2.2.3 Attract-and-Kill, 2.2.4 Repellents, 2.2.7 Cultural Techniques for IPM, 2.2.8 RNAi

Funding

USDA United States Department of Agriculture

National Institute of Food and Agriculture

Specialty Crop Research Initiative

Grant #2011-01413-30937

Collaborating Institutions

University of Delaware

ARS

Penn State

The State University of New Jersey Rutgers

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Washington State University

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VirginiaTech

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2.2.3 Develop attract-and-kill strategies for controlling BMSB

Stop BMSB.org

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NC State University

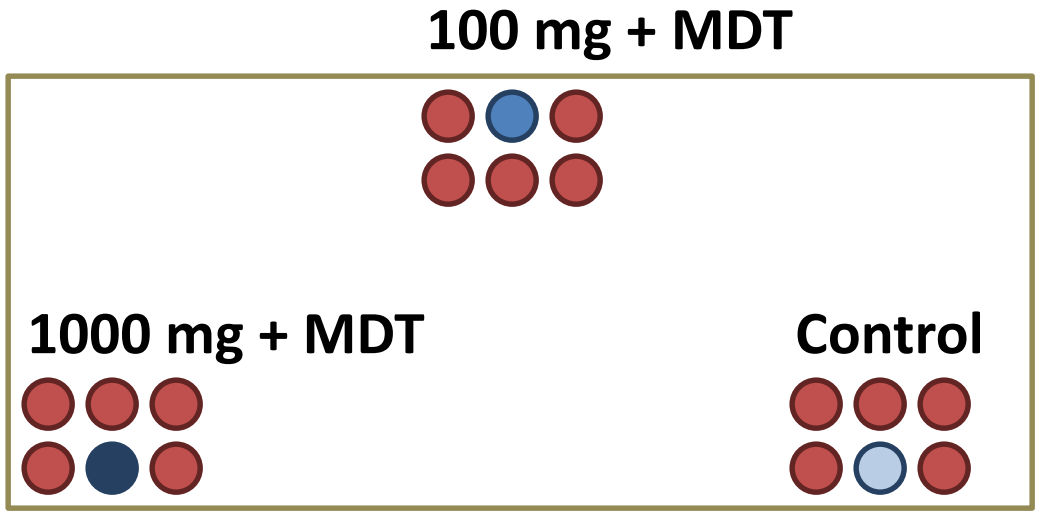
Behavioral Basis of AK

- Baseline questions to be addressed:
  1) How large is the area of arrestment of BMSB around a pheromone source?
  2) How long can we retain BMSB adults on baited vs. non-baited crop hosts?
  3) Can we precisely target management to obtain a large kill of BMSB throughout the season?

Behavioral Basis of AK

- Baseline questions to be addressed:
  1) How large is the area of arrestment of BMSB around a pheromone source? **<2.5 m**
  2) How long can we retain BMSB adults on baited vs. non-baited crop hosts? **~ 24 hrs**
  3) Can we precisely target management to obtain a large kill of BMSB throughout the season?

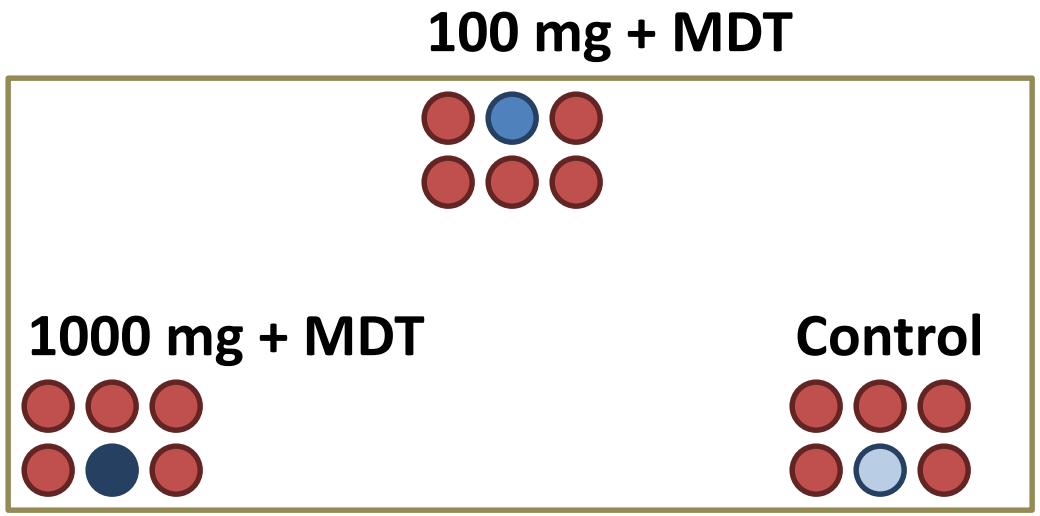
Methods: Attract & Kill



x 4 Blocks
Sprayed every 7 d
Sampled @ 1 & 6 d
16 weeks

(Morrison et al. 2015b)

Methods: Attract & Kill

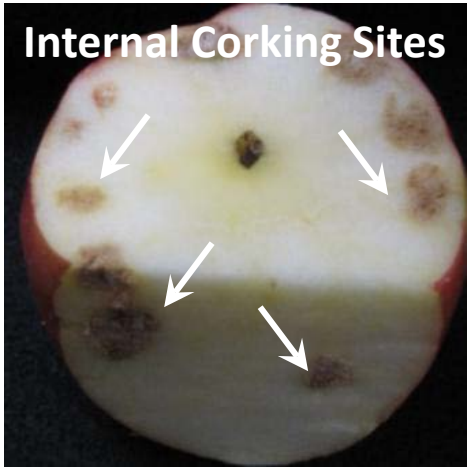


x 4 Blocks
Sprayed every 7 d
Sampled @ 1 & 6 d
16 weeks

(Morrison et al. 2015b)

