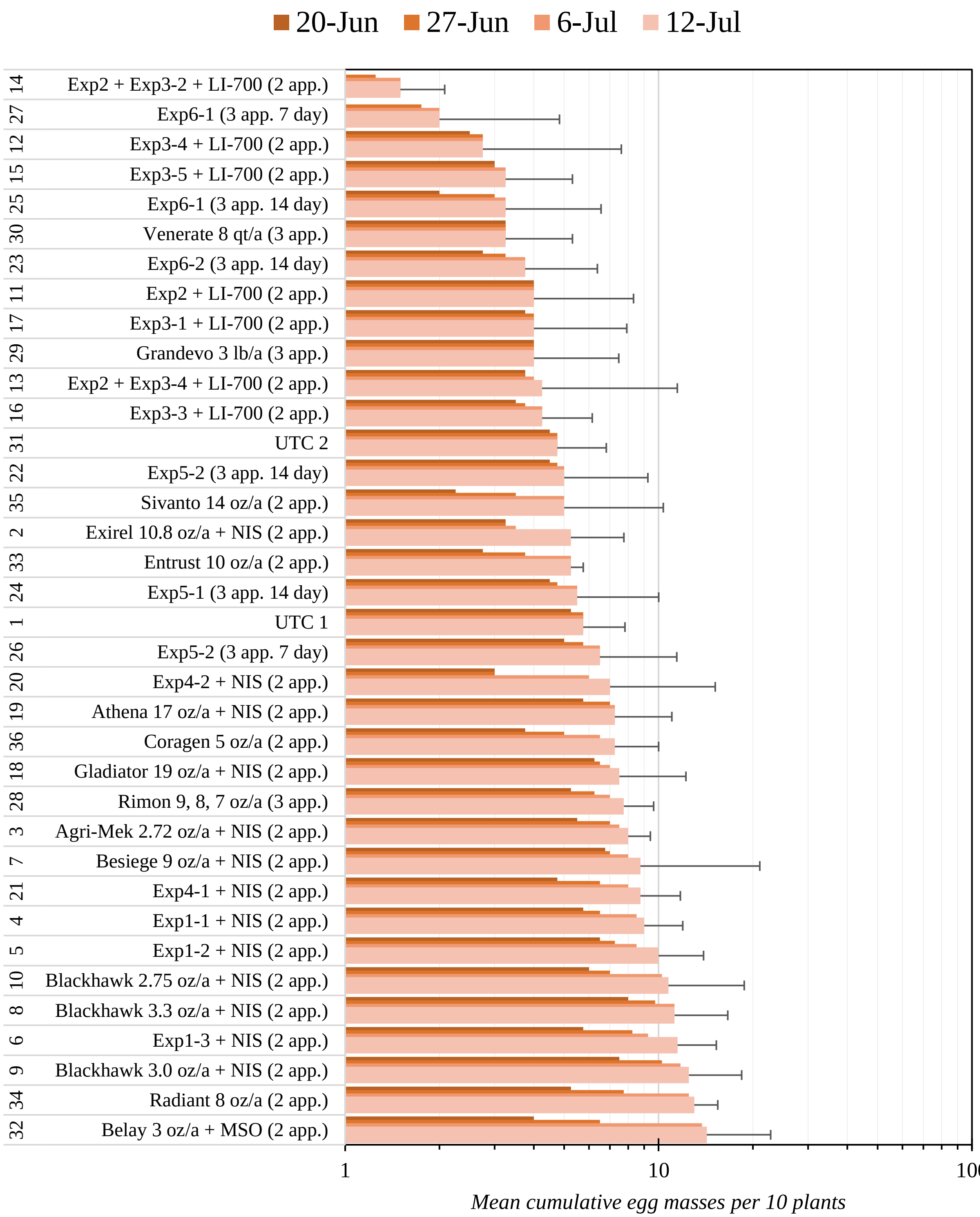


Fig. 4. Cumulative CPB small larvae

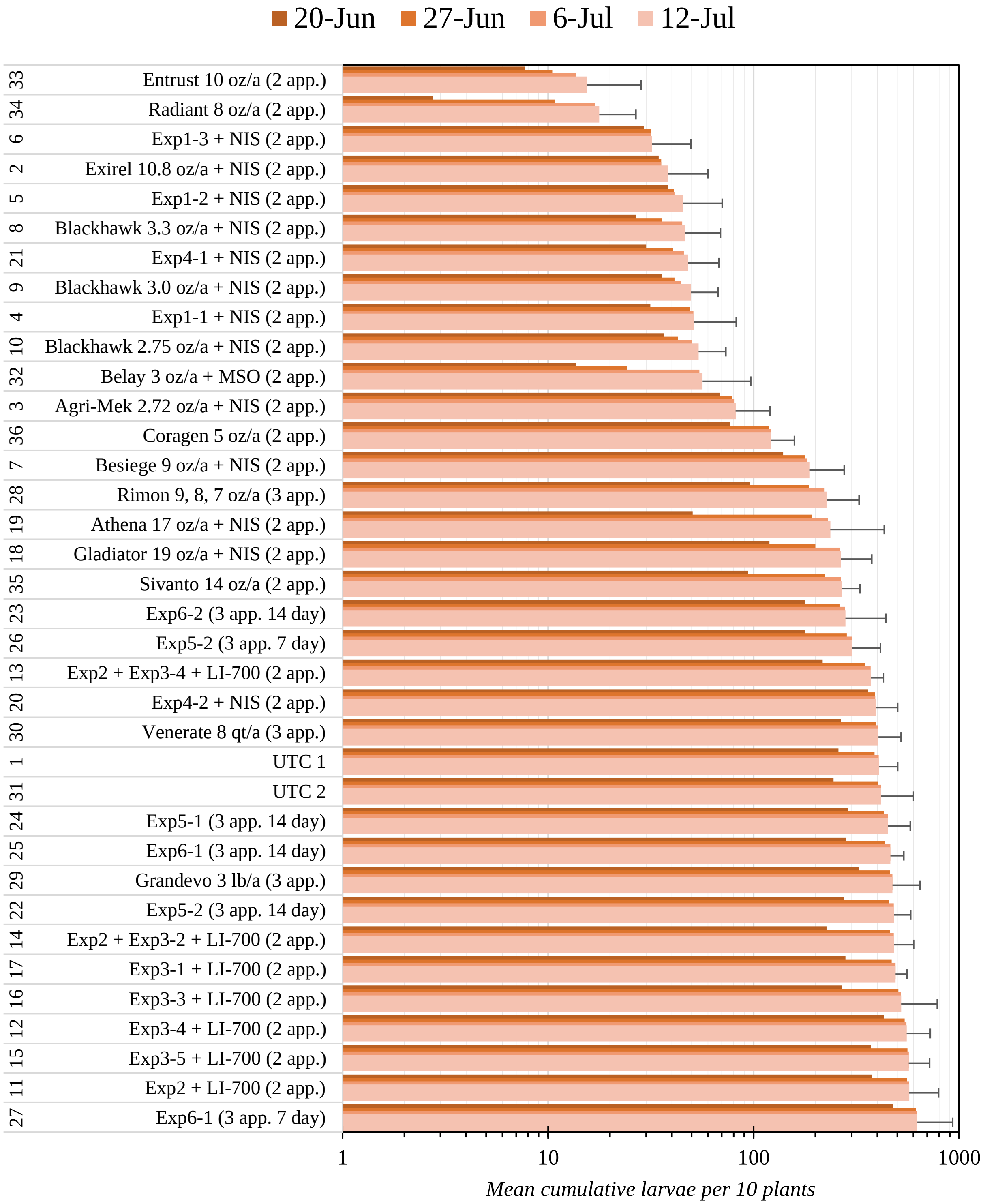


Fig. 5. Cumulative CPB large larvae

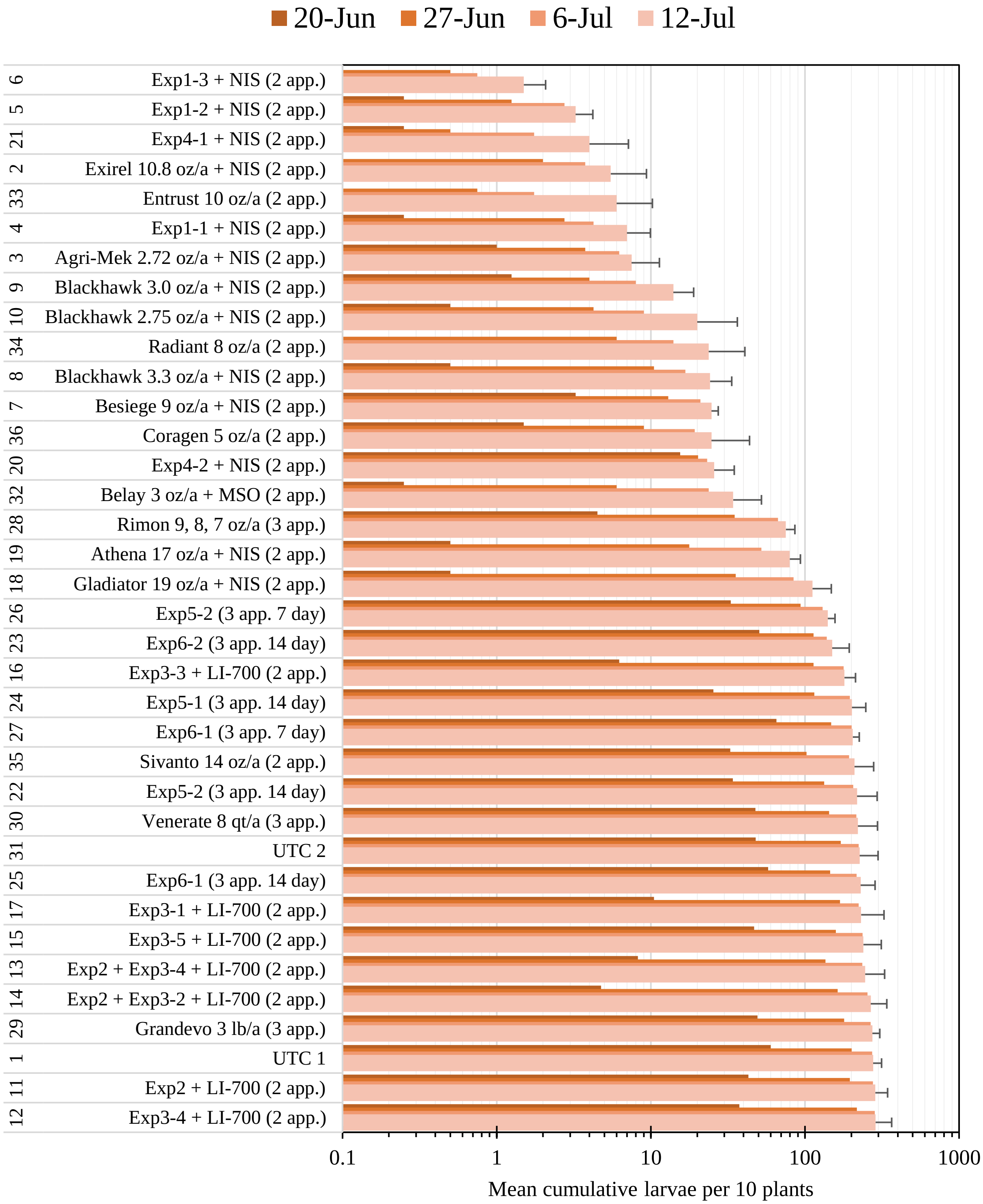


Fig. 6. Cumulative potato leafhopper adults

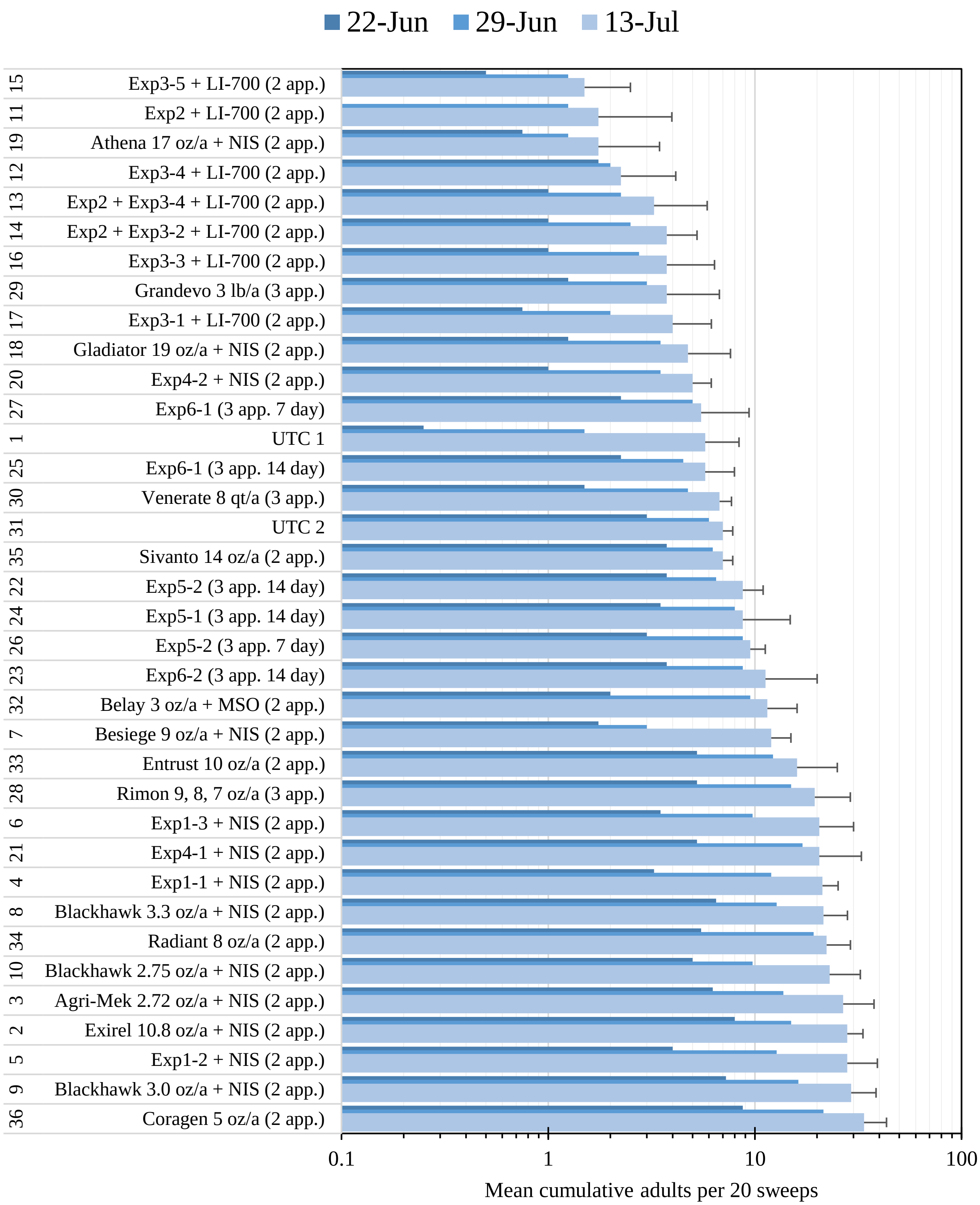


Fig. 7. Cumulative potato leafhopper nymphs

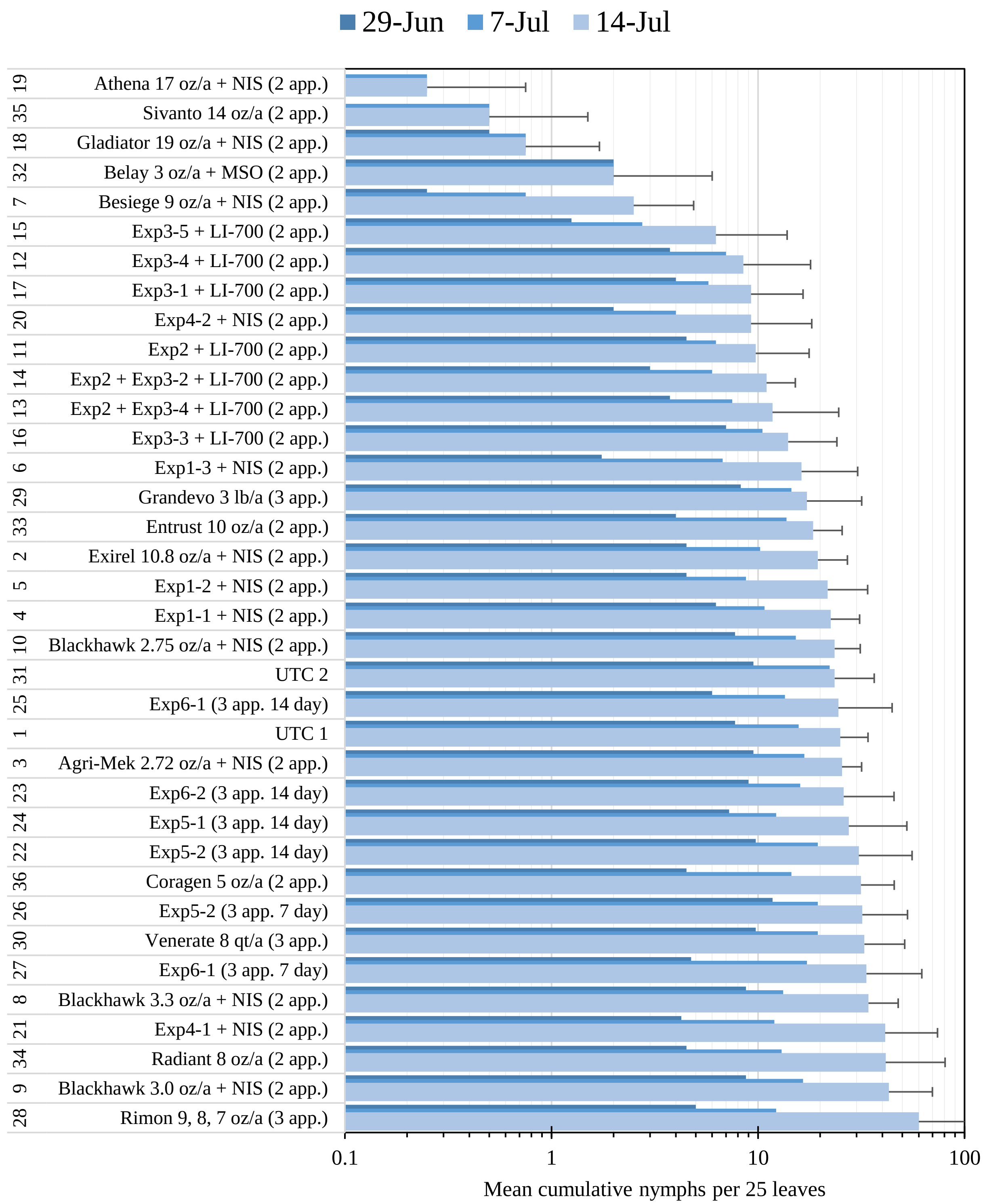


Fig. 8. Cumulative aphid counts

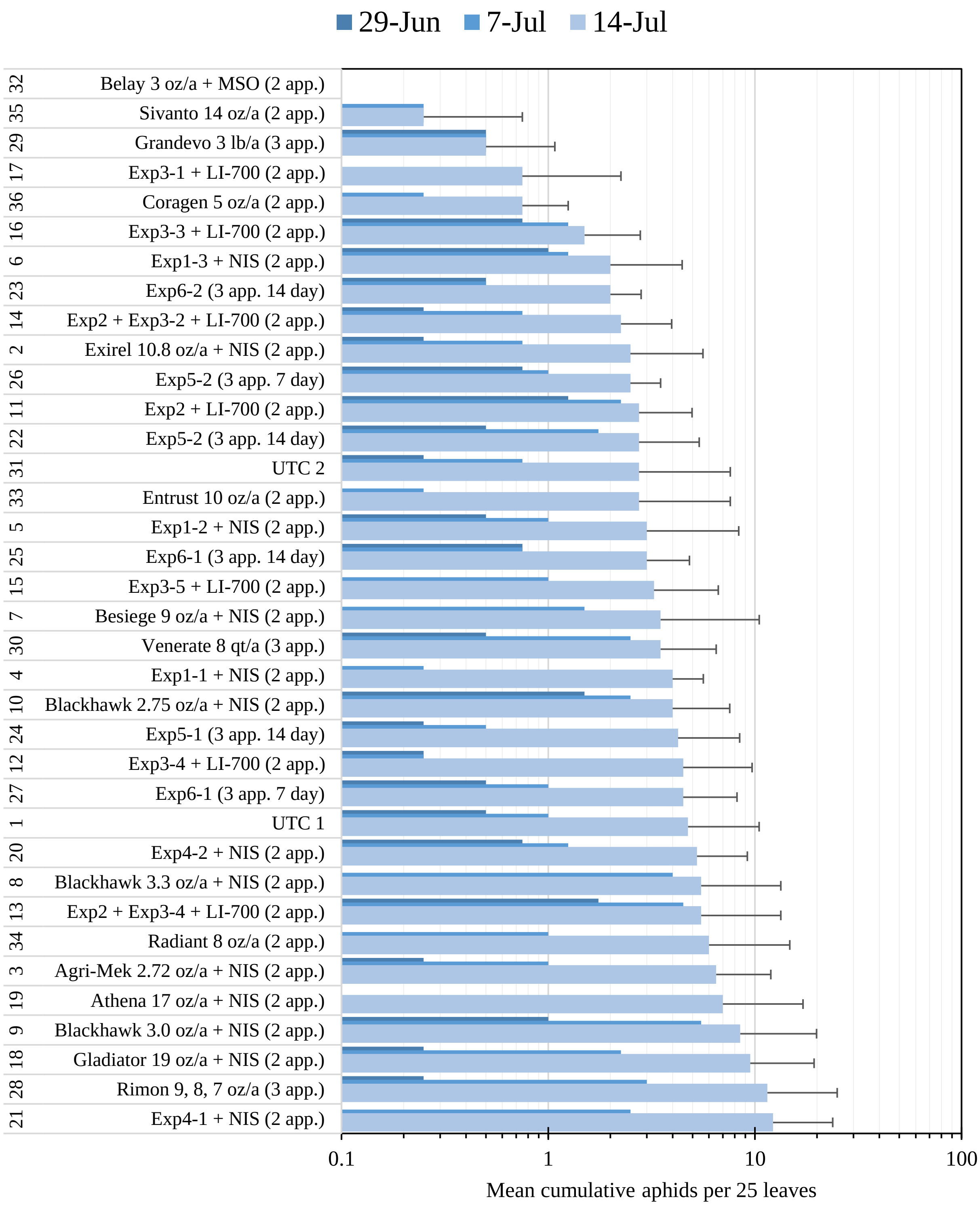
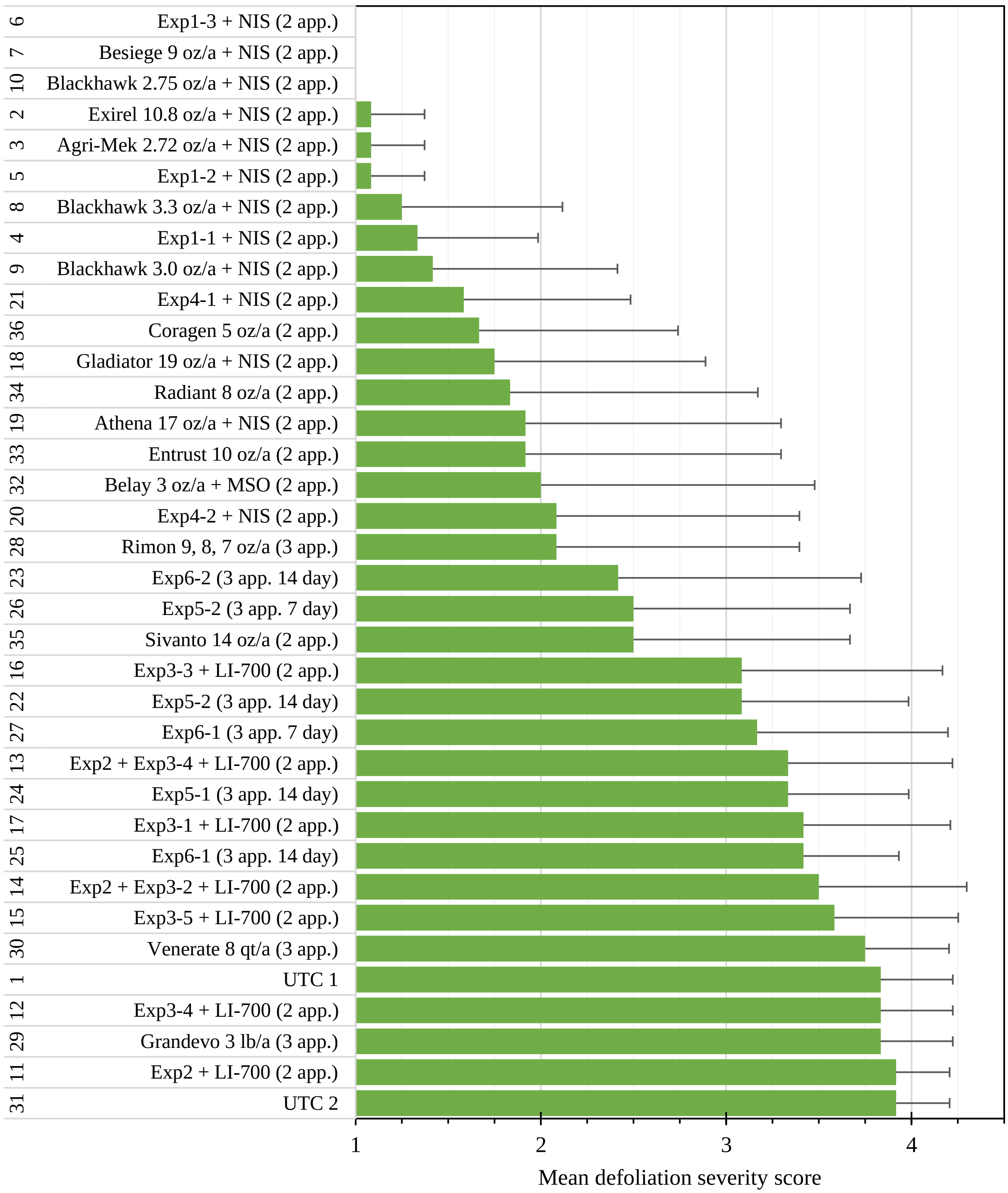


Fig. 9. Defliation severity

1: 0-2% 2: 2-5% 3: 5-10% 4: >10%



Trial 3

Foliar insecticide treatments for the control of Colorado potato beetle in Wisconsin potato production (AARS)

Purpose

The purpose of this experiment was to evaluate the efficacy of foliar insecticides *applied to potato for control of* Colorado potato beetle (CPB), *Leptinotarsa decemlineata*.

