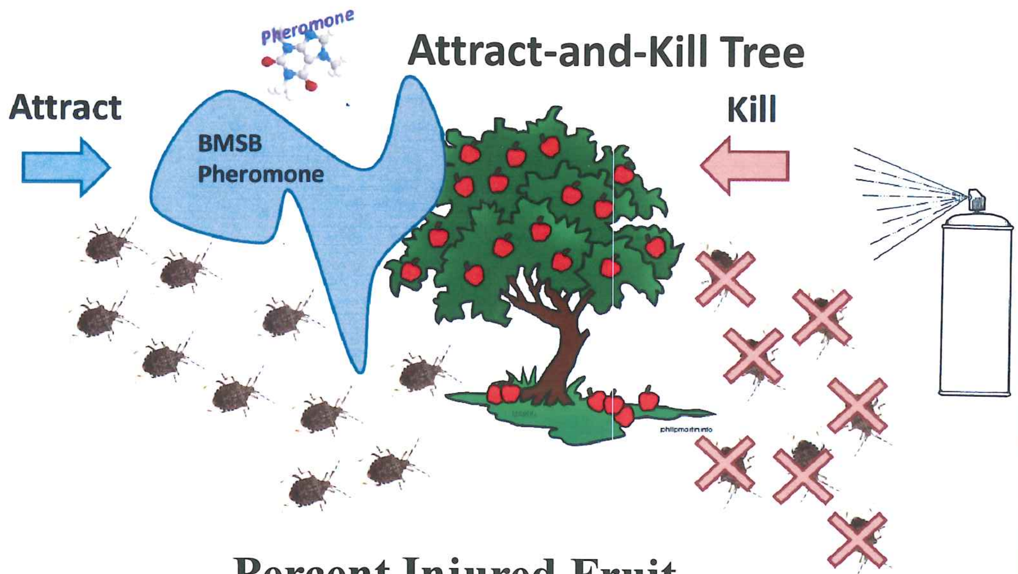
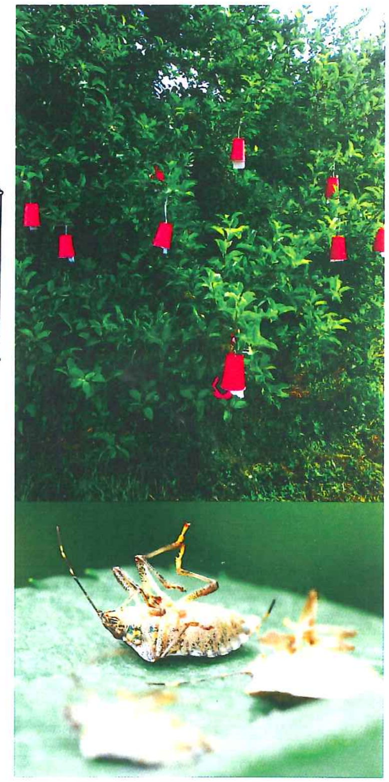
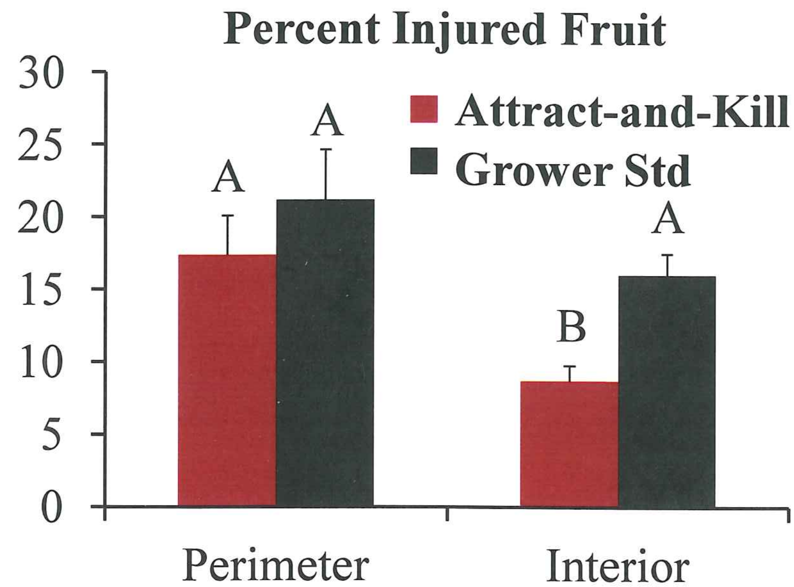
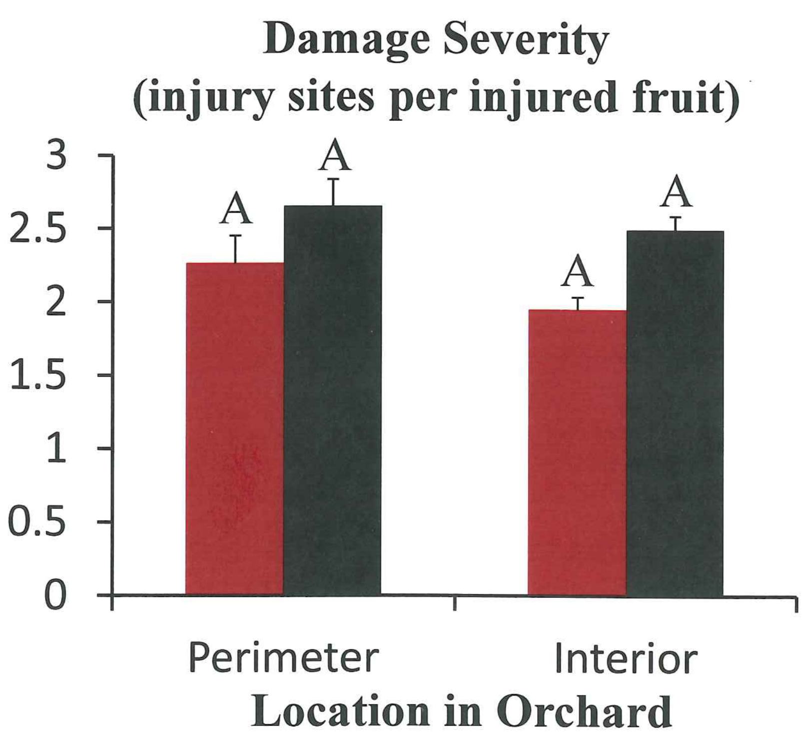
Attract-and-Kill for BMSB







