Brown Marmorated Stink Bug – Trapping Study
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Note: For updates, conclusions, and recommendations, scroll to the end of this document.
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INTRODUCTION

The following study analyzed and evaluated the use and placement of the Rescue© brand stink bug trap. The Rescue® trap is designed to attract and trap the brown marmorated stink bug (*Halyomorpha halys*), hereafter referred to as “BMSB.” According to the manufacturer (Sterling International), the trap utilizes the aggregation pheromones of four species of Asian stink bugs. The quantity and type of aggregation pheromones utilized in the trap lures is proprietary information. None of the pheromones used in the lures are derived from the BMSB. They do have some cross-reactivity, though they aren't as attractive as the BMSB aggregation pheromone which is not yet available for use in the traps. The BMSB is known to feed on over 700 host plants. Because BMSBs can detoxify the defensive compounds of so many host plants, they also have the ability to detoxify many pesticides.

STUDY AREA

The study area was a 3,000 square foot vegetable garden in a semi-rural residential area near Charlottesville, VA. The garden contains a wide variety of vegetables, flowers, and herbs. It also includes a 16-foot row of blackberries, an 11-foot row of raspberries, 2 elderberries, 2 bush cherries, 3 trentberries, and 13 blueberries). The study period was August 21 through September 24, 2011. All sides of the garden are surrounded by lawn, which it turn is surrounded by woods on three sides and a house on the fourth side, 90 feet.

INITIAL OBSERVATIONS

BMSB were first noted in the fall of 2009 clustering on the outside of house as well as other houses in the area. In 2009, about one-third of the garden was converted from lawn. BMSB were not noted in the garden that year. By October 2010, the garden beds had been completed. That year, low levels of BMSB were in the garden, though there was only minor, mostly cosmetic damage on blackberries, tomatoes, and sweet peppers. Perhaps only 5% or so of the berries and vegetables were affected in 2010.

Beginning about mid-May 2011, BMSB first appeared in the garden. By the beginning of June, large numbers of BMSB had begun migrating from the surrounding woods, settling largely on a 16-foot row of blackberries on the eastern edge of the garden. The raspberries which fruited a month earlier were relatively unaffected. By June 25, the BMSBs were so thick on the blackberry vines that many of the young leaves and berries hosted BMSBs. Some berries had as many as 4 BMSBs per berry, while other berries, especially those on the lower part of the vines, had few stink bugs. In an attempt to control the stink bugs, each morning several hundred stink bugs were swept by hand into a large tray of soapy water. This had little effect in reducing damage because stink bugs continued to migrate onto the vines Each morning, the population levels of stink bugs seemed to be just as high, if not higher than the day before. The normally black fruits of the blackberry(which are aggregates of druplets) became a mosaic of black and tan druplets. Consequently, most of the berries were inedible. After the blackberry production had ceased by the end of June, the BMSB migrated in a slow moving wave for several weeks, moving across the garden from east to west, colonizing mostly tomatoes and peppers. The subsequent damage was so severe that the tomatoes became heavily mottled and liquified. Most ripe tomato fruits were affected by the stink bugs. By the middle of July there were no edible tomatoes or peppers to be found. Tomatoes liquified, rotted, and fell to the ground. Pepper fruits became heavily mottled, scarred, and diseased.

PRE-TEST TRAPPING

A Rescue® BMSB trap was purchased from Plow and Hearth in early July 2011. It was hung about 5 feet high at the north end of the row of blackberries. The trap was initially placed about 3 feet from the end of the row, and moved 3 days later so that it touched the foliage at the end of the row of blackberries. After 10 days, only about two dozen BMSB had been trapped even though there were hundreds of BMSBs on the blackberries. BMSBs on nearby tomatoes slowly increased. Because initial trapping results were not promising, the trap was returned to Plow and Hearth, and feedback was placed on their website. After calling Plow and Hearth asking why the feedback had not appeared on the website, the response was that unlike other products reviewed on the site, the trap manufacturer wanted to first review the feedback. After further discussion with Plow and Hearth and the trap manufacturer, Plow and Hearth (in conjunction with the trap manufacturer) arranged to supply 10 traps for testing purposes.

STUDY GOALS

The basic study goals were to: (1) evaluate the effectiveness of the trap in attracting BMSB; (2) determine if the traps could reduce the population of BMSB below damaging levels; and (3), determine best practices for placement and positioning of traps (i.e. placement of the trap within the foliage of the crop to be protected, or placement several feet from the foliage, or placement outside the garden as a perimeter trap to intercept stink bugs before the migrate to the garden (while attracting stink bugs from the garden).

MATERIALS, AND METHODS

Determine number of traps to use: According to the manufacturer, each trap will attract stink bugs from a radius of about 20 feet. This represents an area of 1,256 square feet. Thus to protect a 3,000 square foot garden, at least 2 traps are needed [(3,000 sq. ft./1,256 sq. ft.) = 2.4 traps]. When garden geometry is taken into consideration, a minimum of 3 traps are needed. The manufacturer recommended 10 traps for the purpose of testing. If the average gardener were to use 10 traps for a garden of this size, 10 traps (with 2-week lures) would represent a sizable investment ($200 to start, plus another $100 for 7-week replacement lures). However, by using 10 traps more data could be collected than by using the minimum number of 3 traps.

