What's Effective in Controlling SWD

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Northern Highbush varieties are the most widely planted blueberries in the Pacific Northwest. These cultivars have a long fruiting season, from late June through September with a ripening period of 2-5 weeks for each variety. Spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura), lays its eggs in ripening berries (Fig. 1). This behavior causes premature berry softening and microbial contamination that results in rapid decay. SWD infestations in blueberries were first discovered in late season varieties in the Pacific Northwest following its arrival in early August 2009. Potential SWD damage in early and mid-season blueberry varieties still remains problematic. The prognosis for blueberry growers for the 2012 season is uncertain because blueberry has the longest fruiting season of all small fruits in the PNW and thus the longest period of susceptibility.

Fig.1. SWD laying egg in blueberry.

Because of extreme cold temperatures in February of 2011, blueberries in northwestern Washington experienced economic losses due to bud freeze (Fig. 2). The sudden freezing temperatures that occurred over 2 days are believed to have impacted overwintering adult SWD. Populations of SWD appeared 3-4 weeks later than the previous two seasons. Commercial growers with early-mid-season cultivars experienced no economic losses. Organic and commercial producers that did not make 5-7 day rotations of protective cover sprays in mid-late varieties did experience worm-infested berries that never made commercial fresh grade. Management of this vinegar fly species in "normal" seasons in the PNW can be especially challenging due to concurrent maturing red raspberry, wild Himalayan blackberry and late season caneberries which could provide a reservoir for the infestation of early to mid-season blueberry cultivars (e.g., Duke, Patriot, Bluecrop).

Fig. 2 Blueberry flower bud freeze injury. Photo -Tom Walters.

Several non-labeled insecticides and combinations provided very good lab and field efficacy for adult SWD control. Discussions with respective formulators are ongoing and those interested in further trials for possible submission to IR-4 will be continued in more detail next season. Our major research emphasis for the 2011 season was to explore non-invasive methods to make commercial insecticide applications at initial blueberry ripening and through the harvest period. The three control tactics researched that will enable growers with different economic constraints good options for successful management outcomes were: trellising, helicopter application and micro-sprinkler chemigation. Trellising and good pruning practices will allow a grower more flexibility with his standard orchard sprayer while minimizing fruit drop, facilitating handpicking, machine harvesting and other cultural management activities such as mowing. Helicopter applications provided excellent contact knockdown of active adult populations in a blueberry canopy laden with ripening fruit. Mustang Max, Lannate LV and Success provided excellent knockdown up to three days following treatment. Stand-alone micro-sprinklers provided economic knockdown and residual control of SWD with excellent coverage of blueberry leaf surfaces and mixed maturing berries with Mustang Max. Micro-sprinklers give the grower flexible timing options for field-wide applications given SWD population levels, weather conditions such as wind and rain, harvesting schedules and opportunity to tank mix pesticides. The main challenge for this unique chemigation system is to calibrate each stand-alone system to consistently deliver the recommended field rate of the pesticide on target with minimal wash-off and drift.

Field efficacy trials. Trials were conducted on the WSU NWREC 7 year-old 'Duke' blueberries. Plots were single bushes replicated four times in a RCBD. Treatments were applied with a CO_2 backpack sprayer equipped with an 8002VS nozzle, delivering 100 gal/ac at 60 psi. All treatments contained the R-56® spreader sticker. Other than Lannate LV, the following chemicals are not labeled or registered for commercial application on blueberry. Eleven treatments were evaluated and samples for each treatment were taken from four random bush replicates from which three leaves were removed after 2, 4 and 7 DAT. The three leaves were placed in standard Petri dishes, infested with five adult SWD and evaluated after 24 hrs. The insecticides evaluated were: Lannate® LV (1.5 & 3 pts/ac), unregistered Group 28 HWG86 10SE (13.5 fl oz/ac, 13.5 fl oz/ac + NIS, 20.5 fl oz/ac + NIS), standard Mustang Max® (4 fl oz/ac), untreated check and combination formulations of Endigo® ZC (lambda-cyhalothrin + thiamethoxam) (4.5 fl oz/ac), Brigadier® (bifenthrin + imidacloprid) (6.14 fl oz/ac), Leverage® 2.7 (β cyfluthrin + imidacloprid) (5.1 fl oz/ac) and Warrior® II (lambda-cyhalothrin) (2.56 fl oz/ac).

