California Melon Research Board
2013 Annual Report

I. Project title:

Comparative evaluation and breeding of new sources of host plant resistance to CYSDV and sweet potato whitefly biotype B, and continued efforts to develop a field-based serological detection method for CYSDV

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V. Location(s) where work was performed

University of California, Desert Research and Extension Center (DREC), Holtville
USDA-ARS, U.S. Agricultural Research Station, Salinas, California,

VI. Objectives

A. Characterize host plant resistance to CYSDV and introgress to western U.S. shipping type background adapted to the desert southwest U.S.
   1. Three putative resistant plants identified in 2009 and 2010.
   2. Six selections identified in 2011.
   3. Selections made in 2012 from 18 Indian accessions.
   4. Inter-crosses of PI 313970, TGR-1551 and TGR-1937.
   5. Repeat studies of heritability of resistance in TGR-1937, TGR-1551, and PI 614479
   6. Continue to select and introgress resistance to western U.S. shipping type background adapted to the desert southwest U.S.
B. Test germplasm identified in 2012 as potential sources of resistance to SPWF-B.

VII. Results and Analysis

The field test was planted at the University of California, Desert Research and Education Center, Holtville (DREC) August 13 to 15 and watered on August 16. Whiteflies were abundant at time of planting, and CYSDV symptoms were evident on September 13, four weeks post-planting. CYSDV symptoms were uniformly expressed across the field when evaluated 10 weeks post-planting. The federal shutdown precluded evaluation of CYSDV symptom severity and plant condition 7-weeks post planting (WPP) (October 1 to 4) as has been done in previous years. They were thus only evaluated 10-WPP (October 22 to 29), which was also done in previous years.

1. New putative resistance sources. Nine putative resistant sources derived from 27 putative resistant plants identified in 2009, 2010 or 2012, and their F_1 families from crosses with susceptible cultivars were included in the 2013 test. Table 1 summarizes CYSDV rating and notable observations on five of the accessions in 2013. Several accessions from southern India produced dessert-type fruit and several of them had plants that appeared to be potential sources of resistance to CYSDV. PI 123496 had large plants that produced numerous large melons with ivory rind, light net and white flesh. The F_1 PI 124550 x 'Impac' was especially notable for fruit number, size and "marketable" appearance.

2. Advanced backcross progenies from crosses involving PI 313970, TGR-1551 and TGR-1937 were selected for further backcrossing and selfing. There are three groups. The first group is derived from PI 313970 as the resistance source in crosses with 'Top Mark' and 'Impac' (Table 2). The second group is derived from crosses of CYSDV-resistant F_2, F_3, and F_4 PI 313970 x TGR-1551 selections for use as resistant parents in crosses with susceptible western shipping melon the goal of combining these two resistance sources in western shipping type melons (Table 2). A variant of the second group will be derived from the F_5 PI 313970 x TGR-1551 or later generation (Table 2). The third group is newly established in 2013 to combine TGR-1937 with the resistance genes of PI 313970 and TGR-1551.

Table 1. Summary of observations of CYSDV symptom rating and plant notes of five accessions and their F_1 progeny 10-weeks post-planting (wpp). Caveat: small numbers of plants

Accession	CYSDV rating	Notes
PI 122847		
Remnant seed	2	Flowering and excellent plant condition 13-wpp
self	4.5	
F_1	6	
PI 123496 self	2.0	Round, "marketable" fruit
PI 124550		
self	5.5	deep vine, large fruit, uniform plants and fruit
F_1	5.5	Outstanding "marketable" fruit, large and either round or oval
PI 145594 self	3	
PI 614486 self	2	

[z]rated using a visual scale: 0 = asymptomatic, 1 = 10%, 2 = 20%, 3 = 30%, …10 = 100%.

Table 2. Numbers of CYSDV-resistant, single-plant selections in advanced progenies from crosses of PI 313970 and TGR-1551.

