Summary of Brown Marmorated Stink Bug Infestations in Maryland Crops

Submitted by Galen Dively, Cerruti Hooks, and Terry Patton, University of Maryland

Field studies to investigate BMSB population dynamics and feeding injury in selected crops were conducted in 2011 at three UM research farms (Keedysville-Washington County, Beltsville and Upper Marlboro-Prince George's County), where significant infestations were present. Key field, fruit and vegetable crops were grown according to recommended commercial practices and not treated with insecticides, unless otherwise indicated. All crops were in close proximity with each other and close to woodlots. Whole fields, orchard blocks, or small plots, depending on the crop, were sampled weekly to assess population densities of BMSB adults, egg masses, and nymphs (recorded by size as small, medium, large). Vegetable crops were also harvested to measure and characterize cumulative fruit injury over the crop cycle. To monitor BMSB activity, pheromone and blacklight traps were operated at five research farms from May to late September and serviced either daily or three times weekly.

Trap Monitoring. At Salisbury (Lower Shore), Queenstown (Mid Shore), Upper Marlboro (Southern MD), Beltsville (Lower Central MD), and Keedysville (Western MD), light trap captures averaged 0.7, 25, 77, 94, and 46 BMSB adults per night during July and August, respectively (Fig. 1). Activity at Keedysville was significantly less than captures in 2010, which averaged 108 adults per night during the same period. Traps at the other four farms captured 2.5 to 3 times more stink bugs than captures in 2010. Peak captures at Beltsville and Upper Marlboro exceeded 400 per night during the 3rd week of July. Both types of pheromone traps failed to capture stink bugs during the peak activity. Only a few adults and nymphs were captured later in the summer.

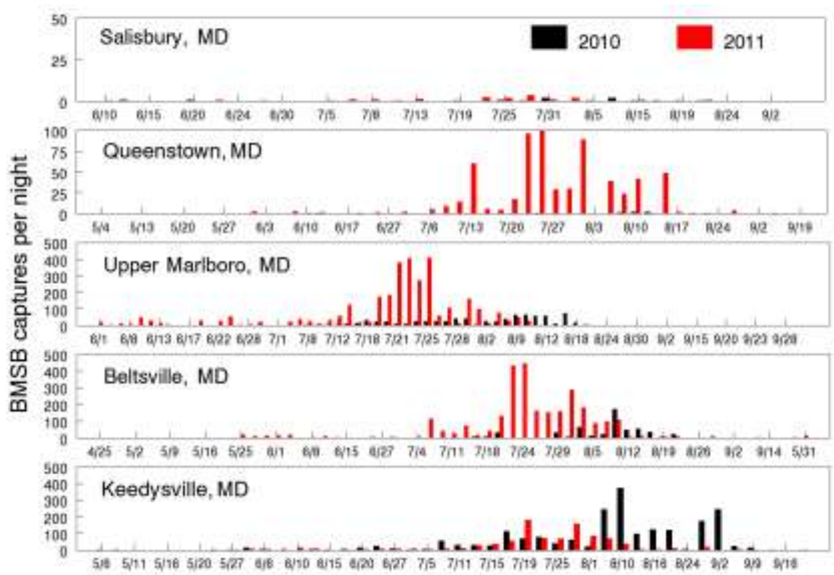

Figure 1. Blacklight trap captures of brown marmorated stink bug adults at five locations in Maryland during 2010 and 2011.

Small Grains – Two fields each of wheat and barley were sampled weekly from May to harvest at the Keedysville farm. Sampling unit consisted of 25 sweeps at two sites per field (outer rows, 50 feet from edge). One to 4 green and brown stinkbug adults per 25 sweeps were found on the outer rows but only an occasional adult were detected in the field interior. BMSB stages were essentially absent from these crops. Moreover, intensive sampling in other wheat studies at Beltsville found no BMSB activity and there have been no reports of BMSB infestations in small grains by crop advisors.

Field corn – Three fields (early, mid season, and full season hybrids) were sampled each week during July to mid-September at the Keedysville farm. Sampling unit consisted of a visual search of 10 consecutive plants at two sites (outer rows, 50 feet from edge). No BMSB activity was observed until last week of July, when milk-stage kernels were forming, but only adults were active for about 10 days and then they moved out. Fields experienced significantly lower numbers (10-25 per 10 plants at edge, less than 5 per 10 plants within field) and much shorter infestation periods compared to 2010, when adults and nymphs were present in corn until early Sept. Fields at Beltsville and Marlboro also experienced less BMSB activity and only adults for a short time. Drought conditions accelerated ear maturation and plant senescence rendering plants less favorable as food sources. As a result, very little reproduction occurred in field corn at the research farms and kernel damage was negligible.

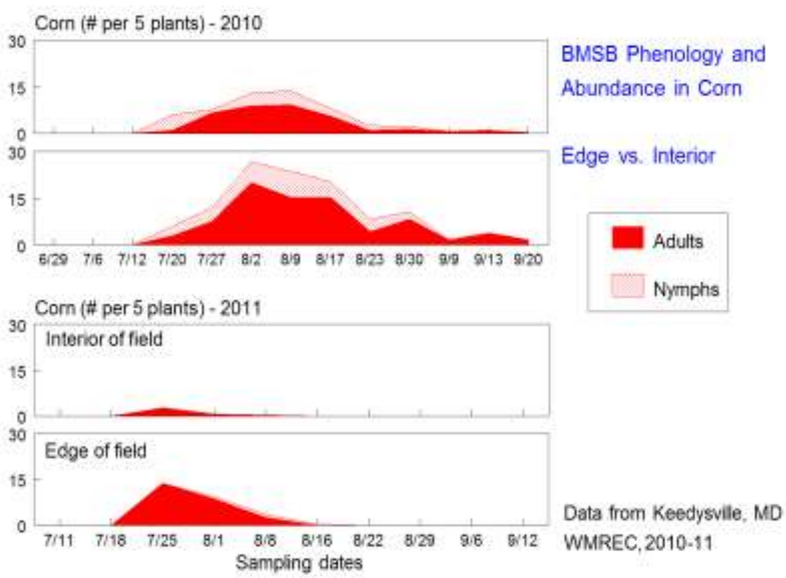

Figure 2. Seasonal abundance of BMSB adults and nymphs at the edge and in the interior of corn fields during 2010 and 2011.

Another study funded by a grain board grant was conducted to investigate the spatial dynamics of the BMSB within corn fields located on the USDA farm at Beltsville, MD. Preliminary findings by Dr. Hooks and his graduate student suggest that BSMB infestations were highest in corn fields adjacent to houses, followed by other crops or woods. Although numbers were highest at the field edge, they dropped off quickly as one moved away from the overwintering sources (Fig. 3).

Numbers recorded at the edge averaged as high as 1.2 per plant but sharply declined to zero at 15 to 40 feet from the edge.

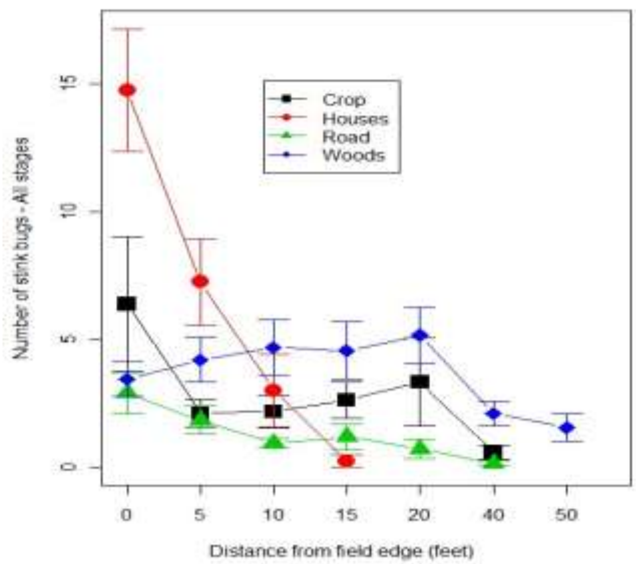

Figure 3. Abundances of BSMB in relation to both adjacent habitat and distance within corn fields from edge.

Crop advisors working in central and western MD and northern VA reported high populations in many fields during the milk stages of kernel development. Field infestations varied widely in relation to drought stress, planting date, and the maturity group of the hybrid. Follow-up visits to infested field to examine ears prior to harvest show scattered discolored, poorly developed kernels and cob areas of missing kernels (incomplete fill). Also, silage corn was heavily infested with levels as high as 20 bugs per ear. Infestations were strongly aggregated along the field margins and concentrated in rows adjacent to woodlots. Very few fields were treated along perimeters due to the inaccessibility of margin areas by ground applicators.

Soybean – Three fields (full season and double-cropped) were sampled each week during July to mid-September at the Keedysville farm. Several fields ranging in planting dates were also scouted on a regular basis at Beltsville. Sampling unit consisted of 25 sweeps at two sites (outer rows, 50 feet from edge) in each field. Infestations started to show up in early August in full season beans at higher numbers compared to levels in 2010, probably because field corn was not a suitable host at that time. Sweeping captured significantly more nymphs than adults through August and September. As the full season bean pods matured, adults moved to double-cropped beans and continued to reproduce. BMSB exhibited strong aggregations along field margins going in 10-25 feet and higher densities were invariably associated with adjoining woodlots (Fig. 3). Counts ranged 10-27 bugs per 25 sweeps at field edges and less than 10 per 25 sweeps within the field interior. As of mid September, adults were still laying a few egg masses but markedly fewer young nymphs were detected. Significantly high numbers of green stinkbug adults and nymphs were also detected in association with BMSB along the field edges.

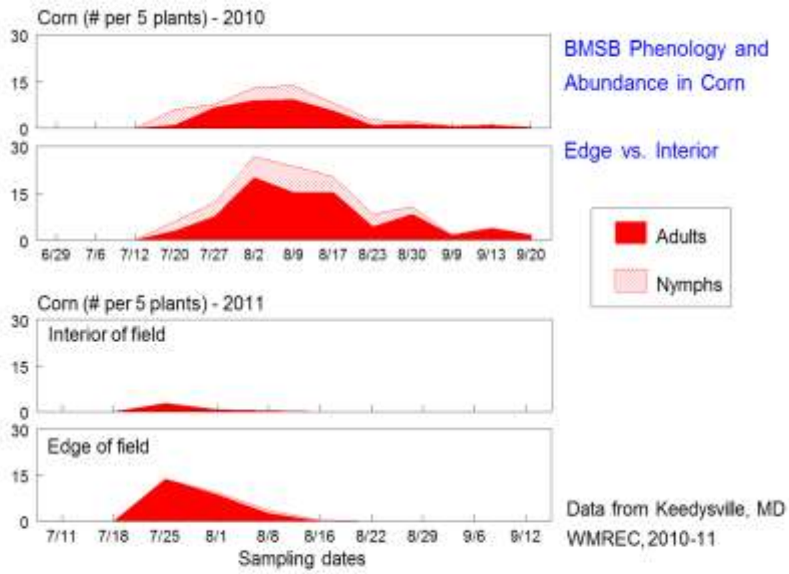

Figure 4. Seasonal abundance of BMSB adults and nymphs at the edge and in the interior of soybean fields during 2010 and 2011.

