# Biological and Selective Control of the Sweetpotato Whitefly, *Bemisia tabaci* (Gennadius) (Hom.: Aleyrodidae)

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Sweetpotato (*Ipomoea batatas*) whitefly (SPWF), *Bemisia tabaci* (Gennadius) is widely spread throughout the tropics and subtropics. The pest infests many food crops, ornamentals, and weeds. In temperate countries, whitefly infestations often occur in greenhouse crops.

For the most part, infestations have been trivial. Then, in the 1970s and 1980s, extraordinary whitefly outbreaks occurred in such diverse areas as Sudan, the Middle East, and California and Florida in the United States.

In most cases, whitefly outbreaks have been associated with the intensive use of insecticides, greater tolerance of the pest for insecticides and destruction of natural enemies. Insecticides have been reported to stimulate whitefly fertility (Castle, 1998). There are cases, however, of outbreaks before the appearance of modern insecticides.

**A new whitefly species**

In the 1990s, widespread whitefly infestations occurred in the tropics and subtropics, including Central and South America and the Caribbean. This new aggressive whitefly was initially thought to be a new strain of *B. tabaci* (strain B). It now has been described as a new species, *B. argentifolii* Bellows & Perring. It is commonly called silverleaf whitefly (SLWF), an apparent reference to the symptoms produced in cucurbit plant leaves (Cohen et al., 1992).

Compared with SPWF, SLWF is becoming one of the most important crop pests because of its higher rate of increase (Bethke et al., 1991), wider range of thermotolerance (Salvucci et al., 1998), efficient transmission of a group of geminiviruses (Gilbertson et al., 1998), high levels of resistance to insecticides (Byrne et al., 1998), more honeydew production (Byrne and Miller, 1990), and a wider range of host plants (Byrne et al., 1990).

**Occurrence of SPWF in Peru**

The occurrence of SPWF in Peru was overlooked until 1982 when it was reported for the first time in a review of sweetpotato insect pests (Cetraro and Ortiz, 1982). Rodriguez and Redolfi (1993) reported the first evaluations of SPWF population densities in cotton, string beans, and sweetpotato. Population densities were low (av 1.0 nymph/leaf for Rimac Valley and 3 nymphs/leaf for Cañete Valley). According to Gerling (1985), whitefly infestations are considered low when nymph/leaf is < 5.

This situation changed dramatically in 1997 and part of 1998 with climatic changes brought about by El Niño. Heavy infestations were even higher in areas where insecticides were applied. That could be interpreted as a result of the destruction of the whitefly's natural enemies.

These heavy infestation coincided with reports of SLWF in the Cañete Valley. High infestations are seen on sweetpotato, cucurbits, and cotton, leading to specula-

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tion that the pest may be replacing SPWF as a sweetpotato pest.

**Natural enemies of SPWF**

Numerous predators, parasitoids, and some entomopathogenic fungi attack whiteflies. They are usually able to effectively regulate whitefly populations. That was so much the case that for years outbreaks were linked to mismanagement of the agroecosystem, particularly the destruction of natural enemies. General surveys in sweetpotato fields conducted from 1987 to 1991 indicated 65 species of natural enemies that prey upon or parasitize sweetpotato pests. For decades, entomologists considered sweetpotato fields that had not been sprayed with insecticides as natural refuges for biological control agents.

**Effects of nonselective compounds on the upsurge of SPWF**

More than 50 conventional insecticides are registered for use against *Bemisia* whiteflies, in some cases for reducing virus transmission. All kinds of products are involved including organophosphates, carbamates, and pyrethroids. Most treatments are directed toward controlling adults, because immature life stages are usually less susceptible and more difficult to reach. Whiteflies at those stages are immobile and located on the underside of leaves.

Additional applications are required as new adults emerge from undamaged puparia. Nine to 15 applications may be necessary to keep adult populations low. Under these conditions whitefly readily develops resistance to insecticides.

