Peach and Plum

Where: Grand Gallery (main level) Room C
MI Recertification credits: 2 (1C, COMM CORE, PRIV CORE)
CCA Credits: PM(1.0) CM(1.0)
Moderator: Will Bristol, MSHS Board, Romeo, MI

9:00 am — Challenges in Management and Monitoring of Oriental Fruit Moth in Pennsylvania Orchards
- Greg Krawczyk, Entomology Dept., Pennsylvania State Univ.

9:25 am — Susceptibility of Michigan Processing Peaches, Fresh Peaches, and Plums to Spotted Wing Drosophila
- David Jones, MSU Extension, Oceana County, Hart, MI

9:50 am — Brown Marmorated Stink Bug - Challenges and Some Solutions
- Greg Krawczyk, Entomology Dept., Pennsylvania State Univ.

10:15 am — Peach Systems: Trials, Tribulations, and What the Future Might Hold
- Jim Schupp, Fruit Research & Extension Center, Pennsylvania State Univ., Biglerville PA

10:40 am — Experiences with Non-Traditional Peach Training Systems - Grower Panel
- Bill Shane, Extension Fruit Specialist, MSU Extension, Benton Harbor, MI
- Bill Nyblad, Kent City MI
- Jake Rasch, Rasch Family Orchards, Grand Rapids MI

10:55 am — Session Ends

Brown Marmorated Stink Bug, *Halyomorpha Halys* (Stal) Challenges and Some Solutions

Greg Krawczyk, Marcelo Zanelato Nunes, Hillary D. Morin and Lauren Shaak

Penn State University, Department of Entomology,
Fruit Research and Extension Center
Biglerville, PA 17307

(The original full version of this report was submitted to the State Horticultural Association of Pennsylvania and published in the Pennsylvania Fruit News 97(1): 52-56 (2017).

Introduction: Brown marmorated stink bug (BMSB) *Halyomorpha halys* (Stäl) (Heteroptera - Pentatomidae) continues to dominate the spectrum of insect pests on fruit in Pennsylvania and other Mid-Atlantic states. Unfortunately, management of BMSB happen at the cost of a significant increase in the number of used broad spectrum insecticides directed specifically against BMSB. The overuse of carbamates (e.g., Lannate) and pyrethroid insecticides (e.g., Brigade, Danitol or Warrior) negatively impacts the environmental balance between the complex of beneficial and pest insects and consequently causes almost uncontrolled outbreaks of secondary pests such as woolly apple aphids, San Jose scales and mites.

Results of the previous BMSB related research projects sponsored by the State Horticultural Association of Pennsylvania documented availability of potential alternative management practices against BMSB. Although broad spectrum insecticides from three main groups: carbamate (IRAC Group 1A), pyrethroids (IRAC Group 3A) and neonicotinoids (IRAC Group 4A) are still the main tools utilized in an effective management of BMSB, a better utilization of BMSB monitoring practices proved to be an effective way to significantly reduce the number of needed insecticide applications. Trap based BMSB treatment thresholds utilizing the captures of BMSB adults and/or nymphs, although still somehow provisional, appear to be viable BMSB management decision tool. Also, the utilization of "ghost traps "and Attract and Kill strategy proved very promising in reducing the direct reliance on pesticides to reduce fruit injury caused by BMSB.

Recent BMSB monitoring studies documented the viability of monitoring of BMSB adults and nymphs by commercially available traps and lures from Ag-Bio Inc., (Westminster, CO), Rescue trap and lures from Sterling International Inc. (Spokane, WA) and BMSB traps and lures from Trece (Adair. OK). Additionally, experimental clear sticky plastic traps and net based traps baited with commercial BMSB lures captured comparable numbers of BMSB adults (clear plastic) and adults and nymphs (net traps) as currently available BMSB traps. And while we are still in the early phases of being able to precisely correlate the numbers of captured BMSB with the actual levels of injured fruit, employing traps in the orchard is a very reliable indicator of the stink bugs presence in the orchard.

In this report we discuss the results from our field experiments related to a) evaluation of the effectiveness of alternative BMSB management options such as Attract and Kill strategies, "ghost traps" and threshold based BMSB treatments within the whole-orchard pest management program; b) evaluation and development the most effective BMSB monitoring practices with special emphasis on development of effective trapping methods; and c) re-establishment of the IPM related balance between insecticide based BMSB management options and management of traditional fruit pests.

Material and methods: During our 2016 BMSB monitoring project we evaluated new BMSB commercially available lures and traps designs. Trials were conducted in two commercial apple orchards in Adams County, PA. The current standard BMSB traps and lures from Ag-Bio Inc. and Sterling Inc. (Rescue traps and lures) were compared to experimental clear plastic sticky traps from AlphaScent Inc. (West Linn, OR) and Trece Inc. (Adair, OK), cylinder traps (Trece) and experimental BMSB lures. At each site, three replicates of seven different combinations of BMSB trap and lure tools were placed at the orchard border and the data was collected at weekly intervals. The evaluated BMSB lure x trap combinations included: 1) Ag-Bio commercial lure (BMSB Xtra Combo lure) x Ag-Bio tall pyramid trap, 2) Ag-Bio lure x Ag-Bio sticky clear trap, 3) AlphaScent lure x AlphaScent sticky clear trap, 4) Rescue stink bug lure x Rescue stink bug trap; 5) Rescue lure x AlphaScent sticky clear trap; 6) AlphaScent lure x AlphaScent blue sticky trap; 7) AlphaScent lure x AlphaScent white sticky trap; 8) Trece lure x Trece cylinder trap; and 9) Trece lure x Trece clear sticky trap.