Group	Pedigree	No. of single plant selections
PI 313970	S_1BC_1F3 Impac (Top Mark x PI 313970)	1
	$S_1BC_1F_3$ Top Mark (Top Mark x PI 313970)	2
PI 313970 x TGR-1551	$S_1BC_1F_2$ (PI 313970 x TGR1551) Impac	3
	$S_1BC_1F_3$ (PI 313970 x TGR1551) Impac	1
	$S_2BC_1F_2$ (PI 313970 x TGR1551) Impac	6
	$S_1BC_1F_4$ Laredo (PI 313970 x TGR1551)	2
	F_4 (PI 313970 x TGR1551)	2
	F_5 (PI 313970 x TGR1551)	1

3. **Inheritance of resistance to CYSDV in TGR-1551, TGR-1937 and PI 614459**
   a. *TGR-1551*. The F_1 mean CYSDV rating was significantly different from TGR-1551, but not from the susceptible parent, 'Top Mark' (Table 3). The backcross to the susceptible parent did not differ from 'Top Mark'. The backcross to the resistance parent was significantly different from both parents and the F_1. Frequency distributions of numbers of plants versus CYSDV symptom ratings (not shown) were consistent with the mean ratings. Resistance to CYSDV in TGR-1551 was expressed as a recessive trait under Imperial Valley conditions of continuous and high whitefly feeding pressure and high CYSDV inoculum load that resulted from whitefly feeding. These data are consistent with data from Texas (Sinclair, 2003) under field conditions, but contradict the data from controlled inoculation studies in Spain from

which it was concluded that resistance to CYSDV was conditioned by a single, dominant gene (López-Sesé and Gómez-Guillamón, 2000).

b. TGR-1937. This accession was reported to have an intermediate level of resistance to CYSDV (López-Sesé and Gómez-Guillamón, 2000). Resistance in this accession was recessive to susceptibility as indicated by the parental and F_1 means (Table 3) and frequency distributions (not shown).

c. *PI 614479*. This accession was identified as a potential new source of resistance in previous field studies in Imperial Valley. Resistance in this accession was recessive to susceptibility as indicated by the parental and F_1 means (Table 3) and frequency distributions (not shown).

Table 3. Mean CYSDV ratings 10-weeks post-planting for populations from crosses of CYSDV-resistant TGR-1937, TGR-1551, and PI 614459 with susceptible, western shipping type cantaloupes.

Generation	TGR-1937	TGR-1551	PI 614459
Susceptible parent (P_S)	8.8 ab	8.3 a	10.0 a
Resistant parent (P_R)	2.5 d	1.3 d	3.7 d
F_1	7.8 abc	7.6 ab	8.2 bc
F_2	7.8 b	6.8 b	8.5 b
BC P_S	8.6 a	8.5 a	9.6 a
BC P_R	7.1 c	5.9 c	7.5 c

[z]means separation by protected Student's *t*-test (ANOVA, Generation effect Prob > F <0.0001)

4. **ELISA detection of CYSDV in resistant and susceptible plants.**
Previous studies showed stronger correlation between virus titer determined within 7-weeks of planting and symptom severity at about 10-weeks post planting than virus titer at 10-weeks. This may be due to constant inoculum pressure from high whitefly populations. There was low correlation with symptom severity in 2013 (not shown), much like that observed in 2011 when sampling also occurred later in the season. Two distinct sources of antisera gave comparable results.

Leaf sampling, i.e., old symptomatic leaf vs. young leaf, may contribute to the low correlation between virus titer and symptom severity. A preliminary comparison of virus titer in leaves along a single branch was done using susceptible 'Top Mark' and four resistance sources (Table 4). One branch near the crown was selected at random from each of the five melon lines, and four leaves from each branch were assayed by ELISA using CYSDV antiserum provided by R. L. Gilbertson, UC Davis. The data suggest that virus titer does not change significantly with leaf position along a branch (Table 4). Mean titer in 'Top Mark' ranged from 2.4 to 7 times higher than in the resistant lines. A larger study of more plants and multiple branches per plant should be done to confirm these data.

Table 4. CYSDV Titer in 'Top Mark' and four sources of CYSDV resistance. Values are ELISA absorbance (background corrected)..

