Varietal response to resistance-breaking *tomato spotted wilt virus*

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Summary:

Tomato spotted wilt virus present in Central California is capable of infecting and moving within plants with the Sw5 single gene resistance that is common in processing tomato varieties. Within Fresno, Kings and Merced counties, twenty-one commercial variety trials were evaluated for *Tomato spotted wilt virus* over three years and forty-six entries were compared. In addition, at each site, the ability of the virus present to break Sw5 resistance was tested. Lowest TSWV levels were observed in HM5522, BQ 400, SVTM1082, SV8011TM, N2428, HM4521, HM58801, BQ403, HM58841, H1428, HM58871, N6416, H5608, UG16609, HM5235 and SVTM9000, were among those expressing the lowest incidence of symptoms. Highest levels of TSWV expression were in HM 7885, N6420, HM8163, HM5369, N6366, AB0311, H1293, BOS0811, HM5511, H5508, DRI319, H2401, BQ273 and HM58811. In all areas tested, the TSWV present could break the resistance gene in tomato.

Introduction: *Tomato spotted wilt virus (TSWV)* caused substantial damage through 2003-2009. Regional evaluations of epidemics and integrated approaches to management were established. A single gene resistance (Sw5) became heavily utilized since 2011 in high-risk areas and the gene has been widely deployed in all California production areas since. In 2016, very high incidence of *TSWV* symptoms occurred in varieties with Sw5-resitance and the presence of a SW5 resistance-breaking strain of TSWV was confirmed in symptomatic resistant varieties in three production areas within Fresno County (Batuman et al. 2017). The distribution of the resistant-breaking strain within Fresno County included most production areas by the end of the 2017 production season. In addition, at that point, it was also detected in the surrounding counties.

As the resistance-breaking issue was becoming more severe and widespread, differences among varieties in symptom severity and incidence were repeatedly observed. In 2018, a project was initiated with the support of California Tomato Research Institute (CTRI) to test these antidotal observations and quantify any differences in response of the common processing tomato varieties to the TSWV that is currently present in this production area under commercial field conditions.

With cooperation with Ag Seeds and TS&L, twenty-one industry trials in commercial fields were evaluated for relative incidence and character of TSWV symptoms from 2018 through 2020. Based on that data, there were differences among entries in incidence. In three trials each season, representative symptomatic samples were tested for resistance-breaking status in Robert Gilbertson's laboratory. In all trials tested, the Sw5 resistance-breaking virus was detected.

Methodology and Results:

In collaboration with commercial companies that conduct variety trials, TS&L and Ag Seeds, TSWV symptom expression among varieties was compared. By mid-season, seed company representatives provided trial maps. All trials evaluated were grown within commercial fields on subsurface drip irrigation with the field variety being a Sw5 variety. Trial size varied from 80 to 120 entries; however, we were not provided with variety information for entries at earlier stages of development and some were not included in all trials. For purposes of this report, the focus is on 46 varieties.

Varieties analyzed include the following:

resistance	variety		resistance	variety		resistance	variety
Sw5	AB 0311		No Sw5	H2401		Sw5	HM5522
Sw5	BOS 0811		Sw5	H5508		Sw5	HM58811
Sw5	BP 13		Sw5	HM 3887			N 2428
Sw5	BP 16		Sw5	HM 4521		No Sw5	N 6366
Sw5	BQ 273		Sw5	HM 4885		Sw5	N 6415
Sw5	BQ 400		Sw5	HM 4909		Sw5	N 6416
Sw5	BQ 401		Sw5	HM 58801		Sw5	N 6420
Sw5	BQ 403		Sw5	HM 58841		Sw5	N 6426
Sw5	BQ 413			HM 58871		Sw5	N 6428
Sw5	DRI 319		Sw5	HM 5900		Sw5	N 6441
No Sw5	H 1015		No Sw5	HM 7885		Sw5	SV 2756TM
Sw5	H 1293		Sw5	HM 8163		Sw5	SV 8011TM
Sw5	H 1428		Sw5	HM5235		Sw5	SVTM 1082
Sw5	H 1662		Sw5	HM5369		Sw5	SVTM 9000
Sw5	H 5608		Sw5	HM5511		Sw5	UG 16609
Sw5	H1776						

Decision to evaluate trials was based on presence of levels of TSWV symptoms of 5% incidence in the most severely impacted varieties. Field trials included in the analysis are six fields from 2018 (two in the Five Points area, two in Huron area, one near Mendota and one near Dos Palos in Merced County), seven fields from 2019 (two in Huron, two in Five Points, one in Cantua Creek, one in Mendota, one near Lemoore and one near Dos Palos) and eight from 2020 (one in Corcoran, one in Huron, two in Five Points, two in Helm, one in Firebaugh and one in Los Banos).