Materials and Methods

This experiment was conducted at the Arlington Agricultural Research Station (AARS), Arlington, WI in 2016. Potato, *Solanum tuberosum* cv. 'Yukon Gold' seed pieces were planted on 27 May. Seed pieces were spaced 12 inches apart within rows. Rows were 3 ft apart. The two-row plots were 6 ft wide by 20 ft long, for a total of 0.003 acres. Two guard rows separated the plots. The plots were managed according to commercial pest management (herbicide and fungicide) practices as well as fertility recommendations prescribed by AAES.

Four replicates of 8 experimental foliar treatments and 1 untreated control were arranged in a randomized complete block design. The foliar treatments were applied 3 July and 10 July. Treatments were applied with a CO_2 pressurized backpack sprayer with a 6 ft boom operating at 30 psi delivering 20 gpa through 4 flat-fan nozzles (Tee Jet XR8002XR) spaced 18" apart while travelling at 3.5 ft/sec.

CPB adults (CPB-A), egg masses (-EM), small larvae (-SL), large larvae (-LL) were assessed by counting the number of each life stage on 10 randomly selected plants from the center two rows in each plot. Defoliation ratings (% DF) were determined by visual observation of the entire plot. (**See tables and graphs below**). Insect counts occurred on three dates during July: 6 July (3 DAT), 11 Jul (8, 1 DAT), and 13 July (10, 3 DAT). Count data were Log10 transformed prior to data analysis using ANOVA and means were compared using a Tukey's HSD means separation test (P=0.05).

Aphid numbers were very low throughout the trial and were not included in the summary. No sign of phytotoxicity were observed.

Table 1. 7/6/2016 – 3 days after treatment

Trt	Product	Rate		CPB-A		CPB-EM		CPB-SL		CPB-LL		% DF	
1	UTC	-		0.50	-	1.50	-	234.75	b	103.50	b	15.75	b
2	Exirel	10.8	fl oz/a	1.50	-	3.00	-	1.25	a	0.00	a	5.00	a
3	Agri-Mek	2.72	fl oz/a	0.75	-	1.50	-	10.00	a	0.00	a	7.00	a
4	A21390F	5.5	fl oz/a	2.00	-	1.75	-	5.25	a	0.00	a	4.50	a
5	A21390F	8	fl oz/a	2.00	-	2.25	-	5.75	a	0.00	a	5.00	a
6	A21390F	10	fl oz/a	2.50	-	1.00	-	6.75	a	0.00	a	4.00	a
7	Besiege	9	fl oz/a	0.50	-	1.75	-	1.50	a	0.00	a	5.75	a
8	Blackhawk	3.3	oz wt/a	1.25	-	0.25	-	0.25	a	0.00	a	6.50	ab
9	Radiant	8	fl oz/a	1.25	-	0.75	-	0.75	a	0.00	a	6.75	ab
			P	0.105		0.689		<.0001		<.0001		0.001	
			HSD	0.466		0.693		0.987		0.207		0.431	

a. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)

Table 2. 7/11/2016 - 8 and 1 days after treatment

Trt	Product	Rate		CPB-A		CPB-EM		CPB-SL		CPB-LL	
1	UTC			12.50	-	0.25	-	56.75	c	58.25	b
2	Exirel	10.8	fl oz/a	3.00	-	0.75	-	0.50	a	0.50	a
3	Agri-Mek	2.72	fl oz/a	12.75	-	2.00	-	0.00	a	0.00	a
4	A21390F	5.5	fl oz/a	55.50	-	2.25	-	0.00	a	0.50	a
5	A21390F	8	fl oz/a	8.00	-	1.25	-	0.75	a	0.00	a
6	A21390F	10	fl oz/a	49.50	-	0.50	-	0.00	a	0.00	a
7	Besiege	9	fl oz/a	43.50	-	1.00	-	0.50	a	0.75	a
8	Blackhawk	3.3	oz wt/a	3.75	-	2.00	-	11.50	b	0.50	a
9	Radiant	8	fl oz/a	15.25	-	3.25	-	0.50	a	0.00	a
			P	0.779		0.093		<.0001		<.0001	
			HSD	1.366		0.599		0.457		0.347	

a. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)

Table 3. 7/13/2016 - 10 and 3 days after treatment

Trt	Product	Rate		CPB-A		CPB-EM		CPB-SL		CPB-LL	
1	UTC		-	320.25	-	0.50	-	27.50	b	15.00	b
2	Exirel	10.8	fl oz/a	39.50	-	1.50	-	1.00	a	0.00	a
3	Agri-Mek	2.72	fl oz/a	95.00	-	0.75	-	0.50	a	0.00	a
4	A21390F	5.5	fl oz/a	1257.50	-	0.25	-	0.00	a	0.00	a
5	A21390F	8	fl oz/a	464.75	-	1.25	-	0.50	a	0.00	a
6	A21390F	10	fl oz/a	615.25	-	0.50	-	0.00	a	0.25	a
7	Besiege	9	fl oz/a	844.75	-	0.50	-	0.00	a	0.75	a
8	Blackhawk	3.3	oz wt/a	287.00	-	1.25	-	1.75	a	4.50	a
9	Radiant	8	fl oz/a	537.75	-	1.25	-	0.75	a	0.25	a
			P	0.179		0.899		< .0001		< .0001	
			HSD	1.612		0.622		0.614		0.540	

a. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)

Fig. 1. Mean number of CPB adults per 10 plants

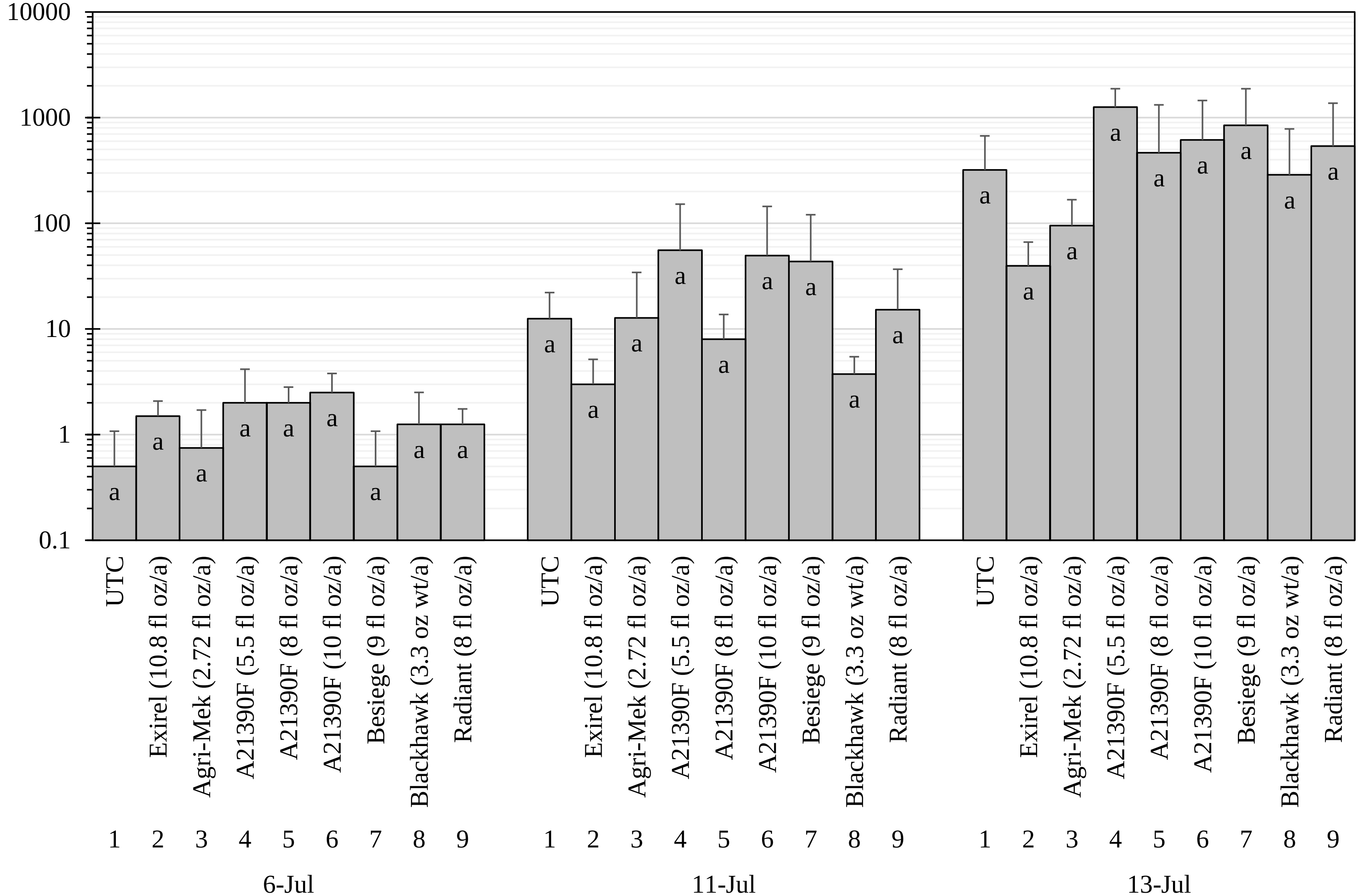


Fig. 2. Mean number of CPB egg masses per 10 plants

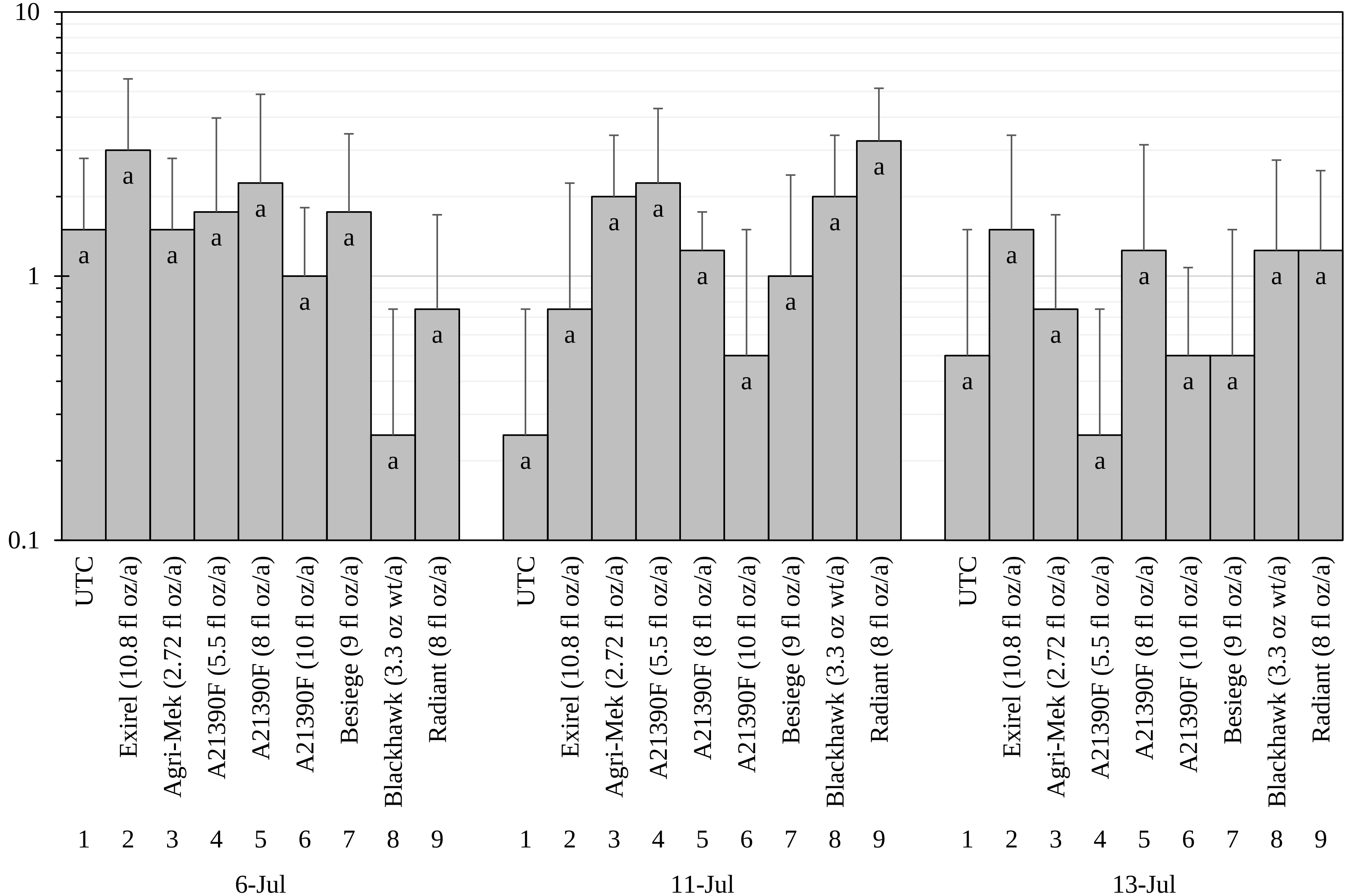


Fig. 3. Mean number of CPB large larvae per 10 plants

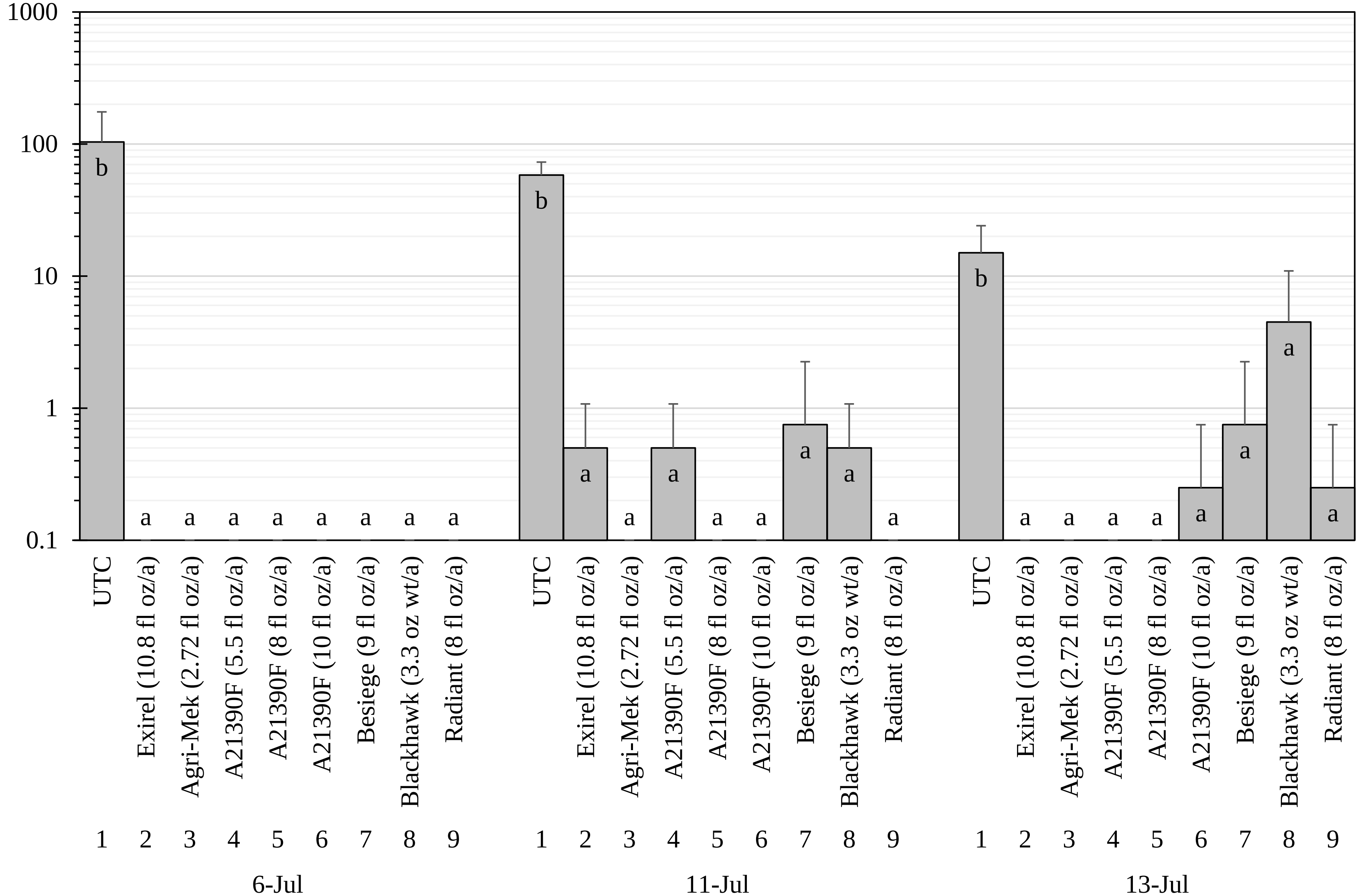


Fig. 4. Mean number of CPB small larvae per 10 plants

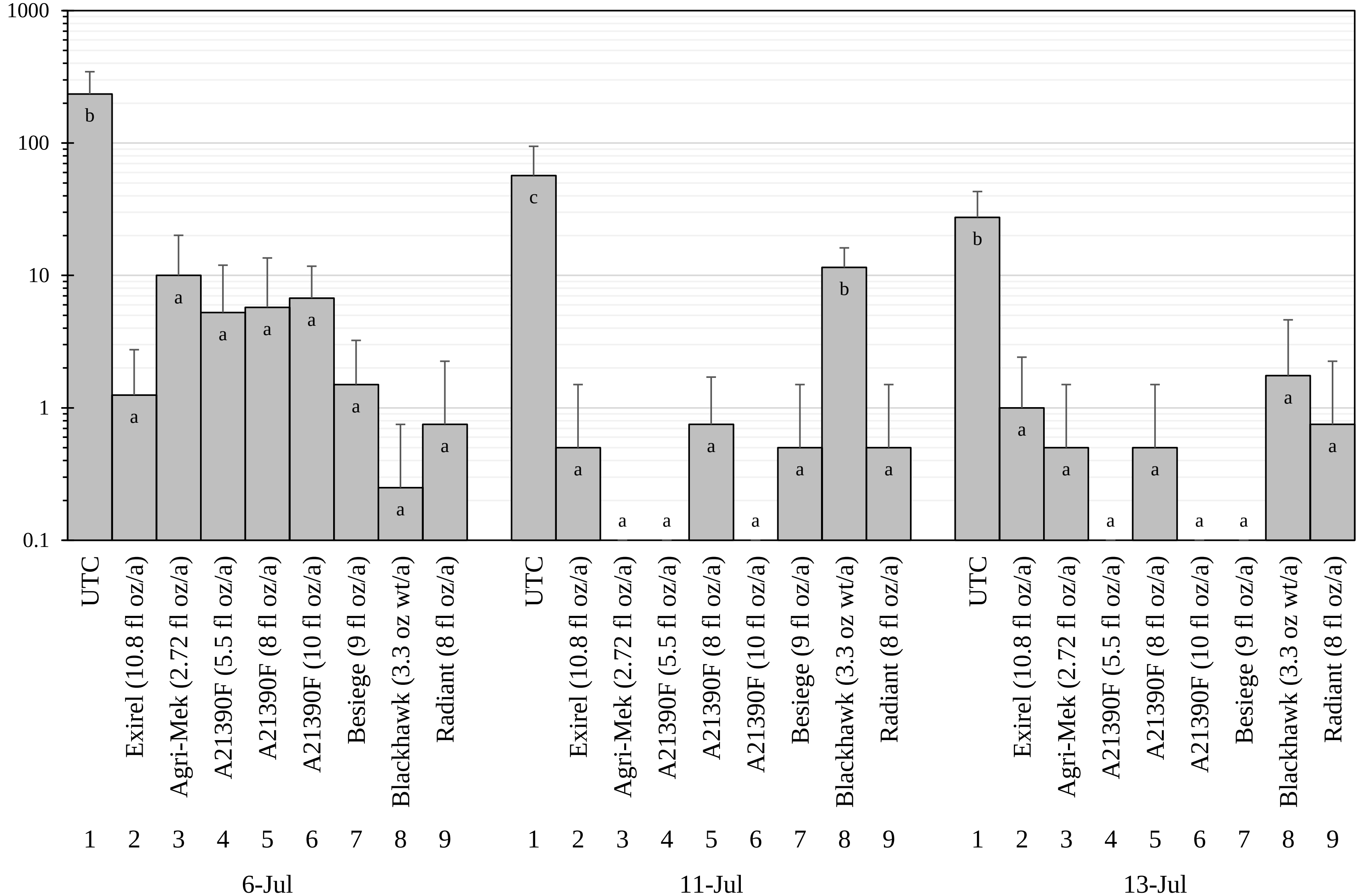
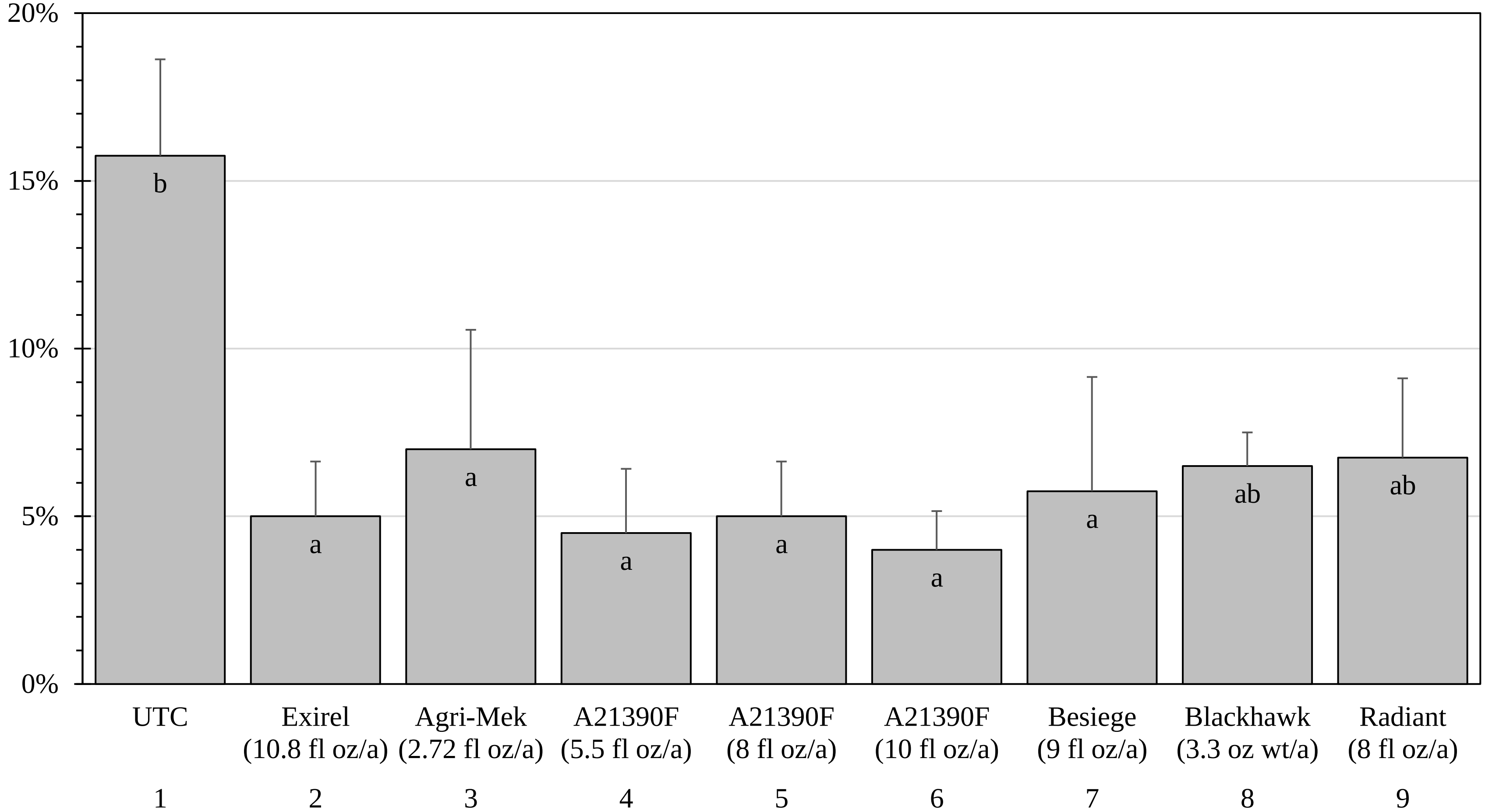


Fig. 5. Mean defoliation percentage (July 6th)



Trial 4

Foliar insecticide treatments to limit the spread of Potato virus Y in Wisconsin seed potato production (Antigo, WI)

Purpose

The purpose of this experiment was to evaluate the efficacy of a new foliar-applied experimental compound, LIFEGARD, alone and in combination with mineral oil, in limiting the spread of potato virus Y (PVY) to foundation and certified seed potato. The goal is the refinement of PVY 'best management practices' to limit current season spread of the virus in seed potato using different application timing, application intervals, and tank mixes of mineral oils and plant defense activators in the PVY susceptible variety, Silverton Russet.