Leaf[z]	TM	TGR 1937	PI 313970	PI 614479	TGR-1551
1	2.835	0.505	0.259	1.022	0.370
2	2.062	0.869	0.297	1.254	0.473
3	3.094	0.800	0.293	0.931	0.340
4	1.629	0.774	0.512	0.728	0.351
Mean	2.405	0.737	0.340	0.984	0.384

[z]The leaf samples were taken at four locations on the vine. Sample 1 is the largest (oldest) leaf near the cut. Samples 2 and 3 were taken up the vine approximately 6 to 10 inches apart. The 4th sample was the terminal leaf, which is the newest and youngest leaf.

Objective B. Test germplasm identified in 2012 as potential sources of resistance to SPWF-B.

Fourteen lines were assessed in a replicated field test. They included 'Top Mark', 'Impac', TGR-1937, TGR-1551, PI 313970, and five plant introductions observed in 2012 to have significantly lower (three accessions) or higher (one accession), or not different (one accession) numbers of adult whiteflies per sampled leaf than TGR-1937, TGR-1551, or PI 313970. There were as expected significant differences among the lines for CYSDV resistance and plant condition 10-weeks post-planting (WPP; Table 5). CYSDV symptom severity and plant condition were negatively correlated (r = -0.87, P = 0.003).

Numbers of adult whiteflies per sampled leaf were significantly different among entries on seven weekly sampling dates from three (6 Sept.) through nine (18 Oct.) weeks post-planting (Table 6). Numbers of eggs cm^{-2}, crawlers cm^{-2}, and nymphs cm^{-2} among the entries differed significantly (significance level was <0.01) on only a few dates, e.g., eggs and crawlers on 20 Sept. (Table 6). Interestingly, total numbers of eggs (E), crawlers (C), and nymphs (N) cm^{-2} differed significantly (significance level was <0.05) 3-, 4,- and 5-WPP (Table 6).

Means comparisons of adults per sampled leaf show great variation among the entries including the F_1 progenies from crosses of PI 313970, TGR-1937, TGR-1551 and PI 123689 with 'Impac' or 'Top Mark' (Table 7). Numbers of adults per leaf varied among weeks, but appeared to decrease between 4- and 5-WPP, and decreased again by 6-WPP. PI 116482 had consistently high numbers of adults per leaf, though not always the highest, e.g., PI 124431 3-WPP (Table 7). PI 145594 consistently had lower adults per leaf than most of the other entries though it was not always significantly lower than all the other entries or different from the lowest, e.g., 6-WPP (Table 7). The differences among the entries for numbers of adults per sampled leaf are more apparent when numbers of adults are plotted against sample date (Figure 1).

The differences observed among the entries for numbers of nymphs 10-wks post-planting in a non-replicated field test in 2012 were not confirmed in 2013. A soilborne disease, likely incited by Monosporascus, may have confounded our observations in 2012 of apparent differences among accessions for numbers of whiteflies and plant performance, i.e., CYSDV symptom severity and plant condition.

The 2013 study did, however, reveal potentially useful differences among melon accessions for number of adults per sampled leaf over an eight-week period. Correlations of numbers of adult whiteflies per leaf with CYSDV symptom severity and plant condition ratings were low, but significant, and decreased weekly through the study. For example, the correlation of CYSDV and number of adults was 0.20 at 3 WPP, 0.13 at 8 WPP, and essentially zero at 9 WPP.

Literature Cited

López-Sesé, A.I. and M.L. Gómez-Guillamón. 2000. Resistance to *Cucurbit yellowing stunting disorder virus* (CYSDV) in *Cucumis melo* L. HortScience 35:110–113.

Sinclair, J.W. 2003. Screening for resistance to cucurbit yellow stunting disorder virus, gummy stem blight, and monosporascus root rot and detection of RAPD markers associated with QTL for soluble solids, sugars, and vitamin C in melon (*Cucumis melo* L.) PhD Diss., Dept. Hort. Sci., Texas A&M Univ., College Station.