In 1997, under the influence of high temperatures brought on by El Niño, most affected farmers applied insecticide 2-4 times, some up to 6 times, against the West Indian sweetpotato weevil (*Euscepes postfasciatus*), whiteflies, and white grubs. As many as 30 commercial insecticide formulations were used. One of the most commonly used against the West Indian sweetpotato weevil was carbofuran. Fields treated with carbofuran showed the highest populations of whiteflies. This effect was not only due to the destruction of natural enemies, but to the trophobiotic effect of the insecticide on the whitefly.

**Effects of bioinsecticides and other selective compounds on whiteflies**

A search for alternative compounds led to the use of rotenone, pyrethrum, a chitin inhibitor, and entomopathogenic fungi against the whitefly pest.

**Plant-derived insecticides and mineral oil.** Plant-derived insecticides, particularly rotenone and pyrethrins, are coming back into use to control crop pests in response to the need for safer products. Mineral oils act as a suffocating agent for immature stages of whiteflies.

**Selective compounds.** Several chitin inhibitors have been introduced in recent years (buprofezin, pyriproxyfen, diafenthiuron, and imidacloprid) to control *Bemisia* whiteflies on cotton and other crops. Most of them have low toxicity to mammals and to biological control agents. Buprofezin shows low toxicity to *Encarsia formosa* Gehan and *Cales noacki* Howard, parasitoids of whiteflies (Mendel et al., 1994; Garrido et al., 1984). It affects embryogenesis in adults and moulting in immature stages.

**Entomopathogens.** Pathogens most commonly recorded infecting *Bemisia* whiteflies in nature are *Paecilomyces fumosoroseus*, *Verticillium lecanii*, and *Aschersonia* sp. Occasional pathogens infecting *Bemisia* whiteflies, also under natural conditions, are *Beauveria bassiana* and *Entomophthora* sp.

There is not much information on the occurrence of epizootic diseases caused by pathogenic fungi. But under high humidity, and if sufficient numbers of pathogenic spores are present, disease should develop. Experiences with the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), and the citrus woolly whitefly, *Aleurothrixus* *floccosus*, have shown that pathogenic fungi can be effective (Fransen, 1990; van der Shaaf et al., 1991).

**Project goal**

A strategy has been developed for an integrated pest management (IPM) program for the management of *Bemisia* whiteflies in sweetpotato. The activities reported here were aimed at evaluating the occurrence of natural enemies and the effectiveness of selective compounds, including bioinsecticides, plant-derived products, and a chitin inhibitor to identify an alternative to chemical insecticide use.

These studies were undertaken before the incidence of SLWF in the Cañete Valley. It is hoped that the methods reported here will have similar efficacy in the management of SLWF.

## Materials and methods

**Natural enemies of the whitefly**

CIP, in collaboration with the Department of Entomology of the Agrarian University, La Molina, Peru, has studied sweetpotato pests and their natural enemies along the central coast of Peru since 1986. In 1997 and 1998, the research emphasis was on studying the natural enemies of whitefly.

**Soil-inhabiting predators.** Pitfall traps, 1-L plastic cups containing 500-cc formaldehyde (5% concentration), were placed in sweetpotato fields. Traps were collected weekly and the number of predators recorded.

**Foliage-inhabiting predators.** Predators were collected directly from the canopy of sweetpotato plants and their presence and numbers recorded. Samples (25 plants/field) were taken weekly.

**Parasitoids.** Whitefly-infested leaves of sweetpotato were gathered at 15-day intervals during the sweetpotato-growing season. Collected leaves were placed in plastic containers and covered with a fine mesh until the emergence of parasitoids.

**Selective compounds**

Several compounds from different groups (plant-derived insecticides, entomopathogens, a chitin inhibitor, and mineral oil) were tested for their effectiveness against whitefly (Table 1).

