

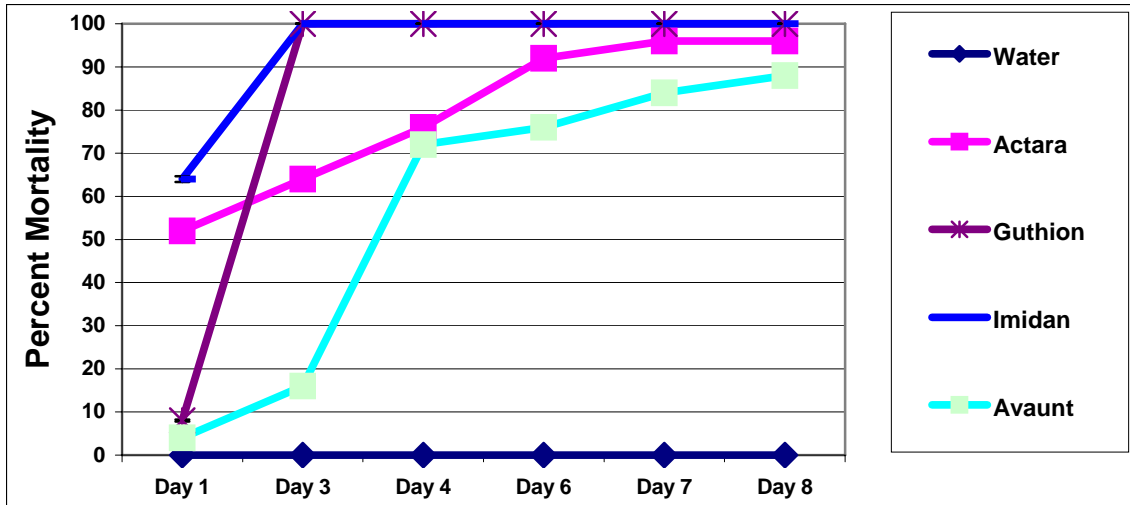
# RAMP Project: Northwest Objectives and Results, 2006

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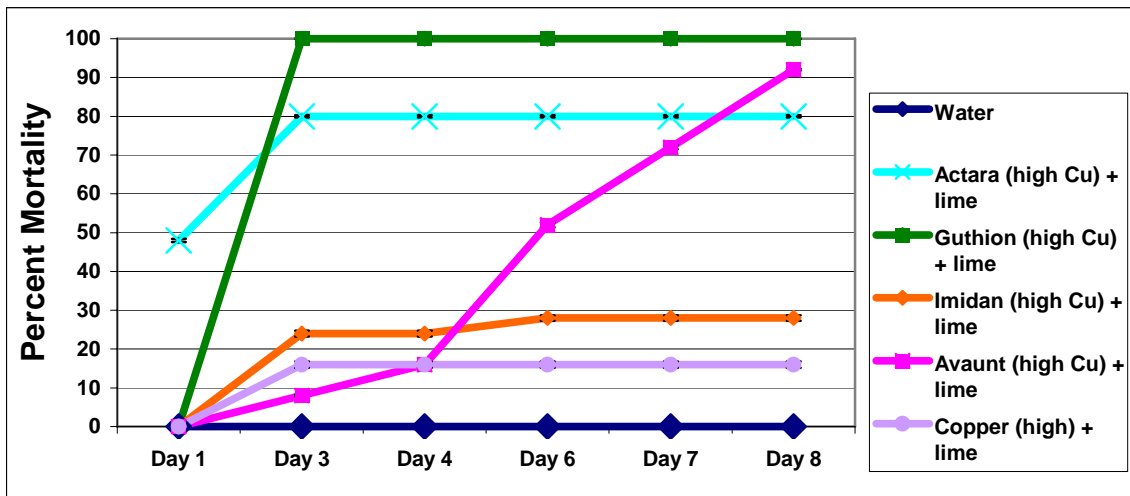
1. **Copper/insecticide tank mixes lab assay.** With the re-introduction of copper into the cherry pesticide program, growers have expressed concern about this strategy and its compatibility with insecticides. When copper is used as a fungicide, it has always been mixed with some formulation of lime to prevent phytotoxicity. The addition of lime to a spray tank changes the pH of the water, and many insecticides have pH restriction requirements. To determine if the primary insecticides used in the RAMP project, Guthion and Imidan in the comparison blocks and Avaunt and Actara in the RAMP blocks, were effective against plum curculio when mixed with copper and lime, we conducted two laboratory bio-assays. In the second bio-assay, we tested four insecticides with copper that were not used in the RAMP project: Warrior, Provado, Ambush and Asana. All insecticides were mixed with high (1.5 lb of actual Cu) and low (0.75 lb of actual Cu) amounts of copper and high (6 lbs) and low (3 lbs) of lime. All insecticides were tested alone, and water alone was used as the untreated check. Because Avaunt and Provado activity are enhanced with ingestion and Actara is a strong anti-feedant, we performed a 'dipped' cherry trial with those products. With the remaining products, the chemical mixture was placed onto filter paper in the petri dish to simulate contact activity. Copper/lime mixtures decreased efficacy of Imidan throughout the duration of the experiment. Copper and lime also reduced the efficacy of Actara, Provado, and Warrior in the first day of the study.

**Table 1.** This table displays the first bio-assay of four insecticides against plum curculio. Percent mortality was recorded every 24-48 hours.