The BMSB Attract and Kill (A&K) project was localized in two individual apple orchards in western Pennsylvania. Individual trees spaced about 50 meters located at the edge rows of the orchard were baited with specially prepared 10x rate of standard BMSB attractant (Ag-Bio, Inc.). In the A&K block trees baited with the pheromone plus two surrounding trees were sprayed on weekly intervals with various BMSB effective insecticides starting in mid-June, while the Standard grower block was treated against BMSB as needed determined by the provisional treatment threshold. Each A&K tree had a 2.4 m wide round plastic tarp placed under the tree to count the numbers of affected BMSB adults and nymphs. Additionally, three BMSB monitoring tall pyramid traps baited with Ag-Bio lures were placed in the center of each A&K and Standard orchards to monitor BMSB population inside the block.

To evaluate potential usefulness of the insecticide treated nets as a BMSB monitoring and/or management tool we evaluated commercially available ZeroFly® PermaNet® nets (Vestergaard Frandsen, Inc. Lousanne, Switzerland) treated with deltamethrin (pyrethroid, IRAC Group 3A) insecticide. Six net stations baited with commercial Ag-Bio or Rescue BMSB lures were deployed in mid-July between woods and fruit orchard. Individual nets were placed on a 2.4 m high shepherd hooks and baited with AgBio (3x) or Rescue (3x) lures. Each net so called a "ghost trap" had a plastic tarp 1.8 m wide placed directly under the net to collect killed bugs. The numbers of dead stink bug adults and nymphs were evaluated weekly from mid-July to early October.

Results and discussion: During the 2016 BMSB monitoring program all evaluated lure x trap combinations collected BMSB adults and nymphs. The commercially available combination of Rescue lure and trap collected the highest numbers of BMSB adults and nymphs. The Ag-Bio lure and trap sets collected similar numbers of BMSB with the numbers of BMSB collected by the experimental Trece traps (e.g., sticky clear plastic and cylinder traps) baited with experimental Trece lures. With the exception of the Trece sticky clear plastic trap baited with the Trece lure, under relatively heavy BMSB pressure, the sticky traps were less effective than currently available commercial trap/lure combinations. Also, the clear sticky traps collected significantly lower number of nymphs than container based traps. The experimental traps and lures from Trece Inc. provided comparable captures of BMSB adults and nymphs to the current standards (Figure 1A and 1B).

The results of the Attract and Kill project conducted in two commercial apple orchards provided positive results indicating potential of this tool as one the BMSB management options. The numbers of BMSB collected by the monitoring traps were lower in the in the A&K orchards than in the Standard orchards, with 3.1 and 6.9 stink bugs captured per trap/week, respectively. The examples of results from monitoring traps and collection from tarps from a single orchard are presented in the Figure 2A and 2B. Utilizing the USDA ARS developed BMSB treatment threshold (10 BMSB cumulative capture of BMSB adults per trap) no specific BMSB targeting insecticide treatments were needed in one of the A&K blocks, while the second orchard received a single insecticide application against BMSB at the end of the season. Standard blocks needed at least two insecticide applications specifically targeting BMSB. The fruit evaluations conducted during the early, mid and late part of the season in each case detected lower number of injured fruit in the A&K blocks than in the Standard blocks.

The commercially available ZeroFly® PermaNet® nets treated with deltamethrin and baited with BMSB aggregation pheromones placed between woods and orchard border captured high numbers of BMSB adults and nymphs (Figures 3). No differences were observed between the lures used to attract the bugs. The insecticide treated nets baited with the Ag-Bio lures collected on average 19.3 adults and 17.2 nymphs per trap per week, while the net traps baited with the Rescue stink bug lures collected 17.7 adults and 25.2 nymphs. The twelve weeks long observations documented continuous effectiveness of the nets during that period.

Summary: The 2016 results of BMSB monitoring project documented the reliability of currently available commercial BMSB lures and traps for monitoring of this pest. The sticky clear plastic traps under high BMSB pressure collected lower numbers of bugs, however the new clear sticky trap from Trece baited with Trece lure performed at similar level as the currently available commercial traps. The Attract and Kill approach to manage BMSB is an effective tactic to manage BMSB in commercial apple orchards although the economics of such tactics, mostly due to the high price of BMSB attractants' still need to be improved. The "ghost traps" deployed between the potential source of BMSB influx (e.g., woods) and orchard captured very high numbers of migrating BMSB adults and nymphs. Additional studies are needed to evaluate various aspects of the "ghost trap" tactic and to validate the actual net's efficacy in protection of fruit.

Acknowledgement: We would like to thank Nathan Cafarcio, Nikki Halbrendt, Chandler Robey and Kristlyn Whitlock for their assistance in collecting results of these projects during the season. We also would like to thank the State Horticultural Association of Pennsylvania Research Committee for financial support to conduct this project. Additional thanks are due to Vestergaard Frandsen Company, AlphaScent, Inc., Ag-Bio, Inc., Sterling International, Inc. and Trece Inc., for donations and/or reduced prices of some of their products tested in reported field trials.