Materials and Methods

The trial consisted of seven main effect treatments and one untreated control arranged in a RCB design with four experimental replicates (Table 1). Treatments consisted of an untreated control, the experimental compound LIFEGARD alone and in combination with two rates of Aphoil, two rates of Aphoil, and two rates of the commercial product Actigard in combination with a single rate of Aphoil.

Experimental plots consisted of four row plots measuring 12 ft. (3.7 m) wide and 40 ft. (12.2 m) in length with unplanted guard rows on each side. Potato *Solanum tuberosum* L., 'Silverton Russet' was machine planted on 20 June, 2016 at the Langlade Agricultural Research Station in Antigo, north central Wisconsin. Rows were planted on 36-inch row centers (0.9 m) with 12 inches (0.3 m) between plants and 12 ft. (3.6 m) alleys separating replications.

Treatments were applied with a CO2 pressurized tractor-mounted sprayer with a 12 ft. boom operating at 40 psi delivering 28.4 gpa through extended range flat fan nozzle tips (Tee Jet XVS8004) travelling at 4.5 mph. Application frequency varied by compound and by treatment as noted in Table 1.

Vine-kill occurred on August 29, and plots were machine harvested on September 12. Only the center two rows (240 square ft; 0.00551 acre) were harvested and graded for each plot. Tubers were graded by weight: A's if greater than 1.25 oz; B's if not.

Results

Both mineral oil applications and plant defense activators can reduce yield in potato, though by different mechanisms: Mineral oil can partially break down the cuticle and may interfere with transpiration; LIFEGARD (mode of action: induced systemic resistance) and Actigard (mode of action: systemic acquired resistance) both cause additional metabolic demands on the plant by up-regulating plant defenses proactively.

In this trial, tuber yield at harvest was not found to vary significantly by treatment for class A tubers (size > 1 7/8"), class B tubers (between 1.5" and 1 7/8"), or total market weight tubers (A

& B). Yield data are presented in Table 2 and Graph 1. Yield drag, or the reduction in total yield relative to the control plots, was calculated for each treatment and is presented in both units of cwt/a and percent in Table 2 and Graph 2. Yield drag did not differ significantly by treatment; statistical tests for yield drag are equivalent to total marketable yield as it was calculated from those values.

PVY incidence was determined by growing out a sample of harvested tubers at a research facility in Hawaii. No statistically significant difference in PVY incidence was observed due to low mean incidence levels and high variance (Table 3 and Graph 3).

Table 1. Treatment detail

Trt	Product	Type	Form			Rate		Frequency
1	UTC	-		-			-	-
2	CX 10250	INSE	100	%	WP	1.78	oz wt/a	biweekly
3	CX 10250	INSE	100	%	WP	1.78	oz wt/a	biweekly
	Aphoil	ADJ	100	%	SL	2	% v/v	biweekly
4	CX 10250	INSE	100	%	WP	1.78	oz wt/a	biweekly
	Aphoil	ADJ	100	%	SL	4	% v/v	biweekly
5	Aphoil	ADJ	100	%	SL	2	% v/v	weekly
6	Aphoil	ADJ	100	%	SL	4	% v/v	weekly
7	Actigard	INSE	50	%	WG	0.75	oz wt/a	3 total
	Aphoil	ADJ	100	%	SL	2	% v/v	weekly
8	Actigard	INSE	50	%	WG	1	oz wt/a	3 total
	Aphoil	ADJ	100	%	SL	2	% v/v	weekly

Table 2. Yield data

Trt	Product(s)	Rate		Application frequency	Class A (cwt/a)				Class B (cwt/a)				Mkt Yield (cwt/a)				Yield Drag (cwt/a)			Yield Drag (%)		
1	UTC				333.27	±	48.94	a	30.17	±	3.26	a	363.44	±	48.90	a		-			-	
2	CX 10250	1.78	oz wt/a	biweekly	323.98	±	75.15	a	32.78	±	10.53	a	356.76	±	64.86	a	-6.68	±	19.54	-2.31%	±	5.68%
3	CX 10250 Aphoil	1.78 2	oz wt/a % v/v	biweekly biweekly	314.68	±	45.10	a	32.10	±	6.08	a	346.78	±	41.43	a	-16.67	±	7.58	-4.42%	±	1.67%
4	CX 10250 Aphoil	1.78 4	oz wt/a % v/v	biweekly biweekly	285.52	±	62.08	a	29.83	±	1.83	a	315.36	±	62.33	a	-48.09	±	38.69	-13.50%	±	10.83%
5	Aphoil	2	% v/v	weekly	295.45	±	65.19	a	30.63	±	4.59	a	326.07	±	63.63	a	-37.37	±	26.12	-10.79%	±	8.19%
6	Aphoil	4	% v/v	weekly	317.97	±	61.57	a	30.29	±	6.52	a	348.25	±	57.73	a	-15.19	±	33.74	-4.15%	±	8.70%
7	Actigard Aphoil	0.75 2	oz wt/a % v/v	3 total weekly	318.99	±	16.15	a	29.49	±	7.47	a	348.48	±	20.86	a	-14.96	±	31.13	-3.24%	±	8.85%
8	Actigard Aphoil	1 2	oz wt/a % v/v	3 total weekly	298.11	±	49.02	a	25.07	±	0.68	a	323.18	±	49.54	a	-40.26	±	3.58	-11.27%	±	2.06%
				P	0.317				0.703				0.137									
				HSD	68.654				13.471				60.878									

a. Results shown as Means ± Standard Deviations with means separation letter codes following (Tukey's HSD test, α=.05)
Statistical results for Yield Drag are the same as for Market Yield

Table 3. PVY Incidence

Trt	Product	Rate		App. Freq.	N tested	N Positive	% Incidence			
1	UTC				66.00	2.00	3.10%	±	2.97%	a
2	CX 10250	1.78	oz wt/a	biweekly	68.00	1.00	1.44%	±	1.18%	a
3	CX 10250	1.78	oz wt/a	biweekly	66.50	0.00	0.00%	±	0.00%	a
	Aphoil	2	% v/v	biweekly						
4	CX 10250	1.78	oz wt/a	biweekly	63.50	0.25	0.37%	±	0.75%	a
	Aphoil	4	% v/v	biweekly						
5	Aphoil	2	% v/v	weekly	68.00	0.75	1.10%	±	1.39%	a
6	Aphoil	4	% v/v	weekly	63.25	0.50	0.76%	±	1.52%	a
7	Actigard	0.75	oz wt/a	3 total	66.25	1.75	2.62%	±	2.45%	a
	Aphoil	2	% v/v	weekly						
8	Actigard	1	oz wt/a	3 total	65.25	0.75	1.29%	±	1.72%	a
	Aphoil	2	% v/v	weekly						
				P			0.162			
				HSD			0.199			

a. Results shown as Means ± Standard Deviations with means separation letter codes following (Tukey's HSD test, α=.05)

Fig. 1. Marketable yield

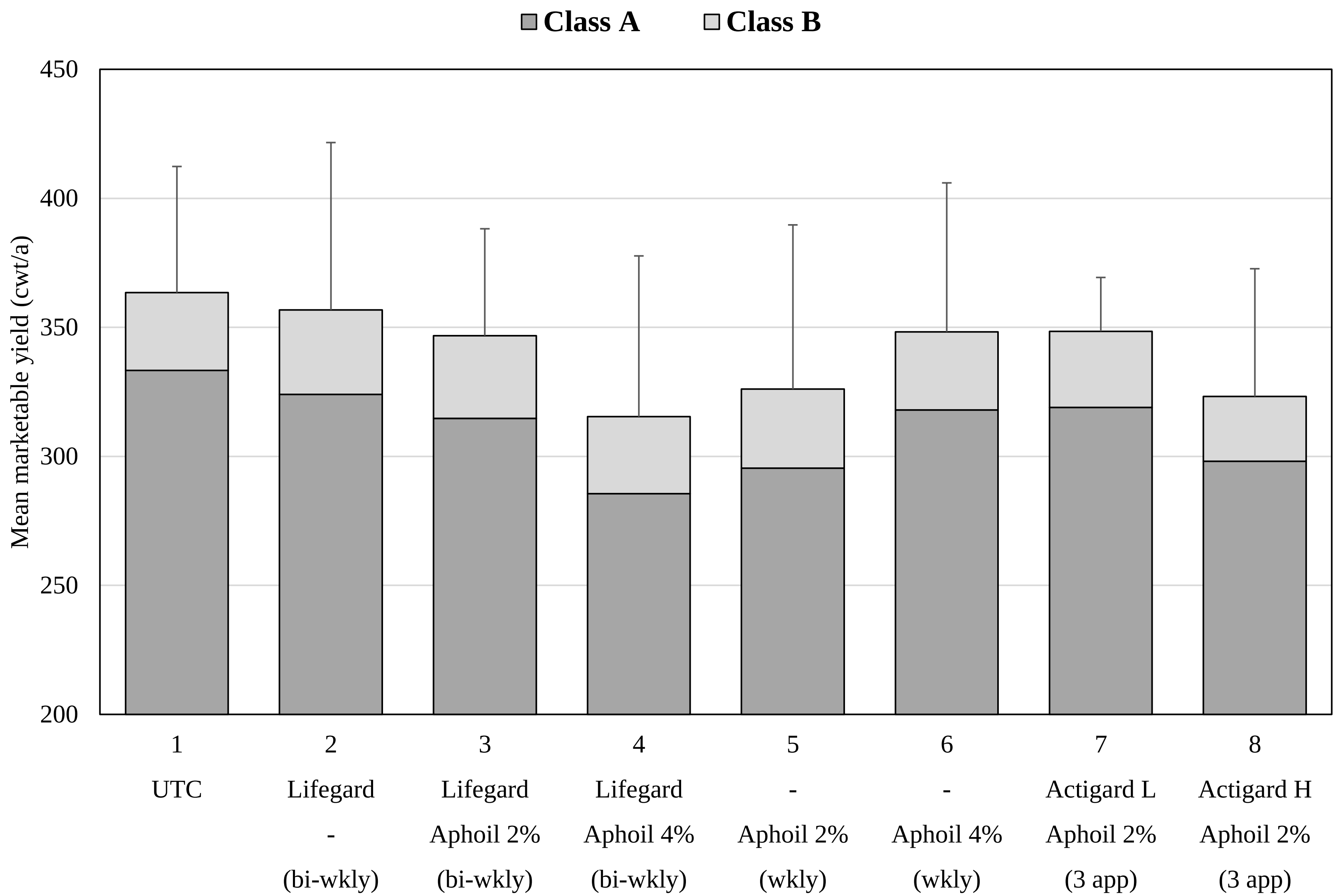


Fig. 2. Mean yield reduction vs control

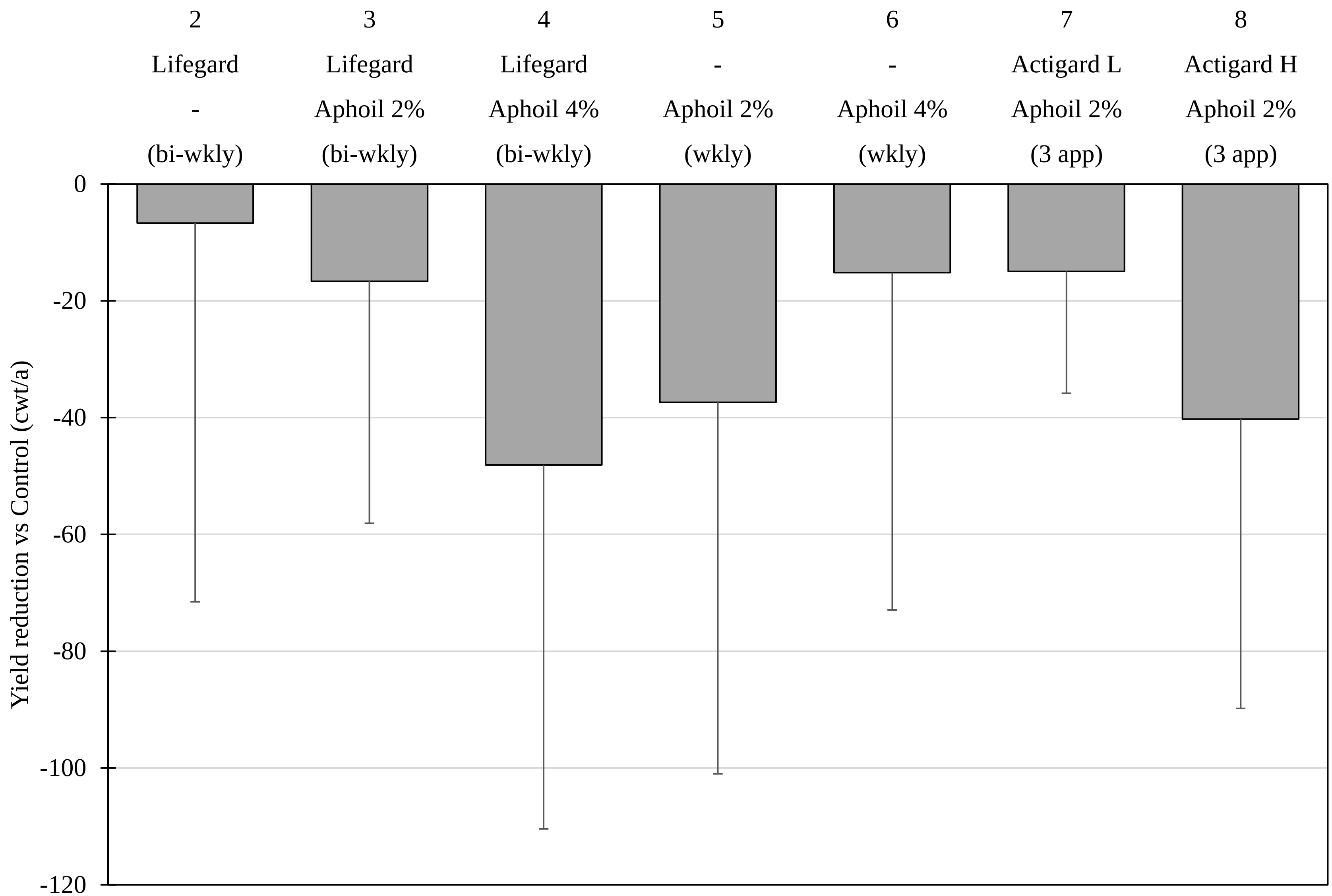
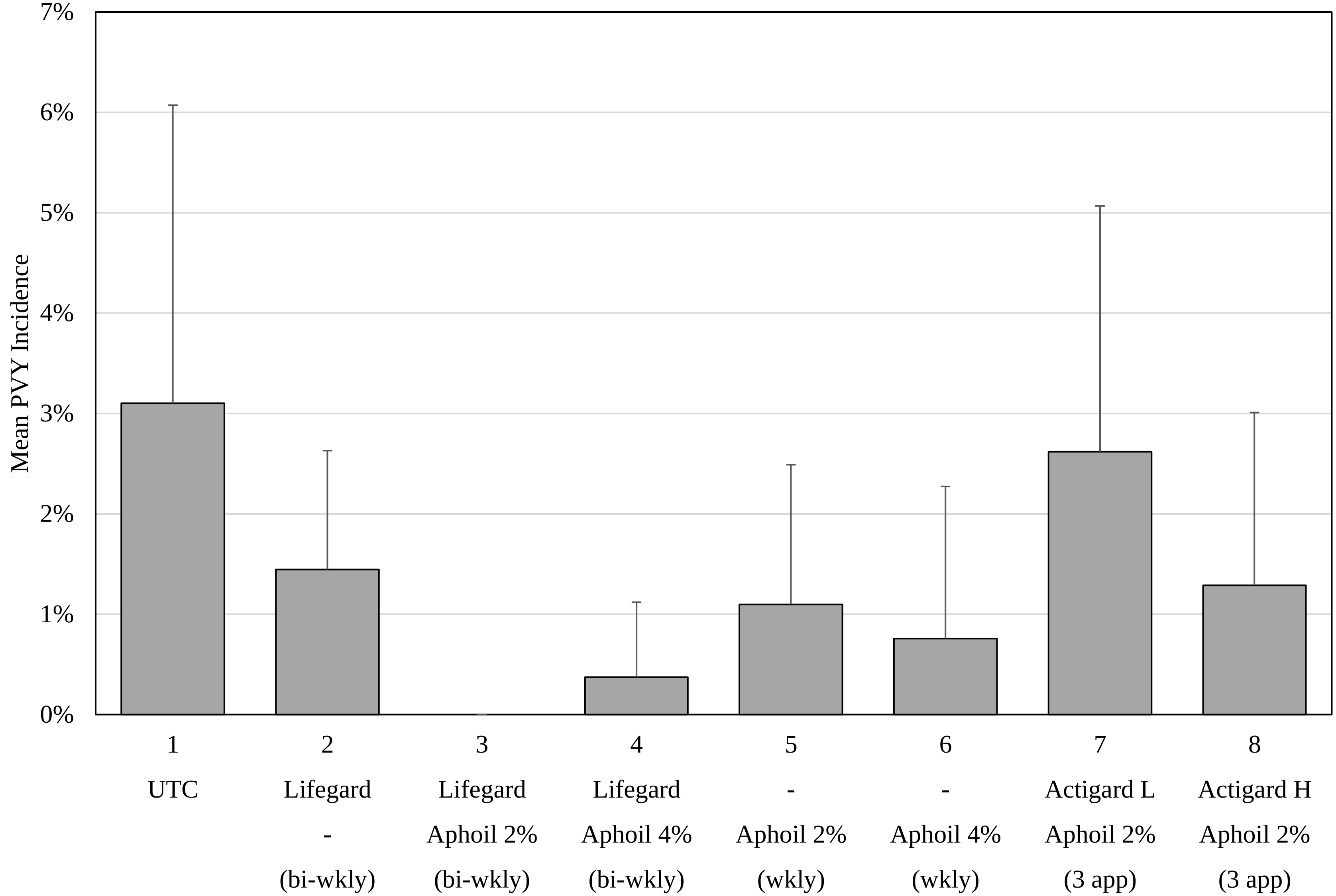


Fig. 3. PVY incidence



Trial 5

Evaluation of systemic insecticides for the control of the Colorado potato beetle, potato leafhopper, and aphids on potato (HARS)

Purpose

The objective of this experiment was to assess the efficacy of at-plant systemic insecticides to control Colorado potato beetle (CPB), *Leptinotarsa decemlineata*, potato leafhopper (PLH), *Empoasca fabae*, and potato colonizing aphid species on potatoes.

Materials and Methods

This experiment was conducted at Hancock Agricultural Research Station (HARS) located 1.1 mile (1.8 km) southwest of Hancock, Wisconsin on a loamy sand soil in 2016. Potato, *Solanum tuberosum* cv. 'Russet Burbank', seed pieces were planted on 21 April. Seed pieces were spaced 12 inches apart within rows. Rows were 3 ft apart. The four-row plots were 12 ft wide by 20 ft long, for a total of 0.006 acres. Two untreated guard rows separated plots. Plots were arranged in an 8 tier design with 12 ft alleys between tiers. All plots were maintained according to standard commercial production practices by HARS staff.

Four replicates of 11 experimental treatments and 1 untreated control were arranged in a randomized complete block design. Seed treatments were applied in 130 ml of water per 50 lb of seed on 21 April using a single nozzle boom applying 9.1 gpa equipped with a Tee Jet XR8002VS flat fan spray tip powered by a CO_2 backpack sprayer at 30psi. In-furrow insecticides were applied at planting with a CO_2 pressurized backpack sprayer operating at 30 psi with a 2 nozzle boom with Tee Jet 8001 flat fan nozzles delivering 11 gpa. Furrows were cut using a commercial potato planter without closing discs attached. Immediately after the in-furrow treatments were applied and all seed piece treatments were placed in open furrows, all seed was covered by hilling.

Stand counts were conducted on 3 June (43 DAP) by counting the number of emerged plants per 20 ft. section of row. CPB efficacy was assessed by counting the number of these insects per plant on 10 randomly selected plants in each plot. Defoliation ratings (% DF) were determined by visual observation of the entire plot. CPBs were recorded in the following life stages: adults (A), egg masses (EM), small larvae (SL), large larvae (LL). Potato leafhoppers were recorded as nymphs (N) or adults (A). Adult PLH were sampled using sweep net techniques (15 sweeps per plot). PLH nymphs and aphids were assessed by visual inspection of 25 leaves per plot.

Insect counts occurred on several dates throughout the summer, and insect count averages reflect time periods during the summer when specific life stages peaked in the plots (**Table 1).** Cumulative data are shown in **graphs.** Count data were Log10 transformed prior to data analysis using ANOVA and means were compared using a Tukey's HSD means separation test (P=0.05).

No signs of phytotoxicity were observed among experimental treatments.