**Preliminary trial.** A preliminary study was conducted in a commercial sweetpotato field, 30 d after planting, with sweetpotato cultivar INA-100, at San Luis, Cañete, Peru, May 1998. Five compounds were evaluated (rotenone, buprofezin, *Verticillium lecanii, Entomophthora virulenta*, and detergent). Carbofuran was used as a farmers' check. The field was set up in a randomized complete block design (RCBD), with seven treatments and four replicates, in plots 30 rows (l m between rows) wide and 50 m long (1,500 $m^2$). Dosages are presented in Table 1. The plots were sprayed on 27 May with a motorized, backpack sprayer at a rate of 300 L/ha.

**Trials with bioinsecticides and other selective compounds.** Four trials were conducted to evaluate the effectiveness of the five compounds listed in the preliminary experiment. The compounds were tested individually and in mixtures. Trials were carried out in a sweetpotato field 60 d after planting with sweetpotato cultivar INA-100 in San Luis, Cañete, Peru, May-July 1998.

**Trial 1 - Plant-derived insecticides.** Plant-derived insecticides selected were three commercial formulations of rotenone, an emulsifiable concentrate (EC), a wettable powder (WP), and a commercial mixture of rotenone and pyrethrin (EC).

**Trial 2 - Chitin inhibitor.** The chitin inhibitor, buprofezin, was tested in a mixture with plant-derived insecticides.

**Trial 3 - Entomopathogens.** Three fungi pathogens were selected and tested in the

**Table 1.** Treatments used in 5 different trials with selective compounds (entomopathogens, plant-derived insecticides, mineral oil, and a chitin inhibitor) against sweetpotato whitefly. Checks included are absolute checks and insecticide-treated checks. Cañete Valley, Peru, 1998.

| | | Technical name | Trade name[a] | Concentration/ dosage |
|---|---|---|---|---|
| Preliminary experiment | T1 | Buprofezin | Aquitin | 0.1% |
| | T2 | Rotenone | Extracto 50 WP | 0.1% |
| | T3 | *Verticillium lecanii* | Vertisol | $1x10^9$ conidias/bottle |
| | T4 | *Entomophthora virulenta* | Vektor | $1x10^9$ conidias/bottle |
| | T5 | Detergent | Ace | |
| | T6 | Treated check: carbofuran | Carbofor 75 WP | 0.2% |
| | T7 | Absolute check | | |
| Experiment 1 | T1 | Rotenone + buprofezin | Rhotenox 10 EC + Aquitin | 0.4% + 0.1% |
| | T2 | (Rotenone and pyrethrum ) + buprofezin | Rhotenox-SP + Aquitin | 0.4% + 0.1% |
| | T3 | Rotenone + buprofezin | Extracto 50 WP + Aquitin | 0.1% + 0.1% |
| | T4 | Check | | |
| Experiment 2 | T1 | Rotenone | Rhotenox 10 EC | 0.4% |
| | T2 | Rotenone and pyrethrum | Rhotenox-SP | 0.4% |
| | T3 | Rotenone | Extracto 50 WP | 0.1% |
| | T4 | Check | | |
| Experiment 3 | T1 | Oil mineral | Triona-5 | 1% |
| | T2 | Oil mineral + rotenone | Triona-5 + Extracto 50 WP | 1% + 0.1% |
| | T3 | Treated check: endosulfan | Thiodan 35 EC | 0.15% |
| | T4 | Treated check: carbofuran | Carbofor 75 WP | 0.2% |
| | T5 | Check | | |
| Experiment 4 | T1 | *Verticillium lecanii* | Vertisol | $1x10^9$ conidias/bottle |
| | T2 | *Entomophthora virulenta* | Vektor | $1x10^9$ conidias/bottle |
| | T3 | *Beauveria bassiana* | Bauveril | $5x10^{11}$ conidias/bottle |
| | T4 | Check | | |

[a] WP= wettable powder; ED=emulsifiable concentrate, SP=supension powder.

field: *Verticillium lecanii, Entomophthora virulenta,* and *Beauveria bassiana*. Formulations of the fungi (dehydrated conidia) were commercially-produced. Dosages used were those recommended by the manufacturer.

