

Pheromones: Discovery, Commercial Development, and Uses

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 United States Department of Agriculture National Institute of Food and Agriculture
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Collaborating Institutions

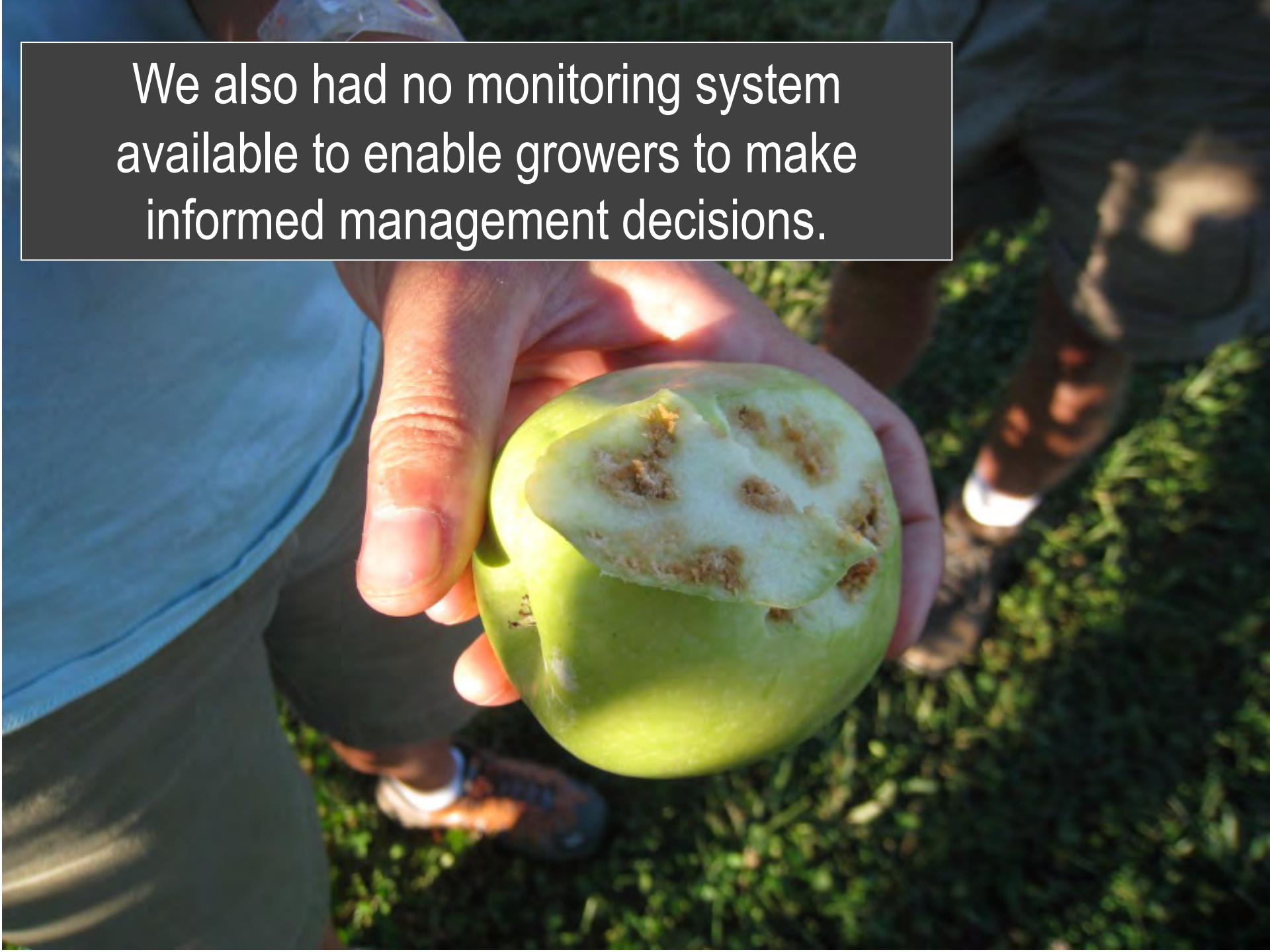
  

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When BMSB emerged as a serious invasive species in 2010, we had no management recommendations in any cropping system

We also had no monitoring system available to enable growers to make informed management decisions.



How can we monitor BMSB?



©WJ Hershberger

- Tools that provide accurate measurements of presence, abundance, and seasonal activity of BMSB.
- Growers can make informed management decisions.
- Countries can detect, exclude and eradicate BMSB.

JUNE 2011

		SPRAY SCHEDULE - BMSB		- ARMS in Stone Fruit		apples - peaches -		McHenry Highland Festival*
		* every other row lg. apples, peaches * every 4th row bellis apples		Pome Fruit + Brambles				Blueberries Brambles Cherries (4-1)
5	6	apples peaches, plums strawberries (OUTSIDE)	cherries) 1/2 potatoes tomatoes vegetables	cherries 1/2 1/2 Brambles 1/2 Blueberry blackberry	apples peaches, plums (INSIDE)	blueberries 37/40 +4 Brambles 13, 15, 16, 44, 41		Early Summer Sea- rates begin this weekend check spray cherries
12	13	vegs. tomatoes cherries grapes, gooseb plums, apricot	Blueberries Brambles	apples peaches (INSIDE)	check spray cherries cherries tomatoes, flowers	Blueberries Brambles vegetables		Peach Apple (OUTSIDE)
19	20	Brambles, Blueberries, grapes, gooseberries (OUTSIDE)	peaches apples (INSIDE)	cherries/plums (inside)	cherry check spray	cherry check spray		18
26	27	brambles blueberries (outside)	apples peaches cherry	tomatoes vegs. flowers potatoes	bramble (inside) blueberry (inside)	peach apple (outside)		Summer Season rat begin this weekend
28	29	brambles blueberries (inside)	apples peaches (outside)	tomatoes, veg potatoes, flowers				25
30	7/1							wood's edge orkens

Key Components of Trap-Based Monitoring



1. Attractive Visual Stimulus

Large black pyramid (trunk-mimicking stimulus)