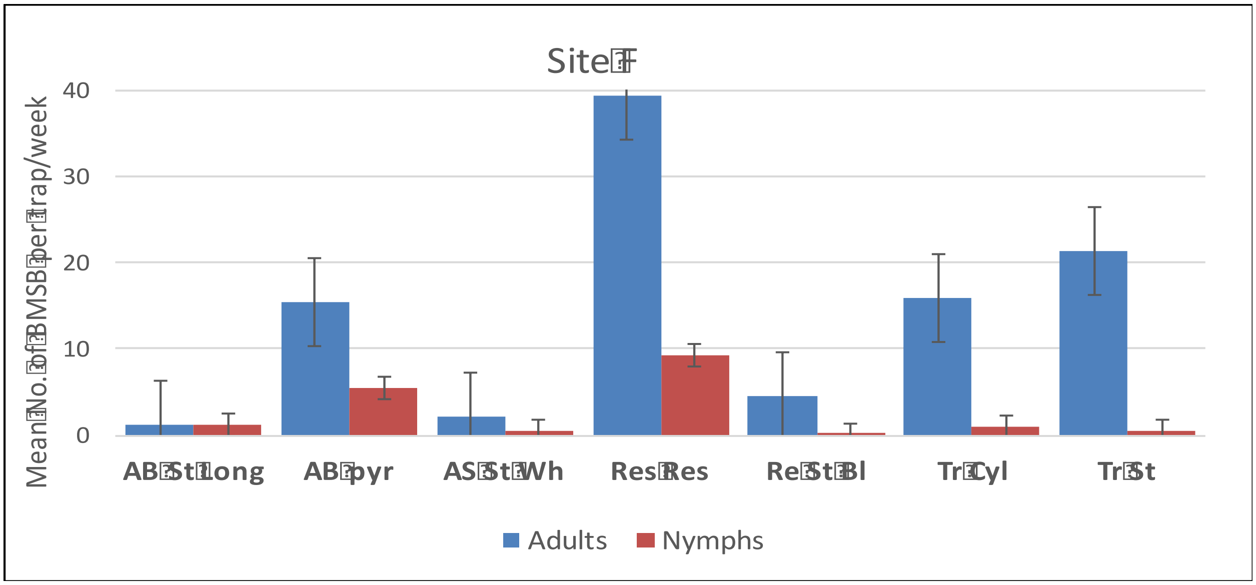

Figure 1 A. Monitoring of brown marmoraeted sting bug using various BMSB lure x trap combinations (Site F). PSU FREC 2016.
Key to abbreviations: AB St Long – Ag-Bio lure x Ag-Bio sticky clear plastic long trap; AB pyr – Ag-Bio lure x Ag-Bio tall pyramid trap; AS St WH – AlphaScent lure x sticky white trap; Res Res – Rescue lure x Rescue trap; Re St Bl – Rescue lure x Alpha scent sticky black trap; Tr Cyl – Trece lure x Trece cylinder trap; TR St – Trece lure x Trece clear sticky trap.

