

Annual Leafy Greens Research Report For the Period April 1, 2012 to March 31, 2013

Project title: Evaluation of relative susceptibility of lettuce varieties to *Tomato spotted wilt virus* and Fusarium wilt.

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Abstract

In the lettuce production area in Fresno County, California, *Tomato spotted wilt virus* (TSWV) and Fusarium wilt have increased in distribution and severity over the last 10 years. To address these disease problems in western Fresno County, trials were conducted to evaluate response of 22 to 25 lettuce varieties or breeding lines to these pathogens and there was a study to evaluate the potential value of drip injected biological materials as a component of management program in a commercial field. The trial site was in an area with a history of TSWV and it was naturally infested with *Fusarium oxysporum* f. sp. *lactucum*. On 17, 30 Aug and 13 Sep, seed was sown and sprinklers were turned on in variety and drip applied control program evaluations. Multiple evaluations were made in each trial over the season and in the trials planted on 17 and 30 Aug, quality was evaluated for all iceberg entries. The romaine varieties had lower levels of Fusarium Wilt than the iceberg entries, but there were differences within iceberg entries in terms of Fusarium susceptibility. Salinas, Sharpshooter and Sniper had lower levels of wilt than most iceberg types. Among the iceberg entries, Lighthouse, Patriot and Vanguard had the highest levels. Romaine entries; Conquistador and Del Sol also had lower levels of this disease, and romaine-like entries, Sawa Up and CR#4 had very low Fusarium, but these and the romaine entries had higher levels of TSWV. The 2012 Fall season had higher than average temperatures so Fusarium wilt levels were very high and quality was low. Of the iceberg varieties included in the study, core lengths were consistently over 2 in for varieties evaluated. The drip-inject biological materials did not show promise.

Long-range objectives:

Generate a list of varieties with varying levels of susceptibility to *TSWV* and Fusarium wilt to enable producers to better assess risk associated with planting that variety.

Immediate objectives

- Evaluate performance of varieties seeded in mid-Aug, late-Aug and early-Sep.
- Evaluate performance of putative control agents against Fusarium wilt of lettuce

Procedures

Lettuce was direct seeded into a Panoche clay loam soil in a naturally *Fusarium oxysporum* f. sp. *lactucum*-infested field west of Five Points. Fertility, pest management and irrigation and all other operations were as representative of common grower practice as possible, but due to the size of the irrigated area, it was necessary to use microsprinklers rather than high pressure sprinklers to germinate the seed. This study was conducted in a field in which drip irrigation buried at a depth of 6 inches was used, which is consistent with commercial practice of some growers in the area.

Varietal influence on disease severity: On 17 and 30 Aug, and on 13 Sep from 22 to 25 entries were seeded and irrigated. A four-replication randomized complete block design. Seventeen ft long, single-bed plots were used for these studies.

Entries for each study are presented in the following tables. Note that entries followed by “*” are included because of either extreme susceptibility or tolerance to Fusarium in other studies; entries followed by “**” are currently used in this production area and were provided by the grower.

17 Aug planting

<u>Iceberg</u>		<u>Romaine</u>
Autumn Gold*	Laguna Fresca	Conquistador*
Patriot*	Lighthouse	CR#4*
Salinas*	Raider	Del Sol*
Vanguard*	Sidewinder	Sawa Up*
Vanguard 75 *	Sharpshooter	
Beacon	Sniper	
Coyote	Heat Master**	
Diamondback	Sun Devil**	
Javolina	Sun Quest**	

30 Aug planting

<u>Iceberg</u>		<u>Romaine</u>
Autumn Gold*	Lighthouse	Conquistador*
Patriot*	Raider	CR#4*
Salinas*	Sidewinder	Del Sol*
Vanguard*	Sharpshooter	Sawa Up*
Vanguard 75 *	Sniper	
Beacon	El Guapo	
Coyote	Crusader**	
Diamondback	Heat Master**	
Javolina	Sun Devil**	
Laguna Fresca	Sun Quest**	

13 Sep planting

<u>Iceberg</u>		<u>Romaine</u>
Autumn Gold*	Raider	Conquistador*
Patriot*	Sidewinder	CR#4*
Salinas*	Sharpshooter	Darkland**
Vanguard*	Sniper	Del Sol*
Vanguard 75 *	El Guapo	Sawa Up*
Beacon	Crusader**	
Coyote	Deuce**	
Diamondback	Maxim**	
Javolina	Heat Master**	
Laguna Fresca	Sun Devil**	
Lighthouse	Sun Quest**	

* Standards for Fusarium wilt, which were obtained from Jim McCreight.

