Fire Blight Studies Investigating the Effects of Surround® WP and Shredded Cuttings

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Problem and its significance:

In recent years, codling moth insecticide programs have increasingly relied on pheromone mating disruption and the use of softer, pest-specific insecticides. The discontinued use of Guthion in some orchards has led to reduced pest pressure from some pests, such as mites and psylla, but it has also led to increases in secondary pests, such as leafrollers, leaf miners, and pear slugs, and possibly other non-pest insects, including predators and flies.

Along with the softer insecticide programs in recent years have come fairly serious outbreaks of fire blight, particularly in May and June, after antibiotic sprays have ceased. Many growers and PCAs have questioned whether the increased presence of flies and other flying insects as a result of softer insecticide programs has led to increased potential for the spread of blight.

Surround® WP (kaolin clay) is used by several organic growers for control of codling moth and other insect pests. It works in part by repelling insects by making the surface of the fruit and foliage less hospitable. Surround was shown to strongly repel glassy-winged sharpshooter (GWSS) nymphs and adults on lemon trees in the San Joaquin Valley (Puterka et al. 2003). In a related field study conducted in three vineyards, Surround WP was as effective as dimethoate and methomyl in the reduction of GWSS adult density and oviposition (Puterka et al. 2003). Laboratory and field trials conducted in Israel showed almost complete protection against infestation by medfly with the use of Surround WP (Mazor et al. 2003). In experiments conducted in Italy on Abate Fetel pear trees, Surround was applied before or at the onset of egg laying during overwintering (Pasqualini et al. 2002). No eggs were found on the treated plants and no nymphs were observed inside the flowers of the kaolin-treated plants. In a single-tree trial, 9 applications of Surround completely controlled codling moth in an organic mating-disrupted orchard, but European red mites significantly increased (Elkins 2003). In one study, however, Surround applications resulted in undesirable residues in the basin and in the cavity of harvested fruit that were not satisfactorily removed by brushing on a commercial packing line (Schupp et al., 2002). This drawback could be reduced by making applications relatively early in the season.

The conventional strategy for dealing with fire blight cuttings was to haul them out of the orchard and burn them. University of California recommends, “Burn prunings so that they do not become a source of new infections” (Ohlendorf 1999). However, stricter air pollution controls may reduce growers’ ability to burn prunings. Senate Bill 700, recently signed into law, will impose more stringent air quality standards, probably phasing out open field burning of tree crop prunings by Jan. 1, 2006. Also, to reduce costs, many growers in the Sacramento River district currently shred the blight cuttings and leave them in the row middles. Furthermore, in some severe blight years, removal and burning of the cuttings is virtually impossible due to the huge numbers of cut branches. The concern with shredding cuttings is that rains and sprinkler irrigation may re-activate the strikes and cankers, and wind or insects may move the bacteria to newly opened flowers or tender young shoots. However, no obvious blight epidemics have been observed as a result of shredding.

It appears very possible that the major risk associated with shredding cuttings would be to aerosolize the pathogen, *Erwinia amylovora*, allowing it to move to nearby flowers or shoots that had previously remained free of infestation. Surprisingly, we find no evidence that this phenomenon has been addressed for fire blight disease. In related work, scientists in Georgia found that when tomato plants infected with *Pseudomonas syringae* pv. tomato were shredded in the process of pruning transplants, high numbers of cells of the pathogen were released form the field as aerosols (McInnes et al. 1988). They reported that such sources of inoculum could be important in the epidemiology of this disease on tomato. Given that *E. amylovora* has been reported to survive for extended periods of time in aerosols (Southey and Harper 1971), it seems possible that inoculum released by chopping newly-cut infected shoots of pear could supply airborne inoculum that could travel to nearby flowers and shoots. While a distinct possibility, the practical importance of such an event will be addressed in our proposed work.

The purposes of this study were to test the concept that increasing numbers of insects in orchards where “soft” insecticide programs are used, are causing greater numbers of blight strikes, and to determine whether blight cuttings shredded in the orchard increase the potential for new blight strikes.

Objectives

1. To determine the effects of broad spectrum and repellent insecticides on insect activity and fire blight.
2. To evaluate the blight incidence and movement of airborne E. amylovora bacteria from cuttings shredded in the orchard.