We feel the leaf bioassay is a more accurate bioassay of commercial efficacy when applying dilute rates of SWD protective sprays by ground equipment to blueberries. Both field and lab bioassays of treated blueberries reflect the difficulty of achieving good coverage on all surfaces of the blueberry fruit clusters that are located within the foliage of a blueberry bush. Contact coverage is critical to the rapid knockdown of egg laying female SWD seeking ripening fruit. After 2 DAT, all of the selected insecticides and combinations provided > 90% adult mortality except Brigadier at 85%. Leaf residual at 4 DAT showed compounds with ≥ 90% mortality; HGW86 (13.5 fl oz/ac), HGW86 (13.5 fl oz/ac + l qt/100 NIS) and Endigo ZC. Compounds ≥ 80% were HGW86 (20.5 fl oz/ac + NIS) Leverage and Warrior II. By 7 DAT, field-aged residual on blueberry foliage had dramatically declined to ≤ 40% for all of the insecticides. These data for field-aged residues strongly indicate the need to conduct further research on effective SWD insecticides registered in OR and WA by repeating and replicating similar field trials to determine more precise spray intervals when managing field rotations for different classes of insecticides within the context of IRM. This research is often mitigated by environmental parameters such as temperature and rain that are often seasonally different from year to year and from region to region. Another season's research will provide data and understanding about the rotation of different MOA chemistries during the long blueberry harvest period.

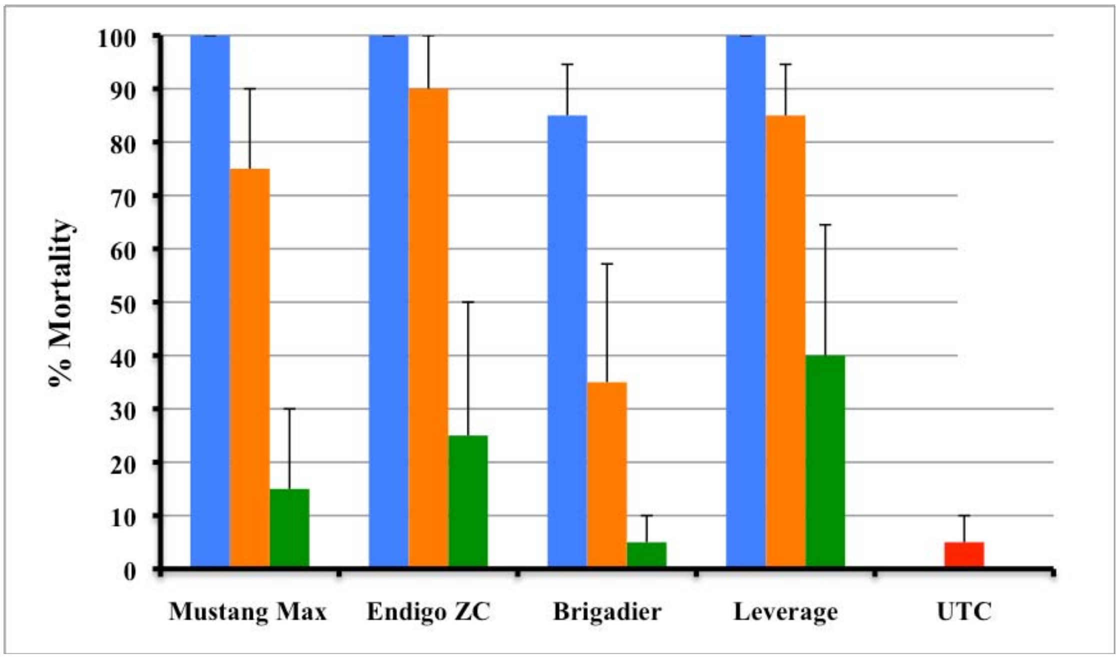

Fig. 3. Efficacy of field residuals for 4 foliar insecticides on highbush blueberry.

Trellising to maintain alleyway access. Two unreplicated, 1.5 acre blocks of un-trellised and trellised 'Bluecrop' and two similar blocks of 'Bluejay' were established in Woodland, WA. Both six years-old varieties were heavily pruned prior to placing #12 gauge high tensile wire approximately 4 ft above the ground. The wires were held in place by 12 in hooks attached to metal posts in the row spaced at 18 ft and anchored at both ends with traditional wooden end posts (Figs. 4-5).

