# "Status of the Invasive Brown Marmorated Stink Bug and Spotted Wing Drosophila in NY"

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Generally, invasive pests acquire a foothold as agricultural pests owing, at least in part, to the lack of host finding cues used by native predators and parasites to locate invasive hosts. Many parasitic wasps need to 'learn' how to find a host insect, 'buying time' for newly invasive insects to establish. The invasive brown marmorated stink bug (BMSB), *Halyomorpha halys* and spotted-wing drosophila (SWD), *Drosophila suzukii* (Matsumura 1931), have had little in the way of resistance in establishing populations from biological controls such as predators and parasites, helping to pave the way to damaging pest levels resulting in economic injury in agricultural commodities throughout parts of NY State. In China, parasitoid wasps in the genera *Trissolcus* and *Anastatus* cause high levels of egg parasitism in the BMSB. Among these, *Trissolcus halyomorphae* (Hymenoptera: Scelionidae) has shown itself to be the most promising candidate for biological control of brown marmorated stink bug in North America.

It is important to understand that not all invasive insects become pests, and of those that do, not all maintain high levels of pestilence. However, in tree fruit, pests such as the pear psylla, oriental fruit moth, European apple sawfly and San Jose scale remain as economic pests in tree fruit. Secondly, the native complex of insects in the same genera, often create a diverse pest complex that leads to higher levels of injury from the entire group. One such genera of pests are found in the stink bug complex (Heteroptera: Pentatomidae) comprised of three species. These include the green stink bug (GSB), *Acrosternum hilare* (Say), brown stink bug (BSB) *Euschistus servus* (Say), and the newly invasive brown marmorated stink bug (BMSB), *Halyomorpha halys.*

The injury between species is indistinguishable, yet because the injury resembles hail marks and the physiological disorder known as cork spot, it has occurred at varying levels and likely misdiagnosed during packout. Reasons for a recent increase in injury are not completely understood, but changes in chemistries used for pest management (substitution of Delegate, Altacor and neonicotinoids for Lorsban, Penncap-M and other organophosphates), decreased levels of susceptibility, late season crop irrigation during periods drought and introduction of the newly invasive BMSB are believed to be contributing factors to increasing damage by the stink bug complex.

Recently, the stink bug complex has caused serious crop loss to cherry, peach, nectarine, apple and pear in NYS Hudson Valley Orchards. Control with insecticides is difficult as this pest is very sporadic, usually occurring mid to late season, right up to the harvest of stone and pome fruit. Over the past two years the stink bug complex invade orchards late in the growing season when choice of chemical controls is limited by pre-harvest interval restriction (PHI) considerations. Repeat sprays are often required because stink bugs continually migrate to and from the orchards, moving from weed hosts or woodlands. Migration often coincides with drought conditions and is concentrated near orchard edges, near abandoned or unmanaged land typical of the Hudson Valley and New England agricultural landscape. The insect will move into orchards to begin feeding on secondary host weed plants along the orchard edge and weed species in row middles and beneath trees that are flowering and producing seed. As these hosts dry, are killed by herbicides or mowed down, the stink bug moves to apple to begin feeding on fruit.

Research to verify stink bug occurrence and feeding damage on apple by Dr. Mark Brown, USDA entomologist (retired) has found that stink bug feeding injury differs from cork spot in three ways: 1) the edge of the depression on the fruit surface from stink bug feeding is gradual instead of abrupt as in cork spot; 2) the corky flesh is always immediately beneath the skin in stink bug injury, but may not be in contact with the skin in cork spot; and 3) a puncture is always present from stink bug feeding, yet may require the aid of magnification. Brown also found that orchards most likely to experience stink bug injury are those with poor weed control adjacent to woods and/or weedy borders. Stink bugs are very difficult to manage because they: 1) are highly mobile; 2) have a broad host range, including many crops and broadleaf weeds; 3) move frequently between weed hosts and fruit trees; and 4) are therefore not continually exposed to insecticide residues for long periods of time. As in the case of the brown marmorated stink bug, proximity of tree hosts to agricultural commodities play an important role in BMSB infestation levels.