**Trial 4 - Other products.** Selective products were an emulsifiable mineral oil and mineral oil mixed with rotenone. Two nonselective products were used as farmers' check (endosulfan and carbofuran).

Each trial was an RCBD with four replicates. Experimental plots were 14 rows wide and 25 m long (350 m²). Plots were treated twice at 14-d intervals (24 June and 10 July) using a motorized, backpack and sprayed at a rate of 400 L/ha. Sprayers used special nozzles to ensure wetting of the underside of leaves where whiteflies live.

**Sampling methods**

At weekly intervals, 20 leaves/plot were collected from among the most heavily infested leaves on the bottom or middle part of the plant. Nymphs and pupae were counted under a stereoscope in the laboratory. Mortality of nymphs and pupae was determined when they were dry. Population density was expressed as number of immature stages/cm² due to the differences in leaf size.

Estimates of the whitefly populations were done 0, 7, and 14 d after application in the preliminary trial. In the four other trials, estimates of the whitefly population were done 0, 7, and 14 d after the first application; and 7, 14, and 21 d after the second application. Adult populations were not evaluated because of the high migratory movement of whiteflies from highly infested surrounding fields.

**Statistical analysis**

Data were transformed (square root) before statistical analysis and were analyzed using 1-way ANOVA. Means were separated by LSD (P = 0.05). To separate the effects of pesticide treatment from those caused by natural factors, the percent of population reduction was corrected using a modified Abbott's formula (Fleming and Retnakaran, 1985).

## Results and Discussion

**Natural enemies of the whitefly**

**Predators.** Predators collected in the canopy of sweetpotato plants (Table 2) were as varied as the groups reported worldwide by Nordlund and Legaspi (1995), except for mites, which were not sampled. The most abundant predators were spiders of two genera, *Anyphaena* and *Pardosa,* and the fly, *Condylostylus similis*. The predatory

**Table 2.** Ocurrence of canopy inhabitant predators[a] in sweetpotato infested with white fly *Bemisia tabaci* in the Cañete valley, Peru.

| Predators | 1994 | | 1995 | | 1996 | |
|---|---|---|---|---|---|---|
| | No | % | No | % | No | % |
| Spiders | 101 | 57.4 | 93 | 45.5 | 113 | 38.4 |
| *Chrysoperla externa* | 3 | 1.7 | 15 | 7.3 | 9 | 3.1 |
| *Orius sp.* | - | - | - | - | 7 | 2.1 |
| *Hyaloides sp.* | - | - | - | - | 5 | 1.4 |
| *Nabis punctipennis* | 5 | 2.8 | 8 | 3.9 | 7 | 2.4 |
| *Rhinacloa sp.* | 18 | 10.2 | 24 | 11.7 | 7 | 2.4 |
| *Aknisus sp.* | 4 | 2.3 | 9 | 9.4 | 3 | 0.3 |
| *Scymmus sp.* | - | - | - | - | 13 | 4.3 |
| Coccinelids | 18 | 10.2 | 18 | 8.8 | 30 | 10.1 |
| *Condylostylus similis* | 26 | 14.8 | 30 | 14.6 | 93 | 32.1 |
| Syrphidae | - | - | - | - | 8 | 1.3 |
| *Geocoris sp.* | 1 | 0.6 | 8 | 3.9 | 8 | 3.2 |
| **Total** | **176** | **100** | **205** | **100.0** | **292** | **100.0** |

[a] Number of predators in 1.25 m²

activity of nonwebbing spiders on whiteflies is not well known, but *Anyphaena* spp. efficiently trapped whitefly adults in their webs. The coccinellids (*Cycloneda sanguinea*, *Scymnus* sp., *Hippodamia convergens*, *Eriopis connexa,* and *Coleomegilla maculata*) were fairly abundant and preyed upon whitefly immature stages. Other, less abundant species, that also preyed upon the immature stages were *Chrysoperla* spp. *Hyaliodes* sp., *Rhinacloa* spp., *Nabis punctipennis*, and *Geocoris punctipes*.