Figs 4 & 5. Trellised blueberry (left) and un-trellised blueberry (right).

The grower applied a protective sp ray of Brigade® WSB (1 lb/ac) on 20 July and Mustang Max (4 fl oz/ac) on 26 July 2011 with a conventional orchard air blast sprayer. Five replicates, each consisting of 5 mature blueberries (n = 25) were randomly sampled from each of the 4 treatment blocks, after 12 HAT. Five berries were placed in a standard Petri dish with a small wedge of water moistened dental wick. Five even-aged SWD adults were placed in each Petri dish and percent mortality was assessed after 1 DAT for both treatments.

Brigade residuals on berries from un-trellised 'Bluejay' and 'Bluecrop' provided poor contact mortality to adult SWD of 50 ± 50 SEM, 26.7 ±43.5 and 3.3 ± 7.5 and 3.3 ± 7.5 percentages at 1 and 6 DAT, respectively. However, the trellis and upright architecture of 'Bluejay' resulted in very good coverage for Brigade with 100 and 90 percent mortality at 1 and 6 DAT, while the fuller profile of 'Bluecrop' showed large variability and only 43 and 30 percent adult mortality. Mustang Max provided excellent adult knockdown of SWD after 1 and 3 DAT for both trellised and un-trellised 'Bluejay' and 'Bluecrop'. This observation for Mustang Max was also corroborated from lab bioassays, helicopter and micro-sprinkler trials on blueberries as well. An approximation of berries dropped 2 DAT after an air blast Mustang Max application with a 1 ft^2 tile showed 1.7-fold and 1.9-fold more berries dropped from un-trellised 'Bluecrop' and 'Bluejay', respectively.

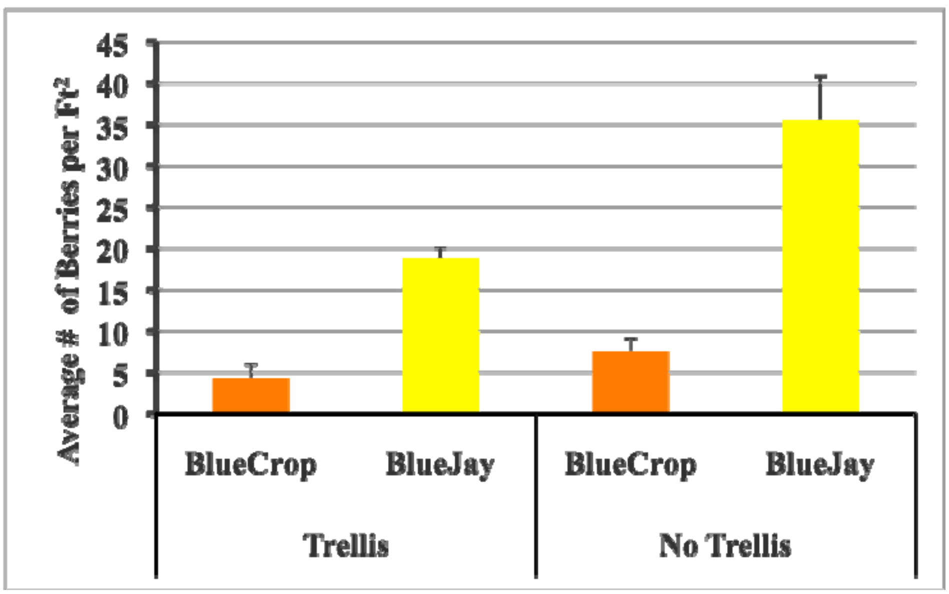

Fig. 6. Berries drop comparison in trellised and un-trellised plots following air-blast treatment.

Helicopter aerial applications. Four commercial helicopter applications were monitored for contact knockdown at 24 hr after treatment and field residual on foliage from random bushes in a large 'Aurora' blueberry block near Salem, OR, 2011. Aerial applications of Malathion 8 (2 pts/ac, 3 July), Success® (6 oz/ac, 30 July), Lannate LV (1.5 pts/ac, 10 August) and Lannate LV (1.8 pts/ac, 2 September) were applied at 10 gal/acre. Droplet size and distribution patterns from the helicopter were determined with water sensitive paper attached to sentinel cages (Figs. 7-8). Each cage consisted of a 16 fl oz plastic cup with a screened, snaptop lid, containing 5 adult SWD and a water saturated cotton core. Adult mortality was assessed at 2, 12 and 26 hrs posttreatment. Sentinel cages were placed at the top, middle and lower positions of five randomly selected bushes.