Studies conducted by Drs. H. Hogmire and T. Lesky (USDA) on trapping native stink bug to monitor for presence have indicated that although stink bug presence can be correlated between traps and presence in the tree, traps have not yet been developed as useful IPM tools in determining the timing of preventative measures. However, Leskey, USDA ARS, Kerneyville ,West Virginia, has recently found correlation in perimeter pheromone trap data using 10 BMSB per trap to trigger control measures from 1st trials. At this time, the use of scouting observations are still a more reliable methodin determining stink bug presence until trap coorelations are varified. The use of trap crops has also been considered as a possible strategy to manage stink bug populations. Work done on cotton and soybean have pointed to the preference of soybean as a food source for the stink bug complex. Yet in a 2004 study conducted at Clemson University, the use of soy bean as a trap and kill crop did not significantly reduce damage to cotton by stink bug and does not appear to be a feasible alternative in controlling these pest species.

In a study conducted by USDA-ARS, G. L. Snodgrass et. al. in Stoneville, Mississippi, point to the differences in species susceptibility to insecticides efficacious to stink bug. The pyrethroid bifenthrin was equally toxic to brown and southern green stink bugs, whereas cypermethrin, cyfluthrin, and cyhalothrin were significantly more toxic to southern green than they were to brown stink bugs. They also found that bifenthrin was more toxic to brown stink bugs compared with southern green stink bugs by exposing adults in the laboratory to cotton bolls treated in the field. Organophosphate efficacy studies showed Methyl parathion > Acephate > Dicrotophos > Malathion; and pyrethroid evaluations showed Cypermethrin > Cyfluthrin > Bifenthrin > Permethrin. Yet many of the more efficacious products used on other commodities are not registered on apple in NYS. Newer chemistries with different target sites and modes of action have yet to be tested. Recent studies by Tracy Leskey at the USDA ARS in Kernysville, WV on efficacy of insecticides against the BMSB had shown similar disparity between insecticides (Image 1). The best performance through residual bioassay studies in control of this species was provided by bifenthrin in the pyrethroid class, dinotefuran in the neonicotinoid class, endosulfan, a chlorinated hydrocarbon, chlorpyrifos, an organophosphate and methomyl in the carbamate class.

In Central Washington State, laboratory studies conducted on field-aged pesticide residues indicated that Asana 0.66 EC (esfenvalerate) was active as a one-day-old residue against native stink bug species but was not very active as a seven-day-old residue. Guthion (azinphos-methyl) was not effective against stink bug species as one-day or seven-day-old residues. Studies on the residual activity of insecticides against the BMSB conducted in the Hudson valley of NY have shown excellent residual of both endosulfan and bifenthrin of 72 hour old residual on foliage with reduced efficacy of most insecticides used against the stink bug complex (Image 2.)

Native stink bug weed hosts include breadgrass, bushberries, curly dock, everlasting peas, milkweed, mallow, morning glory, mullein, mustard, plantain, thistles, vetch, velvetgrass, and other broadleaf plants. BMSB has been found to feed and reproduce on red-root amaranth or pigweed *Amaranthus retroflexus* along with sunflower, *Helianthus annuus*. The addition of enhanced broadleaf weed management, and timely seasonal mowing have been shown to reduce stink bug injury. Conversely, Dr. Mark Brown found late season mowing and poor weed management enhanced stink bug damage to apple. BMSB and the green stink bug are both arboreal, with increases of both species occurring simultaneously in the Hudson Valley in 2012. Both the BMSB and GSB were found to utilize the Tree of Heaven, *Ailanthus* altissima, throughout the growing season. Late in the season BMSB have been found to infest Catalpa, Black Walnut, Sugar Maple, American Ash as host plants and can be observed feeding on tree seeds. The BMSB movement off of woodland trees to late season tree fruit is believed to coincide with the development of the 2nd generation adult and loss of viable or depleted resources in woodland host trees.