Across **10 farms** in **5 mid-Atlantic States** at harvest



Explanation:

Overall for the project, the percent injured fruit was numerically or significantly less in the AK treatment compared to the grower standard, while the severity of injury was numerically less for those fruit that were injured between the two treatments.

The following pages are examples of Attract-and-Kill spray programs separated by different cultivar harvest times. In our research trials, sprays were applied to specific trees on a weekly basis (about 7 trees per 2 acres).

Mention of specific insecticide trade names is solely for the purpose of providing scientific information and does not imply endorsement by the United States Department of Agriculture.

Mid- to Late-August Apple Ripening Schedule for Brown Marmorated Stink Bug

Attract-and-Kill

Week of Application	Trade Name	Active Ingredient	Recommended Rate/Acre	PHI (days)
June 6	Belay	Clothianidin	6 oz	7
June 13	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
June 20	Leverage 360	Beta-cyfluthrin + imidacloprid	2.8 oz	7
June 27	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
July 4	Bifenture EC/Bifenture DF	Bifenthrin	10 oz/16 oz	14
July 11	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
July 18	Danitol	Fenpropathrin	21 oz	14
July 25	Belay	Clothianidin	6 oz	7
August 1	Danitol	Fenpropathrin	21 oz	14
August 8	Bifenture EC/Bifenture DF	Bifenthrin	10 oz/16 oz	14
August 15	Venom	Dinotefuran	6.75 oz	3
August 22	Venom	Dinotefuran	6.75 oz	3

Insecticides with negligible impact on BMSB:

Altacor (chlorantraniliprole)

Avaunt (indoxacarb)

Belt (flubendiamide)

Delegate (spinetoram)

Imidan (phosmet)

Intrepid (methoxyfenozide)

Rimon (novaluron)

Mid- to Late-September Apple Ripening Schedule for Brown Marmorated Stink Bug

Attract-and-Kill

Week of Application	Trade Name	Active Ingredient	Recommended Rate/Acre	PHI (days)
June 6	Belay	Clothianidin	6 oz	7
June 13	Tombstone	Cyfluthrin	2.8 oz	7
June 20	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
June 27	Bifenture EC/Bifenture DF	Bifenthrin	10 oz/16 oz	14
July 4	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
July 11	Wrangler	Imidacloprid	8 oz	7
July 18	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
July 25	Wrangler	Imidacloprid	8 oz	7
August 1	Bifenture EC/Bifenture DF	Bifenthrin	10 oz/16 oz	14
August 8	Danitol	Fenpropathrin	21 oz	14
August 15	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
August 22	Danitol	Fenpropathrin	21 oz	14
August 29	Belay	Clothianidin	6 oz	7
September 5	Bifenture EC/Bifenture DF	Bifenthrin	10 oz/16 oz	14
September 12	Venom	Dinotefuran	6.75 oz	3
September 19	Venom	Dinotefuran	6.75 oz	3

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Avaunt (indoxacarb)

Belt (flubendiamide)