Table 5. Mean (least squares) comparisons CYSDV and plant condition of 14 melon entries 10 weeks post-planting.[z]

Entry	CYSDV[y]	Condition[x]
Impac	9.8 a[z]	2.2 e
F_1 PI 313970 x Top Mark	9.2 a	3.0 de
Top Mark	8.8 a	3.0 de
PI 124107	8.2 ab	4.0 d
F_1 PI 123689 x Impac	8.0 abc	3.0 de
F_1 Top Mark x TGR-1937	7.8 abc	2.2 e
PI 116482	6.2 bcd	6.0 c
PI 123689	6.0 cd	6.5 bc
PI 124431	5.5 d	6.0 c
PI 145594	5.2 d	6.4 bc
PI 313970	4.8 d	5.8 c
F_1 Top Mark x TGR-1551	4.7 de	6.5 abc
TGR-1937	2.5 ef	7.8 ab
TGR-1551	1.2 f	8.2 a

[z]protected Student's *t*-test (ANOVA, Entry effect Prob > F <0.0001)
[y]rated using a visual scale: 0 = asymptomatic, 1 = 10%, 2 = 20%, 3 = 30%, …10 = 100%.
[x]plant condition rated using a visual: 1 (dead) to 10 (vigorous, flowering).

Table 6. Significance level (P) for entry effect in analyses of variance of numbers of adult whiteflies per sampled leaf, and numbers of whitefly eggs, crawlers, nymphs and their total per cm^2 of leaf area at different dates post-planting.

	Significance level				
Sample date[z]	Adults	Eggs (E)	Crawlers (C)	Nymphs (N)	E + C + N
6 Sept.	0.0085	–	–	–	–
13 Sept.	0.0010	0.4780	0.4442	0.63	0.0050
20 Sept.	0.0105	0.0333	0.0016	0.64	0.0057
27 Sept.	0.0108	0.1567	0.0096	0.0027	0.0015
4 Oct.	0.0010	0.4440	0.7392	0.2981	0.6341
11 Oct.	< 0.0001	0.6252	0.0705	0.1636	0.1984
18 Oct.	< 0.0001	0.0971	0.6150	0.0815	0.4574

[z]from three (6 Sept.) through nine (18 Oct.) weeks post-planting.

Table 7. Mean (least squares) numbers of adult whiteflies per sampled leaf from 3 to 9 weeks post-planting. Means followed by the same letters within columns are not significantly different (P <0.05).

	Week post-planting						
Entry	3	4	5	6	7	8	9
Top Mark	345.9 cd	336.2 bcde	132.7 cde	71.1 bcd	40.3 bc	28.4 d	25.0 d
Impac	483.3 abc	369.1 bcd	157.7 bcde	68.0 bcd	46.0 b	26.9 d	19.4 d
PI 313970	388.7 bcd	206.9 ef	121.3 de	60.1 cd	17.1 c	10.3 e	11.4 d
TGR-1551	439.4 bcd	424.6 bc	119.6 de	58.3 cd	28.2 bc	13.2 de	26.2 d
TGR-1937	361.4 cd	298.4 cdef	146.0 bcde	36.9 d	19.6 c	13.8 de	21.8 d
PI 116482	558.4 ab	632.5 a	238.5 a	115.0 a	78.0 a	54.8 ab	124.1 a
PI 123689	400.8 bcd	255.2 def	109.3 de	42.8 d	17.7 c	13.5 de	19.4 d
PI 124107	561.1 ab	458.2 b	207.7 ab	105.3 ab	46.4 b	44.9 bc	101.9 ab
PI 124431	635.7 a	477.0 b	200.2 abc	71.4 bcd	37.9 bc	66.9 a	86.3 bc
PI 145594	258.4 d	162.5 f	91.6 e	59.5 cd	19.8 c	13.3 de	19.4 d
F_1 PI 313970 x Top Mark	500.1 abc	499.4 ab	135.4 bcde	99.2 abc	16.7 c	11.5 de	7.4 d
F_1 Top Mark x TGR-1551	298.5 bcd	512.2 abc	182.4 abcde	27.9 d	27.1 bc	24.8 cde	33.7 cd
F_1 Top Mark x TGR-1937	299.2 cd	339.1 bcde	151.8 bcde	34.6 d	27.8 bc	19.4 de	21.8 d
F_1 PI 123689 x Impac	483.7 abc	414.7 bcd	179.7 abcd	55.2 cd	35.1 bc	24.3 de	14.4 d

