Integrated Trap Crop and Pheromone Trap System for Organic Management of Brown Marmorated Stink Bug

C.R. Mathews[1,2] and M.H. Hallack[1]

This project tested a chemical-free approach that combined a sunflower trap crop perimeter with commercially available pheromone traps to manage the invasive Brown Marmorated Stink Bug (BMSB), *Halyomorpha halys*. We tested this system in 2012 on four cash crops with previously high BMSB susceptibility: okra, sweet pepper, tomato and summer squash, in replicated field plots under USDA certified organic production. We observed a high degree of BMSB attraction to the sunflower trap crop, with > 2-fold increase in average BMSB densities in the trap perimeters, as compared to the cash crops. The trap crop perimeters also delayed BMSB colonization of the cash crops, resulting in lower BMSB densities for tomatoes and peppers late season (> 15 Aug). However, reduced BMSB densities in the cash crops did not translate into significantly lower crop damage or higher yields in the trap crop plots as compared to control plots. We found a 14-d earlier colonization and 2-fold higher density of BMSB in plots with prior history of vegetable production, as compared to plots previously in grain. No overall directional affect for BMSB colonization was found within fields, suggesting that presence of the cash crops in the previous year was a more important factor for BMSB. Our results indicate that this system is effective for organic production but will require a BMSB-specific pheromone lure, or an organic mortality inducing agent, that can be incorporated within the trap crop perimeter in order to effectively reduce BMSB damage to the cash crops.

Methods

Field Sites & Crop Production. Four study plots (900 sq ft each, in hay the previous year) at Redbud Farm (Berkeley County, WV) were established in a randomized complete block design study using two blocks (one field, designated 'old block,' had >10 yr history of vegetable production, the other, designated 'new block,' was previously in grains). Each study plot contained 4 linear crop rows (each 3x36 ft) covered with black plastic (1 ml embossed) and 3 ft wide bare aisles in between (Fig. 1). Sweet pepper ('Red Ace') and tomato ('Big Boy') seedlings were started from seed (Johnny's Select Seeds) in the greenhouse and transplanted 18 May; Okra ('Clemson Spineless,' Johnny's Select Seeds, 4/hole) and squash ('Zephyr,' Johnny's Select Seeds, 2/hole) were direct seeded 21 May. All crops were spaced 24 in within rows and aisles mulched with straw (22 May, Fig. 1).

Figure 1. One field plot shown after application of straw mulch (May, 2012).

The 3 ft wide trap crop perimeter was direct seeded 23 May with amaranth (green variety from saved seed, 4 oz/plot) and sunflower

[1] Redbud Farm, LLC, Inwood, WV 25428; www.redbudfarm.com
[2] Institute of Environmental and Physical Sciences, Shepherd University, Shepherdstown, WV 25443

(open pollinated mix, Johnny's Select Seeds, 24 oz/plot) seeds broadcast by hand (Fig. 2).

Figure 2. One field plot with sunflower trap crop perimeter fully established and 4 'RESCUE' stinkbug traps baited with pheromone lures, one trap installed in each cardinal direction (June, 2012).

No insect or disease control was applied to any of the plots throughout the growing season. Four 'RESCUE' stinkbug traps (Sterling International) baited with dual pheromone lures were placed on wooden stakes (3 ft high) located on each side (N, E, S, W) of the trap crop perimeter of each treatment plot (6 June; Fig. 2). Lures were replaced 12 July and 9 August, according to manufacturer's instructions.

Sampling. BMSB (adult, nymph and egg) densities were estimated in each crop (3 plants/row randomly selected at each sample) at weekly intervals 4 June–21 August, 2012) via visual examination of the entire plant (Fig. 3). BMSB (adult and nymph) in traps also were removed and recorded weekly. Crop damage (# damaged fruit/3 plants/row randomly selected at each sample) and yields (total lbs/row) were assessed weekly (beginning 4 July) and totaled within crop type across the growing season.

Figure 3. BMSB observed on tomato (left) and okra (right) during whole-plant samples (August, 2012).