Set up three test situations:

- **Test# 1 (10 traps):** The first test involved placing 6 traps around the perimeter of the garden, such that each trap was located about 4 feet from the outside garden edge. Each trap was suspended about 3.5 to 4 feet above the ground on a metal stake. Each 6-foot metal stake was pounded into the ground at about a 30 degree angle. Traps were then hung from the top of the stake, and one fin of the trap was secured to the side of the stake using a long twist tie supplied with the trap. The remaining 4 traps were placed in the garden, mounted on stakes, each trap in contact with the leaves of a different tomato variety, each variety consisting of 6 at least plants. Daily counts of the number of BMSB in each trap were obtained for 7 days. See data collection method below.
- **Test#2 (10 traps):** In the second test, the 4 traps that had been placed inside the garden, were relocated to the perimeter of the garden, such that the garden perimeter was surrounded by 10 traps instead of the 6 traps used in Test#1. Daily counts of the number of BMSB in each trap were obtained for 7 days. See data collection method below.

> **Data collection method for Test#1 and Test# 2:** Daily rounds of the traps were made each morning. The number of stink bugs per trap was counted while the stink bugs were in the trap. This was done in the cool of the morning, about 8 a.m., while the stink bugs were relatively inactive, before the sun warmed up the traps. If the number of stink bugs in the trap made it too difficult to obtain an accurate count (about a maximum of 40 or so), the trap was removed, frozen for 30 minutes, the bugs removed and counted, and the trap cleaned, and re-suspended.

- **Test#3 (4 traps):** The third test involved only 4 traps, each placed on the north side of the garden, between the house and the garden. Two traps were placed about 8 feet apart with a small (5 foot tall) fringe tree between them, and 7 feet from the garden edge which contained a planting of tomatoes. The other two other traps were placed 16 feet from the garden, and about 20 feet apart.

Stink bug population counts on crop plants ("stink bug density"): At the beginning and end of each testing period the "stink bug density" (number of stink bugs per tomato fruit [green or red]) was counted. This "density" measurement provided some quantitative indication of the amount of "pest pressure" on the crop plants as well as some indication of the effectiveness of the traps in reducing the stink bug population density. Density measurements provide some information about the possible effectiveness of the traps. These measurements are reasonably reliable until the BMSBs begin to migrate when temperatures drop in late summer/early fall.

Trap lures: All traps had 7-week lures, except trap T-6 which had only a 2-week lure.

Garden schematic showing the test area and trap locations: The garden schematic on the following page shows the location of crops within the garden, the trap ID number, and the placement of traps used in each test.

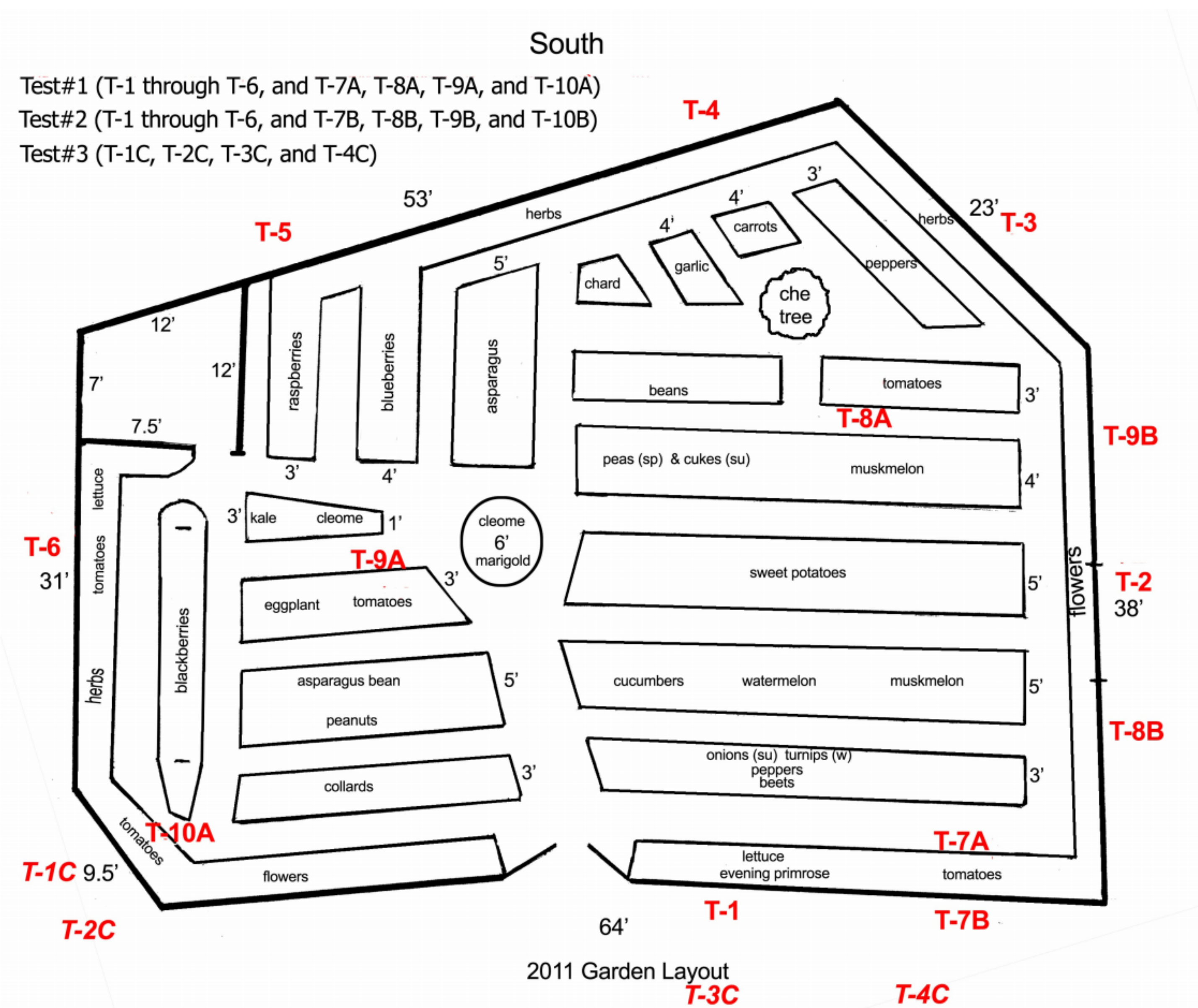
Test#1 – Trap IDs: Traps were numbered "T-1" through "T-6," and "T-7A," "T-8A," "T-9A," and "T-