** Used commercially and obtained from grower

Plots were evaluated for disease symptoms of TSWV and Fusarium wilt at multiple times during the season for each planting. When the majority of the varieties were at maturity, 5 plants per plot were evaluated. Maturity levels were quantified on a 1-5 rating scale as follows: 0 = no head or open; 2 = cap leaves have closed but head is puffy; 3 = fully formed and filled head that yields under pressure; 4 = solid head that does not yield under pressure; 5 = head that is splitting. Five heads per plot were cut, trimmed and weighed. These 5 heads were sliced vertically. Head length and height, and core length were measured. The trial planted on 17 Aug was harvested on 29 Oct, the trial planted on 30 Aug was harvested on 15 Nov, and the trial planted on 13 Sep was not harvested.

Assessment of biological agents for control: Trials were conducted to evaluate the potential of mitigating Fusarium wilt of lettuce with applications of biological control agents. Iceberg lettuce varieties used were Heatmaster for the 17 Aug planting, Lighthouse for the 30 Aug

planting and Crusader for the 13 Sep planting. All trials were sprinkler irrigated for 3 to 4 weeks and then, were irrigated by drip irrigation lines buried to a 6 inch depth.

Treatments are detailed below (tables 6-8). The SoilGard product used in the first trial was from 2010, but all other products were received shortly before applications, which include SoilGard in the second and third plant dates. In all plantings, the treatments were arranged in a randomized complete block design with 4 replications. Each plot was one 40 inch bed 50 ft long with two lettuce seed lines. The first treatments were applied in a 4 to 6 inch band over the seed and the second applications were injected into the buried drip irrigation system. Materials were applied immediately after planting with a CO₂-pressurized backpack sprayer at 30 psi and 20 gallons per acre. The sprinklers were turned on as soon as possible. However, there was a 4- and 2-hour delay between the time of application of materials and the sprinkle irrigation on the first and second plant dates. Forty-five minutes passed between application of materials and irrigation at the third plant date. Generator-powered electric metering pumps were used to inject materials into the buried drip system. All drip applied materials were applied over 45 mins and water was run for 1 hour after the injections. The plants expressing Fusarium wilt symptoms were counted several times during the season and representative samples were taken and cultured to confirm the association of the pathogen with the symptoms.

Results

Varietal influence on disease severity: Differences in levels of disease among varieties were documented (Tables 1-3). Although most romaine entries had lower incidence of Fusarium wilt, there were also a few iceberg entries with relatively low levels of the disease. In addition, there were also differences in levels of TSWV, but some of the romaine varieties that appeared tolerant of Fusarium had among the highest levels of TSWV.

Consideration of the very high rates of decline in some varieties due to Fusarium wilt in the first two trials must be considered in interpretation of the TSWV-susceptibility data. Due to very high mortality at early stages of development in the first planting date, the percentage of TSWV incidence in varieties such as Coyote, Heatmaster, Laguna Fresca, Lighthouse, Patriot, Vanguard and Vanguard 75 could be understated (Table 1). However, some varieties, such as Sharpshooter had little mortality due to Fusarium and had very low levels of TSWV, so there are clearly differences in susceptibility to TSWV separate from the influence of Fusarium (Table 1). Furthermore, the influence of mortality due to Fusarium wilt on TSWV incidence is less important in the second planting date when rates of plant death were lower, and differences among varieties in TSWV levels remained apparent (Table 2). In the last planting date, there was little mortality and lower levels of TSWV, but Laguna Fresca, Vanguard and Vanguard 75 had TSWV incidence that were among the highest levels so they are susceptible to the virus (Table 3).

