Managing Brown Marmorated Stink Bug in Michigan Orchards

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KEY POINTS:

- Adults **hibernate** in woodlots and manmade structures, becoming a nuisance pest in many MI homes before migrating out to feed on fruit, fruiting vegetables, nuts, and seed pods.
- **One generation** is expected per season in Michigan.
- Females lay **eggs in clusters** on the underside of leaves.
- **Adults and nymphs cause fruit damage** when they feed, but the damage may only become apparent weeks later or after fruit are brought out of storage; damage will look similar to other stink bugs and tarnished plant bugs.
- **Peaches** are attractive at any stage when fruit is present; **apples** become attractive mid-season and feeding damage close to harvest can be mistaken for bitter pit.
- Adults and nymphs are attracted to many other fruits, vegetables, field crops, and wild plants; these **other plants can act as reservoirs** for the highly mobile insects.
- Use **on-farm monitoring** to assess when the pest in moving into orchards and to determine when to begin management.
- Protect fruit from damage with effective registered **insecticides**; target insecticide applications at the tops of trees and orchard edges.
- **Plant flowers in orchard margins** to boost local populations of parasitoids and other beneficial insects.

DISTRIBUTION, BIOLOGY, IDENTIFICATION

Distribution of BMSB in Michigan

Brown marmorated stink bug (BMSB), *Halyomorpha halys,* is a tree-loving pest native to Asia. It was first detected in the U.S. mainland in Pennsylvania in 1996. By 2006, it was causing major damage to apple and peach crops in the mid-Atlantic region. The first Michigan detection was in Berrien County in 2010, followed several years later by the start of reports of suspected BMSB fruit damage. Nuisance reports from thousands of Michigan residents as of Summer 2020 indicate that BMSB populations are well-established in the southern Lower Peninsula. BMSB has been reported in all but four Michigan Counties (Alger, Baraga, Gogebic, and Luce).

Key features

Adult BMSB (Fig. 1) are ½ inch long by 5/8 inch wide, with a banded pattern along the margin of their abdomen and banding on their antennae and legs; they also have smooth shoulders rather than toothed like some of our native species. Eggs are greenish-white in color and laid in clusters. There are five nymphal stages. The first nymphal stage is black and red. The other four nymphal stages are brown like the adult (Fig. 2).

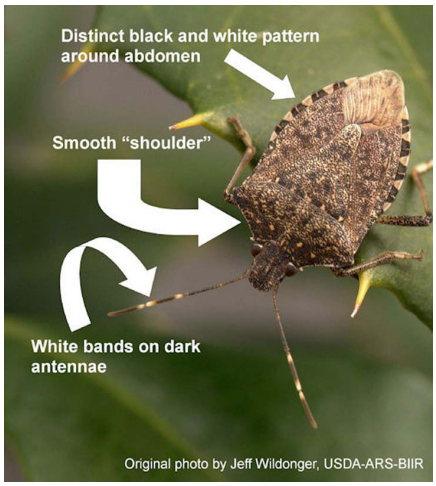


Fig. 1. Key identifying features of brown marmorated stink bug adults include a banded pattern along the abdomen and antennae with smooth, rounded shoulders.

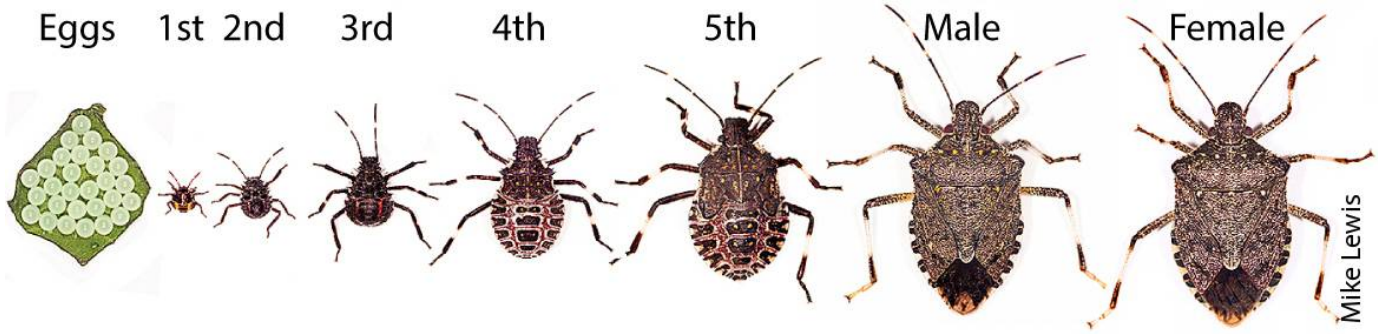


Fig. 2. Life stages of the brown marmorated stink bug. Nymphs and adults feed on plants and can cause crop damage.

