Silverleaf Whitefly Resistance Strategies in Melon

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ABSTRACT. Control of Bemisia whiteflies (Bemisia tabaci Gennadius, sweetpotato whitefly; and Bemisia argentifolii Bellows & Perring, silverleaf whitefly) is critical for sustained production of high quality melons (Cucumis melo L.) in key melon production areas of the United States, Mexico, and Central America and South America. Differences in whitefly population sizes among the affected U.S. southern production areas of Arizona, California, Florida, South Carolina, and Texas support the hypothesis that different types of whitefly resistance per se and resistance to viruses vectorèd by Bemisia species may be sufficient, needed or required perhaps as part of an overall strategic integrated pest management plan to reduce losses to this insect.

The presence of the sweetpotato whitefly (SPW) has been known in Europe and North America for over 100 years as noted in a recent review (Henneberry et al., 1998), but it was not recognized as a pest until 1948 when it was found to transmit cotton leaf crumple virus (Dickson et al., 1954). Research in the early 1960s indicated that SPW was, however, not an important pest of cotton except when pesticides were applied to the crop (Gerling, 1967).

Unprecedented severe damage from SPW had occurred in Sudan, the Middle East, and southwest U.S. from 1970–1979 (Gerling and Mayer, 1996). The first observation of SPW affecting a cucurbit in the U.S. was in 1977 when squash leaf curl was observed on Cucurbita maxima in the Imperial Valley (Cohen et al., 1987; Flock and Mayhew, 1981). Squash leaf curl was endemic in the Imperial Valley and other parts of the Sonoran Desert through the 1980s. Later, melon leaf curl, and watermelon curly mottle were also described (Brown and Nelson, 1989; Duffus et al., 1985).

Lettuce infectious yellows (LIYV), transmitted by SPW, was first observed in 1981 in the Imperial Valley on lettuce (Duffus and Flock, 1982; Duffus et al., 1986). Melon which was adversely affected by LIYV infection, although the yellowing symptoms are not obvious until late in plant development when fruits are setting. Fall melons (primarily planted in July–August) were a major source of LIYV for the winter lettuce crop (planted September–November) in the southwest United States.

The SPW was blamed for causing silvering of squash and irregular ripening of tomato in Florida in the mid-1980s (Costa et al., 1993; Henneberry et al., 1998; Schuster et al., 1990), but SPW was soon regarded as a different strain (biotype B instead of biotype A) by some investigators, while others later regarded it as a new species, the silverleaf whitefly (SLW); Bemisia argentifolii Bellows & Perring (Bellows et al., 1994; Costa et al., 1993). The taxonomic status of whether there is a biotype complex or separate species is not yet resolved. Herein, SLW is the same as SPW biotype B. SLW was reported to be identical to the whiteflies maintained in Israel from 1960 through 1993 (Cohen, 1993). The SLW was found infesting field crops across the southeastern and southwestern U.S. from 1988–92 (Henneberry et al., 1998). The
SLW appeared in the low deserts encompassed by the Coachella and Imperial Valleys of California, and the Yuma Valley of Arizona in the 1990–91 winter season, and had essentially displaced the SPW by Fall of 1991 when it caused severe feeding damage to melons and lettuce as well as other vegetable, agronomic and fruit crops (Brown and Costa, 1992). SPW also appeared in the lower Rio Grande Valley of Texas with similar results on vegetable and melon production. Fall melon production in the lower deserts of Arizona and California dropped to virtually zero for several years. Beginning in 1996, fall melons were grown again in the lower deserts where growers could plant in fields isolated from other crops.

In Spain, *Trialeurodes vaporariorum* (Westwood), the greenhouse whitefly, was similarly displaced in 1991 by the SLW, and, perhaps, another strain sweetpotato whitefly designated biotype Q (Guirao et al., 1997).