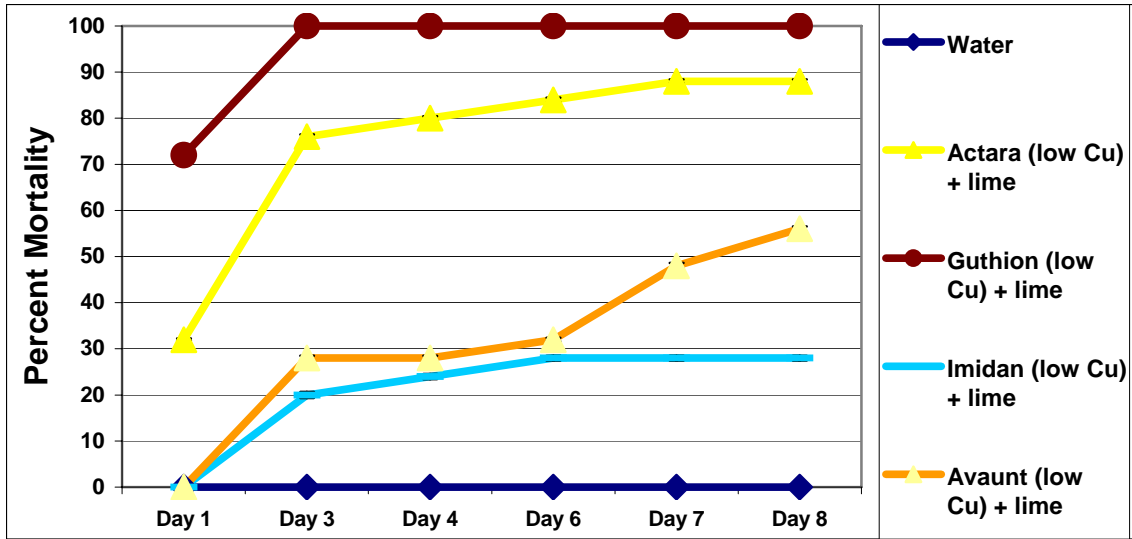
Chemical	Day 1 % Mortality	Day 3 % Mortality	Day 4 % Mortality	Day 6 % Mortality	Day 7 % Mortality	Day 8 % Mortality
Water	0	0	0	0	0	0
Actara	52	64	76	92	96	96
Actara (low Cu) + lime	32	76	80	84	88	88
Actara (high Cu) + lime	48	80	80	80	80	80
Guthion	8	100	100	100	100	100
Guthion (low Cu) + lime	72	100	100	100	100	100
Guthion (high Cu) + lime	0	100	100	100	100	100
Imidan	64	100	100	100	100	100
Imidan (low Cu) + lime	0	20	24	28	28	28
Imidan (high Cu) + lime	0	24	24	28	28	28
Avaunt	4	16	72	76	84	88
Avaunt (low Cu) + lime	0	28	28	32	48	56
Avaunt (high Cu) + lime	0	8	16	52	72	92
Copper (low) + lime	0	52	52	52	52	52
Copper (high) + lime	0	16	16	16	16	16
Lime (low)	0	0	0	0	4	4
Lime (high)	0	0	0	24	44	48



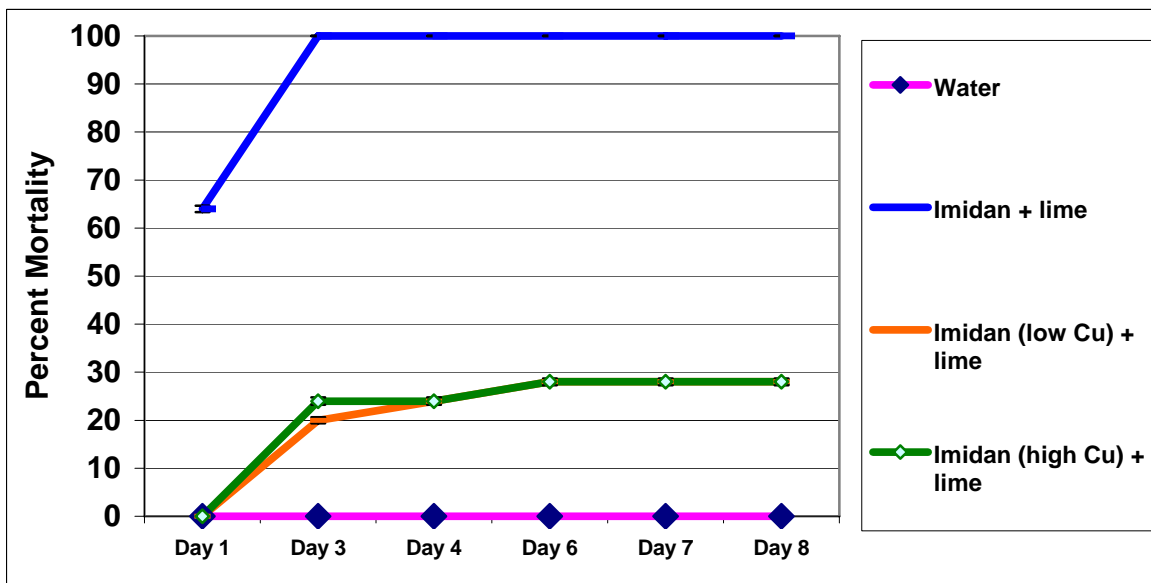
**Figure 1.** Percent plum curculio mortality with insecticides alone in a laboratory bio-assay performed on 5/18/06.



