Project Title: Tomato Powdery Mildew Control

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Summary

This was the final year of a four-year project looking at the impact of powdery mildew on processing tomatoes and evaluating control programs. These past three seasons there has been lighter disease pressure from powdery mildew in commercial fields than we had observed during the 2007 to 2009 seasons. In our 2012 trial fields, there was a moderate level of powdery mildew by mid-September at two of the four trial locations. Out of all eighteen trials over four years, ten developed significant mildew. From these, we conclude that the fungicide programs evaluated have the potential to increase soluble solids (observed in 9 out 10 trials), increase yield (2 out of 10 trials), reduce sunburning of fruit (5 out of 10 trials), improve fruit color (5 out of 10 trials), and lower fruit pH (2 out of 10 trials). The impact likely depends on a number of factors such as disease pressure, onset date, crop variety, and weather. Best control programs were those which included sulfur dust, and programs beginning 6 to 8 weeks after transplanting were generally more effective than programs starting later.

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 2012. Two trials were located within commercial fields (north Dos Palos-area, Merced Co. and Union Island, San Joaquin Co.), while another two were conducted at the UC West Side Research and Extension Center near Five Points (Fresno Co.) and at the Plant Sciences field facility at UC Davis (Yolo County). Trials were established in fields transplanted in mid-May, three were in fields of the variety SUN 6366 or 6368, while one was H 9780 At each location, a minimum of eight treatments/control programs were evaluated. At most locations, additional treatments were evaluated. Four of the treatments were variations on a spray program of a strobilurin + DMI fungicide (azoxystrobin + difenoconazole = Quadris Top @ 8 oz per acre) rotated with sulfur dust (40 or 50 lbs per acre depending on the trial and treatment). These four programs varied in the timing of the applications (i.e. varying intervals and treatment start dates). Other treatments

evaluated sulfur alone either as a dust or wettable sulfur formulation (10 to 20 lbs per acre depending on trial location). The eighth treatment was a nontreated control. Most trials also included other fungicides programs or experimental materials, but these varied by location and were supported with other funding sources, therefore we have not attempted to report on these treatments here, but you may obtain findings from individual advisors. 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 bed and were 40 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 rest of the field. Plots were evaluated for powdery mildew severity, foliar necrosis severity, marketable yield, sunburn damage, and fruit quality as determined by analysis by PTAB grading station staff. 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 trial located on the UCD campus, powdery mildew infection occurred in mid-August, just over one month before harvest. Within two weeks, the disease had increased to a moderately high level (76% incidence), resulting in leaf drying. All treatments held up relatively well; the best programs were sulfur dust on a 7- or 14-day schedule, or sulfur dust alternated with Quadris Top on a 7-day schedule. Each of these three programs reduced disease incidence down to 13% (from 79% in the non-treated control). There were no statistically significant differences in yield (either total fruit or marketable fruit), but there were differences in fruit quality between groups. Fungicides as a group reduced sunburned fruit from 7.7% (% of affected fruit by weight) down to 5.6%. Soluble solids were increased to 5.7 °Brix in the fungicide-treated plots, up from 4.95 °Brix in the non-treated control. And raw fruit color was improved from 23.8 to 22.7. All results from the Yolo trial are presented in Table 2.

At the Fresno County location (UC WSREC, Five Points), powdery mildew reached detectable levels by the end of July and increased slowly during the season. By August 20th, one month prior to harvest, the disease was still at a low level of 2 to 3% of the foliage affected in non-fungicide-treated plots. By September 10th, this level had increased to around 25% of the foliage affected. All fungicide programs held up well under these conditions; with fungicide treatments on average reducing disease to below 1% of the foliage affected (from ~25% in the non-treated). The best programs were those which included sulfur dust; wettable sulfur was not as effective as dust, although it still provided a commercial level of control. Fruit yield and quality was significantly impacted by the powdery mildew. Fungicide-treated plots had higher yield (20% higher than non-treated), improved soluble solids (6.76 vs. 6.13 °Brix), and slightly better color and pH. The incidence of sunburned fruit was also reduced slightly by the fungicide programs. All results from the Frenso trial are presented in Table 3.

