Project Title: Tomato Powdery Mildew Control

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Summary

The performance of chemical control programs for tomato powdery mildew varied with the trial location. However, the sulfur-dust control program stood out as best at all three locations. This program, which began in early July for a mid-May transplanted crop, and involved 5 to 9 dust applications depending on location, consistently and sometimes dramatically reduced the percentage of the leaf area affected by powdery mildew as well as the severity of foliar necrosis at season end. At some locations, the sulfur program had less sunburnt fruit, higher marketable yield and soluble solids and better fruit color relative to the nontreated plots. The performance of the other fungicide programs varied with location, which might be attributed to the differences in timing of when mildew began increasing at each location. The most dramatic results were seen at the Fresno County location, where powdery mildew started early, two months prior to harvest and intensified quickly. At that location, programs that included early applications of sulfur or other fungicides resulted in significantly higher yield compared to nontreated plots.

Objective: To evaluate fungicide spray programs for their impact on powdery mildew control, fruit yield, and fruit quality.

Procedures

Four powdery mildew control trials were conducted in processing tomatoes in 2009. Three trials were located within commercial fields (north Dos Palos-area, Tracy-area and Dixon/ Davis - area), while a fourth was conducted at the West Side Research and Extension Center near Five Points. Trials were established in fields transplanted in mid-May, three were in fields of the variety SUN 6368, while the Davis/Dixon-area trial was in a field of AB2. At each location, a minimum of six treatments/control programs were evaluated. At some locations, additional treatments were added. Four of the treatments were variations on a spray program of a strobilurin fungicide (pyraclostrobin/Cabrio or azoxystrobin/Quadris) rotated with a DMI fungicide (myclobutanil/Rally) with the four programs varying in the timing of the applications (i.e. varying intervals and treatment start dates). A fifth treatment evaluated sulfur dust applications. The sixth treatment was a non-treated control. Spray program details for each trial are listed in Table

1. Fungicides were applied with a backpack sprayer operating at 32 to 40 psi and a hand-held boom. Spray volumes were equivalent to 50 gallons water per acre. Sulfur dust was applied with a hand-crank operated duster. Plots consisted of a single 60- or 66-inch bed and were 50 to 75 feet in length. Each plot was replicated four times at each location, in a randomized complete block design. There were non-treated buffer rows between each treatment row and between the trial rows and the grower-treated rows. Plots were evaluated for powdery mildew severity, foliar necrosis severity, marketable yield, sunburn damage, and fruit quality as determined by analysis by PTAB. Results of each trial are reported separately due to differences in control programs and powdery mildew pressure between trial locations (see table 1 for trial details and control program/treatment descriptions).

Results

At the southern Sacramento Valley location (Dixon/Davis-area, Timothy & Vigue), powdery mildew pressure was light until just two weeks prior to harvest. All fungicide treatments had less mildew than the nontreated control (table 2), although there were no differences among the treatments with respect to powdery mildew infection. However, at the end of the season, the amount of foliar necrosis was significantly less in the 7-day interval programs when compared to the 14-day interval program. The sulfur dust program resulted in the least amount of foliar necrosis at the end of the season. There were no differences in marketable yield among the treatments, however sunburn levels were significantly lower in the sulfur dust program and in the program that included weekly late-season applications of fungicides and kaolinite clay (Surround) (table 3).

At the San Joaquin County location (Tracy-area, Del Terra Farms), powdery mildew pressure began in mid-August, about one month prior to harvest. On August 20th, mildew pressure was low, and at that point the best programs were the sulfur dust program, the July/August 7-day interval fungicide program, and the 14-day interval program (table 4). Later, two weeks prior to harvest, foliar necrosis was evaluated and was lowest in the sulfur treatment, followed by the July/August 7-day interval fungicide program and the program with two late-season fungicide applications (table 4). Although there were no significant differences in marketable yield among the treatments, there were differences in fruit quality. Fruit soluble solids were highest in the sulfur dust program (0.5° Bx higher than nontreated control), followed by the July/August 7-day interval fungicide program (table 4). As a group, the fungicide program treatments had a slightly lower fruit pH level (0.05 units lower than the nontreated control).

At the Merced County location (north-Dos Palos-area, San Juan Ranch), there was no powdery mildew. Therefore, no disease control or yield data are presented.

At the Fresno County location (Five Points-area, WSREC), powdery mildew pressure began around July 20th, about two months prior to harvest. Powdery mildew pressure was high, with the nontreated plots reaching nearly 100% of the foliage affected by mildew by the end of the season. In early ratings, the best control was achieved with programs that began in late June or early July and had 7-day intervals (table 5). Later in the season, the best programs were those that included late season applications. However, marketable yield was higher with programs that included early applications: highest yield was in the sulfur dust program (50% higher yield than nontreated), followed by the early 7-day interval fungicide program and by the July/August 7-day interval fungicide program (all three programs had more than 5 chemical applications, see table 6). All programs except the 14-day interval program had improved soluble solids compared to the nontreated control; soluble solids were highest in the sulfur dust program (1.4 °Bx higher than the nontreated control, table 6). The sulfur program also had the best color (2.7

units lower than the nontreated control). Fruit pH levels varied significantly depending on the treatment and were worst in the nontreated control (table 6).