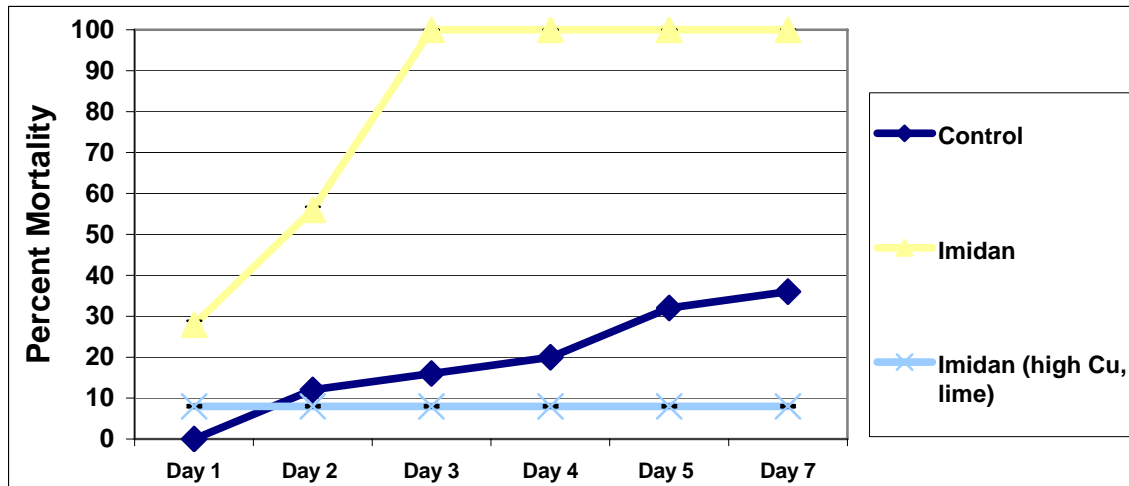
**Figure 2.** Percent mortality of four insecticides (Actara, Avaunt, Guthion, and Imidan) when mixed with high levels of Cu and lime. Bio-assay performed on 5/18/06.



**Figure 3.** Percent mortality of four insecticides (Actara, Guthion, Imidan, and Avaunt) when mixed with low levels of Cu and lime. Bio-assay performed on 5/18/06.



**Figure 4.** Percent mortality with the insecticide Imidan when mixed with high and low levels of Cu and lime. Bio-assay performed on 5/18/06.



**Figure 5.** Percent mortality with the insecticide Imidan when mixed with high Cu and lime. From bio-assay performed on 6/12/06.

**Table 2.** Percent mortality of laboratory plum curculio bio-assay with eight different insecticides.

Time in Days	Day 1	Day 2	Day 3	Day 4	Day 5	Day 7
	% Mortality	% Mortality	% Mortality	% Mortality	% Mortality	% Mortality
Water	0	12	16	20	32	36
Actara	68	92	96	96	100	100
Actara (high Cu, lime)	*32	64	72	92	100	100
Ambush	64	95	100	100	100	100
Ambush (high Cu, lime)	36	72	92	96	100	100
Asana	36	92	100	100	100	100
Asana (high Cu, lime)	48	100	100	100	100	100
Avaunt	4	32	36	80	100	100
Avaunt (high Cu, lime)	0	12	44	68	100	100
Guthion	36	88	100	100	100	100
Guthion (high Cu, lime)	32	84	100	100	100	100
Imidan	28	56	100	100	100	100
Imidan (high Cu, lime)	8	*8	*8	*8	*8	*8
Provado	76	92	100	100	100	100
Provado (high Cu, lime)	*12	44	84	100	100	100
Warrior	36	52	72	96	100	100
Warrior (high Cu, lime)	*4	64	84	96	96	96

\* Means significantly different according to Fisher's Protected LSD ( $P \leq 0.05$ ).

**2. Copper as fungicide alternative for SI-resistant cherry leaf spot.** Due to the paucity of available fungicide chemistries that incorporate different modes of action, we have been reevaluating the use of copper compounds as an alternative fungicide for control of CLS and SI-resistant *B. jaapii* in Michigan orchards. Copper was widely used for tart cherry disease control in the 1930's and 1940's until its gradual replacement by modern synthetic fungicides. Successful efficacy of copper compounds aids both conventional growers, as copper extends the life of traditional fungicides, and organic growers because copper is the only option for disease control in tart cherry. Copper is also 1/3 the cost of traditional fungicides, an attribute that lends appreciably to the economic stability of Michigan orchards, particularly smaller orchard operations.

Copper was shown to be an effective tool in reducing CLS in trials conducted at the NWMHRS in 2004. In 2005, very little CLS infection occurred due to hot dry weather, therefore, the experiment was not evaluated. The experiments for the 2006 season are described in the following protocols:

- a. *Reducing amount of copper in field trials.* We determined if we could reduce the amount of actual copper needed to control CLS in field trials at the Northwest Michigan Horticultural Research Station (NWMHRS):