The most abundant soil inhabiting predators were a carabid beetle (*Pterostichus* sp.) and one species of earwig (*Labiduria riparia)* (Table 3).

**Parasitoids.** Three genera of parasitoids were recorded in the Cañete Valley (Table 4). As in other parts of South America and the world, *Encarsia* species were the most abundant, with *E. portieri* being the most frequently found. Parasitism used to be the most important mortality factor of whiteflies in the Cañete Valley. In 1987, an average of 41% parasitism was recorded, ranging from 4% in fields with insecticide treatments to 70% in untreated fields (Table 5).

Parasitism has been reduced with increased insecticide use. At the same time, infestations of whitefly have steadily increased to present levels. Donet and Vergara (1994) recorded the destruction of spider populations in sweetpotato fields treated with insecticides against the West Indian sweetpotato weevil. Velapatiño and Sanchez (1996) recorded low populations of predators in Cañete fields commonly treated with insecticides.

**Table 3.** Soil inhabitant predators captured by pitfall traps in sweetpotato fields in Cañete Valley, Peru, 1998.

| Year | Predators /trap/season (No) | |
|---|---|---|
| | *Pterostichus* sp. (Coleoptera: Carabidae) | *Labiduria riparia* (Dermaptera:Labiduridae) |
| 1994 | 306.4 | 94.8 |
| 1996 | 100.0 | 44.9 |
| 1998 | 26.0 | 350.7 |

**Table 4.** Parasitoids[a] of sweetpotato whitefly nymphs, central coast of Peru.

| Parasitoids | Locality | |
|---|---|---|
| | La Molina | Cañete |
| Platygasteridae | | |
| *Amitus* sp. | VS | - |
| *Encarsia* sp. prob. *bicolor* De Santis | S | VS |
| *Encarsia porteri* (Mercet) | A | S |
| *Encarsia (Prospaltella)* sp. (A) | VS | VS |
| *Encarsia* sp. (B) | VS | - |
| *Eretmocerus* sp. | - | VS |

[a] VS= very scarce; S= scarce; A=abundant.
(A) and (B) non-identified species.

**Table 5.** Variation in the level of parasitism of the sweetpotato whitefly *Bemisia tabaci*, on sweetpotato during the last 11 years, Cañete Valley, Peru, 1987-1988.

| Year | Nymph/leaf | Parasitism (%) | | |
|---|---|---|---|---|
| | | Minimum | Maximum | Average |
| 1987 | 1.9 | 4.0 | 70.0 | 41.2 |
| 1989 | 2.4 | 5.0 | 27.0 | 28.0 |
| 1994 | 20.5 | | (few, not quantified) | |
| 1995 | 39.8 | 0.0 | 2.6 | 0.3 |
| 1996 | 46.4 | 0.0 | 0.0 | 0.0 |
| 1998 | 853.5 | | (few, not quantified) | |

**Selective compounds**

**Preliminary trial.** Buprofezin was very effective against nymphs, reducing the whitefly population of 32.1 nymph/cm$^2$ to 0.9 nymph/cm$^2$ in 14 d (98% mortality). No significant differences in nymph number were observed between other treatments (rotenone, entomopathogens, and detergent) and the check, but a decrease in the adult population in the field was observed. Plots treated with carbofuran had an increase in whitefly populations from 62.7 nymphs/cm$^2$ to 102.9 nymphs/cm$^2$ in 14 d. In the trials discussed below, rotenone and buprofezin were mixed for better whitefly control.