Objective 1. To determine the effects of broad spectrum and repellent insecticides on insect activity and fire blight.

Methods and Materials

Surround vs. No Surround Trial. Three orchards were used to test Surround vs. no Surround on insect activity and fire blight. Surround was applied to single 10-acre plots in two of the orchards. In the third orchard, it was applied in two 5-acre blocks since the rows were short and the blocks were nearly square. Therefore, four plots were treated with Surround, and these plots were compared side-by-side with plots not treated with Surround. One tank of Surround was applied with antibiotic sprays in alternate rows. A few days later, another tank of product at the same rate was applied to the other rows in the same plot. Therefore, a complete application was spread over two alternate-row sprays. The goal was to apply Surround at 50 lb per acre + Breakthru in the first application, and to make two additional applications at 25 lb without Breakthru. The actual applications are shown in Table 1.

Table 1. Rate of Surround and Breakthru used in the three orchards used in this trial.

	Rate of Surround per Acre (Alternate Rows)		
Date	Orchard 1	Orchard 2	Orchard 3
Apr 5-8	50 lb + 10 oz Breakthru	50 lb + 10 oz Breakthru	25 lb
Apr 14-16	25 lb	25 lb	25 lb
Apr 26-May 1	25 lb	--	25 lb

Greater vs. Reduced OP. Two different orchards were used to compare insect activity and blight strikes with side-by-side comparisons of different insecticide programs. Each block was about 20 to 40 acres in size. Timing of insecticide treatments is shown in Table 2.

Table 2. Insecticide sprays used in side-by-side blocks in two orchards.

Orchard 1				**Orchard 2**			
Greater OP		**Reduced OP**		**Greater OP**		**Reduced OP**	
Guthion	Apr 15	--	--	Guthion	Apr 16	Intrepid	Apr 23
Imidan	Jun 1	Imidan	Jun 1	Imidan	May 11	--	--
Intrepid/ Warrior	Jun 26	Intrepid/ Warrior	Jun 26	--	--	--	--

Five yellow sticky flytraps, each with a BioLure Fruit Fly (putrescine) lure attached, were placed at eye level at three different time periods near the center of each plot in both of the trials. Fifty shoot tips in each plot were examined in the spring to determine the infestation level of *Campylomma verbasci* nymphs. Blight strikes were counted on 50 trees near the center of each plot, however, there was only one period (late May) when blight was present.

Results

Surround vs. No Surround Trial. The number of Campylomma nymphs were not significantly different between Surround (Avg. = 17 per 50 shoots) and no Surround (Avg. = 16 per 50 shoots) plots.

The number of flies trapped in three time periods is shown in Table 3. Flies in the family Muscidae include many common flies, most of which resemble houseflies. Tachinids include many larger flies that also resemble houseflies, but they also include smaller flies, and virtually all larvae are parasitic on other insects. Adults of flies in both families are likely to feed on nectar in flowers, as well as on fire blight ooze. Syrphids are beneficial insects that resemble bees, and adults also use nectar. Gnats are tiny flies. There were few differences in the number of trapped flies between plots sprayed vs. those not sprayed with Surround (Table 3). The only significant difference was the greater number of Tachinidae flies where Surround was used compared to where it was not. Very few syrphids were found overall, whereas large numbers of gnats were trapped.

Only one minor period of blight occurred in these orchards in late May, when significantly more strikes were found in blocks not treated with Surround compared to Surround-treated blocks (8.8 vs. 4.8 strikes per 50 trees, respectively).

Table 3. Number of flies trapped in plots treated with Surround vs. those not treated with Surround.

	Treatment	Muscidae	Tachinidae	Syrphid	Gnats
Apr 10 – Apr 28	**Surround**	14.1 a	11.8 a	0.1 a	856 a
	No Surround	13.6 a	8.7 a	0.3 a	696 a
Apr 29 – May 15	**Surround**	16.9 a	11.3 a	1.8 a	616 a
	No Surround	15.8 a	8.0 a	1.7 a	632 a
May 15 – June 10	**Surround**	4.9 a	17.4 a	1.2 a	1120 a
	No Surround	5.9 a	12.0 b	1.1 a	1008 a
MEAN	**Surround**	12.2 a	13.7 a	1.1 a	864 a
	No Surround	11.8 a	9.9 b	0.8 a	779 a

Means with the same letter in each paired comparison are not significantly different (Fisher's LSD, $P<0.05$).