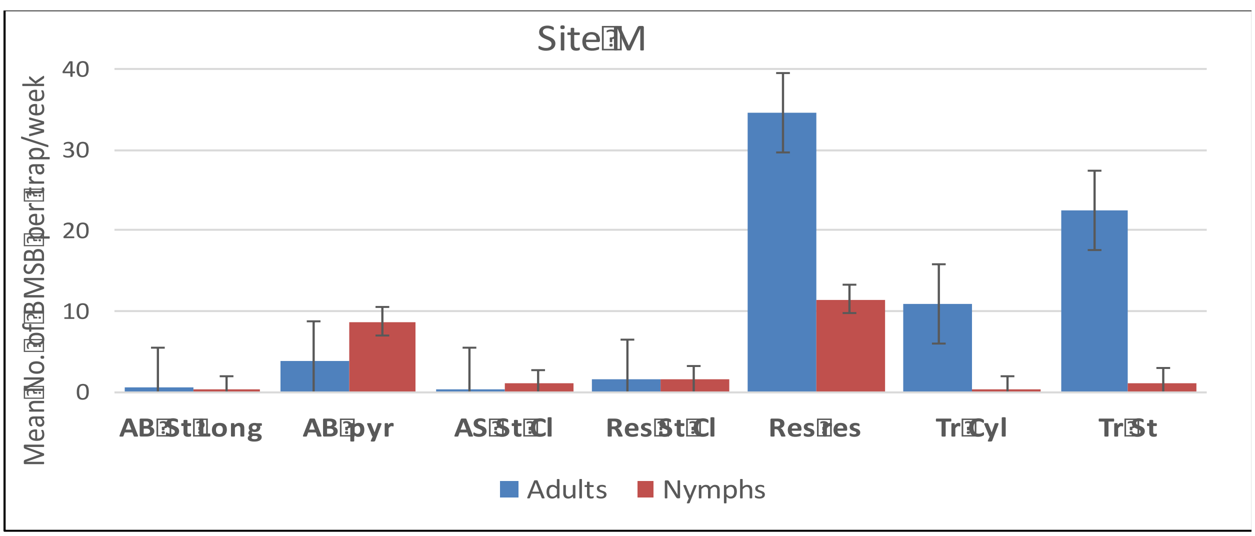

Figure 1 B. Monitoring of brown marmoraeted sting bug using various BMSB lure x trap combinations (Site M). PSU FREC 2016.
Key to abbreviations: AB St Long – Ag-Bio lure x Ag-Bio sticky clear plastic long trap; AB pyr – Ag-Bio lure x Ag-Bio tall pyramid trap; AS St Cl – AlphaScent lure x AlphaScent sticky clear trap; Res St Cl – Rescue lure x AlphaScent clear sticky trap; Res res – Rescue lure x Rescue trap; Re St Bl – Rescue lure x Alpha scent sticky black trap; Tr Cyl – Trece lure x Trece cylinder trap; TR St – Trece lure x Trece clear sticky trap.

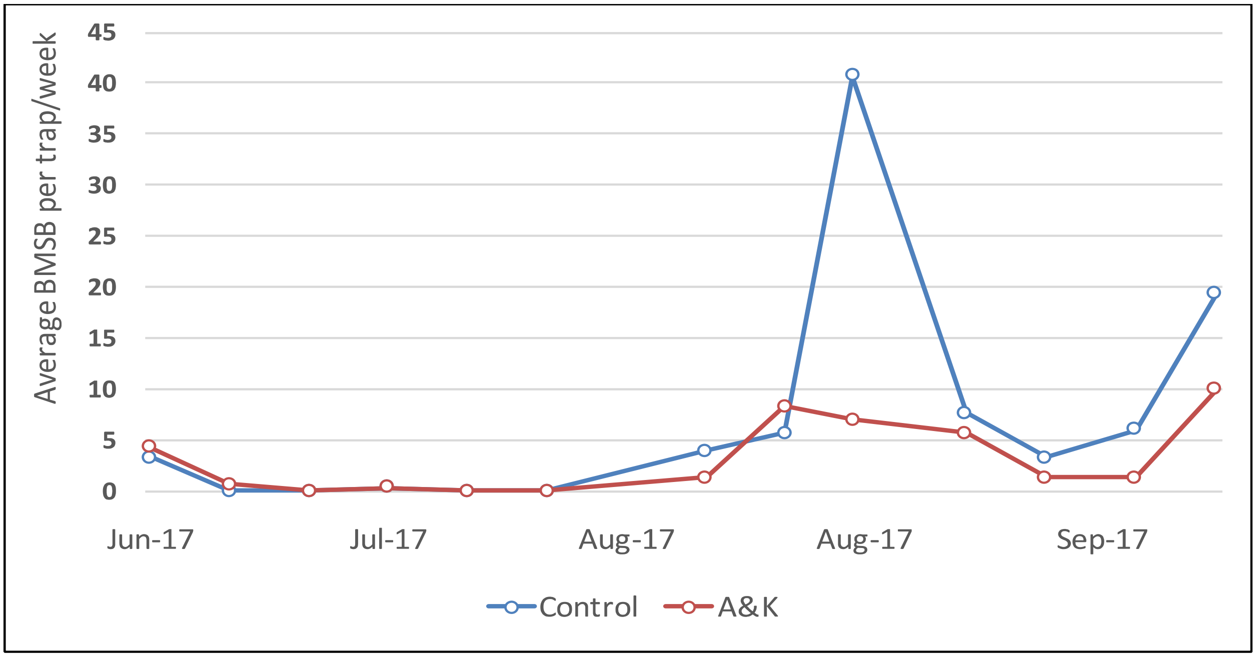

Figure 2 A. Average captures of BMSB adults and nymphs per week in traps (Ag-Bio lure x Ag-Bio tall pyramid trap) placed in the center of the Attract and Kill and Standard orchards. PSU FREC 2016.