At the Beltsville farm, BMSB infested the field edges of full season soybeans during August and then moved to later maturing beans in September. However, overall densities were lower than levels in 2010 and the green stem syndrome along the field margins was less evident. Despite higher activity in trap captures, drought conditions and extreme temperatures likely had an adverse effect on egg and nymphal survival.

Crop advisors working in central and western MD, northern VA, and panhandle of WV reported that densities of BMSB infestations varied widely but generally were lower than levels in 2010. One difference from the previous year was a greater number of stink bugs in full-season soybean fields, followed by later movement to double-cropped beans. One agribusiness company estimated that 75, 60, and 100% of the clientele acreage was either perimeter or whole field treated in northern VA, western MD (Washington and Frederick Counties.), and central MD (Carroll, Montgomery, Howard Counties), respectively. Of the treated acreage, about half were whole-field treatments, particularly the smaller fields of double-cropped beans, and some fields were treated twice. On many dairy farms, harvesting silage corn with high populations triggered mass movement to nearby soybeans. Another company reported that their field personnel used a trigger threshold of 6 per 15 sweeps along the field margins to implement treatment, and <5% of the fields received perimeter treatments in Washington Co. and the panhandle of WV. Generally, reports of insecticide efficacy indicated good to excellent control and residual activity for several weeks with pyrethroids (Hero was the most common product used) and combination products (i.e. Indigo). However, re-colonization after treatment was not a major issue in most fields, so it was not possible to evaluate residual activity.

Paulownia – BMSB populations in a grove at Keedysville were monitored weekly from mid-May to mid-September. Sampling consisted of a visual search of a similar-sized branch from each of four trees. Adults colonized paulownia during the 3rd week of May and nymphs were present by early June. BMSB reproduced continuously throughout the summer until the end of August, at which time the proportion of adults to nymphs abruptly switched in favor of adults and adult numbers increased 5-10-fold. Counts ranged 1-6 adults/nymphs per branch during May-August, and then increased to 13-32 adults per branch during early September. Adults apparently stopped reproducing as the leaf quality declined in September. A significant influx of adults from the outside probably contributed to the surge of activity in September. Clearly, this introduced tree, along with the Tree of Heaven, is a major reproductive host of BMSB.

Apples, Grapes, and Peaches – Orchard blocks of apples and peaches were sampled weekly from early May to mid-September at the Keedysville farm. Sampling unit consisted of a visual search of the whole side of two apple and peach trees at two sites (orchard edge, interior). Grapes were sampled weekly at two sites (outer row, interior) by visual searching both sides of three consecutive plants of two varieties. Infestations were relatively low compared to the two previous years, because these crops were treated with combinations of insecticides plus Surround on a 10 day schedule. A few adults were detected, primarily at the orchard edge and mainly in peaches at the end of June, but there was no evidence of nymphal development. In grapes, most adults were observed on the outer row and in the variety Chambourcin.

Raspberries – A mixed-variety planting was monitored weekly at the Keedysville farm from early May to mid-September. Sampling unit consisted of a visual search of foliage and fruit along the side of a row (3 feet section). One section was searched on the outer row, and another on an interior row. Adults colonized plants during mid-June and sustained high populations to early September. Densities averaged 13.6 and 11.6 bugs per sampling unit in the outer and interior rows, respectively. Feeding caused severe fruit damage, rendering the crop unmarketable. Raspberries was undoubtedly a favorable food source for adult BMSB, but relatively few nymphs were present, accounting for only 5% of the total numbers recorded.

Pumpkins – An over-the-canopy visual search along the edge and interior rows was conducted weekly from late July to mid-September in a variety trial study at Keedysville. No adults or nymphs were present. Sampling pumpkin plants in an insecticide residue study and casual inspections of mixed winter squashes at Beltsville also revealed no evidence of feeding injury or nymphal development.

Tomatoes – At three farms, a plot of trellised tomato was sampled weekly from early July to mid-September by inspecting plants and examining harvested fruit for damage. No stinkbug activity was observed until ripe fruit appeared, but then consistently low numbers of adults (<0.5 per m^2) and only a few nymphs were found relative to the level of subsequent fruit injury. Green and brown stinkbugs were abundant than BMSB (making up 85% of all detections) and may be more damaging. It is possible that stinkbug adults move in and out of tomatoes following a diurnal pattern, since numbers detected did not account for the fruit injury which ranged from 32 to 48% of the total number of fruit harvested.

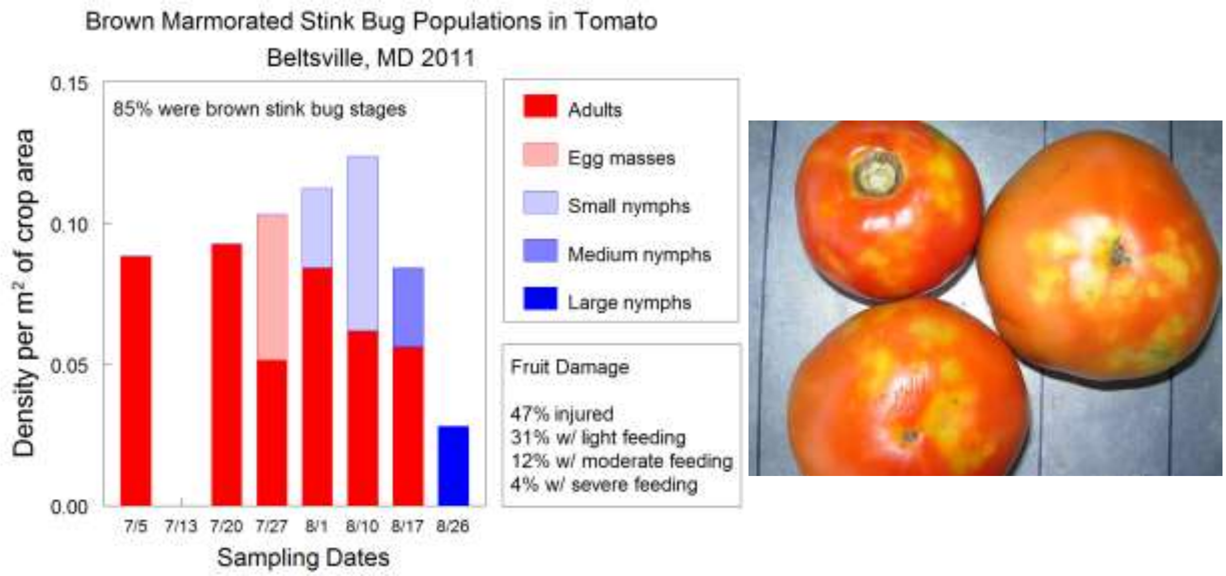

Figure 5. Seasonal abundance of stink bug adults, egg masses and nymphs (all species combined) and resulting damage in tomato during 2011.

Peppers – Paladin bell peppers were grown at the three farms and sampled from early July to mid-September by inspecting plants and examining mature fruit for damage. Adult stinkbugs started to invade plots in mid-July and numbers peaked the 1st week of Aug, followed by all stages of nymphs present through August. Plots that were directly next to woods at the Beltsville farm were heavily infested (peak densities averaged 4.1 bug stages per m^2), resulting in damage to 14.2% of the cumulative number of marketable fruit. Other later-planted peppers for insecticide trials were farther away from the woods, surrounded by other crops, and significantly less infested (less than 5% damaged fruit). Other crops and non-cropped areas separated the pepper plots from woodlots at Upper Marlboro and Keedysville; however, BMSB eventually invaded plots, reaching peak densities of 1.8 and 0.7 bug stages per m^2, and damaging 7.2 and <5% of the fruit, respectively.

At Beltsville, replicated plantings of bell (Paladin), banana (Bounty), hot jalapenos (Sparky) peppers were about equally infested with adults and nymphs, which damaged 24.7, 22.9 and 22.5% of fruit pooled over five harvests, respectively. Small demonstration plots of other pepper varieties (Serrano Tampiqueno, Atelier Jalapenos, Giant Marconi Italian Fryer, Intruder Bell, King Arthur Bell, Gold Rush Banana, Chinese Giant Bell) were susceptible with damage ranging from 19 to 86% due to BMSB feeding. Two hot types (Thai Super Chili, Cheyene) were less susceptible to fruit injury, and, unexpectedly, a black bell variety, Black Knight, showed no evidence of injury over the entire crop cycle.

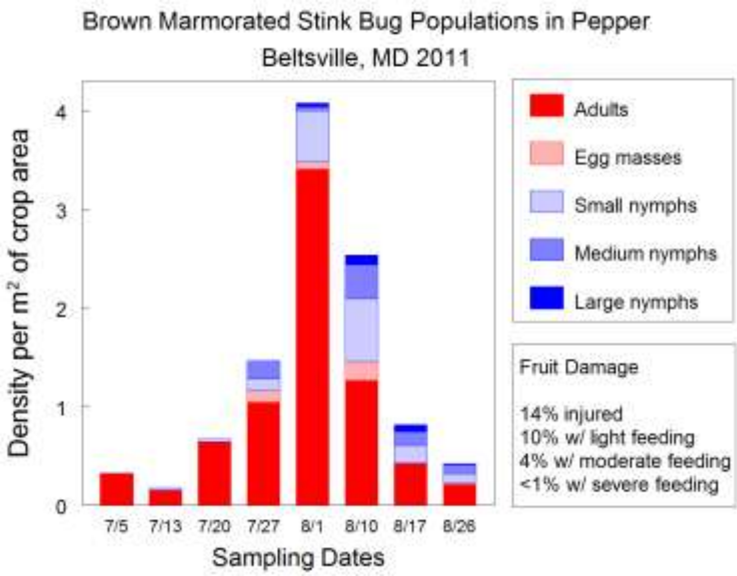

Figure 6. Seasonal abundance of BMSB adults, egg masses and nymphs and resulting damage in bell pepper during 2011.