Native to southeast Asia, the spotted-wing drosophila (SWD), was widely observed throughout parts of Korea, and China prior to its identification in Japan in 1913. Its 1980 arrival into the United States as an invasive pest began in Hawaii, appearing in central California by August of 2008, spreading into Washington, Oregon and Florida the following year. By 2011 the SWD has become widespread, captured in Utah, Louisiana, Arkansas, Kentucky, Tennessee, North and South Carolina, Wisconsin, Michigan, West Virginia and Virginia, Maryland, Pennsylvania, New Jersey, New York and all of the New England States (Image 1). The pest has also been found in Europe, including the countries of Italy, France, and Spain. In NY the SWD flies were first captured in apple cider vinegar traps in the experimental vineyard at the Hudson Valley Laboratory in Highland late in August of 2011. Damage to small fruit was first reported by Laura McDermott, a Regional CCE Specialist in the Capital District with traps placed in late raspberry, grown organically in Ancram, NY.

The SWD female differs from other vinegar flies in possessing a unique ovipositor, capable of inserting eggs into un-ripened fruit, which gives them a biological advantage over other *Drosophila*. Thus the SWD can reproduce on fruit earlier in the season to outcompete other fly species, producing as many as 13 generations per year in Asia, with 6-9 generations predicted for NY depending on the season. Another advantage this fly has is its use of multiple hosts including *Cornus kousa*, dogwood, *Eugenia uniflora*, Surinam cherry, *Fragaria ananassa*, strawberries, *Morus spp*., mulberry, *Murraya paniculata*, orange jasmine , *Myrica rubra*, Chinese bayberry , *Prunus spp.* - *P. avium*, sweet cherries; *P. domestica*, plums; *P. persica*, peaches, *Pyrus pyrifolia*, Asian pears, *Ribes spp*., currants, *Rubus spp. - R. armeniacus*, Himalayan blackberries; *R. loganobaccus*, loganberries; *R. idaeus,* raspberries; *R. laciniatus,* evergreen blackberries; *R. ursinus,* marionberries, *Vaccinium spp.*, blueberry, cranberry, *Vitis vinifera*, wine grape. In NY it has been reared from The tartarian honeysuckle, *Lonicera tatarica*, is an invasive plant that also hails from Asia and Siberia. It grows along the wooded edges of agricultural crops, carrying red berries in pairs that become heavily infested with SWD by early July. In the Hudson Valley, SWD developed in very high numbers on this host in the spring of 2013, providing an ideal reproductive site for the fly to disperse to small fruit later in the month as fruit became available (Image 2). The black cherry*, Prunus serotina*, A woodland tree species, is also a preferred wild host for SWD. This tree grows in forests and landscapes throughout the Northeast and is native to North America. On Long Island, recent observations by Faruque Zaman, Suffolk County Cornell Cooperative

Extension, showed 90% infested fruit with SWD. On average, 112 adult SWD emerged after incubating 4 oz. samples of black cherry fruit in the lab. In Long Island, it appears that black cherry is the earliest wild host utilized by SWD. Pokeweed, *Phytolacca acinosa*, another known wild host of SWD, is found to have 80% infested fruit in late August. Fruit of these two wild hosts appear to be the most preferred in late summer and early fall, providing an additional point source of SWD along agricultural edge late into the growing season.

Over the past two years we have seen SWD spread throughout the fruit growing regions of the Hudson Valley and Lake Champlain in western NY in 26 NY counties (http://www.fruit.cornell.edu/spottedwing/dist.html). Across the Hudson Valley of NY, Suffolk County of Long Island and Hampshire County, Massachusetts, the first SWD captures occurred during the week of June 10$^{th}$. Through the use of yeast and vinegar baited traps we have observed the fly nearly one month earlier then in 2012. Traps hung on 1 May in small fruit plantings of raspberry and blackberry throughout the lower Hudson Valley captured SWD 2 weeks prior to fruit infestations. The sustained capture of SWD flies prior to egg laying provided growers with a pest management start date to initiate preventative treatment. However, under the best of pest management programs in raspberry and blackberry, following a 3 to 4 day application schedule, rain events combined with pick-your-own weekend schedules forced application delays of up to 7-days, allowing SWD to infest fruit beyond rescue. All growers in the programs monitored by the ENY Fruit Team had infestation levels exceeding 17% using the best materials under tight treatment protocols.