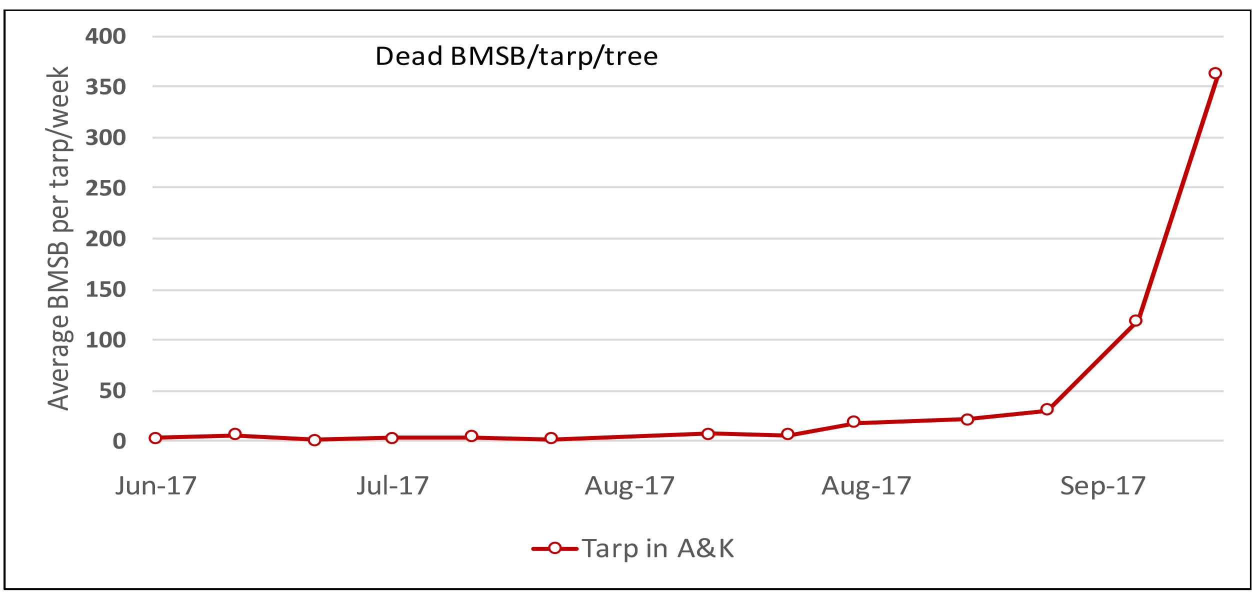

Figure 2B. Average collection of dead brown marmorated stink bug adults and nymphs from tarps (n = 4) placed under the Attract and Kill trees baited with a high dose of BMSB aggregation pheromone. PSU FREC 2016.

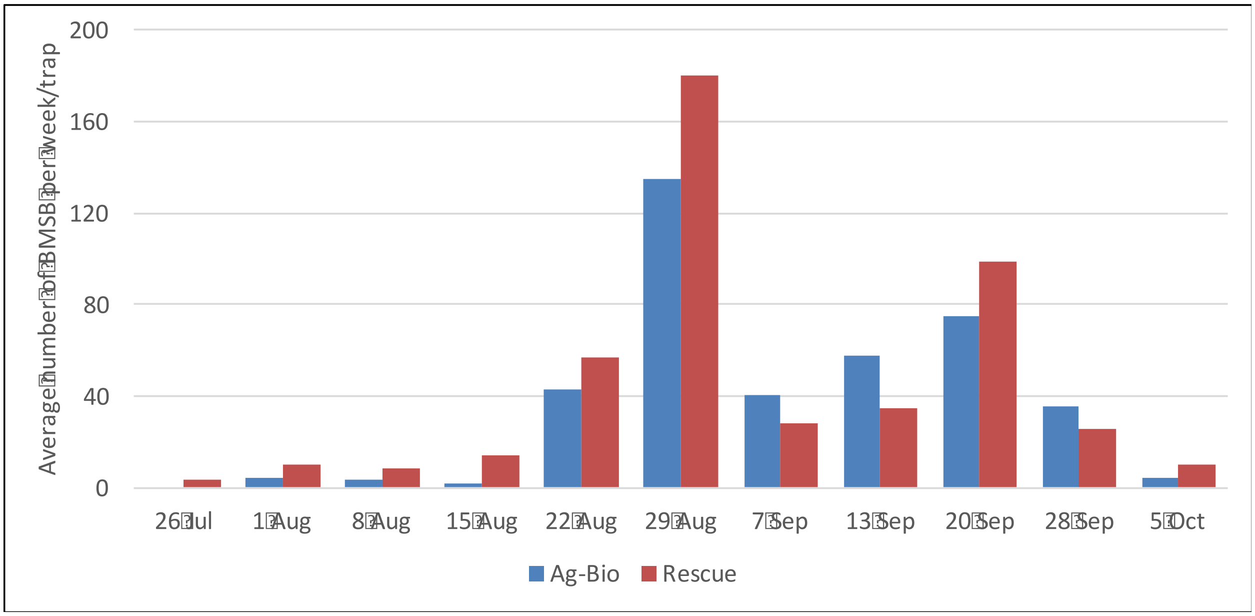

Figure 3. Average collections of brown marmorated stink bug adults and nymphs from plastic tarps placed under the "ghost traps" baited either with 3x doses of Ag-Bio or Rescue commercial stink bug lures. PSU FREC 2016.

Do Growers Have to Manage for SWD in Processing Peaches?

Dave Jones and Larry Gut, Michigan State University Extension.

Tag: We have demonstrated that processing peach is not a preferred host for SWD, and are now able to answer several common questions about SWD concerns in this crop.

Processing peaches are a niche crop in the west central region of Michigan. These fruits are distinct from fresh market free-stone peaches in several ways, including thicker skin, denser pubescence ("fuzz"), and a firmer texture. While this crop is not necessarily a majority of acreage on most regional fruit farms, it is present on most operations that produce tree fruit crops. Because a sizeable portion of the region's tree fruit is either sweet or tart cherries, growers are used to having to initiate aggressive SWD management programs once these fruits begin to ripen and soften. These considerations have led to confusion on the status of SWD management in processing peaches. This has been further complicated by recent reports of SWD showing up in fresh market nectarines and fresh market peaches. Well aware of the increased cost of production for cherry that has accompanied the need for intensive SWD management inputs, growers are reluctant to make a similar, high investment, to manage this pest in peach without evidence demonstrating that it is necessary. At the same time, growers are all too aware of what can happen when SWD is not managed in a susceptible crop.