10A."

Test#2 – Trap IDs: This is a variation of Test#1. Traps numbered T-1" through "T-6" retained the same position as in Test#1. The remaining 4 traps, "T-7A through "T-10A" were moved from inside the garden to a position outside the garden perimeter, and were renumbered as "T-7B" through "T-10B"

Test#3 – Trap IDs: Trap T-6 with a 2-week lure (a spent lure, 3 to 5 weeks old during the test) was moved to position T-1C. The remaining 3 traps had 7-week lures (3 to 5 weeks old). These traps were labeled T-2C, T-3C, and T-4C.

Garden schematic with Test# and corresponding Trap IDs.



House location is 90 feet north of the garden.

RESULTS

Test# 1 – Trapping Results (8/21 to 8/27)

Test# 1											8/21/11 to 8/27/11
Rescue®	Lure	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	#/trap	Day 7	Location &
Trap #	Type	#/trap	#/trap	#/trap	#/trap	#/trap	#/trap	#/trap	Ave/	nymphs	Comments
Date >>>	Weeks	08-21	08-22	08-23	08-24	08-25	08-26	08-27	day	#/trap	
1	7-wk	1	3	3	3	4	4	12	2	1	north outside garden ~4'
2	7-wk	0	2	2	2	2	2	2	0	0	west outside garden ~4'
3	7-wk	0	0	0	0	0	0	1	0	0	southwest outside garden ~4'
4	7-wk	0	1	1	1	2	2	4	1	0	south outside garden ~4'
5	7-wk	0	0	0	0	1	1	2	0	0	south outside garden ~4'
6	2-wk	1	0	0	0	0	0	0	0	0	east outside garden ~4'
7-A	7-wk	2	4	4	4	4	6	10	1	1	trap in tomatoes (AmySGem)
8-A	7-wk	8	14	17	19	24	28	42	6	2	trap in tomatoes (Rutgers)
9-A	7-wk	2	36	42	47	62	65	85	12	2	trap in tomatoes (EvaPurple)
10-A	7-wk	0	0	0	0	3	11	39	6	1	trap in tomatoes (Glacier)
Cumulative #		**14**	**60**	**69**	**76**	**102**	**119**	**197**	**28**	7	
Average #/trap		**1.4**	**6.0**	**6.9**	**7.6**	**10.2**	**11.9**	**19.7**		0.7	
Day total		14	46	9	7	26	17	78			

Test# 1 – Stink Bug Densities (change from 8/21 to 8/27)

Beginning density (8/21/11): 0.3 BMSB per tomato fruit
Ending density (8/27/11): 0.8 BMSB per tomato fruit
Gain (loss): 0.5 BMSB per tomato fruit

Test# 2 – Trapping Results (8/27 to 9/3)