Table 1. Mean Colorado potato beetle (CPB) counts per 10 plants of adults (AD), egg masses (EM), small (SL) and large (LL) larvae, adult (AD) and nymphal (NY) potato leafhoppers (PLH) and defoliation rating (DF)

Trt	Product(s)	Type	Rate	Unit	CPB-A1		CPB-A2		CPB-EM		CPB-SL		CPB-LL		PLH-A		PLH-N		Aphid		DF	
1	UTC		-	-	18	a	146	a	356	d	335.5	cd	168.5	c	4.51	ab	51.21	b	12.08	b	3.25	e
2	Exp 1	S	1		30.75	abc	88	a	364	d	395.8	d	200.8	c	4.24	ab	38.66	b	3.77	ab	3.25	e
3	Exp 1	S	2		33.75	abc	76	a	426.5	d	254.3	bcd	252.8	c	4.57	ab	33.40	b	3.16	ab	2.92	de
4	Exp 1	S	1		29.25	abc	76.75	a	498.8	d	265.5	bcd	201	c	5.80	abc	25.93	b	9.71	ab	3.25	e
	Convoy		0.5	fl oz/cwt																		
5	Exp 2	S	1.0		41.75	bc	70.5	a	389.5	d	286.3	bcd	285	c	6.50	ab	18.14	b	10.78	ab	2.75	cde
6	Exp 2	S	1		33.5	abc	96.5	a	304.3	cd	335.8	bcd	192	c	1.71	abc	25.41	b	6.55	ab	2.42	bcd
	Convoy		0.5	fl oz/cwt																		
7	CruiserMaxx	S	0.27	fl oz/cwt	59.5	c	67.5	a	135.5	bc	286	bcd	157.3	bc	3.56	a	3.20	a	0.50	a	2.08	abc
8	Platinum	IF	2.67	oz/a	50.5	bc	146.8	a	16.5	a	57.5	a	37	a	3.00	a	0.50	a	0.96	a	1.75	ab
9	Verimark	IF	10.3	fl oz/a	46.5	bc	185.8	a	78.75	b	133	abc	59.25	ab	6.85	c	41.37	b	3.59	ab	1.67	a
10	Verimark	IF	13.5	fl oz/a	49	bc	160	a	57.25	ab	137	ab	67.75	ab	12.77	bc	57.11	b	3.11	ab	1.83	ab
11	Sivanto	IF	21	fl oz/a	32.25	abc	71.25	a	502.3	d	337.8	cd	231.8	c	3.70	a	4.19	a	6.00	ab	3.17	e
12	Sivanto	IF	28	fl oz/a	24.5	ab	109.3	a	309.5	cd	317	bcd	173.5	c	1.89	ab	5.32	a	1.50	a	3.17	e
			P		<.0001		0.12		<.0001		<.0001		<.0001		<.0001		<.0001		0.0053		<.0001	
			HSD		0.3522		0.5903		0.3999		0.4197		0.4383		0.4894		0.7084		0.9243		0.7124	

Means not follow by the same letter in columns are significantly different (P<0.05).
IF = In furrow, S = Seed treatment