At the San Joaquin County location (Union Island, north of Tracy, Steve Arnaudo), no powdery mildew was observed. There were no differences in fruit quality (PTAB measurements) and three blocks of the trial were harvested with no apparent yield differences between treatments.

At the Merced County location (north-Dos Palos-area, Nickels Farming, San Juan Ranch), there was a detectable but very low level of powdery mildew. There were no significant effects of the fungicide programs on disease, yield (two blocks harvested) nor on fruit quality as indicated by PTAB measurements.

Final Project Summary

Over a four-year period, our group conducted eighteen field trials funded by CTRI with additional treatments and trial locations conducted with the support of the chemical manufacturers. Out of the eighteen trials, ten trial locations developed powdery mildew to a sufficient extent to provide meaningful results.

Figures 1 a though f summarize some of our results from over the four years of trials. At all ten locations with powdery mildew, we are able to significantly reduce the level of mildew and necrosis with our fungicide programs (Fig. 1a). In general the most effective programs were those which included sulfur dust, wettable sulfur was somewhat less effective. Programs in which applications started early (at 6 to 8 weeks after transplanting) tended to be more effective than those program which started later (10 to 12 weeks after transplanting). In two trials, we saw a yield increase attributable to controlling the mildew (Fig. 1b), in both cases the disease got started in these fields in July, more than one month prior to harvest. At all other locations, we did not detect yield differences between treatments. The proportion of fruit exhibiting sunburn tends to be highly variable and therefore it can be hard to draw conclusions about treatment effects; however at five of the ten locations a significant impact of fungicides on sunburn was documented (Fog. 1c). Over the four years of trials, soluble solids increases due to mildew control were observed in nine out of ten trials where mildew was present (Fig. 1d). The average soluble solids increase from the weekly sulfur program was 0.6 °Brix (increase ranged from 0.07 to 1.38 °Brix). Color was improved in the fungicide-treated plots at half of the trial locations, and pH was improved at only two locations (Figs 1f and 1e, respectively).

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Table 1. Programs evaluated, trial details	Yolo (UC Davis) trial	Fresno (UC WSREC/Five Points) trial	San Joaquin (Union Island) trial	Merced (Dos Palos-area) trial
Variety	SUN 6366	SUN 6366	H 9780	N 6385
transplant date	26-May	13-May	16-May	15-May
harvest date	20-Sep	19-Sep	27-Sept	25-Sep
program 1: Quadris Top alternated w/ sulfur dust, 7-day interval	7 applications; 7/15 to 9/3	11 applications; 6/27 to 9/4	9 applications; 7/11 to 9/5	8 applications; 7/5 to 9/10
program 2: Quadris Top alternated w/ sulfur dust, 14-day interval	4 applications; 7/15 to 8/27	6 applications, 6/27 to 9/4	5 applications, 7/11 to 9/5	4 applications; 7/5 to 8/27
program 3: Quadris Top alternated w/ sulfur dust, 7-day interval, delayed start	4 applications; 8/13 to 9/3	6 applications, 8/1 to 9/4	5 applications, 8/8 to 9/5	4 applications, 8/13 to 9/10
program 4: Quadris Top alternated w/ sulfur dust, 7-day interval, early stop	5 applications; 7/15 to 8/13	5 applications, 6/27 to 7/25	5 applications, 7/11 to 8/8	5 applications; 7/5 to 8/13
program 5; sulfur dust, 7 day interval	7 applications; 7/15 to 9/3	11 applications; 6/27 to 9/4	9 applications; 7/11 to 9/5	8 applications; 7/5 to 9/10
program 6: sulfur dust, 14-day interval	4 applications; 7/15 to 8/27	6 applications, 6/27 to 9/4	5 applications, 7/11 to 9/5	4 applications; 7/5 to 8/27
program 7 sulfur wettable, 14-day interval	4 applications; 7/15 to 8/27	6 applications, 6/27 to 9/4	5 applications, 7/11 to 9/5	4 applications; 7/5 to 8/27
program 8: Non-treated control	none	none	none	none
Other programs evaluated with other funding sources, varies with the trial	various experimental materials evaluated	sulfur fb. Luna fb. Quadris Top fb. Luna fb. Quadris Top fb. Luna	sulfur dust at half rate of program 6, 14-dy interval, 5 applications	6 other programs incl. grower std: 2 sulfur dusts fb 2 Cabrio; experimental materials incl. Quintec, Priaxor and BAS 700