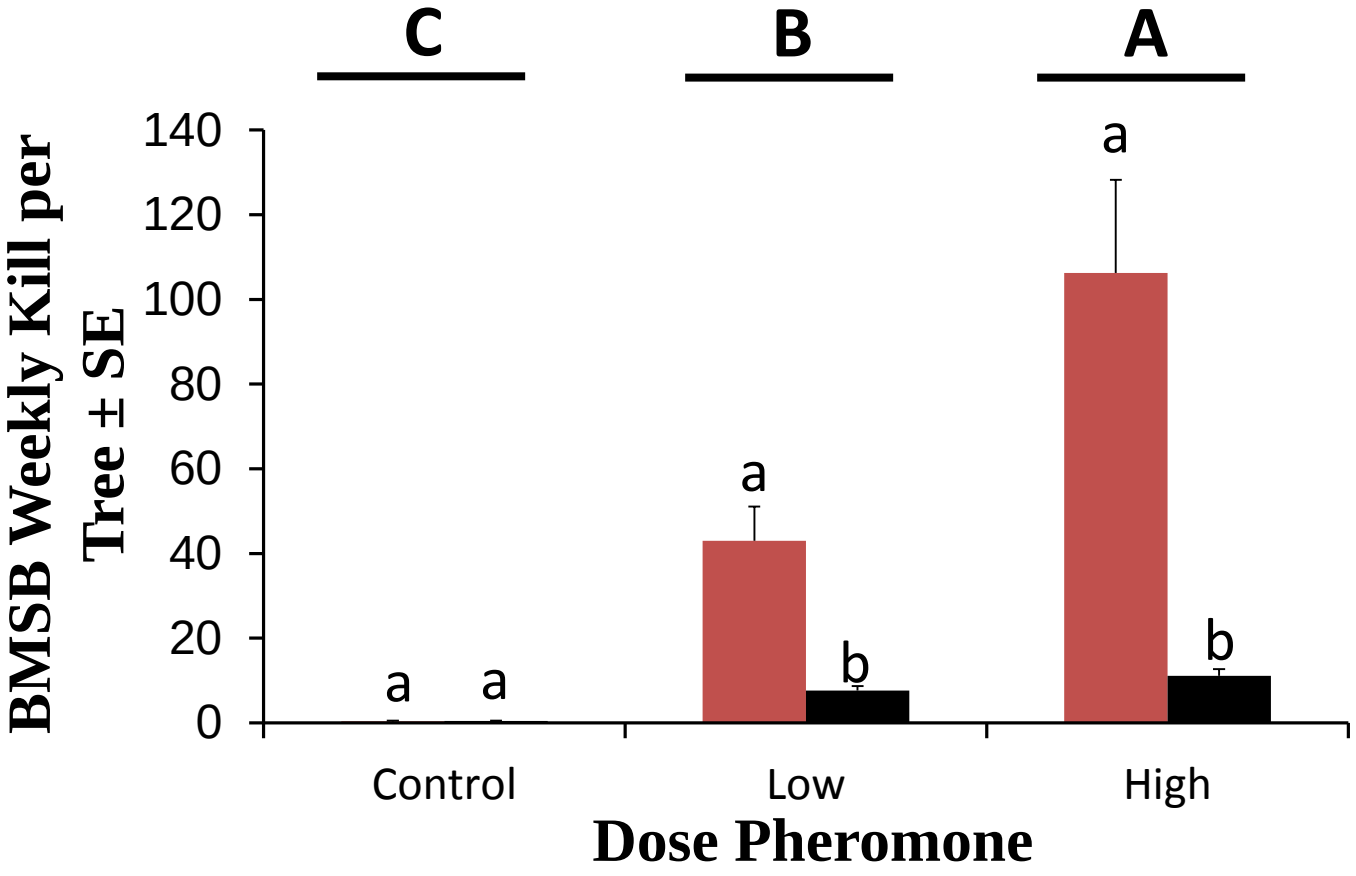
Methods: Attract & Kill

Harvest sample at end of season
From **baited** & **adjacent** trees
50 fruit per tree



(Morrison et al. 2015b)

Adults: Efficiency of Kill Sites & Spillover



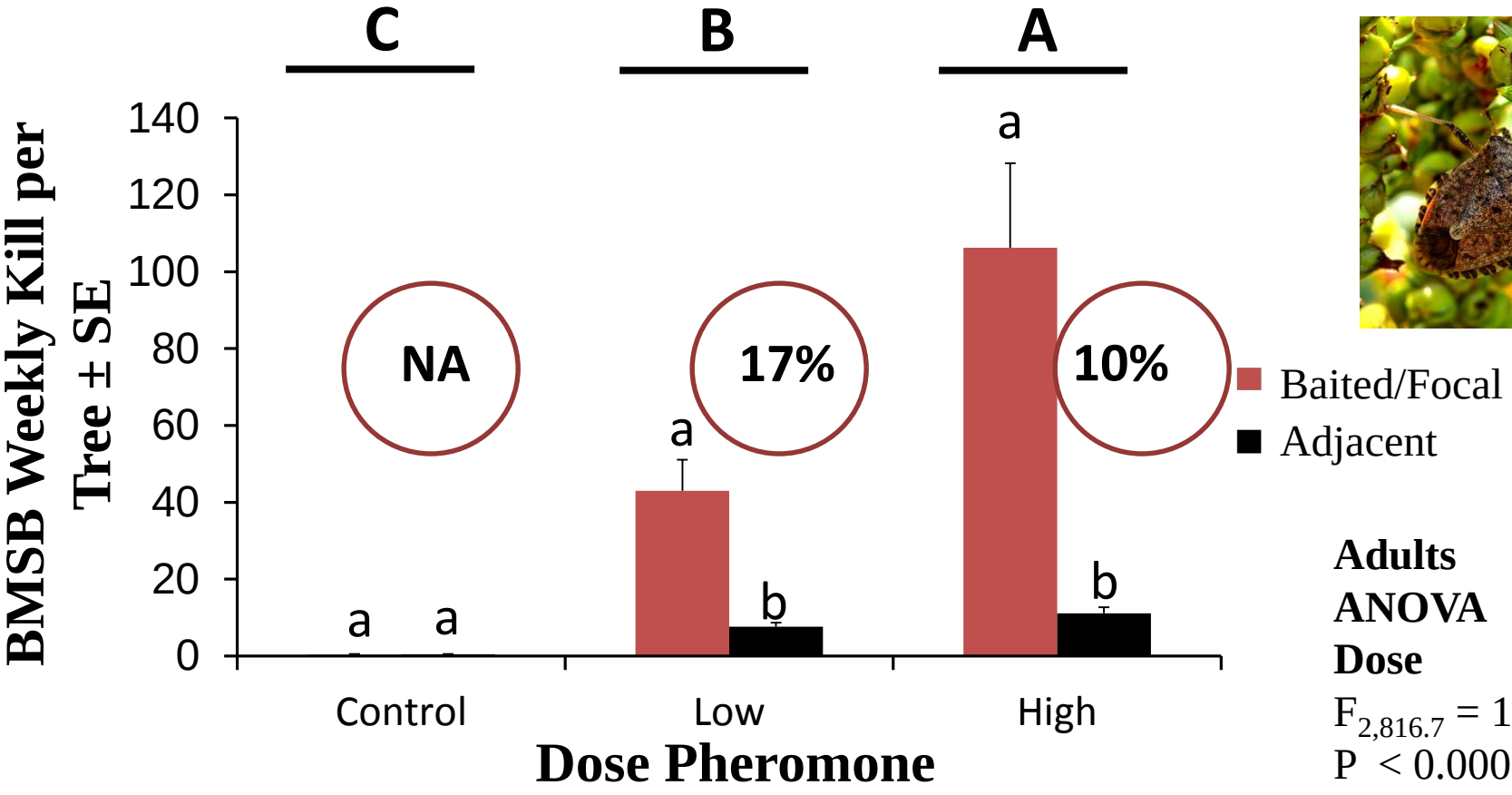
Baited/Focal

Adjacent

Adults
ANOVA
Dose
$F_{2,816.7} = 1091.3$
$P < 0.0001$
Focal Tree
$F_{1,816.5} = 401.8$
$P < 0.0001$

(Morrison et al. 2015b)

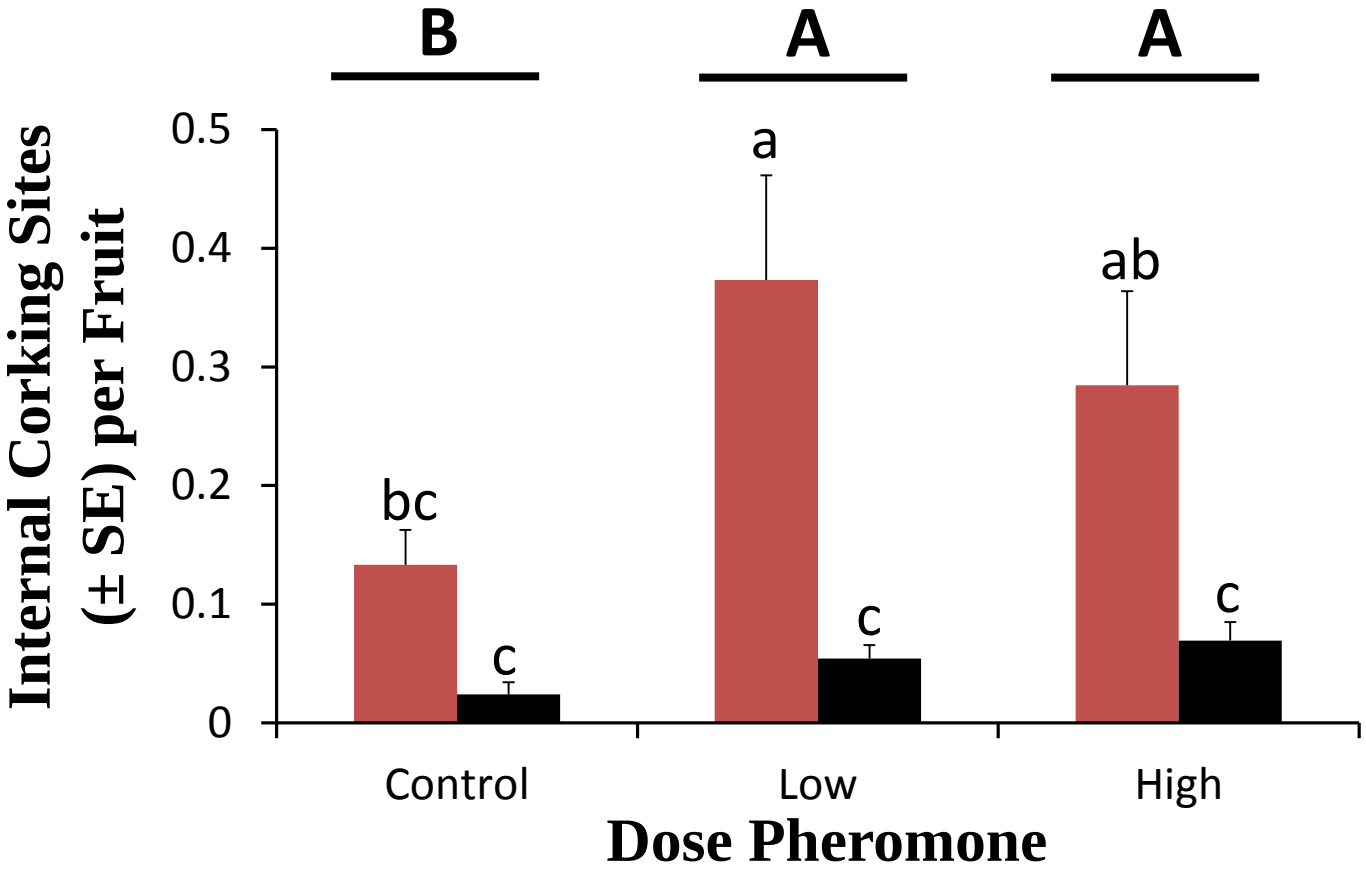
Adults: Efficiency of Kill Sites & Spillover