At the Beltsville farm, Paladin bell pepper plants were enclosed within mesh bags and infested with three BMSB adults at bud stage. Plants were left infested for five weeks and then harvested to compare with the fruit production of bagged control plants. Infested plants produced significantly less mature peppers, averaging 627 g per plant compared to 1364 g of peppers per control plant. Forty% of the peppers on the infested plants were damaged.

Summer Squash – Several plantings of summer squash were grown at the three farms and sampled from early July to mid-September by inspecting plants and examining marketable fruit. Only a few BMSB adults were detected (<0.4 per m^2 of crop area), and there was no evidence of feeding activity on squash or nymphal development throughout the crop cycle of each planting. Most plantings were heavily infested with squash bugs, which may have competed with feeding sites and impeded colonization by BMSB. However, if more attractive crops are available, squash will likely not be a preferred host plant.

Sweet Corn – Early and late plantings of an untreated Bt bicolor hybrid (BC0805) were established at six research farms. At Upper Marlboro, Beltsville, and Keedysville, plots were sampled weekly from early July to mid-September by inspecting plants and evaluating ear damage due to BMSB at harvest maturity. At two Eastern Shore farms (Queenstown, Salisbury) and one in central Maryland (Clarksville), comparable plantings of BC0805 sweet corn were only sampled at harvest time for ear damage. None of the Eastern Shore plantings were infested with BMSB or showed evidence of stink bug feeding injury on the kernels. At the other locations, adults invaded during early tassel emergence and began feeding at the base of green tassels. This injury caused necrotic symptoms on 17% the tassels in the early planting at Beltsville, which clearly affected pollen shed and kernel fill. The highest BMSB infestations were present when developing ears were forming kernels. Adults, eggs and all instars of nymphs were present from silking through to about two weeks after peak harvest. Later plantings that reached harvest maturity in September and early October showed much lower infestations and only minor ear damage. These plots may have avoided injury due to their close proximity to more attractive soybeans.

With exception of the later plantings, sweet corn harbored the highest numbers of BMSB in terms of population density per unit area of crop. Peak densities reached 16.8, 12.8, and 7.5 of all stages per m^2 at Beltsville, Upper Marlboro, and Keedysville, respectively. Significant kernel injury (average range of 4 to 26 collapsed kernels per ear), and incomplete kernel fill were recorded on 95 to 100% of the mature ears at these locations.

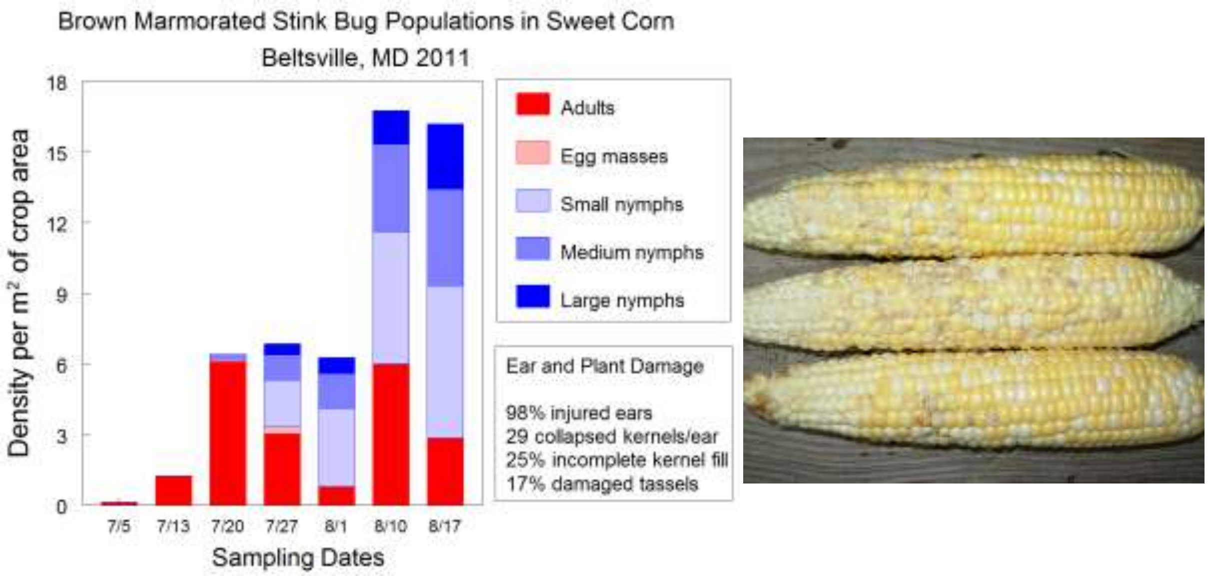

Figure 7. Seasonal abundance of BMSB adults, egg masses and nymphs and resulting damage in sweet corn during 2011.

At Upper Marlboro, individual row sampling was conducted in an early planting of untreated sweet corn, which was infested with a varying gradient of BMSB densities across rows leading inward from the field edge adjacent to woods. At harvest, densities ranged from 0.2 to 2.6 adults and nymphs per plant, causing injury to 5 to 54 kernels per ear. Densities were highly correlated with kernel injury, and regression revealed a damage rate of 20 kernels per BMSB stage.

An extensive monitoring project was conducted on the Delmarva Peninsula to determine the incidence and distribution of BMSB infestations in processing sweet corn. About 100 fields ranging in location from Salisbury, MD to Middletown, DE were scouted, each visited several times during full tassel to detect initial invasion of stink bugs and then later after insecticides were applied for worms. The assumption was that BMSB, if present, would be likely found at field edges next to woodlots or adjacent areas with dwellings. So sampling was targeted to these areas of the field. Native brown stink bugs were found on the outer rows in many fields but at very low numbers and infestations did not extend very far into the field. BMSB were found only in the latest plantings around Middletown, DE, but also well below damaging levels.

BMSB has been detected and reported as nuisance problems in homes throughout the Delmarva Peninsula. However, these results, along with trap captures and reports from crop advisors, confirm that populations have not yet reached levels causing widespread damage to agronomic crops.

Green Beans – Several plantings were grown at the three farms and each sampled during flowering and pod development stages by inspecting plants and examining mature pods for damage. In early plantings, adult BMSB invaded in July when pods were forming, and all nymphal instars were present from mid-July to about two weeks after peak harvest. Green beans harbored the second highest population density of BMSB per unit area. Peak densities reached 6.7, 8.5, and 0.2 of all stages per m^2 at Beltsville, Upper Marlboro, and Keedysville, respectively. Feeding damage was characterized by white sunken areas on 4 to 12% of the pods in the early plantings. Later plantings of green beans and lima beans that developed pods in September and early October experienced less BMSB activity and no pod injury. Like late-planted sweet corn, these plantings possibly avoided injury because of the more attractive soybeans grown nearby.

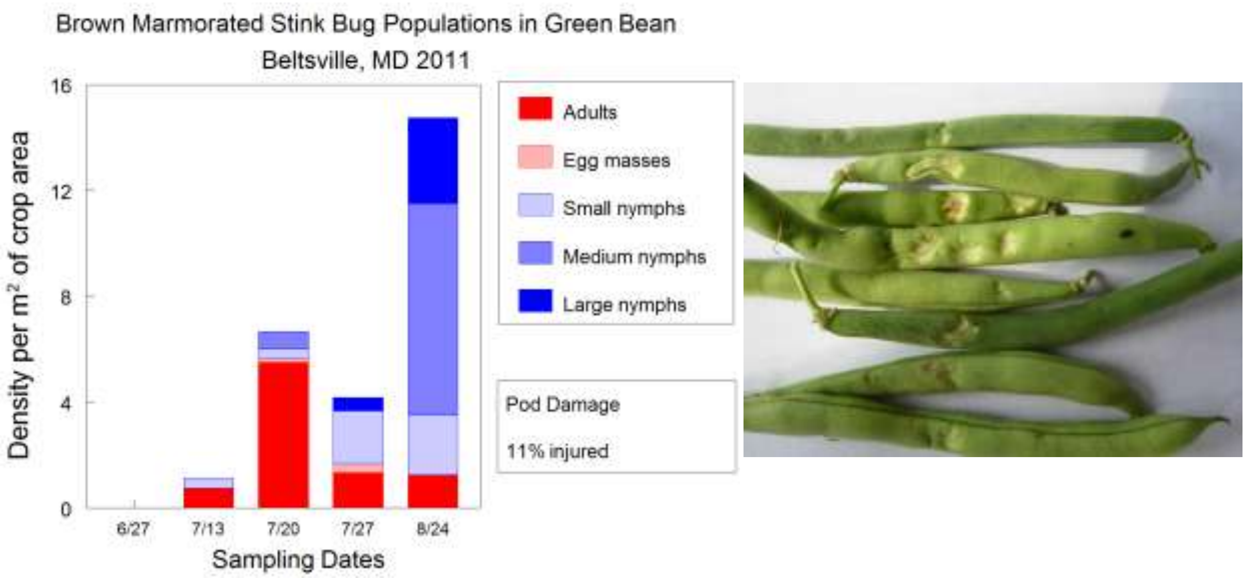

Figure 8. Seasonal abundance of BMSB adults, egg masses and nymphs and resulting damage in green beans during 2011.

Eggplant – At the Beltsville farm, three varieties of eggplant (white, purple, and dark purple) were transplanted on plastic mulch adjacent to a woodlot and next to other vegetable crops. Sampling was conducted weekly from early July to mid-September by inspecting plants and examining harvested fruit. Adults invaded during late June when plants were flowering and only a few small fruit were forming. At this time, the eggplant plot provided the tallest plants and most dense canopy in contrast to nearby plots of other vegetables. Egg laying and nymphal development started shortly after and continued through the summer until mid-September.

Eggplant harbored the third highest population density of BMSB per unit area. Peak densities reached 3.2 adults and nymphs per m^2. However, because of the indeterminate flowering and fruit set, population recruitment in eggplant occurred over a longer period compared to green beans and sweet corn, which had higher density peaks. Both adults and nymphs feeding on fruit were regularly seen but it was difficult to identify feeding punctures or tissue damage. Pits within very small depressions on the skin were considered suspect feeding sites but there were no consistent signs of discolored tissue beneath the skin, even after affected eggplants were held in cold storage for a week. To confirm that these pits were associated with feeding, very small fruit was enclosed in mesh bags until harvest maturity and then examined for pitting symptoms. Similar-sized exposed eggplants had five times more pits than bagged eggplants and there were no varietal differences with respect to the number of pits per fruit.