Table 2. Evaluation of fungicide programs; effect on powdery mildew severity, yield, and fruit quality, UC Davis campus trial, 2012.

			Powdery mildew disease severity (%)									
Treatment	interval (days)	sprays (#)	21-Aug incidence	3-Sep necrosis	3-Sep incidence	15-Sep necrosis	15-Sep incidence	Yield (tons/A)	Sunburn (% fruit by weight)	Soluble solids (°Brix)	color	pH
Sulfur dust alt. w/ Quadris Top	7	7	2	18	3	25	13	38.0	6.4	5.80	22.8	4.43
Sulfur dust alt. w/ Quadris Top	14	4	2	18	3	22	22	38.5	4.7	5.68	23.8	4.47
Sulfur dust alt. w/ Quadris Top, delayed start	7	4	8	32	22	50	46	25.3	7.1	5.45	23.5	4.49
Sulfur dust alt. w/ Quadris Top, early stop	7	5	2	18	3	28	25	39.2	6.1	6.03	22.8	4.47
Sulfur dust	7	7	2	10	3	16	13	37.6	5.1	5.98	22.5	4.48
Sulfur dust	14	4	3	16	3	25	13	38.2	4.7	5.63	22.0	4.49
Wettable sulfur	14	4	2	32	5	39	29	27.4	6.0	5.56	22.0	4.55
Non-treated control	-	0	9	69	76	76	79	36.3	7.7	4.95	23.8	4.47
Quadris Top	14	4	1	13	3	25	19	46.8	4.8	5.48	22.5	4.44
LSD 5%			*3.7*	*12.2*	*7.8*	*13.3*	*16.4*	*NS*	*NS*	*NS*	*NS*	*NS*
CV			*102*	*34*	*52*	*26*	*40*	*34*	*44*	*9*	*5*	*1*
Group comparisons												
Non-treated control			9	69	76	76	79	36.3	7.7	4.95	23.8	4.47
vs. fungicide treated			2	20	6	29	22	36.4	5.6	5.70	22.7	4.48
P value			*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*NS*	*0.139*	*0.008*	*0.10*	*NS*

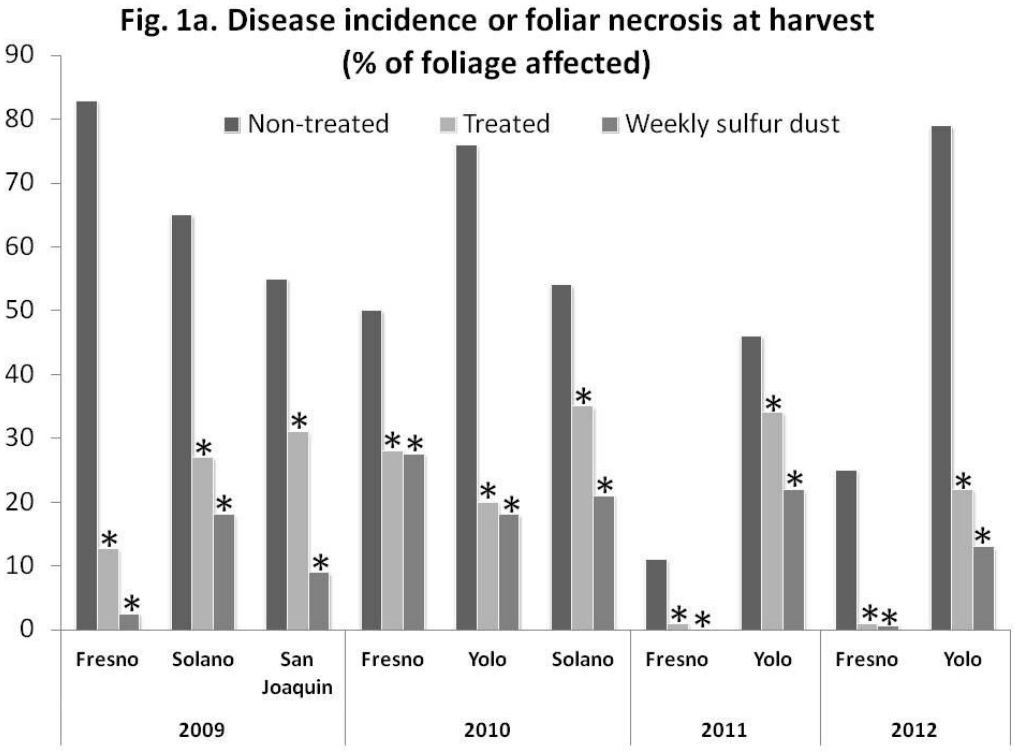
Note: Means in the same column followed by the same letter are not significantly different. NS = not significant