Adults
ANOVA
Dose
$F_{2,816.7} = 1091.3$
$P < 0.0001$
Focal Tree
$F_{1,816.5} = 401.8$
$P < 0.0001$

(Morrison et al. 2015b)

Damage: Internal Corking



Baited/Focal

Adjacent

Internal Corking ANOVA

Dose

$F_{2,67.89} = 226.2$

$P < 0.0001$

Focal Tree

$F_{1,1255} = 4580$

$P < 0.0001$

(Morrison et al. 2015b)

SPLAT Attract-and-Kill Technology

Funding

USDA United States Department of Agriculture

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Grant #2011-01413-30937

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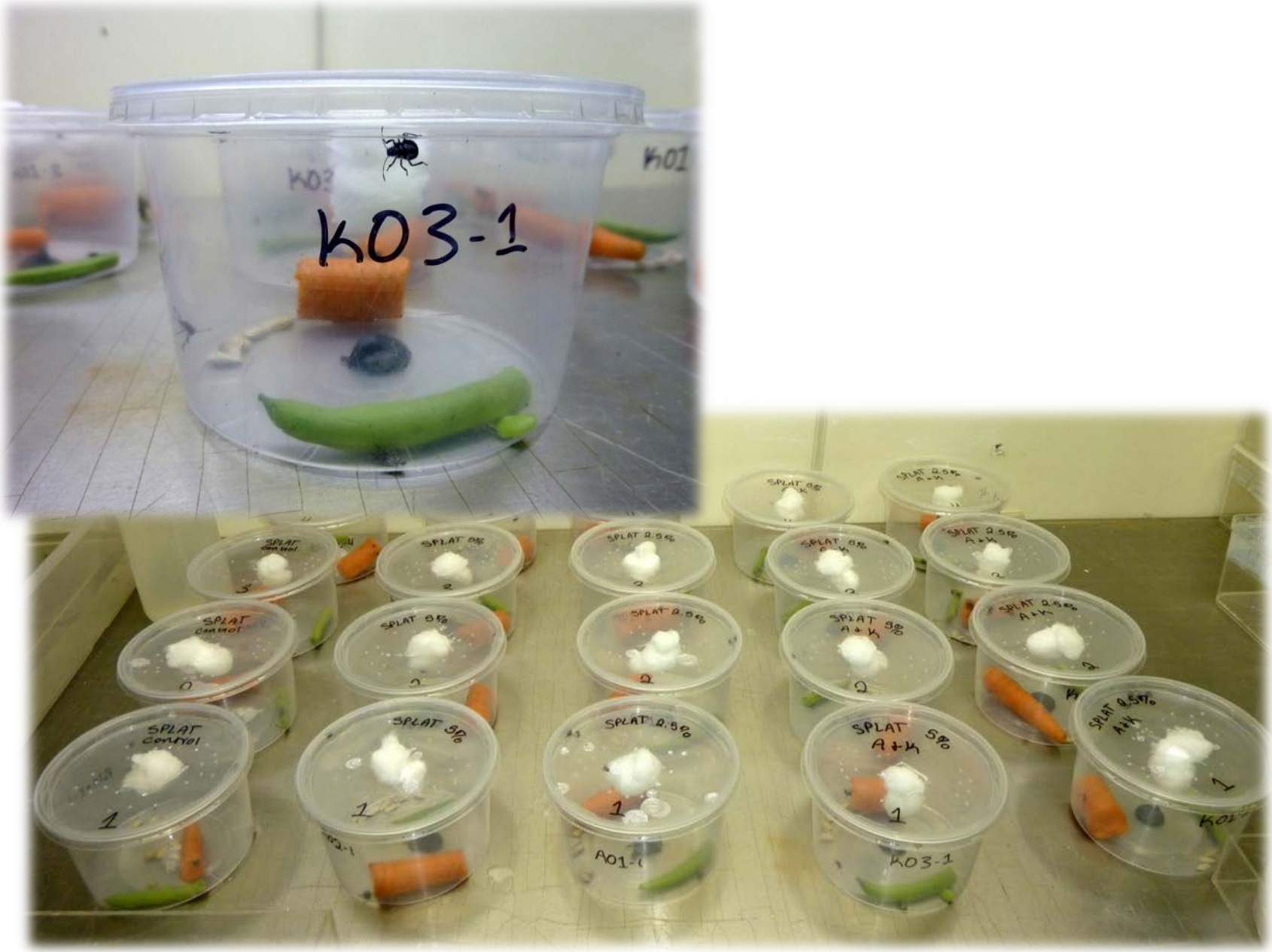
Methods IV. SPLAT Bioassays

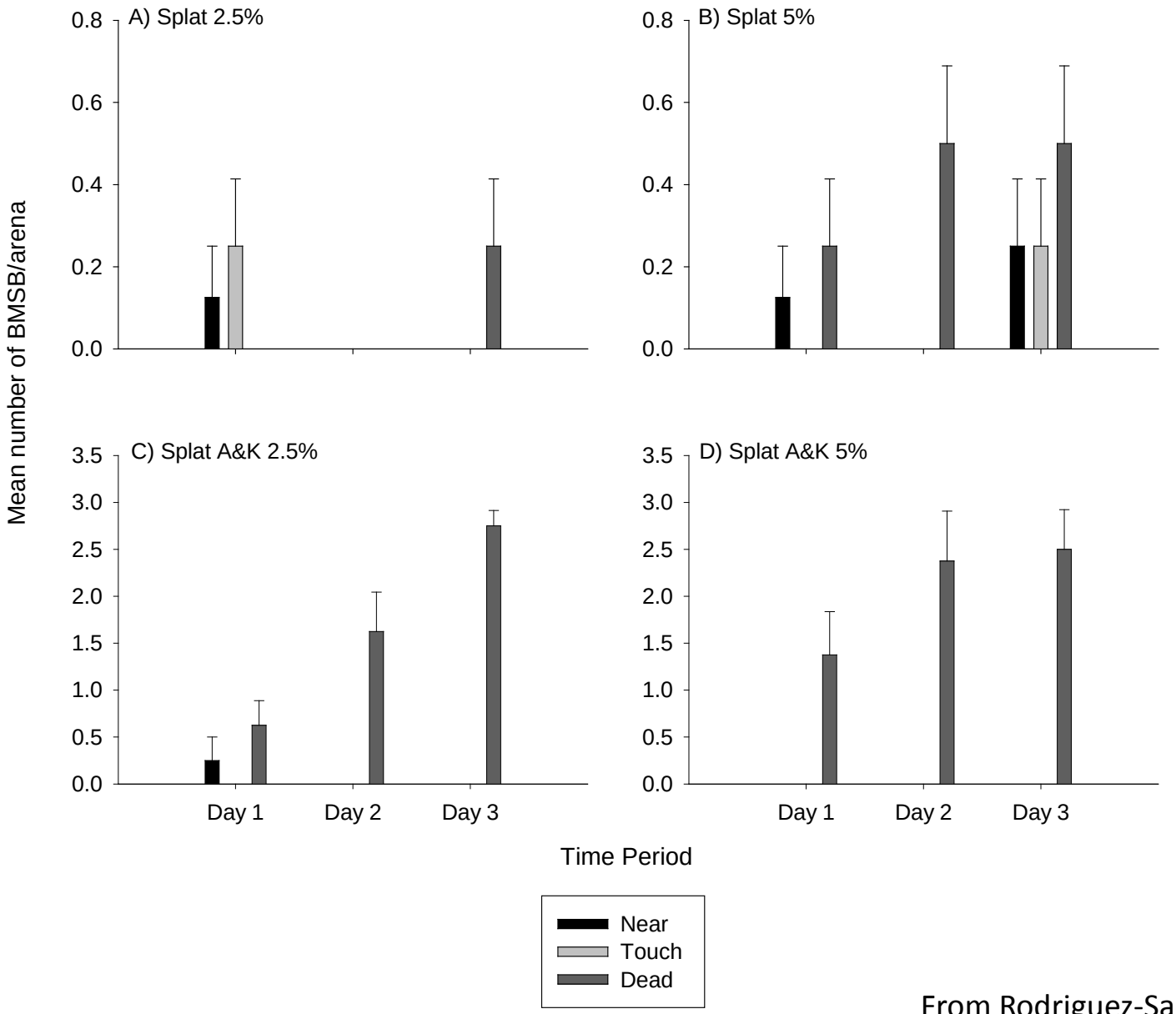
- Treatments
  - SPLAT for attraction of BMSB (2.5%)
  - SPLAT for attraction of BMSB (5%)
  - SPLAT for A&K of BMSB (2.5%)
  - SPLAT for A&K of BMSB (5%)
  - SPLAT control
- 1 g dollop per arena
- 5 3rd or 4th instar nymphs
- 4 replications/treatment
- Recorded
  - mortality every 6 and 12 hours for 3 days
- All arenas contained green beans, carrots, sunflower seeds and water