Figs. 7 - 8. Helicopter application with sentinel cage and water sensitive paper attached.

In addition to the sentinel cages, which measured aerial kill, residual mortality was determined through bioassays of three leaves collected at each level from both sides of the five bushes. Sets of three leaves, along with five SWD adults were placed into standard disposable Petri dishes and mortality assessed after 24 hours.

The average aerial knockdown for the three positions after 26 HAT (arranged by date as above) were: Malathion 8 (47.3 ± 24.5 SEM), Success (44.0 ± 11.6), Lannate (96 ± 2.3) and Lannate (85.3 ± 12.7). The contact toxicity and warm weather fuming activity of Lannate was excellent through the canopy of mature sized 'Aurora' bushes, especially for the 10 August application. The residual mortality of Lannate on foliage supports the sentinel aerosol knockdown results, given 1 DAT foliage mortality for both treatment dates at 94.9 ±1.5 and 92 ± 3.6 percent and 89.2 ± 5.8 at 8 DAT and 98.3 ± 1.7 at 6 DAT.

Micro-sprinkler chemigation. A novel chemigation application method using Netafim® micro-sprinklers for control of SWD was field tested on approximately 1/3 acre of late season 'Elliott' highbush blueberry near Salem, OR on 26 July 2011 (Fig. 9). This plot was part of a 22 acre mixed planting of 7 year-old 'Elliott', 'Liberty' and 'Aurora' equipped with 139 Supernet #90 nozzles/acre that are intended for cooling maturing blueberries when temperature reach 95 ^{o}F. The nozzle size is .069 inches and when operated at 50 psi will produce a 23.8 GPH flow rate with 23 ft diameter coverage. These micro-sprinklers are spaced 12 ft apart in every other row. This spacing and offset of 6 ft between rows of micro-sprinklers resulted in an overlapping spray pattern whereby each bush is covered by three sprinklers. Three rows were selected for the micro-sprinkler field test. An orchard air blast sprayer, operating at 30-35 psi was used to inject 50 gal of a 4 fl oz/acre rate of Mustang Max

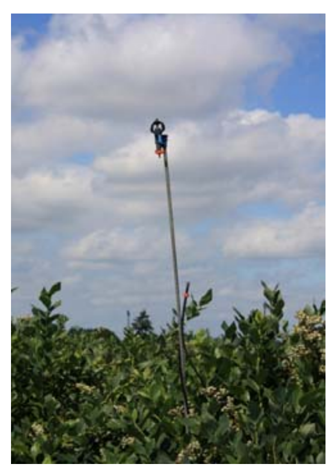

Fig. 9. Netafim microsprinkler above blueberry canopy.

through a manifold equipped with two connector hoses that were coupled into each sprinkler line (Fig. 10). Twenty-four ventilated, 16 fl oz sentinel cages, each containing 10 adults.

Fig. 10. Modified orchard air-blast sprayer injection.

SWD, were randomly place on top, middle, lower and inside of each of six blueberry bushes placed at random in the middle row. A four-minute micro-sprinkler application of Mustang Max resulting in 93.7 ± 17 percent mortality of caged SWD, averaged from four different positions, indicated adequate cove-age. There was no significant percent mortality differences of adult SWD between canopy positions when chemigated with Mustang Max.

A full-scale chemigation was initiated in a 7-acre section of the 22-acre block with Mustang Max at 4 fl oz/ac, applied through the main pumping station on 10 August (Fig. 11).

Fig. 11. Seven-acre microsprinkler trial, Salem, OR.