Based on the first year study, BMSB may have a minor impact on eggplant quality; however, feeding on stems and fruiting bodies could cause abnormal abortion of buds and young fruit, thus reducing yields. This was suggested by a sharp decline in fruit set in late August which coincided with the highest infestation of nymphs. However, plants again set fruit and produced marketable eggplants in late September and early October, after most of the new adults emigrated from the plot.

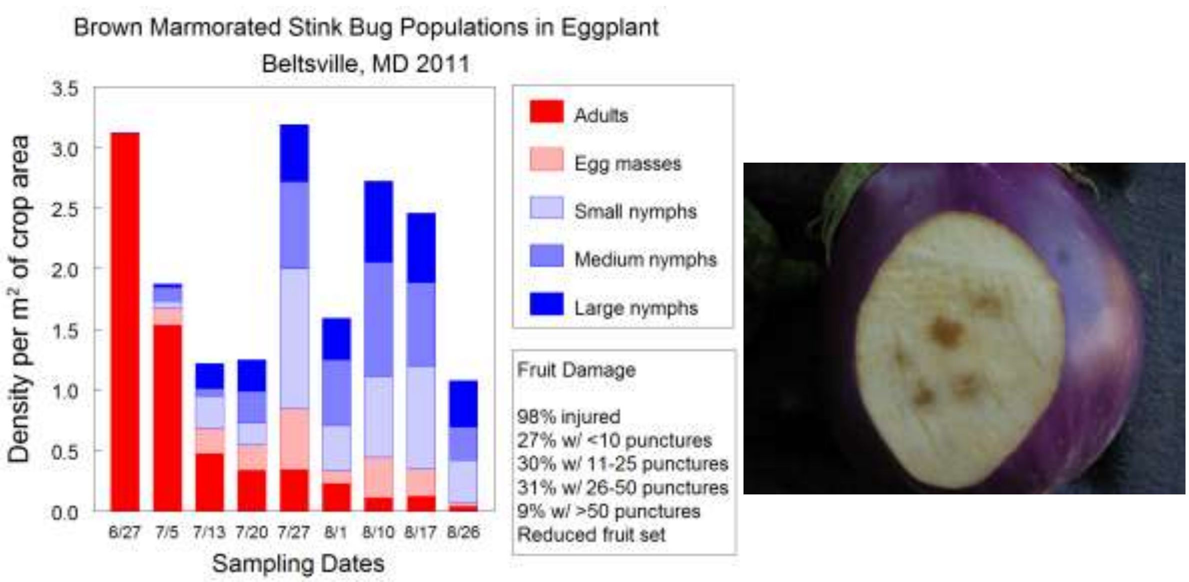

Figure 9. Seasonal abundance of BMSB adults, egg masses and nymphs and resulting damage in eggplant during 2011.

Okra – At the Beltsville farm, okra was transplanted in early May on plastic mulch rows adjacent to a woodlot and next to other vegetable crops. Sampling was conducted weekly from early July to mid-September by inspecting plants and examining pods. BMSB seasonal activity and infestation levels were similar to that of eggplant. Adults, eggs, and nymphs were present at relatively high numbers through July and August. Peak densities reached 2.2 adults and nymphs per m^2, and 39% of the pods pooled over multiple harvests were distorted or twisted and exhibited raised spots (suspected to be feeding sites). Similar to eggplant, BMSB feeding on flower buds may also impact pod development and crop yield.

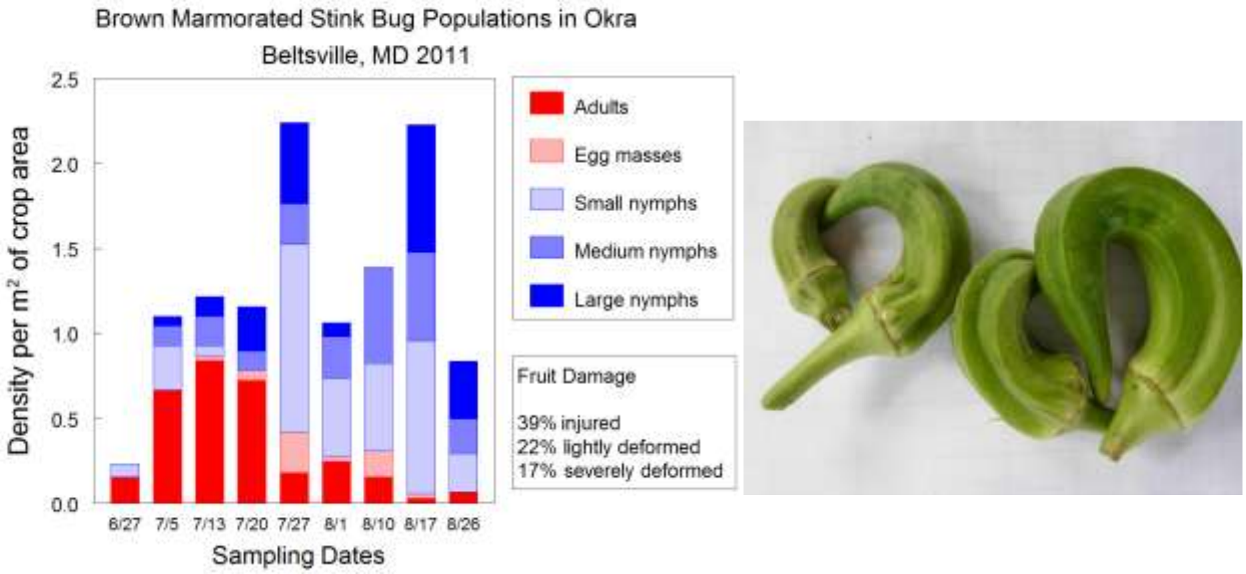

Figure 10. Seasonal abundance of BMSB adults, egg masses and nymphs and resulting damage in okra during 2011.

Spring/Fall Cabbage, Spring/Fall Broccoli, Kale, Boy Choi, Onion, Beets, Cantaloupe, Cucumber, Watermelon, Sweet Potato, and White Potato – Plantings of these crops at the Beltsville farm were established for variety testing and insecticide screening work. Most plots were adjacent to vegetables that were heavily infested with stink bugs. Intensive sampling for other insect pests and periodic inspections produced no evidence of BMSB activity and feeding injury. However, these crops may be more attractive and susceptible to stink bug feeding if isolated and not grown close to more preferred host plants.

2011 Insecticide Trials to Evaluate Control of Brown Marmorated Stink Bug

Galen Dively and Terry Patton, University of Maryland

1. EVALUATION OF CONVENTIONAL INSECTICIDES FOR CONTROL OF BROWN MARMORATED STINK BUG ON PEPPER – NE IPM Project

Bell pepper (var. Paladin) was transplanted into black plastic mulch on 23 May at the Central Maryland Research and Education facility, Beltsville, Maryland. Fertilizer and drip irrigation were applied according to commercial practices, and plants were staked and tied after 4 weeks of growth to prevent lodging. Twelve treatments plus an untreated control were arranged in a randomized complete block design with four replicates. Individual plots measured one row 18 ft long spaced 5 ft apart. Each plot contained 18 plants, spaced 12 inches apart. All insecticides were applied as foliar treatments using a CO_2 backpack sprayer calibrated to deliver 25 gal/acre at 40 psi. Three hollow cone nozzles covered each row, one directed on each side of the foliage and one over the top. Applications of each treatment were applied on 7 July, 2 August, 9 August, and 16 August. Sampling was conducted on 13 July, 4 August, 8 August, 15 August, and 23 August to record the number of stink bug stages (adults, egg masses including newly-hatched with 1st instar nymphs, 2nd-3rd instars, 4th instars, and 5th instars) on 15 plants per plot. On each sampling date, except 4 August, marketable fruit was picked from each plot and carefully examined for stink bug injury. Data were recorded on the number of fruit harvested and the numbers showing light damage (one feeding site or cloud spot), moderate damage (2-3 feeding sites on <1/3 of the fruit surface), and severe damage (many feeding sites over >1/3 of the fruit surface). Mixed model SAS procedure was used to test for treatment effects after adjustments were made for lack of normality and auto-correlation among repeated sampling dates. The Tukey option was used to test for significance among multiple mean comparisons.

Brown marmorated stink bug infestations were light, reaching a peak number of only 6.6 combined life stages per 15 plants on 8 August in the untreated plots. Overall populations in the untreated plots consisted of 62% adults, 25% egg masses (including newly-hatched with 1st instar nymphs), 4% 2nd-3rd instars, 4% 4th instars, and 3% 5th instars. Based on relative numbers of adults compared to immatures, reproduction was suppressed and thus recruitment was very low, apparently due to the hot, weather during July, followed by heavy rains in August. Populations in all plots significantly declined after 8 August, as evident by a significant date effect ($F_{(4, 195)} = 14.53$, $P < 0.001$).

Despite low numbers of stink bugs, all 12 insecticide treatments provided significant reductions (61-96% control) of stink bug numbers (treatment effect: $F_{(12,195)} = 4.81$, $P < 0.001$) (Figure 1). However, there were no statistical differences among these treatments, although Leverage, Venom, and Brigade showed the most consistent control over the sampling dates. As evident by a non-significant interaction effect (P=0.80), relative control efficacy of the treatments was consistent across the sampling dates.

An overall 18 % of the marketable peppers in the untreated plots showed signs of feeding injury, of which 66% was rated light, 34% rated moderate, and 0% rated severe. In most plots, injury peaked on 8 August (levels up to 55%) when the highest stink bug counts were recorded. Only Leverage, Venom, Orthene, and Belay reduced the level of fruit injury by 71 to 93% (treatment effect: $F_{(12,156)} = 6.70$, $P < 0.001$) (Figure 2). The treatment by date interaction was also significant ($F_{(36,156)} = 3.72$, $P < 0.001$), indicating differences in percentage injured fruit among treatments changed over the sampling dates. Injury data was highly variable among plots and there was a weak positive relationship between stink bug numbers and resultant injury (correlation coef. = 0.34), suggesting inconsistent trends in efficacy over time and the possibility that some adults may have recovered after certain treatments.