In contrast to SPW biotype A, the SLW does not at present pose a threat to melons as a virus vector in the U.S. production areas. Cucurbit yellow stunting disorder virus (CSYDV) is transmitted by SLW, but CYSDV has so far been restricted to the Old World (Celix et al., 1996; Wisler et al., 1998). Although SLW is capable of transmitting LIV under experimental conditions, the success rate is extremely low (Duffus, 1995). SLW can also transmit SLC to squash although less efficiently than does the SPW (J.E. Duffus, personal communication). SLW was found to transmit lettuce chlorosis virus, a newly described virus, to lettuce but not to any cucurbit (Duffus et al., 1996). SLW has been and continues to be a devastating pest of melon through feeding by the nymphs and adults (Perring et al., 1993; Riley and Palumbo, 1995b).

Currently, melon growers in the affected areas are relying upon an integrated pest management (IPM) program consisting of a combination of chemicals, including insect growth regulators, and cultural practices to keep SLW below the threshold level (Riley and Palumbo, 1995a) needed to permit profitable melon production. In the lower deserts of Arizona and California, this combination of practices has enabled farmers to successfully grow melons in the fall season. There is concern that with prolonged use of chemicals in these areas that SLW will develop resistance to the chemicals used for their control (Prabhaker et al., 1985, 1992). Use of parasitoids, predators, and microbials including nematodes, fungi and insects to control SLW is being investigated and pilot-tested in these areas. Host plant resistance is a key component in the concept of integrated pest management, but management of SLW through host plant resistance has yet to be exploited.

**Resistance to SLW**

Resistance to SLW has been sought by at least four groups. Moreno et al. (1993) screened a diverse array of *Cucumis* sp. and eight unrelated cucurbits in Almería, Spain. They found differences in the numbers of adults and eggs among all the species and among the *Cucumis* sp. The best *C. melo* entry was *C. melo* ssp. *agrestis* accession Gatersleben CuM 190/1982 (CuM190).

Gomez-Guillamon and colleagues have been looking for resistance to SLW and the greenhouse whitefly, for greenhouse melon production in southern Spain (Sese et al., 1996; Soria et al., 1996). They reported reduced numbers of empty SLW pupae cases on CuM190 in a no-choice test (Soria et al., 1996). In choice and no-choice tests with the greenhouse whitefly, reproduction on this accession CuM190 was less than on the susceptible control. These results indicate that the resistance to greenhouse whitefly in this *agrestis* accession is conditioned by antixenosis and antibiosis (Soria et al., 1996). The same mechanisms may be effective against SLW.

Riley and colleagues in Texas have been working with a glabrous mutant that occurred in ‘SR-91’ (Foster, 1963). This mutant is conditioned by the recessive gene *glabrous* that is symbolized by *gl*. They have demonstrated a reduction in numbers of adults, eggs, and nymphs per leaf on glabrous F₁ segregants compared with their pubescent or hirsute F₁ siblings (see Riley et al. in this volume). Their results to date are encouraging.

McCreight and Simmons have screened melon PIs in naturally infested field plantings in Imperial and Yuma Valleys (McCreight, 1992, 1993, 1994, 1995) and in controlled greenhouse tests (Simmons and McCreight, 1996). A number of lines with different levels of resistance to SLW have been
identified. These lines showed significantly increased plant tolerance, reduced oviposition, and reduced survival compared with susceptible controls (Simmons and McCreight, 1996; unpublished). The surviving adults on these resistant lines have significantly lower body weights than those on susceptible plants (unpublished).

The brief descriptions of these four SLW resistance projects do not provide any indication of the whitefly pressure, i.e., numbers of SLW adults and/or nymphs/cm² of leaf area, on the melons from the SLW populations in the three distinct areas where the research has been done. Moreno et al. (1993) conducted their test in a naturally infested plastic house. They reported relative numbers of adults and eggs on a one to five scale. Sese et al. (1996) presented numbers of empty pupae cases per plant starting with a single, recently emerged female SLW confined in a clip-on leaf cage. The numbers of empty pupae cases were relatively low and ranged from 24 to 142 per plant.