Biology and lifecycle

BMSB adults emerge from overwintering sites (e.g. woodlots, manmade structures) in response to a day length of 13.5 hours, which is mid-April in Michigan (Table 1). Egg laying begins after 170 degree days (DD = base 57.2°F) have accumulated, around the end of May. Females lay clusters of up to 28 greenish-white eggs on the undersides of leaves of preferred host plants (Table 2), and between 10-20 egg clusters in their lifetime. Feeding and development continue through five nymphal stages before molting into the adult stage in early to late August. High densities of BMSB and the potential for damage in orchards become more likely at this time. The summer generation continues to feed before moving to overwintering sites beginning in early September through November. The adult produces an attractant, called an aggregation pheromone, which attracts other adults to the same location. This is why clusters of adults can be found gathering on buildings. One generation is thought to occur in Michigan.

Table 1. Estimated dates when brown marmorated stink bug (BMSB) life stages are expected to appear during the season. The model is based on using a 13.5-hour day as the biofix for BMSB emerging from overwintering, 170 degree days (DD base 57.2 °F) until egg laying begins, and then another 964 DD (base 57.2 °F) for those eggs to develop into adults. Scouting for nymphs in orchards with a history of damage should begin by the 2nd week in June.

Event ->	1st overwintered adult expected	Egg laying begins		New (summer) generation adults expected
Environmental cue ->	**13.5 hr day**	**170 DD* (base 57.2 °F)**		**1134 DD* (base 57.2 °F)**
Benton Harbor	19-Apr	26-May	**Various nymph stages present through mid-August**	6-Aug
Romeo	19-Apr	26-May		10-Aug
Fennville	19-Apr	29-May		16-Aug
Sparta	18-Apr	30-May		20-Aug
Hart	18-Apr	1-June		27-Aug
Traverse City	16-Apr	2-June		25-Aug

*Degree days were calculated using the Baskerville-Emin method in Enviro-weather (https://mawn.geo.msu.edu/) starting with the date when day length reaches 13.5 hours in a given area averaged over a 10 year period (2007-2017).

Host plant preferences

The list of plants on which BSMB will feed includes many wild, agricultural, and ornamentals. Preferred hosts are non-native ornamental trees and shrubs that bear seed pods or fruit, but they will also feed on and damage herbaceous fruiting plants. Woodlands are important overwintering sites and a source of non-crop hosts. BMSB move in and out of different habitats over the course of a season, therefore, it is useful to know what highly attractive (i.e. high risk) plants are adjacent to your orchard to focus monitoring efforts (Table 2).

Table 2. Relative risk of damage by brown marmorated stink bugs to Michigan specialty crops, field crops, and ornamentals.

Risk Level	Tree Fruit & Nuts	Berries & Grapes	Vegetables	Field crops	Ornamentals
High	apple, hazelnut, nectarine, peach[1], pear (Asian and European)	grape[2]	beans (green, pole, snap), edamame, eggplant, okra, pepper, sweet corn, Swiss chard, tomato	dry beans, field corn, soybeans, sunflowers	bee-bee tree, black cherry, buckthorn[4], catalpa, crab apple, English holly (female), Japanese pagoda tree, multiflora rose[4], Peking lilac tree, redbud, tree of heaven[4], wild raspberry[4]
Moderate	apricot, cherry[2] (sweet and tart), plum, walnut	blackberry, blueberry[2,3], raspberry	asparagus, broccoli, cauliflower, collard, cucumber, horseradish, lima bean, tomatillo	winter wheat[5]	black walnut, flowering dogwood, littleleaf linden, maples, serviceberry
Low		cranberry, strawberry	carrot, garlic, kohlrabi, leeks, lettuce, onion, potato, spinach, sweet potato, turnip		blackgum, ginkgo, Japanese maple, kousa dogwood

NOTES for Table 2: 1 – Additional risk potential due to bark feeding. 2 – Potential risk of taint/contamination. 3 – Considered moderate to high risk. 4 – Considered to be a particularly attractive and important host plant. 5 – Considered to be a population source more than a crop damaged by BMSB.