The program that stood out as best at all three locations was sulfur dust. This program, which involved 5 to 9 dust applications depending on location, consistently and sometimes dramatically reduced the percentage of the leaf area affected by mildew as well as the severity of foliar necrosis at season end. At some locations, the sulfur program reduced sunburnt fruit, increased marketable yield and soluble solids and better fruit color relative to the nontreated plots. The efficacy of the other programs varied with location, which might be attributed to the differences in when mildew began spreading at each location. The most dramatic results were seen where mildew started early and intensified quickly. At that location, programs that included early applications of sulfur or other fungicides resulted in significantly higher yield.

We recognize that many of these chemical control programs may not often be economically justified (in other words, the cost of control may not be repaid with yield increases under most circumstances). However, our primary focus for these programs was a best-case effort at mildew control. Several of the programs would have repaid themselves at the Fresno County location due to the significant impact of the powdery mildew on fruit yield at that location.

Our experience this year with the difficulty in controlling this disease even with top of the label chemical rates, high water volumes, ground applications and weekly intervals confirms what many in the industry have been experiencing these past three seasons: powdery mildew can be a very challenging disease to control. In future work we hope to continue to address the question of what are the most effective materials. We also hope to gain more insight into the optimum application timing.

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Table 1. Programs evaluated, trial details	Dixon/Davis-area trial	Tracy-area trial	north Dos Palos-area trial	WSREC/Five Points trial
Variety	AB2	SUN 6368	SUN 6368	SUN 6368
transplant date	15-May	14-May	12-May	20-May
harvest date	11-Sep	14-Sep	not harvested	22-Sep
program 1: 6 oz Quadris alt. 4 oz Rally, 7 day interval	10 applications; 6/27 to 9/1	8 applications; 6/26 to 8/24	10 applications; 6/24 to 8/25	10 applications; 6/26 to 8/27
program 2: 6 oz Quadris alt. 4 oz Rally, 14 day interval	5 applications; 7/4 to 9/1	4 applications; 7/7 to 8/20	5 applications, 6/30 to 8/25	5 applications; 7/2 to 8/27
program 3: 6 oz Quadris alt. 4 oz Rally, 7-day interval, late start	5 applications; 7/31 to 9/1	2 applications; 8/5 to 8/17	5 applications, 7/28 to 8/25	5 applications; 7/30 to 8/27
program 4: 6 oz Quadris alt. 4 oz Rally, 7-day interval, early start	7 applications; 7/4 to 8/17	5 applications; 7/7 to 8/5	5 applications, 6/30 to 7/28	6 applications; 7/2 to 8/6
program 5; 50 lbs 98% sulfur dust, 7 day interval	9 applications; 7/4 to 9/1	5 applications; 7/7 to 8/17	5 applications, 6/30 to 7/28	7 applications; 7/2 to 8/13
program 6: nontreated control	none	none	none	none
program 7 (optional): 6 oz Quadris alt. 4 oz Rally, 7-day interval, late start, plus Surround	5 applications; 8/1 to 9/1	not included	not included	not included
Notes:	Program 1: initial two applications with Quadris, then alternated with Rally thereafter	spray interval sometimes longer than 7 days due to wind or irrigation events	16 oz Cabrio used in place of Quadris	trial on research station
Powdery mildew disease pressure:	Infection began 1 month before harvest, mildew pressure light until 2 weeks before harvest.	mildew pressure light until one month before harvest	no powdery mildew present in trial	heavy disease pressure, mildew started in mid July (two months prior to harvest); delayed harvest resulting in high sunburn and rots

Table 2. Evaluation of tomato powdery mildew control programs; effect on disease severity, Dixon/Davis-area trial 2009.

