Yellow Traps and Insecticides for Control of a Strain of Sweet Potato Whitefly and Associated Virus Incidence on Pepper[1]

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ABSTRACT *Bemisia tabaci* (Gennadius) is the most important vector of viruses which cause diseases of "serrano" pepper in southern Tamaulipas, Mexico. This insect is highly attracted to yellow surfaces. When 1,240 yellow traps/ha were uniformly placed in plots, plants with virus symptoms were reduced 61%, 59%, and 15% in 1987/1988, 1988/1989, and 1990/1991, respectively, on the last sampling date yet there was no significant difference in treated and untreated plots. In plots without treatment 78, 91, and 100% of plants exhibit virus symptoms on the last sampling date in the same years, respectively. Plots with traps increased yields of peppers 539%, 202%, and 341% in 1987/1988, 1988/1989, and 1990/1991, respectively, compared to the check. Traps + permethrin at 110 g (AI)/ha reduced populations of *B. tabaci* adults 78% in the 1987/1988. Permethrin-treated plots without traps increased yields 312% and 366% compared to the control in 1988/1989 and 1990/1991 seasons, respectively. During these same years yield increases were greater than the untreated check when *Lambda* cyhalothrin, cypermethrin, phosphamidon, dimethoate, naled, Safer™ soap, amitraz, and endosulfan were applied in the same tests.

KEY WORDS Sweet potato whitefly, *Bemisia tabaci,* insecticides, yellow traps, vector.

Sweet potato whitefly, *Bemisia tabaci* (Gennadius), has been the most important vector of geminivirus of "serrano" pepper in tropical Las Huastecas in southern Tamaulipas, Mexico, since the early 1980s (Avila and Pozo 1986). This disease reduces yields in the Las Huastecas area.

Cohen and Marco (1973) were the first to evaluate sticky yellow traps placed in pepper to catch this insect; they reduced incidence of geminivirus transmissions. Prior to these results, Nitzany et al. (1964) used sticky yellow traps to control adult whitefly populations in cucumbers. Zittler and Simmons (1980) reviewed the literature on yellow traps as control agents.

In this study, efficacy of insecticides, sticky yellow traps, and traps in combination with insecticide were evaluated to reduce populations of whitefly adults, incidence of geminivirus symptoms of "serrano" pepper, and increase yields of pepper at Las Huastecas Estacion Cuauhtemoc, Tamaulipas, Mexico in 1987/1988, 1988/1989 and 1990/1991.

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Materials and Methods

Formulations of amitraz (180 g/l), cypermethrin (100 g/l), diazinon (480 g/l), dimethoate (480 g/l), endosulfan (350 g/l), *lambda* cyhalothrin (600 g/l), naled (960/l), permethrin (340 g/l), phosphamidon (1,000 g/l), and Safer™ soap (100%) were tested at 200, 110, 200, 400, 300, 110, 600, 110, 600, and 847 g (AI)/ha, in 1987/1988, 1988/1989, and 1990/1991, respectively. Only permethrin was tested all three years.

Yellow (peak reflection at 600 nm by British standard) cylindrical traps (15 cm long × 10 cm diameter) with a surface area of 1,178 cm^2 per trap were coated with Trap Tac™ (Animal Repellent Inc., 1016 Everee Inn Road, Griffin, GA) and spaced 2 m apart between two rows at 1,240/ha. Traps were placed 1.1 m above the ground on 1 cm × 1 cm wooden stakes.

All plots were 4 rows wide by 4 m long with three (1987/1988), four (1988/1989), and four (1990/1991) replicates arranged in a randomized complete block. Each plot contained 240 "serrano" cultivar pepper plants at 15 plant/m^2. Traps plus sprays of permethrin were tested in 1987/1988.

Adult whitefly were counted on each of four whole plants in each plot 1 to 2 days before each insecticide application in each of the three seasons. Each plant sampled was covered with a 19-liter metal container 28 cm in diam so that a soil-metal seal was made as described by Avila and Pozo (1991). After placing the container over the plant, it was struck with metal one to three times. Then, each plant was shaken manually for 10 s through a cloth sleeve in the side of the container. In the middle of the top of this container was a screw-top lid for a 200-ml bottle. After placing the container over the plant, it was struck one to three times. Within four minutes all adults moved into the bottle in response to the shaking, sound, and light. The adults were counted as the landed on the glass surface. The labeled bottle was removed, immediately capped, and placed in a freezer at -10°C. Two to four days later, dead adults were removed and counted. Counts of the four plants were totaled for each plot.