BMSB in orchards

When BMSB are abundant, most tree fruit grown in Michigan should be considered at moderate to high risk from BMSB feeding damage. In the high-risk group are apple, nectarine, peach, and pear. In the moderate risk group are apricot and cherry. As populations continue to increase in Michigan, damage to stone fruit and apples is expected to increase with nymphs appearing as early as June and mixed populations of nymphs and adults peaking in August. BMSB nymphs and adults can both cause damage in tree fruit, but the damage may not be detected until weeks or even months later – especially in the case of fruit that is stored before being sold. Tarnished plant bug and other stink bug damage can appear similar BMSB damage. Keep records of where damaged fruit occurred on your farm – those will be the orchards to monitor closely next year.

Fruit damage in nectarines and peaches

Peaches, nectarines, and apricots are vulnerable to damage soon after fruit set until harvest. In these crops, BMSB monitoring should start after shuck-split. Soon after bloom, damaged fruit are likely to drop. Mid-season feeding damage (Fig. 3A) will produce cat-facing injury, weeks after the feeding has occurred, which is also typical of plant bugs (Fig. 3B). Late season damage will look more like water-soaked depressions in the fruit (Fig. 3C), but again, damage may go unnoticed until weeks after the feeding has occurred.

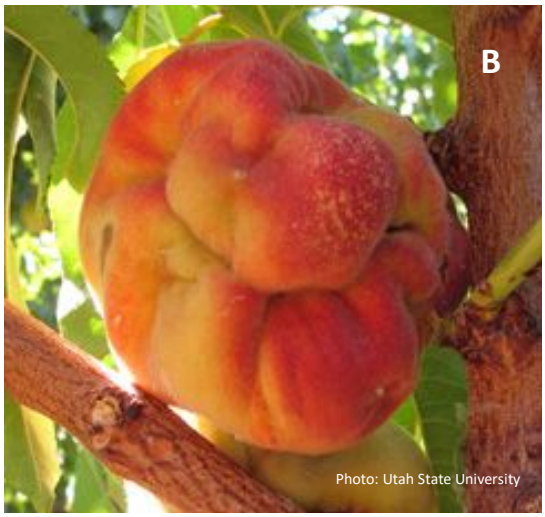


Fig. 3. A) Mid-season feeding by 2nd instar nymphs on a peach in late June; under the yellowed leaf is the egg mass from which they emerged (above). B) Mid-season feeding by stink bugs can turn into cat-facing injury in peaches and nectarines (upper right). C) Injury from stink bug feeding at a later stage will appear as water-soaked lesions (lower right).

Fruit damage in apples

Apple and pear fruitlets may be injured as early as late May where populations are very high. In Michigan, we have seen some feeding damage in fruitlets in early July (Fig. 4). However, the majority of damage in these crops is expected in August and September, with damage becoming apparent weeks after feeding has occurred. Similar to stone fruit, if damage occurs soon after bloom, damaged fruit is likely to abort. Damage occurring later in the season may be confused with bitter pit on the surface, but when the fruit is sliced, the interior will be corky (Fig. 5). If damage occurs 1-2 weeks before harvest, apples may show no visible signs of injury, but will develop brown and necrotic areas in the flesh during post-harvest storage.

Fig. 4. Exploratory feeding injury by stink bugs in early July in Gala apples. This kind of damage has been seen in Golden Delicious and Honeycrisp in Michigan as well. When you cut into the apple, you will see evidence of the stylet (stink bug mouth part) used to feed on the apple. Not seen are the actual culprits. *Photos by Amy Irish-Brown, MSU Extension.*

Fig. 5. Adult stink bugs in late September feeding on ripening apple (left). Injury to apple may be confused with bitter pit except that it will appear anywhere on the apple vs. on the calyx end where bitter pit typically appears (right). When fruit is cut, flesh will be corky (right, inset); late season injury can go unnoticed until fruit is taken out of storage.