Data Analyses. Individual data sets were subjected to visual examination and the univariate procedure (Shapiro-Wilks) to confirm normal distributions and homogeneous variances prior to statistical analysis. Separate mixed model ANOVAs tested for block and trap direction effects and block*trap direction interaction on BMSB densities (nymphs and adults combined) in RESCUE traps within each sample date. An additional ANOVA tested for block effect on BMSB collected in the RESCUE traps over the whole season (totaled over 16 sample dates). Separate mixed model ANOVAs by crop type were performed for BMSB densities (adults, nymphs and eggs combined) within sample dates, as well as seasonal BMSB densities, crop damage levels and yields. All statistical analyses used SAS software (SAS Institute).

[1] Redbud Farm, LLC, Inwood, WV 25428; www.redbudfarm.com
[2] Institute of Environmental and Physical Sciences, Shepherd University, Shepherdstown, WV 25443

Results

The amaranth in the trap crop perimeter did not establish due to competition with the sunflowers. The sunflower trap crop perimeter readily established without any irrigation or weed control flowered beginning in early June, with flowers senescing the second week of August (Fig. 4). The sunflowers were highly attractive to the BMSB from early June through late August, with BMSB feeding on the seeds, backs of flower heads and stems, even after the flowers had senesced (Fig. 4).

Figure 4. Close-up of sunflower trap crop perimeter in early June (left)and BMSB nymphs feeding (right) late season (19 August, 2012).

BMSB Densities. There was a significant block effect for BSMB captured in the RESCUE traps across the season (P=0.22, F=7.59, df=1). Nearly 2X more BMSB were trapped out of the field with a history of vegetable crop production than the field with prior grain crop production (LSD, P<0.05; mean no./trap ±SEM: Old Block 213±36.5, New Block 112±2.3). The BMSB entered the trap crop perimeters of plots in the field with prior vegetable crop production during the third week of June (Fig. 5, 'Old Block') but did not enter the trap crop perimeter of plots in the new field until the first week of July (Fig. 5, 'New Block'). By 12 September, the field with prior vegetable crop production had a two-fold increase in BMSB in trap crop perimeters (Fig. 5, 'Old Block').

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[2] Institute of Environmental and Physical Sciences, Shepherd University, Shepherdstown, WV 25443

