cide applications. As a pheromone-treated field in 1987, it received one insecticide application. *Bacillus thuringiensis*, applied for hornworm and beet armyworm control, was the only insecticide used in any of the pheromone-treated fields.

Fruit damage resulting from other pests (principally armyworms) ranged from 4 to 9% during any one harvest in control fields compared with 1 to 5% damage in pheromone-treated fields. The lower damage in pheromone-treated fields may be attributed in part to more abundant parasite populations, principally *Hyposoter exigua* and *Trichogramma pretiosum*.

Conclusions

Our results suggest that pheromones can be integrated successfully into a TPW management program, as long as the cherry tomato field is isolated from other infested fields and the pheromones are applied before populations build up. Other helpful management practices include discing plant residues after the last harvest to reduce overwintering tomato pinworms and avoiding sites with a history of pinworm infestations.

One registered TPW pheromone is currently available, the Scentry "Attract 'n Kill" fibers. The fibers and adhesive cost about $28 per acre per application and take 0.5 to 1.5 hours to apply. The estimated cost for four applications is $124 to $128 per acre.

By comparison, insecticides cost from $8 to $12 per acre and labor ranges from 1 to 5 hours per application. Using 12 applications for comparison, it would cost $156 to $444 per acre for TPW control.

We conclude that, for the small-scale plantings (1 to 2 acres) that characterize the cherry tomato industry, the pheromone-disruption technique is an effective, economical alternative to chemical insecticide treatment.

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Spray coverage on strawberries

Carolyn Pickel ❑ Norman C. Welch

Complete underleaf spray coverage is essential for good control of several pest problems in strawberries. Two-spotted mites (*Tetranychus urticae*), for example, tend to build up on the undersides of the lowest leaves. Diseases such as common leafspot (*Ramularia tulasnii*) and powdery mildew (*Sphaerotheca humuli*) infect the underleaf and can develop into important sources of disease.

The growth pattern of strawberry plants—close to the ground and with middle and lower leaf tiers overlapping—make complete spray coverage difficult if not impossible with commonly used equipment. Most growers use homemade spray equipment, resulting in a wide variation of nozzle configuration, nozzle type and number, pressure, and spray boom height. Added to these problems is an increasing resistance of mites and leaf disease to currently registered chemicals.

We tested several growers' sprayers to see if any of them provided satisfactory coverage. We evaluated spray coverage on 1-inch-square dye cards stapled to upper and lower surfaces of strawberry leaves in the top, middle, and lower tiers of the plant. All tests were conducted on beds with 52-inch centers, each with two rows of strawberry plants spaced 14 inches apart.

Because most sprayers cover three beds, we used the middle bed for the coverage evaluation. Dye cards were attached to 12 leaves at each test site, starting from the furrow side of the row. This sampling approach allowed data collection from the inside and outside of the bed area. Evaluation was based on the card area covered with dye (red dye No. 40 at 8 oz./100 gal. spray solution): 1 indicated no dye; 2, less than 50% coverage; 3, spots; 4, more than 50% coverage; and 5, completely covered. Coverage rated 1 to 2 would be inadequate; 3 to 4, adequate; and 5, complete.

Equipment evaluations

Tests in 1984 and '85 evaluated grower-designed sprayers near Watsonville during July and August, when plant density was greater and coverage most difficult. We tested several sprayers again in 1985 to see if coverage had improved. In our analysis, we considered each grower in 1984 and 1985 as a treatment and the dye system rating as replicates. In the analysis of overall coverage, results corresponded to underleaf coverage found on the lowest tier. That is, when coverage was poor on the underleaf of the lowest tier, coverage from the entire plant sample was also poor. When data were analyzed from the whole plant, coverage also decreased in the lower tiers; ratings were 3.17 in the highest tier, 2.29 in mid-tier, and 1.70 in the lowest tier. Since underleaf coverage is the most important for control of straw-

TABLE 1. Evaluation of underleaf spray coverage of strawberry plants' bottom tier by growers' sprayers