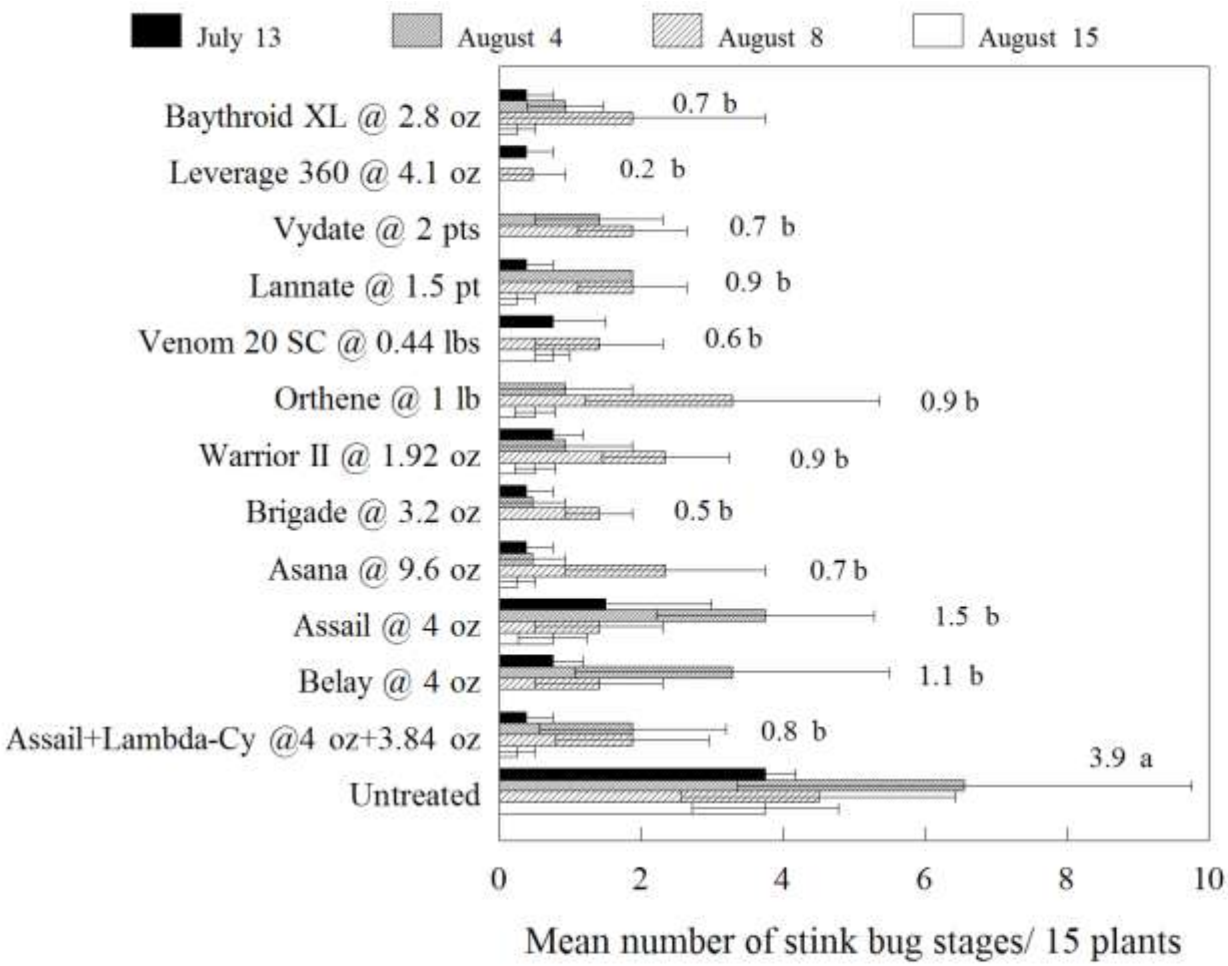

Figure 1. Relative efficacy of conventional insecticides for control of brown marmorated stink bug on bell peppers. Plotted are the treatment by date interaction means (± standard error) of stink bug stages to illustrate changes in efficacy over time. Values above each set of mean bars are the overall treatment means, which are not significantly different if followed by the same letter (P= 0.05). Beltsville Research and Education Center. 2011.

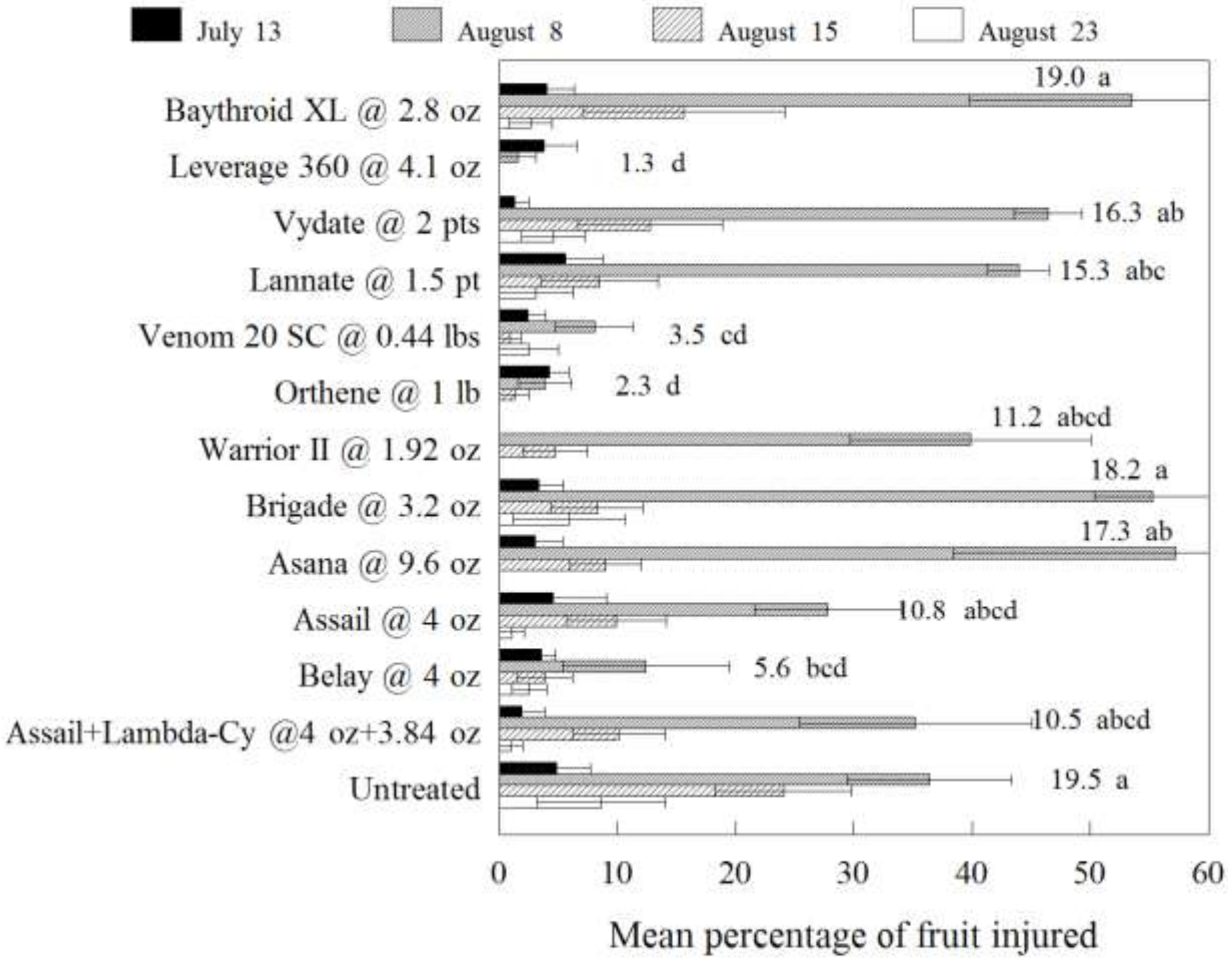

Figure 2. Effects of conventional insecticides on the percentage of fruit damaged by brown marmorated stink bug on bell peppers. Plotted are the treatment by date interaction means (± standard error) to illustrate changes in efficacy over time. Values above each set of mean bars are the overall treatment means, which are not significantly different if followed by the same letter (*P*= 0.05). Beltsville Research and Education Center. 2011.

2. EVALUATION OF CONVENTIONAL INSECTICIDES FOR CONTROL OF BROWN MARMORATED STINK BUG ON PEPPER – FMC Study

Bell pepper (var. Paladin) was transplanted into black plastic mulch on 10 June at the Central Maryland Research and Education facility, Beltsville, Maryland. Fertilizer and drip irrigation were applied according to commercial practices, and plants were staked and tied to prevent lodging. Ten treatments plus an untreated control were arranged in a randomized complete block design with four replicates. Individual plots measured one row 18 ft long spaced 5 ft apart. Each plot contained 18 plants, spaced 12 inches apart. All insecticides were applied as foliar treatments using a CO_2 backpack sprayer calibrated to deliver 25 gal/acre at 40 psi. Three hollow cone nozzles covered each row, one directed on each side of the foliage and one over the top. Applications of each treatment were applied on 3 August, 10 August, and 17 August.

Sampling was conducted on 9 August, 16 August, and 24 August to record the number of stink bug stages (adults, egg masses including newly-hatched with 1st instar nymphs, 2nd-3rd instars, 4th instars, and 5th instars) on all plants in each plot. Each plant was carefully inspected by two technicians, each examining the foliage and fruit of one side of the row. On the last two dates, marketable fruit was picked from each plot and carefully examined for stink bug injury. Data were recorded on the number of fruit harvested and the numbers showing light damage (one feeding site or cloud spot), moderate damage (2-3 feeding sites on <1/3 of the fruit surface), and severe damage (many feeding sites over >1/3 of the fruit surface). Mixed model SAS procedure was used to test for treatment effects after adjustments were made for lack of normality and auto-correlation among repeated sampling dates. The Tukey option was used to test for significance among multiple mean comparisons.

Hot weather and heavy rains during August suppressed stink bug reproduction and recruitment, and infestations were much lower than levels experienced in 2010 at the same study site. Populations reached peak numbers of only 9.6 combined life stages per 18 plants on 9 August in the untreated plots, of which 62% were adults, 12% were egg masses (including newly-hatched with 1st instar nymphs), and 26% were 2nd-4th instar nymphs. No 5th instars were observed. Numbers in all plots significantly declined after 9 August, as evident by a significant date effect ($F_{(2,99)} = 14.53$, $P < 0.001$).