As the lettuce approached maturity, many entries had suffered levels of mortality such that there were few or no heads present. In the first two trials, all iceberg entries with heads that might be marketable were harvested. The lettuce in the trial planted last did not reach maturity by the time that the season was over due to cold weather, so nothing was harvested. None of

the iceberg entries were commercially acceptable due to small head size and in some, long cores at the first harvest date (Tables 4-5).

Assessment of biological agents for control: Disease pressure was very high in the first two trials, but even under lower pressure there was not a treatment that performed better than the untreated control. In the first trial the stand was poor due to the very high temperatures. On the first plant date, there were no commercially acceptable treatments (Table 6). Throughout the majority of the season, treatments were not different ($P=0.05$). On the last evaluation date of the trial, Taegro 5.2 oz in 4 to 6" band over seed at planting and through drip post-thinning had lower disease levels than the control and some of the other treatment. However, under the conditions of this study, with nearly 42% mortality, it was not an acceptable treatment. If there is consistent evidence of benefit, it may be a component of a program in combination with varieties and planting dates, however that was not seen in the second and third trials (Tables 7 and 8).

Table 1. Response of lettuce cultivars to Fusarium wilt and *Tomato spotted wilt virus* in lettuce planted on 17 Aug in Fresno County.

cultivar	Fusarium wilt incidence (%)				TSWV (%)		Plants per plot	Healthy plants
	13-Sep	24-Sep	3-Oct	26-Oct	26-Sep	29-Oct		29-Oct
Autumn Gold	18.7	44.9	48.5	54.7	3.6	3.6	24.0	16.1
Vanguard 75	19.0	74.2	74.2	92.6	0.0	0.0	27.5	0.0
Conquistador	7.3	20.1	20.1	24.1	7.8	20.6	19.0	57.0
CR#4	0.0	0.0	0.0	7.9	22.0	20.5	26.0	43.4
Salinas	3.8	25.1	25.1	28.4	5.2	6.9	29.3	35.2
Sawa Up	0.0	0.0	0.0	0.0	5.4	13.4	22.5	69.7
Heat Master*	11.6	73.9	73.9	76.4	1.0	3.6	23.5	6.3
Patriot	4.3	68.6	75.8	100.0	0.0	0.0	28.5	9.7
Del Sol	3.8	9.9	9.9	21.3	7.5	19.2	20.0	40.0
Sun Devil*	2.0	31.5	33.0	49.2	1.4	9.2	27.0	18.1
Beacon	9.6	75.6	78.7	85.0	0.0	0.0	15.3	0.0
Coyote	23.4	56.9	62.0	73.1	0.9	0.0	25.5	1.8
Diamond back	1.3	37.3	39.9	43.6	3.3	3.3	24.3	32.6
Javolina	8.3	23.4	24.5	32.1	3.4	7.6	26.8	30.3
Laguna Fresca	6.7	50.2	55.3	82.3	0.0	0.0	12.0	0.0
Lighthouse	18.6	64.0	68.4	95.0	0.0	0.0	25.0	0.0
Sidewinder	4.6	37.0	39.3	49.5	0.0	0.0	19.8	23.2
Sharpshooter	3.8	11.5	15.4	15.4	0.0	0.0	21.0	72.5
Sniper	9.8	19.7	21.1	25.2	1.2	1.2	19.8	44.6
Vanguard	27.9	84.0	84.7	96.6	0.0	0.0	31.0	0.0
Raider	4.3	22.0	33.5	55.9	1.1	1.1	27.0	15.3
Sun Quest*	0.0	38.6	44.3	66.9	0.0	0.0	23.3	6.0
LSD _{0.05}	11.96	21.45	21.27	20.51	5.20	6.72	7.96	20.05
CV (%)	97.05	38.45	35.70	21.18	127.48	96.62	23.92	59.66

Table 2. Response of lettuce cultivars to *Fusarium* wilt and *Tomato spotted wilt virus* in lettuce planted on 30 Aug in Fresno County.

