FINAL REPORT
WTFRC Project # AE-01-50 **WSU Project # 8096**

Project title: Control of apple and pear pests with Surround

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Objectives:
1. Determine the optimum timing, rates and application frequency of Surround® against selected apple pests.
2. Determine the optimum timing, rates and application frequency of Surround® against selected pear pests.
3. Determine the negative effects of Surround® on natural enemies.
4. Determine if use of Surround® will increase damage thresholds for spider mites on pear, thus increasing the potential for biological control.

Significant findings:
- Surround WP reduced **codling moth** injury by approximately 50% in field trials. Concerns regarding the effect of Surround on integrated mite control still exist. Neonate codling moth larvae were deterred from entering the fruit by Surround WP residues in a laboratory bioassay, and in whole-fruit treatments the number of entries in Surround WP treated fruit were about 60% of the untreated fruit.
- In leaf disk bioassays Surround WP deterred colonization in choice tests. Only 9% of **pandemis leafroller** larvae chose the Surround WP treated disk over the untreated disk. In leaf disk bioassays with neonate **lacanobia fruitworm** larvae only 6% chose the Surround WP treated disk. Mortality was high for both species in Surround WP only arenas.
- Residual activity of Surround WP was evaluated in a field-aged bioassay. Surround WP showed 7 days of activity against **pandemis leafroller**. Against **lacanobia fruitworm**, Surround WP residues caused significant mortality through 14 days.
- Field trials with Surround WP against **lacanobia fruitworm** showed it to reduce foliage feeding and protect fruit when applied prior to egg hatch.
- Surround applied prior to oviposition of the **western tentiform leafminer** can reduce mines by 50%. However, there was a strong effect of Surround applications on ***Pnigalio flavipes,*** the key biological control agent of leafminer. It may be possible to avoid application activity periods of ***Pnigalio flavipes*** thus reducing the negative aspects of Surround on this beneficial insect.
- Surround has no apparent effect on **campylomma** nymphs or the prevention of damage by this pest on apple. This could be good news for pear where campylomma is considered a valuable early season predator of pear psylla.
- Surround effects on **spider mite**s were variable, having no effect in one test and reducing densities in another. Surround treatments also reduced predatory mite densities in field tests. There is evidence and concern that certain uses of Surround in apple orchards will stimulate spider mite populations through the suppression of **predatory mites**.
- Surround is a highly effective control for **white apple leafhopper**. One or, in the second generation, two applications provide a high level of suppression of this pest.
- Surround effects on **stink bugs** were variable, but in general it appears not to deter fruit injury in late summer from adults immigrating to orchards from native habitats.

- Surround WP was effective in control of **pear psylla** when used season-long, as well as prebloom or postbloom only in combination with conventional controls.
- Surround WP was potentially shown to act as a dispersal deterrent to adult overwintering **pear psylla**.
- **Recommendations in EB-0419** – One output of this research is the recommendations for pest control published in the Crop Protection Guide for Tree Fruits in Washington. Recommendations exist for codling moth, leafhoppers, lacanobia fruitworm and pear psylla.

Methods:
Methods have been provided in previous reports and due to the large number of studies summarized here it would be confusing to report all the methodologies used for various trials. Brief descriptions of methods are offered within the Result and Discussion section for each pest.

Results and discussion:

Codling moth apple dip bioassay: Surround was evaluated in direct choice tests for its ability to deter codling moth neonate larvae from penetrating a treated apple. Treatments were applied to apple at equivalent label rates for dilute applications. Apples treated with Surround were dipped, allowed to dry, then dipped again for a total of two applications. CM entries were evaluated at 10 days after treatment. Surround significantly deterred neonate CM from entering the treated half of the fruit. However, CM larvae found "holes" in the residues and were able to enter at these locations. The reduction in entries is about what is observed in field trials where multiple applications are made.

Surround bioassay

	Avg no. CM entries	
Test	Surround	Untreated
1-sprayed	1.54	1.96
2-dipped 3X	1.20	2.44
3-"painted"	0.86	2.07
3-controls	3.20	4.70
4-Sylwet	0.85	1.59
4-controls	2.50	4.60

Surround bioassay.

	CM entries at 10 days	
Evaluation	Surround	Untreated
Choice test		
Avg % on treated half (SE)	20.9 (1.2)	
No choice test		
Avg number of entries (SE)	3.3 (0.4)a	5.3 (0.3)b

Means in the same ROW followed by the same letter not significantly different (p=0.05, Student's paired t-test).