Despite low numbers of stink bugs, all insecticide treatments, except Brigatier and Beleaf, provided significant reductions (81-98% control) of stink bug numbers (treatment effect: $F_{(10,99)} = 3.92$, $P < 0.001$) (Table 1). There were no statistical differences among these treatments, although Hero at the high rate, Athena, Mustang Max, and Mustang+Lannate showed the most consistent control. There was a significant interaction effect ($F_{(20,99)} = 1.69$, $P = 0.048$), although relative differences in control efficacy among treatments were consistent across sampling dates.

An overall 18.5 % of the marketable peppers in the untreated plots showed signs of feeding injury, of which 58% was rated light, 30% rated moderate, and 12% rated severe. In most plots, injury peaked on 16 August (levels up to 16.5%) when the highest stink bug counts were recorded. Athena, Beleaf, and the higher rates of Hero provided significantly the greatest reduction in fruit injury (treatment effect: $F_{(10,63.2)} = 2.32$, $P = 0.021$) (Table 1). Additionally, all treatments significantly reduced the level of moderate or severe injury (treatment effect: $F_{(10,63.2)} = 6.73$, $P < 0.001$).

Table 1. Relative efficacy of conventional insecticides for control of brown marmorated stink bug on bell peppers. Beltsville Research and Education Center. 2011.

Treatment (rate/acre)	Number of stink bug stages per plot	Percent injured fruit	Percent fruit with moderate and severe injury ratings
Hero (6.4 oz)	0.75 b	7.00 ab	0.00 b
Hero (7.1 oz)	0.56 b	5.10 ab	0.00 b
Hero (8 oz)	0.65 b	4.80 b	1.15 b
Hero (10.3 oz)	0.35 b	5.57 ab	1.32 b
Brigatier (8 oz)	1.27 ab	5.98 ab	0.00 b
Athena (16 o)z	0.08 b	4.87 b	0.92 b
Mustang Max (4 oz)	0.35 b	6.56 ab	0.58 b
Mustang Max+Lannate (4 oz+16 oz)	0.17 b	7.50 ab	1.28 b
Beleaf (2.8 oz)	1.04 ab	4.80 b	0.99 b
F-9318-1 (18 oz)	0.56 b	9.16 ab	1.73 b
Untreated	3.94 a	18.54 a	8.33 a

Means within a column followed by the same letter are not significantly different (P= 0.05).

3. EVALUATION OF ORGANIC INSECTICIDES FOR CONTROL OF BROWN MARMORATED STINK BUG ON PEPPER

Bell pepper (var. Revolution) was transplanted into black plastic mulch on 17 May at the Central Maryland Research and Education facility, Upper Marlboro, Maryland. Fertilizer and drip irrigation were applied according to commercial practices, and plants were staked and tied after 4 weeks of growth to prevent lodging. Seven treatments plus an untreated control were arranged in a randomized complete block design with four replicates. Individual plots measured one row 20 ft long spaced 5 ft apart. Each plot contained 19 plants, spaced 12 inches apart.

Applications of each treatment were applied on 4 August, 11 August, 18 August, and 25 August. All insecticides were applied as foliar treatments using a CO_2 backpack sprayer calibrated to deliver 25 gal/acre at 40 psi. Three hollow cone nozzles covered each row, one directed on each side of the foliage and one over the top. Sampling was conducted on 12 August, 19 August, and 26 August to record the number of stink bug stages (adults, egg masses including newly-hatched with 1st instar nymphs, 2nd-3rd instars, 4th instars, and 5th instars) in the entire plot. On 2 September, all marketable fruit was picked in each plot and carefully examined for stink bug injury. Data were recorded on the number of fruit harvested and the numbers showing light damage (one feeding site or cloud spot), moderate damage (2-3 feeding sites on <1/3 of the fruit surface), and severe damage (many feeding sites over >1/3 of the fruit surface). Mixed model SAS procedure was used to test for treatment effects after adjustments were made for lack of normality and auto-correlation among repeated sampling dates. The Tukey option was used to test for significance among multiple mean comparisons.

Brown marmorated stink bug infestations were light, reaching peak numbers of only 12.3 combined life stages per 19 plants on 26 August in the untreated plots. Overall populations in the untreated plots consisted of 50% adults, 3% egg masses (including newly-hatched with 1st instar nymphs), 11% 2nd-3rd instars, 17% 4th instars, and 19% 5th instars. Plot infestations were highly variable along replicate blocks initially due to an infestation gradient from the adjacent woodlot and then later adults invaded across blocks from harvested sweet corn plots. Reproduction was apparently suppressed by heavy rains in August based on numbers of adults compared to immatures.

Despite low numbers of stink bugs, all treatments except Entrust provided significant reductions (55-86% control) of stink bug adults ($F_{(7,69)} = 8.60$, $P < 0.001$) (Table 1). In order of increasing efficacy, Surround alone and in combinations with Sulfur, Trilogy, and Azera were the better treatments, although these treatments were no statistically different. Relative treatment effects on nymphs were similar to treatment differences for adults but not statistically significant. As evident by non-significant interaction and date effects, control efficacies of the treatments were consistent across the sampling dates.

An average of 18.6 % of the marketable peppers in the untreated plots showed signs of feeding injury, of which the majority was rated light. However, treatment, date, and interaction effects were not significant for the total number of harvested fruit and incidence of stink bug injury (Table 2). Furthermore, injury data was highly variable among plots and there was no relationship between stink bug numbers and the resultant injury, suggesting inconsistent trends in efficacy over time. For unexplained reasons, higher levels of injury were recorded in most treated plots compared to levels in the untreated plots.

Table 1. Relative efficacy of organic insecticides for control of brown marmorated stink bug on bell peppers. Upper Marlboro Research and Education Center. 2011.

		Stink bug stages		
Treatments	Rate	Nymphs	Adults	Combined counts
Azera	32 oz	1.58	2.08 bc	3.67 bc
Entrust	36 grams	4.17	3.25 ab	7.42 ab
Surround	12 lbs	4.08	1.17 bc	5.25 abc
Sulfur	12 lbs	1.58	2.17 bc	3.75 bc
Surround + Sulfur	12 lbs + 12 lbs	4.17	1.00 c	5.17 abc
Surround + Trilogy	12 lbs + 1%	2.08	0.92 c	3.00 bc
Surround + Azera	12 lbs + 32 oz	1.00	0.67 c	1.67 c
Untreated		4.58	4.83 a	9.42 a

Means within columns followed by the same letter or no letter are not significantly different (*P* = 0.05).

Table 2. Effects of organic insecticides on total marketable fruit and incidence of injury caused by brown marmorated stink bug on bell peppers. Means ± standard errors are listed. Upper Marlboro Research and Education Center. 2011.

Treatments	Rate	Total number of fruit	Number of injured fruit	Percent of fruit injured
Azera	32 oz	33.6 ± 5.69	12.2 ± 3.84	36.4 ± 9.83
Entrust	36 g	16.7 ± 4.05	1.3 ± 0.95	5.7 ± 4.53
Surround	12 lbs	25.0 ± 5.58	11.0 ± 3.81	40.5 ± 7.90
Sulfur	12 lbs	12.0 ± 5.20	2.3 ± 1.86	12.3 ± 8.48
Surround + Sulfur	12 lbs + 12 lbs	24.8 ± 5.72	9.5 ± 3.20	37.5 ± 8.11
Surround + Trilogy	12 lbs + 1%	17.3 ± 3.82	6.0 ± 2.48	28.0 ± 10.90
Surround + Azera	12 lbs + 32 oz	11.8 ± 5.45	2.5 ± 1.19	20.8 ± 1.73
Untreated		23.0 ± 5.15	3.3 ± 1.65	18.6 ± 12.11

4. EVALUATION OF CONVENTIONAL INSECTICIDES FOR CONTROL OF BROWN MARMORATED STINK BUG ON TOMATO

Tomato (var. Fresh Mountain Plus) was transplanted into black plastic mulch on 16 May at the Central Maryland Research and Education facility, Beltsville, Maryland. Fertilizer and drip irrigation were applied according to commercial practices, and plants were staked, suckered several times, and trellised. Seven treatments plus an untreated control were arranged in a randomized complete block design with four replicates. Individual plots measured one row 20 ft long spaced 5 ft apart. Each plot contained 13 plants, spaced 18 inches apart. All insecticides were applied as foliar treatments using a CO_2 backpack sprayer calibrated to deliver 25 gal/acre at 40 psi. Three hollow cone nozzles on the boom covered each row, with one dropped and directed on each side of the foliage and one over the top. Applications of each treatment were applied on 8 July, 29 July, and 5 August. Sampling was conducted on 4 August, 11 August, and 17 August to record the number of stink bug stages (adults, egg masses including newly-hatched with 1st instar nymphs, 2nd-3rd instars, 4th instars, and 5th instars) on all 18 plants per plot. Each plant was carefully inspected by two technicians, each examining the foliage and fruit of one side of the row. On each sampling date, marketable fruit (pink and red) was picked from each plot and carefully examined for stink bug injury. Data were recorded on the number of fruit harvested and the numbers showing light damage (one feeding site or cloud spot), moderate damage (2-3 feeding sites on <1/3 of the fruit surface), and severe damage (many feeding sites over >1/3 of the fruit surface). Mixed model SAS procedure was used to test for treatment effects after adjustments were made for lack of normality and auto-correlation among repeated sampling dates. The Tukey option was used to test for significance among multiple mean comparisons.

Brown marmorated stink bug infestations were very low in all plots. In the untreated controls, counts averaged less than one combined life stages, of which adults and egg masses accounted for 16% and 82% of the total numbers, respectively. Native brown stink bug adults were also present at near comparable levels of activity. However, only a few nymphs of all species were detected. This was the case in other tomato plots at the study site, so either the tomato crop was not a good reproductive host or nymphal survival was low due to the hot weather during July and heavy rains in August. Treatments had no effect on stink bug numbers compared to the control, and there was no interaction effect with sampling date (Table 1). However, overall populations in all plots significantly declined after 11 August, as evident by a significant date effect ($F_{(2,72)} = 41.35$, $P < 0.001$).