Test# 2											8/28/11 to 9/3/11
Rescue®	Lure	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	#/trap	Day 7	Location &
Trap ID	Type	#/trap	#/trap	#/trap	#/trap	#/trap	#/trap	#/trap	Ave/	nymphs	Comments
Date >>>	Weeks	08-28	08-29	08-30	08-31	09-01	09-02	09-03	day	#/trap	
1	7-wk	9	10	14	25	37	54	80	11	0	north outside garden ~4'
2	7-wk	1	3	8	10	10	12	23	3	3	west outside garden ~4'
3	7-wk	0	0	0	1	1	2	3	0	0	southwest outside garden ~4'
4	7-wk	1	1	1	3	3	5	5	1	0	south outside garden ~4'
5	7-wk	0	0	0	0	0	0	0	0	1	south outside garden ~4'
6	2-wk	0	0	2	2	2	4	7	1	0	east outside garden ~4'
7-B	7-wk	20	26	27	32	46	56	87	12	3	north outside garden ~4'
8-B	7-wk	8	9	9	17	20	21	35	5	0	west outside garden ~4'
9-B	7-wk	7	14	16	28	29	32	48	7	3	west outside garden ~4'
10-B	7-wk	35	82	116	215	264	292	356	51	1	northeast outside garden ~4'
Cumulative #		**81**	**145**	**193**	**333**	**412**	**478**	**644**	**92**	11	
Average #/trap		**8.1**	**14.5**	**19.3**	**33.3**	**41.2**	**47.8**	**64.4**		1.1	
Day total		81	64	48	140	79	66	166			

Test# 2 – Stink Bug Densities (change from 8/27 to 9/3)

Beginning density (8/27/11): 0.8 BMSB per tomato fruit
Ending density (9/3/11): 0.8 BMSB per tomato fruit

Gain (loss): 0.0 BMSB per tomato fruit

Test# 3 – Trapping Results (9/3 to 9/24)

Test# 3					9/3/11 to 9/24/11
Rescue®	Lure	Day 21	#/trap	Day 21	Location &
Trap ID	Type	#/trap	Ave/	nymphs	Comments
Date >>>	Weeks	09-24	day	#/trap	
1-C	2-wk (weeks 3 through 5) – past effective lure date	369	18	8	north outside garden 7’
2-C	7-wk (weeks 3 through 5)	343	16	3	north outside garden 7’
3-C	7-wk (weeks 3 through 5)	392	19	12	north outside garden 16’
4-C	7-wk (weeks 3 through 5)	208	10	6	north outside garden 16’
Cumulative #		1312		29	
Average #/trap		328	16		

Test# 3 – Stink Bug Densities (change from 9/3 to 9/24)

Beginning density (9/3/11): 0.8 BMSB per tomato fruit
Ending density (9/27/11): 0.2 BMSB per tomato fruit
Gain (loss): – 0.6 BMSB per tomato fruit

TEST#1 — DISCUSSION AND CONCLUSIONS

Test#1 - Purpose:

- Test the effectiveness of the Rescue® trap in attracting and trapping BMSB.
- Determine if placing traps within the foliage results in more effective trapping, compared to keeping traps several feet from host plants.
- Test the effectiveness in reducing BMSB populations low enough to reduce host damage to acceptable levels.
- Test the effectiveness of the traps in attracting nymphs.

Traps varied widely in their effectiveness in attracting and trapping adult stink bugs. It is interesting that 5 of the 10 traps caught fewer than 5 stink bugs. Given the level of infestation (thousands of stink bugs in the garden), this is a less than impressive result. One trap, “T-1,” was placed outside the garden in front of boxes of several mint species (where some repellant effect might be expected). This trap caught 12 stink bugs, whereas trap “T-7A” which was in contact with heavily infested tomato foliage and fruits, caught only 10 stink bugs. It appears from these test results that more stink bugs are caught if the traps are placed in contact with the foliage. However, these results provide no information as to whether the traps are attracting more stink bugs onto the host plants, which would be counterproductive for the gardener. The manufacturer strongly advises anchoring the trap fins to a support support such as a post or plant stems. The reason for this recommendation is that anchoring reduces trap movement by the wind, and helps to trap nymphs. While it makes sense to anchor the trap to reduce wind movement. anchoring the traps for the purpose of capturing more nymphs isn’t justified by the reported trapping data. The percentage of nymphs trapped ranged from 3 to 4 percent of the total BMSB count, a percentage so small, that for practical purposes it is not an effective strategy. During this test period the nymph population was very high, but the number of nymphs trapped was very low — so low as to be insignificant.

Test#1 – Conclusions:
The aggregate results suggest that proper trap placement is critical for trapping, but the results don't provide any guidance on where to place traps. The results do show that more stink bugs will be trapped when the traps are in contact with the plants. Clearly the traps had no noticeable result in reducing stink bug populations in the heavily infested garden. The reported data from this test does not resolve the question of whether the traps should be placed in, or next to, the host plants. It is not clear if additional stink bugs are attracted to the host plants. It is very likely that such a practice may attract even more stink bugs to the plants, thereby aggravating the infestation.

The stink bug densities increased by a factor of 2.7 during the one-week test period (0.8/0.3 = 2.7). Some of this increase might be explained by: (1) sampling error; (2) maturation of nymphs into adults which are more easily caught in the traps; but (3), most likely, an attraction of new adults into the testing area because of the presence of the lures.