Delegate (spinetoram)

Imidan (phosmet)

Intrepid (methoxyfenozide)

Rimon (novaluron)

Mid-October Apple Ripening Schedule for Brown Marmorated Stink Bug

Attract-and-Kill

Week of Application	Trade Name	Active Ingredient	Recommended Rate/Acre	PHI (days)
June 6	Belay	Clothianidin	6 oz	7
June 13	Mustang Maxx	Zeta-cypermethrin	4 oz	14
June 20	Tombstone	Cyfluthrin	2.8 oz	7
June 27	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
July 4	Mustang Maxx	Zeta-cypermethrin	4 oz	14
July 11	Bifenture EC/Bifenture DF	Bifenthrin	10 oz/16 oz	14
July 18	Lannate SP	Methomyl	16 oz	14
July 25	Wrangler	Imidacloprid	8 oz	7
August 1	Mustang Maxx	Zeta-cypermethrin	4 oz	14
August 8	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
August 15	Wrangler	Imidacloprid	8 oz	7
August 22	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
August 29	Bifenture EC/Bifenture DF	Bifenthrin	10 oz/16 oz	14
September 5	Endigo ZC	Lambda-cyhalothrin + thiamethoxam	6 oz	35
September 12	Danitol	Fenpropathrin	21 oz	14
September 19	Belay	Clothianidin	6 oz	7
September 26	Danitol	Fenpropathrin	21 oz	14
October 3	Bifenture EC/Bifenture DF	Bifenthrin	10 oz/16 oz	14
October 10	Venom	Dinotefuran	6.75 oz	3
October 17	Venom	Dinotefuran	6.75 oz	3

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Altacor (chlorantraniliprole)

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Intrepid (methoxyfenozide)

Rimon (novaluron)

Integrated Pest Management for Brown Marmorated Stink Bug in Orchard Crops

A synopsis of what researchers have learned so far and management recommendations using an integrated approach

Authored by the BMSB SCRI CAP Orchard Crop Commodity Team:

Chris Bergh and Angel Acebes-Doria (Virginia Tech), Tracy Leskey, Rob Morrison and Brent Short (USDA ARS Kearneysville, WV), Greg Krawczyk (Pennsylvania State University), Jim Walgenbach (North Carolina State University), Arthur Agnello and Peter Jentsch (Cornell University), George Hamilton, Anne Nielsen and Brett Blaauw (Rutgers University), Vaughn Walton, Nik Wiman, Chris Hedstrom and Peter Shearer (Oregon State University), and Betsy Beers (Washington State University)

Basic Biology and Life Cycle of BMSB

- References herein to specific points in the growing season are based on information from the Mid-Atlantic region, where the seasonal biology of BMSB is currently understood best, and may vary in other regions.
- BMSB is a serious agricultural pest of numerous crops during the late spring and summer.
- After emerging from overwintering sites in May and June, BMSB adults begin mating and laying eggs on various host plants (Fig. 1).
- In most of its range in North America, BMSB completes one to two generations per year, progressing from the egg stage through five nymphal stages (instars) before molting into a winged adult (Fig. 2).

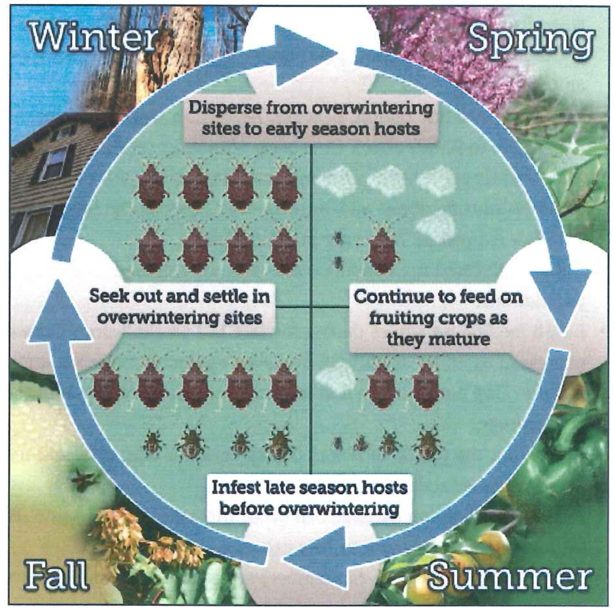

Fig. 1. Typical seasonal biology of brown marmorated stink bug.