Severity evaluations: The trials were evaluated one time per field within two weeks of projected harvest. Total plants per plot were recorded. Tomato spotted wilt symptoms were categorized based on symptom character/severity as follows: a) shoot dieback - expression on young shoots and only the youngest fruit, b) fruit symptoms - expression is limited to color irregularities on red fruit and mild distortions; c) systemic symptoms - chlorosis, necrosis of foliage and majority of fruit expressing symptoms; d) severe - severely stunted or dead plant with TSWV- symptoms (Figure 1). Representative symptoms were tested with TSWV AgDia immunostrips in the field. Incidence is presented as a percentage of the total plants per plot. Analysis of variance was performed on data from 46 entries, and the Least Significant Difference P=0.05 ($LSD_{0.05}$) is presented.

1 shoot dieback

2 fruit symptoms with few foliar symptoms

3 systemic symptoms through leaves and fruit

4 collapse

Figure 1. Categorization of TSWV symptoms, 2018-2020.

Under the conditions of all trials evaluated over the three-year study, most symptoms were either mild or moderate and there were few observations of severe symptoms (Figure 2). Entries HM5522, BQ 400, SVTM1082, SV8011TM, N2428, HM4521, HM58801, BQ403, HM58841, H1428, HM58871, N6416, H5608, UG16609, HM5235 and SVTM9000, were among those expressing the lowest incidence of symptoms p=0.050 (Table 1). Entries that statistically had the highest levels of TSWV expression included HM 7885, N6420, HM8163, HM5369, N6366, AB0311, H1293, BOS0811, HM5511, H5508, DRI319, H2401, BQ273 and HM58811 (Table 1). All other varieties had intermediate levels of disease (Table 1).