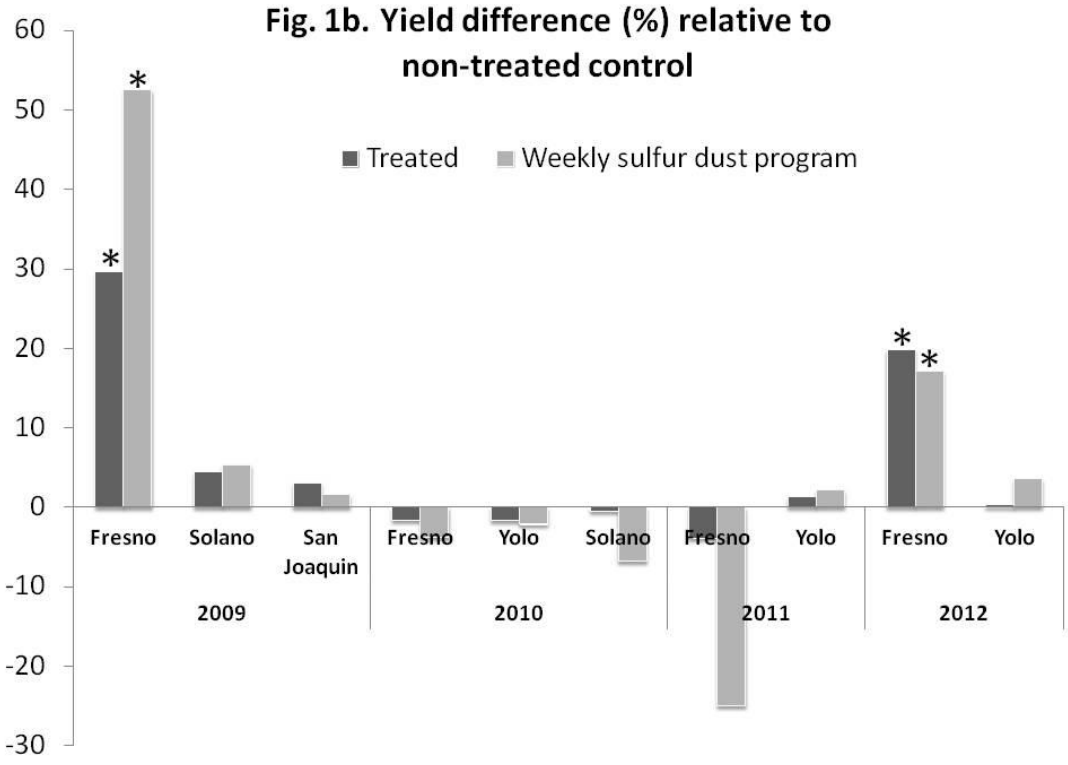
Table 3. Evaluation of fungicide programs; effect on powdery mildew severity, fruit yield and quality, UC WSREC trial, 2012.