Given the need for very tight insecticide schedules, insecticide labeled constraints and the need for resistance management strategies, it is likely that complete control of the SWD is unlikely, even under the most diligent of management programs. The perpetual regenerations and presence of all stages of the SWD life cycle provides insulation, in the form of egg, larva and pupa within the host fruit, to escape most insecticide applications. Under the best scenario, infestations can be significantly reduced by tight management intervals, with commitment to using a 3-4 day pest management program being the essential component to success. To improve on this strategy, cultural management considerations should also be undertaken. Creating a less favorable environment for SWD reproduction should begin by maintaining an open canopy through pruning to increase sunlight and reduce humidity while improving spray coverage. Drip lines should be installed 'in-ground' instead of using overhead irrigation when possible. Removal of infested fruit through cane and ground sanitation will reduce SWD emergence, reducing fly populations. Harvesting frequently and completely will prevent the buildup of ripe and over-ripe fruit. Unmarketable fruit should be removed from the field and either frozen, "baked" in clear plastic bags placed in the sun, or disposed of in bags off-site, killing the larvae and preventing adult emergence. Insecticide sprays directed at the SWD adults will reduce egg laying. Begin insecticide treatments at the first SWD trap catch prior to fruit ripening. Treatments should be applied on a 3 to 4 day schedule, repeated after 1 inch of rain. During July and August the insect can reproduce quite quickly, every 10 to 14 days. Select only the most effective insecticides, rotating insecticide modes of action on a 10-14 day interval during peak flight periods.

A 2013 farm success story: SWD was first found in Orange county, NY on 10 June, 2013. A successful pick-your-own operation in that county was able to keep infestation levels down to levels below 2% through to the end of July, then below 17% to the end of the season using a 3 to 7 day spray interval (as weather and pick-your-own scheduling would allow).

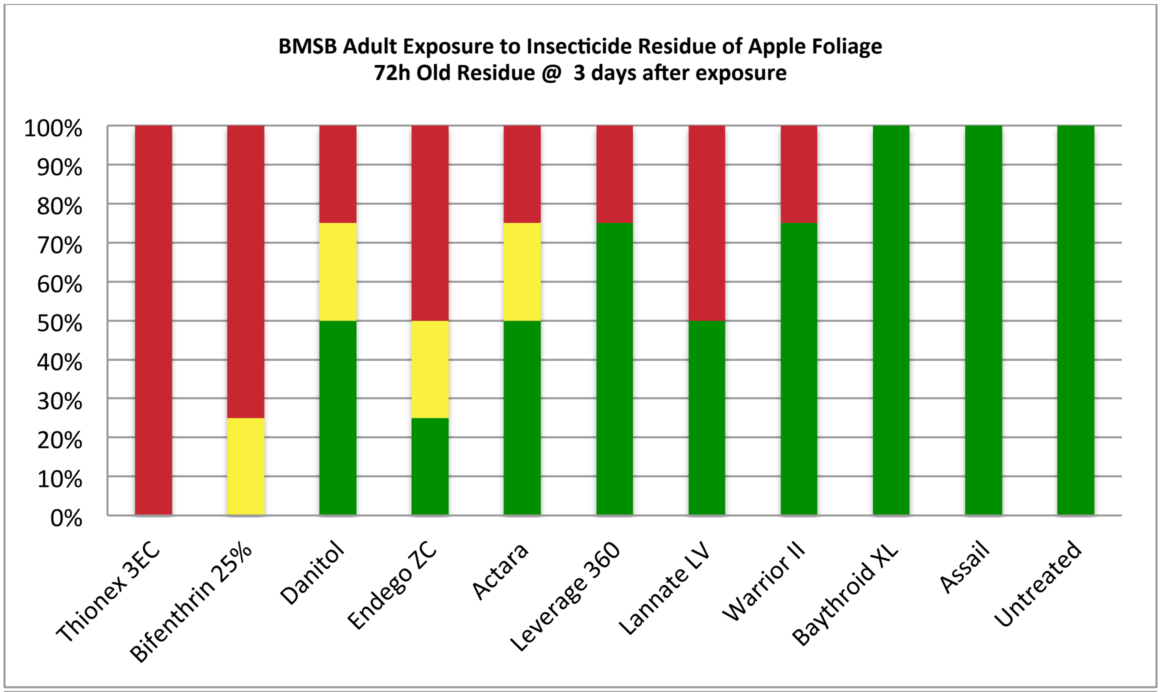
Management was combined with near daily picking, often clean picking on weekends reducing the SWD population potential. Products were employed in 14-day rotational scheduling beginning with Malathion, and followed using alternations of Delegate, Danitol 2.4 EC, Triple Crown and Brigade WSB. His recommendation to the consumers, upon harvesting berries, was to keep fruit cold during storage, which successfully retained fruit quality. Success in this case was not defined by achieving complete control of the pest but by achieving costumer satisfaction in fruit quality and an enjoyable farm / tourism experience.

