

2.1.1 and 2.1.2 Monitoring Tools *and* 2.2.3. Attract and Kill



Funding



United States
Department of
Agriculture

National Institute
of Food and
Agriculture

Specialty Crop Research Initiative
Grant #2011-01413-30937

Collaborating Institutions



Cornell University

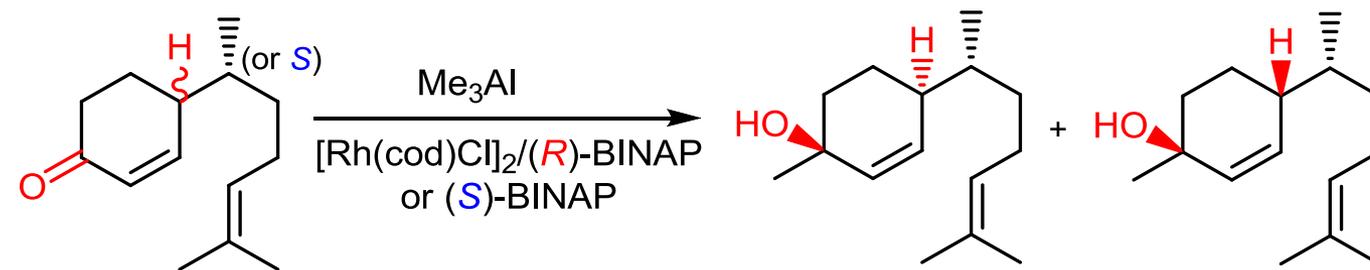


Virginia Tech

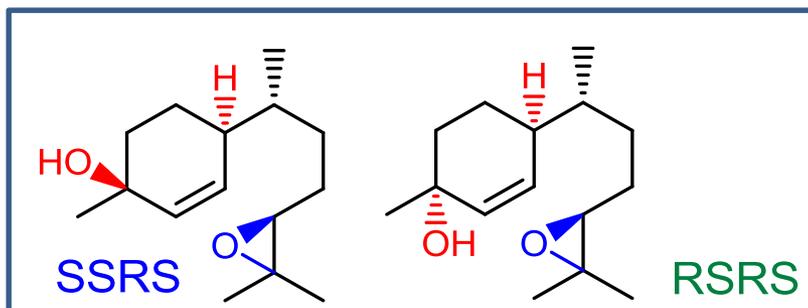


Discovery of the Aggregation Pheromone of the Brown Marmorated Stink Bug (*Halyomorpha halys*) through the Creation of Stereoisomeric Libraries of 1-Bisabolen-3-ols

Khrimian et al.
J. Nat. Prod., 2014



+ all other stereoisomers

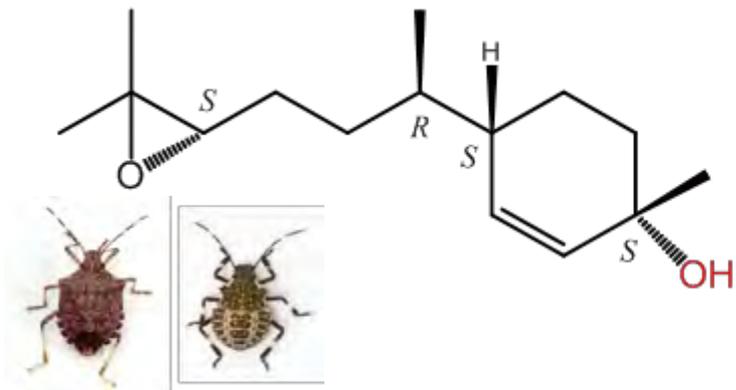


- BMSB lures contain both **SSRS** and **RSRS** plus 6 other stereoisomers.
- Developing methods to increase key stereoisomers *AND* decrease cost of production.

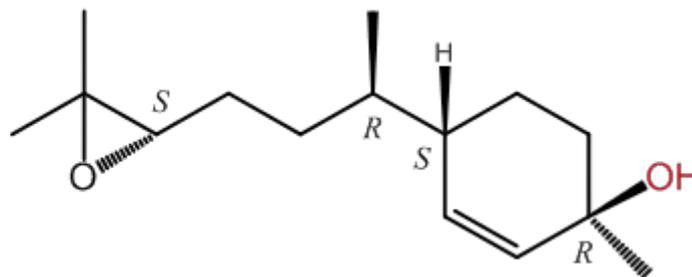
Two-Component BMSB Aggregation Pheromone and Synergist

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

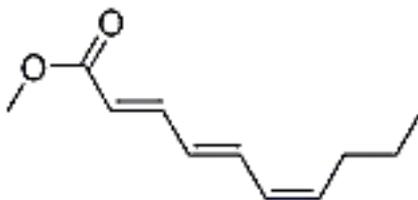
Minor component of BMSB aggregation pheromone
(3*R*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol



+



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



=

Synergism

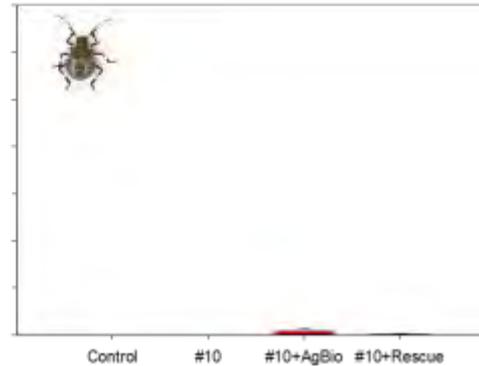
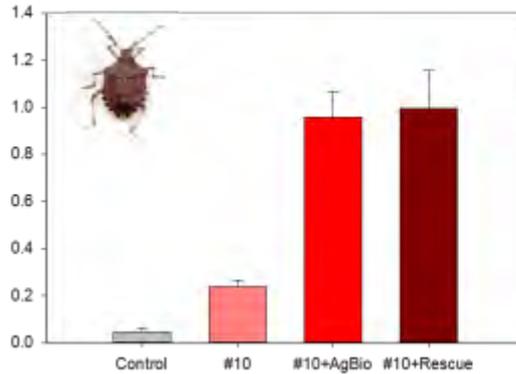
General Protocol

- **Black pyramid traps**
- **Four treatments**
 - 1) BMSB Pheromone (10 mg)
 - 2) BMSB Pheromone (10 mg) + Rescue MDT (119 mg)
 - 3) BMSB Pheromone (10 mg) + AgBio MDT (66 mg)
 - 4) Unbaited control
- **Traps are deployed between wild host habitat and agricultural production areas.**
- **Traps were deployed in mid-April and left in place season-long.**

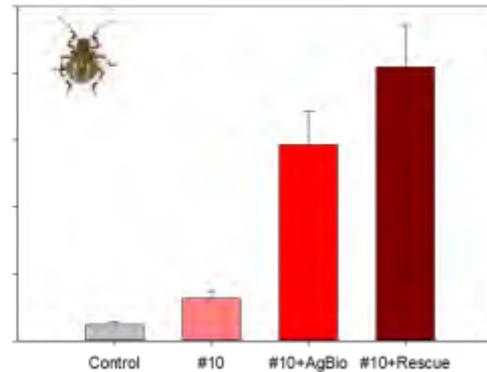
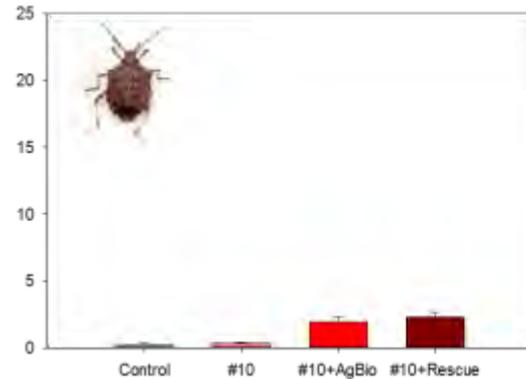