Each pepper plant in the middle two rows per plot was examined for visible symptoms of virus biweekly as described by Avila and Pozo (1991). The virus was determined to be pepper mild tigre (Brown and Pozo 1989). It was determined from a leaf of each plant in each of the three seasons.

Yields were determined in January after harvesting fruit on plants two or three times in 2 m^2 from the middle two rows of each plot and weighing them. Results are expressed as kg fruit/ha from all harvest days each of the three seasons.

In 1987/1988, traps alone and sprays of permethrin plus traps were compared. Plots were planted on day 244. Permethrin was applied ten times on days 273, 280, 287, 294, 301, 308, 315, 322, 329, and 343. Traps were placed in the plots on day 273 and changed weekly until first harvest when they were removed. Peppers were harvested on days 10, 17, and 30.

In 1988/1989, five insecticides and traps alone were compared. Plots were planted on day 242. Insecticides were applied eight times on days 271, 278, 286, 299, 313, 320, 334, and 341. Traps were placed in the plots on day 271 and changed weekly until first harvest when they were removed. Peppers were harvested on days 10, 20, and 42.

In 1990/1991, six insecticides and traps alone were compared. Plots were planted on day 247. Insecticides were applied 12 times on days 301, 304, 311, 318, 325, 332,

337, 344, 351, 357, 3, and 10. Traps were placed in the plots on day 292 and changed weekly until first harvest. Peppers were harvested on days 51 and 71.

In 1992, whiteflies were collected from diseased peppers and analyzed by A. C. Bartlett (USDA-ARS, Phoenix, AZ) for strain identification by DNA according to procedures of Gawel and Bartlett (1993). Collections were not made in previous or subsequent years. Only adults were found on pepper. Only at end of season were low populations of eggs found; no immatures were found.

Significant treatment effects on mean adult whitefly populations for the growing season, infected plants on sampling days during the season, and yields at the end of the season were determined each of the three seasons by F with analysis of variance. Means were separated by Tukey with at $P \leq 0.05$ (Steel and Torrie 1960).

Results and Discussion

In 1987/1988, adult populations (Table 1) of whitefly in both the 1,240 traps/ha plots and in those with traps plus 10 applications of permethrin were similar, but they were both significantly different from the untreated check.

Percentage of infected plants in the check increased from 10% on day 301 to 77% on day 362 which was the last sample date (Fig. 1). On the last four sampling days (317 to 362), the mean percentage of infected plants was significantly lower in the permethrin plus traps treatment than with the traps alone, and both treatments had significantly fewer infected plants than found in the check. There was no significant difference in infected plants between either treatment and the check on all other sample dates. Also, traps alone reduced adult populations 56% and infected plants 61% on the last sampling date compared with the untreated check. Yields were increased 573% and 539%, respectively, where traps plus permethrin and traps were placed. In 1988/1989 only permethrin significantly reduced adult populations of the sweet potato whitefly (51%) compared with the check (Table 2). Traps caused 23% reduction of adults. Yields of all treatments were statistically superior and were increased 232% to 312% compared with the check. On the last sampling date, *lambda* cyhalothrin, permethrin, and cypermethrin and the yellow trap significantly reduced disease incidence compared with the untreated check (Fig. 2). Percentage of infected plants in the check increased from 22% which was 29 days after planting to 91% on the last sample date. There was no significant difference in infected plants between the check and treatments on days 257 to 301.

In 1990/1991, adult populations were lowest following sprays of permethrin. Yellow sticky traps, diazinon, naled, amitraz, and Safer soap were significantly more effective against this insect than the untreated check (Table 3). Whitefly adults (50) were determined to be strain "A" by DNA analysis in 1992 (Bartlett, pers. comm.). Traps caused a 30% reduction of adults. Dimethoate and the untreated check were statistically similar and had the greatest whitefly population.

Permethrin-treated plots had the greatest yields which were significantly greater than the check, as were all the other treatments (Table 3). Yields were increased 303% to 366% by traps and permethrin, respectively.

Percentage of infected plants in all insecticide-treated plots except permethrin or plots with traps were similar on all sample dates (Figure 3). Only permethrin had significantly fewer diseased plants than the untreated check on the last sampling date.