cultivar	Fusarium wilt incidence (%)					TSWV (%)			Plants/ plot	Healthy (%)
	3-Oct	20- Oct	26- Oct	6-Nov	16- Nov	26- Oct	6-Nov	16- Nov		
Autumn Gold	0.0	7.7	8.6	10.4	13.1	0.0	6.0	7.6	27.0	8.9
Vanguard 75	19.0	43.2	70.1	76.8	80.7	1.0	1.0	5.8	25.5	0.0
Conquistador	0.0	2.8	2.8	6.0	8.2	0.0	0.0	0.0	20.8	40.6
CR#4	0.0	0.9	1.7	1.7	5.1	0.9	4.0	6.6	28.5	54.1
Salinas	1.7	4.2	6.8	6.8	7.6	0.0	3.5	3.5	29.3	17.3
Sawa Up	0.0	0.9	0.9	2.7	5.4	1.8	1.8	3.7	27.5	51.7
Heatmaster*	0.0	4.3	2.2	12.1	9.9	0.0	4.3	6.5	25.0	27.8
Patriot	4.4	45.9	47.7	66.8	68.6	0.0	0.0	2.9	28.3	0.0
Del Sol	0.0	0.0	0.0	0.0	6.2	1.2	7.5	11.3	26.7	61.1
Sun Devil*	0.0	4.1	4.1	5.1	8.4	0.0	4.3	9.8	24.3	21.7
Beacon	7.0	48.1	56.0	61.8	71.0	0.0	3.6	5.7	23.0	0.0
Coyote	5.3	10.8	12.8	18.2	29.5	0.0	2.0	3.1	24.0	4.3
Diamondback	1.0	6.8	6.8	10.0	10.0	0.0	0.0	1.6	25.3	22.9
Javolina	0.0	3.0	3.8	4.8	6.7	1.6	2.4	3.2	28.0	38.4
Laguna Fresca	2.2	31.9	43.7	42.7	43.9	0.0	0.0	0.0	23.8	0.0
Lighthouse	7.1	50.3	53.6	74.1	77.7	0.0	0.0	3.6	21.5	0.0
Sidewinder	1.0	3.1	2.2	2.2	5.2	0.0	1.0	4.0	24.5	25.4
Sharpshooter	0.0	0.0	1.7	1.7	1.7	0.0	0.0	0.0	26.8	37.4
Sniper	0.9	0.9	0.9	4.5	5.4	0.0	0.0	0.0	27.8	41.9
Vanguard	11.4	60.9	65.4	70.5	82.9	0.0	0.0	0.8	29.5	0.0
Raider	0.9	5.5	5.5	6.4	9.1	0.0	1.8	1.8	26.8	52.4
Sun Quest*	1.1	4.4	4.2	6.4	12.7	0.0	4.1	9.3	24.0	36.1
El Guapo	0.0	6.2	7.3	11.3	13.5	0.0	2.2	2.2	27.7	42.9
Crusader	0.0	6.1	7.1	10.2	19.4	2.1	3.9	6.0	22.0	47.4
LSD _{0.05}	6.42	18.06	13.49	15.15	15.04	1.982	5.410	7.091	3.94	26.12
CV (%)	172.9	85.0	55.05	50.14	42.44	291.4	145.4	115.4	10.67	55.37

Table 3. Response of lettuce cultivars to Fusarium wilt and *Tomato spotted wilt virus* in lettuce planted on 13 Sep in Fresno County.