2013 Season-Long Attraction To Baited Traps

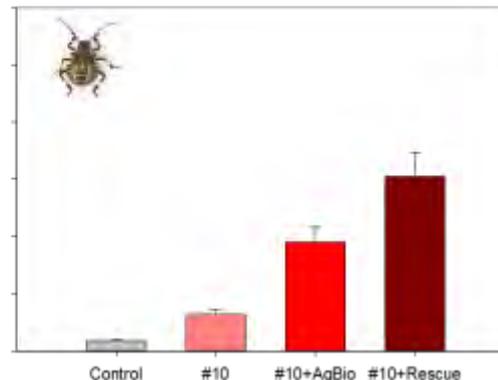
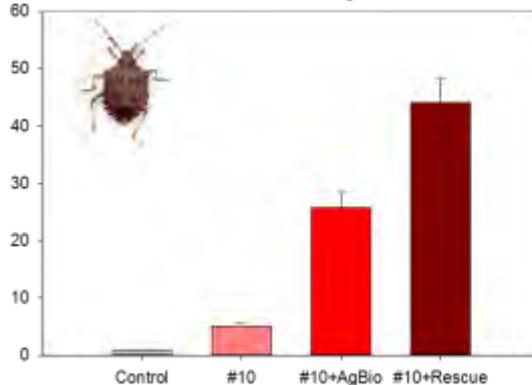
Mean number of BMSB / trap / week



Early Season
Mid-April to Mid-June



Mid Season
Mid-June to Mid-August



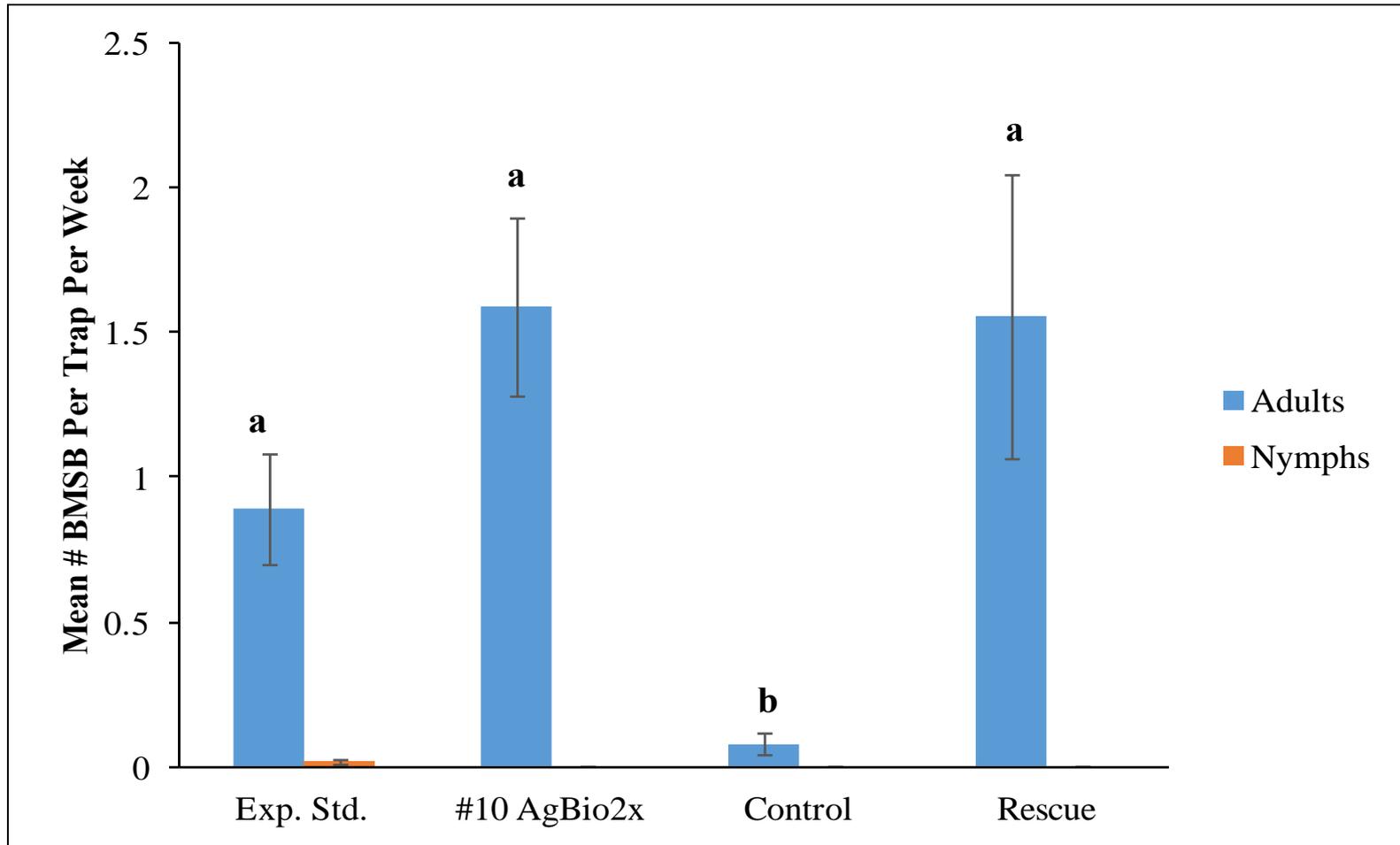
Late Season
Mid-August to Mid-October

2014 Coordinated Trapping Studies

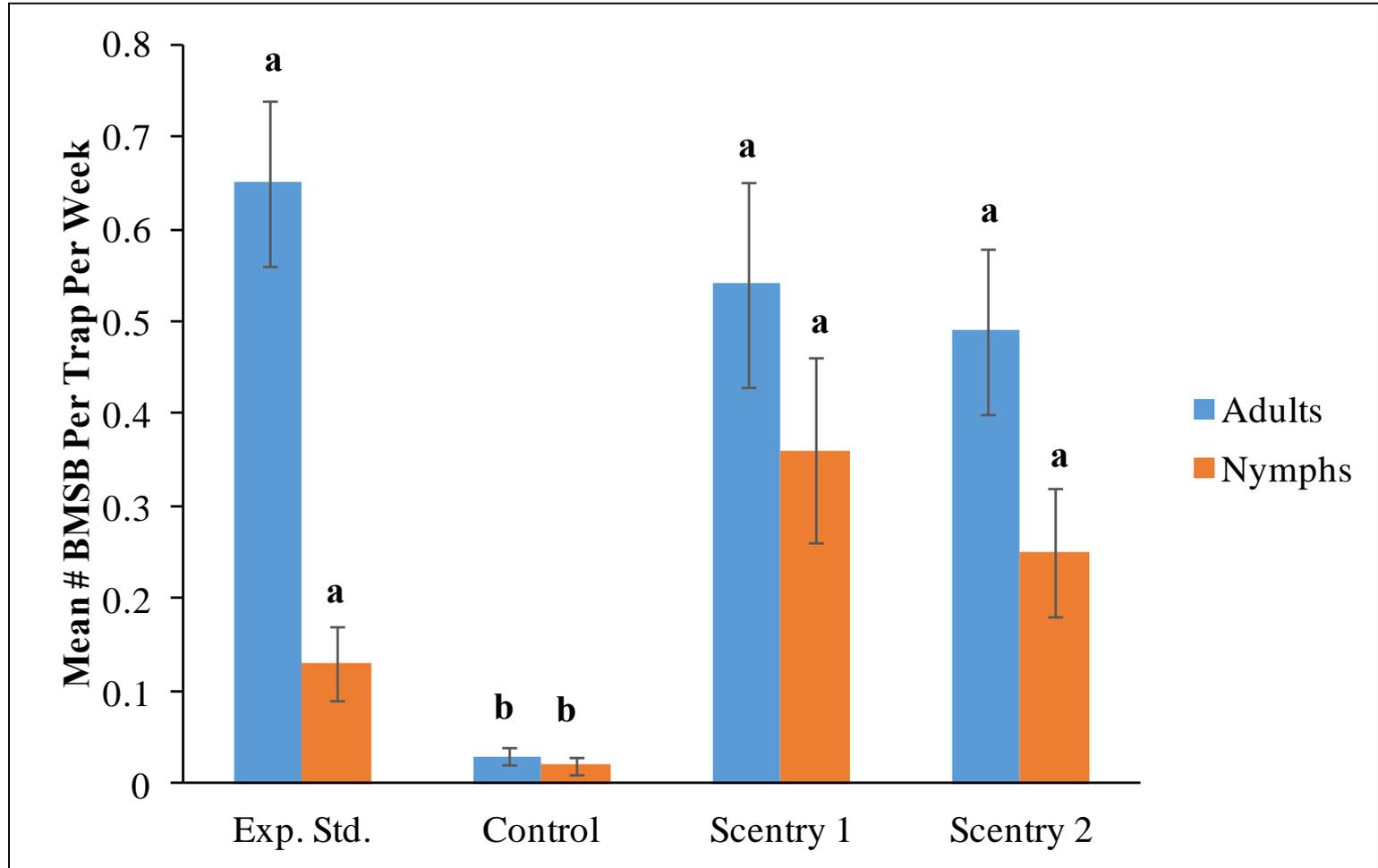
- Provide feedback to commercial companies.
- Monthly assessment of lure formulations provided by commercial companies.
- AgBio/ChemTica, Rescue, Scentry, Trece, AlphaScents, and Hercon (not presented).
- Compared with our experimental standard.
 - BMSB Pheromone(10 mg) + AgBio MDT (66 mg)