Treatment	Interval (days)	Sprays (#)	Powdery mildew severity 20-Aug	Powdery mildew severity 10-Sep	Yield (tons/ acre)	Sunburn (% fruit by weight)	PTAB lab analysis Color	PTAB lab analysis Soluble solids (°Brix)	PTAB lab analysis pH
Sulfur dust alt. w/ Quadris Top	7	11	0.05 b	0.1 b c	34.0 a	1.49	20.3	6.88 a b	4.57
Sulfur dust alt. w/ Quadris Top	14	6	0.03 b	0.1 b c	29.2 a b	2.35	19.8	6.68 a b	4.57
Sulfur dust alt. w/ Quadris Top, delayed start	7	6	0.08 b	0.35 b c	29.5 a b	2.73	20.0	6.68 a b	4.61
Sulfur dust alt. w/ Quadris Top, early stop	7	6	0 b	0 c	30.9 a b	1.45	19.8	6.78 a b	4.53
Sulfur dust	7	11	0 b	0.05 c	29.5 a b	2.77	20.5	7.00 a	4.61
Sulfur dust	14	6	0 b	0.1 b c	28.9 a b	2.58	20.8	6.90 a b	4.56
Wettable sulfur	14	6	0.15 b	0.68 b	29.4 a b	2.37	20.5	6.45 a b	4.60
Non-treated control	---	0	0.98 a	3.13 a	25.2 b	3	20.8	6.13 b	4.66
		LSD $_{0.05}$	*0.2*	*0.62*	*6.3*	*NS*	*0.85*	*0.817*	
		CV (%)	*92.1*	*80.7*	*15.1*	*80.3*	*2.9*	*8.3*	*1.6*
Group comparisons									
Non-treated control vs.			0.98	3.13	25.2	3	20.8	6.13	4.66
fungicide programs			0.04	0.2	30.2	2.25	20.2	6.76	4.58
		P value	*<.0001*	*<.0001*	*0.041*	*0.058*	*0.024*	*0.043*	*0.042*

Note: Means in the same column followed by the same letter are not significantly different. NS = not significant. Disease 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% (10-point pre-transformed rating scale)

Fig 1a-d. Summary of impacts of fungicide programs by year and trial location. Programs evaluated varied slightly by year and location, see individual annual reports for details. Asterisks indicate that differences from the non-treated control were statstically significant at the 5% level.