Fungicide sprays were applied to a block of 12-yr-old Montmorency and 11-yr-old Balaton tart cherry trees at the NWMHRS, near Traverse City, MI. This experiment was designed to test the efficacy of copper sprays as a possible substitute for conventional fungicides as part of a reduced-risk, IPM program. Single rows of Montmorency alternated with single rows of Balaton, and sprays were applied concentrate (6X) at 50 gallons of water per acre with a 3-point FMC air blast sprayer. Treatments were replicated 4-times on 3-tree plots of each variety with buffer trees between each plot. Spray dates and growth stages were: 9 May (bloom); 17 May (early shuck split); 26 May (first cover); 5 Jun (second cover); 15 Jun (third cover) and 29 Jun (fourth cover and final spray). Cherry leaf spot infection periods and their level of severity were identified on 2 May (low); 11 May (low); 12 May (moderate); 25 May (high); 28 May (low); 31 May (high); 6 Jun (moderate); 18 Jun (high); 26 Jun (moderate); 28 Jun (moderate); 1 Jul (moderate); 9 Jul (moderate); 17 Jul (moderate); 26 Jul (low); 1 Aug (high); 9 Aug (low); 14 Aug (low); 23 Aug (moderate); 24 Aug (low) and 26 Aug (moderate) (courtesy of [www.enviroweather.com](http://www.enviroweather.com)). Harvest dates for the Balatons and Montmorency were 28 Jul and 21 Jul respectively. The summer was dry with only 19 days of precipitation from 1 Jun to 22 Aug that totaled 4.21 inches. As a result, cherry leaf spot developed late, and there was an unusually long interval of 54 days between the final spray and the evaluation on 15 Sep.

**Table 3.** Percent defoliation and percent cherry leaf spot infection where three amounts of copper were used: 3 lbs, 2 lbs, and 1 lb.

**Cherry leaf spot on 15 Sep**

Fungicide and rate of Product per acre	Timing	% defoliation		% infection	
		Mont.	Balaton	Mont.	Balaton
Bravo Ultrex 82.5% WDG 3 lb Cuprofix 40 3 lbs Elite 45WG 6 oz + Captan 50W 3 lb....	Petal fall; shuck split First; second; third cover Fourth cover.....	5.7 c*	3.2 c	55.0 d	56.6 bc
Bravo Ultrex 82.5% WDG 3 lb Cuprofix 40 2 lbs Elite 45WG 6 oz + Captan 50W 3 lb....	Petal fall; shuck split First; second; third cover Fourth cover.....	12.0 bc	3.2 c	68.4 c	50.3 bc
Bravo Ultrex 82.5% WDG 3 lb Cuprofix 40 1 lbs Elite 45WG 6 oz + Captan 50W 3 lb....	Petal fall; shuck split First; second; third cover Fourth cover.....	13.7 b	2.9 c	87.8 b	62.7 b
Bravo Ultrex 82.5% WDG 3 lb Pristine 10.5 oz Elite 45WG 6 oz + Captan 50W 3 lb....	Petal fall; shuck split First; third cover  Second; fourth cover.....	6.0 c	2.2 c	55.0 d	25.1 d
Bravo Ultrex 82.5% WDG 3 lb Pristine 10.5 oz Cuprofix 40 3 lbs Elite 45WG 6 oz + Captan 50W 3 lb....	Petal fall; shuck split First cover Second; third cover Fourth cover.....	12.8 bc	2.9 c	78.8 b	49.2 c
Bravo Ultrex 82.5% WDG 3 lb Pristine 10.5 oz Cuprofix 40 2 lbs Elite 45WG 6 oz + Captan 50W 3 lb....	Petal fall; shuck split First cover Second; third cover Fourth cover.....	11.5 bc	8.8 b	66.3 c	49.9 bc
Bravo Ultrex 82.5% WDG 3 lb Pristine 10.5 oz Cuprofix 40 1 lbs Elite 45WG 6 oz + Captan 50W 3 lb....	Petal fall; shuck split First cover Second; third cover Fourth cover.....	10.9 bc	3.4 c	62.4 cd	60.3 bc
Unsprayed control.....		68.7 a	67.8 a	100.0 a	100.0a

\* Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD ( $P \leq 0.05$ ).

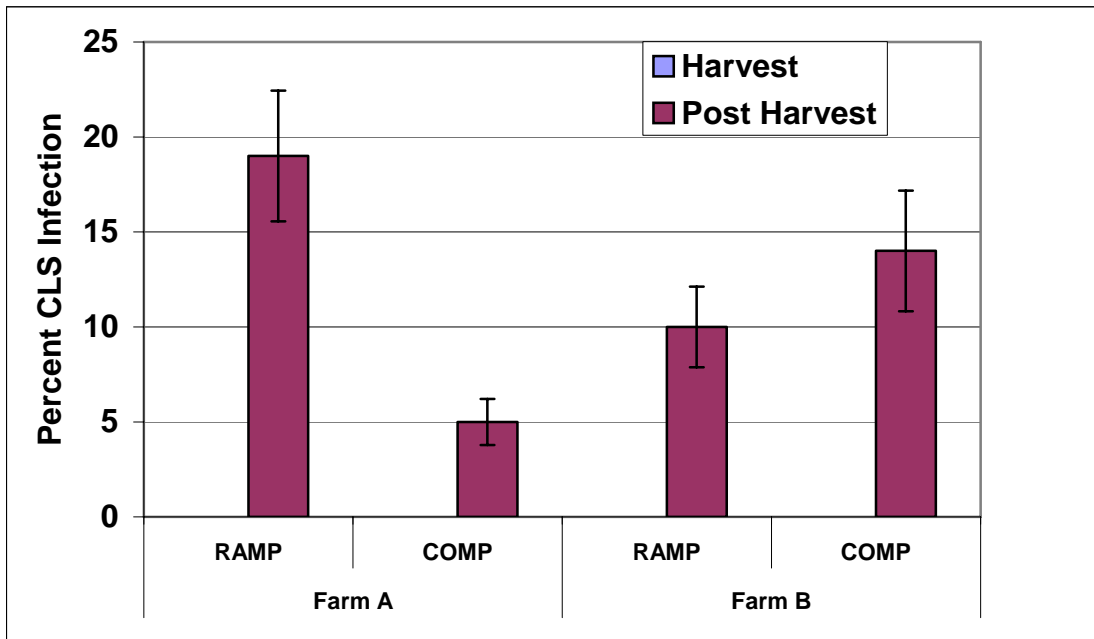
b. *Testing copper against CLS in field trials:* In order to determine if copper is efficacious against CLS at on-farm sites, four grower cooperators used copper in their RAMP blocks and did not use copper in comparison blocks. Copper sprays were not combined with sulfur. All copper sprays were combined with 3-6 lbs of lime at all farms.