Greater vs. Reduced OP. Slightly more Campylomma nymphs were found in reduced OP blocks (Avg. = 24 per 50 shoots) than greater OP blocks (Avg. = 20 per 50 shoots).

Some trends were apparent in flytrap counts in greater OP vs. reduced OP blocks. In both orchards and both time periods, more Muscidae flies were trapped in the reduced OP blocks (Table 4). In the May 15 – June 10 period, more Tachinidae flies were also caught in the reduced OP blocks, however, in the April 29 – May 15 period, more Tachinidae flies were trapped in the greater OP blocks.

The mean number of blight strikes found in late May in the greater OP vs. reduced OP blocks was identical (7.5 strikes per 50 trees).

Discussion

Neither Surround nor organophosphates appear to have a substantial affect on insects. In most cases, slightly more flies were trapped in the Surround blocks than where Surround was not used. This phenomenon may have resulted from less attractive foliage due to the presence of clay particles, and therefore relatively greater attraction to the yellow sticky traps. However, this effect was not measured.

Organophosphates had mixed effects on fly populations. The OPs generally reduced Muscidae fly populations and reduced Tachinidae flies in late spring, but more Tachinidae flies were found in mid spring. Interestingly, the orchard with Guthion/Imidan sprays vs. Intrepid alone (Orchard 2) had relatively small numerical differences, and in some cases more flies were found where Intrepid was used. It appears that flies either have built up Guthion resistant or new flies simply emerge after sprays are applied.

Although the incidence of fire blight was not substantial, less blight was found in blocks that were treated with Surround. However, it is not possible to say conclusively whether or not Surround would reduce blight incidence in years with greater blight pressure.

Table 4. Number of flies trapped in plots treated with greater amounts of organophosphate insecticides (OPs) vs. those treated with reduced OPs.