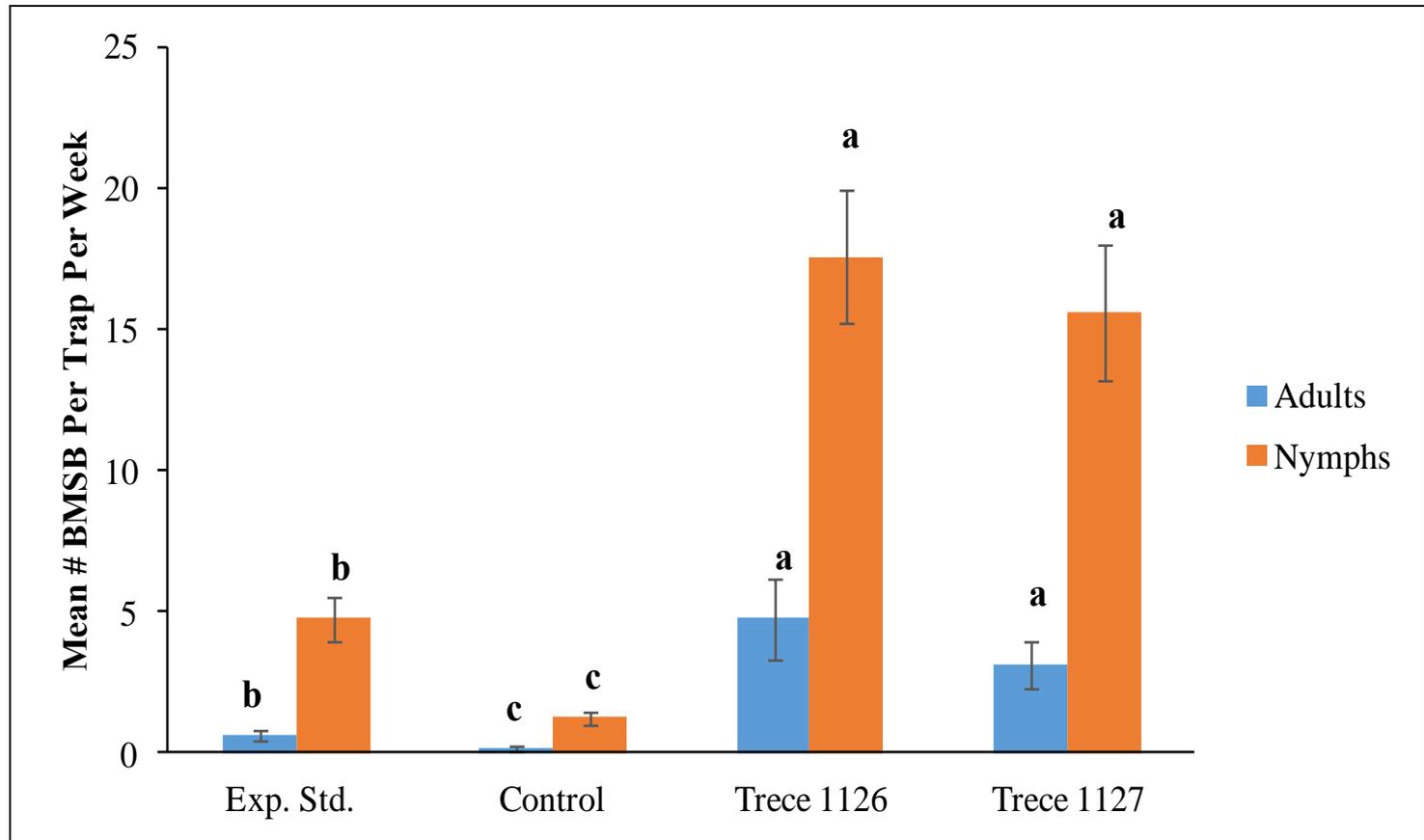
AgBio and Rescue (May)



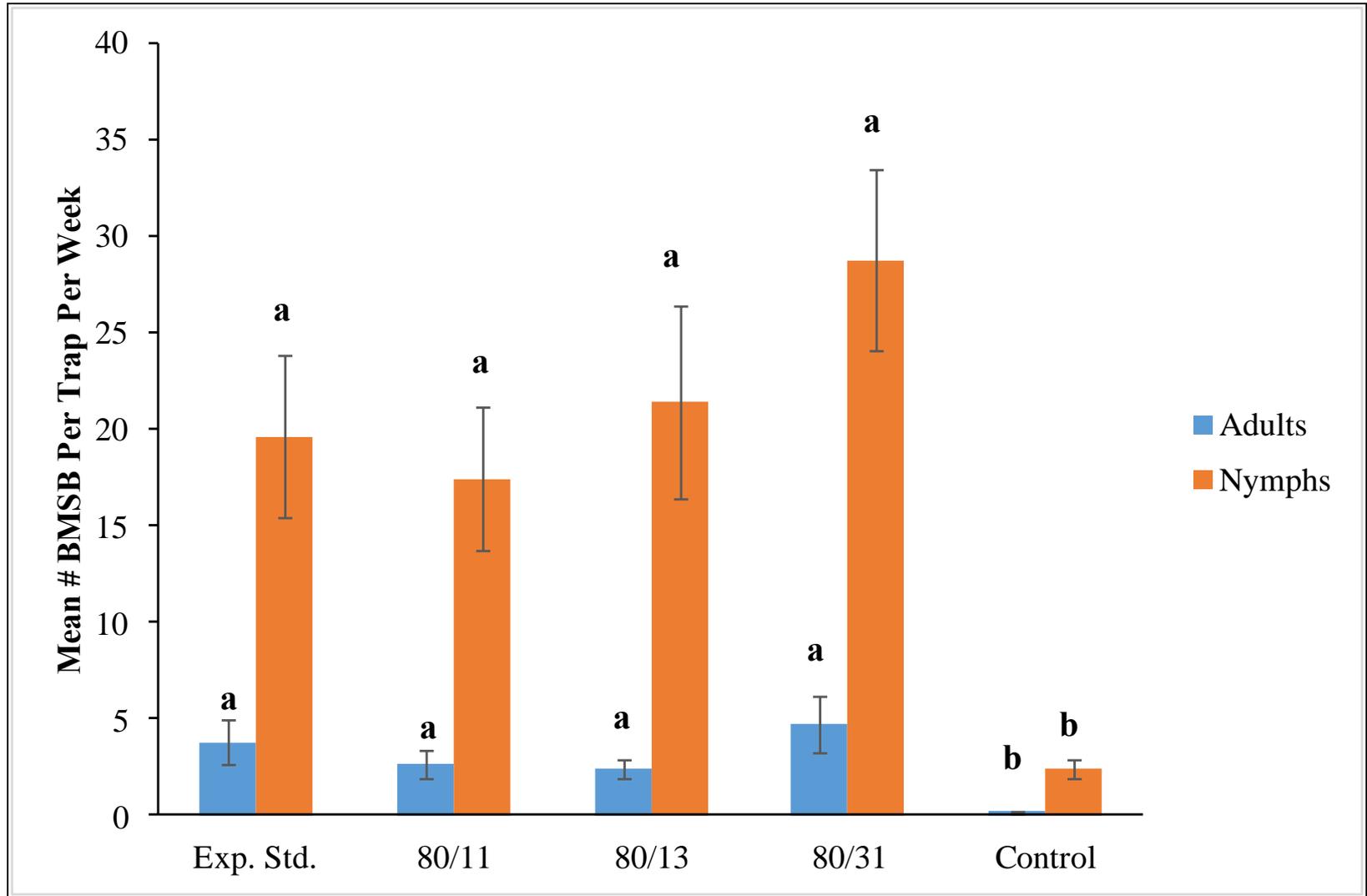
Scentry (June)