TRAPPING FOR NYMPHS & ADULTS

While BMSB are fairly easy to identify and distinguish from native stink bugs, they can be extremely cryptic in orchards. They prefer the tops of trees and their coloring exactly matches tree trunks. Traps are easy to deploy and check, but the area of influence for a single baited trap appears to be relatively small, and not terribly efficient. Therefore, it is best to place traps so that BMSB are intercepted as they move between habitats.

Photo: Julianna Wilson

Photo: Michael Haas

Photo: Chris Adams

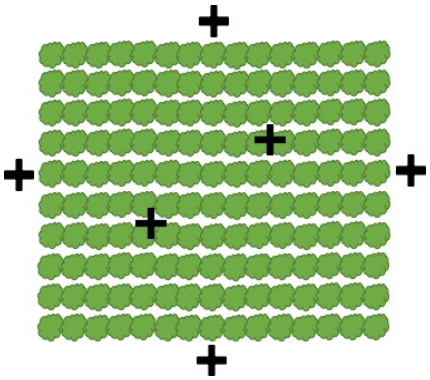
Fig. 6. Examples of traps used to monitor for BMSB: pyramid style (left), Rescue® brand (middle), and a clear sticky panel (right). All of the traps need to be baited with a lure. The fins of the Rescue® trap must touch the trunk or trellis post to which it is attached for the nymphs to be able to crawl up into it.

Traps

Several different kinds of traps are available (Fig. 6). Most tend to have a pyramid shape with fins that need to either touch the ground or be attached to a tree trunk or post in such a way that nymphs can walk up into them. There is also a new clear sticky panel trap that can be attached to a tall stake. All of these traps must be paired with lures.

Lures

Lures are meant to be attractive to both nymphs and adults, but they appear to become more attractive later in the summer when the pest is naturally more inclined to respond to aggregation pheromones. Several commercial lures are available, but all of them appear to have a relatively limited range of attraction. In other words, BMSB need to be in the vicinity in order to pick up on the scent. Follow the manufacturers recommendation for how often to replace lures.



Making the most of BMSB traps

Traps are used to intercept BMSB as they move among different host plant habitats and to guide decisions about when to apply insecticide. It is recommended that growers use six traps per every ten acres, with four traps placed around the perimeter and two traps placed in the interior in orchards where damage has been detected previously or is otherwise considered to be at high risk of damage (see diagram to the left). Traps should be checked, at minimum, once per week and when perimeter traps have captured an accumulation of 10 nymphs or adults, a spray would be triggered.

CROP DAMAGE PREVENTION

As BMSB populations continue to increase in Michigan, growers are strongly encouraged to scout for BMSB. An effective management program entails: 1) Knowing where preferred host plants are located in relation to vulnerable orchards, 2) Scouting and/or trapping for BMSB in orchard margins, 3) Keeping good records of which orchards show signs of damage at harvest or post-harvest, and 4) Using the best application timing and method for insecticides effective against BMSB that are registered for use in your crop.

Pesticide registrations and recommendations will change as we learn how to better manage this pest, and growers can remain informed through the MSU BMSB website, local Extension Educators, and the MSU Extension News for Agriculture (www.canr.msu.edu/fruit).

Fig. 7. Good coverage is essential to protecting tree fruit from BMSB feeding damage. Expect to use high spray volumes, slow down the tractor, use full cover applications, and return with an application of a different effective insecticide after a rainfall event.

Chemical control

Many of the insecticides currently registered for use against other common tree fruit pests will also provide good protection against BMSB. Effective insecticide options may be found in the pyrethroid, neonicotinoid and carbamate chemical classes (Tables 3 and 4) Always follow the specific label restrictions for the target crop, being aware of the pre-harvest interval (PHI), re-entry interval (REI), other pests that may be present, and potential impacts on existing IPM programs (see the Michigan Fruit Management Guide E-154 for more details).

OMRI

There is only one product approved by the Organic Materials Review Institute (OMRI) – Azadirachtin – that shows some activity against BMSB in peach, but is not recommended for use in apple due to the potential for phytotoxicity damage after the pink stage.

