Refining spray strategies to optimize sustainable pest and disease management in cherry orchards

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Introduction. Michigan cherry producers have faced increasing management challenges with the establishment of spotted wing drosophila (SWD). This pest has increased farm business expenses, contributed to in-season operator fatigue, and has the potential to reduce growers' abilities to sustainably produce tart cherries in Michigan. Currently, many growers lack necessary equipment, personnel, and time to meet the demands to control this pest.

From 2014-2017, the percentage of cherry growers managing SWD has risen each year from 39%, 68%, 89%, to 97% (Pochubay and Rothwell unpublished survey data). Our review of spray records has indicated significant increases in the number of sprays and cost to control SWD (Pochubay and Rothwell unpublished data). Although sprays and costs have increased, spray records show that growers use different approaches to manage SWD, and these strategies are in part a reflection of the availability farm resources as mentioned previously. For example, the optimal SWD management program for some farms has been to use alternate row middle (ARM) sprays at ~five-day intervals whereas others apply a full cover every seven to 10 days.

Differing management programs also impact the efficacy of other cherry pests and diseases. In particular, effective control of cherry leaf spot (CLS) disease is a concern due to reduced CLS sensitivity to SDHI fungicides. Preliminary trials conducted at the Northwest Michigan Horticultural Research Center (NWMHRC) have shown CLS incidence is ~15% higher in trees treated at a 10-day ARM spray interval compared with 10-day every row sprays. With increasing SWD pressure and potential resistance development in the CLS pathogen, our goal was to identify the optimal spray intervals for ARM spray programs to refine our recommendations for ARM sprays for both SWD and CLS management.

Lastly, canopy structure and density play important roles in the likelihood of SWD-infested fruit at harvest timing. More open canopies (ex. canopies of younger trees) likely receive better coverage on fruit and foliage using either an ARM or full cover application. Hence, because canopies of younger trees are smaller and less dense than a mature orchard canopy, we also investigated pest and disease efficacy using ARM and full cover applications in trees of different canopy sizes and ages. This research aimed to reduce operator fatigue and optimize pest and disease control by tailoring management recommendations to account for seasonality, orchard age, and/or canopy size.

Objective 1. Compare seasonal spray coverage of ARM vs. full cover applications in 8-yr old and 16-yr old Montmorency tart cherries. *We hypothesized that season-long full cover applications would provide optimal spray coverage compared with season-long ARM application programs that would provide poorer coverage.* We assessed spray coverage in 8-yr old and 16-yr old Montmorency tart cherries blocks located at the NWMHRC. In blocks of both tree ages, 12 replications of three spray strategy treatments were evaluated for spray coverage: A) season-long 10-D full cover, B) season-long 5-D ARM, and C) early-season 5-D ARM sprays followed by mid-season to pre-harvest full cover 10-D sprays. Paper spray cards (1"x2") were secured into tree canopies in nine zones (east high, east middle, east low, middle high, middle middle, middle low, west high, west middle, west low) of 16-yr old trees and six zones (east high, east low, middle high, middle low, west high, west low) of 8-yr old trees. There were two spray cards in each zone of the canopy. A tracer of blue food grade dye at a rate of 0.2% per 60 gal/A was added to the tank of an airblast sprayer to 'trace' coverage at two timings during the season: post-bloom and pre-harvest. During the pre-harvest timing, Treatment B received two applications at 5-D intervals (on 7/11 and 7/16) and the coverage from these two spray dates were combined to compare coverage across treatments. Spray cards were secured in the canopy prior to dye sprays and collected after appropriate re-entry intervals are met. Cards were scanned using a flatbed scanner with 4800 dpi optical resolution and IMAGEJ software was used to measure and analyze the percentage coverage on the spray cards.

Table 1. Percentage of Spray Coverage in Small Trees

Timing and Treatment	Zone						Total Avg. (%)
	eh	el	mh	ml	wh	wl	
Post Bloom (6/1/18)							
A (Full cover)	76	77	75	86	78	72	**77**
B (ARM, one side)	48	53	40	57	48	44	**48**
C (ARM, one side)	16	20	22	42	64	59	**37**
Pre-harvest (7/11/18)							
A (Full cover)	65	61	70	67	74	59	**66**
B (ARM, both sides)	40	62	16	42	47	27	**39**
C (Full cover)	79	48	36	56	61	38	**53**

Results 1. Our data supported our hypothesis that full cover applications would provide optimal spray coverage compared with ARM applications; this result was consistant for both small and large trees. We observed that the percentage of covered area was generally higher in small trees compared with coverage in the large trees (Table 1 and 2). There were also some numeric differences between the timings of the application where better coverage was typically observed when a full cover was applied during early sprays compared with mid to late season sprays (i.e. post bloom vs. pre-harvest). These results were likely due to greater canopy density later in the season that resulted in less total area covered by the spray material. There were also noticeable differences in percentage of area covered in the difference zones of treatments that received only ARM one side application. However, we did not observe significant differences among the zones in the canopy of trees treated with full cover applications or two ARM applications (one on each side of the tree). To gain a better understanding of how coverage would influence efficacy, our second objective measured pest abundance and disease incidence in these spray coverage treatments.