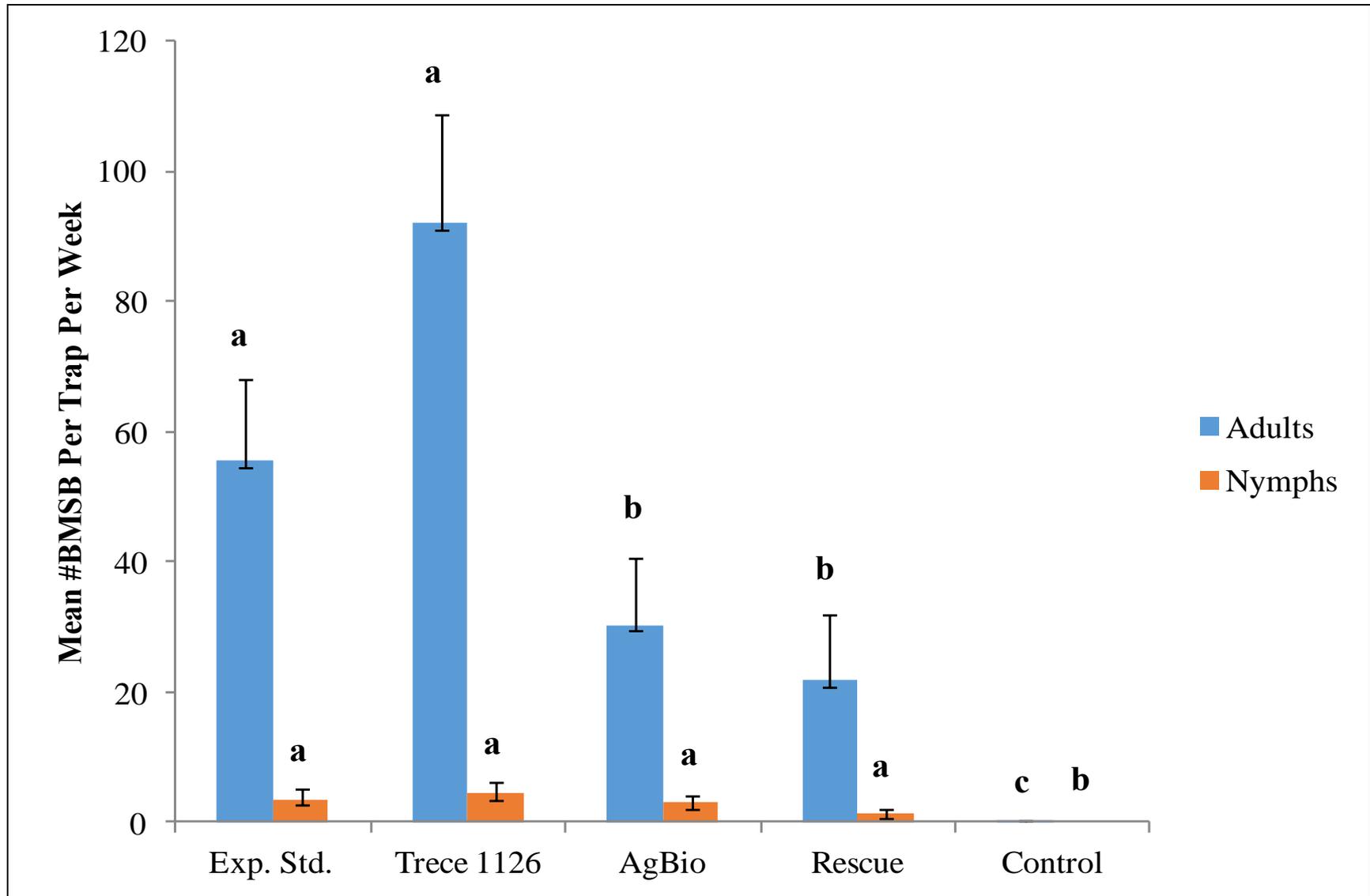
Trece (July)



AlphaScents (August)



Multiple Comparisons (Late-Season)



Tentative Conclusions

- Commercial companies have products that can be used to detect the presence, abundance, and seasonal activity of BMSB in specialty crops.
- In particular, Trece resulted in consistent attraction and has a long-lasting formulation.
- Expect that Trece, AgBio and Rescue will be selling products next year.
- Bedoukian will be manufacturing material.

Can we use biological information provided by trap captures to guide management decisions?

- Traps baited with 10 mg BMSB Pheromone + 66 mg MDT can be used to guide management decisions in apple.
- Provisional threshold of **10 adults/trap** resulted in a **40% reduction** insecticide applications, but **statistically identical levels of injury** compared with weekly ARM.



Can we use other trap designs?

Experimental
Standard
Wooden
Pyramid



Coroplast
Pyramid



Small
Pyramid
(Ground)



Small
Pyramid
(Hanging)



Small
Pyramid
(Limb)

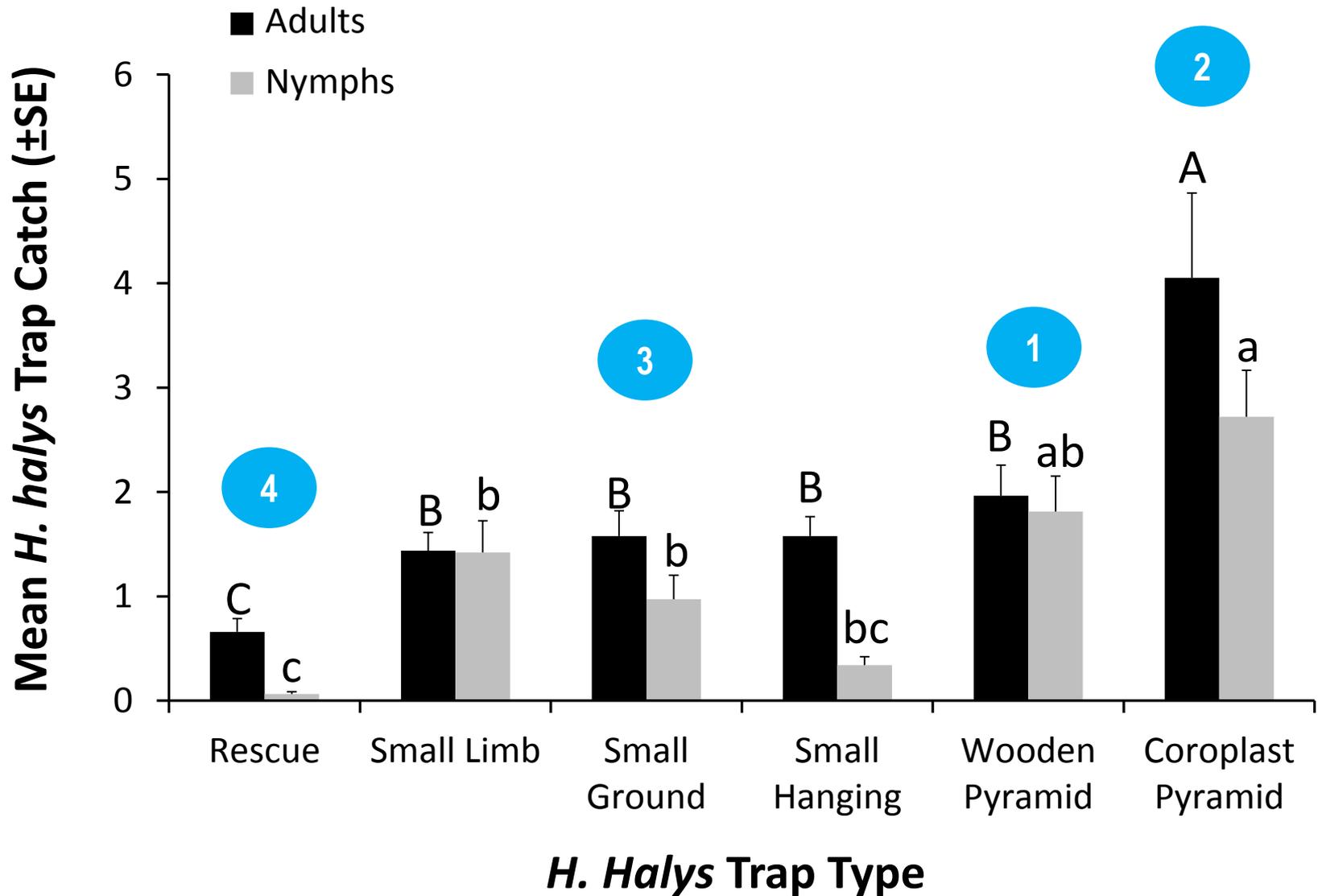


Rescue
(Hanging/
Foliage)



- Are captures similar among other trap types and deployment strategies compared with our experimental standard?
- Baited with 10 mg BMSB Pheromone + 66 mg MDT. Two years of data from commercial orchards.