Fig. 1. Cumulative 1st generation CPB adults

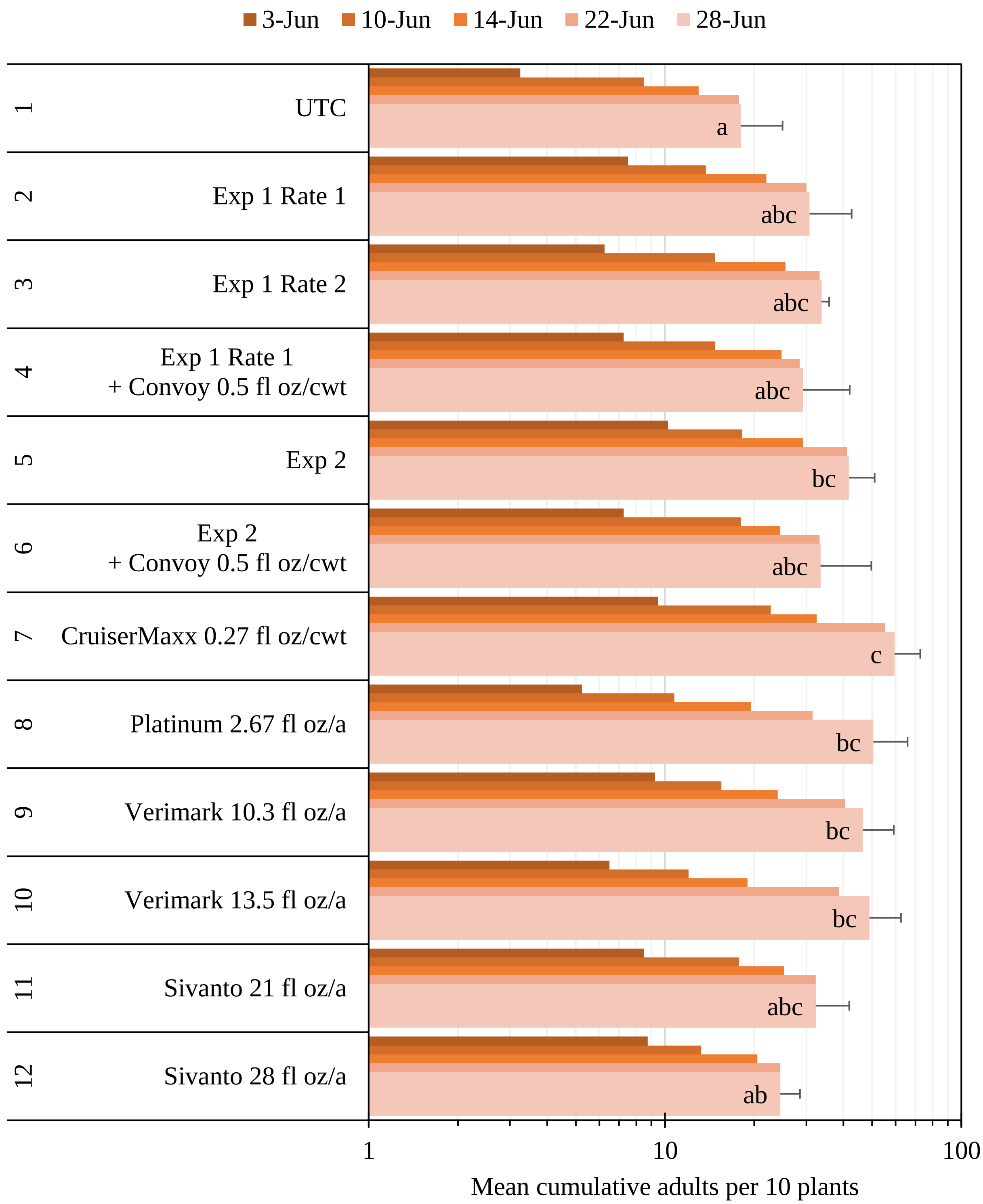


Fig. 2. Cumulative 2nd generation CPB adults

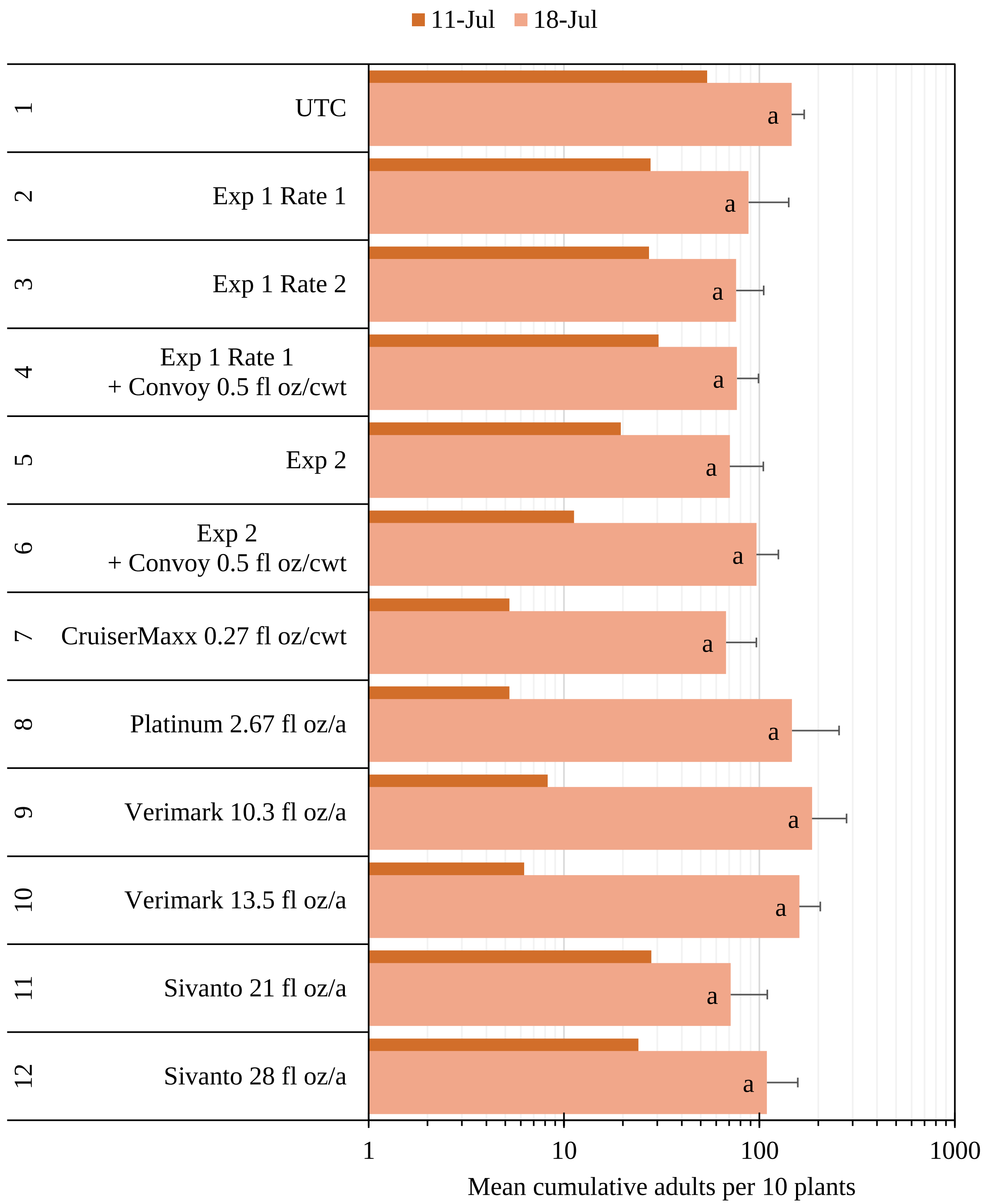


Fig. 3. Cumulative CPB egg masses

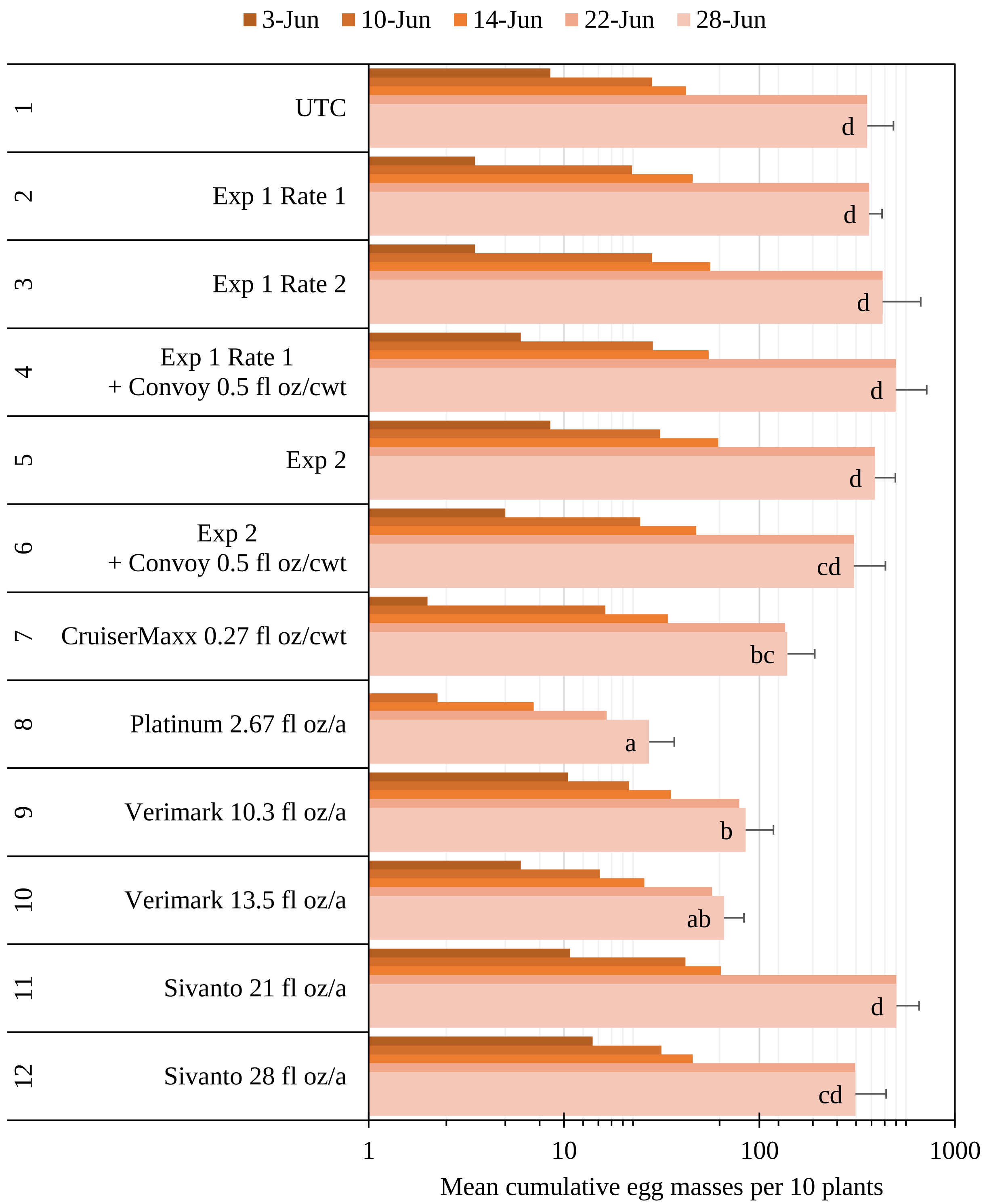


Fig. 4. Cumulative CPB small larvae

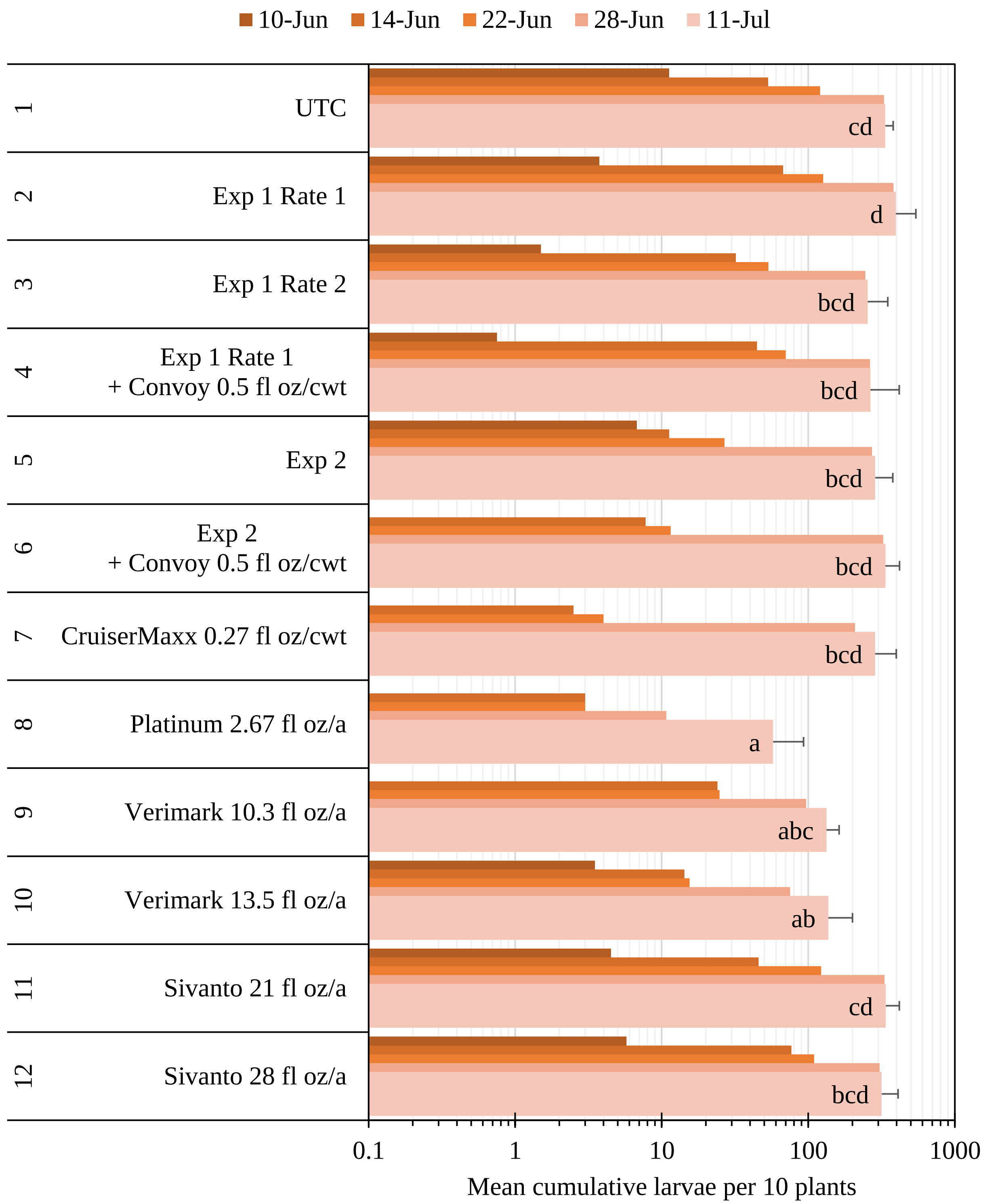


Fig. 5. Cumulative CPB large larvae

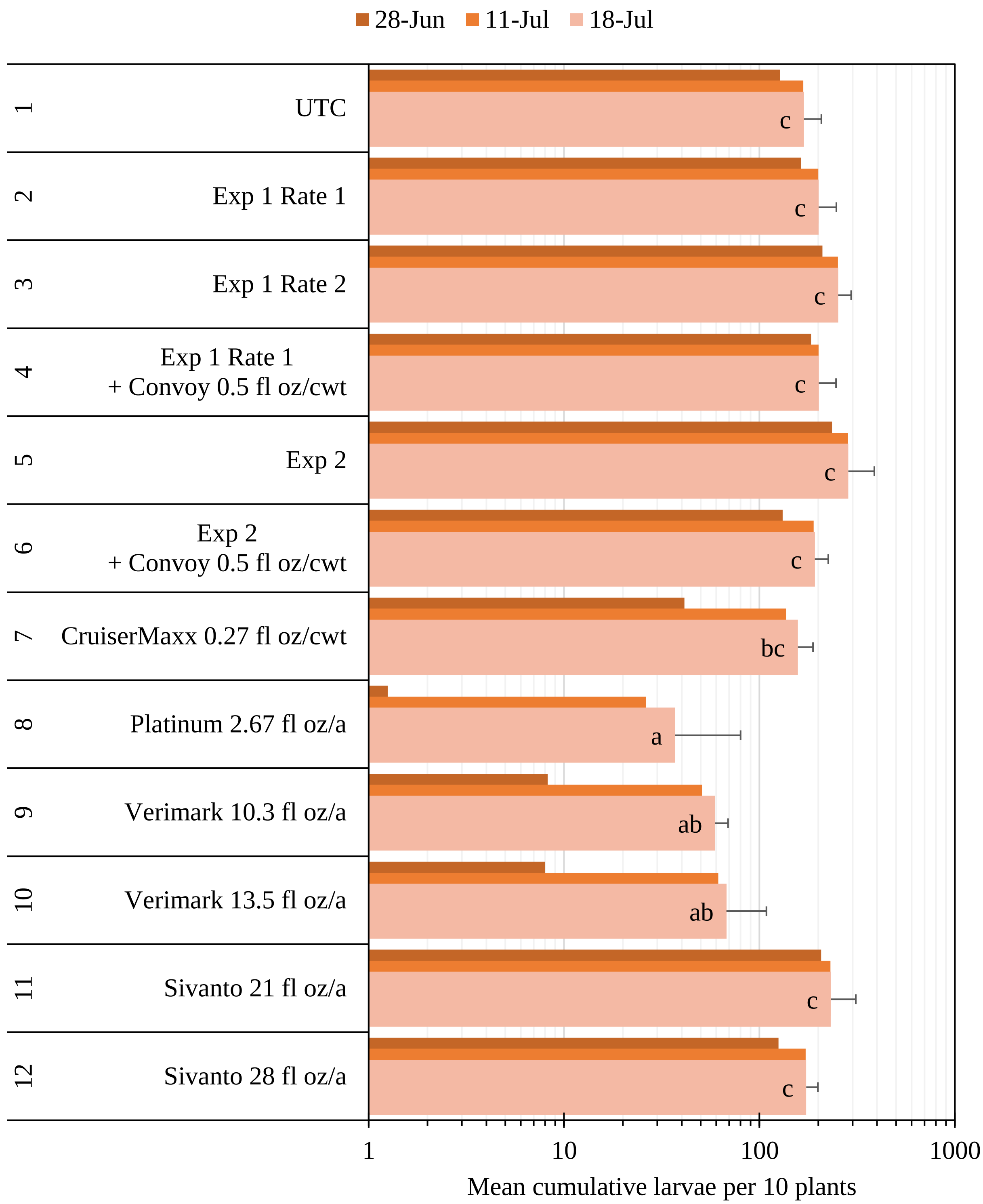


Fig. 6. Cumulative potato leafhopper adults

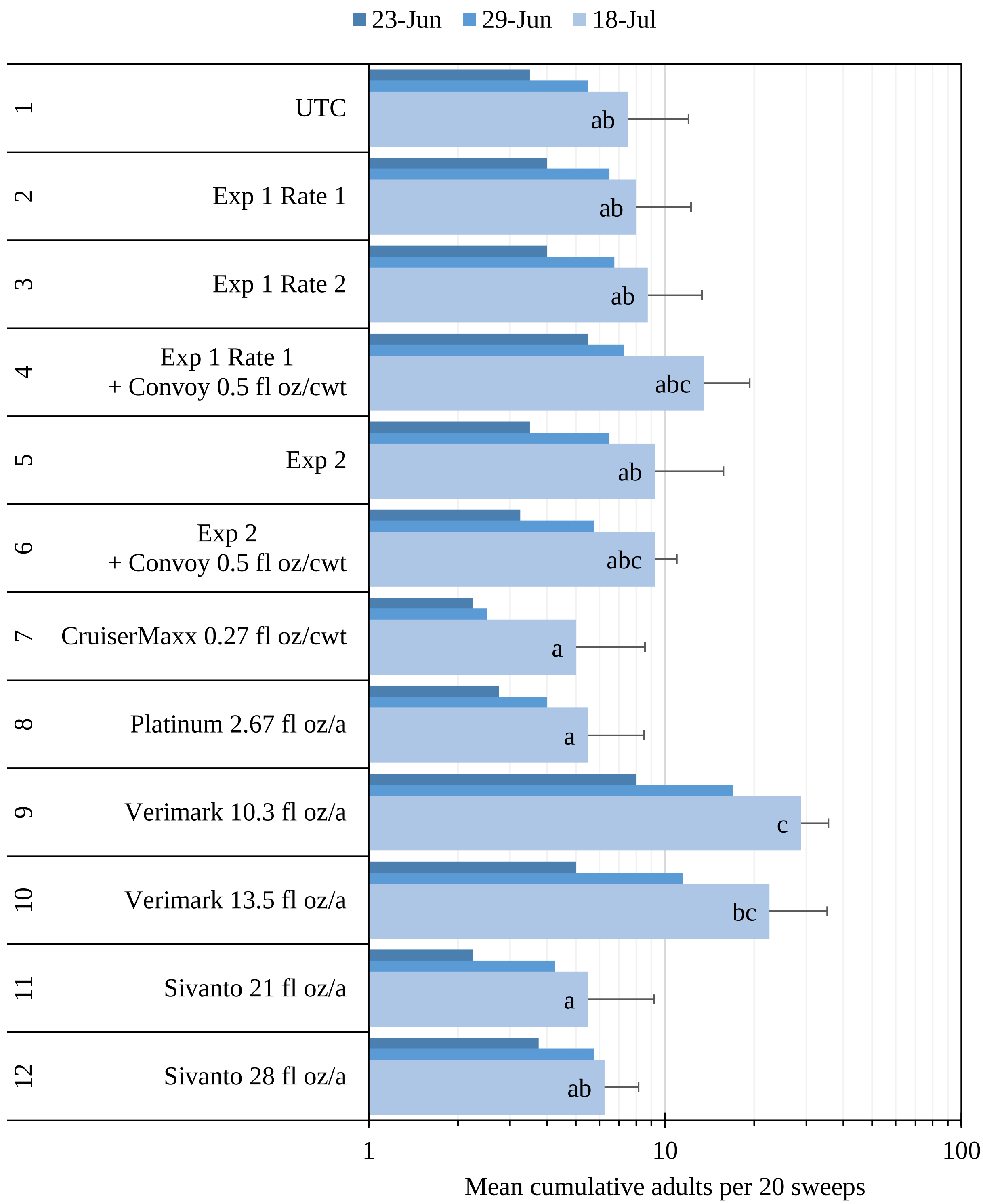


Fig. 7. Cumulative potato leafhopper nymphs

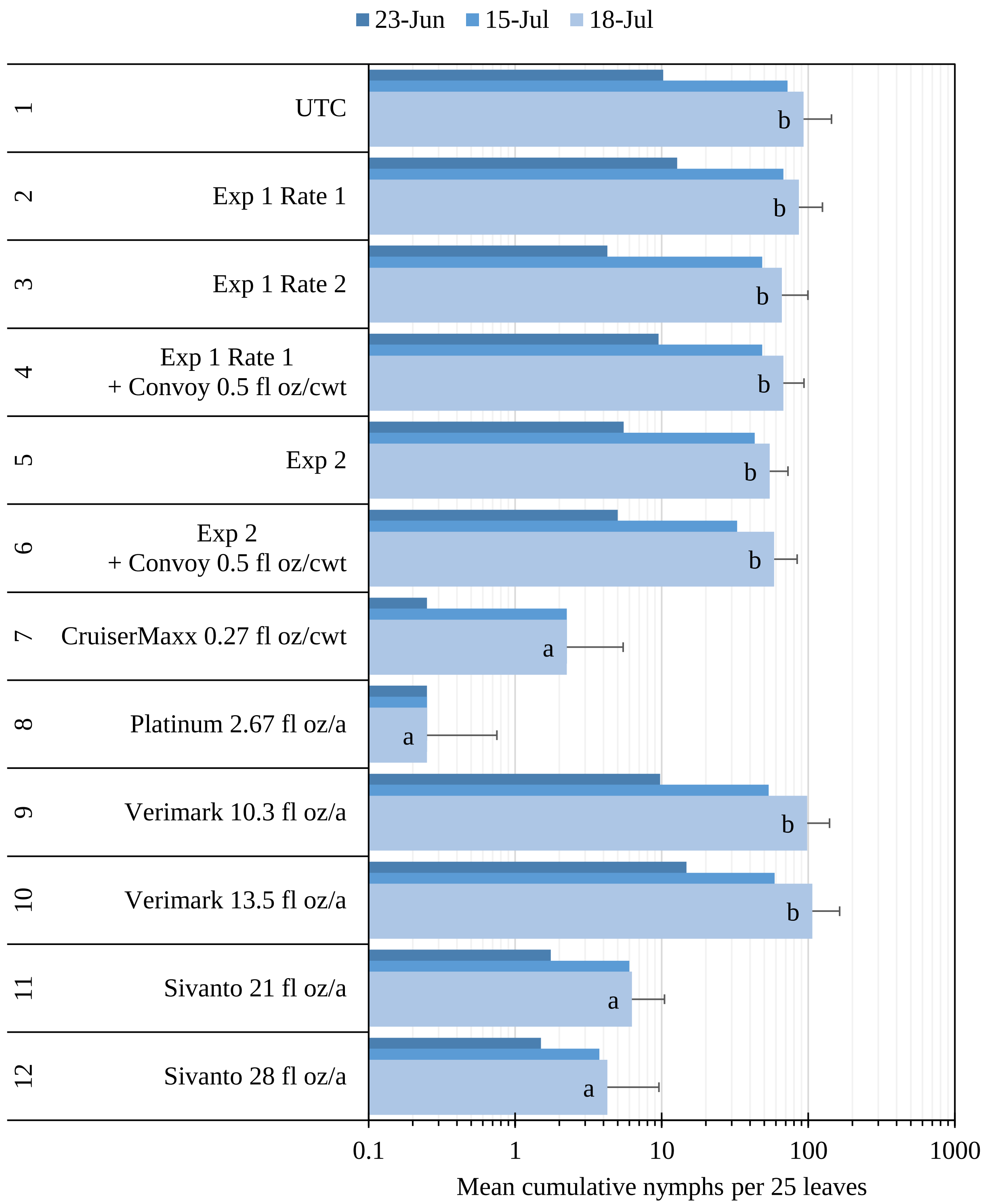


Fig. 8. Cumulative aphid counts

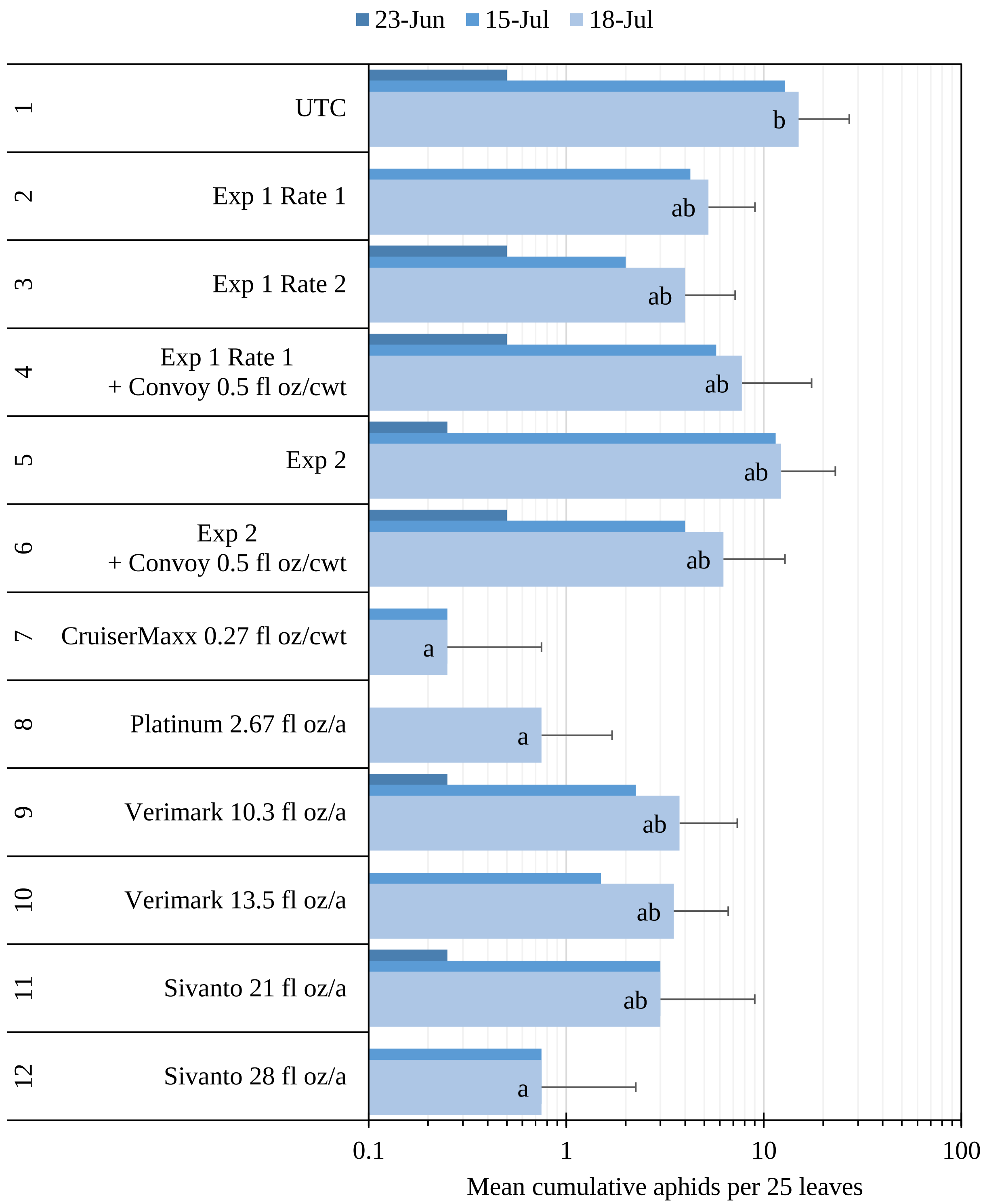


Fig. 9. Defoliation severity

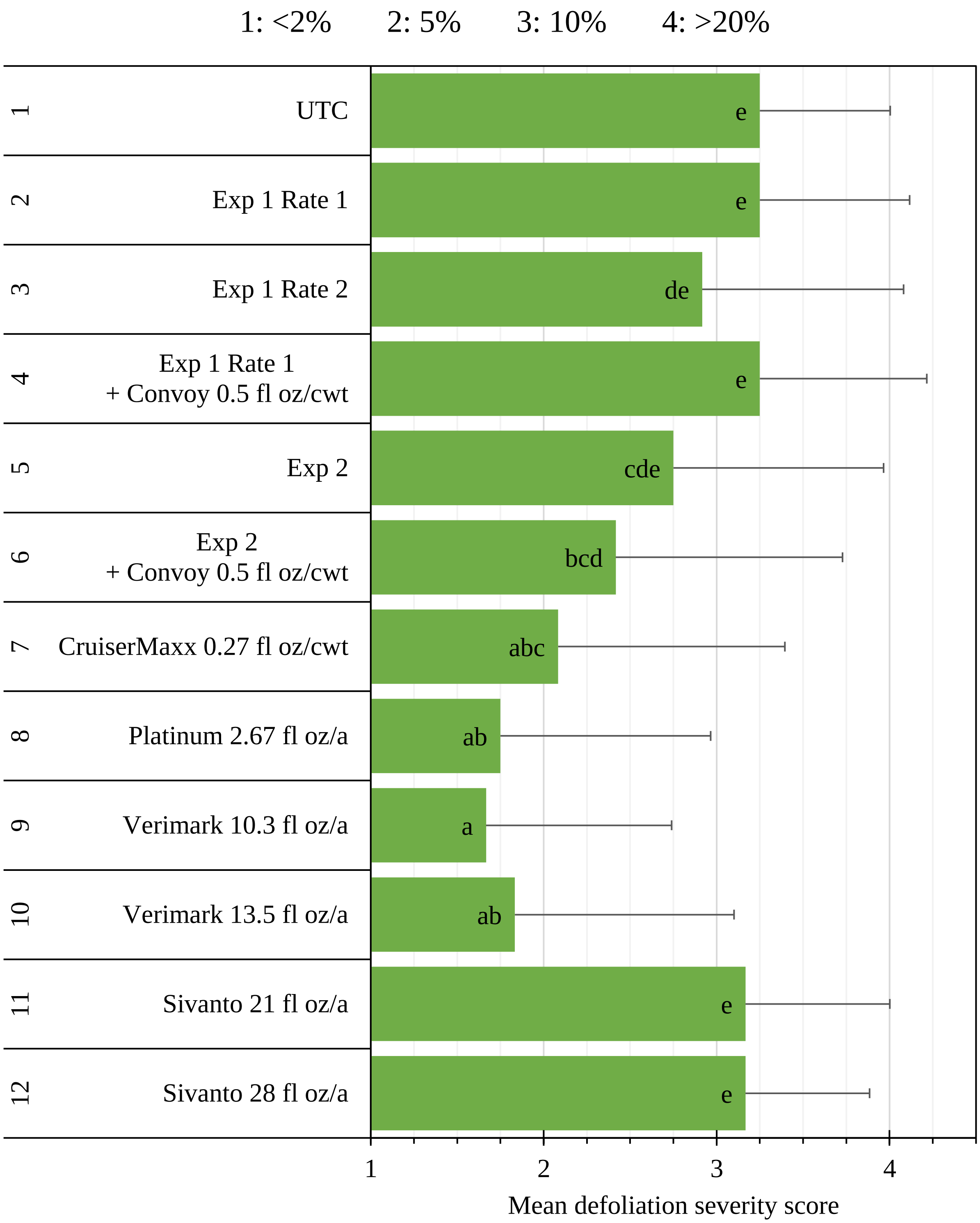


Fig. 10. Marketable yield (A's and B's)

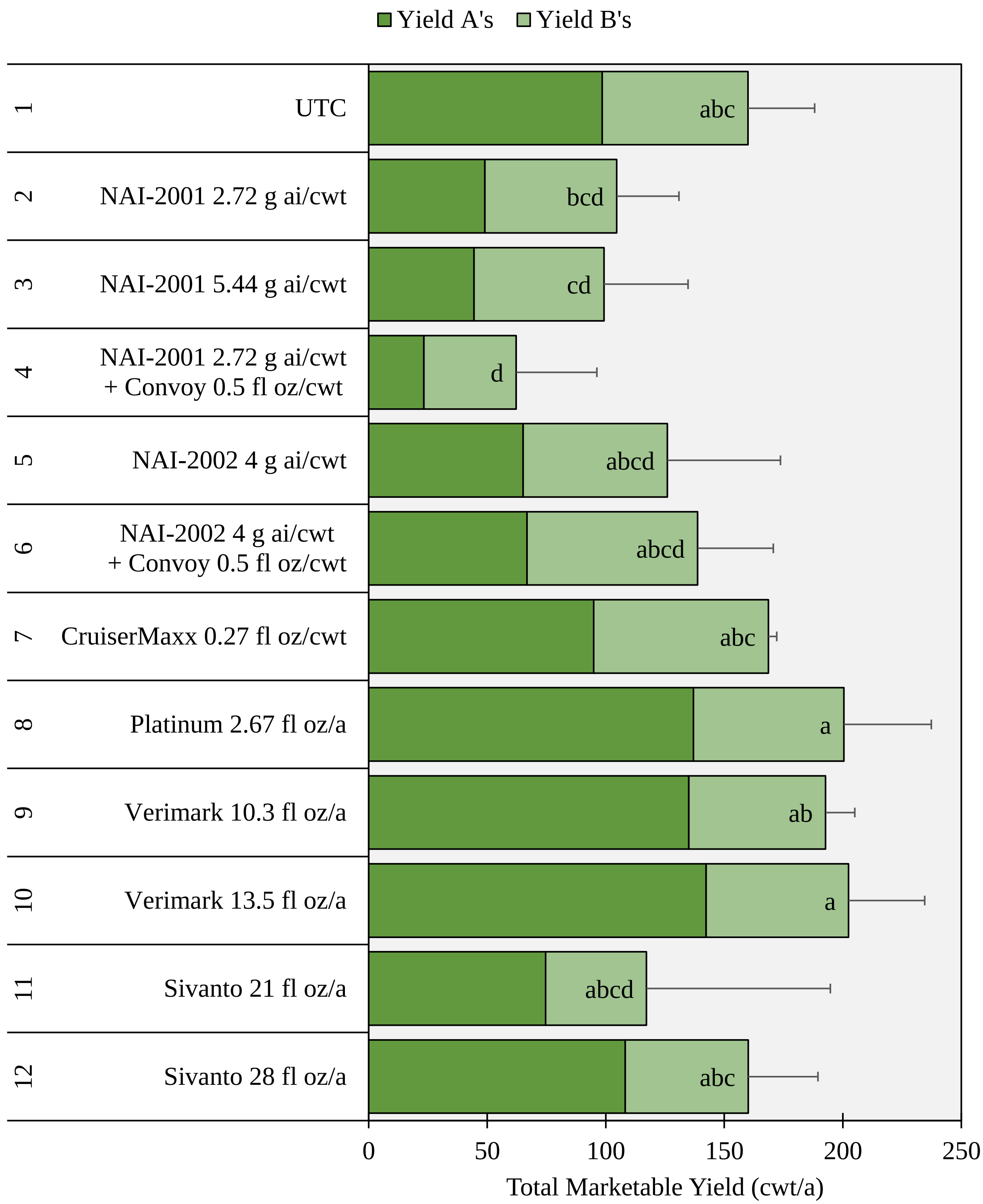


Fig. 11. Tuber class distribution

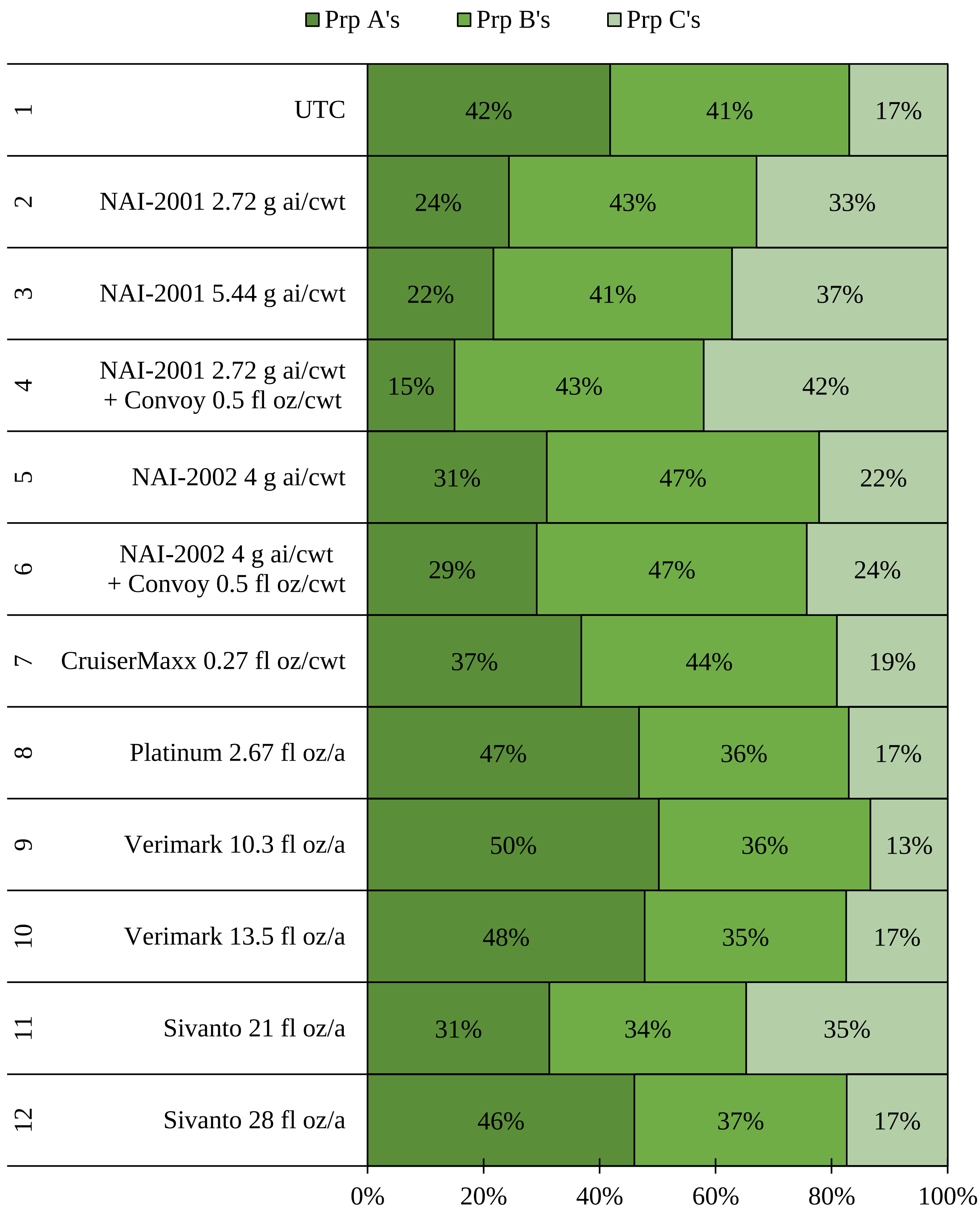
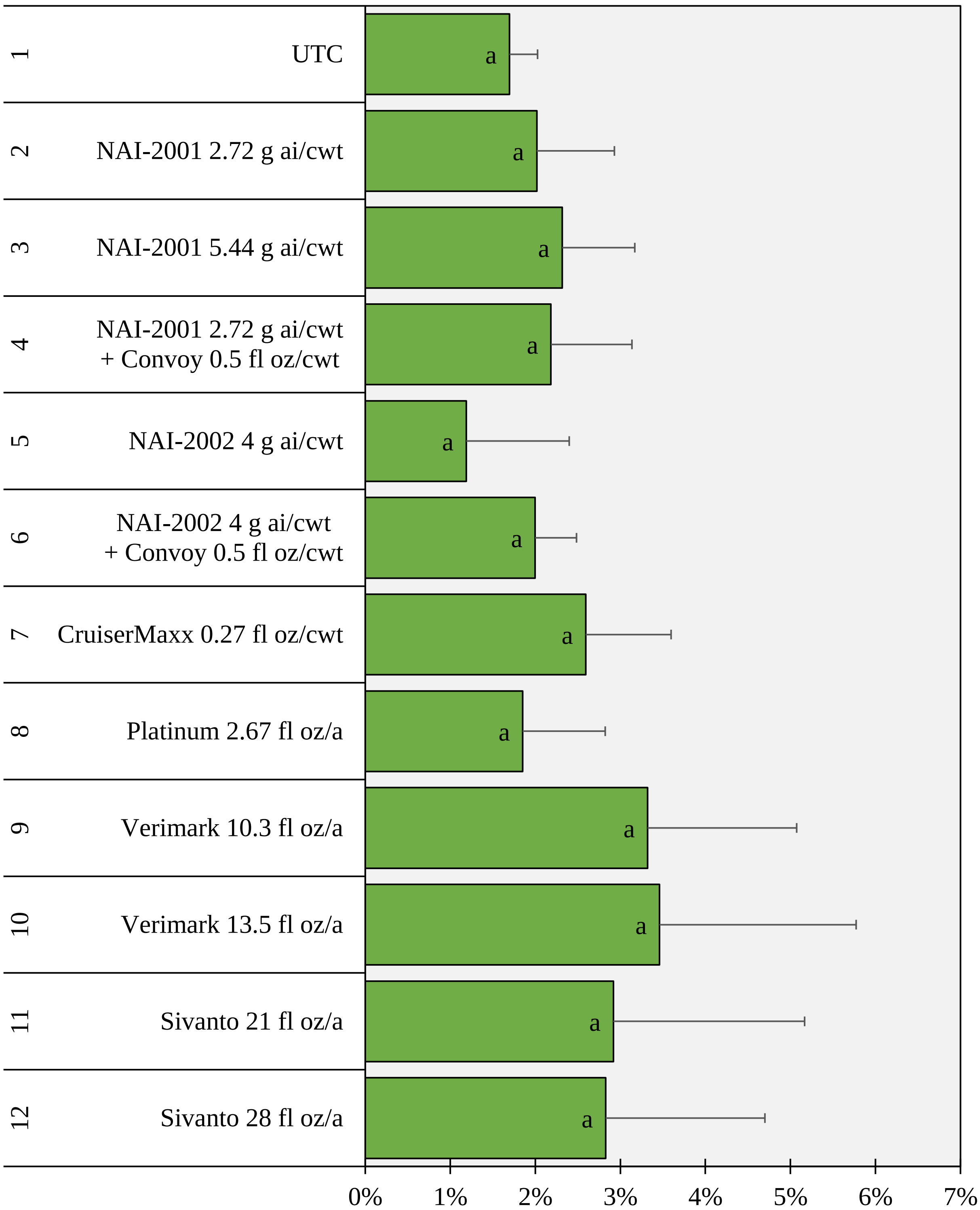


Fig. 11. Proportion hollow tubers



Trial 6

Full season insecticide management programs for Colorado potato beetle in Wisconsin potatoes (HARS)

Purpose

The purpose of this experiment was to evaluate various full-season, reduced-risk, insecticide programs designed to manage Colorado potato beetle (CPB) on potatoes in Wisconsin. With developing nicotinoid insecticide tolerance among CPB populations in the potato production areas in Wisconsin, several systemic based and foliar-based programs were designed to evaluate their effectiveness on managing the CPB on potato.

Methods and Materials

This experiment was conducted on a loamy sand soil at Hancock Agricultural Research station (HARS) located 1.1 mile (1.8 km) southwest of Hancock, Wisconsin in 2016. Potato, *Solanum tuberosum* cv. 'Russet Burbank', seed pieces were planted on 19 April. Plants were spaced 12 inches apart within rows. Rows were 3 ft apart. The 8-row plots were 24 feet wide by 40 feet long, for a total of 0.025 acres/plot. Replicates were separated by a 4 ft border of bare ground.

Three replicates of 12 full-season insecticide programs were arranged in a randomized complete block design. Systemic insecticides were applied in-furrow at planting (19 April for treatments 1-6). The first generation foliar applications were made on 15, 23 June and were applied after peak egg hatch and prior to large larval population dominance (treatments 7-12). Subsequent applications were made on 15, 23 and 29 June (systemic rescue for treatments 4-6 and 11). Second generation CPB foliar applications were made to all treatments on 18 and 25 July. Treatment information is available in **Table 1**.

All in-furrow treatments were applied at 11.0 gpa on 24 April using a two nozzle boom equipped with Tee Jet XR8001 flat fan spray nozzles powered by a CO_2 backpack sprayer at 30psi. Furrows were cut using a commercial potato planter without closing discs attached. Immediately after the in-furrow treatments were applied and all seed piece treatments were placed in open furrows, all seed was covered by hilling. Foliar insecticides were applied using a CO_2 pressurized sprayer with a 24 ft boom operating at 30 psi delivering 20 gpa through 16 Tee Jet XR8002XR flat fan nozzles spaced 18" apart while travelling at 4.0 ft/sec.

CPB control efficacy was assessed by counting the number of CPB adults (CPB-A), egg masses (EM), small larvae (SL), and large larvae (LL) per plant on 10 randomly selected plants in each plot. Percent defoliation (% DF) ratings were taken by visual observation of the entire plot. Potato leafhopper (PLH), *Empoasca fabae*, efficacy was assessed by counting the number of adults collected from 15 sweep net samples in each plot. Aphid and potato leafhopper nymph populations were surveyed by visual assessment of 25 leaves per plot.

Insect counts occurred on several dates throughout the summer and reported means were averaged across those dates (**Tables 2, 3**). Insect count averages reflect time periods during the summer when specific life stages peaked in the plots. Cumulative data are shown in **graphs.** Yield and quality data were collected after harvest (15 Sep) (**Table 4**). Count data were Log10 transformed prior to data analysis using ANOVA and means were compared using a Tukey's HSD means separation test (P=0.05). No signs of phytotoxicity were observed.

Table 1. Full-season, integrated pest and resistance management programs for control of the Colorado potato beetle.