From Rodriguez-Saona et al.



From Rodriguez-Saona et al.

Results IV. SPLAT Bioassays



From Rodriguez-Saona et al.

Outstanding topics:

1) Investigating AK outside protected crops
2) Implementing attract-and-kill in other crops
3) Evaluating SPLAT with BMSB pheromone and in the field.

2.2.4 Repellents and mineral-derived compounds against BMSB

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VirginiaTech
Invent the Future

College of
Agriculture and Life Sciences

Evaluation of kaolin and essential oils as natural repellents of BMSB

Tom Kuhar and Adam Morehead
Dept. of Entomology
Virginia Tech

Kaolin (Surround WP™)

- Kaolin [$Al_4Si_4O_{10}(OH)_8$] is a white, non-porous, non-swelling, low-abrasive, fine-grained, aluminosilicate mineral or clay that is derived from weathered feldspar & quartz
- a fine chemically inert powder that can safely be applied to plants to reduce heat stress, water loss, and sunscalding.

NovaSource® Tessenderlo Group

Surround® WP

Crop Protectant

Surround WP crop protectant forms a barrier film, which acts as a broad spectrum agricultural crop protectant for controlling damage from various insect and disease pests, a growth enhancer, and as a protectant against sunburn and heat stress.

ACTIVE INGREDIENT:	
Kaolin	95.0%
OTHER INGREDIENTS:	5.0%
TOTAL:	100.0%

Essential oils

- Essential oils are secondary metabolite compounds produced by certain plants like rosemary & mint to deter feeding by insect pests.
- Zhang et al. (2014) recently showed that several essential oils including rosemary and spearmint oil had repellent activity against BMSB in the lab.
- Ecotec (EcosSMART Technologies, Inc.) is a commercially-available blend of essential oils

Repellent Choice Test Bioassays

- Arena: 12” mesh rearing cube with two 90 mm Petri dishes on opposite corners
- *Paulownia* spp. leaves trimmed to fit dishes and treated with Surround WP, Ecotec, or Untreated
- Tomatoes placed in the center of trimmed leaves and given the same treatment as the leaf
- 10 insects were introduced into the arena (Adults or Nymphs)
- Checked at 20 min, 40 min, 1 hour, 2 hours, 4 hours, 6 hours, 8 hours, and 24 hours
- Analyzed with a paired T-test

Choice Test Bioassay Results

Nymphs

Average number of interactions over 24 hours

P-value: 0.032

*

Control Surround

P-value: ns

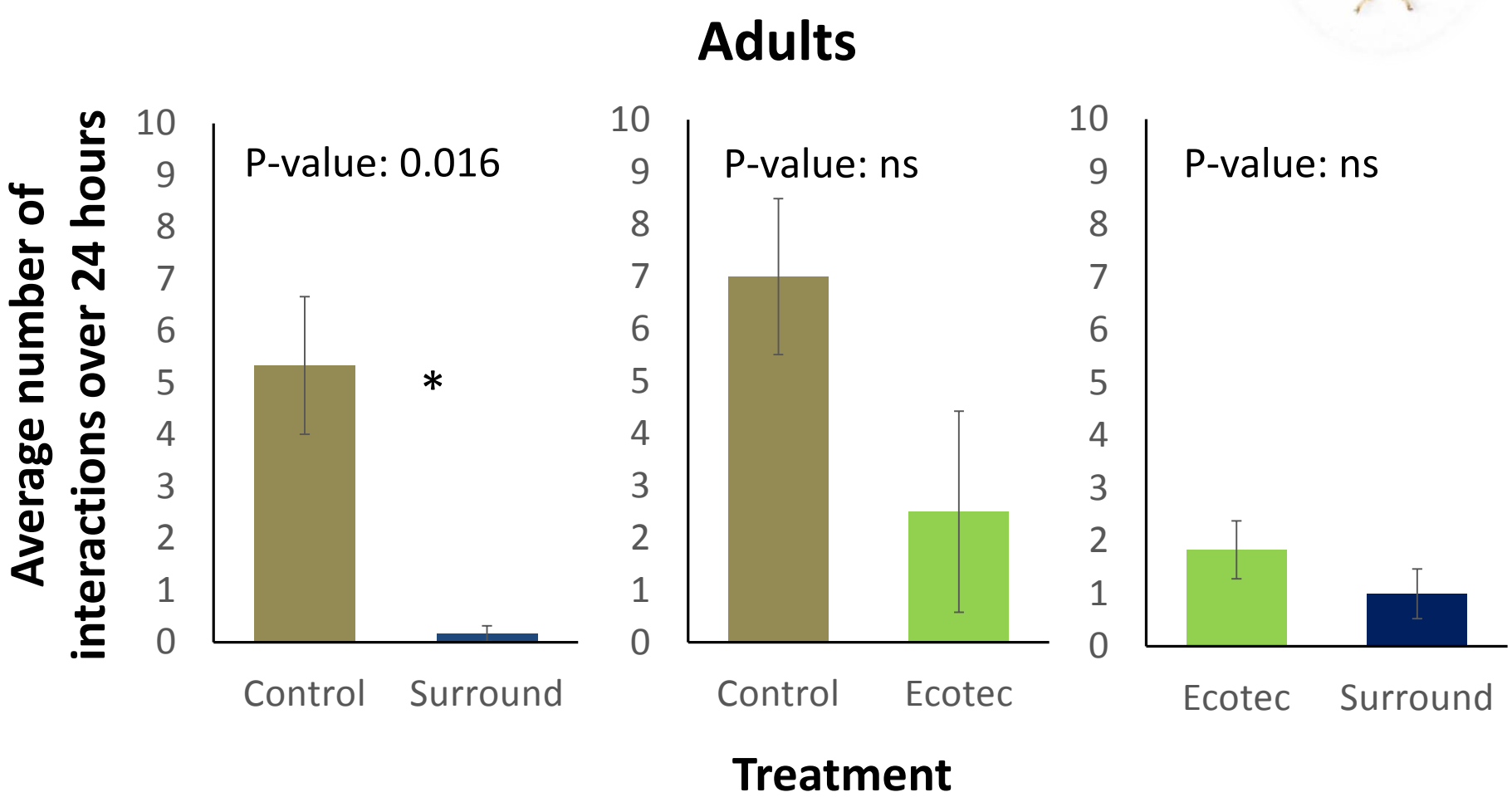
Control Ecotec

P-value: ns

Ecotec Surround

Treatment

Choice Test Bioassay Results



Repellent Field Efficacy Trial

- Aristotle bell peppers planted into blocks and arranged into a randomized complete block design
- Plots were 4 rows x 20 feet
- Treatments were applied weekly with a 3 nozzle drop down boom attached to a CO_2 sprayer for the duration of each experiment
- Subsample per plot was 50 fruit in 2014 and 40 fruit in 2015
- Analyzed with ANOVA and Students T-test