TEST#2 — DISCUSSION AND CONCLUSIONS

Test#2 – Purpose:
This test was a variation of Test#1. It had the following objectives:

- Determine if placement of traps outside the host plants results in more effective trapping, compared to keeping traps in contact with host plants. [In this test, 6 of the traps used in Test#1 were kept in the same position, while 4 traps that were in the garden in contact with tomato foliage were moved to positions on the garden perimeter (where they were not in contact with host plants).
- Test the effectiveness of perimeter trapping in reducing BMSB populations low enough to reduce host damage to acceptable levels.
- Test the effectiveness of the traps in attracting nymphs.

Test#2 – Conclusions:
Results from this test strongly refute the idea that traps need to be placed next to (or in contact with) the host plants. In this trapping arrangement, 3.3 times as many stink bugs were trapped with traps placed in the new arrangement as compared with the trap arrangement in Test#1. Interesting is the fact that 5 of the 6 traps had not been moved from their position in Test#1. These traps caught relatively small numbers of stink bugs, as was the case in Test#1.

Comparing the difference in stink bug densities at the beginning and end of the testing period, there was no change in stink bug densities.

It was fascinating that trap "10-A" caught 1.2 times as many stink bugs (356 total) as the combined total (288) compared to the other 9 traps. This result confirms that trap placement is critical, and that it may be important to experiment by moving the traps into different positions to determine the most effective placement. In this test, even the results of the first day of trapping suggested which traps would be most effective. Thus, a recommendation for trap placement would be that if little or no stink bugs are trapped by the end of the second day, it may time to relocate the trap somewhere else.

The reason trap "10-A" was so effective is unknown. This trap was placed approximately 4 feet outside the garden. The trap had been moved no more than about 7 feet from its former position inside the garden (where it was in contact with tomato foliage) to a position outside the garden. This same trap not only collected 1.2 times as many stink bugs as the other traps in Test#2, it also collected 1.8 times more stink bugs than the combined count of all the traps used in Test#1!

What is unique about this position? Initially, it seemed that a small, 5-foot tall fringe tree (*Chionanthus virginicus*) located within 2 feet of the trap might have been an attractant. The fringe tree was just as heavily infested with stink bugs as the 'Glacier" tomato variety inside the garden (where the trap had been previously located). The fringe tree could not have been the main attractant, because another fringe tree of the same size and shape located 53 feet from the northwest side of the garden had no stink bugs on it. Thus, the fringe tree near the garden could not be the source of attraction. It may be worth noting that this northeast corner of the garden was the same edge of the garden that was first infested by stink bugs. Also there is a brush pile located about 100 feet to the northeast. This brush pile could have been a large source of overwintering adult BSMB. Trap "10-A" was located part shade during the day until about noon, so the pheromones would have been released more slowly from the trap than if it had been placed in a full-sun position; however, trap "T-6" was in a similar part shade position on the east side of the garden, but caught no stink bugs in Test#1. So the question remains, what was so unique about this position? The photographs included in this report illustrate additional details about trap placement, but nothing in the immediate environment of the trap provides any clues as to why this trap placement was so effective. Even more puzzling is that the qualitative estimate of stink bug density in this location was not much different from other locations in the garden.

The effectiveness of the Rescue® traps in trapping nymphs was also evaluated. In Test#1, 4 of 10 traps were placed in contact with host plants. None of the traps in Test#2 were either close to, or in contact with, foliage of host plants. In both tests, the percentage of trapped nymphs was very small. For example, in Test#1, the percentage of nymphs trapped in all traps was 3.6% (7 of 197 BMSB). In Test#2, the percentage of nymphs trapped was 1.7% (11 of 644 BMSB). Considering only the 4 traps in Test#1 which had traps in contact with foliage, the percentage of trapped nymphs was 1.3% (7 of 526). The manufacturer's recommendation is to place traps in or next to foliage to trap nymphs. This recommendation is without merit, as the percentage of nymphs caught is not significantly different whether the traps are placed in contact with the foliage or not in contact with the foliage. And in either case, the small benefit gained by capturing a small percentage of nymphs is not worth the risk of placing traps in contact with the foliage as the traps may attract additional adults, resulting in additional damage to the plants.

Test #3 – Purpose:

- Evaluate the effect of setting the traps at an increased distance from the host plants (mostly tomato plants).
- Evaluate the relative attractiveness of two lures, one with a 2-week "expended" lure (3 to 5

weeks old), versus a 7-week “active” lure (3 to 5 weeks old)). Both lures were set 8 feet apart from each other with a small fringe tree in between the two traps. Both traps were 7 feet away from the host plants (tomatoes) at the garden edge.

- Evaluate the effectiveness of nymph trapping at further distances from the host plants.
- Evaluate the effect of traps on reducing stink bug densities on host plants (tomatoes) within the 20-foot trapping radius and beyond the 20-foot trapping radius.