2. Attractive Olfactory Stimulus

MDT

3. Capture Mechanism

Tapered pyramid attached to inverted funnel jar with DDVP strip

4. Deployment Strategy

Traps placed in peripheral row of orchard

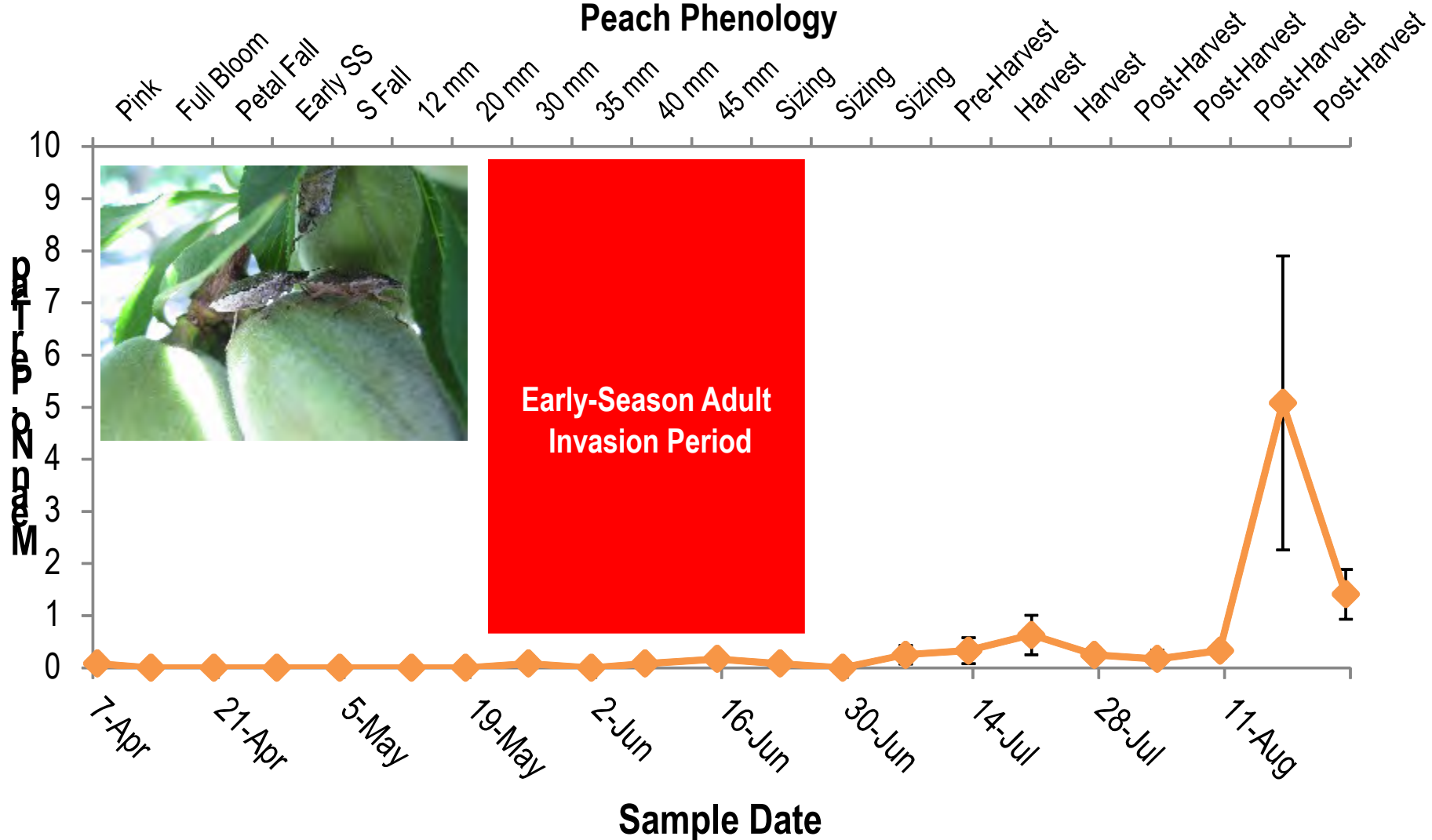
MDT is the Only Attractant Available for BMSB Prior to 2012

- Methyl (2E, 4E, 6Z)-decatrioneate (MDT) is a pheromone produced by the Asian stink bug, *Plautia stali*.
- Cross attractive to BMSB and other pentatomids.



Serious Limitations For Season-Long Monitoring

Peach Phenology

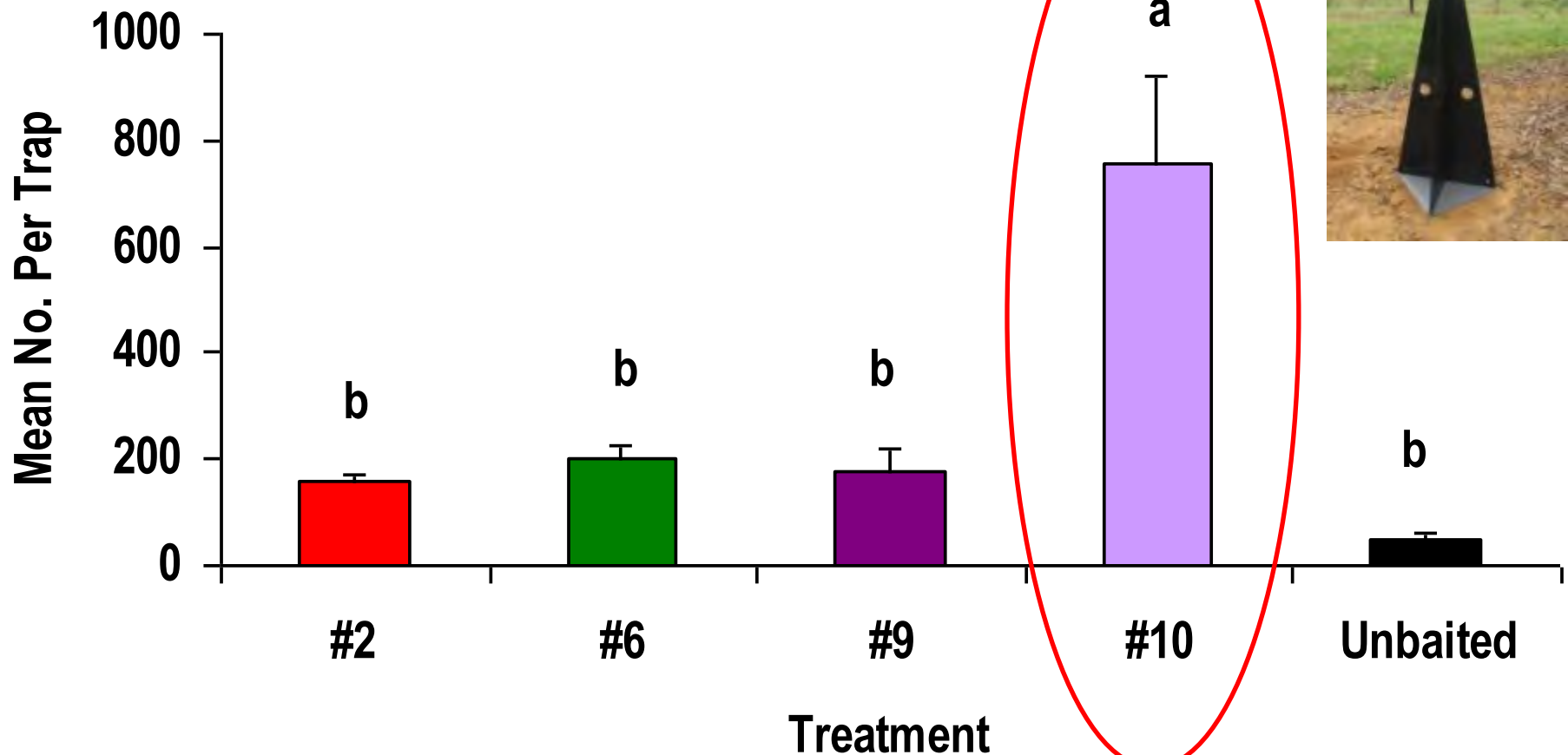


Identification and Commercialization of BMSB Aggregation Pheromone



BMSB Aggregation Pheromone Breakthrough

9-30 September 2011



BMSB SCRI 1: Broad Validation Across The Country

- Is PHER attractive season-long?
- How attractive is PHER relative to MDT?
- Three Treatments.
 - 1) PHER (10 mg)
 - 2) Rescue MDT (119 mg)
 - 3) Unbaited control
- Studies conducted across USA.