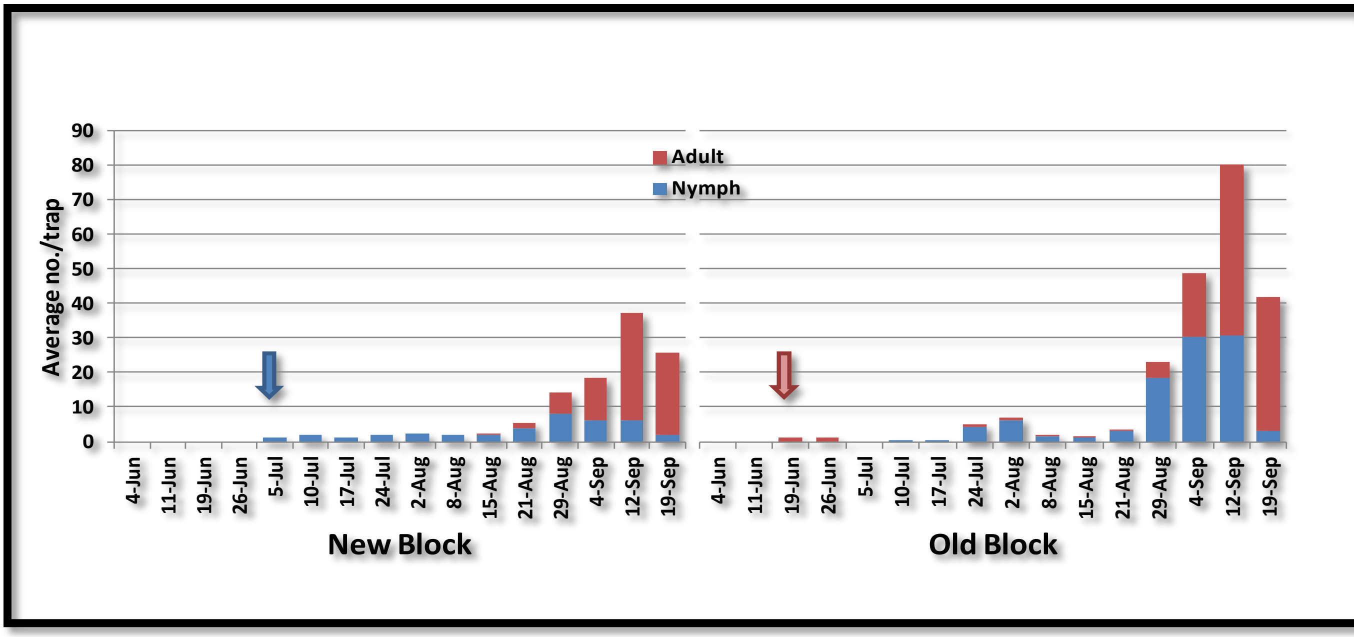

Figure 5. Weekly BMSB (adults and nymphs) densities in 4 'RESCUE' traps placed within each sunflower trap crop perimeter.

No statistically significant differences were found for BMSB trapped weekly in the four cardinal directions of the trap crop perimeters, except for 10 July, when a significant block by trap direction effect was found (*P*=0.029, *F*=10.89, *ndf*=3, *ddf*=4; Fig. 6a). On this sample date, significantly more BMSB were found in the Northern side of the trap crop perimeters than the East, South or West sides (LSD, *P*<0.05; Fig. 6b).

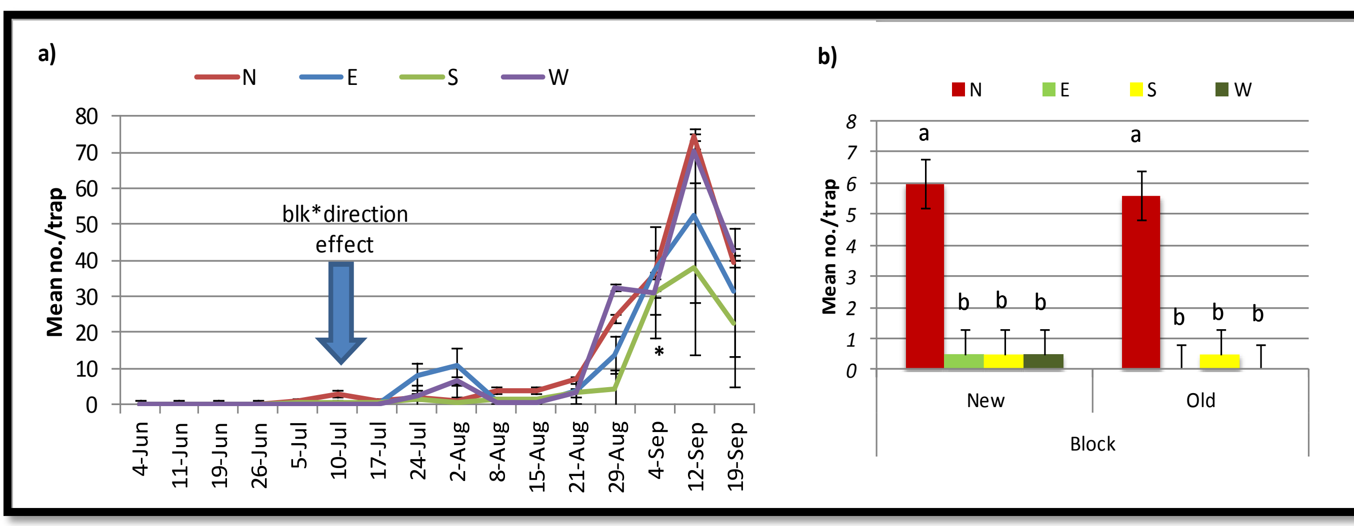

Figure 6. a) Weekly BMSB (adults and nymphs) collected in 4 'RESCUE' traps placed in 4 cardinal directions of sunflower trap crop perimeters; b) block by trap direction effect for BMSB densities on 10 July 2012; means of a block ('new' or 'old') sharing the same letter were not statistically different (LSD; *P*=0.05).