Test #3 – Conclusions:

Comparison of a 2-week versus 7-week lure during weeks 3 through 5

Traps “1-C” and “2-C” were 8 feet apart from each other with a fringe tree in between the two traps, both traps equidistant (7 feet) from the host plants (tomatoes) on the northeast garden edge. The only difference between these two traps is that trap “1-C” (which is identical to trap “T-6” in Test#1 and Test#2) had only a 2-week (“expended”) lure. At the beginning of this test, the 2-week lure had entered its 3rd week, and by the end of the test, had finished its 5th week. Interestingly, the “expended” 2-week lure (Trap “1-C”) captured 392 stink bugs compared to 343 stink bugs caught be the trap with the 7-week lure (Trap “2-C”). The result is puzzling because the trap with the “expended” lure caught more (1.08 times more) stink bugs than the trap with the “active” lure. This result is difficult to interpret, unless the 2-week lure is longer-lasting than specified by the manufacturer, or possibly visual cues of the trap itself play a larger part than expected. This test will be extended for a longer time period for further evaluation of the results. Results are not yet part of this report.

Effectiveness of nymph trapping (all four traps)

During the 3-week testing period, of the 1,312 stink bugs trapped, only 29 were nymphs, which represents only 2.2% of the total trapped population. This result is not significantly different from the results of nymph trapping observed in Test#1 and Test#2. More nymphs (18 total, or 3%) were trapped in the two traps (“3-C” and “4-C”) located 16 feet from the garden than the two traps (“1-C” and “2-C”) located 7 feet from the garden. Those traps captured fewer nymphs (11 total or 1.5%).

Stink bug densities on host plants (tomatoes)

During the 21-day test period, the stink bug density dropped from 0.8 stink bugs to 0.2 stink bugs per tomato fruit. Since the trapping period was between September 3 and September 21, it can not be concluded that the decrease in density is due to trapping, because stink bugs are already migrating out of the vegetation onto the trunks of large trees, into cars, onto houses, and into brush piles and wood piles. Migration typically begins at the beginning of September and continues until the 2nd or 3rd week in October. By August 20th, a few stink bugs had begun aggregating at night on the window screens of the house, located 90 feet to the north of the garden; however, their numbers did not increase significantly on the house during the third test period. Because the traps were located between the garden and the house, those traps might have caught more stink bugs than traps which were located between the garden and woods (three sides of the garden).

Effect of placing the traps at a greater distance from the garden

There are insufficient data to evaluate the effect of short distance variations between the traps and the host plants. A better experimental design is required. Such testing should be done before migration toward fall/winter aggregation sites begin. The two traps that were 7 feet from the garden trapped 712 stink bugs, whereas the traps placed 16 feet from the garden trapped fewer stink bugs (600 total). The trap with the fewest number (208 BMSB) was close to a silver-gray car which attracts stink bugs and also close to the trunk of a large maple. A few stink bugs may have been attracted to those locations, bypassing the trap.

<u>Effect of trap placement on stink bug densities within and beyond the 20-foot trapping radius</u>
Insufficient data were available to evaluate whether the stink bug densities were lower in the tomato plantings furthest from the traps. The sample sizes were too small to make reliable conclusions. Also with the beginning of fall/winter migration and aggregation, results were difficult to interpret.

SUMMARY

It is important to point out that this study utilized 10 Rescue® traps for testing purposes. Normally, only 3 traps should be needed for a 3,000 square foot garden such as the one described in this study. The 3-trap minimum is based on the consideration that each trap attracts BMSB for a distance of 20 feet in all directions, which is equivalent to an area of 1,256 square feet per trap. In this study, 10 traps did not come close to controlling (reducing) the stink bug population. Perhaps better control would be obtained by starting the trapping in the spring before the adults begin laying eggs. That would be the next logical step in continuing this study.

For a gardener, the financial investment in protecting a 3,000 square foot garden for a minimum 16 weeks of the growing season would be $120. This cost is derived from calculating the cost of 3 traps (with 2-week lures) at $20 each, plus 6 (7-week) replacement lures at $10 each.

By comparison, for 10 traps, the cost for a 16-week growing season would be $400. Of course the following year, the traps could be re-used, and the cost of lures would be $200 for 14 weeks, or $300 for 21 weeks. These costs *might be justified* only if the traps were effective in preventing a serious infestation at the onset of the growing season. Even so, this is a considerable financial outlay, and the cost doesn't justify the benefit based on the results of these studies. Perhaps when the aggregation pheromone of the BMSB is isolated and utilized in the Rescue® trap, the cost/benefit ratio will improve.

Based on the results of the three tests reported here, the author of this study has arrived the following conclusions and recommendations. These recommendations are based on both the quantitative results from the research, as well as qualitative observations made throughout the study period:

- Under the right conditions the Rescue® brand trap is effective in trapping BMSB; however, trapping efficiency is highly dependent on trap location. This cannot be over-emphasized, but defining the proper trap location can be very difficult. Apparently there are a number of factors which are not yet understood that have a strong influence on trapping efficiency. Some of these factors consist of the (1) vegetation types and amounts; (2) reproductive state of the host plants (presence of fruits, berries and other succulent reproductive structures); (3) mix of vegetation and associated chemical cues that affect BMSB; (4) distance of traps from host plants; (5) weather and climatic factors; and (6), other biotic and abiotic factors. Based on the results in this study, no patterns have yet emerged that shed much light on where to place the traps, except that the traps should not be placed in contact with, or close to the plants requiring protection.