**RAMP Protocol # 1: (Farms A and B)**

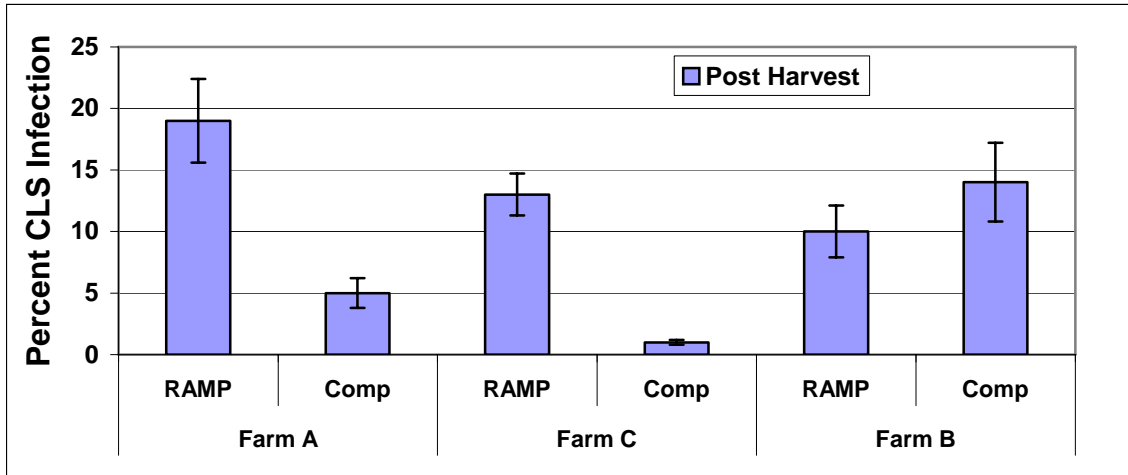
1<sup>st</sup> spray: Bravo, 2<sup>nd</sup> spray: Bravo, 1<sup>st</sup> cover: Flint, 2<sup>nd</sup> cover: 1.2 lb. Cu, 3<sup>rd</sup> cover: 1.2 lb. Cu, 4<sup>th</sup> cover: Elite (full rate) and Captan (3 lbs/acre), post harvest: Bravo

**Conventional Protocol # 1: (Farms A and B)**

1<sup>st</sup> spray: Bravo, 2<sup>nd</sup> spray: Bravo, 1<sup>st</sup> cover: Flint, 2<sup>nd</sup> cover: Pristine (15oz/acre), 4<sup>th</sup> cover: Indar (full rate) and Captan (3lb), post harvest: Bravo



**Figure 6.** Average percent cherry leaf spot infection in RAMP and Comparison blocks; RAMP programs incorporated two copper applications while the comparison program did not apply copper.



**Figure 7.** Average percent cherry leaf spot at three farms in RAMP program in NW Michigan. At harvest there was 0% CLS infection.

In copper field trials conducted at grower cooperator sites, copper did not seem to be as effective against CLS as in plots at the NWMHRS. However, there are potential reasons that could explain such differences. In one instance, Farm A grower was able to spray his comparison block with conventional fungicides prior to the rain, but the RAMP block, which had a copper application, was sprayed after the orchard received 0.25" of rain. Because the comparison block had fungicide on the leaves before the rain, this fungicide would provide better control of CLS in this block compared with the RAMP block. On Farm C, the grower applied his copper applications as 'full cover' sprays every two weeks while his comparison block was sprayed with an alternate row approach on a seven day interval. The difference in spray programs may account for the increased amount of CLS in the RAMP block.

- c. *Benefits of sulfur for disease and insects.* Many growers in northwest Michigan use sulfur to combat disease (powdery mildew and brown rot), although the material is often rated 'fair' against these pathogens. Growers also use sulfur because of its low cost, despite questionable benefit. Entomologists in the western U.S. discourage growers from using sulfur because it flares two spotted spider mites in their drier systems. To determine if sulfur impacts cherry diseases and mites, two growers applied copper in their RAMP blocks, but left the material out of their comparison blocks.

**RAMP Protocol # 3:**

The RAMP Block was divided into 5 acre halves with one half receiving copper applications without sulfur and the other 5 acres with copper **and** sulfur.