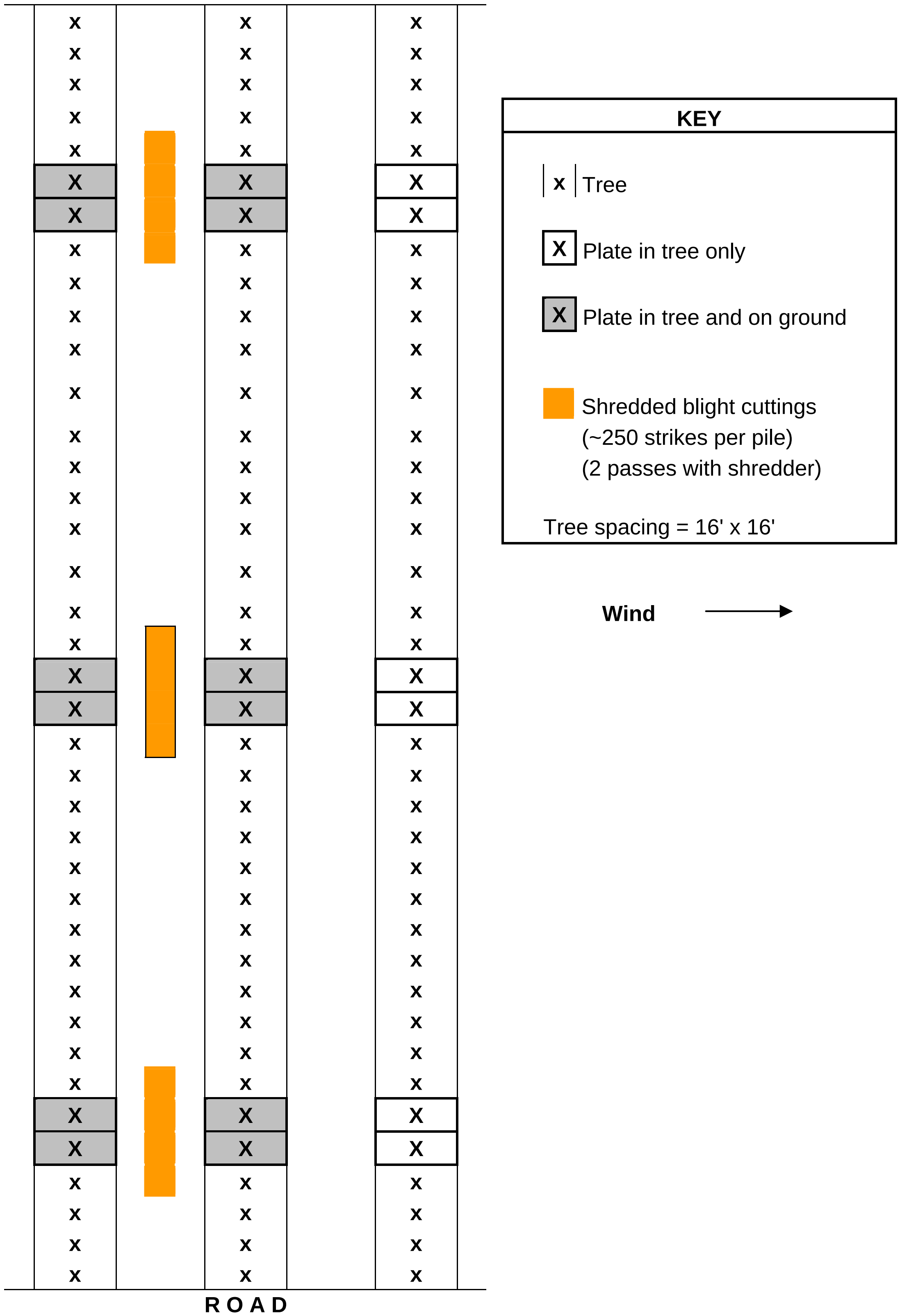
Time Period	Treatment	Muscidae	Tachinidae	Syrphid	Gnats
ORCHARD 1					
Apr 29 – May 15	**Greater OP**	7.8	21.6	2.0	528
	Reduced OP	10.0	13.0	2.0	720
May 15 – June 10	**Greater OP**	1.4	4.8	0.6	864
	Reduced OP	4.4	11.2	0.6	960
ORCHARD 2					
Apr 29 – May 15	**Greater OP**	13.6	6.0	2.0	352
	Reduced OP	20.2	1.4	0.6	208
May 15 – Jun 10	**Greater OP**	1.4	2.2	0.0	608
	Reduced OP	9.0	4.6	0.0	464
MEAN – BOTH ORCHARDS					
Apr 29 – May 15	**Greater OP**	10.7 a	13.8 a	2.0 a	440 a
	Reduced OP	15.1 a	7.2 b	1.3 a	464 a
May 15 – Jun 10	**Greater OP**	1.4 b	3.5 b	0.3 a	736 a
	Reduced OP	6.7 a	7.9 a	0.3 a	712 a

Means with the same letter in each paired comparison are not significantly different (Fisher's LSD, P<0.05).

Objective 2. To evaluate the blight incidence and movement of airborne* E. amylovora *bacteria from cuttings shredded in the orchard.

First Trial. The blight shredding trial was conducted in a Bartlett pear orchard on Randall Island. The orchard was planted in the 1930s at a spacing of 16 x 16 ft. On May 26, 2004, two flatbeds full of blight cuttings were spread in an alley between two tree rows. The cuttings had been removed from trees in an experimental block within a day of spreading and the leaves on the cuttings were still green and stout. The cuttings were placed in three piles in the alley that were each about 6 ft. wide by 1.0 to 1.5' tall, a distance of 4 trees (64 ft.). Each pile had about 250 blighted branches per pile. A flail chopper was used to shred the cuttings in two passes in mid-morning. The temperature at the time of shredding was about 69 F and the wind speed was about 3 mph, blowing perpendicular to the row direction (fig. 1).

Figure 1. Layout of the first blight shredding trial, 5/26/04.



In order to determine if *E. amylovora* spores aerosolize or move with dust from shredding, deposition Petri plates were placed in trees and on the ground before the shredding was done. Two plates were placed in each of 10 locations around each pile: the media of one plate was selective for *E. amylovora.* The medium used, Modified Miller-Schroth medium, inhibits the growth of many but not all bacteria other than *E. amylovora*. *E. amylovora*, however, does produce distinctive orange mucoid colonies that enable them to be distinguished from other bacteria that will grow on the plates. The other medium used, Kings Medium B is a general, non-selective medium on which most bacteria are expected to grow. One set of plates was placed on the ground near the trunk of each of the two middle trees in the two rows adjacent to the cuttings (see fig. 1), and one set was placed in a crotch of these trees about 4 to 5 ft. high and in two other downwind trees, for a total of 10 locations. All plates placed in the trees were opened just before shredding, and all plates placed on the ground were opened just after each pile was shredded because of excessive debris. All plates were left open for about 30 min. and then closed, collected, placed in a cooler, and sent immediately to UC Berkeley for incubation and counting of colonies.