- Because reliable data are not yet available about best practices for locating the traps, the user may have to rely on trial and error to find the best trap placement. If a trap is catching only a few stink bugs under conditions of moderate to severe infestation, it may be advisable to move the trap in order to find a better location—a trial and error process. When considering re-locating traps, first keep in mind that low trapping results may be due to cool or inclement weather which reduces the mobility of the stink bugs. Because of the trial and error nature of finding the best area for trap placement, it may be necessary to use several traps to quickly find the best placement areas. For protecting a large garden such as the one used in this study, at least 3 traps (likely more) may be required at any one time to help locate the best trap placement.
- In this study the Rescue® trap was found to be ineffective in controlling and reducing BMSB populations. By comparison, an effective pesticide, organic or otherwise, typically reduces pest populations by at least 90%, and preferably 95% to 98%. For the Rescue® trap to be effective as a control agent it would need to reduce stink bug populations by a bare minimum of at least 80% or more. At that level it may serve as adjunct for control using an integrated pest management approach (IPM). Reliance on the sole use of traps without other means of control may not lead to a desired outcome in reducing damage to acceptable economic and aesthetic levels.
- The manufacturer of the Rescue® brand trap recommends placing the traps in contact with the foliage of the plants to be protected. The cited reason for placing the traps in contact with the foliage is to trap more nymphs; however, the small percentage of nymphs trapped (typically 3% or less) doesn't justify placing the plants at greater risk for infestation by attracting more adults. The percentage of nymphs caught by placing traps in contact with foliage differs little from the percentage of nymphs caught when the traps are 7 or 16 feet from the plants to be protected. In either situation, the traps have no significant effect on the nymph population.
- Because of the surprising result (in Test#3) in which a trap baited with an "expended" 2-week lure (3 to 5 weeks old) caught significantly more stink bugs than a comparable "active" lure, it might be worth considering use of the lures beyond the expected life time (shelf life) of the lure. The release of the attractant from the trap falls off as a function of time, and the attractant may not fully be released at the end of the 2 or 7-week period. Release of the aggregation pheromones from the trap is affected principally by temperature. Thus a trap located in a shady location will release pheromone more slowly than a trap placed in a sunny location. Wind currents tend to diminish the concentration of the lure in the vicinity of the trap, but still air increases the concentration gradient around the source (the trap). Perhaps the effectiveness of the lure may increased by a "snowball effect" where the amount of aggregation pheromone is increased by aggregation pheromone release from live bugs caught in the trap.
- The trap appears to attract certain BMSB predators both to the trap itself and the immediate vicinity. For example, it was observed during the testing that several large robber flies (*Promachus rufipes*) landed on or near the traps capturing BMSB as prey. The robber flies may have been attracted to the trap color. People should be aware that robber flies are beneficial

insects. See Photo Table II which shows a BMSB caught by a robber fly near the trap.

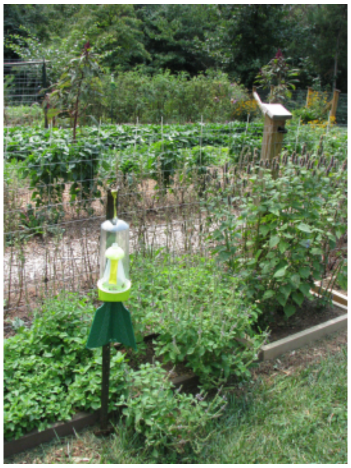
Photo Table I: Illustrations showing trap placement in relation to trap number (see also garden schematic)			
 T-1 (north edge)	 T-2 (west edge)	 T-3 (southwest edge)	 T-4 (south edge west)
 T-5 (south edge east)	 T-6 (east edge)	 T-7A (north edge inside)	 T-8A (west center inside)
 T-9A (east center inside)	 T-10A (northeast edge inside)	 T-1C (2-week lure, on left) T-2C (7-week lure, on right)	 BMSB on tomato fruits with high BMSB density

Photo Table II: BMSB and predator behavior		
		
High BMSB density on green tomato fruits. Trap 10-A is in the background.	Giant robber fly (*Promachus rufipes*) with captured BMSB next to trap	Found on top of a squash leaf – a BMSB nymph feeding on dead bumblebee. Possibly the only record of such behavior. The cause of death of the bee is unknown. No sprays used in the garden.

RECOMMENDATIONS

For protecting vegetable gardens with Rescue® stink bug traps, here are some basic recommendations regarding trap placement:

- Do not place traps in contact with (or next to) the plants to be protected as this may attract more adult stink bugs to the crop, resulting in more damage.
- Do not place the traps inside the garden.
- Place the traps in one or more perimeter locations outside the garden. Traps should be placed at least 7 to 10 feet, but not more than 15 feet, from an outside edge of the garden. The Rescue® trap is designed to attract stink bugs from a distance of about 20 feet.
- If you have 4 traps being used to protect 4 sides of a garden, you should start by protecting each of the 4 sides, but if you obtain low trap counts on one or more sides of the garden you may want to consider moving one or more traps to another side of the garden, possibly 4 traps on only one side, if that proves to be the most effective positioning. A number of factors can affect the effectiveness of trapping, such as the presence of nearby structures, or other vegetation in the area that is attractive to stink bugs, hence it can sometimes be difficult to predict the best starting trap positions.
- If you have a heavy infestation of stink bugs (tens to hundreds) on the host plants, but you only trap 10 to 20 stink bugs within 2 to 3 days, consider moving that trap to another location. If you have 2 or 3 traps, consider moving at least 1 trap to find a better trapping location. Before moving traps, remember that rainy or cool weather may the reason for low numbers of stink bugs trapped.