Managing BMSB in NECTARINES and PEACHES

Begin monitoring for BMSB in peaches in mid to late May, especially along wooded edges. In high-risk orchards or where damaging populations are found, weekly border sprays on 5-10 acre plots (crop border plus first full row) have been shown to be an effective strategy in New Jersey. Dispersal to peaches can be initially monitored using baited traps placed at the edges as described previously. Initiating sprays when BMSB are first detected has not been evaluated but might be an appropriate timing. Peaches on the interior should be monitored for injury or bug presence. If BMSB is detected on the interior a full block spray should be done. Table 3 lists the relative efficacy of insecticides labeled for use against BMSB in nectarine and peach orchards.

Managing BMSB in APPLES and PEARS

Orchards adjacent to woodlots are considered to be at highest risk of invasion. In addition to setting up trapping arrays as described above, scout for BMSB in apple using limb-jarring of upper limbs over a beating tray to determine whether BMSB are present in a given orchard. Keep track of where damaged apples were found from the previous season – these are the orchards that you will want to pay especially close attention to for potential management the following year. Timed to occur with second generation codling moth, orchards that are at risk of BMSB damage should receive a full cover of an insecticide that works on both codling moth and BMSB, making sure that the tops of the trees are well covered. Use traps as described above to monitor areas of concern on your farm and continue a BMSB management program when the threshold has been met, which is when 10 BMSB nymphs or adults have accumulated in an array of traps. Interior traps will help to determine whether follow-up perimeter spray applications are needed every 7 days until harvest. Table 4 lists the relative efficacy of insecticides labeled for use against BMSB in apple and pear orchards.

Relative efficacy of insecticides for controlling BMSB in orchards

Table 3. Relative efficacy against BMSB of insecticides registered for use in Michigan NECTARINE and PEACH.[†]

Trade Name	Active Ingredient (IRAC Group)	PHI (days)	REI (hrs)	Interval bet trts (days)	Rate per acre (lbs of AI)	Max lbs AI/A per season	Relative efficacy
Actara 25 WG	thiamethoxam (4A)	14	12	7	4.5-5.5 oz (0.07-0.086)	0.172	E
Admire Pro	imidacloprid (4A)	0	12	7	2.8 oz (0.1)	0.33	G, S
Assail 30 SG	acetamiprid (4A)	7	12	10	5.3-8 oz (0.1-0.15)	0.6	G
Aza-Direct[‡]	*Azadirachtin* (UN)	0	4	7	1-2 pints; up to 3.5 pints	NS	G
Baythroid XL	beta-cyfluthrin (3A)	7	12	14	2.0-2.4 oz (0.016-0.019)	0.044	E
Belay 2.13 SC	clothianidin (4A)	21	12	10	6 oz (0.1)	0.2	G
Besiege 112 SC	lambda-cyhalothrin (3A) & chlorantraniliprole (28)	14	24	7	6-12 oz (0.059-0.1175)	0.4	G
Danitol 2.4 EC	fenpropathrin (3A)	3	24	10	21.3 oz (0.4)	0.8	E
Endigo ZC	lambda-cyhalothrin (3A) & thiamethoxam (4A)	14	24	7	5-5.5 fl oz (0.08-0.089)	0.37	E
Lannate 90 SP	methomyl (1A)	4	96	7	1 lb (0.9)	5.4	E
Leverage 360 SE	imidacloprid (4A) & beta-cyfluthrin (3A)	7	12	14	2.8 oz (0.066)	0.132	E
Mustang Maxx 0.8 EC	zeta-cypermethrin (3A)	14	12	7	4 oz (0.025)	0.15	E
Scorpion 35 SL	dinotefuran (4A)	3	12	7	5.25-7 oz (0.135-0.18)	0.36	E
Venom 70 SG	dinotefuran (4A)	3	12	7	3-4 oz (0.131-0.175)	0.263	E
Warrior II 2CS	lambda-cyhalothrin (3A)	14	24	5	1.28-2.56 fl oz (0.02-0.04)	0.2	E

Table 4. Relative efficacy against BMSB of insecticides registered for use in Michigan APPLE and PEAR.[†]