In the U.S., data collected in 1993 indicate greatly different levels of infestation among four fall melon locations in California, Florida, South Carolina, and Texas (McCreight et al., 1995). Mean weekly numbers of adults on the abaxial leaf surface at Brawley, Calif., on insecticide-treated plants ranged from 3.8 to 39.5/leaf, and on control plants they ranged from 1.4 to 28.7/leaf. In contrast, the same counts of adults at Weslaco, Texas on insecticide-treated plants ranged from <1 to 16, and on control plants they ranged from <1 to 26/leaf. The difference between Brawley and the other three locations for numbers of eggs and nymphs/cm² is greater. Four weeks postplanting, the numbers of eggs/cm² on control plants were 1, 200 at Brawley, and 4.1 at Weslaco. The numbers of nymphs/cm² at this time were 300 at Brawley and <1 at Weslaco. The differences for numbers of eggs and nymphs eight weeks postplanting between Brawley and the other three locations were similar. SLW feeding resulted in mortality at Brawley but not at the other locations. The mean numbers of dead plants per plot for the control plots were 0.9 and 5.2 and for the insecticide-treated plots were 0.1 and 3.4 at 4 and 8 weeks, respectively.

### SLW populations and resistance to SLW

The three programs working on SLW resistance are evaluating potential resistance sources and segregating populations under greatly different SLW pressures. This may impact the effectiveness of resistance identified under relatively low pressure, e.g., Spain, Texas, Florida, South Carolina, when exposed to high pressure, e.g., California. These differences raise the question of whether resistance should only be evaluated under high SLW pressure. To do so would ensure that resistance which is efficacious under low pressure is not identified and exploited in an IPM program for control of SLW. Presumably, resistance identified under high SLW pressure would also be efficacious under low SLW pressure, but this remains to be demonstrated. Differences among the SLW strains in the widespread geographic areas may limit the effectiveness of resistance identified in one location from being effective in another location.

There are some examples available that give some insight on these questions. Moreno et al. (1993) reported that *C. melo* ssp. *agrestis* accession CuM190 was highly resistant to SLW under typical infestation levels in southern Spain. We included this line in a controlled greenhouse test at Charleston in 1994. The number of eggs/cm² on CuM190 in our greenhouse test was comparable to those on susceptible 'Top Mark', 'Mainstream' and several other entries (Simmons and McCreight, 1996; unpublished). The surviving adults on these resistant lines showed significantly increased plant tolerance, reduced oviposition, and reduced survival compared with susceptible controls (Simmons and McCreight, 1996; unpublished). The surviving adults on these resistant lines have significantly lower body weights than those on susceptible plants (unpublished).
Riley et al. in this volume). In contrast, we found in a greenhouse test that glabrous was as attractive to SLW as were 'Mainstream' and 'Top Mark' (Simmons and McCreight, 1996) when immatures/cm² and percentage reductions of dry biomass and leaf area are compared. Many of the entries in this test were less attractive and had smaller percentage reductions in leaf area and dry biomass than glabrous.

What these differences in SLW pressure mean is not fully clear. However, one implication is that some areas may require fewer Bemisia control measures to produce profitable melon than other areas. The above two examples highlight the difficulty of identifying resistance to SLW that will be efficacious in the wide array of environments where SLW has become established. It may very well be demonstrated that the resistances identified in CAM90 and 'SR-91' glabrous will prove to be efficacious in Spain and Texas where the SLW pressure is apparently lower than in the lower deserts of Arizona and California. The resistances identified in these two cultigens may be useful in developing a higher level of resistance in combination with genes from one or more other sources. The greatest challenge in melon resistance to Bemisia is to obtain resistance to high whitefly pressure. In the United States it is sufficient to focus the resistance of melon to the SLW and not to viruses.

Literature cited.