Orchard Crops at Risk / Crops Not at Risk

- BMSB may move frequently among different wild and cultivated host plant species, feeding alternately among them.
- BMSB nymphs and adults feed by inserting their piercing-sucking mouthparts into fruit, nuts, seed pods, buds, leaves, and stems and appear to prefer plants bearing reproductive structures. Their mouthparts can penetrate very hard and thick tissue, such as the hazelnut hull.
- Older nymphs and adults cause more injury to apples and peaches than young nymphs.
- Peach is considered a preferred and highly vulnerable host. The survival of BMSB nymphs has been studied on only a few hosts, but peach was the only host on which they completed development without feeding on another plant.
- Nectarines show BMSB injury and may be as vulnerable as peach, but the relative susceptibility of apricots is less well known.
- Apples and European and Asian pears are also very susceptible to BMSB feeding injury.
- Economic injury from BMSB to hazelnuts has been documented in Oregon, but other nut crops have been less well studied at present.
- Cherries can sustain BMSB feeding injury, but the effects at harvest are usually small.
- Plums and plum hybrids are not considered as vulnerable to BMSB as some other tree fruits.

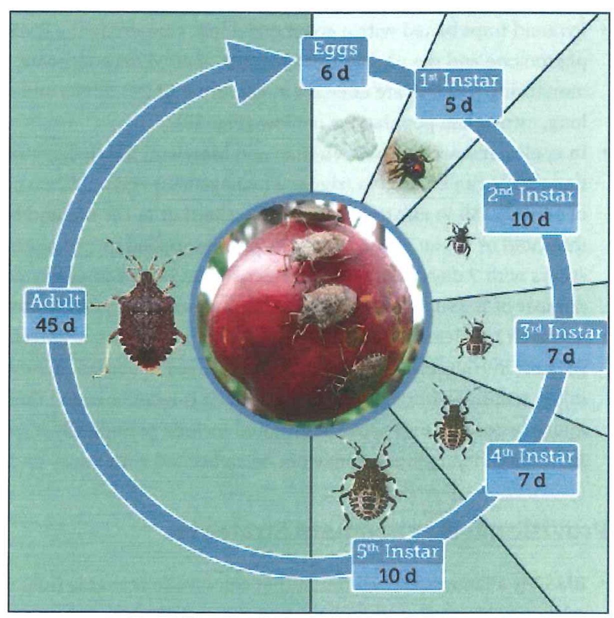

Fig. 2. Life cycle of brown marmorated stink bug.

Orchard Crop Injury Diagnostics

- BMSB feeding through the skin of tree fruits can cause injury to the fruit surface and flesh. These injuries are not immediately apparent, but develop gradually after feeding has occurred.
- Feeding on young peaches, nectarines, and apricots causes gummosis at the feeding site (Fig. 3), deformations on the fruit surface (Fig. 4), and brownish-red internal necrosis (Fig. 5).
- Feeding on more mature peaches and nectarines may or may not result in apparent surface injury at harvest but can cause areas of whitish necrosis in the flesh (Fig. 6), which has been an important marketing issue.
- The mouthpart insertion point on apples and pears leaves a tiny hole in the skin (Fig. 7) and a "stylet sheath" that runs into the flesh (Fig. 8), both of which are best

detected under magnification. Apples and pears also exhibit surface deformations and shallow discolored depressions from BMSB feeding (Fig. 9).

- In apples and pears, most surface depressions are associated with an area of brown necrosis in the flesh beneath (Fig. 10).
- BMSB injury symptoms on apples may be mistaken for the physiological disorders associated with calcium deficiency, known as bitter pit and cork spot.
- Cherries show small punctures in the surface (Fig. 11) and external discoloration, but internal injury has not been as well characterized as for some other tree fruit crops.
- Hazelnuts show no visible external signs of damage. Injury from feeding on the nut flesh can only be determined by shelling the nut, revealing blank nuts (Fig. 12), shriveling (Fig. 13), or corky tissue (Fig. 14).

Period of Risk/Susceptibility

- BMSB adults and nymphs have a strong dispersal capacity and can fly or walk into crops from surrounding habitat and host plants through most or all of the fruiting period. In general, highest populations in orchards have been recorded in August and September.
- In the Mid-Atlantic region, peaches, nectarines, and likely apricots are considered vulnerable to BMSB attack from soon after crop set through harvest.
- Mid-Atlantic apples and pears may exhibit some injury by late May, but this is most common starting about mid-June and increases as the season progresses. The timing of injury expression may vary in other regions.
- Apples harvested in September and later are exposed to the highest annual BMSB populations.
- BMSB feeding on apples during the last 1–2 weeks before harvest may not be expressed as injury at harvest; however, apples showing no surface injury at harvest may develop both surface and internal injuries following a period in post-harvest cold storage.
- At present, the period of risk to cherry varieties with different harvest dates has not been characterized.
- In hazelnut, feeding damage can occur throughout the season. Feeding during nut flesh formation in June and July can cause blank or shriveled nuts. Feeding after nut flesh formation (August–September) can result in corking at harvest (classified as "decay" by processors).