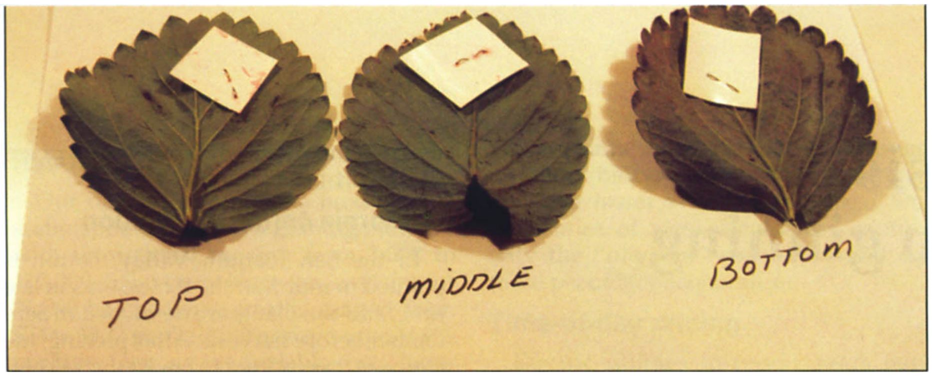
	1984			1985		
Sprayer	Rate	Pressure	Rating*	Rate	Pressure	Rating*
	gpa	*psi*		*gpa*	*psi*	
1	200	200	3.3 c			
2	200	190	3.0 c			
3	200	250	2.5 bc	180	300	0.5 d
4	250	350	1.8 ab	200	250	2.0 b
5	300	200	1.7 ab	300	220	2.8 a
6	200	200	1.5 ab			
7	200	200	1.0 a			
8				250	160	2.8 a
9				100	280	1.8 b
9				100	280	.8 c

* Average coverage rating on scale of 1-5; 5 = best coverage. Means in each column followed by same letter are not significantly different (p = 0.05 DMRT).

TABLE 2. Underleaf coverage with and without air assist at different plant tier heights, three sprayers

	Rating*					
	Air assist on			Air assist off		
	Sprayer			Sprayer		
Tier	B	C	D	B	C	D
Top	4.3 a	3.8 a	3.9 a	3.8 c	3.2 b	3.3 a
Mid	4.2 ab	3.7 a	3.9 a	3.3 d	2.3 c	2.4 b
Low	3.9 bc	3.5 ab	3.8 a	2.4 e	1.8 d	1.4 c

* See table 1 footnote. P = 0.01 DMRT.



Efficiency of growers' homemade spray rigs was tested by stapling 1-inch-square dye cards to leaves in top, middle, and lower leaves of strawberry plants, and measuring coverage. None of the rigs provided adequate coverage for good pest control.

berry pests, we separated out the underleaf lowest tier data for analysis. With this information separated out, there were six replicates.

Underleaf coverage ratings of the lowest leaves varied significantly from 0.5 to 3.3 among sprayers evaluated during the two-year study (table 1). Sprayer one was designed especially for single-row test plots. This sprayer, which had 12 nozzles, gave the best coverage. Few commercial rigs were even close, except sprayer two. The rest of the sprayers had seven or eight nozzles. Coverage by sprayer three decreased in 1985 from that in 1984 possibly because of lower gallonage or greater plant density. Sprayer five made two passes with angled spray nozzles in 1985 in an attempt to improve coverage. Coverage improved by one rating, but this was still not satisfactory.

All test results were disappointing, since they showed that most of the sprayers were not providing adequate control for mites and diseases. Changing the nozzles on sprayer three, using flat fan nozzles in one evaluation and cone-type in another, did not improve coverage.

Air-assist technique

We tested four growers' sprayers in 1985 using an air-assist technique at different pressures (200 and 300 psi), amounts of water (200, 300, 400 gallons per acre [gpa]), and boom heights. Variation in pressure and gallons per acre was limited by the pump capacity of the equipment.

The air-assist device consisted of a manifold attached to the outlet of a backpack duster to allow ducting of the air to the outside and center of the bed. Three 4-inch clothes-dryer ducts were used to direct the air. Air was introduced just below and behind the spray fan in the area where droplets form. Air velocity was high enough to make the leaves shake slightly but not enough to move, flatten, or turn them over.