Season-Long Trap Captures / Sensitivity



Coroplast vs. Standard Wooden Pyramids



Spearman Rank Correlation

$\rho=0.735$

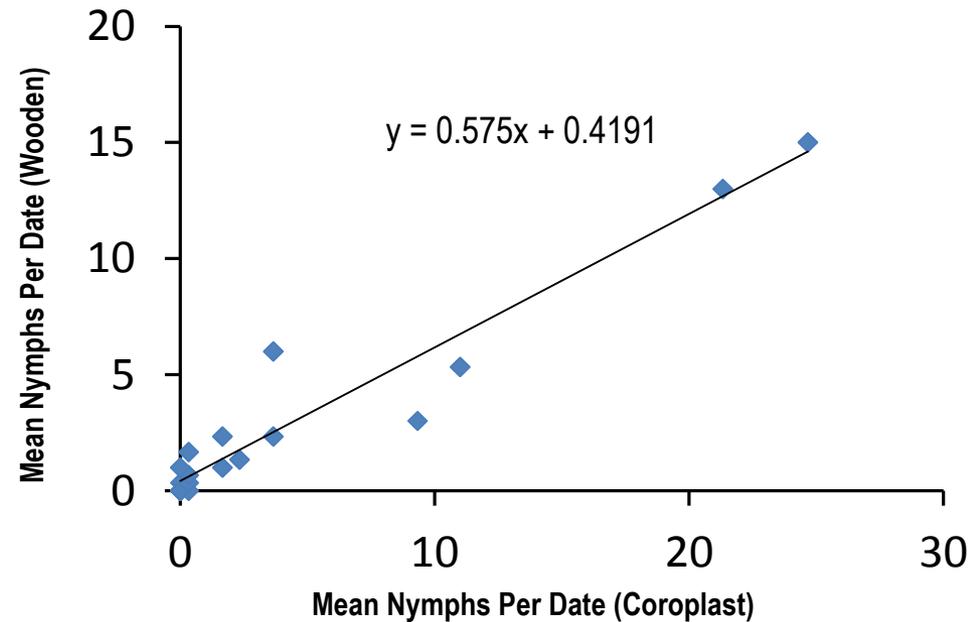
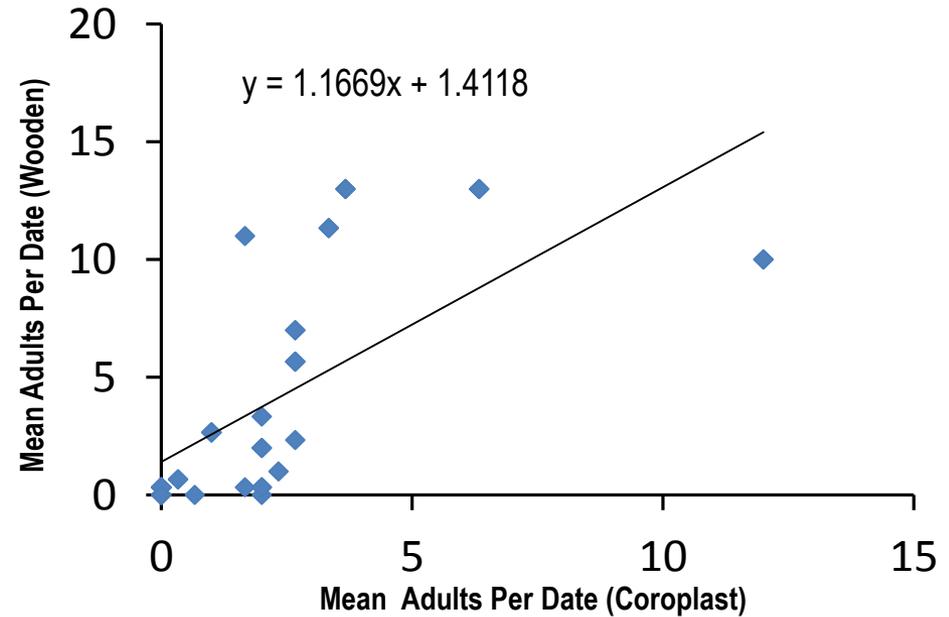
$P < 0.0001$



Spearman Rank Correlation

$\rho=0.900$

$P < 0.0001$



Coroplast vs. Small Pyramids Styles

Coroplast Pyramid



Small Pyramid (Ground)



Small Pyramid (Hanging)



Small Pyramid (Limb)



Rescue (Hanging/ Foliage)



Evaluation of sticky traps for BMSB monitoring

Traps designs:

- Yellow sticky trap (Ag-Bio)
- Clear sticky trap (AlphaScent)
- Rescue Stink Bug Trap (Sterling Int.)

Lures:

- BMSB Smart Lure (Ag-Bio)
- Rescue Stink Bug lure (Sterling Int)

Location:

- Woods (edge of woods surrounding orchard)
- Crop (first row of trees in orchard)

Treatments:

1. Clear trap plus Ag-Bio lure (clAB)
2. Clear trap plus Rescue lure (clearRes)
3. Clear trap plus no lure (clnone)
4. Yellow trap plus Ag-Bio lure (YelAB)
5. Yellow trap plus Rescue lure (YelRes)
6. Yellow trap plus no lure (Yelnone)
7. Rescue trap plus Rescue lure (ResRes)



Observations period : Aug 19 – Sep 25

Evaluation of sticky traps for BMSB monitoring



Yellow sticky traps (Ag-Bio)

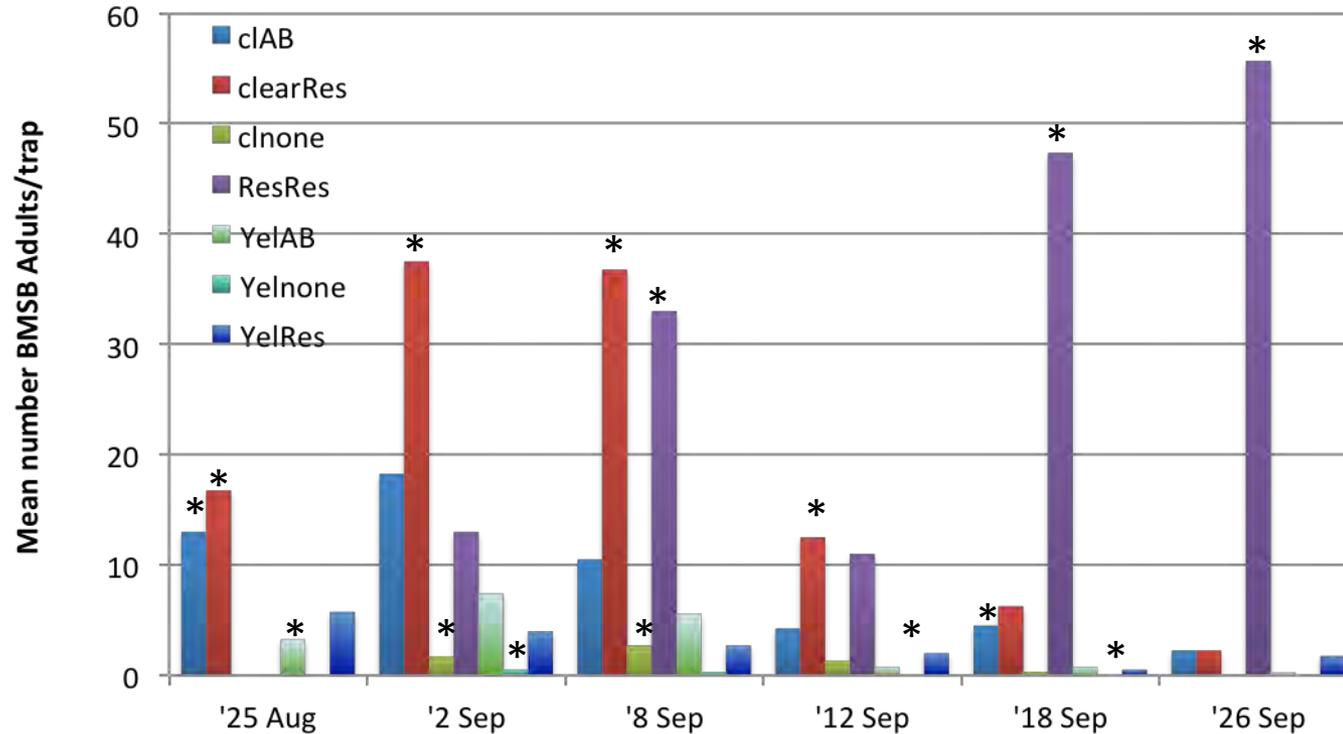


Clear sticky trap (AlphaScent)