Trt	1st generation CPB					2nd generation CPB				
	App Date	Insecticide	Rate		Type[a]	App Date	Insecticide	Rate		Type[a]
1	19-Apr	Platinum 75 SC	2.67	fl oz/a	IF	11-Jul	Besiege 1.25 ZC	9	fl oz/a	F
						25-Jul	Besiege 1.25 ZC	7.5	fl oz/a	F
2	19-Apr	Belay 2.13 SC	12	fl oz/a	IF	11-Jul	Agri-Mek 0.7 SC	3.5	fl oz/a	F
						25-Jul	Agri-Mek 0.7 SC	3	fl oz/a	F
3	19-Apr	Belay 2.13 SC	12	fl oz/a	IF	11-Jul	Assail 30 SG	4	oz wt/a	F
						25-Jul	Assail 30 SG	3	oz wt/a	F
4	19-Apr	Sivanto 1.67 SL	10	fl oz/a	IF	18-Jul	Actara 25% WDG	3	oz wt/a	F
	15, 22-Jun	Entrust (rescue)	10	fl oz/a	F	25-Jul	Actara 25% WDG	2.5	oz wt/a	F
5	19-Apr	Verimark 20 SC	13.5	fl oz/a	IF	18-Jul	Scorpion 35% SL	2.75	fl oz/a	F
	22, 29- Jun	Entrust 2 SC (rescue)	10	fl oz/a	F	25-Jul	Scorpion 35% SL	2.5	fl oz/a	F
6	19-Apr	Admire Pro 4.6 SC	4.6	fl oz/a	IF	18-Jul	IKI 3106 50 SL	16	fl oz/a	F
	22, 29-Jun	Entrust 2 SC (rescue)	10	fl oz/a	F	25-Jul	IKI 3106 50 SL	13	fl oz/a	F
7	15-Jun	Rimon 0.83 EC	12	fl oz/a	F	18-Jul	IKI 3106 50 SL	16	fl oz/a	F
	22-Jun	Rimon 0.83 EC	12	fl oz/a	F	25-Jul	IKI 3106 50 SL	13	fl oz/a	F
8	15-Jun	Exirel 10 SE	13.5	fl oz/a	F	18-Jul	Assail 30 SG	4	oz wt/a	F
	22-Jun	Exirel 10 SE	10	fl oz/a	F	25-Jul	Assail 30 SG	3	oz wt/a	F
9	15-Jun	Agri-Mek 0.7 SC	3.5	fl oz/a	F	18-Jul	Besiege 1.25 ZC	9	fl oz/a	F
	22-Jun	Agri-Mek 0.7 SC	3	fl oz/a	F	25-Jul	Besiege 1.25 ZC	7.5	fl oz/a	F
10	15-Jun	Blackhawk 36 WG	3.3	oz wt/a	F	18-Jul	Exirel 10 SE	5	fl oz/a	F
	22-Jun	Blackhawk 36 WG	2.5	oz wt/a	F	25-Jul	Exirel 10 SE	5	fl oz/a	F
11	15-Jun	Sivanto Prime	14	fl oz/a	F	18-Jul	Assail 30 SG	4	oz wt/a	F
	22-Jun	Sivanto Prime	12	fl oz/a	F	25-Jul	Assail 30 SG	3	oz wt/a	F
	29-Jun	Entrust 2 SC (rescue)	10	fl oz/a	F					
12	15-Jun	Entrust 2 SC	10	fl oz/a	F	18-Jul	Coragen 1.67 SC	5	fl oz/a	F
	22-Jun	Entrust 2 SC	10	fl oz/a	F	25-Jul	Coragen 1.67 SC	4	fl oz/a	F

a. *F=foliar, IF=In furrow*

Table 2. Cumulative mean life stage counts per 10 plants of Colorado potato beetles and defoliation.

Trt	Adults (1st gen)		Adults (2nd gen)		Egg Masses		Small Larvae		Large Larvae		Defoliation rating	
1	25.5	b	132.5	e	20.75	a	91.75	a	30.75	cd	1.11	ab
2	22.25	b	77	bcde	27.75	a	99.75	a	13	abc	1.07	ab
3	15.5	ab	104	de	18.5	a	97.75	a	47	cd	1.25	ab
4	7.5	ab	76.5	cde	16.75	a	153.75	abc	79.25	d	1.18	ab
5	10.5	ab	29.25	ab	22	a	173.25	abc	47.75	bcd	1.25	ab
6	10.75	ab	29.75	ab	23	a	116.75	ab	9.75	abc	1.00	a
7	5.75	ab	31.25	abc	94.75	a	357	bc	45.75	d	1.54	ab
8	12.75	ab	16.25	a	14.75	a	65	a	8.5	ab	1.14	ab
9	5	ab	14.75	a	10.75	a	69.75	a	5	a	1.00	a
10	5.75	ab	39	abcd	17	a	197.75	abc	30	cd	1.36	ab
11	3.25	a	151.5	e	11.25	a	407.75	c	213.25	e	2.21	c
12	7.75	ab	20.25	a	14	a	116.5	ab	12.25	abc	1.71	bc
P	0.006		< .0001		n.s.		< .0001		< .0001		< .0001	
HSD	0.7042		0.4215		0.6979		0.5919		0.5325		0.6739	

a. Means in a column followed by the same letter are not significantly different at $\alpha = 0.05$.
b. Means transformed (square root X +1) prior to separation.
c. Defoliation rating: 1=0-2%, 2=2-5%, 3=5-10%, 4=>10%

Table 3. Cumulative mean potato leafhopper (PLH) and aphid counts

Trt	PLH adults		PLH nymphs		Aphids	
1	8.25	a	0.25	ab	1	a-c
2	9.5	a	0.25	ab	1.25	ab
3	6.5	a	0	a	0	a
4	30.5	b	8.25	c	1.5	ab
5	66.75	cd	59	ef	20.25	d-f
6	23	b	4.5	bc	2.5	a-d
7	109	de	105	ef	100.5	f
8	94.75	de	58.25	ef	10	b-f
9	78	cd	46.75	de	37.5	ef
10	120.75	de	89.5	ef	15	c-f
11	40	bc	13	cd	5.5	a-e
12	175.5	e	198.5	f	32.5	ef
P	< .0001		< .0001		< .0001	
HSD	0.2983		0.6239		0.8782	

a. Means in a column followed by the same letter are not significantly different at α = 0.05.
b. Means transformed (square root X +1) prior to separation

Table 4. Mean yield estimates (cwt/a)

Trt	Total US #1 (lbs)		Proportion US #1-A	
1	378.7885	a	0.8121	ab
2	373.4990	ab	0.8126	ab
3	343.5275	a-d	0.8143	ab
4	324.3365	a-e	0.8101	ab
5	351.5788	ab	0.8413	a
6	348.4059	abc	0.8003	ab
7	268.2130	c-f	0.7706	ab
8	324.4666	a-e	0.7971	ab
9	291.2283	b-f	0.7809	ab
10	267.2761	def	0.7971	ab
11	238.8720	f	0.6525	c
12	253.6870	ef	0.7446	bc
P	< .0001		< .0001	
HSD	81.7609		0.1095	

a. Means in a column followed by the same letter are not significantly different at $\alpha = 0.05$.
b. Means transformed (square root X +1) prior to separation