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BMSB were not detected on the cash crops until the second week of July, when they were found on okra in control plots (Fig. 7: 'Okra'). BMSB adults were found in trap crop perimeters and on the okra plants of both control and trap crop plots during the 3rd week of July but did not move to tomatoes until the 4th week of July and peppers during the second week of August (Fig. 7). No BMSB were found on summer squash plants (either control or trap crop plots) during the entire growing season.

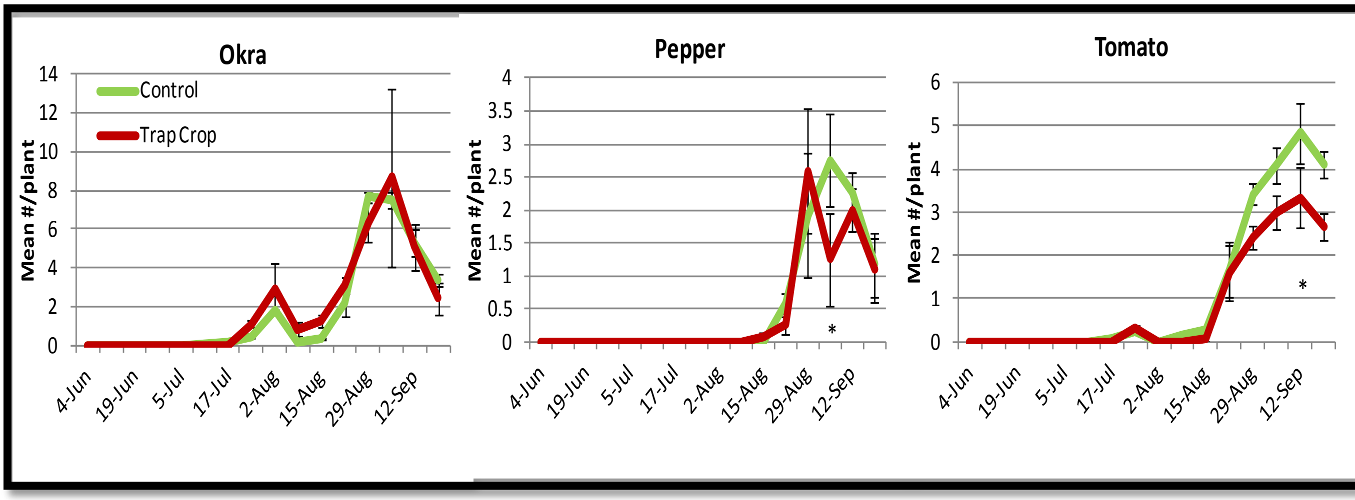

Figure 7. Weekly BMSB (eggs, adults and nymphs) densities on cash crops, detected during whole plant visual samples (3 plants/row).

The field block ('new' versus 'old') significantly affected BMSB densities in okra on 24 July (*P*=0.011, *F*=32.6, *ndf*=1, *ddf*=3), 21 August (*P*=0.01, *F*=34.9, *ndf*=1, *ddf*=3), 29 August (*P*=0.02, *F*=24.8, *ndf*=1, *ddf*=3) and 19 September (*P*=0.04, *F*=11.9, *ndf*=1, *ddf*=3), with significantly more BMSB on the okra plants of the 'old block' with a history of vegetable crop production than the 'new' block on each of these sample dates (LSD, *P*<0.05). A significant block by treatment interaction was detected for BMSB densities in pepper on 4 September (Fig. 7, 'Pepper;' *P*=0.014, *F*=27.1, *ndf*=1, *ddf*=3), with significantly more BMSB on the pepper plants of control plots versus trap crop plots in the 'old' block (LSD, *P*<0.05; Fig. 8).