- Traps are best placed in sunny locations to facilitate release of the attractants in the lure.
- Traps may continue to attract stink bugs for a week or more past the lifetime of the lure, though trapping efficiency will decline. The life of the lure is affected by temperature and sun exposure.
- Update (see below): If *Ailanthus* trees are in the area, the trees should be removed and replaced with native vegetation if economically feasible. Also traps should be located between *Ailanthus* plantings and the area to be protected. In this manner the BMSB may be intercepted by the traps.

UPDATE ON THIS STUDY

May 5, 2012

Subsequent to the analysis the data reported here, it was reported in 2011 that BMSB are strongly attracted to stands of *Ailanthus* (*Ailanthus altissima*) trees, also known as "tree of heaven." This invasive species is native to northeast and central China, where the BMSB is found naturally. In the study area there is a natural, mostly monoculture stand of about 40 to 50 *Ailanthus* located 300 to 420 feet north-northeast of the study area. Several of these trees are fairly large with a trunk diameter of about 18." The location of these trees may explain why the trapping activity in trap in traps "T-1C" and "T-2C" was so high. It was in this corner of the garden that the infestation first appeared in the largest numbers and the area where the trapping was highest in late summer when the BMSB were migrating back into the woods. In addition there is a long, narrow brush pile and several wood piles in the woods extending about 120 feet through the woods where the BMSB may overwinter with some protection from the elements.

UPDATE ON THIS STUDY

November 17, 2014

The following observations and conclusions are noted as follows:

- During the winter of 2013-2014, the population level of BMSB was reduced by at least 95% . In some locations the winter kill approached 99%. This is likely due to the fact that in late winter there was a warm period sufficiently long enough to reduce the natural anti-freeze in BMSB. This warm period was followed by a cold period with a low temperature of 6 F. Normally, many or most BMSB would survive this temperature except that they lost their cold adaption during the warm period that preceded the sudden cold snap. As a consequence of the reduced population numbers there was little to no damage to tomatoes and peppers in the summer through late August, but by September 2014, the population was high enough to make several crops unusable, mainly most tomatoes and peppers. By early October, most BMSB had migrated to their overwintering locations. There was a short period between the end of September and late October when some tomatoes and peppers had minimal damage and were salvageable.

- Rescue® traps are not effective in controlling BMSB either within the garden (next to or near garden plants), nor outside the garden in various locations, regardless of whether those traps are attached to host plants. Though the traps may catch many BMSB both inside and outside garden plots the number of BMSB caught is not sufficient to have a significant reduction of plant damage. In one study (see below), it was reported that use of Rescue® traps increased crop damage. See the studies below:

  - https://entomologytoday.org/2014/03/25/stink-bug-traps-in-gardens-may-increase-damage-to-tomatoes/comment-page-1/
  - www.redbudfarm.com/SARE%20final%20report_2012.pdf

- In September of 2013 I discovered that the number of BMSB caught within a Rescue® trap can be vastly increased (~900 BMSB/trap/week) if the trap is placed within the center of a large (~5 foot tall) cleome plant. This is an extraordinary high number of trapped BMSB, and represents roughly a three-fold increase of trapped BMSB compared to the best-performing traps *not* placed within the center of cleome plants. As impressive as that cleome-trap strategy seems, the number of BMSB trapped was not sufficiently high enough to prevent serious damage to nearby crop plants (observations from September 2014). Although there appeared to be a slight reduction in damage to nearby crop plants (relatively low BMSB levels), there is no quantitative data to confirm this observation.

- Compared to other host plants, *Ailanthus* does not appear to be a major host plant for BMSB as previously reported.

- Major overwintering locations of BMSB are buildings, construction debris, woodpiles, and probably brush piles. Though the loose bark of trees has been reported as an overwintering location, my inspection of the loose bark of locust (*Robinia pseudoacacia*) and *Ailanthus* has yet to reveal the presence of BMSB, but large numbers of BMSB have been located in woodpiles in close proximity. Some overwintering BMSB have been found in the leaf litter on the forest floor.

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- Tulle fabric (available in rolls or bolts in 9-foot widths) is an effective exclusion barrier for BMSB. Unlike row cover, tulle does not retain heat, and the mesh size (about 1/16") is small enough to provide a barrier to BMSB nymph, provided that the edges of the fabric are buried in soil or mulch.

- As a last resort, an effective pesticide is the pyrethroid), bifenthrin, but BMSB may recolonize quickly. Tulle is a far better alternative if applied early enough in the season.