SPRAY PROGRAMS				DISEASE SEVERITY (% FOLIAGE AFFECTED)[z]									
		interval		Total #	16-Aug		23-Aug		29-Aug			9-Sep	
Trt #	Fungicides	(days)	Spray dates	applications	infection	necrosis	infection	necrosis	infection		necrosis		necrosis
1	Quadris alt. Rally	7	6/27 to 9/1	10	4	15	3	16	3	b	25	bc	25 bc
2	Quadris alt. Rally	14	7/4 to 9/1	5	4	19	3	17	3	b	33	b	36 b
3	Quadris alt. Rally: late start	7	7/31 to 9/1	5	4	15	3	16	3	b	33	b	32 bc
4	Quadris alt. Rally: early start	7	7/4 to 8/17	7	4	15	3	17	3	b	33	b	29 bc
5	Sulfur dust	7	7/4 to 9/1	9	4	12	3	14	3	b	18	c	18 c
6	Nontreated control	-	-	0	10	19	3	21	57	a	58	a	65 a
7	Quadris alt. Rally: late start (+ Surround)	7	8/1 to 9/1	5	4	12	3	18	3	b	28	bc	21 bc
				LSD 5%	NS	NS	-	NS	11		13		15
				% CV	50	30	-	29	67		28		31
			Group Comparisons:										
				Fungicides vs.	4.0	14.7	3	16.0	3.0		28.2		26.9
				Nontreated control	9.5	18.8	3	21.0	57.3		57.5		64.8
				P value	0.00	NS	-	0.07	0.00		0.00		0.00

Results Summary:

In general, infection level was light until 2 weeks before harvest but highest in the control which resulted in highest necrosis level.

[z] Means in the same column followed by the same letter are not statistically different

Table 3. Evaluation of tomato powdery mildew control programs; effect on yield, fruit quality and fruit maturity, Dixon/Davis-area trial, Timothy & Vigue, 2009.

SPRAY PROGRAMS				FRUIT YIELD, QUALITY AND MATURITY[z]							
		Spray interval		Total #	Marketable	Soluble		PTAB		Fruit (% by weight)	
Trt #	Fungicides	(days)	Spray dates	applications	yield (tons)	solids (°Bx)	pH	color	Sunburn[z]	Pink	Green	Mold
1	Quadris alt. Rally	7	6/27 to 9/1	10	48.0	5.48	4.20	24.5	6 ab	3	2	1
2	Quadris alt. Rally	14	7/4 to 9/1	5	43.4	5.10	4.20	25.5	6 ab	3	2	1
3	Quadris alt. Rally: late start	7	7/31 to 9/1	5	41.3	5.50	4.20	24.5	6 ab	2	2	2
4	Quadris alt. Rally: early start	7	7/4 to 8/17	7	44.5	5.35	4.19	24.0	6 ab	2	2	1
5	Sulfur dust	7	7/4 to 9/1	9	45.3	5.30	4.22	24.8	3 bc	4	5	2
6	Nontreated control	-	-	0	43.0	5.08	4.20	24.5	7 a	1	1	2
7	Quadris alt. Rally: late start (+ Surround)	7	8/1 to 9/1	5	47.0	5.08	4.20	24.8	4 bc	2	2	2
				LSD 5%	NS	NS	NS	NS	2.6	NS	NS	NS
				% CV	9	4	0.5	4	33	46	80	46
				P value		0.06			0.04			
			Group comparisons:									
				Fungicides vs.	44.9	5.3	4.2	24.7	5.1	2.5	2.3	1.6
				Nontreated control	43.0	5.1	4.2	24.5	7.4	1.5	0.9	1.9
				P value	NS	0.09	NS	NS	0.03	0.09	NS	NS

[z] Means in the same column followed by the same letter are not statistically different

Results summary:

- Marketable yield differences not significant among treatments
- Soluble solids slightly lower in the nontreated control (weakly significant)
- Sun damage level was lower with sulfur or Surround treatments

Table 4. Evaluation of tomato powdery mildew control programs; effect on disease and fruit yield and quality, Tracy-area trial, Del Terra Farms, 2009.

SPRAY PROGRAMS				DISEASE SEVERITY[z]		FRUIT YIELD AND QUALITY[z]				
				20-Aug	2-Sep					
Trt # Fungicides	Spray interval (days)	Spray dates	Total # applications	Mildew severity[z]	Necrosis severity[z]	Marketable yield (tons)	Soluble Solids (°Bx)	pH	PTAB color	Sunburn (% by weight)
1 Quadris alt. Rally	7	6/26 to 8/24	8	1.8 b	3.5 b	61.0	4.73 ab	4.36	24.3	3.4
2 Quadris alt. Rally	14	7/7 to 8/20	4	1.5 bc	4.3 ab	64.7	4.58 bc	4.41	24.5	3.4
3 Quadris alt. Rally: late start	7	8/5 to 8/17	2	2.5 a	3.8 b	62.0	4.53 bc	4.38	24.8	4.0
4 Quadris alt. Rally: early start	7	7/7 to 8/5	5	2.0 ab	4.5 ab	63.0	4.55 bc	4.41	24.3	2.9
5 Sulfur dust	7	7/7 to 8/17	5	1.0 c	1.8 c	61.7	4.90 a	4.37	24.0	2.7
6 Nontreated control	-	none	0	2.5 a	5.3 a	60.7	4.43 c	4.44	24.8	3.7
			LSD 5%	0.7	1.1	NS	0.27	NS	NS	NS
			% CV	25	19	9	4	0.9	4	30
			P value	0.003	0.0001		0.03			
		Group comparisons:								
			Fungicides vs.	1.8	3.6	62.5	4.66	4.39	24.4	3.3
			Nontreated control	2.5	5.3	60.7	4.43	4.44	24.8	3.7
			P value	0.01	0.001	NS	0.03	0.03	NS	NS