Identification of nymphs affected by the different treatments was one of the main difficulties faced during the experiments. Because nymphs and pupae are immobile and fixed to the underside of the leaf surface, movement could not be used as a sign of life. In addition, most products (entomopathogens, rotenone, mineral oil, and buprofezin) are intrinsically slow acting. Mortality does not occur as fast as with conventional insecticides. It was also difficult to spray the underside of the leaf surface even with the special nozzles used.

**Trial 1 – Plant-derived insecticides.** No significant differences (P = 0.05) in nymph number were observed until 2 wk after the second application (Table 6). Rotenone + pyrethrin resulted in an average of 1.2 nymph/cm$^2$ compared with 5.2 nymph/cm$^2$ in the check, representing 73% mortality (Table 6). These formulations can be used under moderate levels of whitefly infestation.

**Trial 2 – Chitin inhibitor.** Buprofezin mixed with other compounds (rotenone or pyrethrin) did not increase control of immature stages (Table 6). The effect of buprofezin was evident (more than 90% mortality) 7 d after the second application when the av was 0.6-0.8 nymph/cm$^2$ compared with 13.3 nymphs/cm$^2$ in the check. The residual effect of buprofezin in the field resulted in nymph mortality of 76-88.5% over 21 d.

**Trial 3 – Entomopathogens.** To separate healthy immature stages from those infected by the entomopathogens was difficult, particularly during the first 10 d after the first application when no external changes in nymphs and pupae were evident. After the second application, only *B. bassiana* was effective, with 69% of nymph population dead (dried) after 21 d (Table 6). We were unable, however, to detect the fungus before dehydration.

**Trial 4 – Other products.** Mineral oil acts as a suffocating agent for immature

**Table 6.** Leaf average nymph population per square cm at the indicated days after application per treatment, Cañete, Peru, 1998.

| | Treatment | Before treatment | | Days after application: First application 7 | | 14 | | Second application 7 | | 14 | | 21 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exp. 1 | Rotenone | 15.5 | a | 5.8 | a | 5 | a | 2.7 | b | 2.4 | ab | 2.03 | a |
| | Rotenone and pyrethrum | 23.6 | a | 5.1 | a | 11.2 | a | 3.7 | b | 1.2 | b | 1.2 | a |
| | Rotenone | 34.6 | a | 7.5 | a | 11.7 | a | 12.3 | a | 4.7 | ab | 3.2 | a |
| | Check | 27.6 | a | 7.3 | a | 11.7 | a | 9.3 | ab | 5.2 | a | 2.73 | a |
| Exp. 2 | Rotenone + buprofezin | 21.9 | a | 7.5 | a | 4.9 | a | 0.7 | b | 0.3 | b | 0.26 | a |
| | (Rotenone and pyrethrum) + buprofezin | 36.5 | a | 6.4 | a | 5.7 | a | 0.6 | b | 0.1 | b | 0.5 | a |
| | Rotenone + buprofezin | 33.4 | a | 7.5 | a | 7.2 | a | 0.8 | b | 0.4 | b | 0.83 | a |
| | Check | 35.7 | a | 8.5 | a | 9.1 | a | 13.3 | a | 3.5 | a | 3.7 | a |
| Exp. 3 | *Verticillium lecanii* | 34.9 | a | 13.9 | a | 8.9 | a | 6.6 | a | 2.8 | a | 0.85 | a |
| | *Entomophthora virulenta* | 30.6 | a | 11.7 | a | 8.2 | a | 4.4 | a | 2.3 | b | 0.83 | a |
| | *Beauveria bassiana* | 34.6 | a | 13.3 | a | 11.8 | a | 6.9 | a | 1.8 | ab | 0.4 | a |
| | Check | 20.9 | a | 14.3 | a | 10.2 | a | 5.7 | a | 2.1 | ab | 0.78 | a |
| Exp. 4 | Oil mineral | 16.2 | a | 6.1 | b | 4.6 | a | 2.2 | c | 3.8 | b | 3.48 | ab |
| | Oil mineral + rotenone | 21.3 | a | 5.6 | b | 6.4 | a | 2.3 | bc | 3.1 | b | 2.6 | ab |
| | Treated check : endosulfan | 24.2 | a | 9.9 | ab | 6.7 | a | 2 | c | 2.7 | b | 2.45 | ab |
| | Treated check : carbofuran | 15.1 | a | 6.6 | b | 9.7 | a | 7.6 | a | 7.8 | a | 5.35 | a |
| | Check | 20.9 | a | 14.3 | a | 9.8 | a | 4.5 | ab | 4.2 | ab | 3.6 | ab |