Provisional Monitoring and Scouting Recommendations

- Pyramid traps baited with a commercial lure containing the BMSB aggregation pheromone and the pheromone synergist, methyl decatrienoate, can be an excellent monitoring tool and are effective at capturing BMSB adults and nymphs season-long, even when populations are low (Fig. 15).
- In apples, research in West Virginia and Maryland has demonstrated that captures in these traps can be used to trigger a management action. When cumulative captures of adult BMSB in any trap within the orchard or at the orchard border reached a threshold of 10, an effective insecticide was applied as two alternate-row-middle sprays with 7 days between. This strategy has been demonstrated to reduce the number of BMSB-targeted sprays while maintaining good control of injury.
- Research has demonstrated that BMSB injury to apples at harvest tends to be greatest in fruit from the upper canopy of trees in border rows next to woods, aiding injury scouting efforts during the season. It is recommended that scouting for BMSB injury to peaches and nectarines should include periodically inspecting sampled fruit for internal injury, since it may not be associated with injury on the fruit surface.

Provisional Management Strategies

- BMSB is a landscape-level threat that can invade orchards from wooded habitats, other nearby crops, and in the spring, potentially from human-made structures (Fig. 16).
- BMSB does not reside permanently in any crop; pest pressure from it is often

Fig. 3. Gummosis from BMSB feeding on peach.

Fig. 4. Surface deformations on peach.

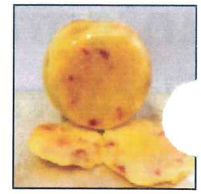

Fig. 5. Reddish-brown internal necrosis on peach.

Fig. 6. Shallow whitish internal necrosis on peach.

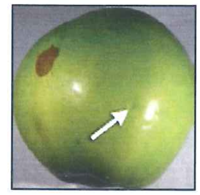

Fig. 7. BMSB stylet insertion point on apple.

Fig. 8. Stylet sheath on apple.

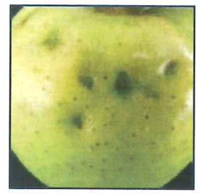

Fig. 9. Discolored depressions on apple.

Fig. 10. Internal necrosis on apple.

Fig. 11. BMSB injury on cherry.

Fig. 12. Blank hazelnut.

Fig. 13. Shriveled hazelnut.

Fig. 14. Internal necrosis on hazelnut.

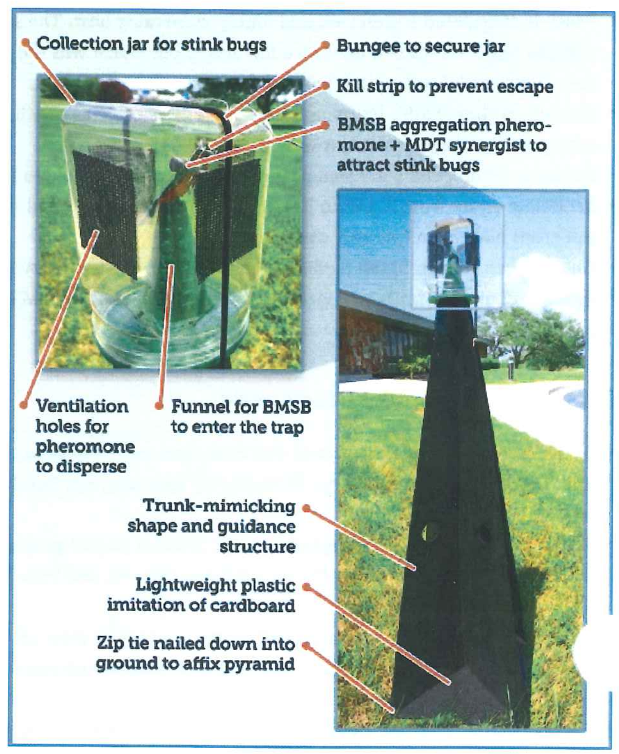

Fig. 15. Commercial stink bug pheromone trap.

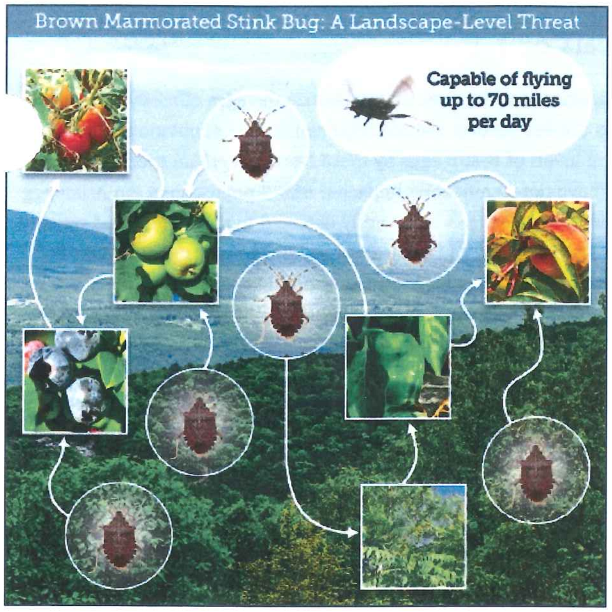

Fig. 16. BMSB is a landscape-level threat that can invade orchards from wooded habitats and other nearby crops.

highest along orchard edges, especially edges bordering woodlands with its wild host plants.