To address these concerns, we conducted a study on SWD susceptibility in processing peaches during the 2017 growing season. We measured adult SWD emergence after harvest in all major processing peach cultivars from the west central region. The cultivars Vinegold, Virgil, Venture, Caterina, Arkansas 9, Johnboy, Babygold5, and Redhaven were all sampled at peak field maturity. Both split-pit and non-split pit fruits were collected. Firmness (lbs) was recorded for both the split pit and non-split pit groups. After harvest, fruits were briefly dipped in a bleach solution to disinfect them and reduce incidence of rot during the study. Split pit and non-split fruits were isolated in mesh capture tents designed to trap any emerging insects for identification. All drosophila flies that emerged were identified and counted. Scentry cup traps were used at a density of 5 traps per field at three processing peach sites to record numbers of adult SWD in the field during the period leading up to harvest.

The questions we addressed with this work, and the answers that we can provide based on our findings are summarized below:

Are processing peaches a preferred host for SWD?

No. While it is possible for SWD to infest peaches with physical damage (suture cracking, split pit, bird pecks, etc.) field infestations in non-damaged fruits were so rare in our trials that we consider them insignificant.

Are peaches with split pit going to cause me problems with SWD?

Sometimes, but this was also uncommon. There was a slight increase in SWD captures from split pit fruits, but it was unusual and not statistically different from catches in intact processing peaches. Peaches that are harvested at the typical firm, early maturity stages should not be an issue for most growers. We did find a couple of instances of infestation in split pits in west central Michigan this season, but it was in split pit fruits with obvious rot setting in. These fruits would be rejected at the processing plant anyway.

Does having problems with brown rot increase my chances of getting SWD in my processing peaches?

Not necessarily. While this is a complicated interaction, work from Brazil (Adreazza et al. 2017) indicates that increased brown rot is not necessarily associated with an increase in fruit infestation by SWD. However, growers should generally assume that any steps that can be taken to reduce physical damage to their processing peaches are the best possible management strategies for avoiding SWD infestation.

Are we sure that there were enough SWD out in the processing peach fields to cause problems if they were susceptible?

Yes. To demonstrate that SWD adults were present in adequate numbers to cause fruit infestations in a susceptible crop, we trapped for SWD adults using Scentry cup traps for the 3 weeks leading up to harvest at three different peach sites that we sampled from. Five traps were placed at each site. The first cup trap was placed at the edge of the field, and additional traps were placed every 5 trees, moving in towards the center of the block. SWD captures comparable or greater than those typically occurring in tart and sweet cherry fields were recorded in all three weeks. In summary, SWD adults were present in sufficient numbers to cause infestation in a susceptible crop and growers at these sites were not managing for the pest. Based on the high catches, we are confident that the reason no SWD problems occurred in these fields was due to the processing peach fruits not being susceptible to the pest. These findings are consistent with recent findings reported from Brazil (Adreazza et al. 2017).

Is there a particular cultivar of processing peach that would be more or less susceptible to SWD?

Any cultivar prone to split pit is more likely to be a problem, although none of the cultivars that we tested are a preferred host for this pest. Growers already do their best to manage split pits, but there may be increased pressure on local processors to accept a smaller size of peach in the future to avoid issues with SWD contamination. Typically split pit occurs when peaches over-thinned and become too large. This often occurs due to a push from a processor for a larger size of peach. Allowing a larger crop to stay on the tree will achieve slightly smaller size and reduce split pit, thus reducing the risk of contamination for both the grower and the processor.

Literature Cited:

Adreazza, F., Bernardi, D., and Botton, M. 2017. *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) in Peaches: is it a problem? Scientia Agricola. Volume 74, pages 489-491.

Susceptibility of Commercial Michigan Plum Cultivars to Spotted Wing Drosophila

Dave Jones and Larry Gut, MSU Extension

While plums are not a major crop in west central Michigan, many growers still have small plantings of both European and Japanese plums. These fruits are sold to processing companies, on the fresh market, and to distilleries for brandy production. The wide array of available plum cultivars, extended season, variability in ripening time, typical grower practice of mixing several different cultivars of plums in within a block, and the widespread presence of spotted wing drosophila (SWD) has led to questions regarding if, when and how to manage this pest. Most growers are unsure of whether their plums should be managed for SWD or whether certain cultivars can be considered less susceptible than others to attack by this pest. If management is necessary, growers do not know when a program should be initiated or how frequently a new application should be made. Most growers assume that earlier plums are less susceptible to SWD, and that Japanese plums are more susceptible than European plums.

To begin to address these concerns, a survey of susceptibility of commercial plums in west central Michigan was conducted during the 2017 growing season. Plums sampled included 20 cultivars spanning early, mid-season, and late season European and Japanese types. Growers did not have a management program specific to SWD in place at the time of sampling. For each cultivar, 20-30 fruits were sampled, fruit pressure was recorded, and the condition of the fruits was rated at time of sampling. Only fruits with no visible signs of insect feeding or rot were sampled. Fruits were submerged in a simple sugar solution of 7lbs of sugar/5 gallons of warm water, gently squeezed, and let stand for at least 15 minutes. Fruits were then strained through fine mesh to remove any larvae that had exited infested fruits. SWD larvae were counted under a dissecting microscope.