Codling moth field trials: Surround was evaluated for its ability to control CM when applied at different timing intervals (1999) or in a full season program (2000) targeting both first and second generation larvae. The experimental design was single-tree plots replicated four times in a randomized complete block. In 1999 trials, there was no advantage to applying treatments covering both oviposition or hatch periods, both having provided about 70% suppression of injury. In 2000 different timing regimes were again evaluated, oviposition versus hatch. There was no difference in

the level of suppression between the treatments, and they provided suppression of fruit damage, 50%, similar to tebufenozide (Confirm) but not as good as azinphosmethyl (Guthion).

1999 field trials.

Treatment	Rate (form./25 gal)	Timing/appl.#[1]	No. per 50 fruits Stings	Entries	% total injury
Surround	25 lbs	Oviposition/3	0.8a	3.0bc	7.6b
Surround	25 lbs	Hatch/3	0.8a	4.0b	9.6b
Surround	25 lbs	Ovip.+hatch/6	0.8a	2.0bc	5.6b
Untreated	NONE		0.8a	12.2a	26.0a

Means in the same column followed by the same letter not significantly different (p=0.05, Duncan's new MRT).
[1] Application dates for "oviposition timing" were 19, 27 Jul and 4 Aug and for the "hatch timing" were 12, 18 and 25 Aug. Applications for the "oviposition+hatch timing" were on all six dates. Treatments were applied only against the second generation.

2000 field trials.

Treatment	Rate (form. /A)	Avg % CM injury[1] 5 Jul Stings	5 Jul Entries	5 Jul Total	31 Aug Stings	31 Aug Entries	31 Aug Total
Surround WP	50 lb.	1.0 ab	1.5 b	2.5 b	3.3 abc	13.0 b	16.3 b
Surround WP	50 lb.	0.8 abc	0.3 b	1.0 bc	4.3 a	10.5 b	14.8 b
Guthion 50WP	2.0 lb.	0.0 c	0.0 b	0.0c	2.0 bc	1.3 d	3.3 d
Confirm 2SC + Orchex 796	21 fl oz 0.25% v/v	0.8 abc	1.0 b	1.8 bc	3.5 abc	8.5 bc	12.0 bc
Untreated		1.3 a	4.3 a	5.5 a	3.8 ab	25.5 a	29.3 a

[1] Means in the same column followed by the same letter are not significantly different (p=0.05, Student-Newman-Keuls).

Leafrollers

Apple leaf disk bioassay: Surround was evaluated in direct choice tests for its ability to deter leafroller neonate larvae from colonizing treated apple leaf disks. The treatment concentration was equivalent to recommended label rates for dilute applications. An untreated control was prepared using water plus the wetting agent only. Surround treatments deterred colonization in choice tests. Only 9% of pandemis leafroller larvae were found on the Surround WP treated disk over the untreated disk.

Field-aged residues: Using a leaf-disk bioassay, Surround® WP was evaluated for residual effects on pandemis leafroller neonate larvae. The test was designed as a direct choice test between treated and untreated leaf disks. The treatments were applied with a handgun sprayer simulating a dilute spray of approximately 300 gal/acre. Surround was applied twice, allowing a drying time between successive applications. Results were similar to those discovered in the leaf disk bioassays. Surround deterred pandemis leafroller from colonizing treated leaf disks for 7 days but the effect did not last through 14 days.

Field-aged residues – pandemis leafroller.

	Avg percentages		
	1 DAT	7 DAT	14 DAT
Choice test – 5 day exposure			
% on Surround (SE)	33.3 (3.3)	30.0 (10.0)	50.0 (0.0)
Controls – 10 day exposure			
% mortality on Surround	37.8b	42.2b	11.1a

Means in the same column followed by the same letter not significantly different (p=0.05, Student's paired t-test). Any mean followed by the letter 'a' not significantly different than the untreated control.

Lacanobia fruitworm

Apple leaf disk bioassay: Surround was evaluated in direct choice tests for its ability to deter lacanobia fruitworm neonate larvae from colonizing treated apple leaf disks. The treatment concentration was equivalent to recommended label rates for dilute applications. Surround treatments deterred colonization in choice tests. Only 6% were found on the Surround WP treated disk. Where there was no choice there was 100% mortality of lacanobia fruitworm larvae.

Field-aged residues: Using a leaf-disk bioassay, Surround WP was evaluated for residual effects on lacanobia fruitworm neonate larvae using methods described under leafrollers above. Surround deterred lacanobia fruitworm from colonizing treated leaf disks, and the effect lasted at least 14 days. Surround caused mortality significantly higher than the untreated control through 14 days for lacanobia fruitworm.

Field-aged residues – lacanobia fruitworm.

	Avg percentages		
	1 DAT	7 DAT	14 DAT
Choice test – 5 day exposure			
% on Surround (SE)	13.3 (3.3)	30.0 (15.3)	33.3 (8.8)
Controls – 10 day exposure			
% mortality on Surround	46.1b	28.1b	34.5b

Means in the same column followed by the same letter not significantly different (p=0.05, Student's paired t-test). Any mean followed by the letter 'a' not significantly different than the untreated control.