At the same time that the above plates were opened, two plates were placed in trees that were 8 rows upwind of the shredded piles, and two plates were placed on the ground near these trees.

Two hours after shredding, the sprinklers were turned on for nearly 24 hours for a regularly scheduled irrigation. Within two hours of irrigation shutoff, selective media plates were again placed in the same locations as the day before. Plates were opened for 30 min. and then closed and taken immediately to UC Berkeley.

Blight strikes in adjacent trees were counted about 2 weeks after shredding.

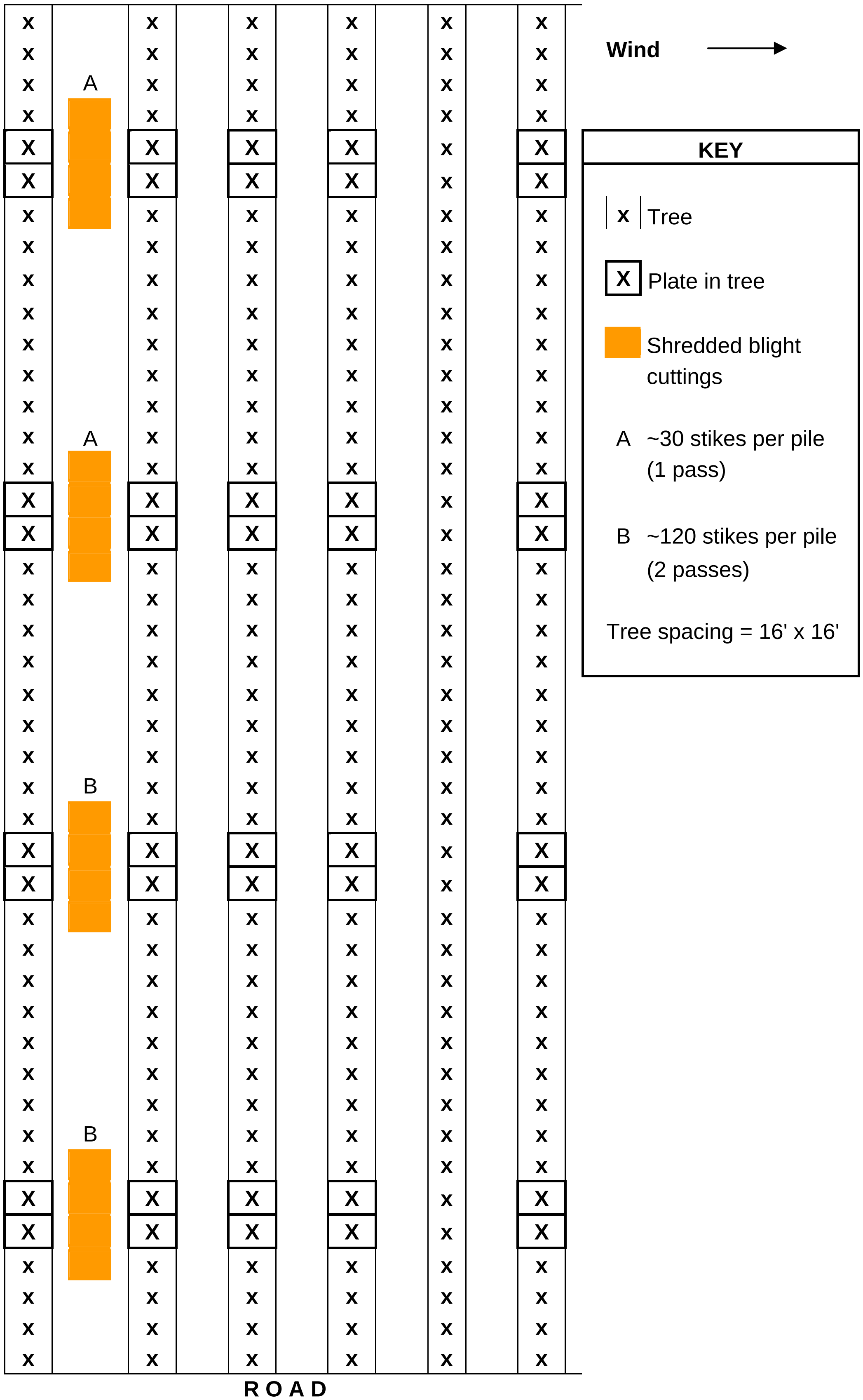
Second Trial. The same orchard block was used for the second trial, but in a different area from the first trial. On June 9, 2004, one flatbed full of blight cuttings was spread in an alley between two tree rows. The cuttings had been removed from trees in an experimental block on the same day. The cuttings were placed in four piles in the alley: (A) two piles contained about 120 strikes per pile, and (B) two piles contained about 30 strikes per pile (fig. 2). Each pile was about 6 ft. wide and extended a distance of 4 trees (64 ft.). A flail chopper was used to shred the cuttings in two passes for the two larger piles (A), and only one pass for the two smaller piles (B). The temperature was about 77 F and the wind speed was about 4 mph, blowing perpendicular to the row direction (fig. 2).