Table 2. Percentage of Spray Coverage in Large Trees

Timing and Treatment	Zone									Total Avg. (%)
	eh	el	em	mh	ml	mm	wh	wl	wm	
Post Bloom (6/1/18)										
A (Full cover)	54	75	63	35	66	39	52	66	59	**58**
B (ARM, one side)	6	33	12	10	32	17	44	56	55	**31**
C (ARM, one side)	11	28	13	16	38	25	46	56	53	**32**
Pre-harvest (7/11/18)										
A (Full cover)	31	59	50	18	67	21	34	57	46	**43**
B (ARM, both sides)	29	68	47	10	39	24	43	57	27	**38**
C (Full cover)	45	63	48	15	38	21	37	40	33	**38**

Objective 2. Measure efficacy of spray strategies for pests and diseases in 8-yr old and 16-yr old Montmorency tart cherry. *We hypothesized that season-long full cover applications would provide optimal efficacy. Early-season ARM sprays followed by full cover applications would be less efficacious against fungal pathogens but would provide acceptable efficacy for*

SWD. Season-long ARM sprays would provide the poorest efficacy against CLS and SWD. We measured the pest and disease efficacy of the three aforementioned spray strategy treatments. In treatments using ARM sprays, applications were made every 5 days; full cover applications were made every 10 days; spray programs are outlined in Table 3. We rated disease efficacy of each treatment by measuring cherry leaf spot and powdery mildew incidence on 20 shoots per treatment. SWD efficacy was measured by collecting and processing ~3 gal of fruit per treatment using the brown sugar extraction method at three timings: pre-harvest, harvest, and post-harvest.

Table 3. 2018 Spray Program (Airblast sprayer, 60 gal/A, 200 PSI, 3.5 mph)		
Date	**Treatment**	**Materials**
22-May	ABC	Chloronil 720 (4 pt/A)
27-May	BC	Chloronil 720 (4 pt/A)
1-Jun	ABC	Actara (5.5 oz/A) + Captan 80W (2.5 lb/A) + Luna Sensation (5.6 oz/A)
6-Jun	BC	Actara (5.5 oz/A) + Captan 80W (2.5 lb/A) + Luna Sensation (5.6 oz/A)
11-Jun	ABC	Captan 80W (2.5 lb/A)
16-Jun	B	Captan 80W (2.5 lb/A)
21-Jun	ABC	Imidan 70WP (2.125 lb/A) + Captan 80W (2.5 lb/A)
26-Jun	B	Imidan 70WP (2.125 lb/A) + Captan 80W (2.5 lb/A)
1-Jul	ABC	Imidan 70WP (2.125 lb/A) + Captan 80W (2.5 lb/A)
6-Jul	B	Imidan 70WP (2.125 lb/A) + Captan 80W (2.5 lb/A)
11-Jul	ABC	Imidan 70WP (2.125 lb/A) + Captan 80W (2.5 lb/A)

Results 2. The 2018 growing season posed little pest and disease pressure due to hotter and drier than normal summer months. No SWD were recovered in our preharvest or harvest timing samples. In our post-harvest sample, two weeks after the last spray had been applied, we found a total of two SWD larvae and two SWD eggs in large and small trees, respectively. There were no significant differences in the number of SWD found in treatments or tree age. Lastly, we are not confident that finding few larvae in our samples was a result of spray programs because overall populations of SWD were too low to discern measurable differences. Similarly, drier conditions resulted in low cherry leaf spot incidence and no significant differences among treatments or tree size/age. Because powdery mildew requires relatively little moisture for disease development, we found higher PM incidence overall. We found numerically higher PM incidence in the younger, more vigorous trees compared with larger trees.

Summary. Through this work, we hoped to gain a better understanding of how to optimally implement different spray strategies to provide effective pest and disease management while also alleviating resource demands on Michigan tart cherry growers. Observing spray coverage provided us with insight into how tree size/age and canopy density over the course of the season impact coverage. Our data showed that full cover applications provide the greatest amount of coverage in both large and small trees with reduced coverage as tree canopies became denser later in the season. To understand how coverage influences pest and disease efficacy, we measured SWD infestation and disease incidence. However, there was relatively low SWD pressure in 2018 that we hypothesize was due to abnormally hot and dry weather. Similarly, there was little CLS incidence this season. Therefore, we did not observe differences among spray strategies for SWD or CLS. These preliminary data suggested that less coverage could have played a role in higher PM incidence as we observed greater PM in small, vigorous trees sprayed with a season long ARM strategy. Future research should continue to investigate how spray strategies impact efficacy in seasons with greater pest and disease pressure.