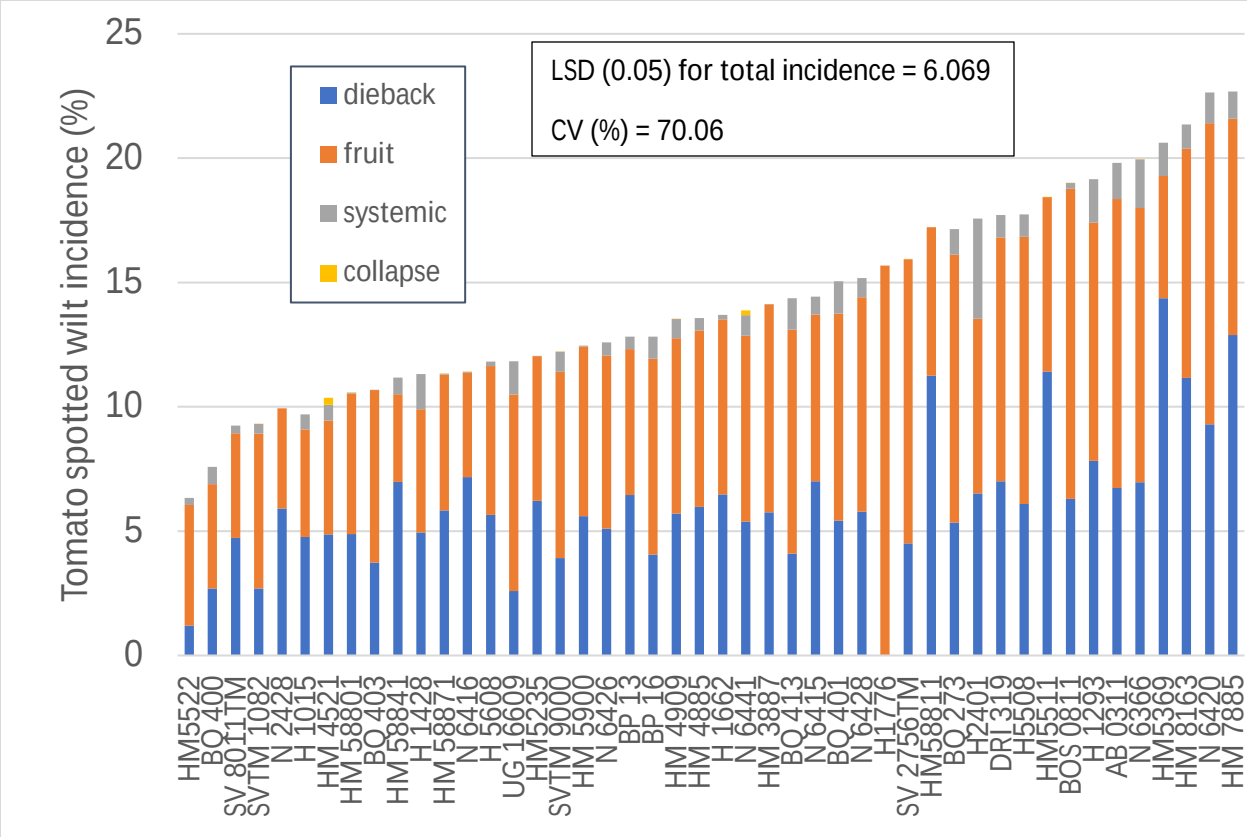

Figure 1. *Tomato spotted wilt virus* expression in forty-six entries over twenty-one sites from 2018 to 2020.

Table 1. Incidence of *Tomato spotted wilt virus* on forty-six entries over twenty-one sites with varietal use information included.

Variety	Use	Total incidence	Variety	Use	Total incidence	Variety	Use	Total incidence
HM5522	inter	6.339	HM5900	inter	12.463	HM58811	thick	16.974
BQ400	early	7.579	N6426	thick	12.589	BQ273	inter	17.15
SV8011TM	inter	9.241	BP13	early	12.823	H2401	thick	17.572
SVTM1082	thin	9.317	BP16	inter	12.824	DRI319	thin	17.718
N2428		9.506	HM4909	inter	13.539	H5508	thick	17.743
H1015	early	9.693	HM4885	thick	13.567	HM5511		18.262
HM4521	inter	10.36	H1662	thick	13.704	BOS0811	thick	19.016
HM58801	inter	10.579	N6441	inter	13.876	H1293	pear	19.15
BQ403	early	10.675	HM3887	inter	14.13	AB0311	thin	19.808
HM58841	inter	11.171	BQ413	early	14.363	N6366	thin	19.956
H1428	thick	11.313	N6415	thick	14.428	HM5369	pear	20.618
HM58871	inter	11.336	BQ401	inter	15.047	HM8163	pear	21.362
N6416	early	11.415	N6428	inter	15.172	N6420	pear	22.641
H5608	thick	11.814	H1776	thick	15.278	HM7885	pear	22.679
UG16609	inter	11.834	SV2756TM	thick	15.783			
HM5235	inter	12.041						
SVTM9000	early	12.226				$LSD_{0.05}$		6.069

Testing for Sw5-resistant *Tomato spotted wilt virus*: In three trials annually, representative samples were collected and sent to Robert Gilbertson's laboratory for race determination for three shoots in each of four to nine entries. In 2018, samples were collected from Five Points, Huron and Merced trials. Samples were collected from trials in Five Points, San Joaquin production area in Fresno County and Dos Palos in 2019. In 2020, Huron, Helm and Firebaugh-area fields were sampled. Entries submitted in 2018 and 2019 included N6366, UG19406, BQ413, UG16609, HM5900, H1293, N2420, BOS0811 and AB0311, although the first five entries listed were omitted from the 2019 Dos Palos collection. In 2020, Entries submitted included H1293, BQ413, UG16609, AB0311, H5608, N6472 and SVTM9016. In all samples, the Sw5 resistance breaking TSWV was detected.

Discussion:

A few consistent patterns were apparent. All pear varieties included were among those with the highest disease levels. In addition, most entries lacking Sw5 (three of four varieties) were among those with highest levels of disease. However, because of the ubiquitous nature of Sw5-resistance breaking virus in the areas evaluated, it is likely that the higher TSWV levels in varieties without Sw5 is due to other genetic characteristics rather than the contribution of the resistance gene.

Throughout this trial and in other samples submitted for testing, *Tomato spotted wilt virus* that has capacity to infect Sw5 tomatoes has become dominant in Fresno, Kings and Merced counties. It is likely that Sw5-resitance breaking TSWV will persist in these production areas. Management will be most effective with an integrated strategy that will include sanitation and avoidance of uncontrollable sources and well-timed thrips management. While an alternative resistance is not immediately available, information regarding relative susceptibility and expression among varieties provides a means of reducing risk in areas with a history of the issue, particularly if there are notable contributing factors that would indicate a likelihood of high virus levels.

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- Jonathon Deniz from TS&L provided maps and more specific trial information through the season, but there were certainly other company personnel that made this possible.

References:

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