Broad Validation of PHER Across The Country

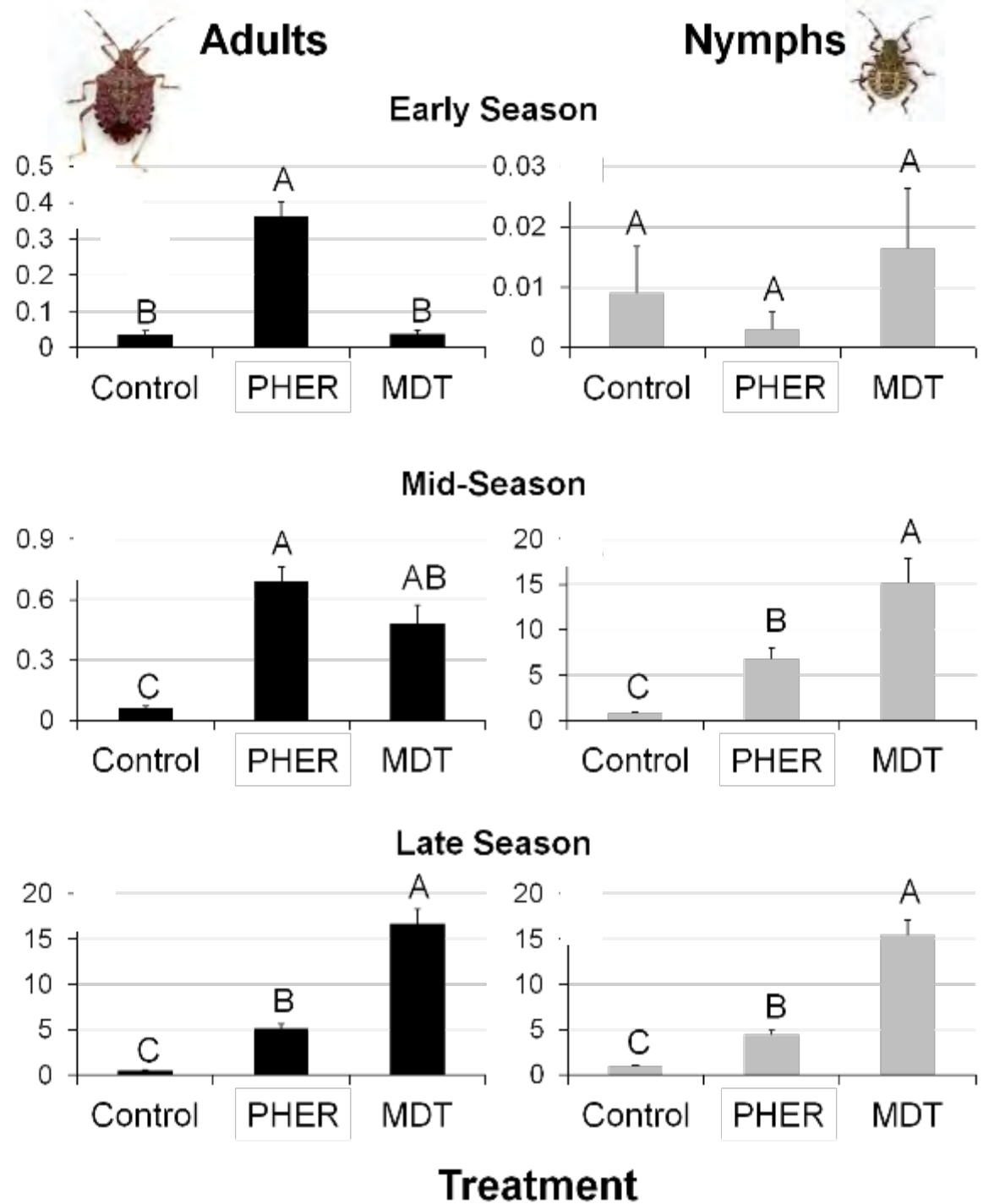
- Is BMSB attracted to the pheromone in the early season?
- Is BMSB attracted to the pheromone season-long?
- How attractive is this stimulus relative to MDT and unbaited traps?
- Three Treatments
 - 1) BMSB Pheromone (PHER, 10 mg)
 - 2) Methyl (2E, 4E, 6Z)-decatrioneate (MDT, 119 mg)
10X greater loading
 - 3) Unbaited control
- Traps evaluated in border areas in over 12 states across the country season-long.



Season-Long Attraction to PHER Documented Across the USA



Mean Weekly Capture (\pm SE) of *H. halys* per Black Pyramid Trap

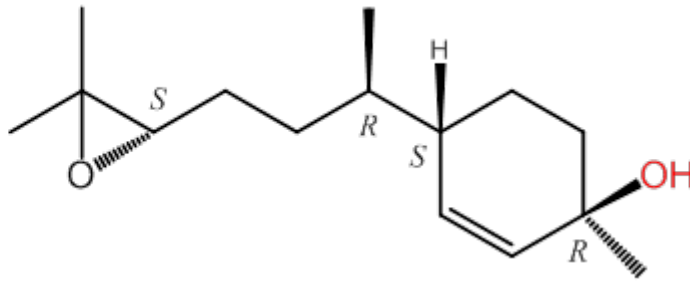
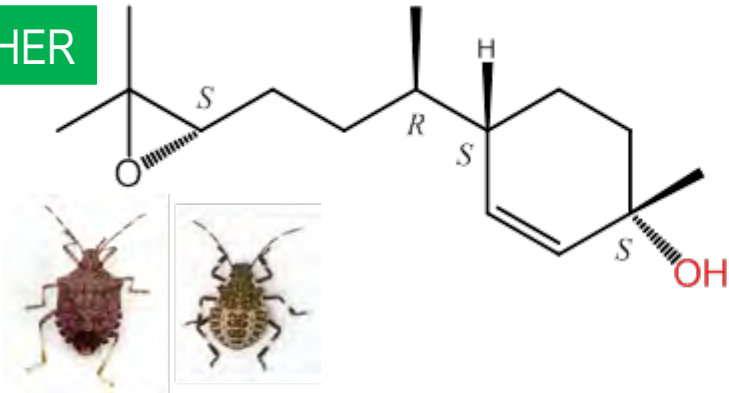


Two-Component BMSB Aggregation Pheromone and Synergist

Main component of BMSB aggregation pheromone
(3*S*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol

Minor component of BMSB aggregation pheromone
(3*R*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol

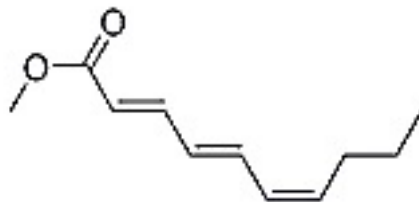
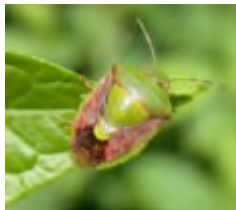
PHER



+

Methyl (*E,E,Z*)-2,4,6-decatrienoate (MDT) acts as a synergist for BMSB pheromone

MDT



=

Synergism

BMSB SCRI 1: Broad Validation Across The Country

- Do we see a synergistic effect by combining PHER + MDT season-long?
- How attractive is the combination stimulus compared with PHER alone?
- Four Treatments.
 - 1) PHER (10 mg)
 - 2) PHER(10 mg) + Rescue MDT (119 mg)
 - 3) PHER (10 mg) + AgBio MDT (66 mg)
 - 4) Unbaited control
- Studies conducted across USA.