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z Disease severity rating scale:

0 = no disease
1 = 2.5% of foliage affected
2 = 10%
3 = 21%
4 = 35%
5 = 50%
6 = 65%
7 = 79%
8 = 90%
9 = 97.5%
10 = 100%

Results summary:

- Disease and necrosis reduced while fruit solids increased in top 2 treatments (5 sulfur applications or 8 fungicide sprays)
- Marketable yield differences not significant among treatments
- Soluble solids higher and pH level lower in fungicide treatments than in non-treated control

Table 5. Evaluation of tomato powdery mildew control programs; effect on disease severity, West Side Research and Extension Center trial, Five Points, 2009. Basal and terminal leaves rated separately on last four rating dates.

SPRAY PROGRAMS				DISEASE SEVERITY (% FOLIAGE AFFECTED)[z]											
				29-Jul	4-Aug	13-Aug		21-Aug		27-Aug		2-Sep	
Trt #	Fungicides	Spray interval (days)	Spray dates	Total # applications			basal	terminal	basal	terminal	basal	terminal	basal	terminal
1	Quadris alt. Rally	7	6/27 to 9/1	10	3 b	1 b	11 d	0	9 b	5 b	16 d	5 c	31 c	14 c
2	Quadris alt. Rally	14	7/4 to 9/1	5	8 a	1 b	22 c	0	15 b	9 b	44 b	18 c	50 b	28 c
3	Quadris alt. Rally: late start	7	7/31 to 9/1	5	7 a	2 b	36 b	0	14 b	4 b	36 bc	4 c	38 c	15 c
4	Quadris alt. Rally: early start	7	7/4 to 8/17	6	2 b	1 b	11 d	0	13 b	12 b	22 cd	35 b	27 c	49 b
5	Sulfur dust	7	7/4 to 9/1	7	2 b	1 b	3 d	1	7 b	11 b	8 d	12 c	14 d	18 c
6	Nontreated control	-	-	0	8 a	5 a	51 a	3	50 a	26 a	94 a	69 a	96 a	87 a
				LSD 5%	3	2	11		22	9	15	17	12	20
				CV (%)	39	63	32		81	52	27	47	18	37

z Means in the same column followed by the same letter are not statistically different

Results summary:

- Early season control best in treatments 1, 4 & 5. Late season control best in treatments 1, 2, 3 & 5.
- Late season foliar necrosis lowest in 7-day interval treatments 1, 3, 4 & 5 (data not shown).

Table 6. Evaluation of tomato powdery mildew control programs; effect on yield, fruit quality and fruit maturity, West Side Research and Extension Center trial, Five Points, 2009.

SPRAY PROGRAMS					FRUIT YIELD, QUALITY AND MATURITY[z]							
									Fruit (% by weight)			
Trt #	Fungicides	Spray interval (days)	Spray dates	Total # applications	Marketable yield (tons)	Soluble solids (°Bx)	pH	PTAB color	Sunburn	Red	Green	Mold
1	Quadris alt. Rally	7	6/26 to 8/27	10	29.7 abc	4.68 bc	4.51	27.8	25.2	34.8	8.5	28.9
2	Quadris alt. Rally	14	7/2 to 8/27	5	23.6 cd	4.23 cd	4.51	27.5	18.7	32.8	16.2	27.3
3	Quadris alt. Rally: late start	7	7/30 to 8/27	5	26.3 bcd	4.88 b	4.46	30.3	21.7	27.7	17.6	27.6
4	Quadris alt. Rally: early start	7	7/2 to 8/6	6	31.0 ab	4.43 c	4.47	29.5	21.8	35.9	9	30.6
5	Sulfur dust	7	7/2 to 8/13	7	34.0 a	5.38 a	4.51	25.3	17.3	47	12.6	19
6	Nontreated control	-	-	0	22.3 d	4.00 d	4.57	28.0	25.2	44	4	25
				LSD 5%	6.2	0.34	0.08	2.5	NS	12.4	NS	NS
				% CV	14.9	4.95	1.13	5.93	27.59	22.27	82.2	24.96

Results summary:

z Means in the same column followed by the same letter are not statistically different

- Marketable yields highest in trts 1, 4 & 5 (weekly applications of sulfur or fungicides beginning early)
- Soluble solids higher in all fungicide treatments (with exception of 14-day interval)