Results:

Plum Cultivar	**Type**	**Sample Date**	**Firmness (lbs)**	**SWD Larvae**
Early Golden	Japanese	7/25/2017	8	0
		8/1/2017	0	99
Beauty	Japanese	7/25/2017	0	52
Methely	Japanese	8/1/2017	0	0
Santa Rosa	Japanese	8/2/2017	0	3
Early Magic	Japanese	8/2/2017	0	0
Shiro	Japanese	8/8/2017	0	0
		8/2/2017	0	1
		8/31/2017	0	0
Black Ice	Japanese	8/8/2017	<3.5	8
Queen Rosa	Japanese	8/8/2017	<3.5	3
AU Rosa	Japanese	8/8/2017	<3.5	8
Castleton	European	8/16/2017	1.79	8
Bluebyrd	European	8/16/2017	10.82	0
		8/22/2017	0.3	2
Unknown yellow	Japanese	8/22/2017	0	1

Damson	European	8/31/2017	5.25	0
Ozark Premier	Japanese	8/16/2017	3.57	0
		8/22/2017	0.2	10
Starking Delicious	Japanese	8/16/2017	7.17	0
		8/30/2017	3.68	0
		8/30/2017	2.25	82
Redheart	Japanese	8/30/2017	3.4	0
Unknown red	Japanese	8/30/2017	2.92	0
Italian	European	9/14/2017	3.42	11
Stanley	European	9/14/2017	7.69	0
NY9	European	9/14/2017	3.57	0

Discussion

Both early and late season plums were at risk of being infested if left on the trees until soft (under 3.5 pounds of pressure). The same was true for both Japanese and European plum cultivars. Growers with an early plum cultivar cannot assume that the seasonality of the fruit will protect it from SWD. SWD is present in large numbers well before even the earliest plum cultivars are being harvested, so SWD management plans are needed for early and later ripening cultivars. Fresh market plums that are traditionally left on the tree until flesh is “melting” in consistency need to be managed for SWD regardless of harvest timing, cultivar, or type.

The findings of the survey also demonstrate that a visual analysis is a poor way of determining whether or not plums are infested by SWD. This same phenomenon is frequently observed in sweet and tart cherry samples. Intact, nice looking fruit often turn out to be infested by SWD. Growers cannot assume that fruit is not infested and safe for market sales just because there are no visible signs of infestation in the field. All of the fruit tested in this study were of acceptable market quality based on the visual assessment.

None of the plum cultivars were infested by SWD if fruit firmness was greater than 3.5 pounds. This is an important observation because plums do not typically fall below this mark until a few days before harvest. This was true in both Japanese and European plums. If consistent between seasons, this observation could have significant management applications for growers. If fruits are not susceptible until they reach this mark, weekly pressure testing could allow growers to initiate spray management programs only when fruit reach this firmness.

While this broad survey did not validate specific SWD management programs for Michigan plum production, the findings do indicate that growers can likely achieve acceptable management if they initiate a spray program before fruit reach 3.5 pounds of firmness, and maintain a cover of “excellent” products every seven days until harvest has concluded. Growers could also consider avoiding SWD by harvesting plums earlier than normal while fruits are in firmer condition (thus, presumably not susceptible to SWD infestation). Plums are a climacteric fruit, which means that they will continue to ripen after they are harvested. As a result, plums picked slightly earlier than traditional harvest dates can still be ripened off the tree and sold at full ripeness. In summary, a spray program initiated before fruit firmness reaches 3.5 pounds and slightly earlier harvest is likely to achieve acceptable management in most situations, but more research is needed to validate the approach.

Peach Systems: Trials, Tribulations, and What the Future Might Hold

Dr. Jim Schupp, Penn State Fruit Research and Extension Center, Biglerville, PA

The ideal peach training system would be productive and pedestrian, precocious and produce high quality, well-colored red fruits. At the same time, the ideal system would be easy to teach to laborers, and compatible with mechanization.

Current peach production practices are labor-intensive, requiring multiple trips through the orchard to dormant prune, hand thin, hang OFM mating disruption, summer prune, and for multiple (often 3) harvests. The traditional approach to training and pruning peach trees in the eastern U.S. has been the low headed open vase, at low tree densities of 113 to 173 trees per acre (Figure 1). In this system, trees are pruned severely, using bench cuts to spread the scaffolds at a wide angle and keep the canopy within 9 feet of the ground. This allows growers to maintain a pedestrian orchard.

The pedestrian objective of the open vase exerts a heavy toll on economic returns. Low tree density equates to low precocity and production of low yields. The severe pruning required by open vase further reduces early bearing and its vigorous regrowth requires that it must be summer pruned to produce fruits of marketable red color. V-shaped canopies such as Tatura, Kearney V (perpendicular-V), Quad V, and Hex V, have been shown to be more productive and more compatible with the natural growth habit of trees. Severe bench cut pruning is not required, and V trees come into bearing earlier as a result. Even a modest increase in early yield per tree is multiplied 2.5 to 3 times because of the higher planting density.

V systems are simpler to manage, and more compatible with mechanization (Figure 2). The high-to-moderate planting density increases the amount of productive bearing surface of these systems, producing higher yields than open vase. V systems are inherently tall, and require the use of a ladder or platform to access the upper canopy. This adds to the cost of labor, although use of mechanical string thinning and labor platforms lessens the additional expense. Refer to Table 1 for a summary of the comparison of open vase and V-canopy systems.