cultivar	Fusarium wilt incidence (%)		TSWV (%)	Plants per
	20-Oct	14-Nov	14-Nov	plot
Autumn Gold	5.0	4.2	0.0	30.0
Vanguard 75	9.7	32.3	3.8	26.8
Conquistador	0.0	0.0	0.0	21.5
CR#4	0.0	0.0	0.0	29.5
Salinas	0.0	1.4	0.7	31.5
Sawa Up	0.0	1.6	0.0	30.5
Deuce*	0.0	10.7	0.0	13.3
Patriot	10.7	39.5	3.7	23.3
Del Sol	0.0	0.0	0.0	26.5
Sun Devil*	1.7	0.0	0.7	31.8
Beacon	8.2	23.2	0.8	29.5
Coyote	1.8	5.9	0.8	28.3
Diamondback	1.0	0.0	0.0	28.8
Javolina	2.3	2.4	0.8	31.8
Laguna Fresca	14.3	31.4	3.9	26.0
Lighthouse	23.5	55.1	0.8	32.8
Sidewinder	0.8	0.0	0.0	34.3
Sharpshooter	0.0	0.0	0.0	31.5
Sniper	2.8	0.0	0.0	26.3
Vanguard	9.5	46.7	3.5	28.0
Raider	2.2	2.2	0.0	30.7
Sun Quest*	1.4	0.0	0.0	32.8
Crusader	8.1	6.4	0.0	31.3
Maxim	5.3	6.1	0.0	28.3
Darkland	0.0	0.0	0.0	27.0
LSD _{0.05}	8.03	12.52	2.63	5.32
CV (%)	131.00	82.42	238.12	13.26

Table 4. Variety harvest quality of lettuce planted on 17 Aug and harvested on 29 Oct 2012 in Fresno County*

	Maturity	Height	Width	Core length	Weight/head
cultivar	(0-5)	(in)	(in)	(in)	(lbs)
Salinas	4.3	4.8	4.4	3.8	1.3
Sun Devil*	3.1	4.4	4.0	2.1	0.9
Diamond back	3.7	4.4	4.1	1.6	1.0
Javolina	3.5	4.4	4.5	1.5	1.0
Sidewinder	3.8	4.1	4.1	1.3	0.9
Sharpshooter	4.1	5.2	4.6	3.6	1.4
Sniper	4.2	4.8	4.3	3.7	1.1
Sun Quest*	3.6	4.3	3.8	1.4	0.9
LSD_{0.05}	1.08	0.82	NS	1.10	NS
CV (%)	19.72	9.94	23.72	44.01	22.50

- Three replications were harvested.

Table 5. Variety harvest quality of lettuce planted on 30 Aug and on 15 Nov 2012 in Fresno County.

	Maturity	Height	Width	Core length	Weight/head
cultivar	(0-5)	(in)	(in)	(in)	(lbs)
Salinas	3.8	5.5	5.6	2.5	1.3
Sun Devil*	2.6	4.5	4.3	0.7	0.9
Diamondback	3.6	4.7	5.0	1.1	1.2
Javolina	3.6	4.6	5.5	1.3	1.3
Sidewinder	3.6	4.7	4.7	0.8	0.9
Sharpshooter	3.1	5.0	5.3	2.8	1.0
Sniper	3.1	5.3	4.0	2.2	1.1
Raider	3.6	5.0	5.0	1.1	1.3
Sun Quest*	3.3	4.5	4.5	1.7	1.0
El Guapo	2.0	4.1	4.3	0.7	0.8
Crusader	3.1	4.7	4.6	1.0	1.1
LSD_{0.05}	1.08	0.82	NS	1.10	NS
CV (%)	19.72	9.94	23.72	44.01	22.50

- Three replications were harvested.

Table 6. Influence of drip injected materials on incidence of Fusarium wilt in lettuce planted on 17 Aug 2012, Fresno County, CA

Treatment	Fusarium affected plants (%)			
	13-Sep	24-Sep	3-Oct	26-Oct
Serenade Soil 2 qts in 4 to 6 in. band over seed ^z at and through drip at thinning ^y .	5.60	33.80	38.09	56.83
Serenade Soil 2 qts in 4 to 6" band over seed at planting and Optiva 16 oz through drip post-thinning.	6.05	35.72	43.49	55.58
Teagro 5.2 oz in 4 to 6" band over seed at planting and through drip post-thinning.	7.52	25.69	32.90	41.96
Teagro 5.2 oz broadcast at planting and through drip post-thinning.	4.45	39.23	48.65	55.73
SoilGard 5.0 lb in 4 to 6" band over seed at planting and CX-9032 16.0 oz through drip post-thinning.	5.50	39.44	58.19	63.52
Control	8.82	41.71	46.07	63.97
LSD _{0.05}	NS	NS	NS	12.85
P	0.59	0.61	0.17	0.03
CV (%)	57.06	37.72	28.18	15.6