Results Field Efficacy Tests

Treatment	Rate/acre	Cumulative average % damage caused by BMSB				
		8/29/2014	9/22/2014	8/12/2015	8/21/2015	8/28/2015
UTC		21.5% ± 3.6 A	13% ± 1.9 A	31.3% ± 3.9 A	33.8% ± 3.5 A	42.5% ± 3.2 A
Ecotec	64 fl oz	20.5% ± 4.9 A	4.5% ± 1.0 B	15% ± 3.6 AB	35.6% ± 4.6 A	35.6% ± 2.4 A
Surround	800 oz	3% ± 1.4 B	1% ± 1.4 C	10% ± 2.0 B	15.6% ± 2.9 B	8.8% ± 1.1 B
P value		0.015	0.003	0.024	0.027	0.001

Feeding Deterrent/Repellent for the Brown Marmorated Stink Bug

Aijun Zhang, Yan Feng, Mark Feldlaufer

Invasive Insect Biocontrol and Behavior Laboratory

USDA - Agricultural Research Service

BARC-West, Beltsville, Maryland

Manguang Liu

Hebei Forestry Academy of Science

Shijiazhuang, Hebei, China

Kevin Ulrich

Entomology Department

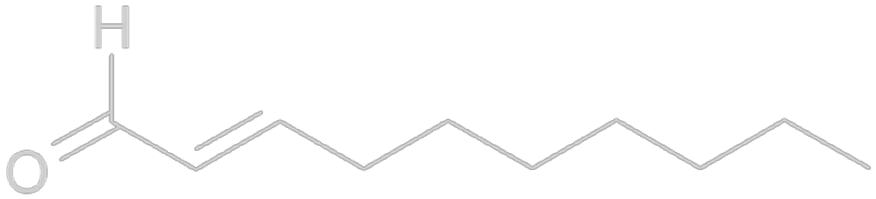
University of Maryland

College Park

BMSB Feeding Deterrent/Repellent

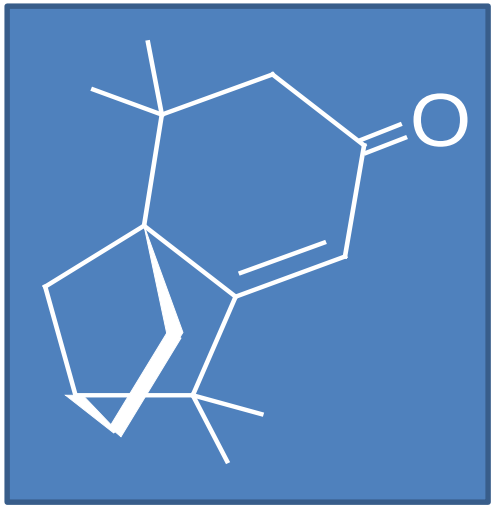
BMSB Major Secretion Compounds

Tridecane (C_{13})



E-2-Decenal (E2)