Within a column, means followed by a common letter do not differ significantly at P=0.05 by DMRT.

stages of whitefly. Its effect was noticeable 7 d after the first application. The number of nymphs was reduced by 45% compared to the check (6.1 nymph/$cm^2$ compared to 14.3 in the check) (Table 6). No residual effect was observed. When rotenone was added to the mineral oil treatment, no significant increase in the effect (P = 0.05) was observed throughout the evaluation dates (Table 6).

Mineral oil treatment was as good as the farmers' check (endosulfan) or better in the cases where farmers used carbofuran. Plots treated with carbofuran showed the highest whitefly population when, 14 d after the second application, the population increased 157% compared with the check. This illustrates the trophobiotic effect of carbofuran on the whitefly nymph population.

## Conclusions

All treatments—entomopathogens, rotenone, mineral oil, and buprofezin—contributed to controlling whitefly by killing nymphs. Mortality probably was higher than the level recorded due to their slow action. The compounds tested are considered fairly safe for natural enemies (except carbofuran and endosulfan, used as treated checks).

Unfortunately, under the experimental conditions, it was not possible to verify the reaction of natural enemies. The area had been under such intensive chemical control for several seasons that no parasitoids were recovered. Under other conditions we might have expected the action of natural enemies to complement treatments.

The whitefly outbreak in Cañete Valley, which coincided with the identification of SLWF, a new species of whitefly displacing SPWF in Cañete, is a repeat of what has happened in other parts of the world. Conditions were similar, in particular the intensive use of insecticides. The effects were also similar: higher populations, wider range of crops affected, more severe damage, and resistance to insecticides.

The use of rotenone, chitin inhibitors, mineral oils, and entomopathogenic fungi were fairly effective in our experiments. These products can be integrated with other IPM components to manage SPWF. Also, these treatments are expected to allow the recovery of parasitoids and predators decimated by the use of conventional insecticides.

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**Literature Cited**

Bethke, J.A., T.D. Paine, and G.S. Nuessly. 1991. Comparative biology, morphometrics, and development of two populations of *Bemisia tabaci* (Homoptera: Aleyrodidae) on cotton and poinsettia. Ann. Ent. Soc. America 84:407-411.

Byrne, D.N. and W.B. Miller. 1990. Carbohydrate and amino acid composition of phloem sap and honeydew produced by *Bemisia tabaci.* J. Insect Phys. 36:433-439.

Byrne, D.N., T.S. Bellows, Jr., and M.P. Parrella. 1990. Whiteflies in agricultural systems. In: Gerling, D. (ed.). Whiteflies: Their bionomics, pest status and management. Intercept Ltd., Andover, Hants, UK. p. 227-261.

Byrne, F.J., M. Cahill, I. Denholm, and A.L. Devonshire. 1998. Understanding insecticide resistance in *Bemisia*. Silverfeaf Whitefly. National Research, Action, and Technology Transfer Plan, 1997-2001: First annual review of the second 5-Year Plan. Proc. of the Ag. Res. Serv. United States Department of Agriculture, Washington, D.C., USA. p. 3.