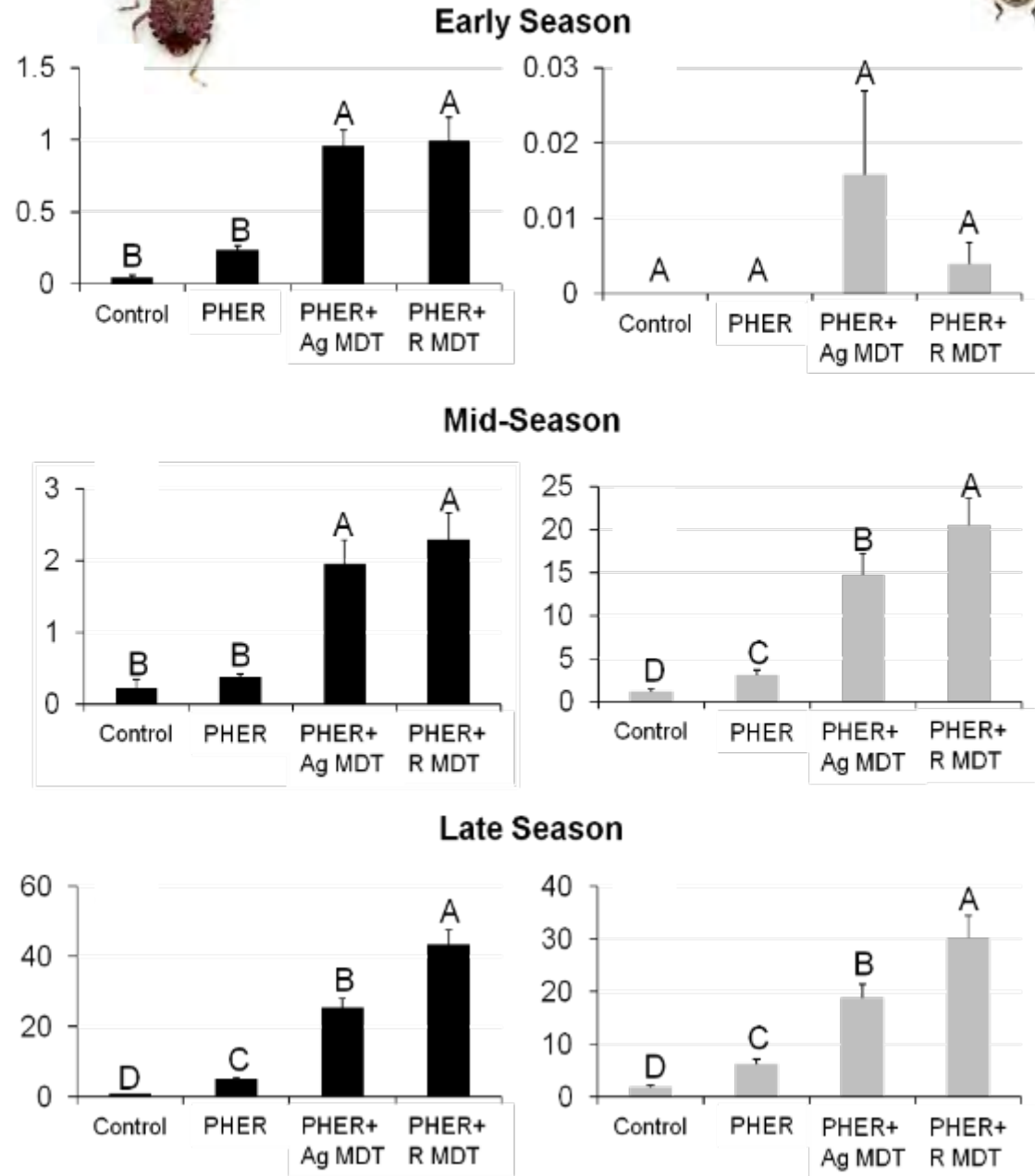
PHER +MDT Combination Resulted in Greatest Captures Due to Synergy



Mean Weekly Capture (\pm SE) of *H. halys* per Black Pyramid Trap



Nymphs



Treatment

BMSB SCRI 2: Can We Improve our Trapping System?

- What is the most sensitive and commercially available cost-effective trap design and lure formulation?
- Can we reliably detect low populations? Do traps work reasonably well in different geographic areas?
- Can we detect nymphal presence, i.e., reproductive populations, with simplified designs?
- What is the size of the area sampled by the most effective trap?

Trap Types Evaluated by Many Collaborators



Delta Trap



Yellow Sticky Card



Standard Coroplast Pyramid



Small Black Pyramid



Pipe Trap



Modified Jar Top Pyramid

Pheromonal Material Provided to Commercial Companies



- A Experimental USDA
- B Rescue
- C,D Hercon
- E AlphaScents
- F Scentry
- G,H,I Trece
- J,K,L AgBio

Targeted Trap Design and Lure Formulation Trial



Similarities

- Ground Deployed
- Upright Visual Stimulus

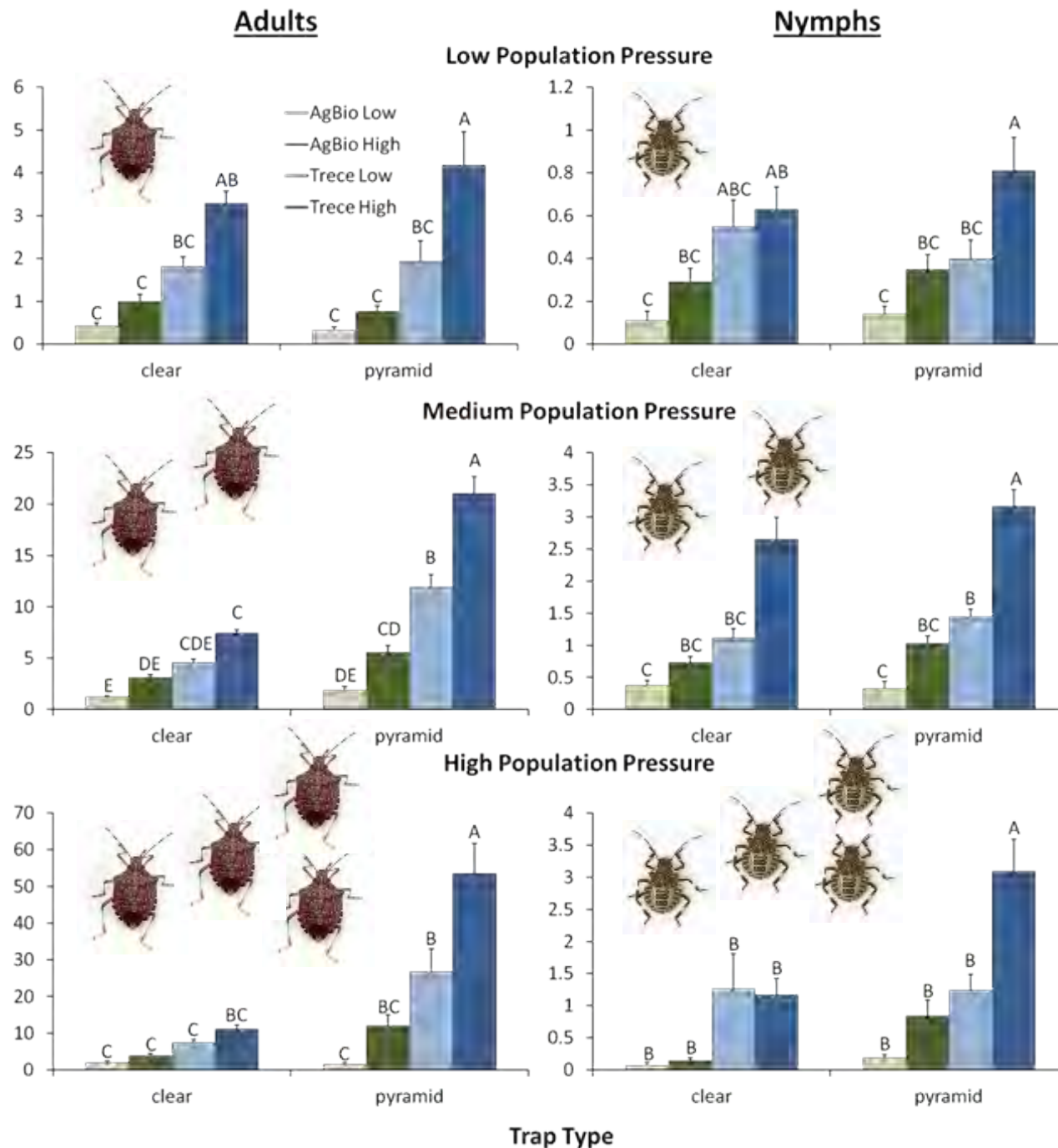
Differences

- Capture Mechanism
- Retention Mechanism/
Killing Agent



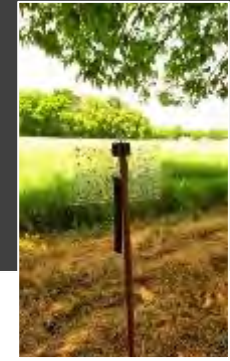
- Trece and AgBio Lures
 - Monitoring (1x) (5mg PHER/50 mg MDT)
 - Surveillance (4x) (20 mg PHER/200 mg MDT)
- Measured season-long captures of adults and nymphs at 12 sites in the mid-Atlantic