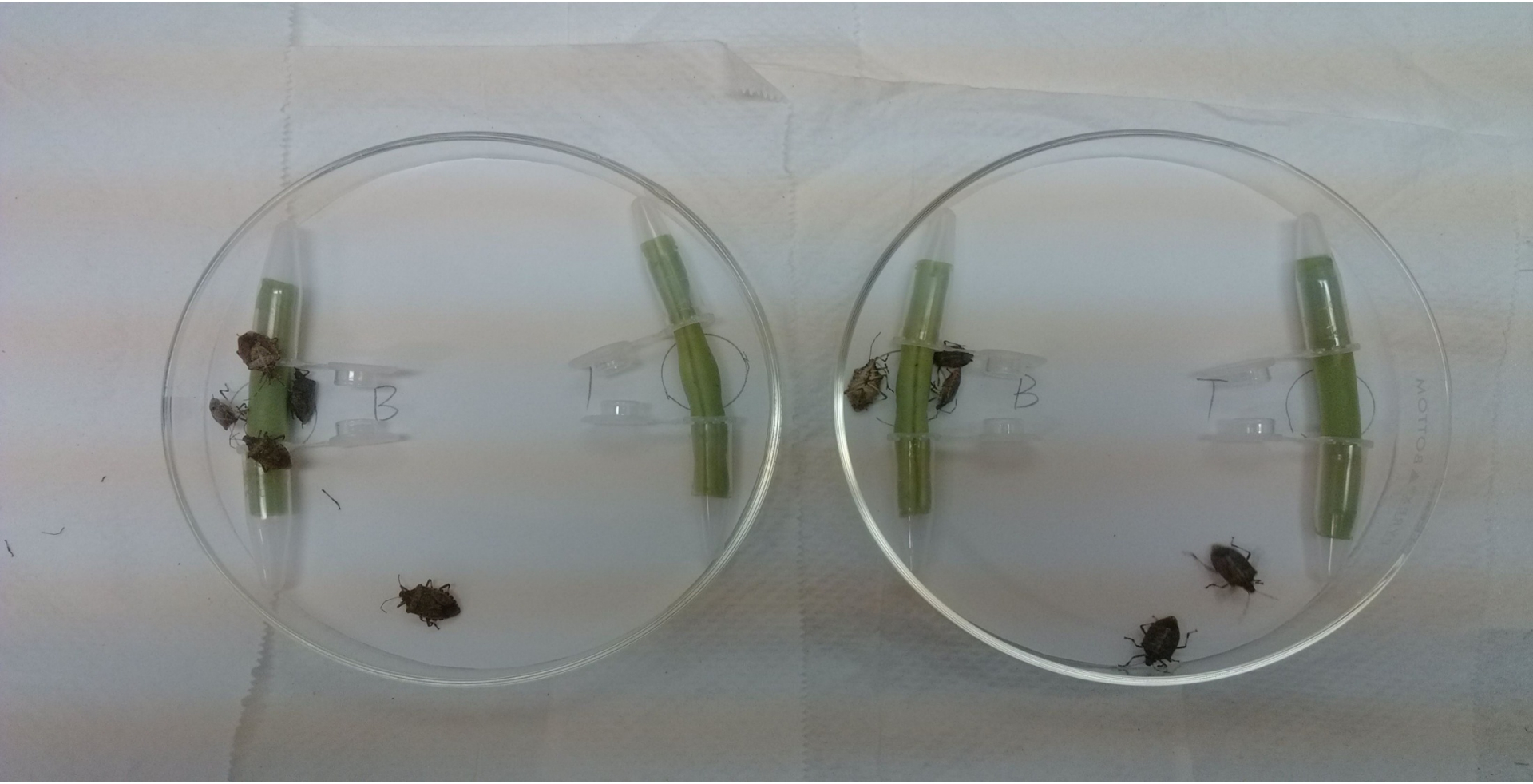
Mosquito & Tick Repellent

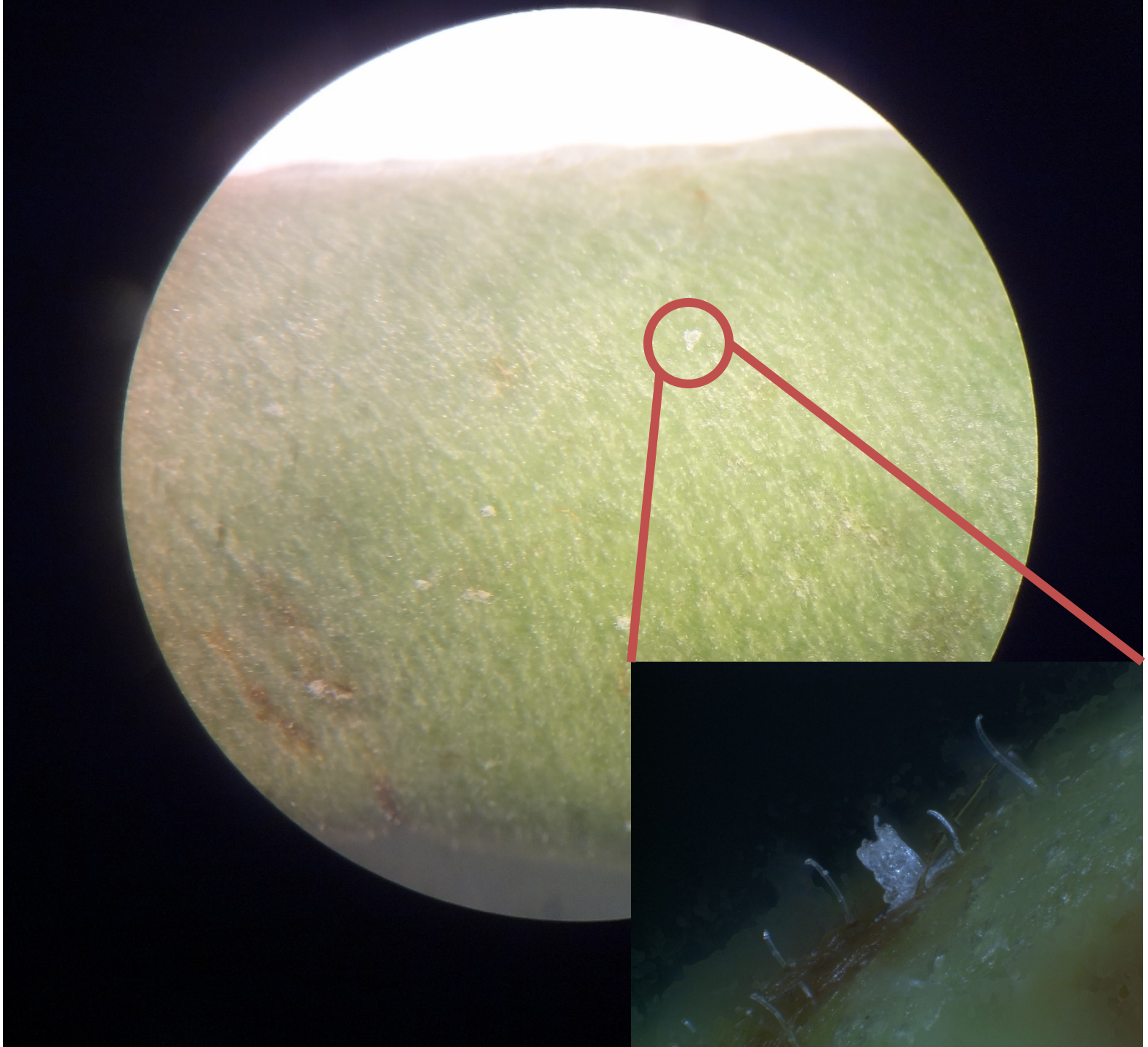


Isolongifolenone (En)

No Choice Test

Two Choice Test





Conclusions

- The major BMSB secretion compound (C13) has no effect on feeding activity.
- E2-decanal (E2) demonstrates dual functions in Petri Dish assay. At low concentration (>100 µg), it acts as feeding stimulant; while at high concentration (<100 µg), it acts as feeding deterrent.
- A blend of tridecane (C13) and E2-decanal (E2) (1:1 ratio) showed significant feeding deterrent activity.
- Isolongifolenone (En), a mosquito and tick repellent, exhibits strong feeding deterrent activity.
- A blend of C13, E2, and En (1:1:1 ratio) also exhibits strong feeding deterrent activity.
- Although identified feeding deterrents are natural products, they can not be directly applied on the plants (surfaces burning). New formulation is ready to be tested in the field in this fall.
- The identified feeding deterrents/repellents can be easily commercialized and used for protecting agricultural crops from *H. halys* damage in support of ongoing *H. halys* management programs.

Outstanding topics:

1) Further repellency studies to refine use in the field
2) Integrate with other management tactics

2.2.7 Cultural Techniques for IPM

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NC State University

Interplanting of bell peppers with red clover

Hanna Kahl & Cerruti RR Hooks

University of MD, Dept. of Entomology

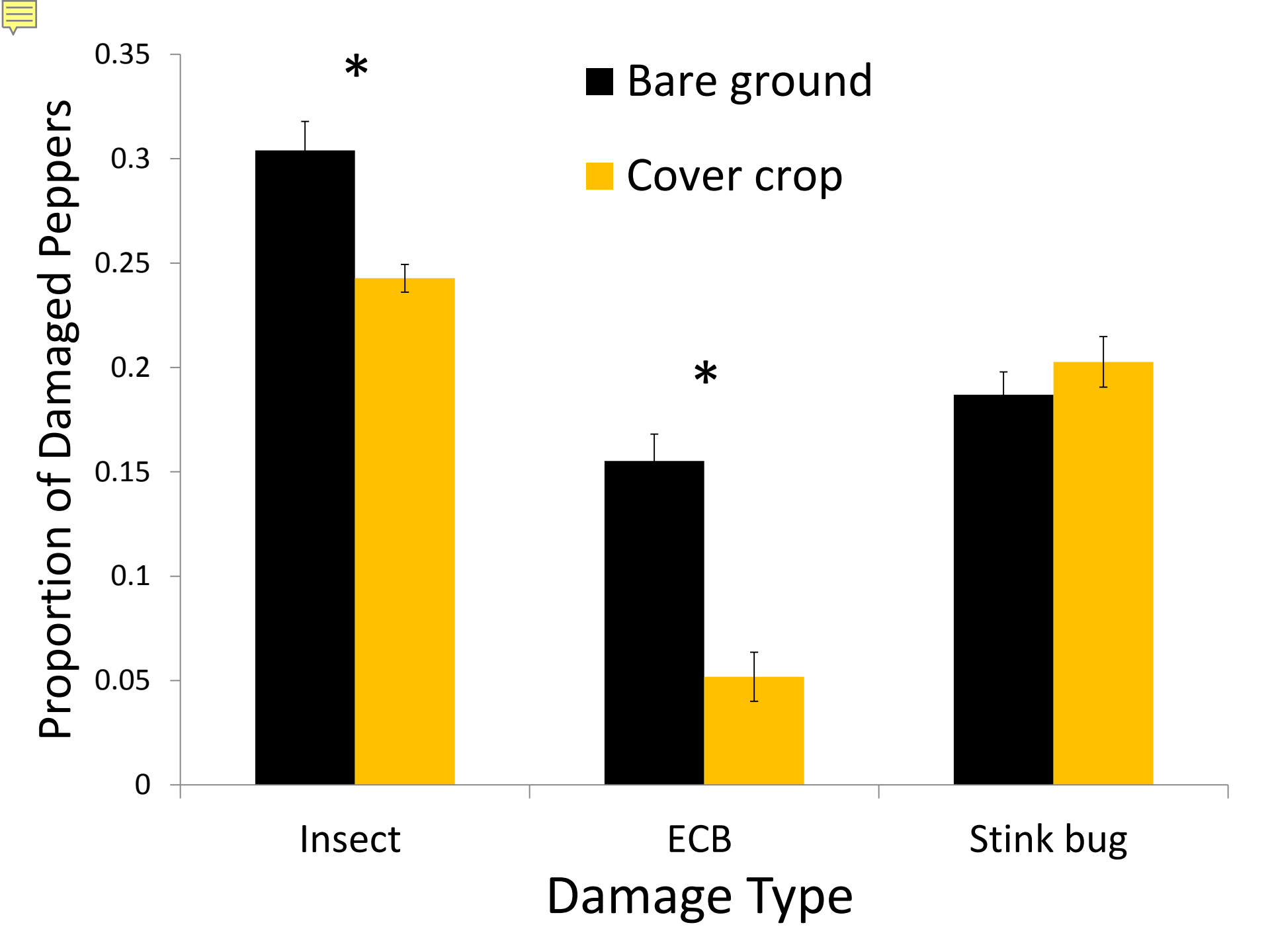
Objective

Determine the impact of inter-planting bell peppers with red clover on:

1) Stink bug egg mortality

2) Percentage of stink bug damaged fruits

3) Fruit yield


Proportion of Damaged Peppers
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
*
*
Bare ground
Cover crop
Insect
ECB
Stink bug
Damage Type

Cages to Exclude Stink Bugs

Two treatments: **caged vs. uncaged**

Consperse stink bug used as surrogate

1,932 fruit harvested: no damage in either treatment

E. Beers et al.

Outstanding topics:

1) Verify cultural control results with additional cover crops and compare with trap cropping
2) Repeat exclusion experiments under higher population pressure

2.2.8 RNAi against BMSB

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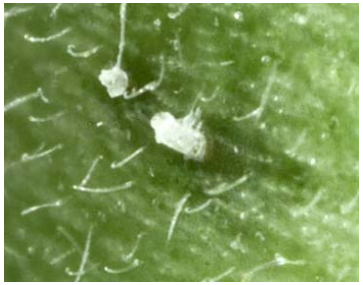
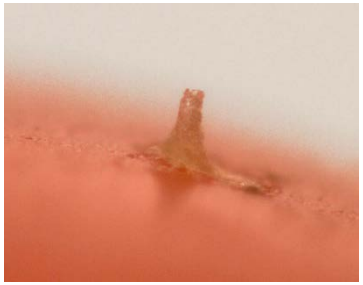
Amylase in BMSB saliva