Despite low numbers of stink bugs, an average 37.6% of the marketable tomatoes in the untreated plots showed evidence of stink bug feeding, of which 76% was rated light injury, 20% rated moderate injury, and 4% rated severe injury. Fruit damage was significantly less in all treatment plots, except for plots treated with Vydate and Lannate ($F_{(7,93)} = 9.59$, $P < 0.001$) (Table 1). Additionally, all treatments significantly reduced the level of moderate and severe injury ($F_{(7,21)} = 4.14$, $P = 0.005$). Leverage, Baythroid, and Endigo in increasing order of efficacy were the better treatments, reducing fruit injury by 61 to 70%. Inconsistently, there was no relationship between stink bug numbers and resultant injury, particularly in the control plots which had fewer bugs than some of the treated plots, yet significantly higher fruit injury. It is possible that some adults may have recovered after certain treatments, and also nocturnal-active stink bugs could have moved in and out of plots and thus not detected during sampling.

Table 1. Relative efficacy of conventional insecticides for control of brown marmorated stink bug on tomato. Beltsville Research and Education Center. 2011.

Treatment (rate/acre)	Number of stink bug stages per plot	Percent injured fruit	Percent fruit with moderate and severe injury ratings
Belay @ 4 oz	2.5	21.9 bcd	4.9 a
Vydate @ 2 pts	2.8	27.8 ab	3.7 ab
Lannate @ 1.5 pts	1.0	25.4 abc	4.9 a
Endigo @ 4.5 oz	1.3	11.3 d	0.3 b
Baythroid XL @ 2,8 oz	1.0	11.9 d	1.1 ab
Leverage @ 4.1 oz	0.5	14.5 cd	1.0 ab
Warrior II @ 1.92 oz	1.0	15.3 bcd	2.4 ab
Untreated	0.8	37.6 a	6.4 a

Means within a column followed by the same letter are not significantly different (*P*= 0.05).

5. EVALUATION OF CONVENTIONAL INSECTICIDES FOR CONTROL OF BROWN MARMORATED STINK BUG ON TOMATO – FMC Study

Tomato (var. Fresh Mountain Plus) was transplanted into black plastic mulch on 7 June at the Central Maryland Research and Education facility, Beltsville, Maryland. Fertilizer and drip irrigation were applied according to commercial practices, and plants were staked, suckered several times, and trellised. Ten treatments plus an untreated control were arranged in a randomized complete block design with four replicates. Individual plots measured one row 20 ft long spaced 5 ft apart. Each plot contained 13 plants, spaced 18 inches apart. All insecticides were applied as foliar treatments using a CO_2 backpack sprayer calibrated to deliver 25 gal/acre at 40 psi. Three hollow cone nozzles on the boom covered each row, with one dropped and directed on each side of the foliage and one over the top. Applications of each treatment were applied on 10 August and 17 August. Sampling was conducted on 16 August and 24 August to record the number of stink bug stages (adults, egg masses including newly-hatched with 1st instar nymphs, 2nd-3rd instars, 4th instars, and 5th instars) on all 18 plants per plot. Each plant was carefully inspected by two technicians, each examining the foliage and fruit of one side of the row. On each sampling date, marketable fruit (pink and red) was picked from each plot and carefully examined for stink bug injury. Data were recorded on the number of fruit harvested and the numbers showing light damage (one feeding site or cloud spot), moderate damage (2-3 feeding sites on <1/3 of the fruit surface), and severe damage (many feeding sites over >1/3 of the fruit surface). Mixed model SAS procedure was used to test for treatment effects after adjustments were made for lack of normality and auto-correlation among repeated sampling dates. The Tukey option was used to test for significance among multiple mean comparisons.

Brown marmorated stink bug infestations were either very low or completely absent in all plots. Because this study was the last planting at the study site, adjacent earlier-planted host crops (mainly peppers, eggplant, and sweet corn) attracted the initial invasion of stink bugs and thus acted as trap crops. Furthermore, stink bug reproduction was low due to the extremely hot weather during July and heavy rains in August, so there was very little movement of new adults from these crops into this study. Also, another contributing factor was the poor quality of the fruit which steadily declined after the nonstop rains of Hurricane Irene.

Despite virtually no stink bugs, about 5% of the marketable tomatoes in the untreated plots showed evidence of stink bug feeding, of which 69% was rated light injury, 23% rated moderate injury, and 8% rated severe injury. However, because of low stink bug activity and variable data, treatments had no significant effect on the percentage of total fruit injury or the percentage of fruit with moderate and severe injury ratings (Table 1). Moreover, the data showed no consistent trends that would suggest possible treatment differences in control efficacy.

Table 1. Effects of conventional insecticides on fruit injury caused by brown marmorated stink bugs on tomato. Beltsville Research and Education Center. 2011.

Treatment	Rate per acre	Percent injured fruit	Percent fruit with moderate and severe injury ratings
Hero	6.4 oz	5.67 ± 1.91	1.09 ± 0.56
Hero	7.1 oz	1.75 ± 0.59	0.79 ± 0.40
Hero	8 oz	3.55 ± 1.56	1.27 ± 0.69
Hero	10.3 oz	3.86 ± 1.52	0.93 ± 0.69
Brigatier	8 oz	5.31 ± 2.00	1.89 ± 1.41
Athena	16 oz	2.74 ± 0.91	0.85 ± 0.56
Mustang Max	4 oz	5.54 ± 1.89	1.79 ± 1.26
Mustang Max + Lannate	4 oz + 16 oz	2.59 ± 1.17	0.72 ± 0.47
Beleaf	2.8 oz	5.03 ± 1.96	1.13 ± 0.89
F-9318-1	18 oz	4.38 ± 1.96	2.24 ± 1.13
Untreated		4.81 ± 2.14	1.21 ± 0.90

Means (± standard error) for both injury measurements were not significantly different (P= 0.05).

6. EVALUATION OF CONVENTIONAL FOR CONTROL OF BROWN MARMORATED STINK BUG ON EGGPLANT

Eggplant (var. Santana) was transplanted into black plastic mulch on 17 May at the Central Maryland Research and Education facility, Beltsville, Maryland. Fertilizer and drip irrigation were applied according to commercial practices.These plots were established first to evaluate IR-4 insecticides for control of flea beetles during early plant growth; however, stink bugs colonized later after the IR-4 study was completed, so the same plots were used to evaluate stink bug control but with different treatments. Treatments were arranged in a randomized complete block design with four replicates. Individual plots measured one row 20 ft long spaced 5 ft apart. Each plot contained 12 plants, spaced 18 inches apart.

Each treatment was applied once on 8 July, using a CO_2 backpack sprayer calibrated to deliver 25 gal/acre at 40 psi. Three hollow cone nozzles covered each row, with one drop nozzle directed on each side of the foliage and another one over the top. Sampling was conducted on 14 July (6 days post-treatment) by carefully examining the entire foliage of all plants per plot to record the number of stink bug stages (adults, egg masses including newly-hatched with 1st instar nymphs, 2nd-3rd instars, 4th instars, and 5th instars). Mixed model SAS procedure was used to test for treatment effects after adjustments were made for lack of normality. The Tukey option was used to test for significance among multiple mean comparisons.

Brown marmorated stink bug infestations reached moderate levels, averaging 1.5 combined life stages per untreated plant, of which adults, egg masses and nymphs accounted for 78%, 14% and 8% of the total numbers, respectively. Because of high plot to plot variation, treatments had no significant effects on the total stink bug stages compared to the control; however, Belay, Endigo, Baythroid, Leverage, Warrior, and Assail+Lambda clearly showed >75% reductions in stink bug numbers. For adults only, treatments resulted in similar reductions in numbers, and plots treated with Belay and Baythroid had significantly lower numbers of adults than levels in untreated plots ($F_{(9,27)} = 2.36$, $P = 0.041$).

Table 1. Relative efficacy of conventional insecticides for control of brown marmorated stink bugs on eggplant. Beltsville Research and Education Center. 2011.

Treatments	Rate per acre	Number of all stages per 12 plants	Number of adults per 12 plants	
Belay	4 oz	4.00 ± 0.57	0.33 ± 0.33	b
Vydate	2 pts	11.14 ± 9.45	4.00 ± 3.37	ab
Lannate	1.5 pts	10.29 ± 5.81	5.00 ± 3.70	ab
Endigo	4.5 oz	4.29 ± 0.86	1.75 ± 0.85	ab
Baythroid XL	2.8 oz	3.86 ± 1.29	0.75 ± 0.48	b
Leverage	4.1 oz	3.43 ± 0.94	1.60 ± 0.68	ab
Warrior II	1.92 oz	4.29 ± 2.27	1.75 ± 1.11	ab
Assail +Lambda-Cy	4 oz + 3.84 oz	3.86 ± 1.46	1.75 ± 0.75	ab
Venom	.44 lb	7.29 ± 4.56	3.50 ± 2.53	ab
Untreated		18.00 ± 6.95	9.25 ± 3.30	a

Means (± standard error) of total stages are not significantly different. Means of adults followed by the same letter are not significantly different (*P*= 0.05).

7. EVALUATION OF CONVENTIONAL AND ORGANIC INSECTICIDES FOR CONTROL OF BROWN MARMORATED STINK BUG ON PEPPER – IR-4 Project

Bell pepper (var. Paladin) was transplanted into black plastic mulch on 23 May at the Central Maryland Research and Education facility, Beltsville, Maryland. Fertilizer and drip irrigation were applied according to commercial practices, and plants were staked and tied after 4 weeks of growth to prevent lodging. Nine treatments plus an untreated control were arranged in a randomized complete block design with four replicates. Individual plots measured one row 16 ft long spaced 5 ft apart. Each plot contained 15 plants, spaced 12 inches apart. All insecticides were applied as foliar treatments using a CO_2 backpack sprayer calibrated to deliver 25 gal/acre at 40 psi. Three hollow cone nozzles covered each row, one directed on each side of the foliage and one over the top. Applications of each treatment were applied on 7 July, 9 August, and 16 August. Sampling was conducted on 13 July, 4 August, 8 August, 15 August, and 23 August to record the number of stink bug stages (adults, egg masses including newly-hatched with 1st instar nymphs, 2nd-3rd instars, 4th instars, and 5th instars) on 15 plants per plot. On each sampling date, except on 4 August, marketable fruit was picked from each plot and carefully examined for stink bug injury. Data were recorded on the number of fruit harvested and the numbers showing light damage (one feeding site or cloud spot), moderate damage (2-3 feeding sites on <1/3 of the fruit surface), and severe damage (many feeding sites over >1/3 of the fruit surface). Mixed model SAS procedure was used to test for treatment effects after adjustments were made for lack of normality and auto-correlation among repeated sampling dates. The Tukey option was used to test for significance among multiple mean comparisons.