Table 1. Adult sweet potato whitefly and yields of "serrano" peppers, Estacion Cuauhtemoc, Tamps., Mexico, 1987/1988.*

Treatment	Rate/ha Traps g(AI)	Adults Plant	Yields (kg fruit/ha)
Traps + Permethrin	1,240 + 110	3.2 a	3,062.00 a
Traps	1,240	3.5 a	2,879.47 a
Check		6.3 b	534.63 b

*Means followed by the same letter were not significantly different from each other by Tukey's hsd at $P = 0.05$.

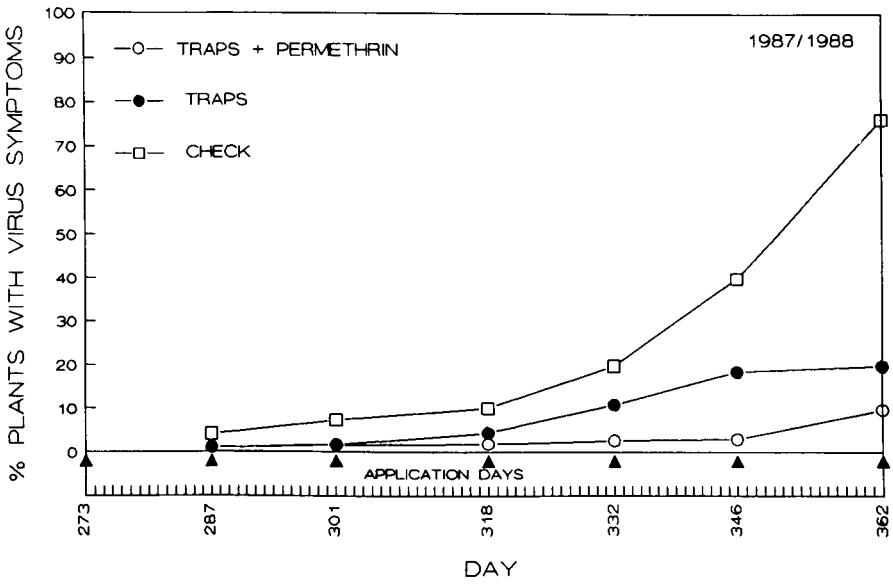

Fig. 1. Virus disease incidence (percentage) during the season in treated and check of "serrano" pepper. Estacion Cuauhtemoc, Tamaulipas, Mexico. 1987-1988.

Table 2. Adult sweet potato whitefly, and yields of "serrano" peppers, Estacion, Cuauhtemoc, Tamps., Mexico, 1988-1989.*

Treatment	Rate/ha		Adults/plant	Yield (kg fruit/ha)
	Traps	g (AI)		
Permethrin		110	2.3 ab	11,346.9 a
Lambda cyhalothrin		110	2.9 abc	11,608.9 a
Cypermethrin		110	3.5 abc	10,767.9 a
Traps	1,240		3.6 abc	7,346.1 a
Phosphamidon		600	3.8 bc	9,165.2 a
Endosulfan		300	3.8 bc	8,437.8 a
Check			4.7 c	3,632.1 b

*Means followed by the same letter are not significantly different from each other by Tukey's hsd at $P = 0.05$.

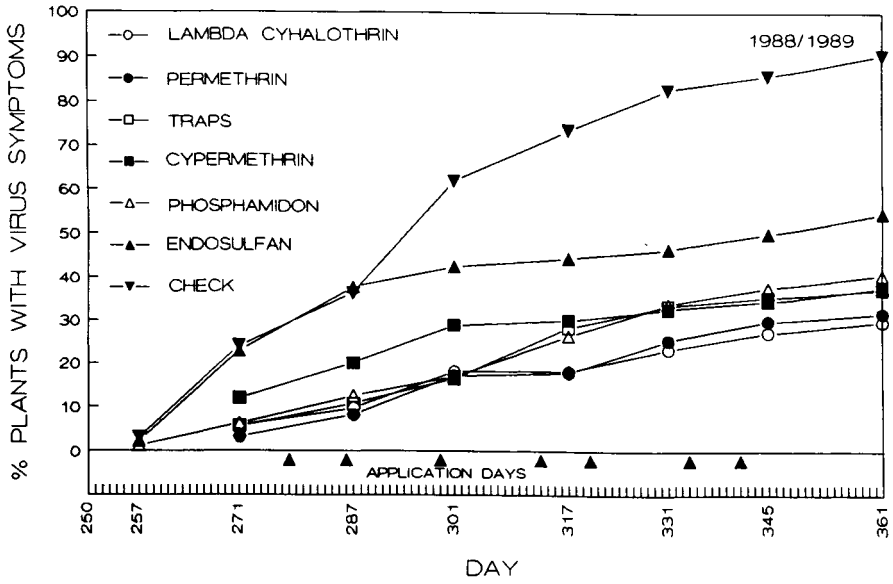

Fig. 2. Virus disease incidence (percentage) during the season in treated and check of "serrano" pepper. Estacion Cuauhtemoc, Tamaulipas, Mexico. 1988-1989.