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[2] Institute of Environmental and Physical Sciences, Shepherd University, Shepherdstown, WV 25443

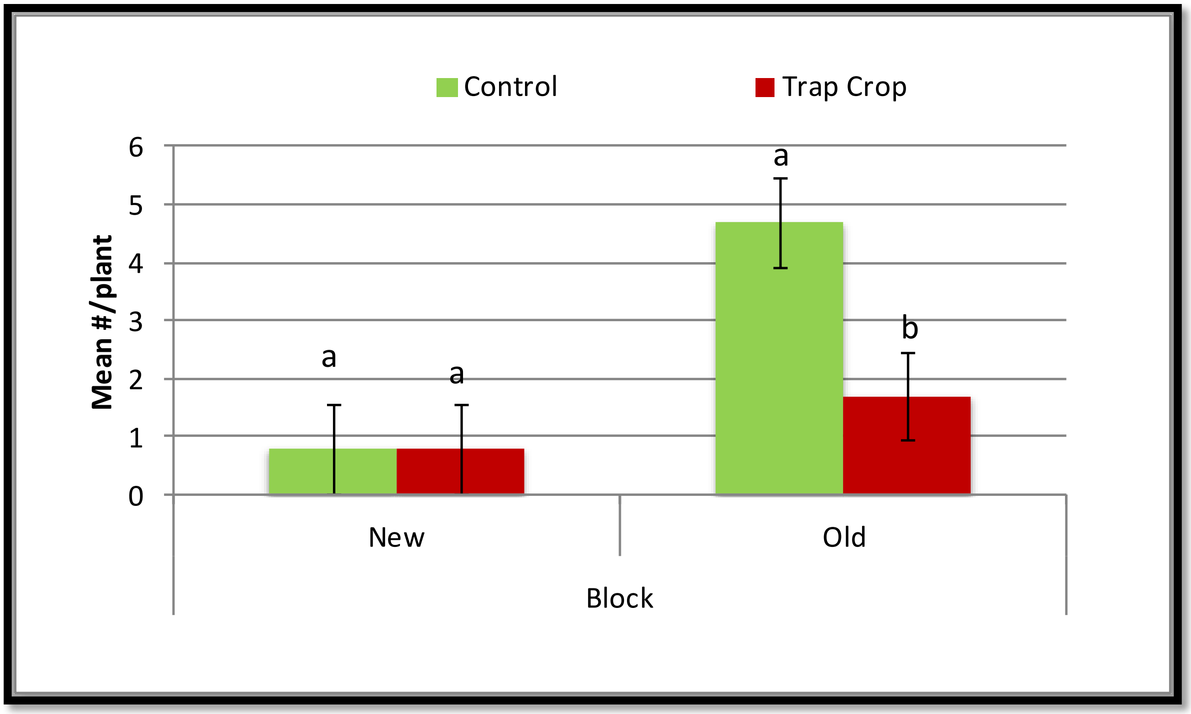

Figure 8. Mean BMSB (eggs, adults and nymphs) densities on pepper plants, detected during whole plant visual samples (3 plants/row) on 4 September 2012; means of a block ('new' or 'old') sharing the same letter were not statistically different (LSD; *P*=0.05).

The trap crop system significantly affected BMSB densities in tomato on 12 September (Fig. 7, 'Tomato;' *P*=0.035, *F*=13.5, *ndf*=1, *ddf*=3), with significantly more BMSB on the tomato plants of control plots versus trap crop plots (LSD, *P*<0.05; mean no./plant ±SEM: Control 4.8±0.7, Trap Crop 3.3±0.7).

Examining BMSB-hostplant dynamics across the season revealed a highly significant block by crop type interaction for BMSB densities totaled across the 16 sample dates (*P*=0.0002, *F*=10.5, *ndf*=1, *ddf*=20). Significantly more BMSB were found on okra plants than any other cash crop in the 'old' block with prior vegetable production (LSD, *P*<0.05; Fig. 9). Furthermore, the hostplant preference profile was the same in both blocks, but the BMSB densities were consistently lower in the 'old' block than the 'new' block (Fig. 9). Based on sample densities, the BMSB appeared to prefer okra plants, followed by tomato, and then pepper, with no use of the squash plants during the entire growing season.