Evaluation of sticky traps for BMSB monitoring

Location: Crop and Woods combined

Weekly observations

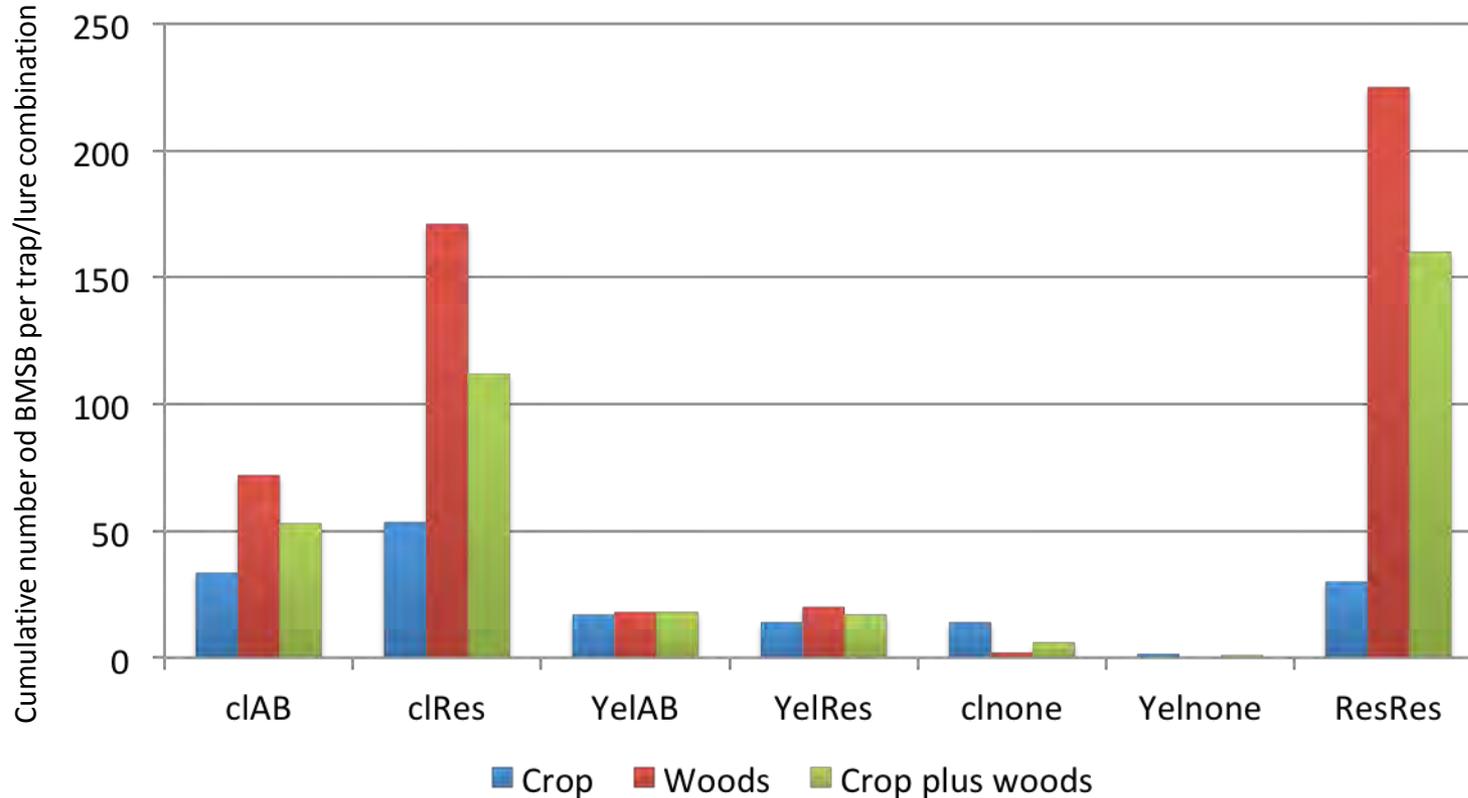


* - means different, $p \leq 0.05$;
 (ANOVA Fisher's LSD, $\text{sqr} \times \text{transformation}$)

Trap	abbrev.	Lure	abbrev.
Clear	cl	Ag-Bio	AB
Rescue	Res	Rescue	Res
Yellow	Yel	No Lure	none

Evaluation of sticky traps for BMSB monitoring

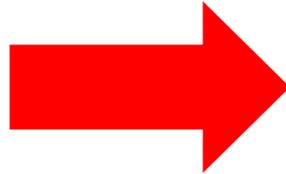
Average cumulative number of BMSB adults captured per trap/lure combination



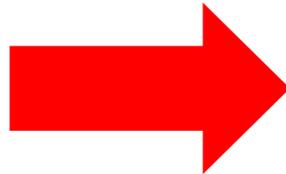
<u>Trap</u>	<u>abbrev.</u>	<u>Lure</u>	<u>abbrev.</u>
Clear	cl	Ag-Bio	AB
Rescue	Res	Rescue	Res
Yellow	Yel	No Lure	none

Behavioral Basis for Attract and Kill

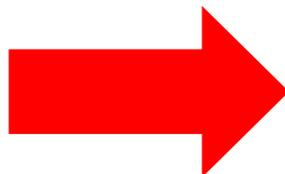
- Attraction To A Spatially Precise Location