**RAMP Protocol # 3a: (Farm C)**

1<sup>st</sup> spray: Bravo, 2<sup>nd</sup> spray: Bravo, 1<sup>st</sup> cover: Flint, 2<sup>nd</sup> cover: 1.2 lb actual copper, 3<sup>rd</sup> cover: same as 2<sup>nd</sup>, 4<sup>th</sup> cover: Elite and Captan, post harvest: Bravo

**RAMP Protocol # 3b: (Farm C)**

1<sup>st</sup> spray: Bravo, 2<sup>nd</sup> spray: Bravo, 1<sup>st</sup> cover: Flint, 2<sup>nd</sup> cover: 1.2 lb actual copper + sulfur, 3<sup>rd</sup> cover: same as 2<sup>nd</sup> cover, 4<sup>th</sup> cover: Elite and Captan, post harvest: Bravo

**Comparison Protocol #1: (Farm A, B, C)**

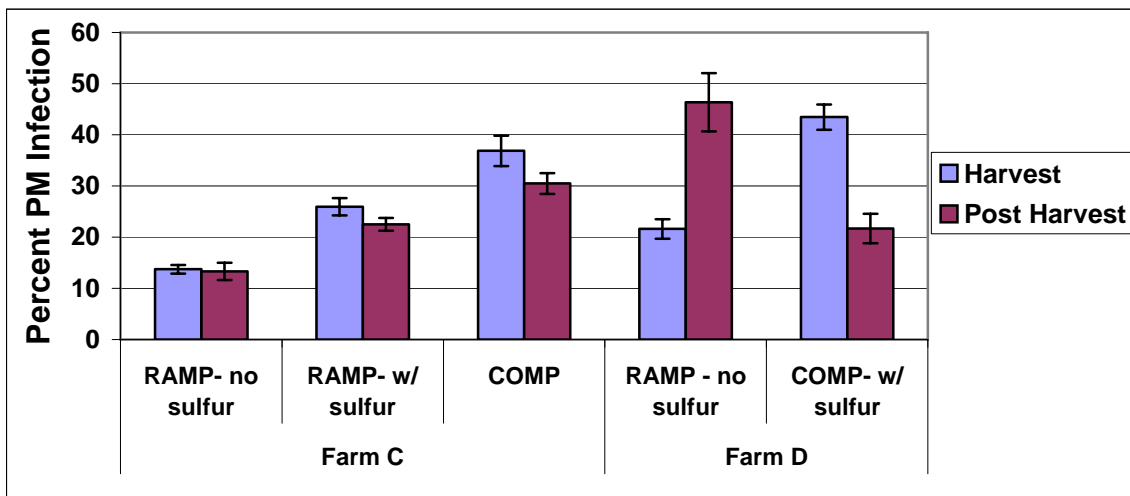
1<sup>st</sup> spray: Bravo, 2<sup>nd</sup> spray: Bravo, 1<sup>st</sup> cover: Flint, 3<sup>rd</sup> cover: Pristine, 4<sup>th</sup> cover: Indar and Captan, post harvest: Bravo

**RAMP Protocol #4: (Farm D)**

Copper sprays with no sulfur: 1<sup>st</sup> spray: Vanguard, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> cover: 1.2 actual lb copper/ac (+lime), 5<sup>th</sup> cover: Pristine, post harvest: 1.2 actual lb copper/ac

**Comparison Protocol # 2: (Farm D)**

Copper plus sulfur applications: 1<sup>st</sup> spray: Vanguard, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> cover: 1.2 actual lb copper/ac + sulfur, 5<sup>th</sup> cover: Pristine, post harvest: 1.2 actual lb copper/ac + sulfur

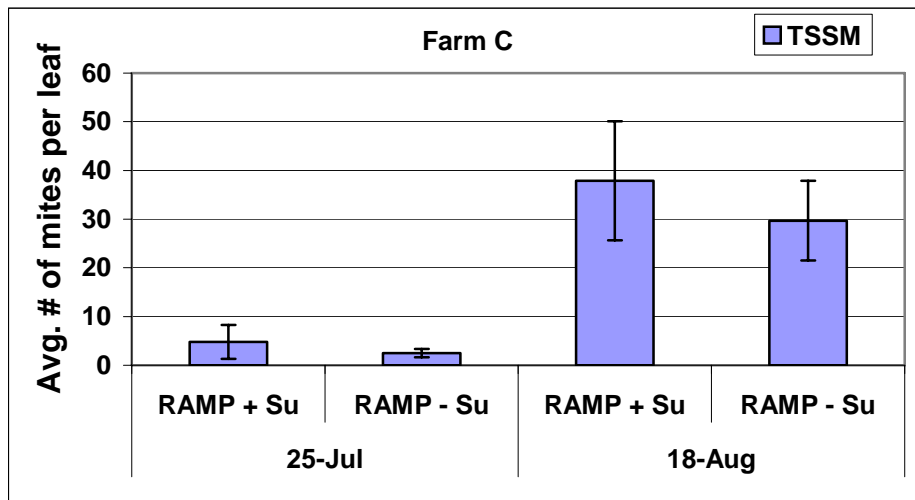


**Figure 8.** Average percent powdery mildew in RAMP and Comparison blocks where sulfur was incorporated into fungicide spray programs. Sulfur showed varying results against the powdery mildew pathogen; based on these studies we cannot say if sulfur has any affect on this disease.