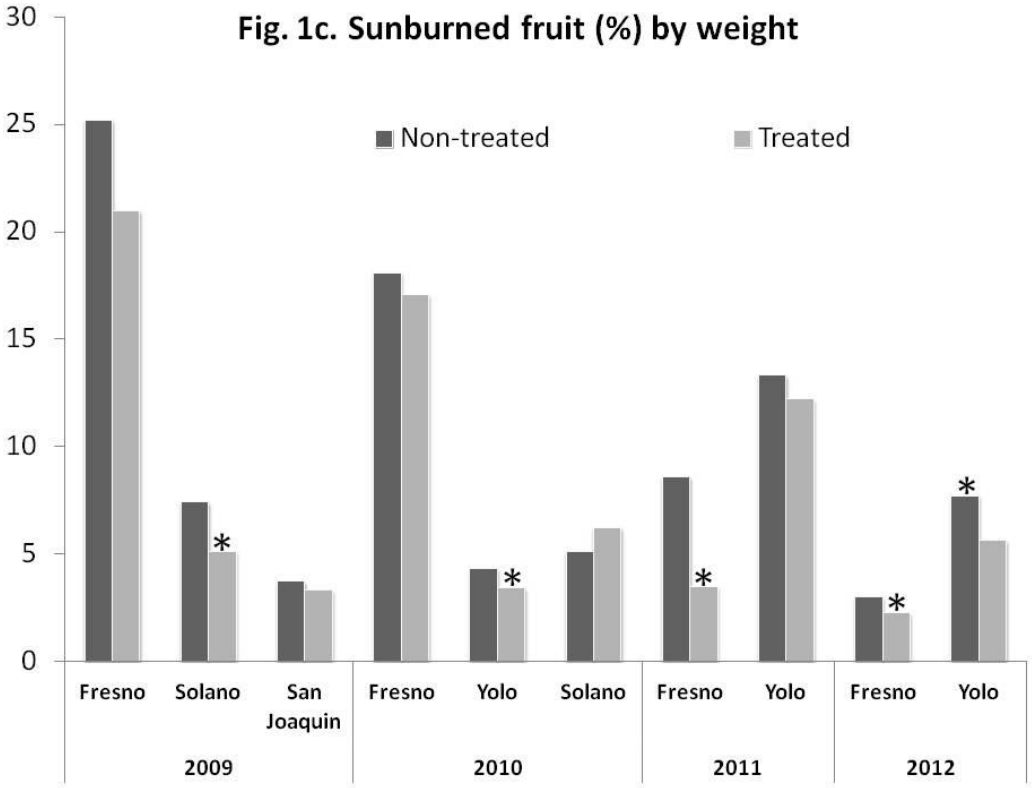


Fig. 1c. Sunburned fruit (%) by weight
Non-treated
Treated
30
25
20
15
10
5
0
Fresno
Solano
San Joaquin
Fresno
Yolo
Solano
Fresno
Yolo
Fresno
Yolo
2009
2010
2011
2012