- The intensity of BMSB management required during each growing season can vary according to the size of the adult population that survives the winter and the subsequent rate of population growth. Winter temperatures lower than about 10°F cause increasing rates of mortality, although BMSB numbers tend to increase substantially between spring and late summer.
- BMSB management in peaches and nectarines may be considered from shuck-split onward. Management in apple and pears may begin in early to mid-June, although in years with high BMSB pressure, intervention beginning in the latter part of May could be prudent.
- In hazelnut, intervention against BMSB in August and September may yield the most beneficial economic impacts.
- Use of the pheromone trap-based provisional threshold (see Provisional Monitoring and Scouting Recommendations) in apples may enhance management effectiveness and efficiency.
- The overwintering generation of BMSB tends to be more susceptible to insecticides than the summer generation. Therefore, products with the best effectiveness against this pest should be used later in the season.
- Insecticides should be rotated among products in different classes with different modes of action (see Table).
- Many of the effective insecticides for BMSB have relatively short residual activity

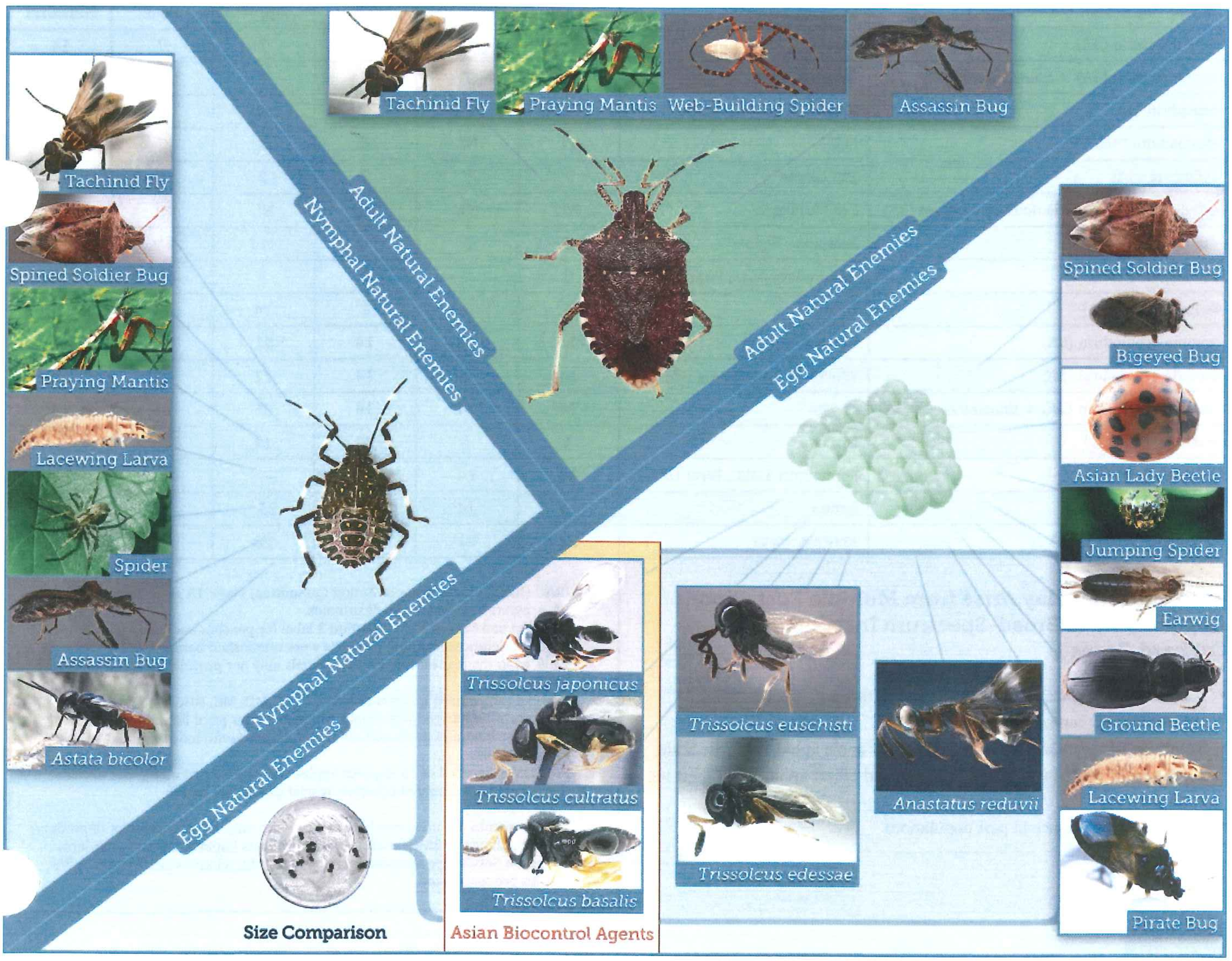

Fig. 17. Arthropod natural enemies of BMSB.

against it; thus, alternate-row-middle applications at about 7-day intervals may improve control.

- Virtually all effective insecticides against BMSB (see Table) also kill natural enemies and should be used only when necessary. Reducing pyrethroid applications in crops and/or limiting sprays to border row trees can help protect important natural enemies.
- Weekly border sprays (insecticide treatment to orchard perimeter plus the first full row) in peach have shown to be equally effective as alternate row middle application at protecting fruit.
- Perimeter-based management tactics, such as orchard border row sprays and pheromone-based "attract-and-kill", are being evaluated and show promise for BMSB management in apple.
- ALWAYS read the label before applying any insecticide.

Biological Control

- Various species of tiny wasps that parasitize the eggs of most native stink bug pests are key natural enemies that can reduce populations. However parasitism levels of BMSB eggs by these North American species have been low and have not significantly impacted BMSB populations. An Asian egg parasitoid of BMSB eggs was recently detected in the eastern and western USA. This species shows high levels of BMSB egg parasitism in Asia and may eventually have significant impacts on BMSB here.