Unlike the first trial, deposition plates were placed in trees only (not on the ground) before shredding. One plate, containing Miller-Schroth media selective for *E. amylovora*, was placed in each of 12 locations in the vicinity of each pile (fig. 2). The plates were in a tree crotch about 4 to 5 ft. high. All plates were opened just before shredding, and were left open for about 30 min. and then closed, collected, and sent immediately to UC Berkeley for incubation and counting of colonies.

At the same time that the above plates were opened, one plate was placed in each of 4 alternating trees that were 8 rows upwind of the shredded piles.

Very few blight strikes occurred after this trial, so counting of strikes could not be done.

Figure 2. Layout of the second blight shredding trial, 6/9/04.



Results

First Trial. Fig. 3 shows the plot layout around a single pile, along with the average number of colonies per plate (average of the two plates in adjacent trees or on the ground). The plates containing non-selective Kings B medium recovered very high numbers of a variety of bacteria, most of which were probably soil-borne bacteria dispersed as dust during the chopping operation. There were such large numbers of total bacteria on the non-selective medium that it was not possible to see the presumably low numbers of *E. amylovora* on the plates, and hence no estimates of *E. amylovora* were made on these plates. Counts from selective media plates showed that numbers of *E. amylovora* per plate were greater downwind than upwind. Downwind trees had more than double the number of colonies and total bacteria per plate than the two upwind trees adjacent to the shredded piles. Plates in untreated control area trees had an average of only one *E. amylovora* colony.

Plates placed in trees and on the ground the next day (after 24 hr. irrigation set) recovered almost no *E. amylovora* and very few total bacteria (data not shown).

Although the mean number of blight strikes per tree in the untreated area (upwind) was numerically greater than that of areas near the blight pile, there were no significant differences among treatments (Table 5).

Figure 3. Mean number of *E. amylovora* colonies (first number) and mean number of non-*E.a.* bacteria per plate (in parentheses) after shredding on May 26, 2004. Each number represents the average of 2 plates (one in each of two adjacent trees or on the ground near the trees) and 3 replications (3 piles).