Mean Weekly Trap Capture of *H. halys* (\pm SE)



- Trece outperformed AgBio. Sticky traps appear promising.
- All traps detected low density BMSB populations.
- Nymphs detected with both trap designs

Significant correlations between sticky trap and pyramid trap captures



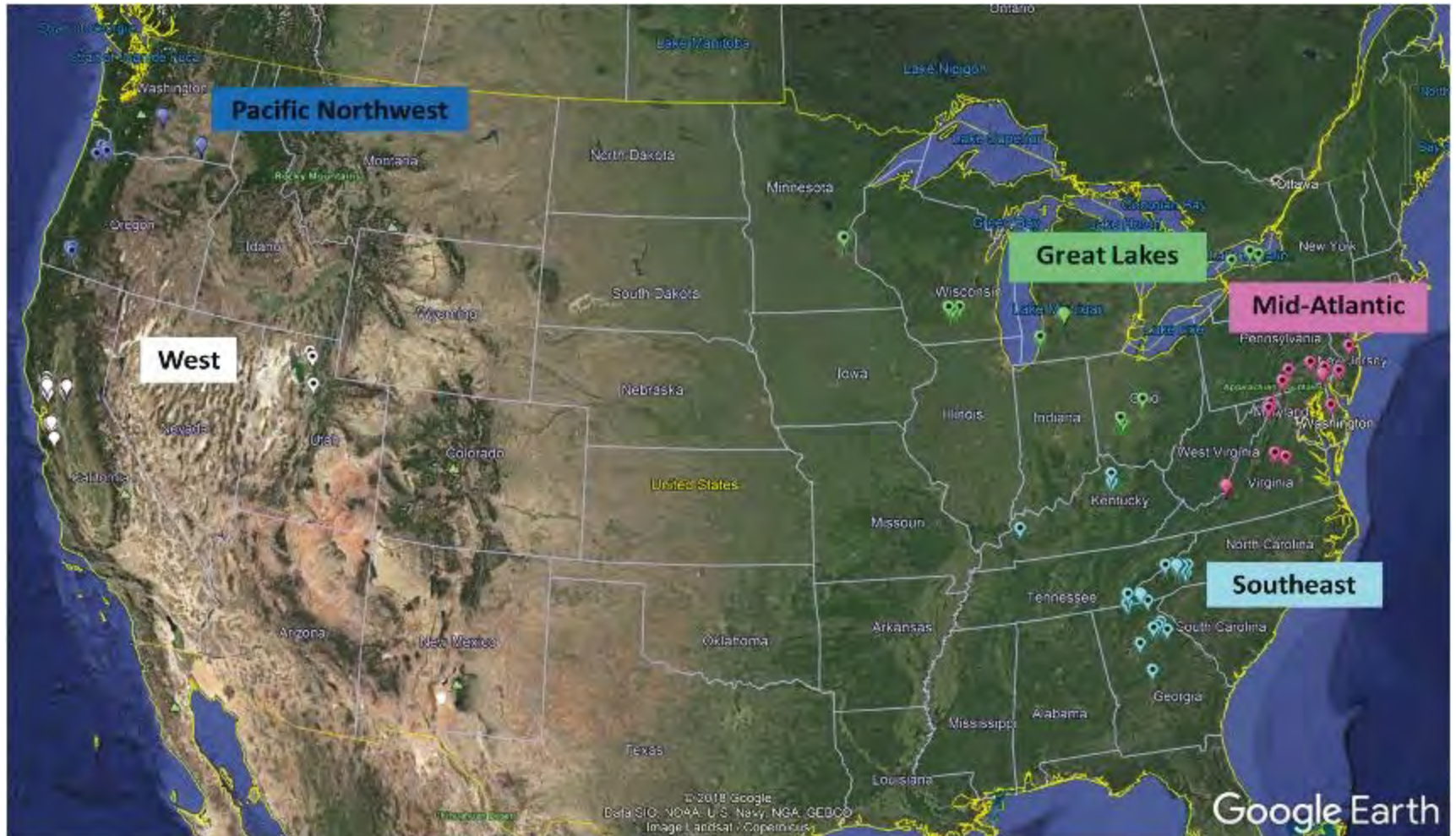
Adults



Nymphs

Population Pressure	Adults			Nymphs		
	r	df	P	r	df	P
<i>Trece Low</i>						
Low	0.777	37	0.0001	0.883	37	0.0001
Med	0.617	158	0.0001	0.499	158	0.0001
High	0.663	40	0.0001	0.414	40	0.007
<i>Trece High</i>						
Low	0.740	37	0.0001	0.703	37	0.0001
Med	0.528	158	0.0001	0.462	158	0.0001
High	0.673	40	0.0001	0.322	40	0.04

Nationwide Trapping Trial By the BMSB SCRI 2 Group



Broad Validation Trial



18 States in 5 Regions

- Mid-Atlantic
- Great Lakes
- Southeast
- Pacific Northwest
- West

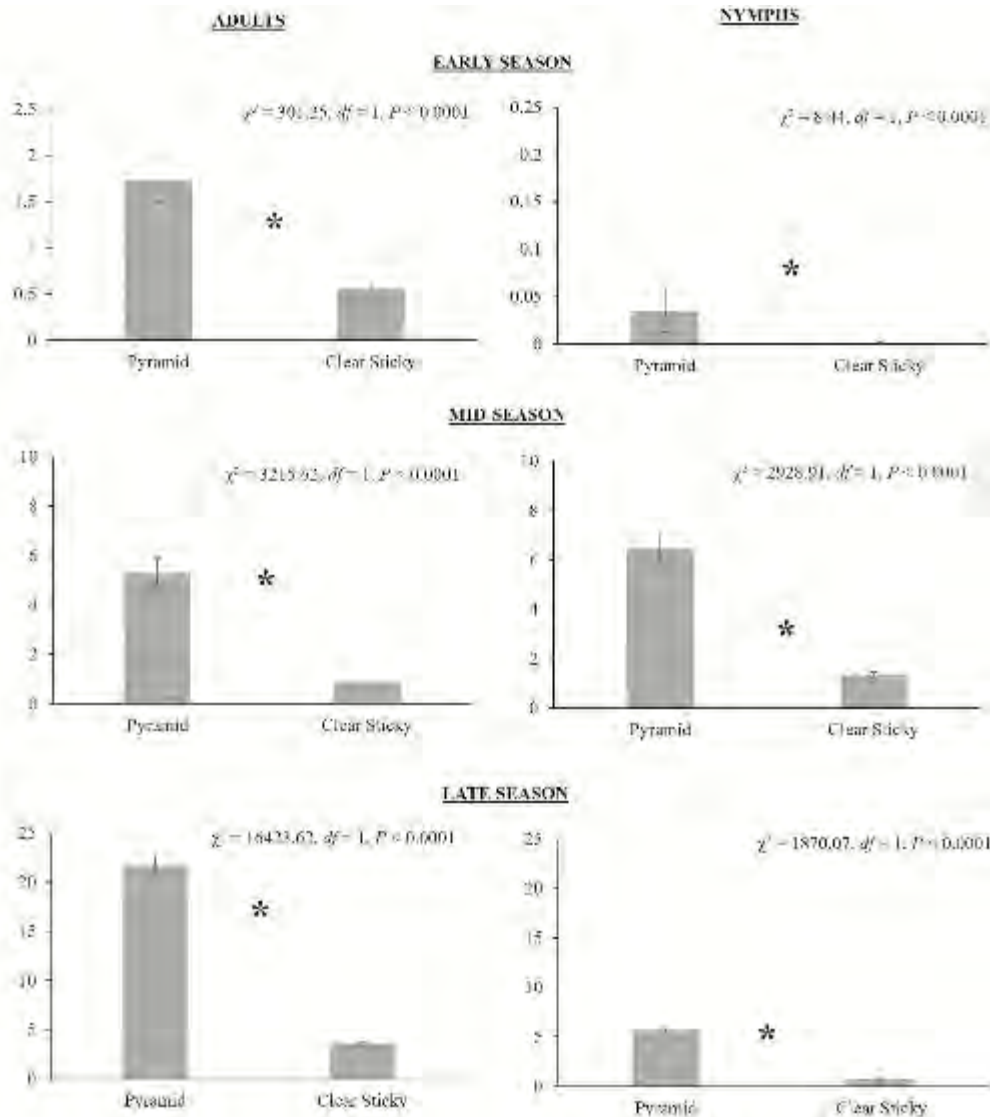
118 Sites



- Pyramid vs. Panel Traps
- Trece Monitoring Lures (1x) (5mg PHER/50 mg MDT)
- Measured season-long captures from late May to early October