Trade Name	Active Ingredient (IRAC Group)	PHI (days)	REI (hrs)	Interval bet trts (days)	Rate per acre (lbs of AI)	Max lbs AI/A per season	Relative efficacy
Actara 25 WG	thiamethoxam (4A)	35	12	10	4.5-5.5 oz (0.07-0.086)	0.258	E
Admire Pro	imidacloprid (4A)	7	12	10	2.8 oz (0.1)	0.5	G, S
Assail 30 SG	acetamiprid (4A)	7	12	12	2.5 oz (0.047)	0.6	G
Baythroid XL	beta-cyfluthrin (3A)	7	12	14	2.0-2.4 oz (0.016-0.019)	0.022	E
Belay 2.13 SC	clothianidin (4A)	7	12	10	6 oz (0.1)	0.2	G
Besiege 112 SC	lambda-cyhalothrin (3A) & chlorantraniliprole (28)	21	24	10	6-12 oz (0.059-0.1175)	0.4	G
Danitol 2.4 EC	fenpropathrin (3A)	14	24	10	16-21.3 oz (0.3-0.4)	0.8	E
Endigo ZC	lambda-cyhalothrin (3A) & thiamethoxam (4A)	35	24	10	5-6 oz (0.08-0.1)	0.45	E
Lannate 90 SP	methomyl (1A)	14	72	7	1 lb (0.9)	4.5	E
Leverage 360 SE	imidacloprid (4A) & beta-cyfluthrin (3A)	7	12	14	2.8 oz (0.066)	0.066	E
Mustang Maxx 0.8 EC	zeta-cypermethrin (3A)	14	12	7	4 oz (0.025)	0.15	E
Warrior II 2CS	lambda-cyhalothrin	21	24	5	1.28-2.56 fl oz (0.02-0.04)	0.2	E

KEY For Tables 3 and 4: NS = not specified on product label; S = specimen label lists this material as suppressive only; G = Good, E = Excellent, based on MSU field/lab bioassays.

NOTES for Tables 3 and 4:

[†] This is not meant to be an exhaustive list, for more ratings on materials registered for use in these crops, please refer to the Michigan Fruit Management Guide E-154. For more on the general use of these materials, please refer to the specimen labels (https://www.cdms.net/Label-Database). Although all products listed are currently labeled for use in these crops as of this revision, not all have BMSB listed on the label as targets.

[‡] Aza-direct is OMRI approved, but tank-mixing with oil-based products will cause plant injury. Not labeled for use in apple or pear after pink stage due to phytotoxicity issues.

Potential for biological control of BMSB

Biological control could help suppress BMSB populations in Michigan, but it is not expected to be a stand-alone tactic for controlling BMSB. Common predators found in Michigan orchards that will feed on BMSB eggs include spiders, lady beetle adults and larvae, minute pirate bugs, lacewing larvae, crickets, and grasshoppers. There are also predators that will feed on BMSB nymphs and adults, including spiders, assassin bugs, and predatory wasps.

Parasitoids – small, non-stinging wasps that lay their eggs inside the eggs of their host – have the potential to help suppress BMSB populations over the long-term. Although several native parasitoids have been collected in low numbers from BMSB egg clusters in Michigan orchards, it is a parasitoid native to the same part of Asia as BMSB that holds the most promise (Fig. 8). Called the Samurai wasp, *Trissolcus japonicus* was detected in Michigan in 2018 and is currently being studied at Michigan State University and other institutions. The extent to which it has established itself in the state is unknown, but growers can help boost local populations of parasitoids and other beneficial insects by planting nectar-producing flowers in orchard margins. Also known as pollinator habitat, these areas provide food and refuge from in-orchard pest management for natural enemies of BMSB and other pests as well.

Fig. 8. The parasitoid, *Trissolcus japonicus*, emerging from a BMSB egg (left). Nine *Trissolcus japonicus* wasps on a US dime for size reference (right). Photo source: USDA

For More Information

- MSU Integrated Pest Management BMSB Resource page: https://www.canr.msu.edu/ipm/invasive_species/brown_marmorated_stink_bug
- MSU Extension News for Agriculture Fruit & Nut page: http://www.canr.msu.edu/fruit
- Michigan Fruit Management Guide: Bulletin E0154 http://shop.msu.edu/product_p/bulletin-e0154.htm
- Pesticide Label Database: http://www.cdms.net/Label-Database
- Complete list of BMSB non-crop host plants: http://www.stopbmsb.org/where-is-bmsb/host-plants

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