Lab studies of fruit emersion in 1% oil (≥ 5 minutes held at room temperature (22°C)) has been shown to kill SWD eggs within the fruit (Fig. 3). Post harvest treatments employing cold temperature (1.1°C for 72 hours) significantly reduces live larva (Fig. 4). It may prove of value to small fruit growers to consider funding post harvest research to determine the viability of this approaches to SWD management.

| Insecticide Group | Product | Active Ingredient | % Adult BMSB Mortality[1] |
|---|---|---|---|
| **Pyrethroid** | **Bifenture** | bifenthrin | 100 |
| | **Danitol** | fenpropathrin | 95 |
| | **Warrior II** | lambda-cyhalothrin | 73 |
| **Carbmate** | **Lannate** | methomyl | 92 |
| | **Vydate** | oxymyl | 68 |
| **Neonicotinoid** | **Actara** | thiamethoxam | 92 |
| | **Assail** | acetamiprid | 87 |
| | **Calypso** | thiacloprid | 58 |
| **Pre-mix** | **Leverage 360** | imidacloprid and bifenthrin | 95 |
| | **Endigo** | lambda-cyhalothrin and thiamethoxam | 98 |
| | **Voliam Flexi** | chlorantraniliprole and thiamethoxam | 98 |

**1. Direct contact activity of insecticides against BMSB adults in a lab setting may be very high, yet the activity of field-aged residue may, over time, quickly becomes ineffective at preventing feeding injury.**

Image 1. Efficacy of insecticides against the BMSB by contact or fresh residue.