We conducted the spray evaluation in the same way as in 1984-85 but used four replications with each sprayer. The air-assist method in all four tests resulted in significantly better underleaf coverage on the lower tier, and less difference in coverage between the upper and lower tiers in the plant (table 2). Without air assist, coverage significantly decreased in the lower tiers.

Using sprayer A, we compared results with the air-assist technique at different pressures. Increasing the pressure from 200 to 300 psi did not significantly increase coverage with or without air assist (table 3). Underleaf coverage was significantly better at both pressures with the air-assist technique.

In a test with sprayer B, pressure was increased from 150 to 250 psi and rates from 300 to 400 gpa, with the air assist on. Underleaf coverage did not improve except at 300 gpa and 250 psi (table 4). With the air assist off, higher amounts of water (400 gpa) and lower pressure (150 psi) increased coverage significantly.

Lower boom height on sprayer C increased coverage with and without the air-assist technique (table 5).

The test with sprayer D showed again that the air-assist technique can be used with lower pressures and lower amounts of water (table 6). Without air assist, 400 gpa and 200 psi appeared to give the best coverage. In this test, air assist improved coverage by 1.5 rating points at 150 psi and 150 gpa.

Conclusion

The air-assist technique in these trials resulted in significantly better underleaf coverage throughout the plant. Pressure and amount of water had less effect on coverage. Without air assist, pressure, water, and boom height had much more effect on underleaf coverage.

Tests with growers' sprayers indicate that changing nozzle number and configuration could achieve some improvement in spray coverage. Changing the nozzle and boom arrangement alone, however, will not result in satisfactory coverage of lower tier underleaf surfaces. Some type of air assist to force spray droplets under the leaves and close to the ground is required. There is great need for additional engineering work to develop sprayers that will improve underleaf coverage.

TABLE 3. Underleaf coverage with and without air assist at different pressures, sprayer A, 200 gpa

200 gpa		
Air assist	Pressure	Rating*
	psi	
On	300	4.2 a
On	200	4.0 a
Off	300	3.1 b
Off	200	2.6 b

NOTE: Application equipment had eight D2-45 cone nozzles.
* See table 1 footnote. P = 0.01 DMRT.

TABLE 4. Underleaf coverage with and without air assist at different pressures and application rates, sprayer B

Air assist	Rate	Pressure	Rating*
	gpa	*psi*	
On	400	250	4.5 a
On	300	150	4.3 ab
On	400	150	4.2 b
Off	400	150	3.7 c
On	300	250	3.7 c
Off	400	250	3.2 d
Off	300	250	3.1 d
Off	300	150	2.7 e

NOTE: Application equipment had eight D2-45 cone nozzles.
* See table 1 footnote. P = 0.01 DMRT.

TABLE 5. Underleaf coverage with and without air assist at two boom heights, sprayer C, 200 gpa and 200 psi

Air assist	Boom height	Tier	Rating*
On	Low	Top	4.1 a
On	Low	Mid	3.9 ab
Off	Low	Top	3.9 ab
On	Low	Low	3.8 ab
On	High	Mid	3.5 ab
On	High	Top	3.5 ab
Off	Low	Mid	3.4 bc
On	High	Low	3.8 c
Off	High	Top	2.5 d
Off	Low	Low	2.5 d
Off	High	Mid	1.3 e
Off	High	Low	1.3 e

NOTE: Application equipment had 10 Teejet 80015 flat fan nozzles.
* See table 1 footnote. P = 0.01 DMRT.

TABLE 6. Underleaf coverage with and without air assist at two application rates and pressures, sprayer D

Air assist	Rate	Pressure	Rating*
	gpa	*psi*	
On	200	150	3.4 a
On	400	200	3.3 a
On	200	200	2.8 ab
Off	400	200	1.6 cd
Off	200	200	1.2 de
Off	200	150	0.9 c

NOTE: Application equipment had 10 D3-45 cone nozzles.
* See table 1 footnote. P = 0.01 DMRT.

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