- Long Retention Time

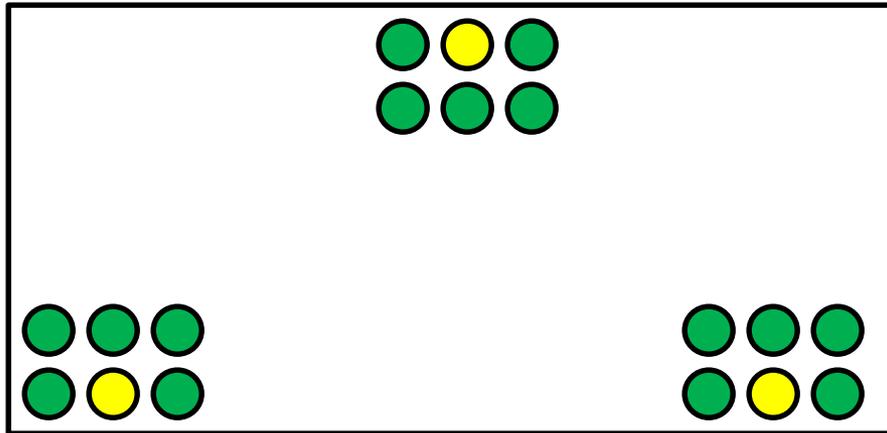


- Effective Killing Mechanism



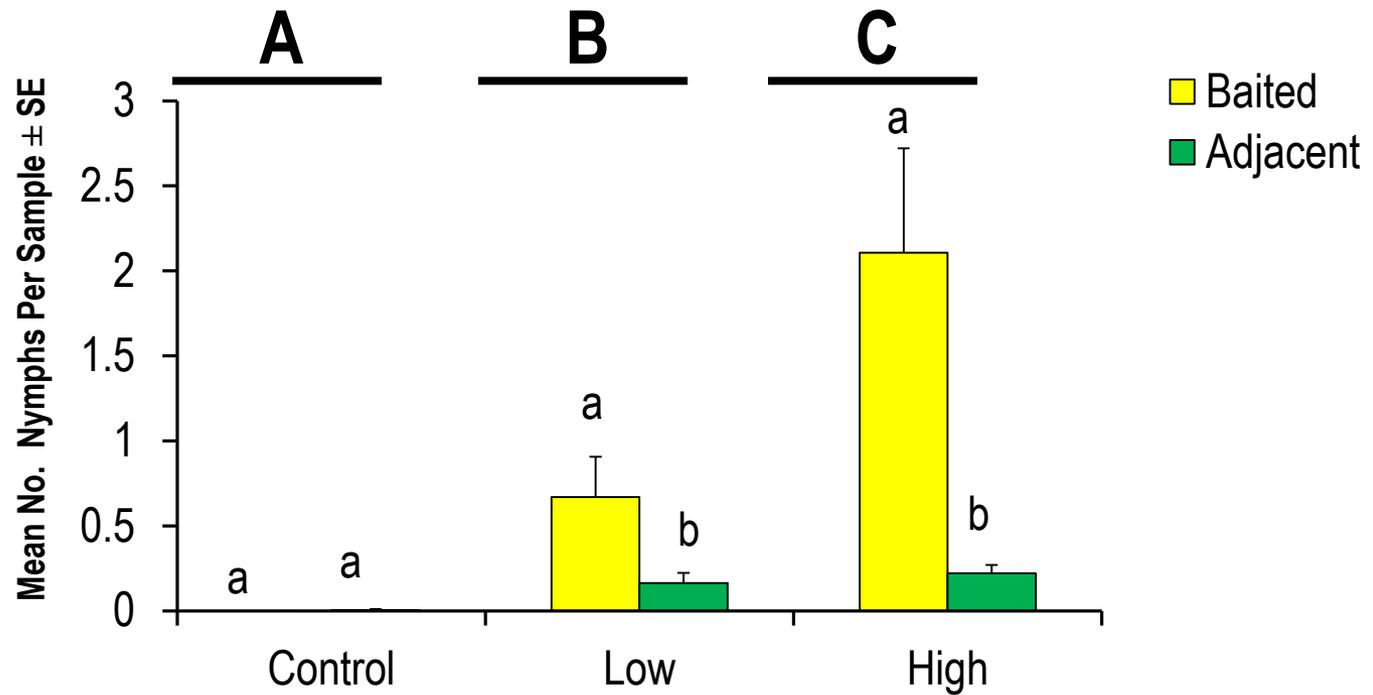
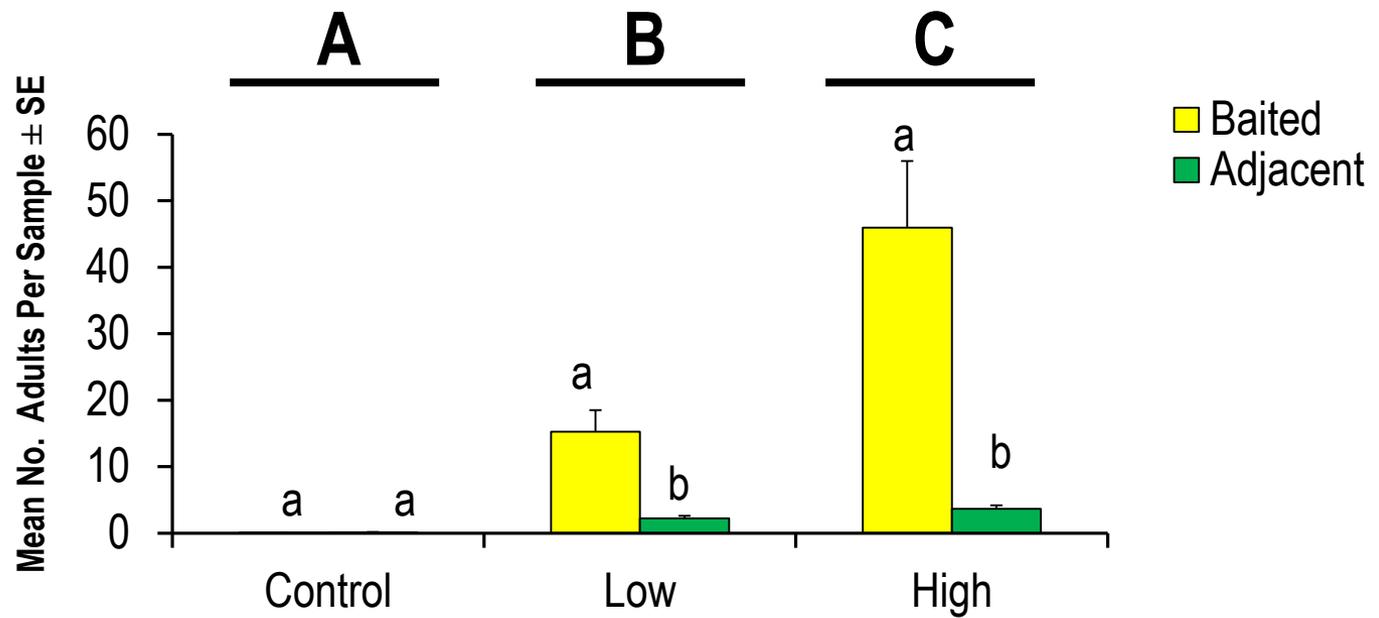
Date of Application	BMSB Trade Name	A.I.	Recommended Rate/A	Gal/A Restrictions	Season Max	Max applications	Min spray interval	PHI
15-May	Lannate SP	methomyl	1 lb	50 gal/A	5 lb/A	none	5-7 d	14 d
22-May	Mustang Maxx	zeta-cypermethrin	4 oz	20 gal/A	24 oz/A	none	7 d	14 d
29-May	Lannate SP	methomyl	1 lb	50 gal/A	5 lb/A	none	5-7 d	14 d
5-Jun	Mustang Maxx	zeta-cypermethrin	4 oz	20 gal/A	24 oz/A	none	7 d	14 d
12-Jun	Lannate SP	methomyl	1 lb	50 gal/A	5 lb/A	none	5-7 d	14 d
19-Jun	Bifenture EC	bifenthrin	6.4 oz	50 gal/A	32 oz/A	none	30 d	14 d
26-Jun	Lannate SP	methomyl	1 lb	50 gal/A	5 lb/A	none	5-7 d	14 d
3-Jul	Endigo ZCX	thiamethoxam + lan6 oz	20 gal/A	20 gal/A	28 oz/A	none	10 d	35 d
10-Jul	Danitol	fenpropathrin	21 oz	none	42,666 oz/A	none	10 d	14 d
17-Jul	Endigo ZCX	thiamethoxam + lan6 oz	20 gal/A	20 gal/A	28 oz/A	none	10 d	35 d
24-Jul	Bifenture EC	bifenthrin	6.4 oz	50 gal/A	32 oz/A	none	30 d	14 d
31-Jul	Endigo ZCX	thiamethoxam + lan6 oz	20 gal/A	20 gal/A	28 oz/A	none	10 d	35 d
7-Aug	Danitol	fenpropathrin	21 oz	none	42,666 oz/A	none	10 d	14 d
14-Aug	Belay	clothianidin	6 oz	100?	12 oz/A	none	10 d	7 d
21-Aug	Endigo ZCX	thiamethoxam + lan6 oz	20 gal/A	20 gal/A	28 oz/A	none	10 d	35 d
28-Aug	Belay	clothianidin	6 oz	100?	12 oz/A	none	10 d	7 d
4-Sep	Bifenture EC	bifenthrin	6.4 oz	50 gal/A	32 oz/A	none	30 d	14 d
11-Sep	Venom	dinotefuran	6.75 oz	50 gal/A	13.5 oz/A	none	2-7 d	3 d
18-Sep	Leverage 2.7	imidacloprid + cyflu 5.1 oz	100 gal/A	50 gal/A	5.1 oz	none	14 d	7 d
25-Sep	Venom	dinotefuran	6.75 oz	50 gal/A	13.5 oz/A	none	2-7 d	3 d

Are BMSB Attracted To A Spatially Precise Location?



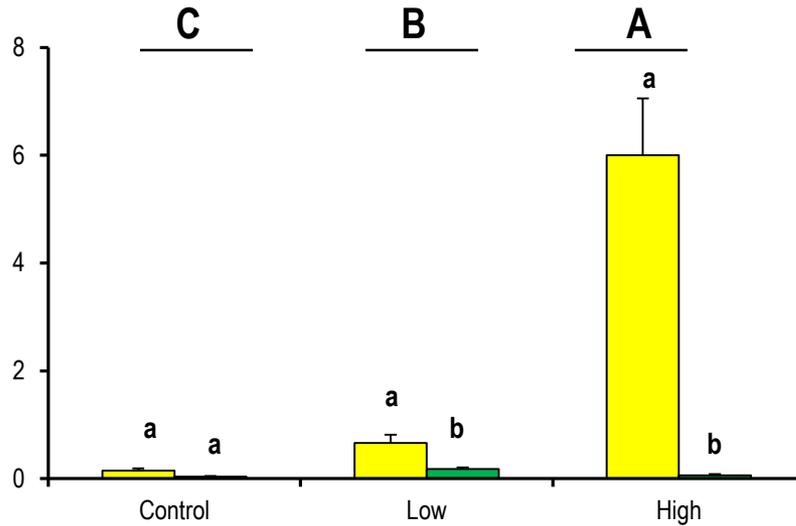
- Baited 'focal' trees (and unbaited tree as control) at the periphery of orchard blocks.
- Three treatments
 - 100 mg + 66 mg MDT (Low)
 - 1000 mg + 66 mg MDT (High)
 - Control
- Baited and adjacent trees sprayed every 7d.
- Counted the number of BMSB adults and nymphs twice weekly.
- Damage samples from focal and adjacent trees at harvest.