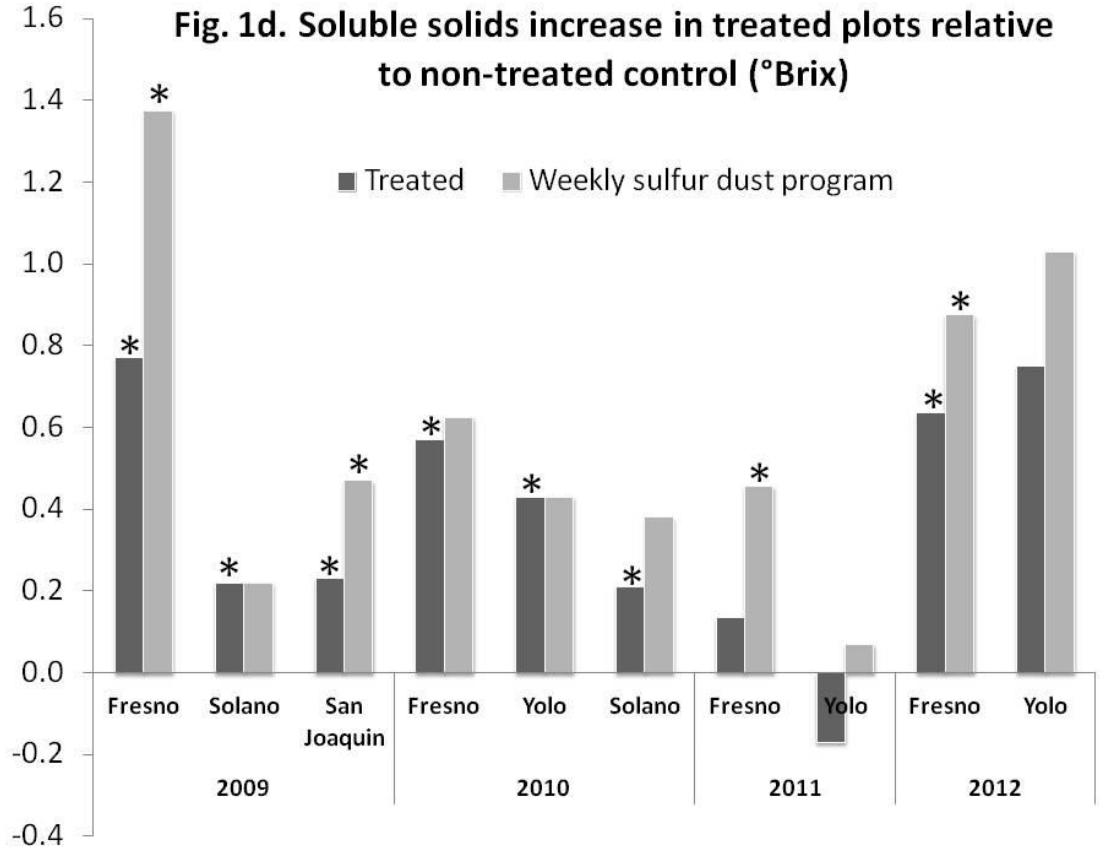


Fig. 1d. Soluble solids increase in treated plots relative to non-treated control (°Brix)
Treated
Weekly sulfur dust program
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Fresno
Solano
San Joaquin
Fresno
Yolo
Solano
Fresno
Yolo
Fresno
Yolo
2009
2010
2011
2012

Fig. 1e. Fruit pH

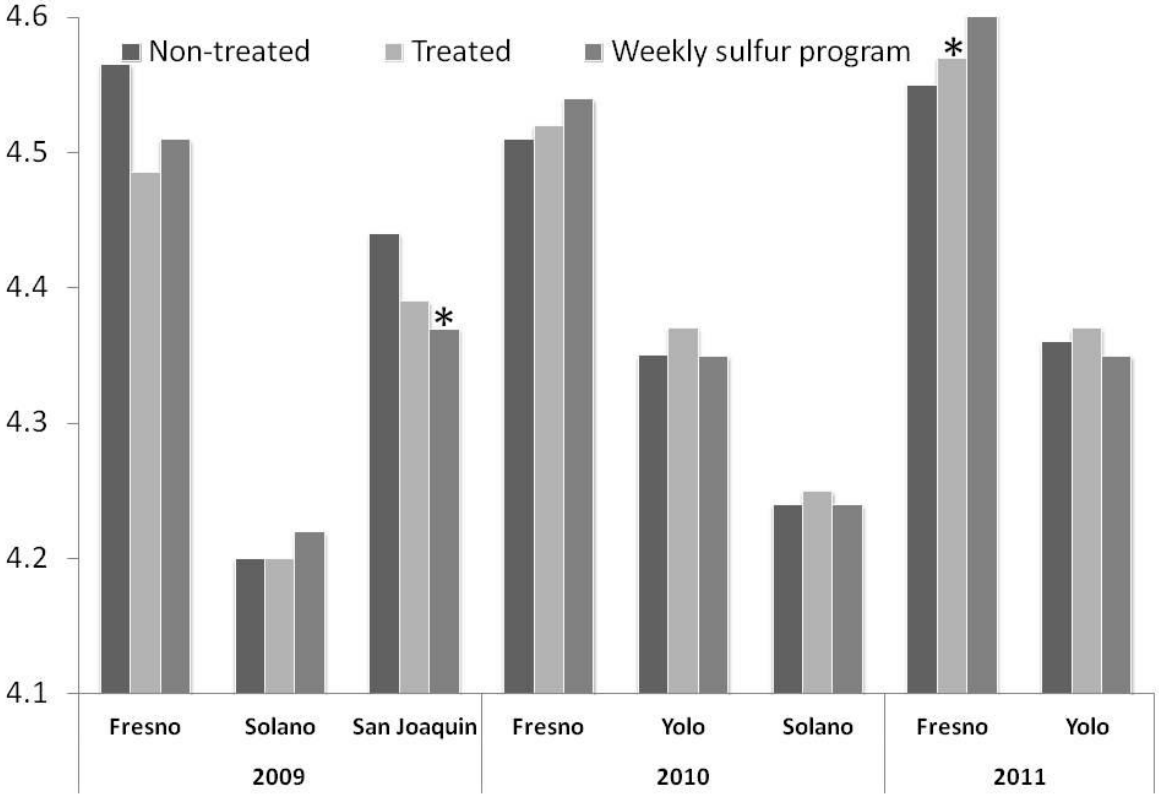


Fig. 1f. Blended fruit color