- Various generalist predatory insects will feed on BMSB eggs and nymphs, and also may provide important biological control services against this pest (Fig. 17).

Effective Insecticides for Controlling BMSB in Orchard Crops

The following is a list of insecticides registered for use on orchard crops in the U.S. that have demonstrated efficacy against BMSB in laboratory and/or field trials. This list may not be exhaustive for every active ingredient or labeled product. Before using any pesticide, ensure that the product is registered for use on the target crop in your state. Some materials that have shown effectiveness against BMSB are not labeled for use in certain states. This list is not to be considered a substitute for pesticide labeling. Always read, understand, and follow the label directions before using any pesticide.

		Crops listed on pesticide label with pre-harvest interval (days). "NL" indicates not labeled on that crop.					
Active Ingredient (IRAC class*)	**Product Name(s)**	**Peach**	**Nectarine**	**Apricot**	**Apple**	**Pear**	**Hazelnut**
beta-cyfluthrin (3A)	Baythroid XL	7	7	7	7	7	14
beta-cyfluthrin (3A) + imidacloprid (4A)	Leverage 360	7	7	7	7	7	14
bifenthrin (3A)	Bifenture, Brigade, Sniper	NL	NL	NL	NL	14	7
clothianidin (4A)	Belay	21	NL	NL	7	7	21
cyfluthrin (3A)	Tombstone	7	7	7	7	7	14
diflubenzuron (15) + lambda-cyhalothrin (3A)	DoubleTake	NL	NL	NL	NL	NL	28
dinotefuran (4A)	Scorpion[1], Venom[1]	3	3	NL	NL	NL	NL
imidacloprid (4A)	Admire Pro, Alias, Wrangler	0	0	0	7	7	7
fenpropathrin (3A)	Danitol	3	3	3	14	14	3
gamma-cyhalothrin (3A)	Declare, Proaxis	14	14	14	21	21	14
lambda-cyhalothrin (3A)	Warrior II, Lambda-Cy, Silencer	14	14	14	21	21	14
lambda-cyhalothrin (3A) + thiamethoxam (4A)	Endigo	14	14	14	35	35	14
methomyl (1A)	Lannate	4	1	NL	14	7[2]	NL
permethrin (3A)	Permethrin 3.2EC, Perm-UP	14	14	NL	—[3]	—[3]	14
thiamethoxam (4A)	Actara	14	14	14	35[4]	35[4]	NL
zeta-cypermethrin (3A)	Mustang Maxx	21	21	21	28	28	7

* – IRAC (Insecticide Resistance Action Committee) class: 1A = carbamates, 3A = pyrethroids, 4A = neonicotinoids.

1 – Scorpion and Venom have a Section 3 label for peaches and nectarines. Since the residue tolerances for these products were established before BMSB became an issue, even the highest rate on these labels may not provide adequate control of BMSB.