Gr. *= Plate on ground,* ***Tr.*** *= Plate in tree*

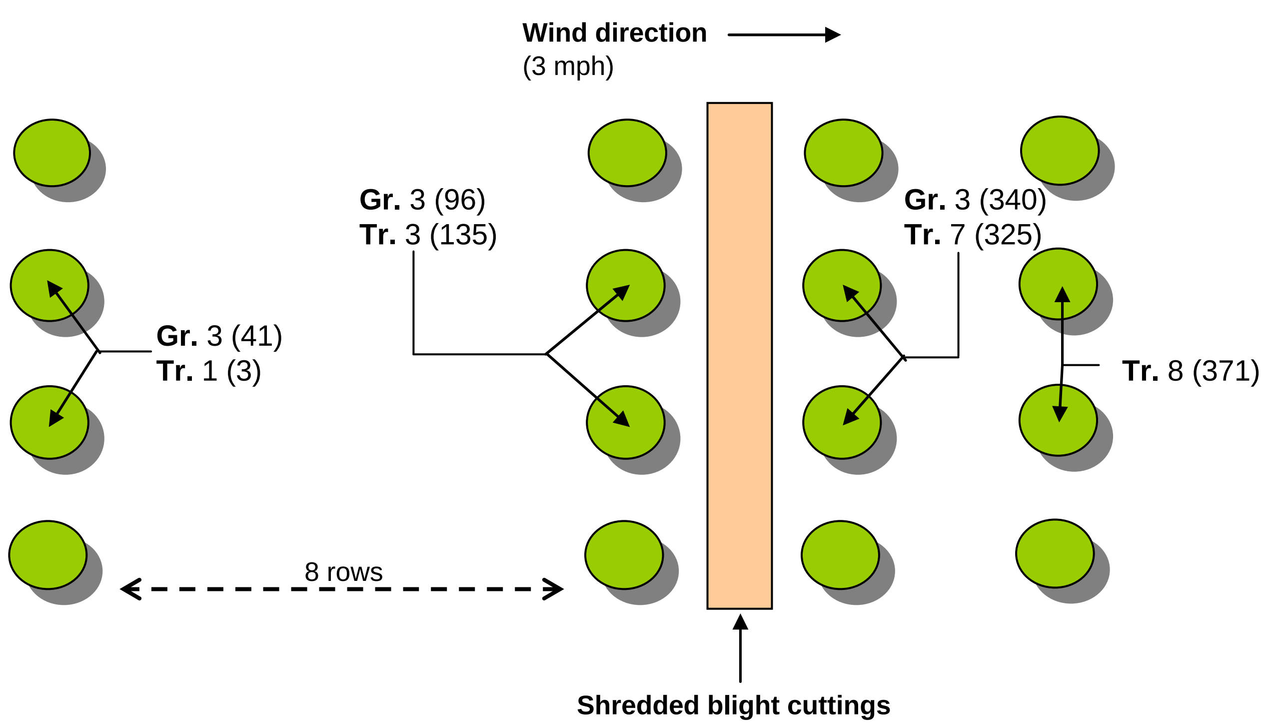


Table 5. Mean number of blight strikes in trees that were upwind and downwind from blight piles.

	Mean No. of Strikes
Downwind	
First 4 trees	1.4 a
Second 4 trees	1.5 a
Third 4 trees	1.1 a
Upwind	
First 4 trees	1.9 a
4 trees, 8 rows upwind	0.8 a

Second Trial. As might be expected, deposition plates placed in trees downwind of the larger piles recovered substantially more *E. amylovora* cells and total bacteria than those of the small piles (fig. 4). Also, the plume of dust and bacteria moved at least three rows downwind, and the counts began to taper off only in the fifth downwind row. Plates in trees upwind but adjacent to the shredded cuttings had low *E. amylovora* counts, and none were found in either the next row upwind or untreated control trees.