Our challenge was to calibrate this system to provide a full field rate, estimated as an 8 minute application wave, from the nearest to the furthest area of the field. Gallonage required to deliver 4 fl oz/ac of Mustang Max was estimated at between 350-500 gallons over 7 acres for 8-minutes. One hour after application, the injector lines were purged for 8 minutes. Sentinel traps with 10 adult SWD each were placed at two sites in 4 middle rows at the top, middle, lower and inside locations (i.e., 8 x 4 = 32 sentinels). The average adult mortality for all of the sentinels was 83.8 ± 5.1 after 1 DAT. The top position averaged 98% mortality while the inside position was 70%. Field-aged residuals were bioassayed using 3 leaves per sentinel site. Leaf sets were placed in Petri dishes as described above, with 5 SWD adults. Percent mortality was recorded at 2 and 6 DAT. Average percent mortality for all foliage collected at 2 and 6 DAT was 95.3 ±3.0 and 71.9 ± 1.8, respectively. Blue dye injected with the insecticide was used as an indicator to assist in determining lag time from the in-line injectors for the 22 acres for subsequent treatments. Without the dye, uncertainty regarding the accuracy of the 8-minute injection period calculation for the 22-acre block remained although our contact and residual activity with live flies indicated good precision and placement throughout the blueberry canopy.

Malathion 8 was applied on 24 August at 1.25 pts/ac + Activator 90 (16 fl oz/ac) with 2 qts of blue dye. The blue dye allowed us to visually monitor the flow of Malathion through the pump house injector to 3 sectors of the 22 acre block. Computer controlled shut-off flow valves for each sector were programmed by the farm manager, for 8 minute applications. For verification, three micro-sprinklers from each sector were detached from their 8 ft high, 3/8” steel rod risers and allowed to empty into 5 gal buckets to follow the presence of the blue dye, to determine duration for the beginning and end of blue dye flow for each sector. Field placement of sentinel cages was similar to the Mustang Max chemigation trial on 10 August. The adult contact mortality for the four positions from top to inside were 100%, 74%, 60% and 91% at 1 DAT. The average for the four positions from 8 sampling sites was 81 ± 6.9 percent. Field-aged residues for Malathion, after 6 DAT on leaves and berries was only 22.3 ± 1.8 and 3.9 ±2.1 percent. These data further support our concerns that Malathion’s residual contact efficacy is only 3-4 days.

After replacement of two faulty shut off valves, the researchers felt confident that the next chemigation applied on 17 September with Mustang Max at 4 oz/ac + Activator 90 (16 fl oz/ac) would result in a more accurate application than the previous Malathion 8 chemigation which might have under dosed the 7 acre section. Row 10 (‘Elliot’), row 72 (‘Liberty’) and row 110 (‘Liberty’) were randomly selected and 4 bush sites were randomly selected in each row. Six leaves were collected from each bush replicate for a total of 24 samples. The six leaves were divided in half and each 3-leaf subsample was placed in Petri dishes with 5 adult SWD and a moistened portion of a standard dental wick. Mortality was assessed after 24 hours. Duration of blue dye in the flow capture studies from the first micro-sprinkler of each row, verified accuracy of the 8 minute estimated injection period for Mustang Max. Adult bioassays of foliar-aged residues at 1, 4 and 7 DAT were 99.2 ± 0.8, 100 and 91.9 ±10.9. These results are very encouraging and reflect the precision of a calibrated micro-sprinkler system to deliver an accurate field rate of Mustang Max during blueberry harvest.

Summary.
Data gathered in 2011 from lab bioassays and field residue tests provided a list of registered compounds effective against SWD. The most commonly applied insecticides all expressed good to excellent contact and moderate 5-7 day residual activity to adult SWD on blueberry. Several experimental and unlabeled insecticide package mixes showed very good contact residual and potential curative control under field conditions. Our 2011 evaluation of helicopter applications of Malathion, Success and two applications of Lannate LV resulted in 47, 44, 96 and 85 percent mortality of SWD sentinels placed at various heights in the canopy of a mature ‘Aurora’ block in Salem, OR. We believe the potential of aerial application lies in immediate knockdown of an invading population of mature SWD adults for 5-7 days. A misting system equipped with microsprinklers used expressly to keep ripening fruit cool in 95^{o} F weather was adapted to chemigate insecticides in a 22 acre block of late season blueberry cultivars. This delivery system was shown, this past season, to precisely deliver contact insecticides (e.g., Mustang Max, Malathion, Delegate) from above the blueberry canopy. These Netafim™ supernet nozzles eliminated the need for row applications with invasive ground sprayer-tractors, while delivering an average droplet size of 250 microns, effectively penetrating the canopy. Field-aged residues and a provisional control threshold efficacy > 90% mortality will be evaluated in more detail next year from blueberry foliage for all of the current insecticides recommended for SWD control.