Key Takeaways – Seasonality

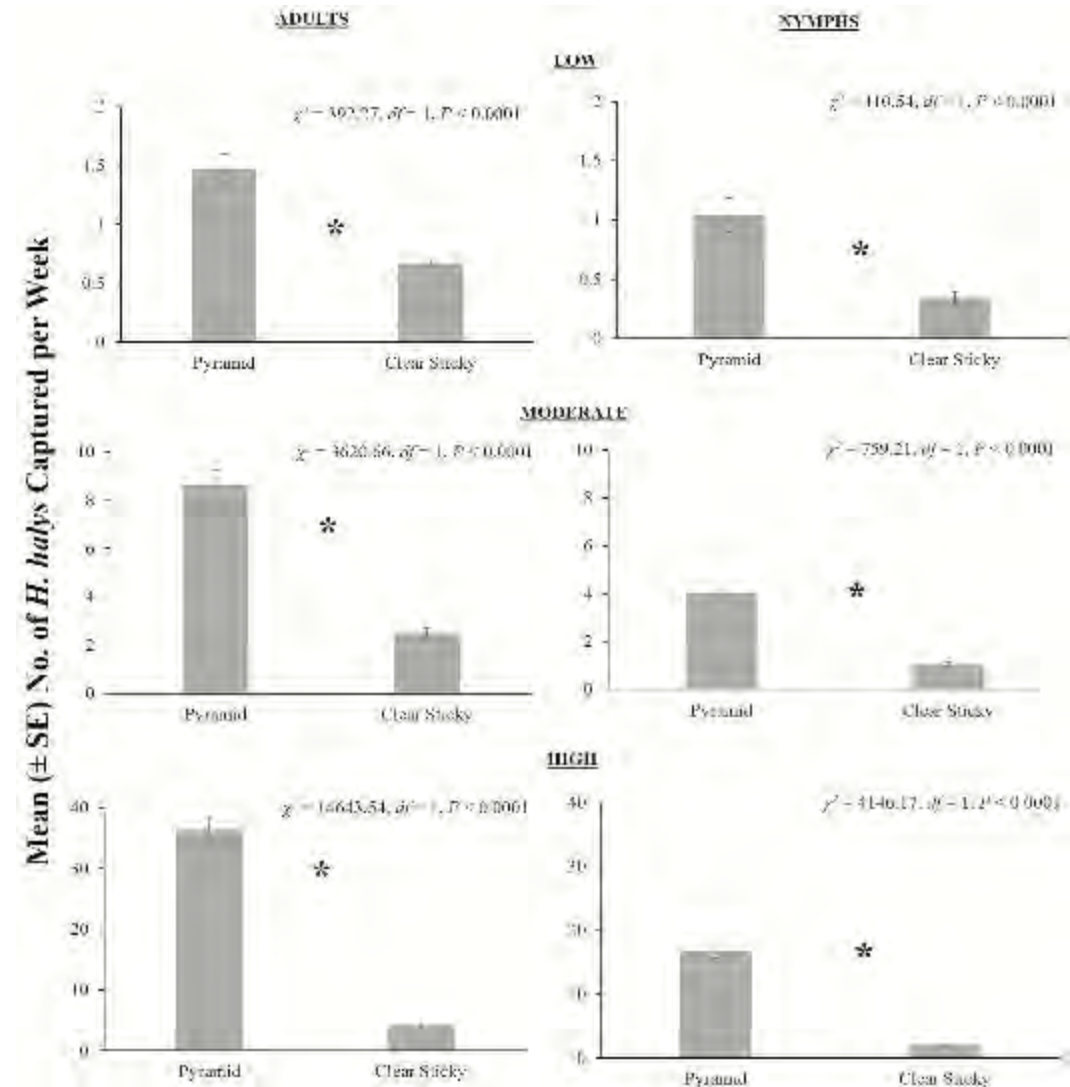
Mean (\pm SE) No. of *H. halys* Captured/Trap/Week



- Pyramid traps captured significantly more adults and nymphs compared with panel traps during seasonal periods.
- Significant correlations between pyramid and panel trap captures indicating they reflect same seasonal patterns.

Period in the season	Adults			Nymphs		
	<i>r</i>	df	<i>P</i>	<i>r</i>	df	<i>P</i>
Early season	0.51	238	<0.0001	-0.01	238	0.9219
Mid-season	0.65	510	<0.0001	0.77	510	<0.0001
Late season	0.63	568	<0.0001	0.56	568	<0.0001