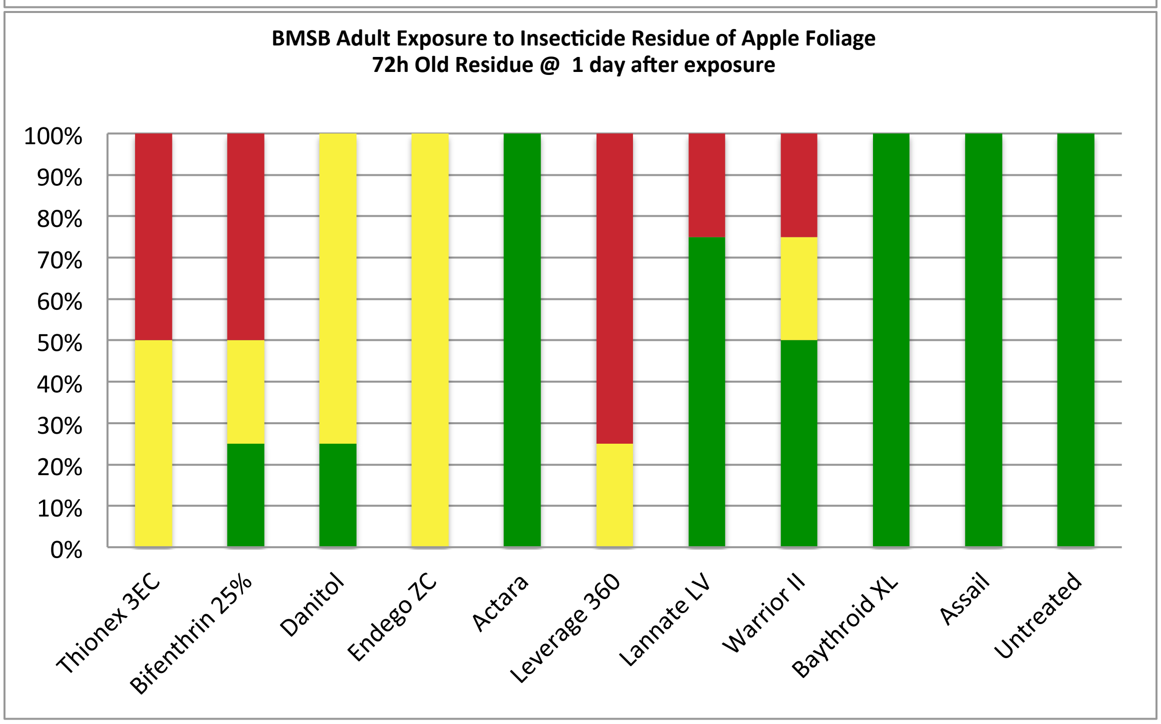




Image 2. Efficacy of insecticides against the BMSB from 72 hour foliar residue, with red (dead), yellow (moribund) and green (live) representing degrees of percent efficacy.

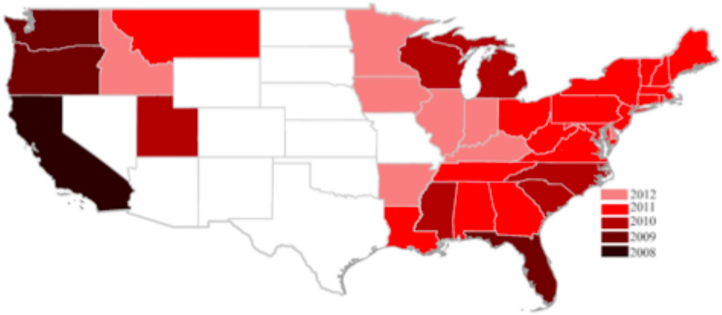



Figure 1. State level SWD in the United States. Burrack, et al. 2012. Journal of Integrated Pest Management.

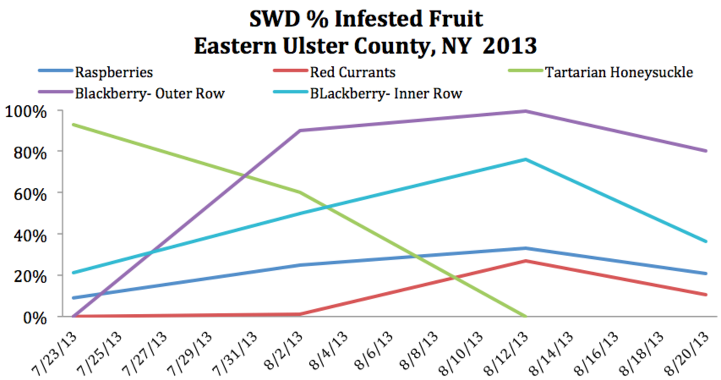



Figure 2. Chart representing field collected small fruit and the border host Tartarian Honeysuckle, *Lonicera tatarica*, from a commercial berry patch in Marlboro, NY 2013.

SWD Larva Survival in Raspberry Post 1% Oil Drench
HVLab, Highland, NY 2012

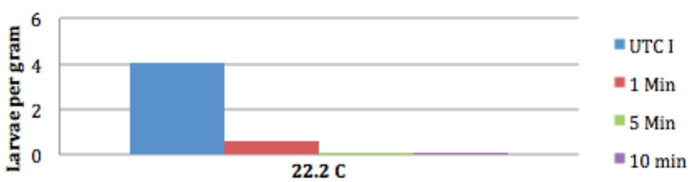



Figure 3. Post harvest evaluation of Amigo (methylated soybean oil) and temperature for controlling SWD.

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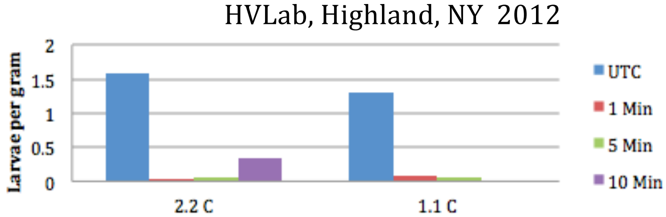


Figure 4. Post harvest evaluation of Amigo (methylated soybean oil) and 2 refrigerated temperatures for controlling SWD.