Field tests with Surround: One-third acre plots were replicated three times at a rate of 50 lbs/100 gal water plus 1 pt M-03/100 gal. Surround provided suppression of lacanobia fruitworm larval feeding and larval populations and appeared to protect fruit from injury.

Surround vs. *Lacanobia subjuncta* field trial, 1999.

			Posttreatment averages			
			19 Jul		9 Aug	
Treatment	Rate/a	Timing	lvs/20 trays	% inf. shoots	% fruit injury [1]	% inf. shoots
Surround	50 lbs.	Oviposition	3.3b	6.8ab	0.0a	30.0b
Surround	50 lbs.	Hatch	1.0a	2.8a	0.0a	11.3ab
Surround	50 lbs.	Ovi + hatch	0.3a	1.2a	0.0a	6.7a
Untreated			4.0b	16.8b	0.3a	99.7c

Means in the same column followed by the same letter not significantly different (Fisher's Protected LSD, p=0.05).

Leafminer: Surround was tested in both laboratory and field formats against western tentiform leafminer. In a caged potted tree experiment, Surround deposits on the leaves did not significantly deter leafminer oviposition in relation to the untreated check. However, in subsequent greenhouse bioassays Surround caused about 50% suppression of mines when applied prior to adult oviposition. In a field test, different strategies were evaluated to try to minimize the possible impact of Surround on the primary leafminer parasitoid, *Pnigalio flavipes*. There was significantly higher parasitism of the first generation when early season Surround treatments were adjusted to avoid the period of parasitoid activity; however, no treatment differences were apparent by the second generation.

Stink bugs: Surround was applied to a number of experimental blocks in areas of historically high stink bug pressure. Each replicate consisted of 0.5 acres of orchard, with Surround-treated and untreated control blocks immediately adjacent to one another and bordering rangeland. Surround applications commenced in late July, and there was a total of five applications applied, at 2-week intervals. Results from these trials were highly variable. In some orchards, stink bug damage was slightly reduced in the Surround treatments; in one site injury was higher in the Surround-treated plot, and in the rest of the sites there was no difference between Surround-treated and untreated plots.

Leafhopper: In first-year tests, both the single and triple applications of Surround provided suppression of leafhopper nymphs (with better control in the triple application), but the residual population was higher than with conventional materials. In the second year of testing, Surround gave good suppression of leafhopper nymphs during both the first and second generations. A second application during the second generation improved control of later-hatching nymphs but only slightly.

Mites: In the first test against mites, treatments were applied with a multi-tank PTO airblast sprayer calibrated to deliver 100 gpa. The treatments were applied on 4 Aug, 1999. In this test Surround and Orchex provided very little suppression of mites. In a subsequent test Surround gave reasonable mite suppression where there was a high initial mite population (e.g. 20-60 mites/leaf). While the activity was slower than conventional miticides, populations were below 1 mite/leaf by nine days after application. The predatory mite population in this test was high initially (0.2-0.9 mites/leaf). The Surround application significantly reduced the predatory mite numbers in relation to the check (48 h posttreatment). In behavioral bioassays on detached leaves, mites (*Tetranychus urticae*) tended to avoid Surround deposits where there was a choice of treated and untreated leaf sections.

Campylomma: This material was tested against the spring generation of nymphs that cause damage to apple fruitlets around bloom. Surround had no apparent effect on nymphs, nor did it prevent fruit damage from occurring.

Pear psylla: Surround has become one of the most important pear psylla controls in north-central Washington. Surround treatments combined with conventional psylla management programs have shown that this product is better used prebloom compared to the postbloom period. Results from work on pear psylla are reported in a separate proposal by Dr. Dunley and will be presented at the pear research review.

Budget:

Proposed project duration: 3 years and this represents a final report
Current year request: 0

Year	**Year 1 (1999)**	**Year 2 (2000)**	**Year 3 (2001)**	**Total 1999-2001**
Total	19,460	22,135	22,348	**63,943**

Item	**Year 1 (1999)**	**Year 2 (2000)**	**Year 3 (2001)**	**Totals 1999-2001**
Salaries[1]	8,391	9,353	9,444	27,188
Benefits (30%)	2,949	2,806	2,928	8,683
Wages	7,000	8,600	8,600	24,200
Benefits (16%)	1,120	1,376	1,376	3,872
Equipment	0	0	0	0
Supplies	0	0	0	0
Travel	0	0	0	0
Miscellaneous	0	0	0	0
Total	19,460	22,135	22,348	**63,943**