Key Takeaways – Relative Densities

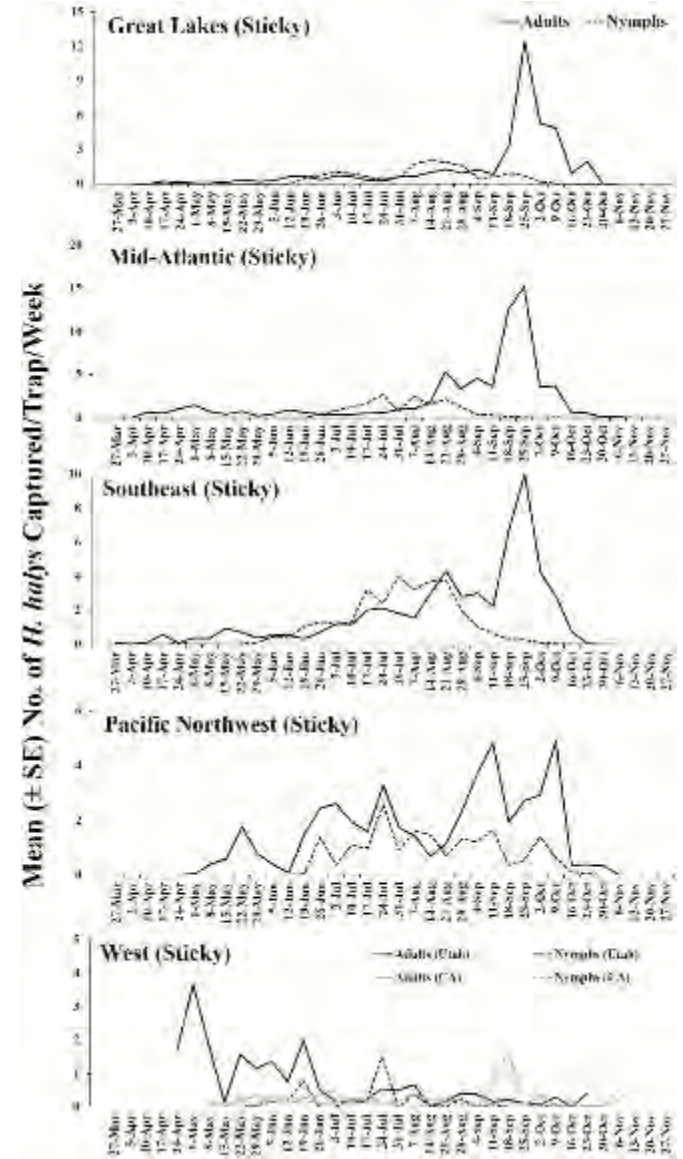
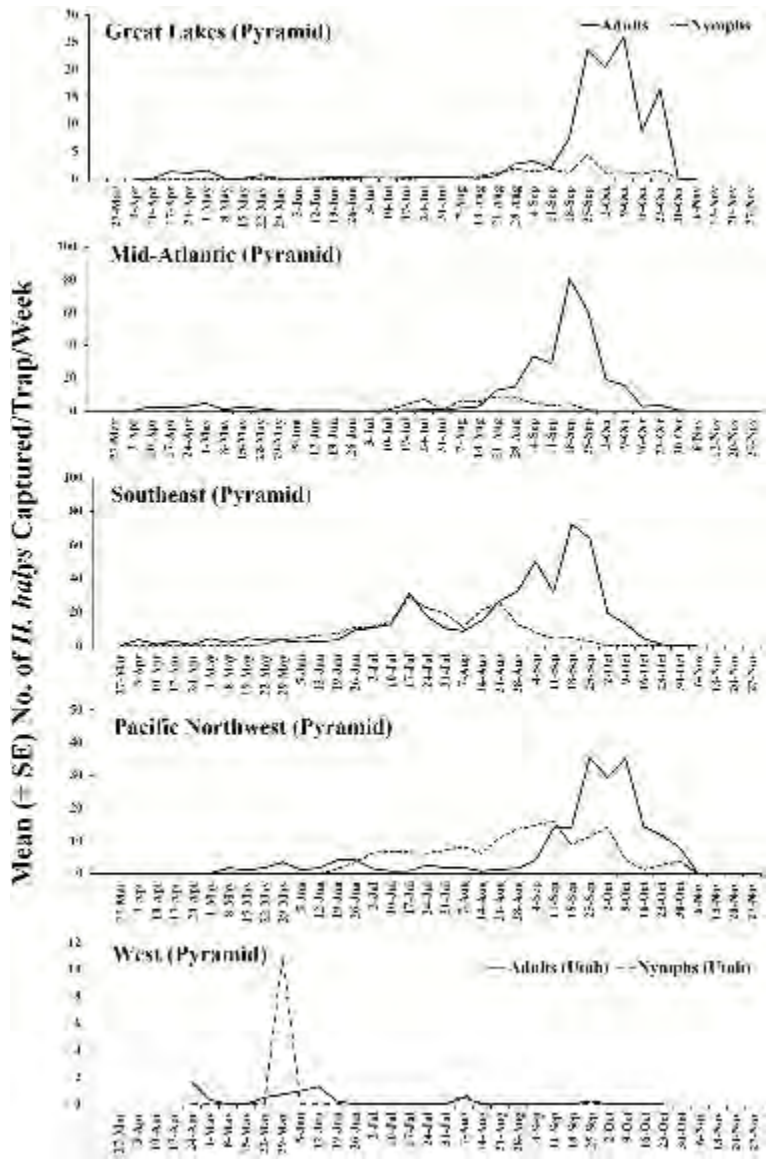


- Pyramid traps captured significantly more adults and nymphs compared with panel traps for different relative densities.
- Significant correlations between pyramid and panel trap captures indicating they reflect same relative density capture patterns.

Relative population density	Adults			Nymphs		
	<i>r</i>	<i>df</i>	<i>p</i>	<i>r</i>	<i>df</i>	<i>p</i>
Low	0.64	545	<0.0001	0.60	545	<0.0001
Moderate	0.49	410	<0.0001	0.42	410	<0.0001
High	0.68	255	<0.0001	0.76	255	<0.0001

Captures across 65 sites from week of 29 May to week of 2 October 2017 were used in the analyses.

Key Takeaways – Both Reflect Seasonal Phenology and Relative Densities and Can Be Used For Biosurveillance and Monitoring Tools



Continued Commercial Pheromone Lure Refinement by BMSB SCRI 2 Team and European Colleagues in Collaboration with Industry (2017-2019)

Running Head: Refining *H. halys* Pheromone Lures

For: Journal of Economic Entomology

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Refining Pheromone Lures for the Invasive *Halyomorpha halys* (Hemiptera: Pentatomidae) Through Collaborative Trials in the USA and Europe

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¹⁴Trécé, Inc., 7569 Hwy 28 W, Adair, OK 74330 (Current Address).

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- Current dispensers most effective.
- Cost of lures can be reduced by decreasing PHER loading rate and increasing MDT loading rate without sacrificing attractiveness.

Table 1. Treatment designations and loading rates of the main *H. halys* pheromone (PHER), and the synergist (MDT), in ratios (PHER:MDT) relative to standard lure loading in experimental trials. Additionally, trials that included EDT are presented relative to their ratio to standard MDT loadings.

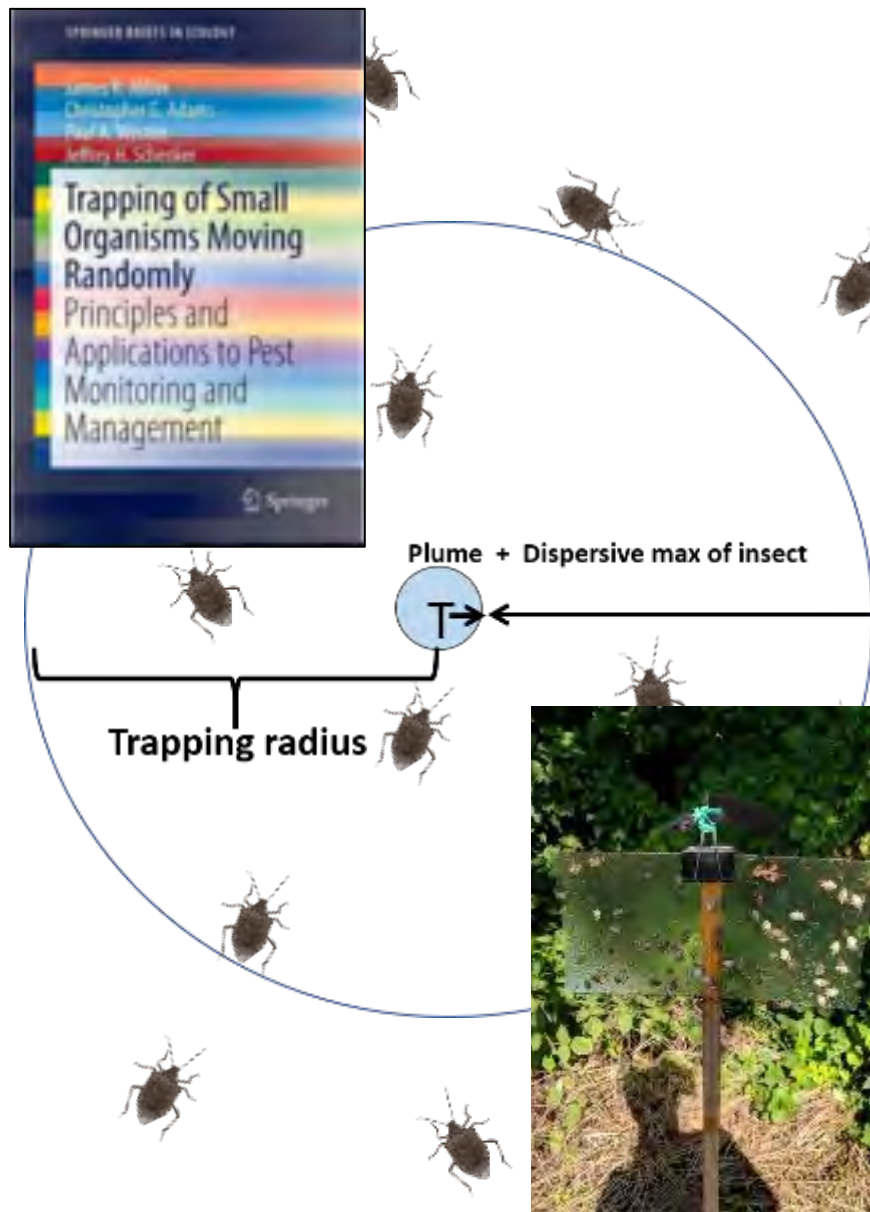
Low Rate Loading ¹	High Rate Loading ²	Attract and Kill Ratio ³	Dispenser Substrate ⁴	EDT Inclusion ⁵
PHER:MDT	PHER:MDT	PHER:MDT	PHER:MDT	PHER:MDT:EDT
0.10:1	2:4	0.75:12	1:1	1:0:1
0.25:1	2:6	3:12	1:1	1:1:3
0.50:1	3:4	12:12	0.5:1	1:0:3
0.10:2	3:6	0.75:24		1:0:9
0.25:2	3:12	3:24		
0.50:2		12:24		