Brown marmorated stink bug infestations were light, reaching a peak number of only 8 combined life stages per 15 plants on 8 August in the untreated plots. Overall populations consisted of 54% adults, 12% egg masses (including newly-hatched with 1st instar nymphs), 11% 2nd-3rd instars, 15% 4th instars, and 7% 5th instars. Recruitment of nymphs relative to the number of adults was low, apparently due to the hot, weather during July, followed by heavy rains in August. Populations in all plots declined after 8 August, as evident by a significant date effect ($F_{(4,148)} = 11.36$, $P < 0.001$).

Despite low numbers of stink bugs, the five conventional treatments provided significant reductions (>75% control) of stink bug numbers (treatment effect: $F_{(9,148)} = 8.52$, $P < 0.001$) (Table 1). However, there were no statistical differences among these treatments. Of the organic treatments, only X-6673-11+Nufilm significantly reduced infestations by 53% less than levels in the control. Plots treated with the other organics had fewer stink bugs but differences from the control plots were not statistically different. As evident by a non-significant interaction effect (P=0.44), relative control efficacy of the treatments was consistent across the sampling dates.

About 20% of the marketable peppers in the untreated plots showed signs of feeding injury, of which 69% was rated light, 25% rated moderate, and 6% rated severe. Treatments reduced the level of fruit injury (treatment effect: $F_{(9,118)} = 7.19$, $P < 0.001$) but differences from the control were only significant for Venom and Venom+Exponent (Table 1).

Table 1. Effects of conventional and organic insecticides on populations of brown marmorated stink bug populations on bell peppers. Beltsville Research and Education Center. 2011.

Treatment @ rate/acre	Number of stink bug stages per 15 plants	Percentage of injured fruit
Warrior II @ 1.92 oz	1.08 de	15.6 a
Venom 20 SG @ 406 g	1.03 de	1.7 c
Venom 20 SG+Exponent @ 406 g+8 oz	0.82 de	3.4 bc
Etofenprox @ 237 ml	0.46 e	13.4 ab
Etofenprox + Exponent	1.13 cde	15.3 a
Pyganic+Nufilm @ 32 oz+4 oz	3.25 abcd	12.5 abc
Azera @ 32 oz	4.19 ab	15.7 a
X-6672-11+Nufilm @ 32 oz+4 oz	3.46 abc	21.9 a
X-6673-11+Nufilm @ 32 oz+4 oz	2.34 bcde	18.5 a
Untreated	4.99 a	19.8 a

Means within columns followed by the same letter are not significantly different (P = 0.05).

8. EVALUATION OF CONVENTIONAL INSECTICIDES FOR CONTROL OF BROWN MARMORATED STINK BUG IN SOYBEAN

Three experiments to test the efficacy of insecticides for control of brown marmorated stink bug (BMSB) in soybean were conducted at the Central Maryland Research and Education Center, Beltsville, MD. In experiments 1 and 2, full-season soybeans (Asgrow 3130) were drilled in 9-inch rows on 11 May in separate fields. Because BMSB populations were low and only abundant along the field edges next to adjacent woodlots, plots were laid out end to end along field edges where sufficient numbers of stink bugs were present to test. Each treatment plot was 10 ft. wide by 20 ft. long and replicated four times in a randomized block design. Experiment 1 tested 11 treatments, while experiment 2 tested 8 treatments, and each study included an untreated control. A single application with a CO_2-powered backpack sprayer calibrated to deliver 21 gal/acre at 40 psi was applied on 2 September and 9 September in experiment 1 and 2, respectively. Treatments were applied with a 10 ft. boom with five hollow cone nozzles directed over the top of the foliage. In both experiments, counts of adults and nymphs observed on the canopy foliage of the entire plot were made at 3 and 7 days post-treatment.

In experiment 3, eleven treatments including the control were evaluated in double-cropped beans (Pioneer 93Y80) which were planted in 30-inch rows on 11 July. Plots were single rows 25 ft. long, bordered with untreated rows, and laid out in a randomized block design with four replicates. Pre-treatment infestations were very light, so BMSB adults and late nymphs were collected from field edges of other soybean fields and added to the existing population at the rate of 30 per plot. A single application with a CO_2-powered backpack sprayer calibrated to deliver 21 gal/acre at 40 psi was applied on 20 September. Treatments were applied with a 3 ft. boom with two hollow cone nozzles directed over the top of the foliage. At 3 and 6 days post-treatment, counts of adults and nymphs observed on the canopy foliage of the entire plot were recorded. In addition, a mesh bag was installed over three plants in each plot on 27 September and manually infested with 10 adults. Counts of live adults in each bag were made 3 days later to evaluate the residual activity of the treatments.

BMSB populations in experiments 1 and 2 averaged 21.6 and 14.1 bugs per plot (pooled over both sampling dates) in the untreated controls, respectively. Although populations were light, counts were high enough to detect significant treatment effects. All treatments in both experiments significantly reduced BMSB numbers compared to the control (Exp. 1: $F_{(11,68)}$ = 11.9, P < 0.001; Exp. 2: $F_{(8,51)}$ = 27.9, P < 0.001). In experiment 1, there were also differences among treatments and rate responses, with Azana and the low rate of Lorsban as the least effective (Figure 1). Infestations also doubled in the control plots over the two sampling dates, as evident by a significant date effect ($F_{(11,68)}$ = 7.35, P = 0.009) but relative treatment differences were consistent. In experiment 2, all treatments provided greater than 95% control (Figure 2) but BMSB population pressure were not high enough to discern differences among treatments or relative residual activity. Similar results were obtained in experiment 3 which showed greater than 98% control for all treatments ($F_{(10,62.1)}$ = 116.7, P <= 0.001) (Figure 3). Moreover, survival of the bagged adults after 10 days post-treatment revealed little if any residual activity. However, heavy days that occurred for several days after treatment probably washed off much of the insecticide residue. In summary, results of the three experiments clearly demonstrated high levels of efficacy against BMSB with one application of the tested products. However, populations were low and invasions were short-lived, so none of the experiments were able to strongly test for residual activity. Also the treatment by sampling date interaction effect was not significant in all experiments, indicating no relative change in efficacy over time among treatments.

Figure 1. Experiment 1 – Relative efficacy of conventional insecticides for control of BMSB on full-season soybeans. Numbers within mean bars are the actual counts and were used in the statistical analysis. Bars with the same letter are not significantly different (*P* = 0.05). Beltsville Research and Education Center. 2011.

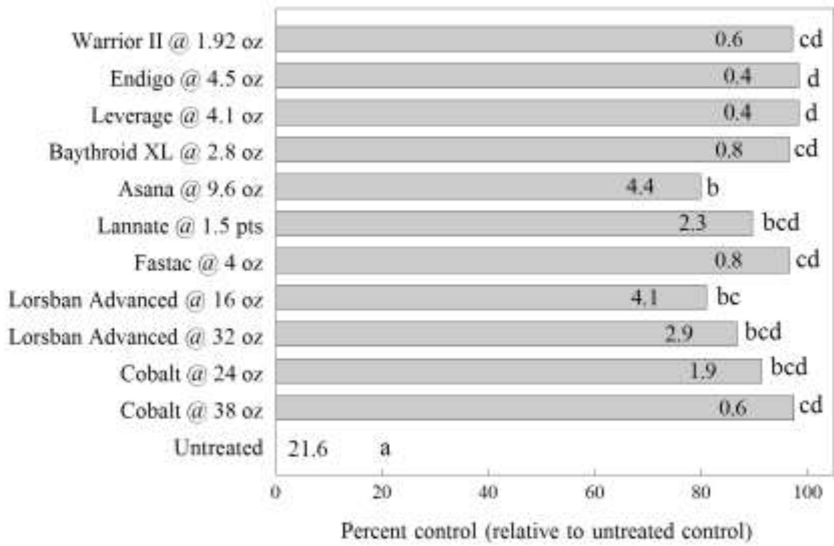

Figure 2. Experiment 2 – Relative efficacy of conventional insecticides for control of BMSB on full-season soybeans. Numbers within mean bars are the actual counts and were used in the statistical analysis. Bars with the same letter are not significantly different (*P* = 0.05). Beltsville Research and Education Center. 2011.

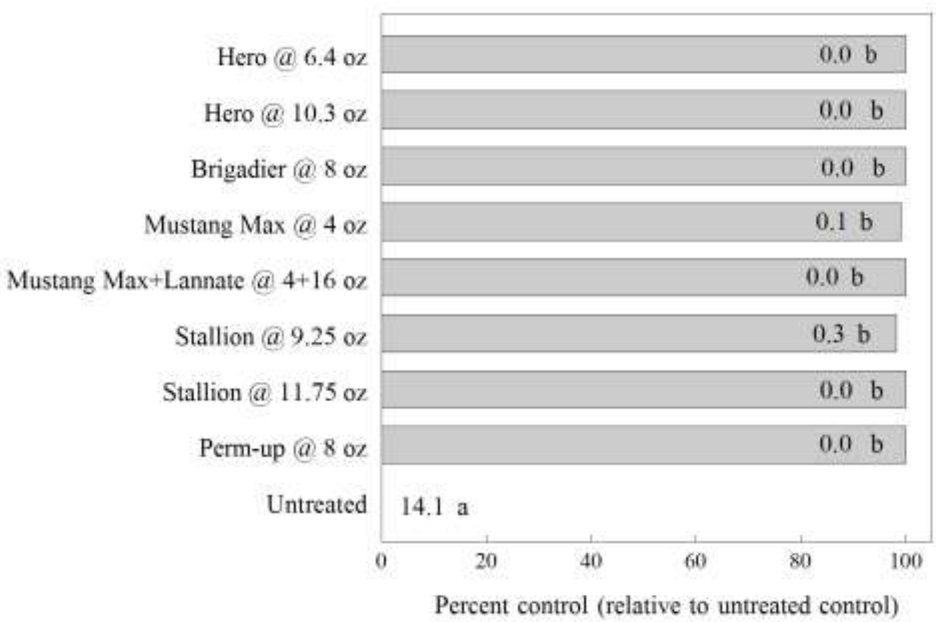

Figure 3. Experiment 3 – Relative efficacy of conventional insecticides for control of BMSB on double-cropped soybeans. Numbers within mean bars are the actual counts and were used in the statistical analysis. Bars with the same letter are not significantly different (*P* = 0.05). Beltsville Research and Education Center. 2011.