^z All applications at planting were made immediately after seeding and a volume of 20 gal/acre was used. Sprinklers were turned on within 4 hours following the application

^y All drip injections were accomplished with electric metering pumps and materials were directly injected into each drip line over 30 min and the system was run for an additional 1 hour after the injection was complete.

Table 7. Influence of drip injected materials on incidence of Fusarium wilt in lettuce planted on 30 Aug 2012, Fresno County, CA

Treatment	Fusarium affected plants (%)				
	3-Oct	20-Oct	26-Oct	6-Nov	16-Nov
Serenade Soil 2 qts in 4 to 6 in. band over seed ^z at and through drip at thinning ^y .	5.13	26.04	38.41	55.47	60.13
Serenade Soil 2 qts in 4 to 6" band over seed at planting and through drip post-thinning.	3.18	29.22	36.86	62.43	62.86
Teagro 5.2 oz in 4 to 6" band over seed at planting and through drip post-thinning.	5.13	26.70	37.43	60.60	62.78
Teagro 5.2 oz broadcast at planting and through drip post-thinning.	4.04	26.84	36.07	58.28	58.49
SoilGard 5.0 lb in 4 to 6" band over seed at planting and CX-9032 16.0 oz through drip post-thinning.	3.44	20.05	41.02	53.06	58.69
CX-9032 8.0 oz in 4 to 6" band over seed at planting and CX-9032 16.0 oz through drip post-thinning.	4.66	20.29	34.27	56.51	62.77
CX-9032 16.0 oz in 4 to 6" band over seed at planting and CX-9032 16.0 oz through drip post-thinning.	3.87	20.14	31.60	51.60	55.82
Control	2.20	26.46	29.01	52.92	56.10
LSD _{0.05}	NS	NS	NS	NS	NS
P	0.93	0.68	0.95	0.96	0.95
CV (%)	89.96	36.28	40.40	25.99	18.52

^z All applications at planting were made immediately after seeding and a volume of 20 gal/acre was used. Sprinklers were turned on within 2 hours following the application.

^y All drip injections were accomplished with electric metering pumps and materials were directly injected into each drip line over 30 min and the system was run for an additional 1 hour after the injection was complete.

Table 8. Influence of drip injected materials on incidence of Fusarium wilt in lettuce planted on 13 Sep 2012 in Fresno County, CA

Treatment	Fusarium affected plants (%)	
	13-Sep	24-Sep
Serenade Soil 2 qts in 4 to 6 in. band over seed ^z at and through drip at thinning ^y .	7.87	7.87
Serenade Soil 2 qts in 4 to 6" band over seed at planting and through drip post-thinning.	2.68	3.51
Teagro 5.2 oz in 4 to 6" band over seed at planting and through drip post-thinning.	4.33	4.33
Teagro 5.2 oz broadcast at planting and through drip post-thinning.	8.39	7.93
SoilGard 5.0 lb in 4 to 6" band over seed at planting and CX-9032 16.0 oz through drip post-thinning.	3.92	4.82
CX-9032 8.0 oz in 4 to 6" band over seed at planting and CX-9032 16.0 oz through drip post-thinning.	6.88	8.22
CX-9032 16.0 oz in 4 to 6" band over seed at planting and CX-9032 16.0 oz through drip post-thinning.	6.27	5.40
Control	4.67	5.51
LSD _{0.05}	NS	NS
P	0.19	24.7
CV (%)	57.42	51.17

^z All applications at planting were made immediately after seeding and a volume of 20 gal/acre was used. Sprinklers were turned on within 45 minutes following the application

^y All drip injections were accomplished with electric metering pumps and materials were directly injected into each drip line over 30 min and the system was run for an additional 1 hour after the injection was complete.