¹Trials in the USA were conducted at one location in MD (22 May-23 October), two locations in NJ (NJ-1, 18 July-16 October; NJ-2, 24 July-18 October), one location in UT (16 July-20 October) and two locations in WV (21 May-22 October) in 2018. Trials in Italy were conducted at two locations in Emilia-Romagna (ER-1, 22 August-10 September; ER-2, 25 August-10 September) and one location in Friuli Venezia Giulia (FVG, 16 August-4 October) in 2018.

²Trials in the USA were conducted at two locations in MD (25 June-5 November) and one location in WV (25 June-12 November).

³Trials in the USA were conducted in two locations in MD (MD-1, 24 May-24 October; MD-2, 22 May-23 October), one location in OR, one location in VA and one location in WV (21 May-22 October). Trials in Italy were conducted at three locations in Emilia-Romagna (ER-1, 25 August-10 September; ER-2, 22 August-10 September; ER-3, 14 August-16 October), one location in Friuli

Trapping area of a pheromone-baited sticky trap?



Plume reach (Area of Aggregation)

Distance from a baited trap that elicits a behavioral response from an insect randomly foraging through the environment.

Maximum Dispersive Distance

Furthest distance from which 95% of the population can reach the trap.

Trapping radius

Longest distance from the trap that can yield captures of target individuals.

Trapping area

Circular area around the trap over which a single trap can reliably capture target insects.

Experimental Set-up





Release Cage

Pheromone-baited trap



Marked bugs released during pre-dawn hours

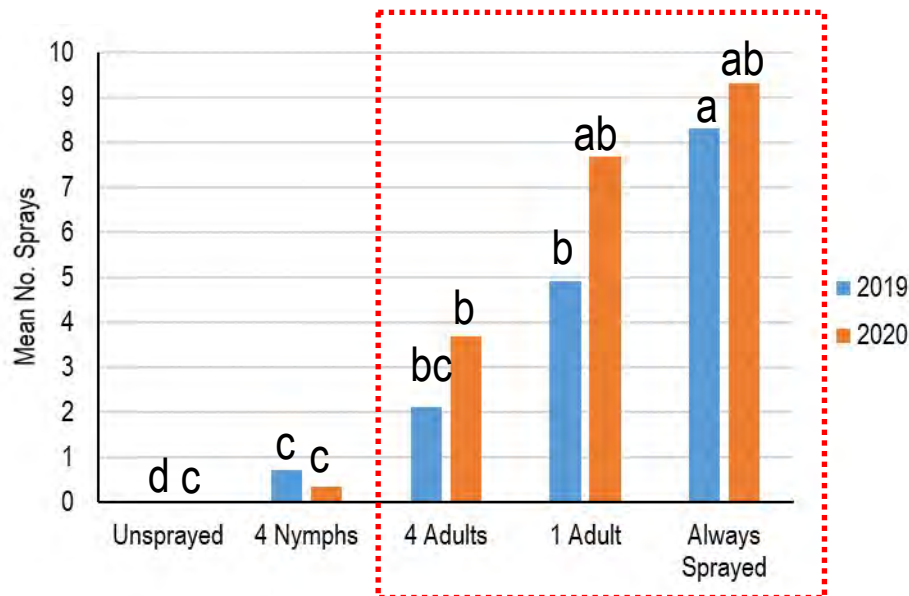
Baited Sticky Panel Trapping Area

Life Stage	Experiment	Percent Recaptured	Plume Reach	Maximum Dispersal Distance	Trapping Area
Adults 	Open Field	0.6%	< 3 m	130 m	5.56 ha
	Apple Orchard	1.1%	< 3 m	70 m	1.67 ha
Nymphs 	Open Field	6.6%	< 3 m	40 m	0.64 ha

- Estimated plume reach is short for both adults and nymphs. However, BMSB are very dispersive and increases the area over which a single trap is effective.
- Maximum dispersive distance was reduced from 5.56 ha in field to 1.67 ha in orchard. Indicates that more traps would be necessary to reliably capture adults when in presence of a cultivated crop host.
- Spacing traps ~50 m apart should reduce competition, but reliably capture individuals.

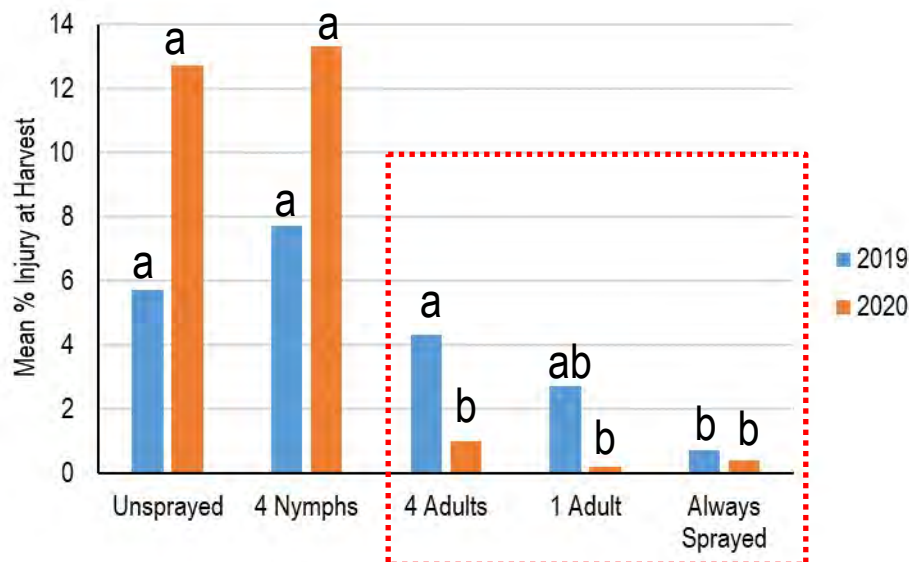
Sticky Panel Threshold Results for Apple: 4 Adult (cumulative)/Trap

Spray Events



Number of sprays reduced by 50% when using 4 adults compared with 1 adult threshold

Injury at Harvest



Damage with 4 adults is not significantly different than 1 adult threshold

Attract and Kill





Next Steps

- Remain vigilant.
- Create threshold-based systems for other specialty crops.
- Integrate biological control with other IPM tactics across vulnerable agroecosystems.

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- USDA NIFA OREI #2012-51300-20097
- NE SARE # LNE14-334
- Ministry of Primary Industries
- USDA NIFA SCRI # 2016-51181-25409
- USDA ARS Areawide Funds



Thank You

**It's time for a few polling
questions**