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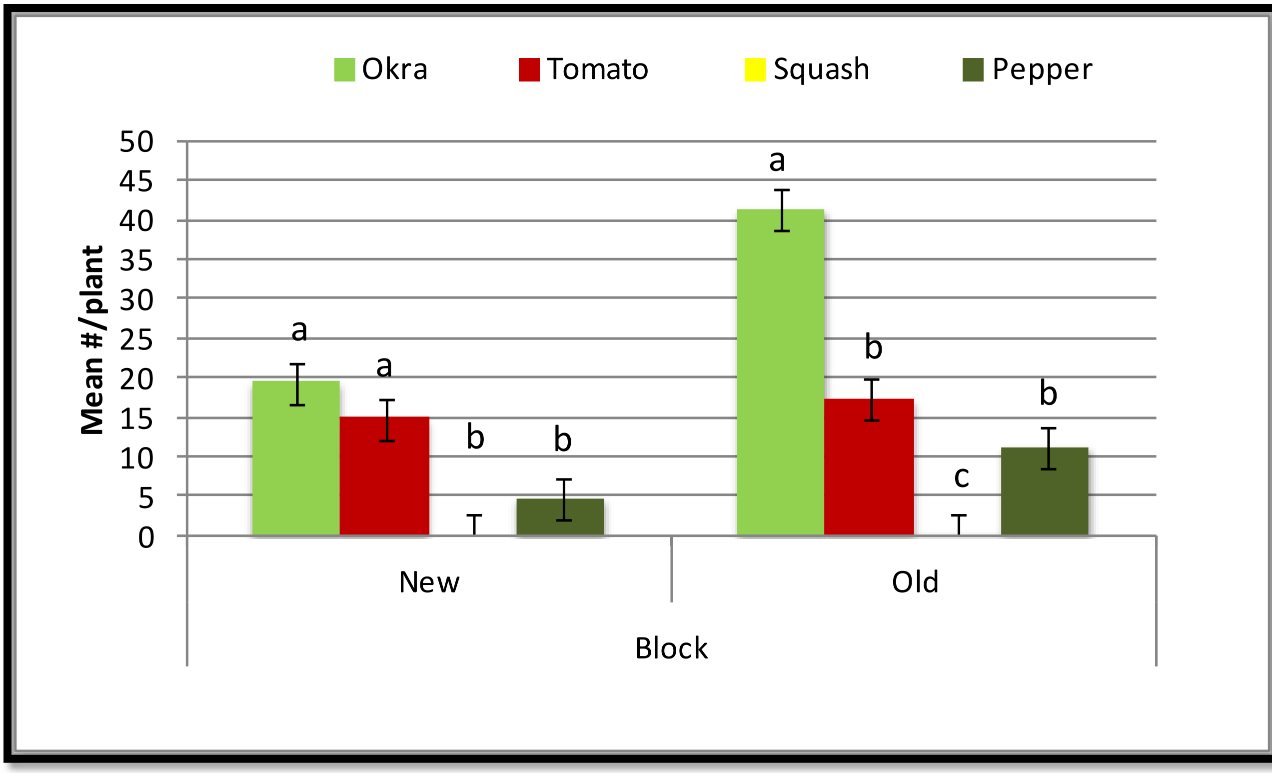

Figure 9. BMSB (eggs, adults and nymphs) densities on four cash crops, detected during 16 whole plant visual samples (3 plants/row) in 2012; means of a block ('new' or 'old') sharing the same letter were not statistically different (LSD; *P*=0.05).

Crop Damage and Yields. Seasonal crop yields and BMSB damage data are shown in Fig. 10. Neither seasonal crop yields nor BMSB damage were statistically affected by the trap crop system.