- In cooperation with DOW Chemical, proteome data has been re-analyzed with the newly available BMSB genome(www.hgsc.bcm.edu/brown-marmorated-stink-bug-genome-project)

- We are focusing on 2 amylases:

1. HHAL004834 is an α-amylase identified in both watery saliva and the salivary sheath
2. HHAL001011 is an α-amylase identified in watery saliva only





Salivary sheaths on green bean (left) and tomato (right)

- Currently we are using the SMARTer RACE technique to clone the full length genes and obtain complete sequence information
- The sequence information will be used to create small silencing RNA to suppress amylase in the saliva

Outstanding topics:

1) Create effective RNAi materials for use against BMSB in the field

Acknowledgements

- USDA-ARS, USDA NIFA SCRI # 2011-51181-30937,
- USDA-APHIS

United States Department of Agriculture
National Institute of Food and Agriculture

BMSB SCRI CAP Team

Funding

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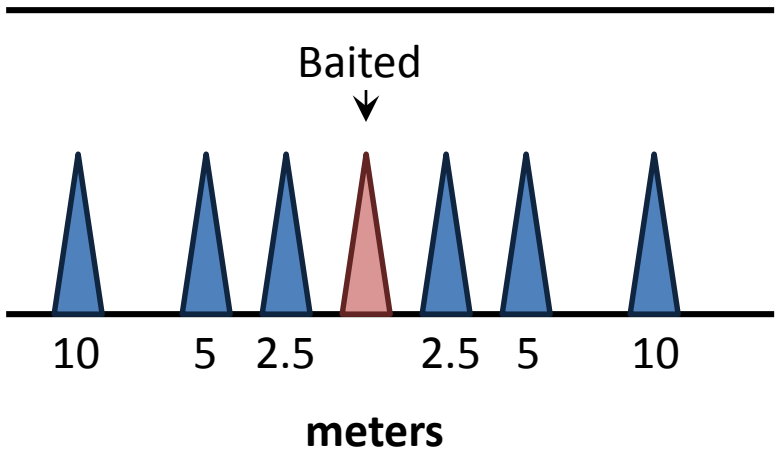
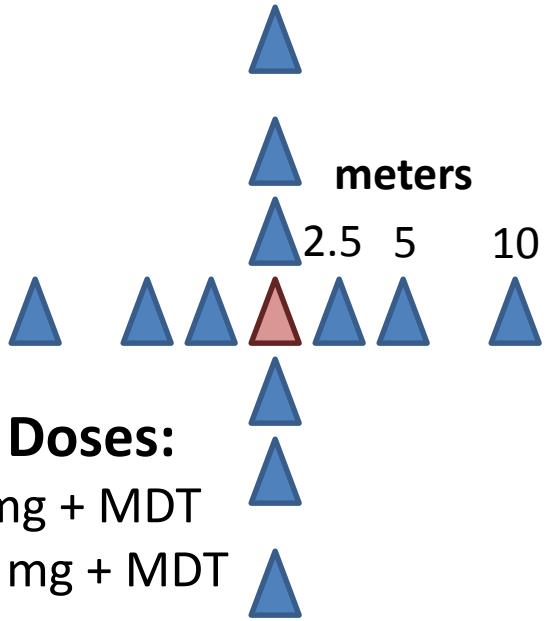
Stop BMSB

Thank you for your attention!

In the field one morning…

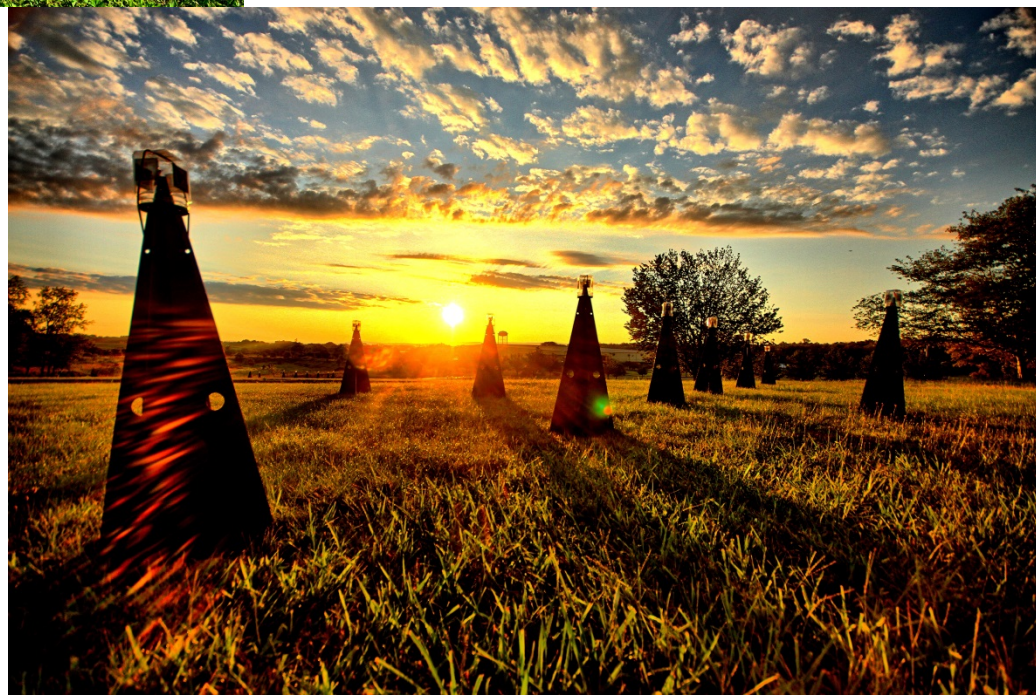




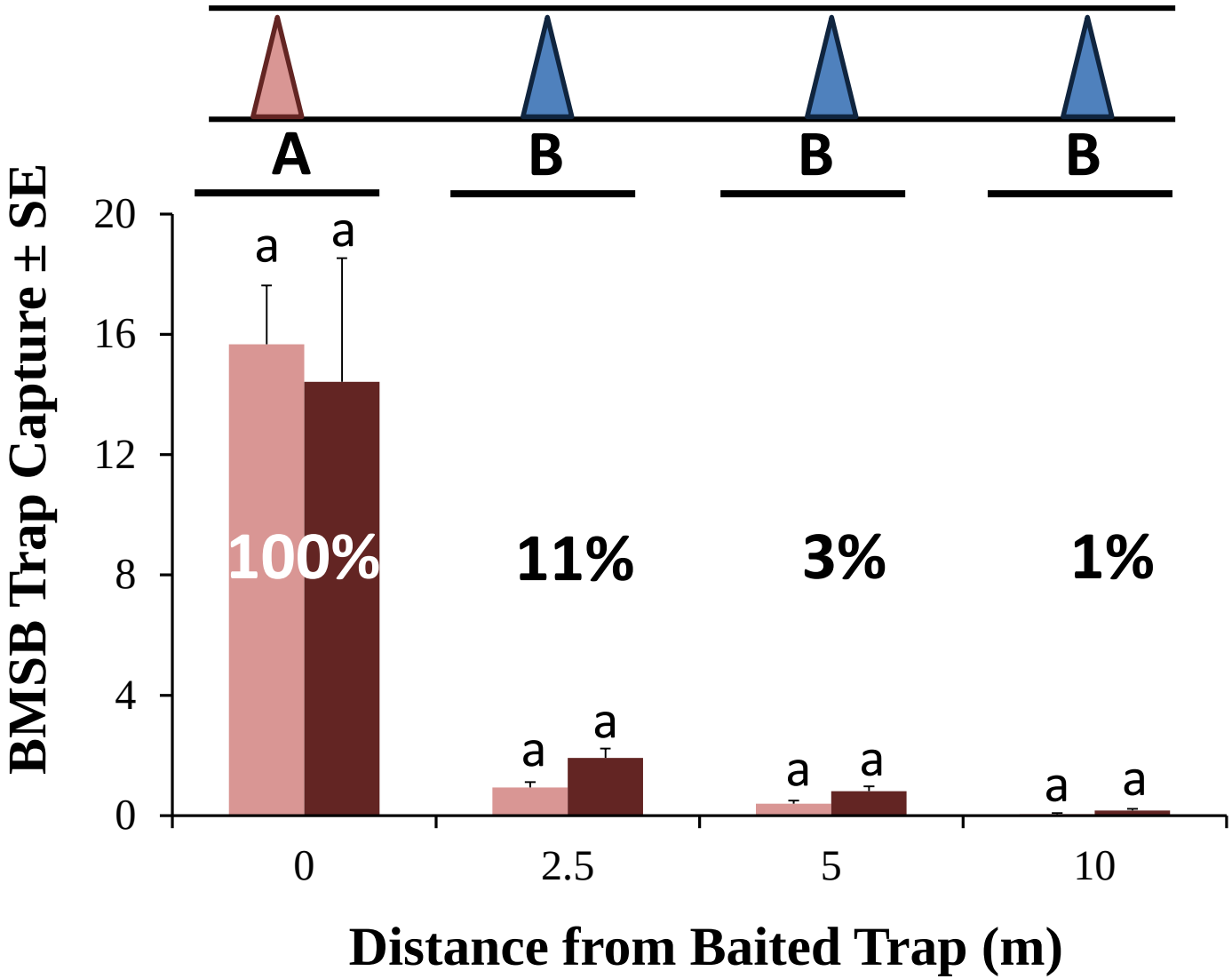
Two Doses:

100 mg + MDT

1000 mg + MDT



Adults



100 mg

1000 mg

ANOVA

Dose

$F_{1,382} = 1.44$

$P < 0.23$

Distance

$F_{3,382} = 17.1$

$P < 0.0001$

(Morrison et al. 2015b)

Apple Tree

Mowed Grass

Measuring: Retention time, distance from the release point

Apple Tree

Mowed Grass

Unbaited

Apple Tree

Mowed Grass

Baited

Measuring: Retention time, distance from the release point

Apple Tree

Mowed Grass

Apple Tree

Mowed Grass

Unbaited

Baited

Sampling after release

1 hr

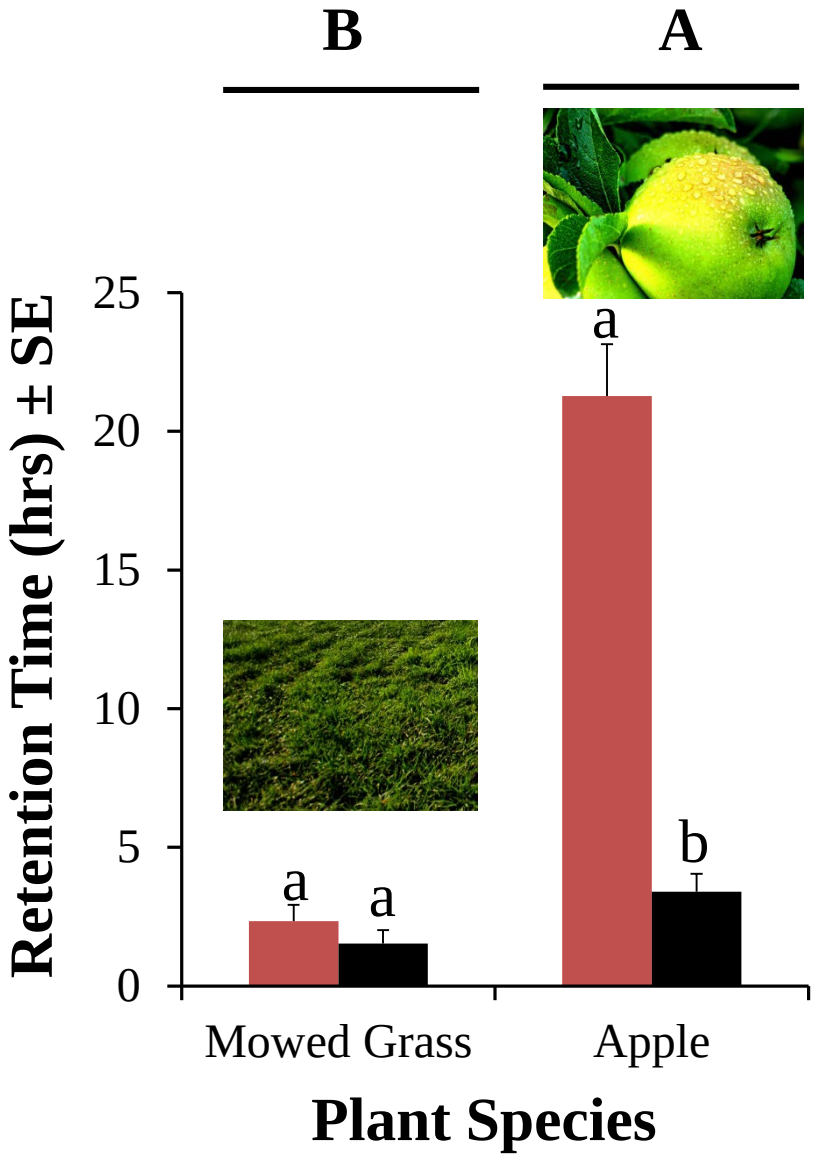
3 hrs

6 hrs

24 hrs

Measuring: Retention time, distance from the release point

Retention Time



ANOVA

Tree Sp.

$F_{1,70} = 9.76$

$P < 0.0002$

Bait

$F_{2,70} = 6.22$

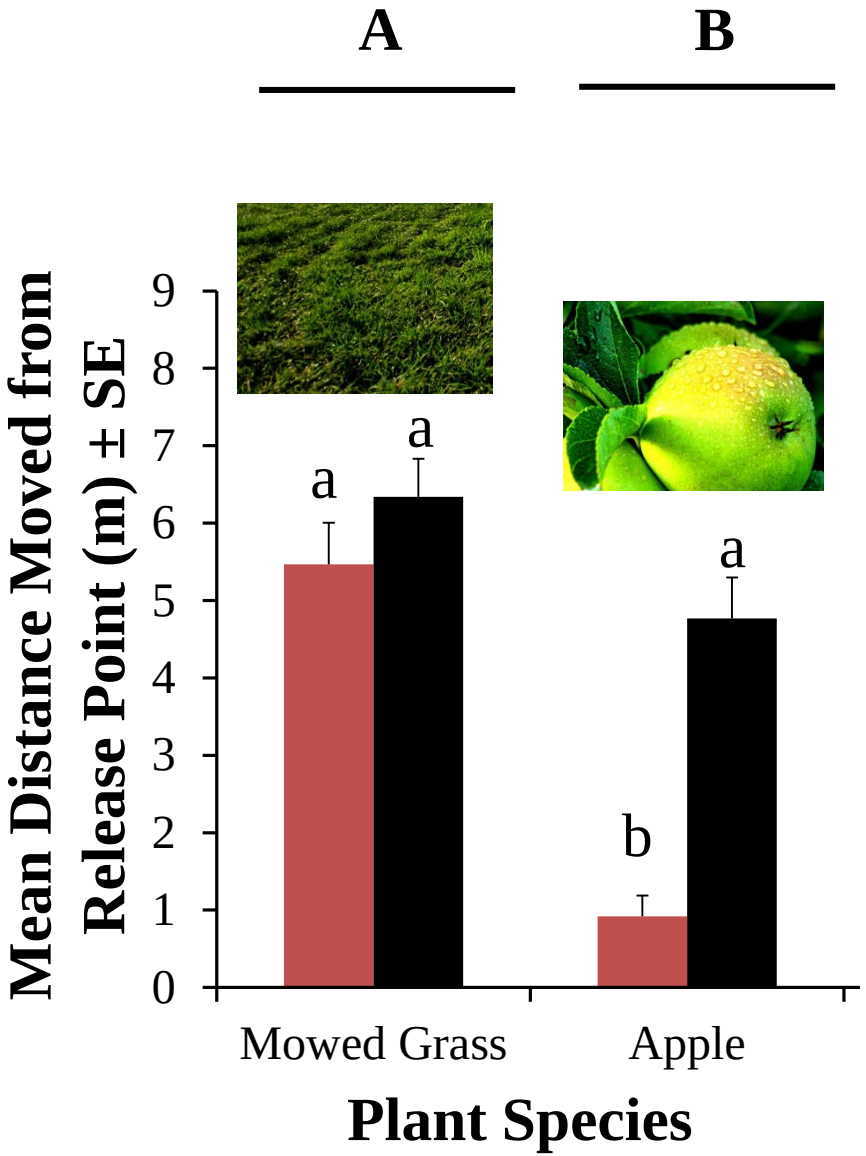
$P < 0.02$

Baited

Unbaited

(Morrison et al. 2015b)

Distance Moved



ANOVA

Tree Sp.

$F_{2,306} = 83.7$

$P < 0.0001$

Bait

$F_{1,306} = 84.1$

$P < 0.0001$

Baited

Unbaited

(Morrison et al. 2015b)