Both vase and V systems have challenges inherent to the natural tree form of the peach tree. Peach bears fruit on 1-year-old wood, so a substantial amount of annual vegetative re-growth is needed to generate a new bearing surface each year. The pattern of growth in peach is acrotonic, meaning most of the new growth occurs in the outer portion of the canopy. This growth pattern is an inherent trait, and it is amplified by the species' intolerance of shade. Shaded portions of a peach canopy grow weakly, fail to flower, and quickly die off. As a peach tree matures, its bearing canopy migrates up and out of reach from the ground.

Migration of the bearing surface can be slowed, but not eliminated, by pruning with bench cuts in the open vase system. The heavy bench cuts required to keep the trees short result in strong local invigoration of the canopy and increase shading. Early season shading reduces flowering the following year, and late season shading reduces red fruit coloration. The strong regrowth that results from heavy pruning must be counteracted with summer pruning once or twice a season to prevent severe shading effects.

In the taller V systems, the acrotonic growth pattern and shade intolerance of peach makes it challenging to renew new fruiting laterals within reach of workers on the ground. Peach does not readily renew fruiting branches from short stubs as does apple. As a result, short sections of 2-year-old wood (secondary branches are stubbed back to the most proximal fruiting lateral. This increases the complexity of the canopy and of pruning decisions, which is counterproductive to the original intent of the simplified pruning rules of the V systems.

There is not presently an ideal peach production system, as all of them have flaws. Furthermore, our 2007 trial of open vase, perpendicular V, quad V and hex V systems in Pennsylvania showed that, at prices received for fresh market peaches from 2009-2015, all 4 systems were profitable. That doesn't mean that there isn't much difference among these systems.

In this trial, V systems came into full production 3 years sooner than open vase, were 50% more productive over the 8 year trial, and produced 20% more red fruit. Depending on planting density V systems were 16% to 54% more profitable. Unlike apples, the most intensive (and expensive) perpendicular V system wasn't the best. Moderate planting density with quad V training created more bearing surface, and more peaches per acre than the perpendicular, with 29% fewer trees (346 versus 484) per acre.

Low-headed open vase trees still fit in special circumstances. For instance on hillside sites with steep slopes, or in financial circumstances when the enterprise needs to minimize planting costs.

For the present, we recommend a quad V peach training system spaced at approximately 7 ft. between trees and 16-18 ft. between rows. Quad V is productive, precocious, and produces higher packout, with a system that is easily taught and compatible with mechanization. That leaves "pedestrian" as the only pin still standing when the characteristics of the quad V are considered. For information on training trees to quad V see: https://extension.psu.edu/innovations-in-peach-training-systems. This Learn Now video is available in Spanish or English and can be used for employee training.

What about the future? In the near term, several dwarfing rootstocks may provide a measure of success with keeping peach trees shorter. In particular, some of the Controller series from UC Davis show promise. Controller 8 has been the best in PA trials, producing a precocious tree that is 70% the size of Lovell, with the same level of productivity as seedling peach trees and great survival. Our results to-date indicate that trees on Controller 8 rootstock are putting more energy into fruit and less into vegetation, which is necessary for more efficient production on dwarfed trees. Another rootstock in this series, Controller 7, also shows promise. If trees with 70% vigor could be managed at 70% shorter canopy height, then the vast majority of fruit will be within reach from the ground.

In the long term, we must continue to study techniques for further reducing labor inputs through mechanization. In the 1980s, a "meadow orchard" system was described and tested. Peach trees were planted at very close density and mechanically harvested, by cutting off the entire tree at harvest, much like combining corn. Even in regions with an extended growing season, [Georgia (US), and Israel], it wasn't possible to grow annual crops of quality peaches. In Israel it could be accomplished only with early maturing cultivars, and even then, fruit maturity was delayed and fruit quality suffered when the growing of annual crops was attempted.

The meadow orchard system was modified to two scaffolds at 2 ft. x 6 ft., and named the "intensive system". Initially it looked much like the perpendicular V, except that one of the two scaffolds was pruned to a short stump while dormant, leaving the second to bear fruit the following season, while the other side regenerated. By alternating removal of the 2 scaffolds, the trees maintained enough vigor to produce adequate flowering, fruit set and yield. Since the canopy of an intensive system will never be more than two years old, it follows that the orchard would remain pedestrian. Concerns with the intensive system include lower tree survival, rapid development of mineral nutrient deficiencies, and small fruit size. One limitation of the intensive concept is the lack of small machinery to deal with the very tight spacing. Modifications of this system should be investigated further.

Table 1. Comparison of relative differences between traditional open vase and higher density V canopy production systems for peach.

Characteristic	**Open Vase**	**V shaped canopy**
Tree density per acre	100 – 172	242 – 544
Establishment cost	Low	Moderate
Need for irrigation	Beneficial	Essential
Final canopy height	7’ – 10’	12’ - 14’
Pedestrian orchard?	Yes	No
Set crop potential with pruning?	Feasible	Precise
Compatibility to mechanization	Low	High
Years to full production	8 -9	5-6
Yield (bushels per acre)	350 – 450	550 - 670
Average fruit size (Loring)	3.5”	3.25”
Average red color (Loring)	50%	70%
Relative income	“100% of standard”	“116% - 154% of standard”

Figure 1. The open center-trained tree has been the industry standard for over 150 years.

Figure 2. Quad V peach systems are productive and compatible with technology.