BMSB Annihilation



Damage at Harvest

External



■ Baited
■ Unbaited Adjacent

ANOVA

Dose

$$F_{2,67.89} = 281.8$$

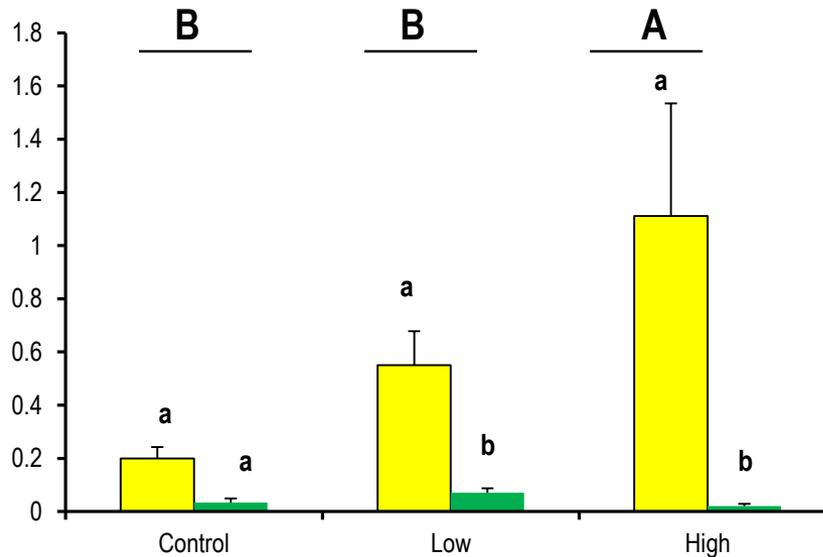
$$P < 0.0001$$

Focal vs. Neighboring Trees

$$F_{1,1255} = 17.3$$

$$P < 0.0001$$

Internal



■ Baited
■ Unbaited Adjacent

ANOVA

Dose

$$F_{2,67.89} = 226.2$$

$$P < 0.0001$$

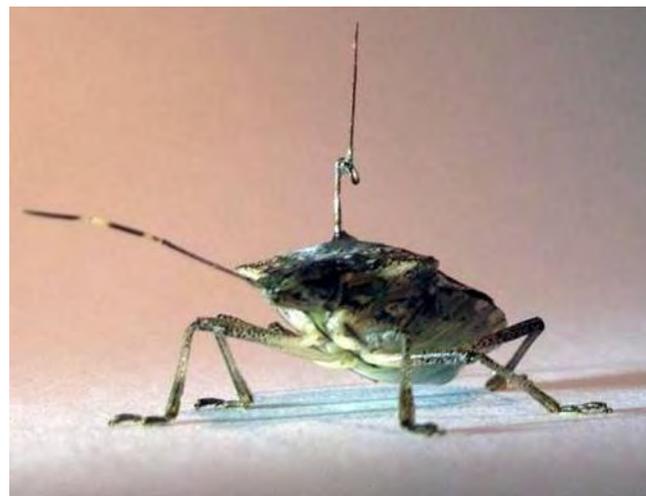
Focal vs. Neighboring Trees

$$F_{1,1255} = 4580$$

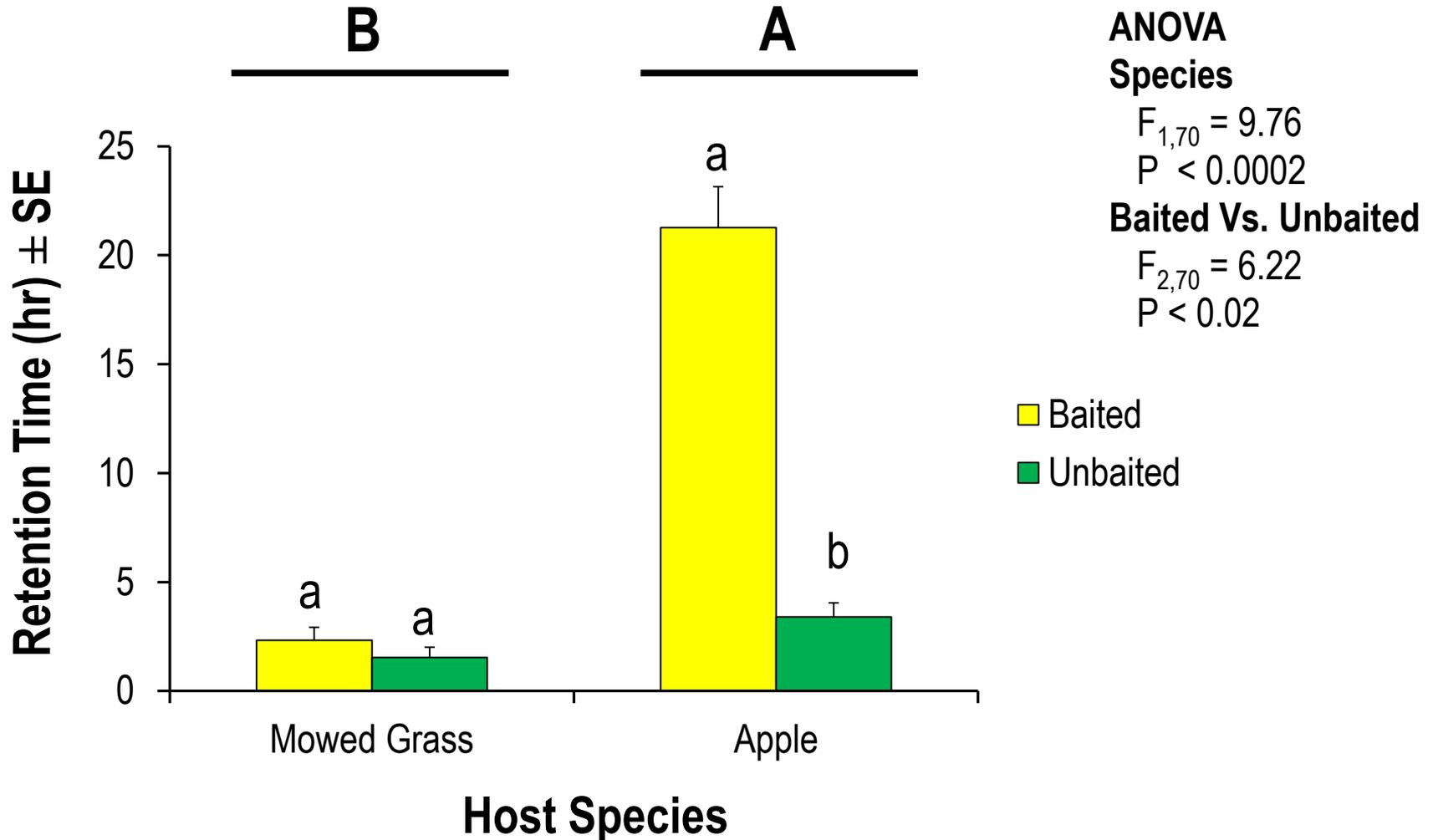
$$P < 0.0001$$

How long are BMSB retained at 'attract and kill' sites?

- Released tagged adults at sunrise.
- Treatments
 - Baited (1000 mg pheromone + 66 mg MDT) apple trees and mowed grass
 - Unbaited apple trees and mowed grass.
- Retention checked using harmonic radar at 1, 3, 6 and 24h after release.



Retention Time Adult BMSB



Conclusions

- BMSB can be attracted to a spatially precise location by using pheromonal stimuli.
- Greater numbers of individuals are attracting with increasing dose/release rate, but the area of aggregation around a stimulus does not increase.
- Retention time is maximized when stimuli are deployed in association with a host plant.
- Weekly insecticide applications in association with attractive stimuli appeared to improve overall efficacy (repeated exposure to chemicals).

Overall Project Summary

- Pheromone + synergist provides reliable, season-long detection and monitoring of BMSB.
- Commercial companies are making reasonable formulations, but they will continue to be refined.
- Coroplast pyramids are a good baseline trap design, but other designs also seem like they could work as well.
- Traps can be used to guide monitoring.
- Behavior of BMSB and their response to pheromonal stimuli lend itself to spatially precise attract and kill strategies.



Next Steps

- Continued collaboration with commercial companies to ensure reliable pheromone-based products and traps are available.
- Further validations of pheromone-based trapping in commercial orchards and other crops.
- Attract and kill strategies for spatially precise management.