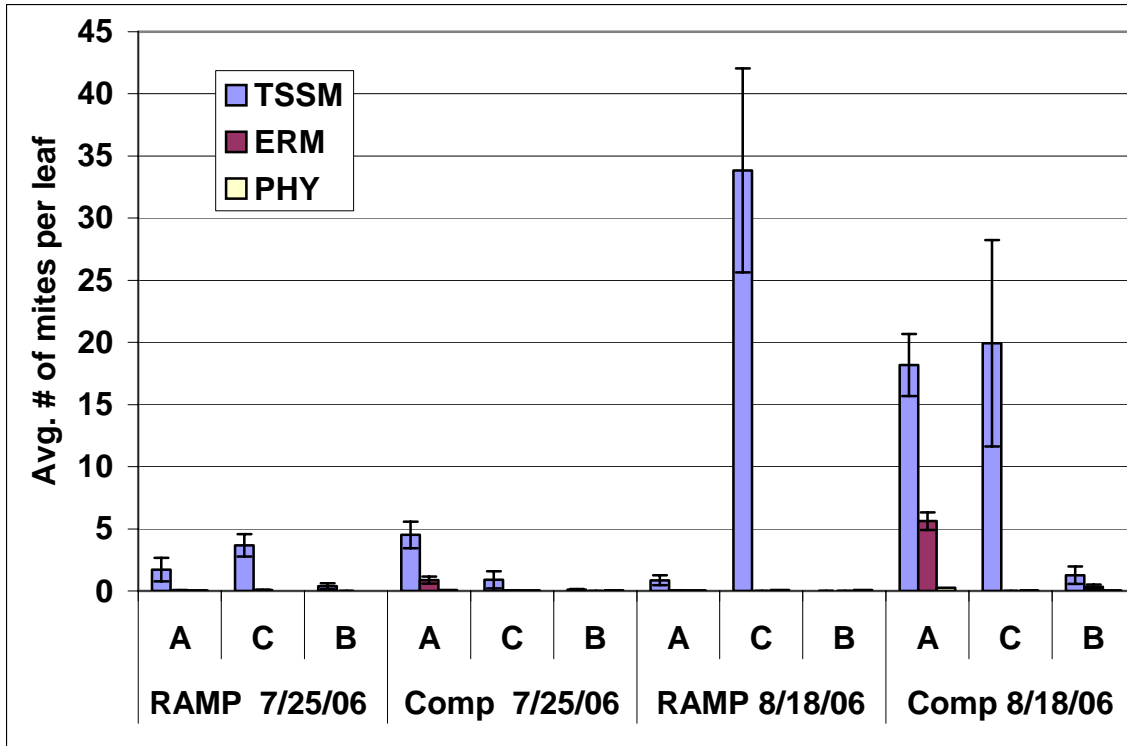
- d. Mites from both RAMP and Comparison blocks were compared two times throughout the season (7/25/06, 8/18/06) to determine copper's impact on plant parasitic mites, such as two-spotted spider mites (TSSM) and european red mites (ERM).

To determine the number of mites per leaf, we collected 25 leaves from 10 trees from the inner portion of the canopy, the middle of the canopy, and the outer portion. Trees were selected on a diagonal transect through the orchard. All leaves were placed into plastic bags

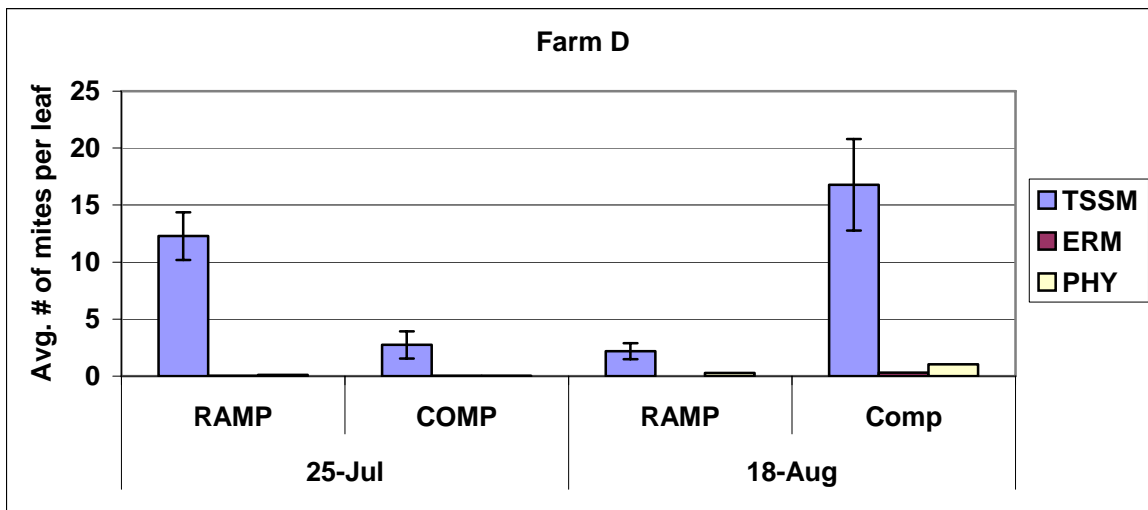
and held in the cooler until mites could be quantified. Leaves were brushed with a mite brush onto a plastic disk covered with film of oil. The number of mites on the radii of the disk were counted under a microscope, and this figure was multiplied by 0.1648 to determine the number of mites/leaf.



**Figure 9.** Average number of mites per leaf collected from Farm C where the RAMP block was divided in half and one side received sulfur and the other did not (recall RAMP Protocol #3a and #3b). On 18 August, there were slightly more mites/leaf in the half of the block with sulfur, but these differences are not significant.