Castle, S.J. 1998. Primary pest or synthetically induced? The role of insecticides and other factors in the pest status of *Bemisia tabaci*. Silverfeaf Whitefly. National Research, Action, and Technology Transfer Plan, 1997-2001: First annual review of the second 5-Year Plan. Proc. of the Ag. Res. Serv. United States Department of Agriculture, Washington, D.C., USA.

Cetraro, L. and M. Ortiz. 1982. Ocurrencia estacional de insectos de camote (*Ipomoea batatas*), en la costa central del Perú. Rev. Per. Ent. 25(1):17-32.

Cohen, S., J.E. Duffus, and H.Y. Liu. 1992. A new *Bemisia tabaci* biotype in the southwestern United State and its role in silverleaf of squash and transmission of lettuce infectious yellow virus. Phytopathology 82:86-90.

Donet, C.J. and C. Vergara. 1994. Fluctuación poblacional de *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae) y de sus controladores biológicos en tres variedades comerciales de camote en el valle de Cañete. Informe de Investigación Convenio UNALM-CIP. 39 p.

Fleming, R. and A. Retnakaran. 1985. Evaluating single treatment data using Abbott's formula with reference to insecticides. J. Econ. Entomol. 78:1179-1181.

Fransen, J.J. 1990. Natural enemies of whiteflies. In: Gerling, D. (ed.). Whiteflies: Their bionomics, pest status and management. Intercept Ltd., Andover, Hants, UK. p.187-210.

Garrido. A., F. Beitia, and P. Gruenholz. 1984. Effects of PP618 on inmatures stages of *Encarsia formosa* and *Cales noacki* (Hymenoptera:Aphlelinidae). Proceedings of the British Crop Protection Conference – Pests and Diseases. p. 305-310.

Gerling, D. 1985. Parasitoids attacking *Bemisia tabaci* (Hom.: Aleyrodidae) in eastern Africa. Entomophaga 30:163-165.

Gilbertson, R.L., M.R. Sudarshana, H. Wang, Y. Hou, R. Salati, E.G. Ramirez, and W.J. Lucas. 1998. An update of the status of whitefly-transmitted geminivirus: The good, the bad and the ugly. Silverfeaf Whitefly. National Research, Action, and Technology Transfer Plan, 1997-2001: First annual review of the second 5-Year Plan. Proc. of the Ag. Res. Serv. United States Department of Agriculture, Washington, D.C., USA. p. 1-3.

Mendel, Z., D. Blumberg, and I. Ishaaya. 1994. Effect of insect growth regulators on natural enemies of scale insects (Hom.:Coccidae). Entomophaga 39:199-209.

Nordlund, D.A. and J.C. Legaspi. 1995. Whitefly predators and their potencial for use in biological control. In: Gerling, D. and R.T. Mayer (eds.). *Bemisia*: Taxonomy, biology, damage, control and management. Intercept Ltd., Andover, Hants, UK. p. 499-513.

Rodriguez, C. and I. Redolfi. 1993. *Bemisia tabac*i (Homoptera:Aleyrodidae) y sus parasitoides en la costa central peruana. Rev. Per. Ent. 35:77-81.

Salvucci, E.M., G. Wolfe, and D.L. Hendrix. 1998. Polyol synthesis as a mechanism for thermotolerance in *Bemisia*. Silverfeaf Whitefly. National Research, Action, and Technology Transfer Plan, 1997-2001: First annual review of the second 5-Year Plan. Proc. of the Ag. Res. Serv. United States Department of Agriculture, Washington, D.C., USA. p. 1.

Van der Shaaf, D.A., W.J. Ravensberg, and M. Malais. 1991. *Verticillium lecanii* as a microbial insecticide against whitefly. IOBC/WPRS Bulletin 14:120-123.

Velapatiño, J. and G. Sánchez. 1996. Fluctuación poblacional de *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae) en dos variedades comerciales de camote en el valle de Cañete. Informe de Investigación Convenio UNALM-CIP. 30 p.