Table 3. Adult sweet potato whitefly, and yields of "serrano" peppers, Estacion, Cuauhtemoc, Tam., Mexico, 1990-1991.*

Treatment	Rate/ha		Adults/plant	Yield (kg fruit/ha)
	Traps	g (AI)		
Permethrin		110	2.9 a	6,780 a
Traps	1,240		3.9 ab	6,310 a
Naled		600	4.2 b	6,400 a
Diazinon		200	4.1 ab	6,274 a
Amitraz		200	4.2 b	5,910 a
Safer Soap		847	4.2 b	5,840 a
Dimethoate		400	4.4 bc	5,614 a
Check			5.6 c	1,850 b

*Means followed by the same letter were not significantly different from each other at $P = 0.05$ by Tukey.

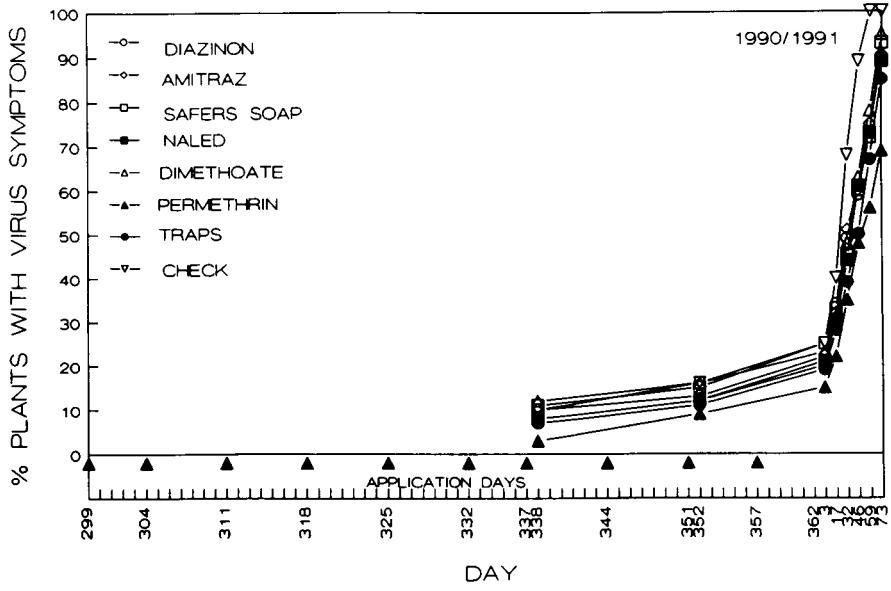

Fig. 3. Virus disease incidence (percentage) during the season in treated and check of "serrano" pepper. Estacion Cuauhtemoc, Tamaulipas, Mexico. 1990-1991.

Incidence of diseased plants were first observed on days 287, (1987/1988), 257 (1988/1989), and 338 (1990/1991), a difference of 81 days (Figures 1-3). We recognize that symptom expression can be influenced by plant stress and environmental factors. Yet, at the end of the season, disease incidence was greatest in 1990/1991 and least in 1987/1988.

Traps alone reduced whitefly populations and incidence of geminiviruses; however, none of the differences were significant compared to the untreated check. Results do show that populations are reduced by traps and this treatment is environmentally acceptable. Perhaps twice as many traps/ha would be an even more effective treatment.

The best treatment was the use of traps combined with sprays of permethrin. Treatment would reduce time of feeding by whitefly populations because they would be killed by the trap before feeding or they would be killed by the insecticide during feeding. There is a reduction of geminivirus transmission any time feeding by adult populations can be reduced; Avila and Pozo (1991) showed that 15 min of feeding by an adult caused 4% infection of plants while 60 minutes of feeding caused a 10-fold increase in infection.

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