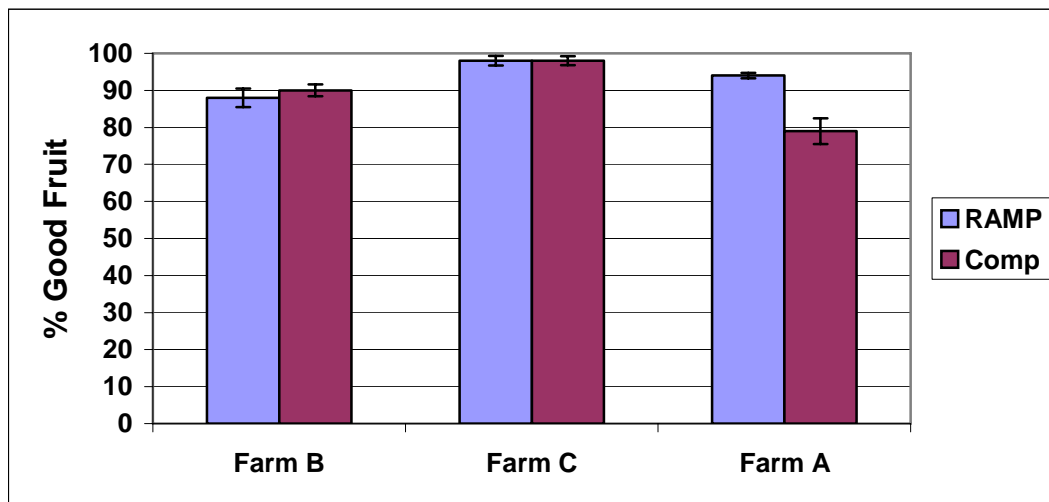
**Figure 10.** Average number of mites per leaf on two sample dates in RAMP and Comparison blocks; RAMP programs incorporated copper applications where Comparison blocks had no copper applications. There were no differences with numbers of mites and the amount of copper used. However, mite counts jumped in number at Farm C in both the RAMP and Comparison blocks and also in the Comparison block of Farm A.



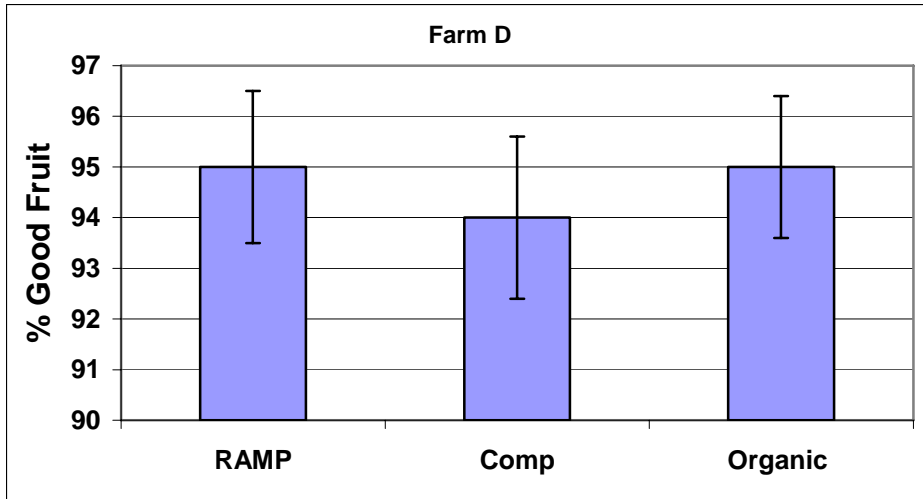
**Figure 11.** Average number of mites per leaf on two sample dates at Farm D in both the RAMP and Comparison blocks where copper was used at both sites. RAMP blocks had no sulfur sprays. Comparison block had 4 sulfur applications. At Farm D where sulfur was used in the Comparison blocks, we had high mite counts on 25 July in the RAMP block, which dropped off on 18 August. Mite numbers increased in the Comparison blocks at the August sample date.

e. We also investigated the use of copper to combat the problem of soft fruit. Tart cherries are harvested mechanically by tree shaking; when fruit drops from the tree onto the harvester canvas, this symptom of softness impacts fruit integrity. Soft fruit decompose during transport and clog cherry-pitting machines. Orchards that are prone to soft fruit problems often face lower profitability due to soft fruit downgrades at the processor. Losses to the cherry industry of as much as \$14.3 million in a single year have been attributed to soft fruit (Jim Nugent, personal observation). Horticultural investigations have targeted many aspects of tree physiology that potentially play a role in the occurrence of soft fruit; a proposed solution is to investigate the role of micronutrients, such as copper, that show promise in reducing occurrences of soft fruit. Unfortunately, marginally soft fruit is not observable until after the cherry has been mechanically harvested or physically handled, as firmness cannot be measured on the tree. In recent studies conducted in an organic tart cherry orchard, the percentage of good (non-soft) fruit was increased from about 70% from trees not treated with copper to over 90% in trees treated with copper (J.A. Flore, unpublished results).

One hundred fruit were collected per tree, 25 from each quadrant. The fruit were run through the Harvest Stimulator and caught in pans. Any fruit that did not land in the pans were discarded. Each fruit was tested for softness by rolling between the fingers and if the pit was detected, the cherry was considered "soft." Any fruit with cracking due to the Harvest Stimulator drop was considered split and added to the "soft" category. We did not detect any differences in soft fruit with copper use.



**Figure 12.** Percent good (non-soft) fruit at three farms, in RAMP (w/ Cu) and Comparison blocks (w/o Cu).



**Figure 13.** Percent good (non-soft) fruit at Farm D, where both the RAMP and Comparison blocks had four copper sprays applied and the Organic block had six copper sprays applied.

3. Weekly sampling: PC, CFF, and beneficials. Monitor beneficials in blocks with and without copper to determine if copper influences predators in cherry.