Fig. 1. Cumulative 1st generation CPB adults

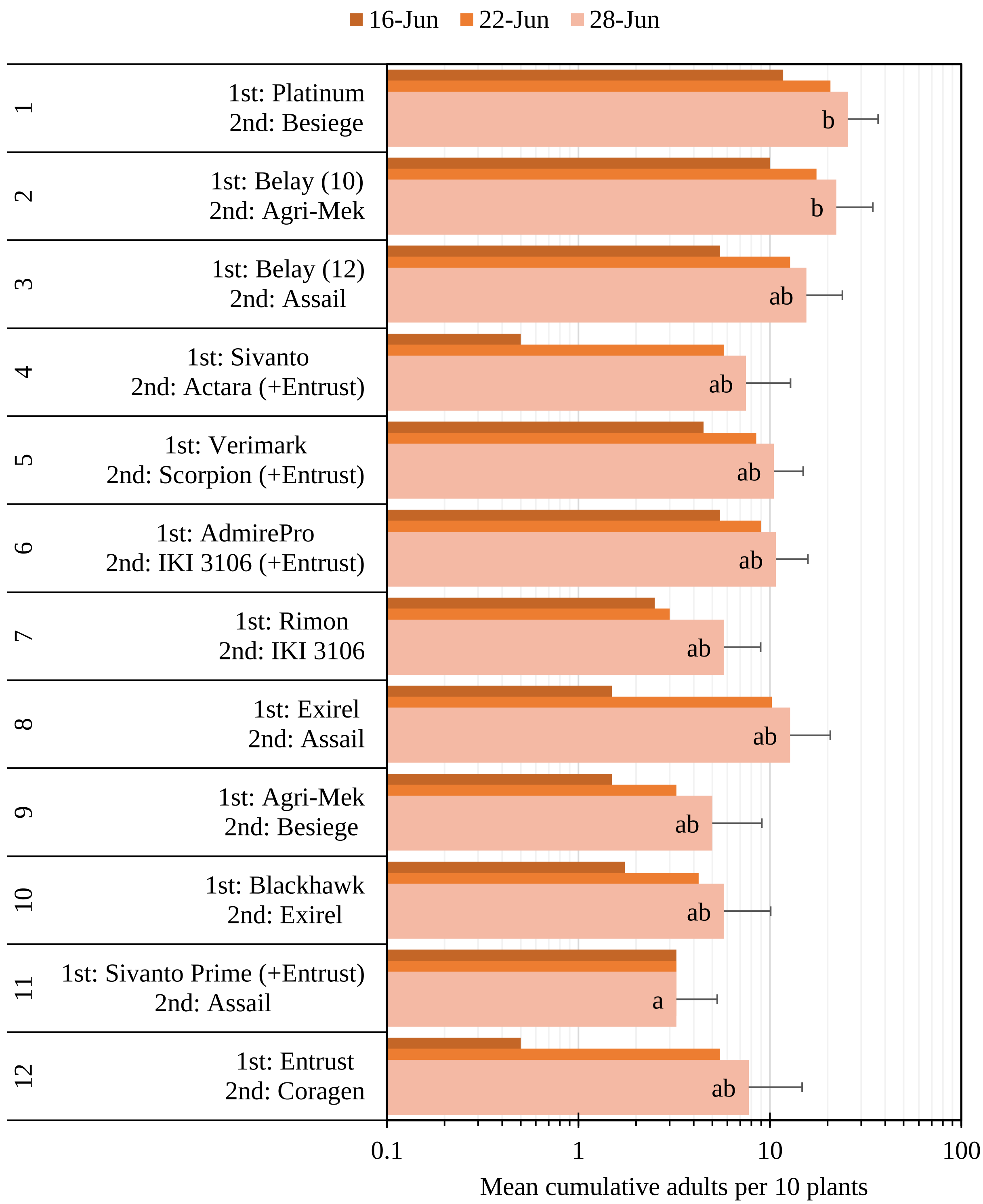


Fig. 2. Cumulative 2nd generation CPB adults

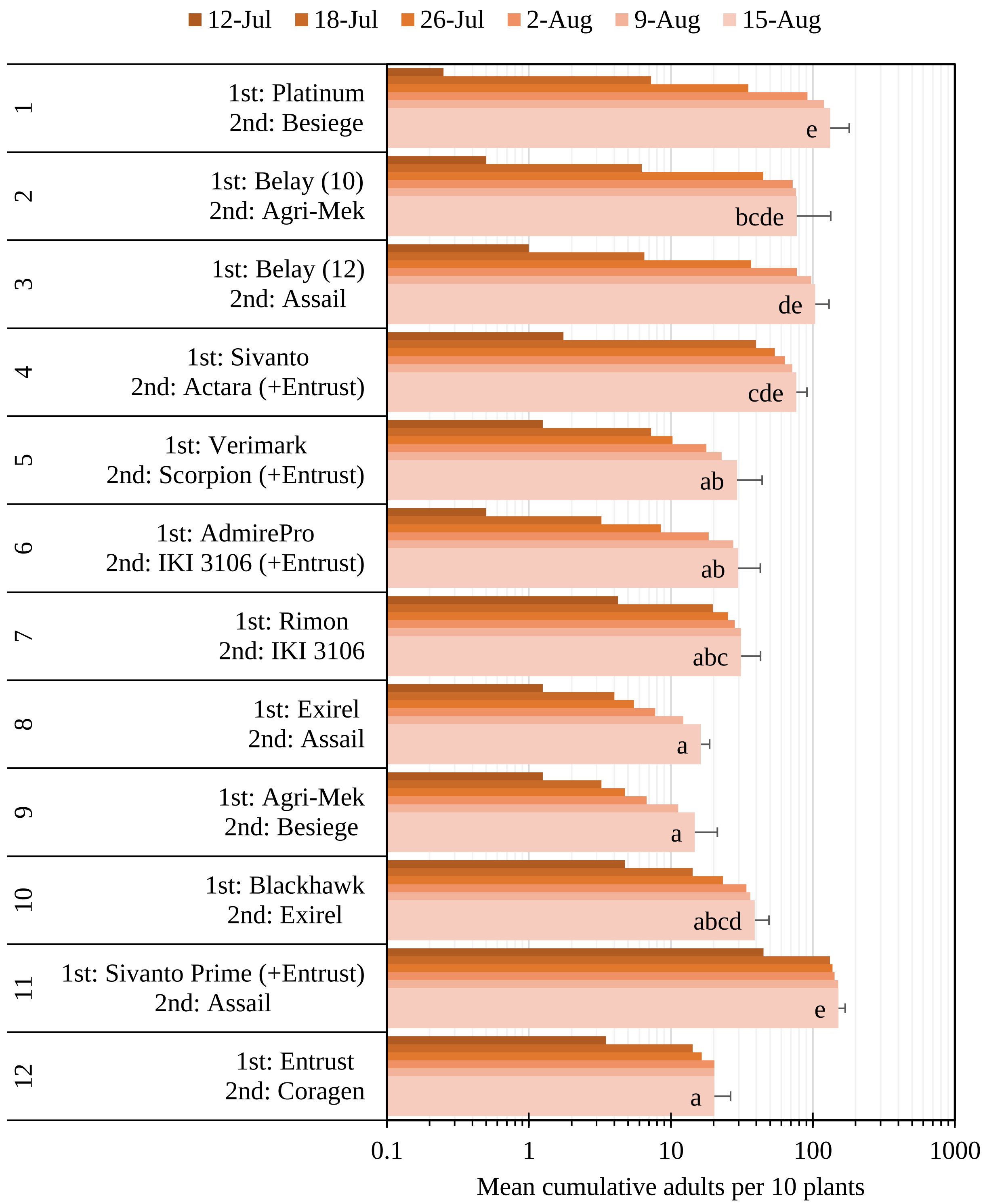


Fig. 3. Cumulative CPB egg masses

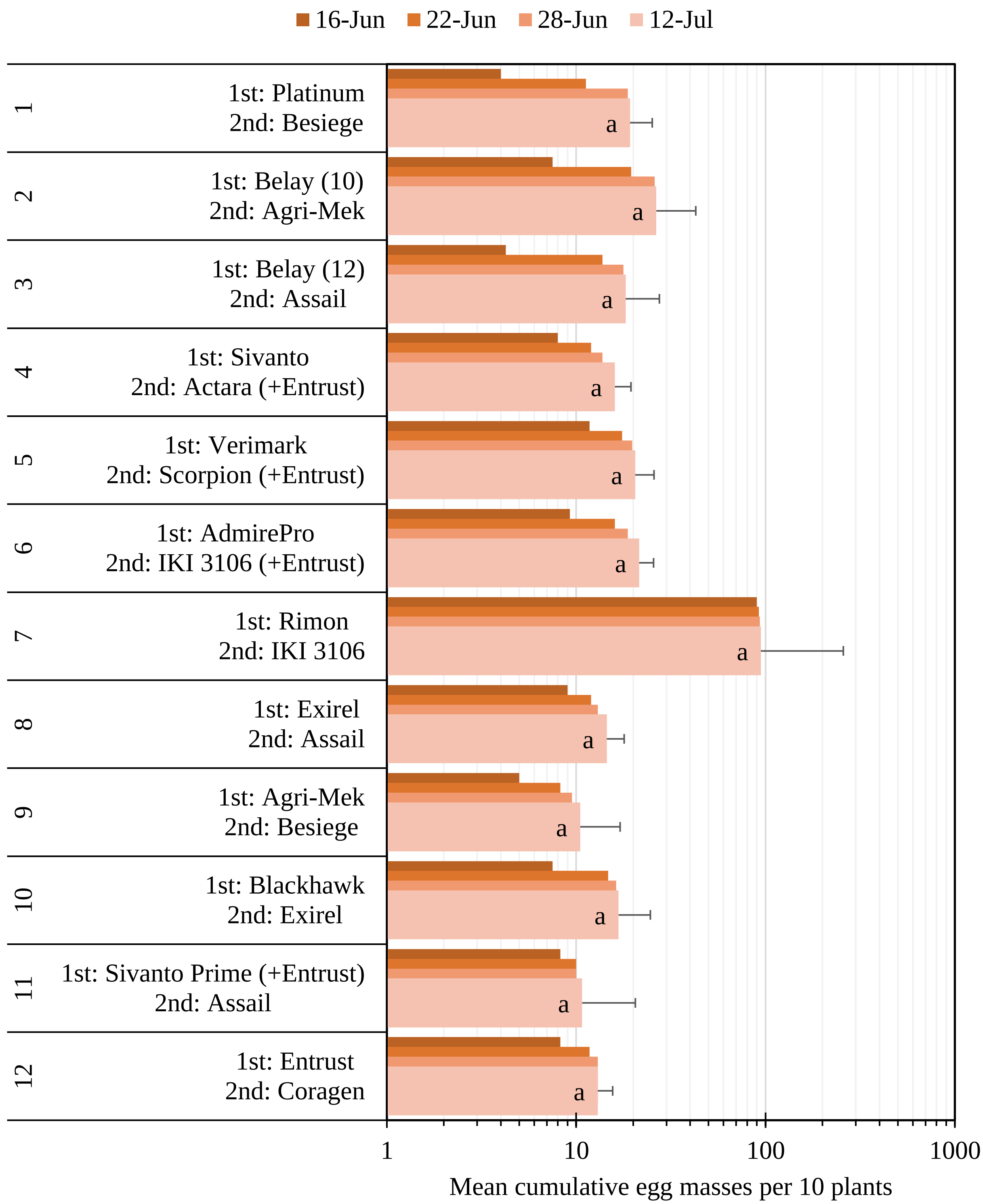


Fig. 4. Cumulative CPB small larvae

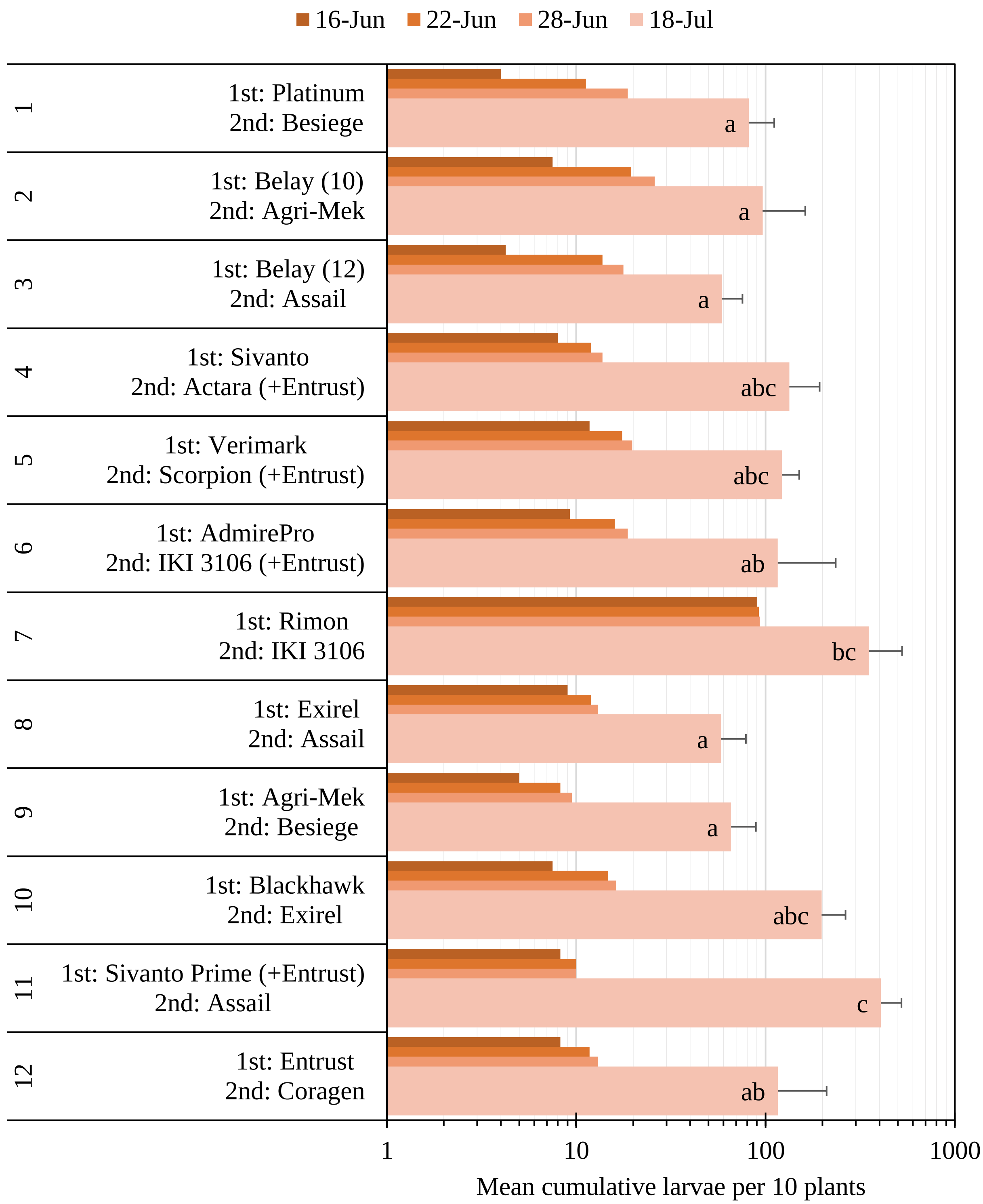


Fig. 5. Cumulative CPB large larvae

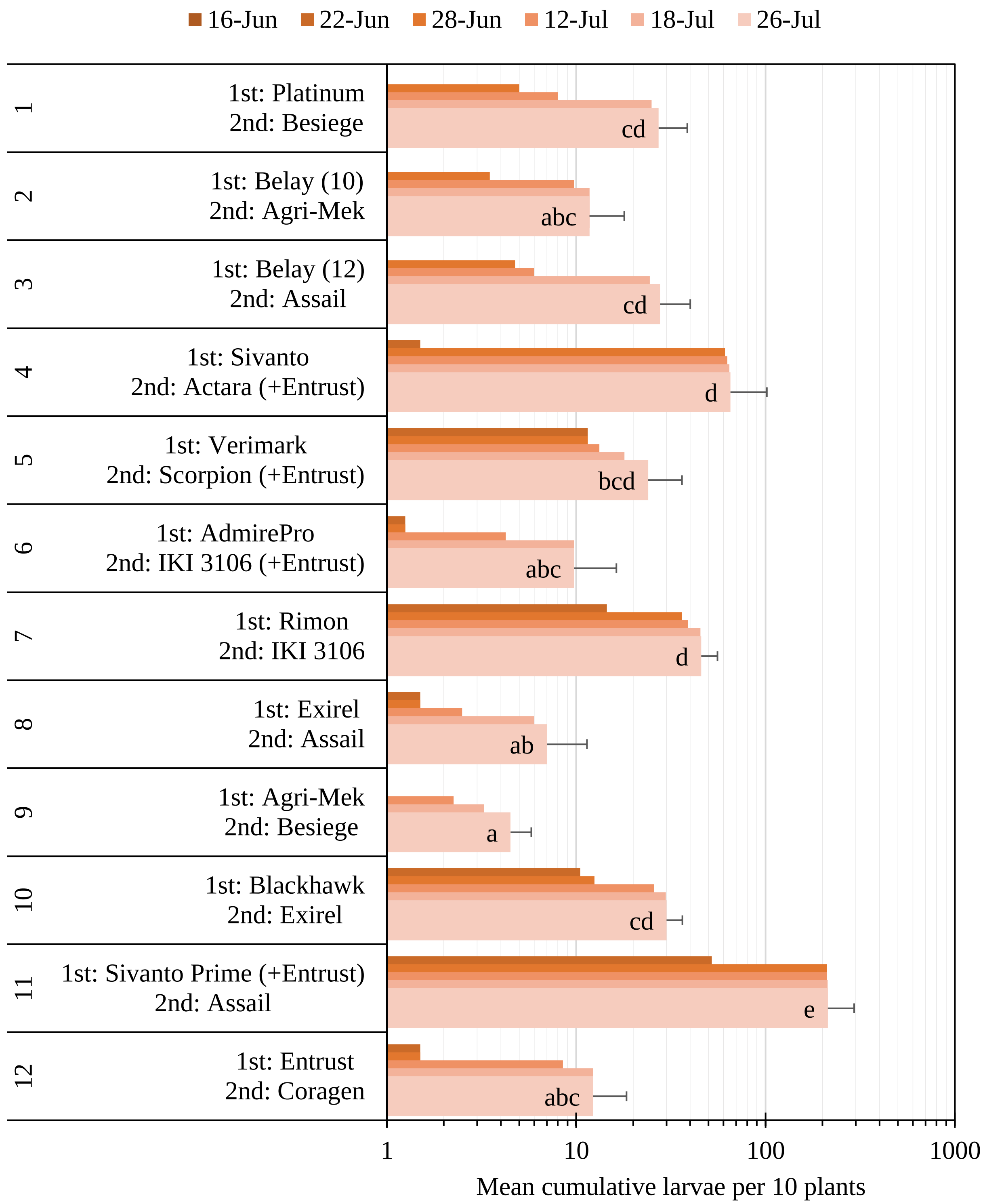


Fig. 6. Cumulative potato leafhopper adults

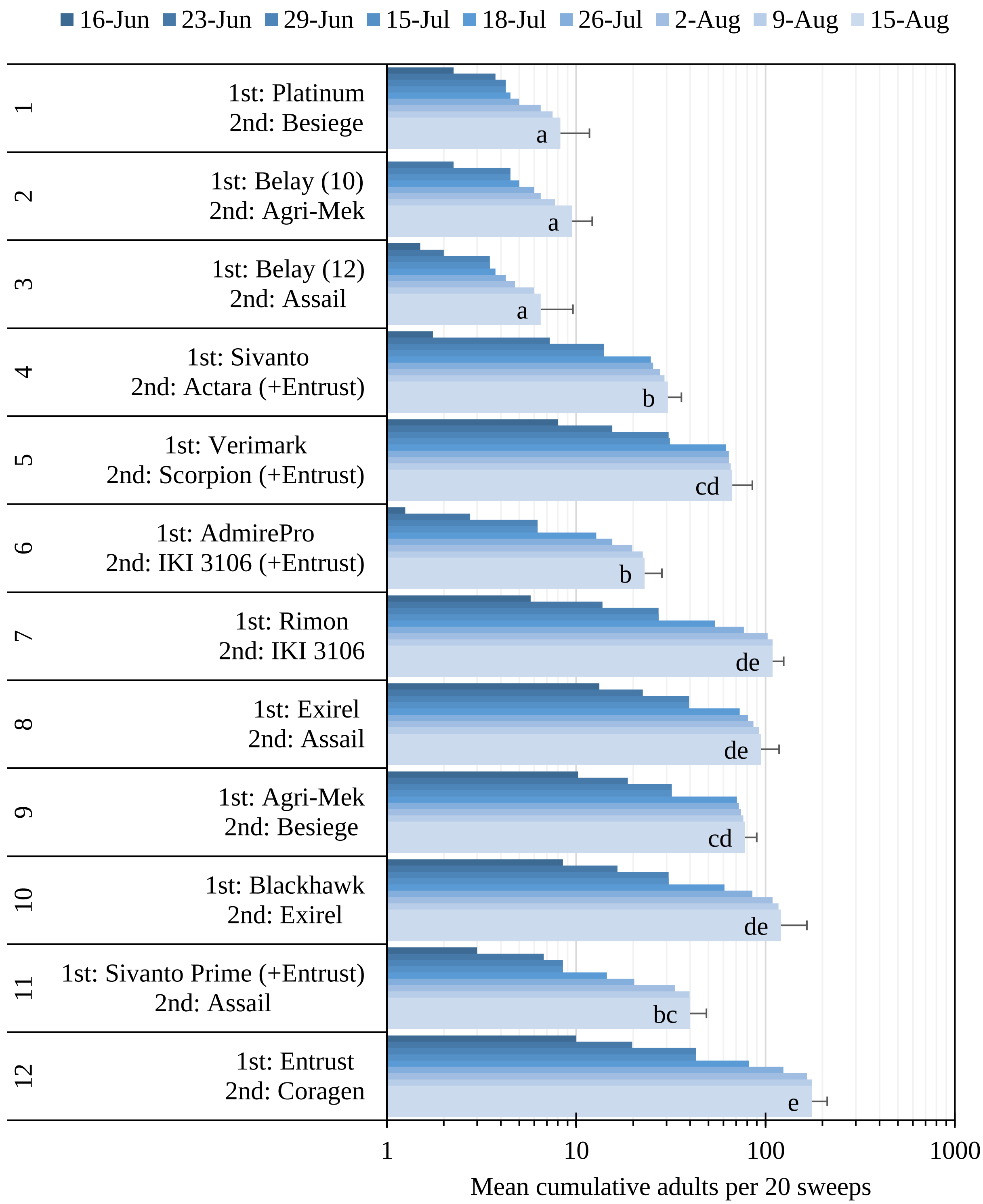


Fig. 7. Cumulative potato leafhopper nymphs

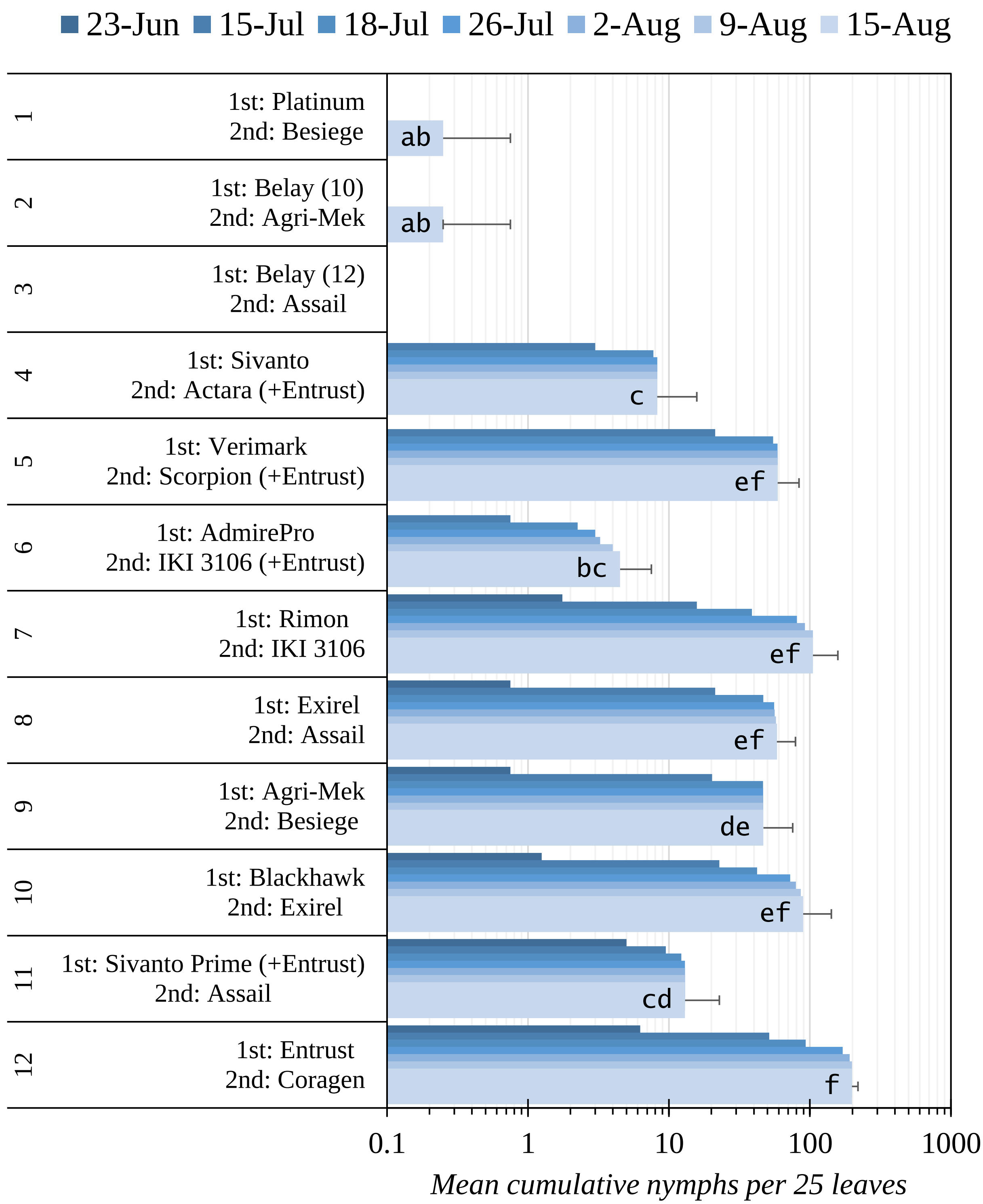


Fig. 8. Cumulative aphid counts

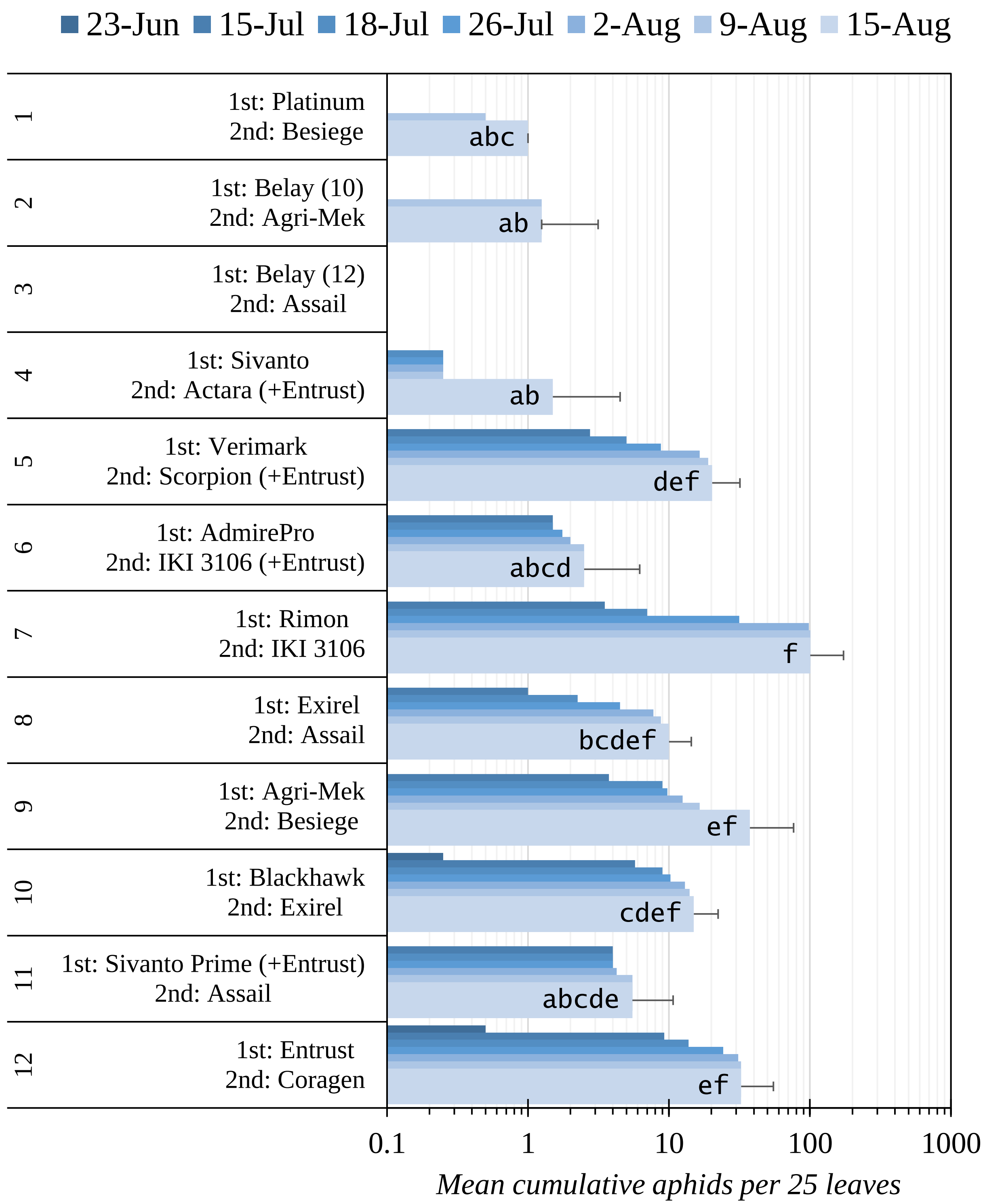
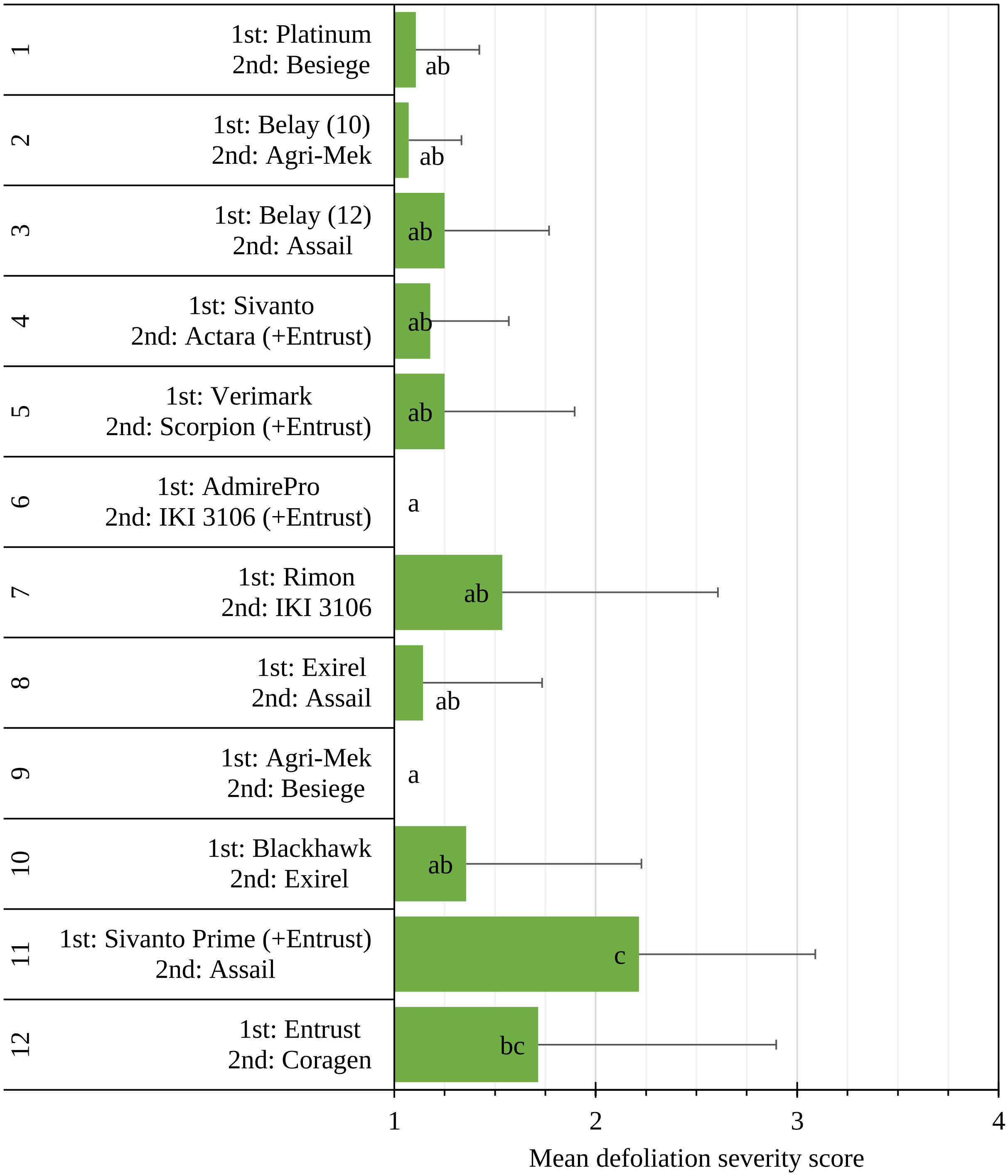


Fig. 9. Defoliation severity

1: < 2%   2: 2-5%   3: 5-10%   4: >10%



Trial 7

Foliar insecticide treatments for the control of European corn borer on Wisconsin snap bean production (Plover, WI)

Purpose

The purpose of this experiment is to evaluate various foliar-applied, registered and experimental insecticides targeting populations of European corn borer (ECB), *Ostrinia nubilalis*, larvae in snap beans.

Materials and Methods

This experiment was conducted at the Del Monte Foods Experimental Plots, near Plover, WI in 2016. Snap bean, *Phaseolus vulgaris* var. 'Blue Lakes 04-95' was seeded on 3 June at a rate of 8 seeds per foot within rows. Rows were 30 inches apart. The two-row plots were 5 ft wide by 25 ft long, for a total of 0.003 acres. Replicates were separated by two untreated rows. All plots were managed per commercial management practices.

On 1 July, each plot was infested with egg masses of European corn borer (ECB), *Ostrinia nubilalis*. Five successive plants were infested with 10 egg masses, for a total of 50 egg masses, each containing approximately 20-30 eggs / mass. Egg masses were pinned to plants within the lower canopy of the plots.

Four replicates of 7 treatments and 1 untreated control were arranged in a randomized complete block design. The foliar treatments were applied 5 July when plants had reached the flowering and pin-bean development stage. Treatments were applied with a CO_2 pressurized backpack sprayer with a 6' boom operating at 30 psi delivering 20.2 gpa through a flat-fan nozzle (Tee Jet XR8002VS) spaced 18" apart while travelling at 3.5 ft / sec.

Populations of ECB and associated damage estimates were surveyed 21 July from 5 plants from the center row of each plot by counting (1) total number of pods from 5 plants, (2) number of damaged stems, and (3) number of damaged pods. Means were compared using a Tukey's HSD means separation test (P=0.05). Data are presented in **Table 1**. No overt signs of phytotoxicity were observed.

Table 1. Estimates of European corn borer damage on snap bean stems and pods

Trt	Product(s)	Adj.	Inse. Rate		N dmg stems		Prp. dmg stems		Prp. dmg pods	
1	Untreated				0.75	a	0.20	a	0.014	a
2	Exirel	NIS	13.5	fl oz/a	0	a	0	a	0	a
3	Besiege	NIS	10	fl oz/a	0	a	0	a	0	a
4	Radiant	NIS	8	fl oz/a	0.5	a	0.10	a	0	a
5	Exp 1 (1 app) Exp 2 (2app)	LI-700	16.9 4	fl oz/a qt/a	0	a	0.10	a	0.013	a
6	Exp 1 (1 app) Exp 2 (2app)	LI-700	16.9 2	fl oz/a qt/a	0	a	0	a	0	a
7	Brigade	NIS	6.4	fl oz/a	0	a	0	a	0	a
8	Blackhawk	NIS	3.3	oz wt/a	0.5	a	0.15	a	0.004	a
				P	0.258		0.124		0.111	
				HSD	1.242		0.538		0.123	

a. *NIS added at 0.1 % v/v, LI-700 added at 0.125 % v/v*
b. *Means in columns followed by the same letter are not significantly different (Tukey's Honestly Significant Difference Test, P = 0.05)*

Trial 8

In-furrow insecticide treatments for the control of seedcorn maggot in Wisconsin snap bean production (Plover, WI)

Purpose

The purpose of this experiment was to evaluate the efficacy of several in-furrow treatments on Seedcorn maggot (SCM), *Delia platura* in snap bean.

Materials and Methods

This experiment was conducted at the Del Monte Foods Experimental Plots, near Plover, WI in 2016. Snap bean, *Phaseolus vulgaris* var. 'Blue Lakes 04-95', was seeded on 3 June at a rate of 8 seeds per foot within rows. Rows were 30 inches apart. The two-row plots were 5 ft wide by 25 ft long, for a total of 0.003 acres. Replicates were separated by two untreated rows. All plots were managed per commercial management practices.

Four replicates of 5 treatments and 1 untreated control were arranged in a randomized complete block design. In-furrow treatments were applied at planting with a CO_2 pressurized backpack sprayer with a single nozzle boom operating at 30 psi delivering 11.1 gpa through a flat-fan nozzle (Tee Jet XR8015VS) traveling at 3.5 ft/sec. In-furrow treatments were applied 3 June with a CO_2 pressurized backpack sprayer with a single nozzle boom operating at 30 psi delivering 20.2 gpa through a flat fan nozzle (Tee Jet XR8015VS) traveling at 3.5 ft/sec.

Counts of emerged plants per row were taken from the center row of each plot on 14 June. Populations of SCM and associated damage estimates were surveyed 21 July from 5 plants from the center row of each plot by counting (1) total number of damaged stems, (2) total number of damaged plants. Means were compared using a Tukey's HSD means separation test (P=0.05). Data are presented in **Table 1**. No overt signs of phytotoxicity were observed.

Table 1. Damage estimates of snap bean stems/plants from seedcorn maggot

Trt	Product	Adj.	Rate		N damaged stems per 5 plants		N damaged plants	
1	Capture	APSA-80	6.8	fl oz/a	0.50	a	0.25	a
2	Capture	-	6.8	fl oz/a	0.50	a	0.50	a
3	Verimark	APSA-80	13.5	fl oz/a	0.75	a	0.75	a
4	Verimark	-	13.5	fl oz/a	0.75	a	0.75	a
5	Lorsban	APSA-80	1.8	fl oz/row	0.25	a	0.50	a
6	Untreated	-	-		0.25	a	0.25	a
				P	0.977		0.965	
				HSD	1.525		1.479	

a. *APSA-80 added at 0.2 % v/v*
b. *Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P=0.05)*
c. *1000 ft row*

Trial 9

Foliar insecticide treatments for the control of European corn borer in Wisconsin processing pepper production

Purpose

Evaluate various foliar-applied, registered insecticides targeting populations of European corn borer (ECB), *Ostrinia nubilalis* larvae in processing pepper, with the goal of developing efficacy data in support of future registration of novel insecticides.

Materials and Methods

This experiment was conducted at Arlington Agricultural Experiment Station in Arlington, WI in 2016. Pepper, *Capsicum annuum* cv. 'Turnpike', (green bell variety) transplants were planted 3 June. Plants were spaced 18 inches apart within rows, rows were 3 ft apart, plots were single rows and were 15 ft in length. Experimental plots were managed according to commercial herbicide and fungicide recommendations for weed control and control of the pepper blight resulting from *Phytophthora capsici*.

On 5 Aug, each plot was infested with egg masses of European corn borer (ECB), *Ostrinia nubilalis*. Five successive plants were infested with 10 egg masses, for a total of 50 egg masses, each containing approximately 20-30 eggs / mass. Egg masses were pinned to plants within the lower canopy of the plots.

Four replicates of 6 experimental foliar treatments and 1 untreated control were arranged in a randomized complete block design. The foliar treatments were applied 10 Aug when plant growth stage was at flowering and mature fruit set. Treatments were applied by a CO_2 pressurized backpack sprayer with a 3' boom operating at 30 psi delivering 22 gpa through 2 flat-fan nozzles (Tee Jet 8002XR) spaced 18" apart @ 3.5 ft / sec. See **Table 1** for a summary of key field activity dates.

Populations of ECB and associated damage estimates were surveyed on 19 Aug by counting (1) total number of fruit, (2) number of damaged fruit, and (3) the number of viable larvae observed in fruit (**Table 2 and graphs**). Means were compared using a Tukey's HSD means separation test (P=0.05). Natural populations of ECB at the experimental site are annually variable and require that experimental plots be artificially infested with test insects. No signs of phytotoxicity were observed.

Table 1. Summary of key field activity dates.

Action	Planting	Infestation	Insecticide app.	Evaluation
Date	3 Jun	5 Aug	10 Aug	19 Aug
Days since last action		63	5	9

Table 2. Mean damage estimates per 5 plants in pepper.