2 – Lannate can be used in pears only in CT, DE, MD, ME, NH, NJ, NY, PA, RI, & VT.

3 – Permethrin-based products cannot be applied after petal fall in apples and only during pre-bloom in pears and are therefore not useful for BMSB management in those crops.

4 – Pre-harvest interval of 35 days for apples and pears based on the use of rates that would be considered effective against BMSB (see label).

Product names are mentioned for convenience only. No endorsement of products is intended, nor is criticism of unnamed products implied. Consult your local Extension Service for more information about the relative effectiveness of the various products listed.

Problems That May Arise from Multiple Post-Bloom Applications of Broad-Spectrum Insecticides in Orchard Crops

- Destruction of natural enemies, including arthropod predators and parasitoids that can control other pests
- Outbreaks of secondary pests such as woolly apple aphid, San Jose scale, white peach scale, spider mites, hazelnut and filbert aphid, and filbert big bud mite
- Selection for resistance in pest populations

Produced by the Brown Marmorated Stink Bug SCRI CAP Orchard Crop Commodity Team in conjunction with the Northeastern IPM Center.
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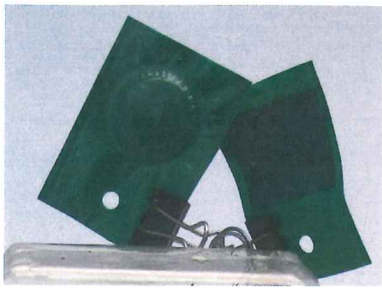
Brown Marmorated Stink Bug Lures and Traps

AgBio.

Monitoring lure ("Stink Bug Xtra Combo") = $7.95 each. Lure lasts 4 weeks.



Reusable 4 ft. black pyramid trap ("Dead-Inn Grower Trap") = $32.00 each. Killing agent needed inside trap, but not included. Lure not included.

Reusable 2 ft. black pyramid trap ("Dead-Inn Professional Trap") = $22.00 each. Killing agent needed inside trap, but not included. Lure not included.

Reusable 16" black pyramid trap ("Dead-Inn Homeowner Trap") = $19.00 each. Killing agent needed inside trap, but not included. Lure not included.

Grower Trap

Professional Trap

Homeowner Trap

AgBio continued.

Clear sticky trap = $3.95 each. 6" x 28" single-sided sticky trap. Should be back-folded for best results. No lure included. Probably needs changed every 4-6 weeks, but the glue will last longer if trap is clear of debris.

Alpha Scents.

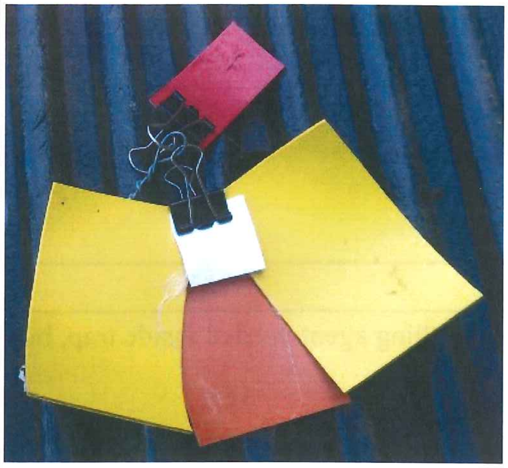
Monitoring lure = $6.25 each (no minimum), $4.60 each (25 minimum), $4.25 each (100 minimum). Lure lasts 30 days.

Reusable black pyramid trap = $14.00 each. Killing agent needed inside trap, but not sold with trap. Lure not included.

Reusable black modified panel trap = $26.00 each. Killing agent needed inside trap, but not sold with trap. Lure not included.

Hercon Environmental.

Monitoring lures = Pricing not available. Lures last 8 weeks.



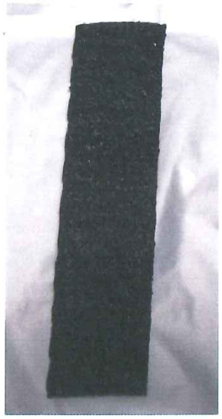
Rescue (Sterling International).

Monitoring lures = $8.00. Lasts 7 weeks.

Reusable stink bug trap = $15.00. No killing agent needed.

Trece, Inc.

Monitoring lures ("Pherocon BMSB Lure") = Approx. cost: 5pk =$24.69. Lure lasts 8 weeks.



Clear sticky traps = Approx. cost: 5pk = $17.50. 6" x 9" double-sided sticky trap. No lure included. Probably needs changed every 4-6 weeks, but the glue will last longer if trap is clear of debris.

Funnel traps = Approx. cost: $33.75 for 5 pk. Lure sold separately. Killing agent may be needed inside trap, but sold separately.