Discussion

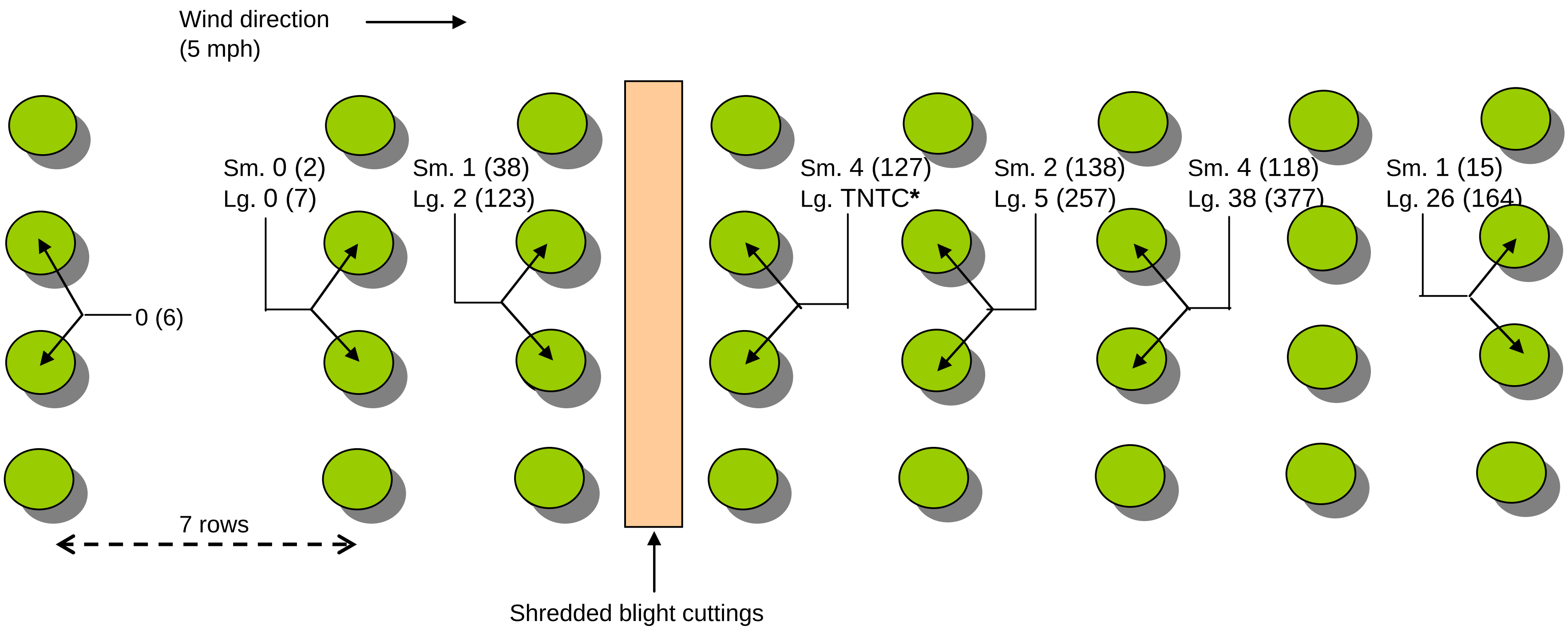
The results of this study show that shredding blight cuttings clearly aerosolizes *E. amylovora* bacteria. The dust and bacteria move with wind at least several rows downwind of the shredded pile, potentially contaminating open flowers and/or tender young shoots. The movement of airborne bacteria through the orchard does pose a potential threat, especially if shredding occurs when substantial numbers of flowers (mainly rattails) are still open and weather conditions are optimal.

Several factors must, however, be considered in addressing the potential risk of aerosolized inoculum of *E. amylovora*. Whereas we easily detected aerosolized inoculum of this pathogen in this study, the relative numbers of cells recovered on deposition Petri dished was relatively small. Generally we recovered only about 10 *E. amylovora* cells per Petri dish. The area of the Petri Dish on which *E. amylovora* was recovered is very large compared to that of the stigma of pear flowers, which is the normal and most susceptible site for infection of pear. It is also probably safe to assume that little airborne dispersal of *E. amylovora* occurred after the shredding event, and hence most of the deposition of *E. amylovora* that was going to occur with the chopping operation was detected by our deposition Petri plates that were open for 30 minutes during and after the operation. Thus the recovery of about 10 *E. amylovora* cells per Petri dish would suggest that very few of the pear flowers that were open during the shredding operation had received even a single *E. amylovora* cell.

Putting these facts in perspective, if there were sufficient blight trimmings to necessitate their disposal by shredding, then most trees in the orchard would likely have had several fire blight strikes, and thus there would most likely be considerable amounts of *E. amylovora* inoculum that was already present in the orchard, mostly in flowers. The dispersal of this inoculum by flower-visiting insects most likely would result in many flowers having at least a few cells of *E. amylovora*. Thus, weather conditions that are conducive to further multiplication of this natural inoculum would most likely be far more important in enabling new blight strikes to occur than the small increase in inoculum in flowers that would result from the shredding operation.

Figure 4. Mean number of E. amylovora colonies (first number) and mean number of non-E.a. bacteria per plate (in parentheses) after shredding on June 9, 2004. Each number represents the average of one plate in each of two adjacent trees and 2 replications (2 piles).

Sm. = *Small piles (n=2),* ***Lg.*** *= Large piles (n=2)*



*TNTC - Too numerous to count

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