Trt	Product	Rate		Total No. Fruit		Prp. Damaged Fruit		# Larvae /Plant	
1	Untreated	-		7.75	ab	0.430	a	1.00	a
2	Exirel	13.5	fl oz/a	9	ab	0.195	a	0.50	a
3	Besiege	10	fl oz/a	12.25	a	0.198	a	1.00	a
4	Radiant	8	fl oz/a	13.25	a	0.168	a	1.00	a
5	Brigade	6.4	fl oz/a	9.25	ab	0.136	a	1.25	a
6	Blackhawk	3.3	oz wt/a	5.5	b	0.396	a	0.50	a
			P	0.005		0.36		0.9	
			HSD	5.802		0.580		0.541	

a. Treatments 2-6: NIS added at 0.1% v/v

b. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)

Fig. 1. Number of fruit per plant

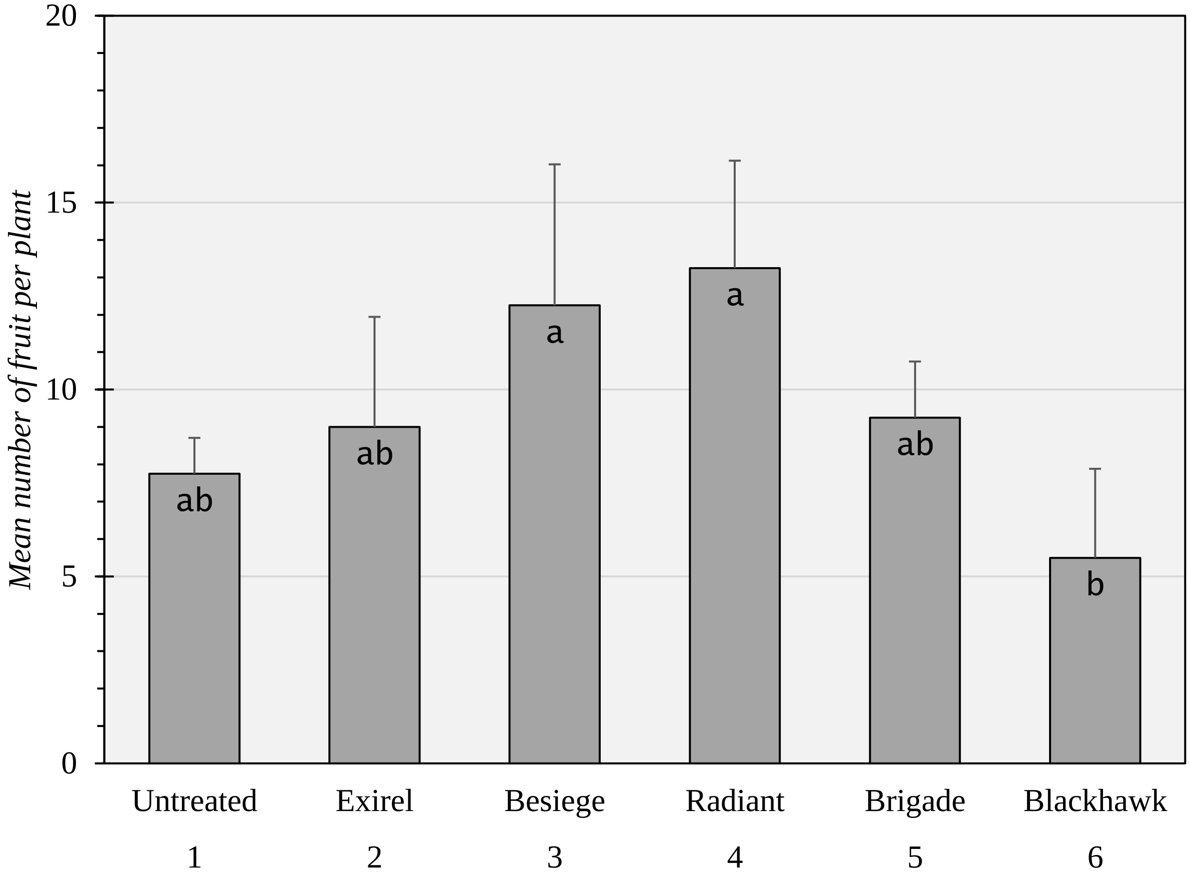


Fig. 2. Mean Proportion of damaged plants

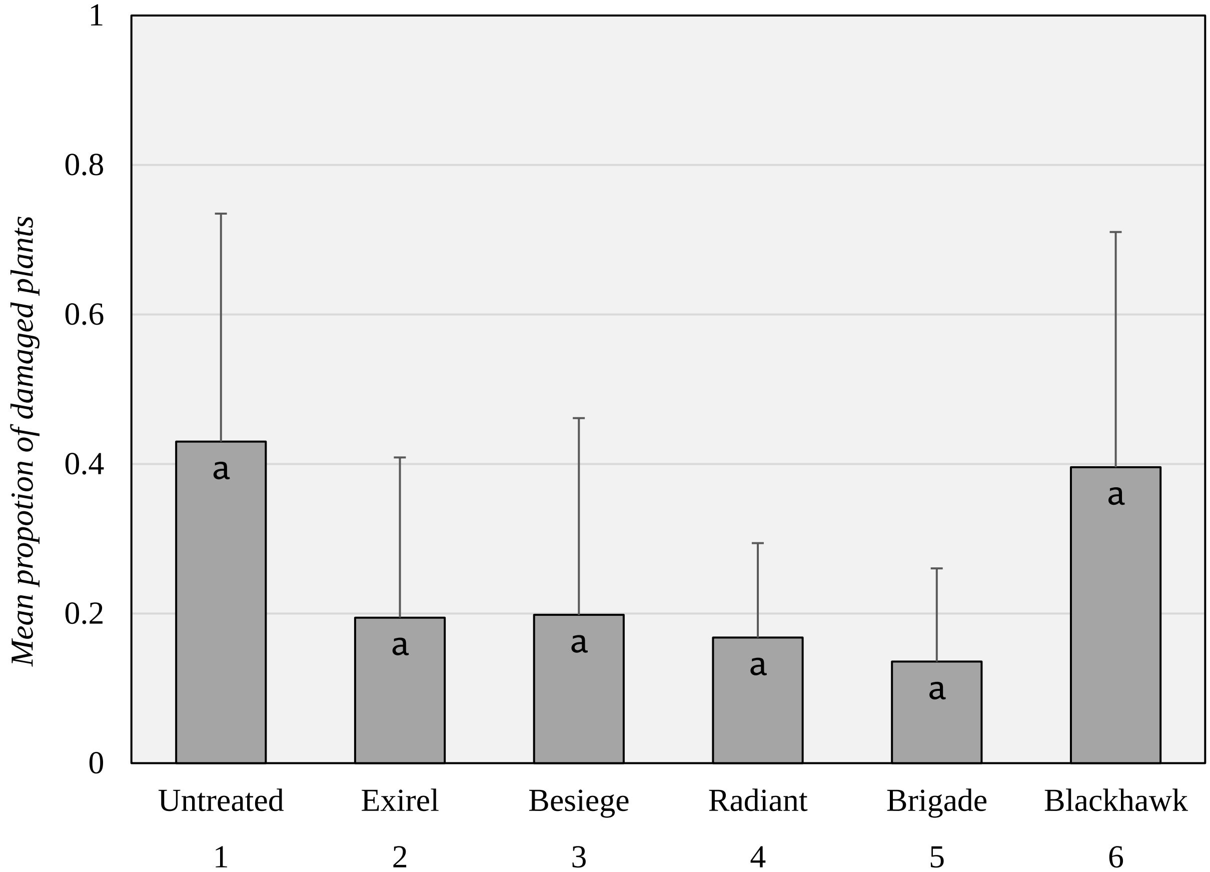
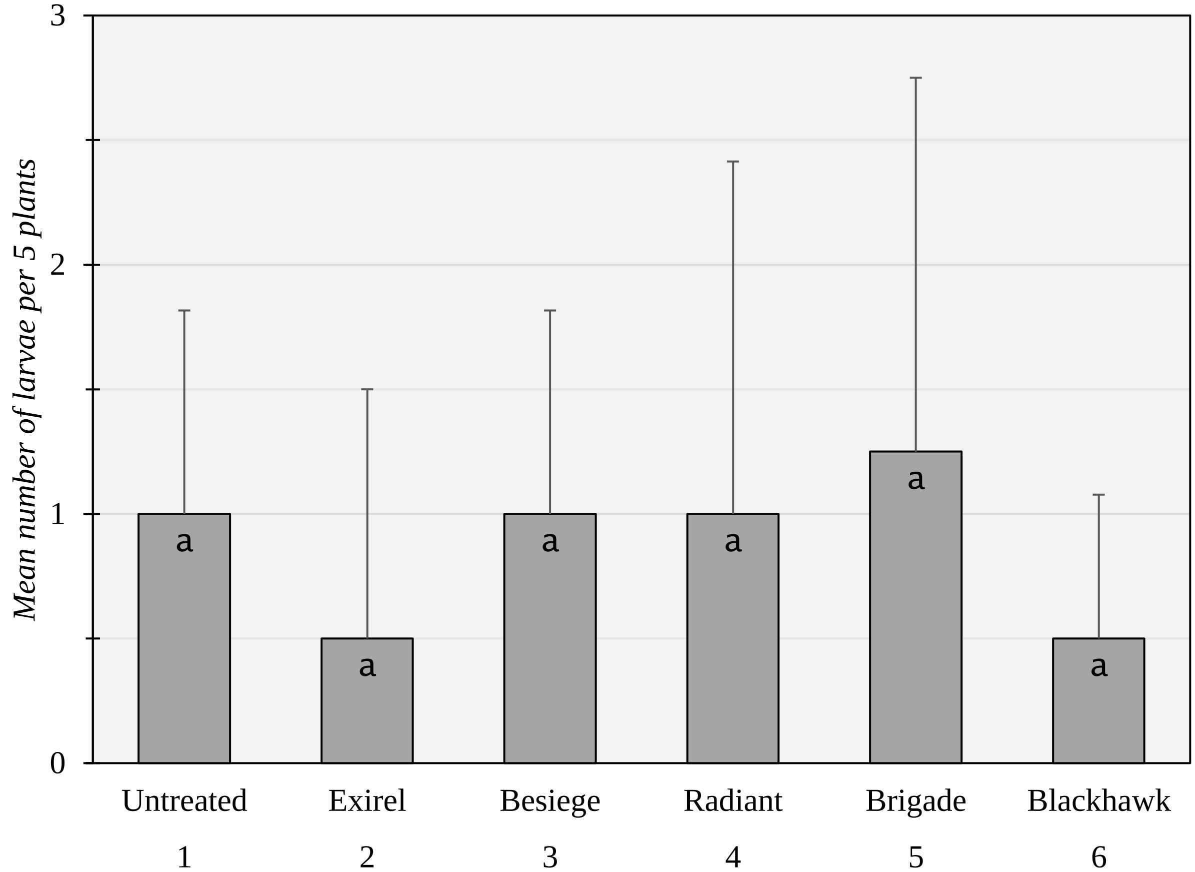


Fig. 3. Mean number of larvae per 5 plants



Trial 10

Evaluation of at-plant banded insecticides for the control of cabbage maggot insect pests in cabbage (Randolph, WI)

Purpose

The objective of this experiment was to assess the efficacy of at plant insecticides to control cabbage maggot, *Delia radicum*, pests in cabbage.

Materials and Methods

This experiment was conducted in a cooperating producer's cabbage field located near Randolph, WI in 2016. Cabbage, *Brassica oleracea* cv. 'Supergreen', transplants were planted on 3 May. Plots were 20 ft in length and contained 12-13 plants, spaced 18 inches apart within rows. Plots were arranged into four replications with no alleys between replications. All plots were maintained according to standard commercial practices.

Four replicates of 7 experimental foliar treatments and 1 untreated control were arranged in a randomized complete block design. All at plant treatments were applied on 3 May, with treatments 1 and 2 re-applied on 6 May. Treatments were applied with a a single, flat-fan type nozzle (TSVX 8004), on the end of a hand-held wand and boom operating at 35 psi and delivering 13.5 gpa over a 5" band applied immediately over the planted row within 4 hrs after transplanting.

Plant stand counts were made on 20 May, 2016. Damaged plant counts occurred on 3 June (31and 33 DAT), and plant stand counts were taken again on 21 June. Means were separated using ANOVA with a Least Squared Difference (LSD) means comparison test (P=0.05).

No signs of phototoxicity were observed among treatments.

Table 1. Initial and final stand counts and proportion survivorship

Trt	Product	Rate		Adjuvant	Stand Ct May 5				Stand Ct Jun 21				Prp Survivorship			
					Mean		SD		Mean		SD		Mean		SD	
1	Aza-Direct	4.5	pt/a	APSA-80	11.75	±	0.50	a	4.00	±	1.41	d	0.341	±	0.12	c
2	Pyganic	2	qt/a	APSA-80	12.00	±	0.00	a	6.25	±	1.89	bcd	0.521	±	0.16	bc
3	Capture	6.4	oz/a	APSA-80	11.75	±	0.50	a	4.75	±	0.96	cd	0.405	±	0.09	bc
4	Capture	7.4	oz/a		11.75	±	0.96	a	3.75	±	2.87	d	0.330	±	0.25	c
5	Coragen	7.5	fl oz/a	APSA-80	12.00	±	0.00	a	8.50	±	2.52	abc	0.708	±	0.21	abc
6	Verimark	13.5	fl oz/a	APSA-80	11.75	±	0.50	a	10.00	±	1.63	ab	0.852	±	0.14	ab
7	Lorsban	4.5	pt/a	APSA-80	11.75	±	0.50	a	11.50	±	0.58	a	0.979	±	0.04	a
8	Untreated				11.75	±	0.50	a	6.00	±	2.16	bcd	0.515	±	0.20	bc
				P	0.983				< .0001				< .0001			
				HSD	1.219				4.440				0.554			

a. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)
b. APSA-80 added at 0.2%

Table 2. Damage assessment

Trt	Product	Rate		Adjuvant	Initial Stand Ct May 5				N Damaged Plants Jun 3				Prp Damaged Plants			
					Mean		SD		Mean		SD		Mean		SD	
1	Aza-Direct	4.5	pt/a	APSA-80	11.75	±	0.50	a	7.75	±	1.708	c	0.659	±	0.137	c
2	Pyganic	2	qt/a	APSA-80	12.00	±	0.00	a	7.25	±	2.500	bc	0.604	±	0.208	bc
3	Capture	6.4	oz/a	APSA-80	11.75	±	0.50	a	4.5	±	1.291	bc	0.386	±	0.126	bc
4	Capture	7.4	oz/a		11.75	±	0.96	a	6.25	±	2.754	bc	0.531	±	0.223	bc
5	Coragen	7.5	fl oz/a	APSA-80	12.00	±	0.00	a	5.5	±	1.291	bc	0.458	±	0.108	bc
6	Verimark	13.5	fl oz/a	APSA-80	11.75	±	0.50	a	3.25	±	1.258	ab	0.277	±	0.104	ab
7	Lorsban	4.5	pt/a	APSA-80	11.75	±	0.50	a	0.25	±	0.500	a	0.021	±	0.042	a
8	Untreated	-			11.75	±	0.50	a	7	±	1.826	bc	0.593	±	0.139	bc
				P	0.983				< .0001				< .0001			
				HSD	1.219				4.161				0.380			

a. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)
b. APSA-80 added at 0.2%

Trial 11

Evaluation of at-plant insecticides for the control of seedcorn maggot and cucumber beetle insect pests in Cucurbits (Cashton, WI)

Purpose

The objective of this experiment was to assess the efficacy of at plant insecticides to control seedcorn maggot (SCM), *Delia platura*, and cucumber beetle (CB), *Diabrotica undecimpunctata* and *Acalymma vittatum* pests in Cucurbits.

Materials and Methods

This experiment was conducted in a cooperating producer's field located 1.5 mi SW of Cashton, WI in 2016. Squash, *Cucrbita pepo* cv. 'Tivoli', seeds were planted 3 June. Ten seeds per plot were spaced 18 inches apart within rows. Rows were 30 inches apart by 20 ft long. Plots were arranged into four replications with no alleys between replications. All plots were maintained according to standard commercial practices.

Four replicates of 7 experimental foliar treatments and 1 untreated control were arranged in a randomized complete block design. All treatments were applied at plant on 3 June. Treatments were applied as a drench application using a single, flat-fan type nozzle (TSVX 8002) on the end of a hand-held wand with the boom operating at 20 psi and delivering 5.4 ml/sec directly into the seed hole for a 3 second application period, immediately after planting the seed.

Plant emergence and damage counts were made on 17 June (14 DAT) and are reported as the proportion of non-emerged plants (seedcorn maggot damage). Cucumber beetle counts were collected on 13 and 19 July (40 and 46 DAT). Means were separated using ANOVA with a Least Squared Difference (LSD) means comparison test (P=0.05). A summary of the data are presented in the following **graphs**. No significant difference is noted as N.S.

No signs of phototoxicity were observed among treatments.

Table 1. Squash emergence and damage assessment.

Trt	Product	Rate		Emergence				Damage			
				Mean		SD		Mean		SD	
1	Aza-Direct	4.5	pt/a	9.00	±	0.00	a	7.75	±	1.26	b
2	Pyganic	2.0	qt/a	8.25	±	0.96	a	7.25	±	1.71	b
3	Capture	6.4	fl oz/a	8.50	±	1.73	a	5.50	±	0.58	ab
4	Verimark	13.5	fl oz/a	9.25	±	0.96	a	5.75	±	1.50	ab
5	Coragen	7.5	fl oz/a	9.00	±	1.15	a	7.25	±	0.50	b
6	Admire Pro	10.5	fl oz/a	9.25	±	0.96	a	3.75	±	2.06	ab
7	Entrust	10.0	fl oz/a	8.75	±	1.26	a	6.75	±	0.96	b
8	Untreated	-		8.75	±	1.89	a	7.25	±	1.50	b
			P	n.s.				0.004			
			F	0.326				4.097			

a. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)

Table 2. Cucumber beetle counts on 5 random squash plants

Trt	Product	Rate		13-Jul				19-Jul				Cumulative			
				Mean		SD		Mean		SD		Mean		SD	
1	Aza-Direct	4.5	pt/a	4.00	±	1.90	a	4.55	±	2.01	a	4.28	±	1.83	a
2	Pyganic	2.0	qt/a	2.15	±	1.17	a	3.60	±	1.95	a	2.88	±	1.68	a
3	Capture	6.4	fl oz/a	5.80	±	3.09	a	7.10	±	3.57	a	6.45	±	3.17	a
4	Verimark	13.5	fl oz/a	6.85	±	2.84	a	7.65	±	2.28	a	7.25	±	2.42	a
5	Coragen	7.5	fl oz/a	4.70	±	1.41	a	6.40	±	1.53	a	5.55	±	1.64	a
6	Admire Pro	10.5	fl oz/a	5.60	±	1.97	a	6.40	±	2.44	a	6.00	±	2.10	a
7	Entrust	10.0	fl oz/a	3.93	±	1.66	a	5.50	±	1.01	a	4.71	±	1.53	a
8	Untreated	-		4.50	±	2.09	a	6.10	±	1.94	a	5.30	±	2.06	a
			P	n.s.				0.004				n.s.			
			F	0.326				4.097				1.696			

a. Means in columns followed by the same letter are not significantly different (Tukey's Honest Significant Difference Test, P = 0.05)

Fig. 1. Squash seedling emergence ratings

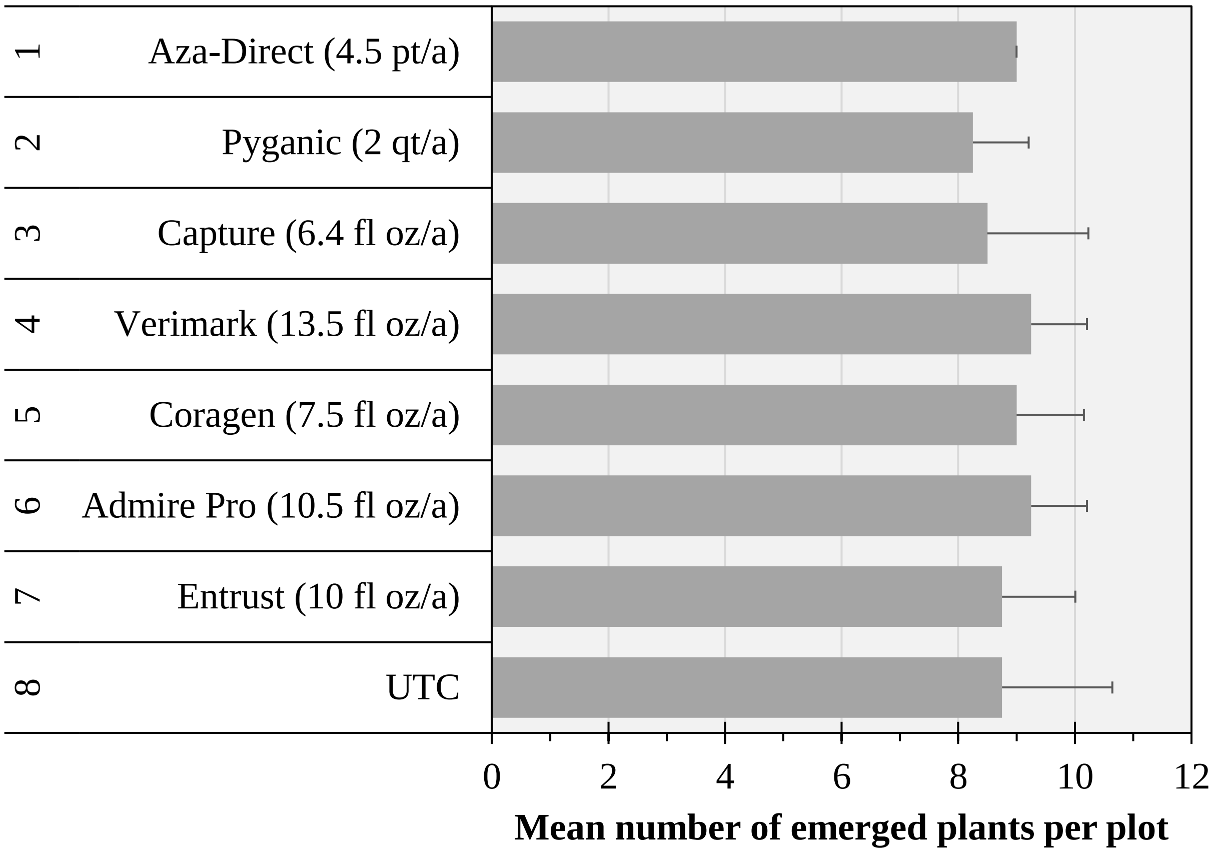


Fig. 2. Squash damage ratings

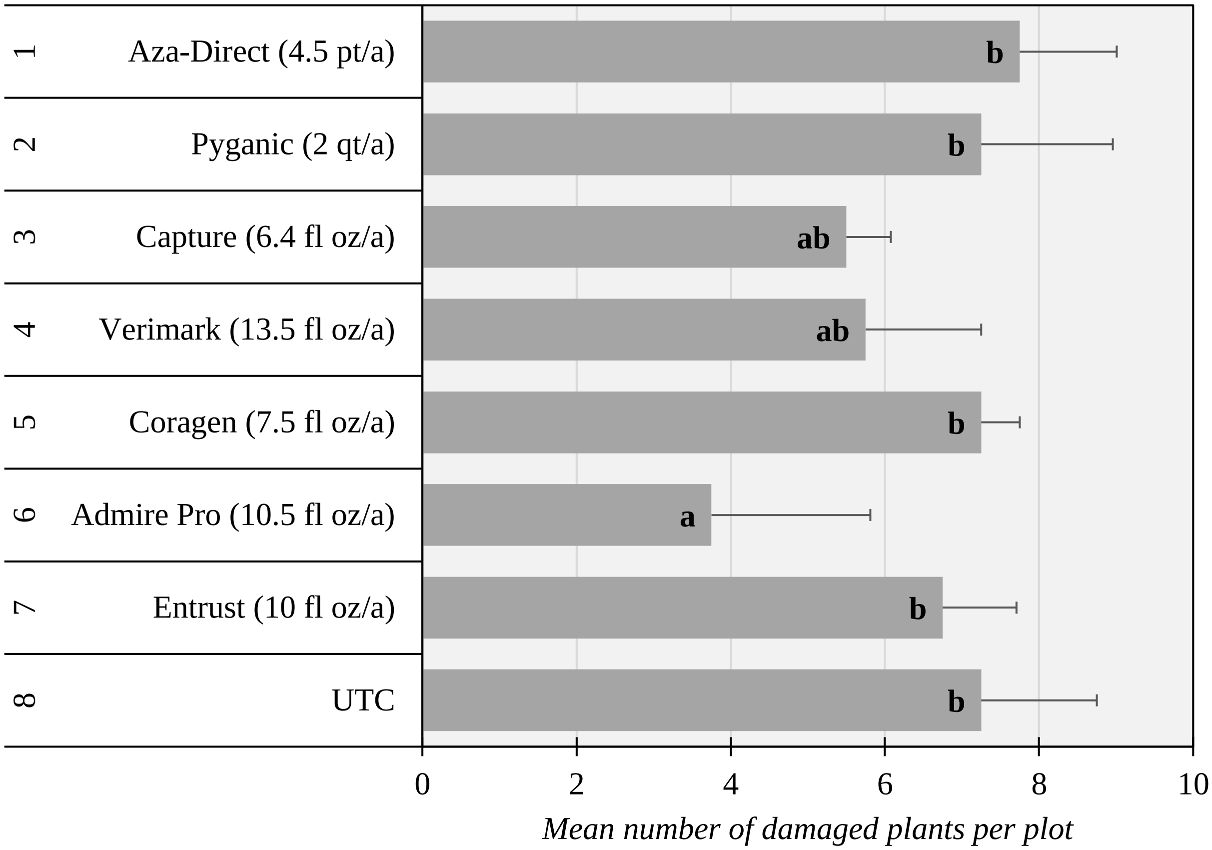


Fig. 3. Cucumber beetle counts on squash plants