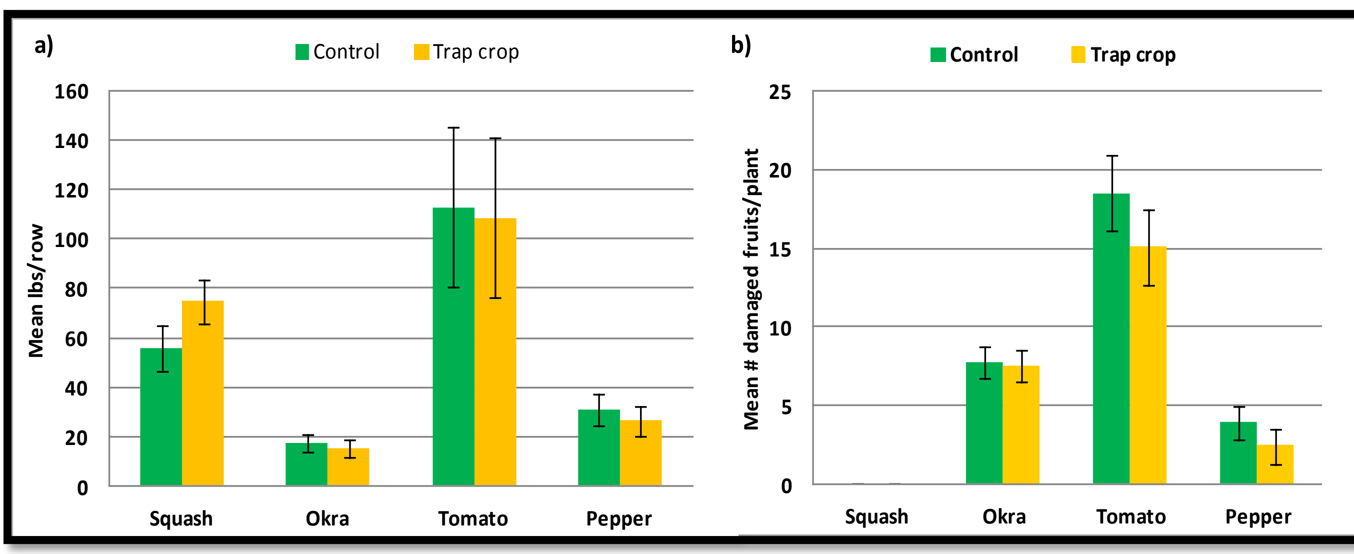

Figure 10. a) Seasonal yields, and b) BMSB damage for four cash crops grown with or without trap crop system, 2012.

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While seasonal squash yields, on average, were higher in the trap crop plots (mean ±SEM: 74.7±9.1) than in the control plots (mean ±SEM: 56.0±9.1), this difference apparently was attributed to decreased squash bug densities in the trap crop plots (mean ±SEM: 23.3±7.1) as compared to the control plots (mean ±SEM: 32.1±7.1).

Conclusions

Overall, the trap crop system was effective in attracting BMSB and delaying their colonization of the cash crops, resulting in lower BMSB densities for tomato and pepper during the latter part of the growing season. The sunflower trap perimeter was more attractive than the cash crops, resulting in a > 2-fold increase in BMSB densities, as compared to cash crops, and the RESCUE traps removed, on average, 112 and 213 BMSB from the new and old field blocks, respectively, across the season. However, the reductions in BMSB in the cash crops did not translate to significantly lower crop damage or higher yields in the trap crop plots. The RESCUE traps that were available at the time of the study did not contain species-specific pheromone lures for *Halyomorpha halys*, limiting their effectiveness at trapping out BMSB from the trap crop perimeters. Thus, without an effective trapping mechanism or mortality causing agent incorporated within the sunflower trap perimeter, this system is limited in terms of its ability to reduce BMSB damage to the cash crops within the perimeter.

Okra was preferential as a BMSB hostplant, as compared to the other cash crops, and squash was not utilized at all.

The BMSB were found to colonize earlier and use hosts more effectively in fields with a history of production of these specific vegetable crops, with 14 d earlier colonization and 2-fold higher density in old vs. new blocks. No overall directional affect for BMSB colonization was found within the fields, suggesting that presence of the cash crops in the previous year was a more important factor for the BMSB.

Future research should address the need to incorporate an effective BMSB removal or mortality causing agent within the trap crop perimeter, such as vacuuming, flaming, or use of species-specific pheromone lures with early season effectiveness, in order to enhance the effectiveness of this system.

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[1] Redbud Farm, LLC, Inwood, WV 25428; www.redbudfarm.com
[2] Institute of Environmental and Physical Sciences, Shepherd University, Shepherdstown, WV 25443