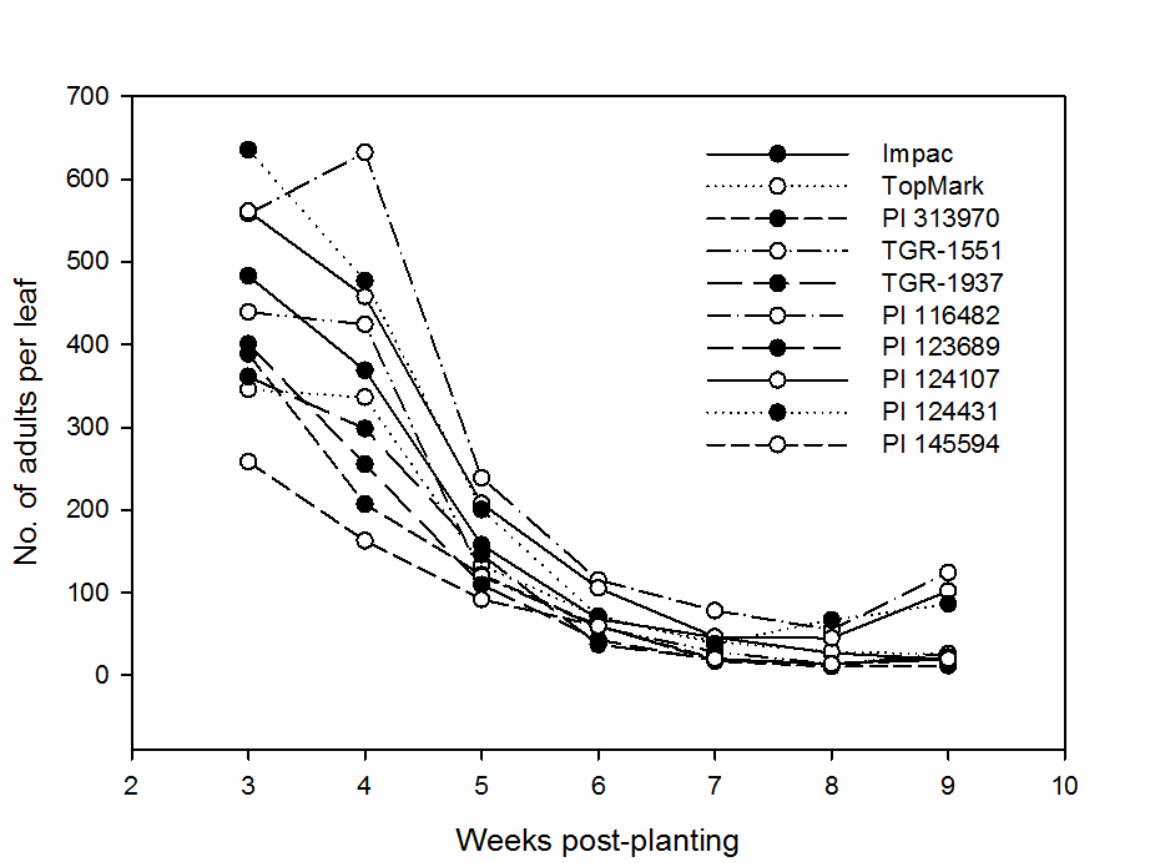

Figure 1. Numbers of adult whiteflies per sampled leaf of melon cultivars ‘Impac’ and ‘Top Mark’, and eight vegetable type melons from India and Zimbabwe at weekly intervals form 3- (6 Sept.) to 9-weeks (18 Oct.) post-planting. Progenies from crosses of PI 313970, TGR-1937, TGR-1551 and PI 123689 with ‘Impac’ or ‘Top Mark’ were not included.