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Texas Agricultural Extension Service
The Texas A&M University System

Managing the Sweetpotato Whitefly in the Lower Rio Grande Valley of Texas

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Introduction

The sweetpotato whitefly, *Bemisia tabaci* (Gennadius), has become an important pest of cotton, vegetables and ornamentals in the Lower Rio Grande Valley of Texas with the introduction of a new B-strain (also referred to as the "silverleaf whitefly"). Strains of sweetpotato whitefly are morphologically identical, but can differ in host range, reproductive behavior and other characteristics. In general, the B-strain is a more aggressive crop pest than the A-strain, which has been displaced by the B-strain in many areas. In a 1991 outbreak of B-strain sweetpotato whitefly in Texas, cotton and vegetables sustained estimated direct losses of $24 million and $29 million, respectively. Losses in ornamentals that year were estimated at $23.8 million. Neither chemical, biological nor cultural controls used alone have controlled the sweetpotato whitefly where it has become a predominant pest in field crops. However, the integration of several control tactics can be effective in reducing the overall impact of this pest and may lead to an acceptably low level of whitefly infestation.

To manage this pest, it is necessary to know **what plants are affected** by whiteflies and to understand the nature of its **damage to crops**, the **biology of the sweetpotato whitefly**, and

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Photo 1. Close-up of sweetpotato whitefly adult.

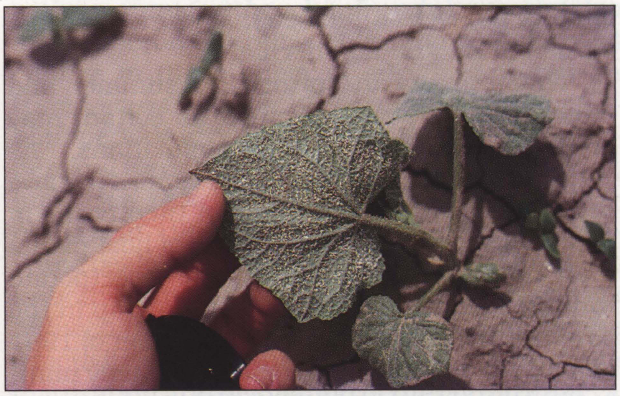

Photo 2. Sweetpotato whiteflies on melon leaves.

Photo 3. Melons killed by sweetpotato whitefly

Photo 4. Sooty mold on cotton.

how to **monitor whitefly populations** (sites, population dynamics, action thresholds). Also, it is critical to know the limitations of various control tactics, which include cultural controls (such as altered planting practices and physical barriers), host plant resistance, chemical controls and natural controls.

Plants Affected by Whiteflies

Although the sweetpotato whitefly has a wide range of host plants (more than 500 species) not all of these plants support large populations of whiteflies. The B-strain is a pest on a wider range of host crops than the A-strain; for example, the B-strain reproduces well on cabbage while the A-strain does not. Also, relatively low numbers of the B-strain can cause striking plant disorders, such as silver leaf of squash and irregular ripening of tomatoes. Low numbers of the A-strain do not produce noticeable direct damage. Crops that support large numbers of the B-strain sweetpotato whitefly include cotton, cabbage and other cole crops, cucumber, squash, melons, tomatoes, eggplant, sesame, soybean, peanuts and many ornamentals, including poinsettia, hibiscus, lantana, verbena, garden mum and mandevilla.

Crops grown in spring and summer and crops in large acreages, such as cotton, may produce very large whitefly populations. As cotton is defoliated, whiteflies are forced to move in search of new hosts and can then occur in higher numbers on a wider range of host plants than normal. For example, the sweetpotato whitefly migrations from the cotton crop in the Lower Rio Grande Valley in the summer of 1991 resulted in a dramatic increase in whitefly numbers in some citrus orchards, which typically do not have problems with this pest. Susceptible crops grown in greenhouses or other protected areas that maintain warm temperatures throughout the year may have whitefly outbreaks year-round.

Whitefly Damage

Direct crop damage occurs when whiteflies feed in plant phloem, remove plant sap and reduce plant vigor. With high populations plants may die (Photo 3). Whiteflies also excrete honeydew, which promotes sooty mold that interferes with photosynthesis and may lower harvest quality. In cotton, the sugars excreted during whitefly feeding make the cotton fibers sticky and can promote growth of sooty mold, both of which reduce quality (Photo 4). In some hosts, damage can result from whitefly feeding toxins that cause plant disorders such as silver leaf of squash (Photo 5) and irregular ripening of tomato (Photo 6). Plant viruses also can be transmitted by whiteflies, such as the gemini viruses in tomatoes (Photo 7) and peppers (Photo 8). Plant disorders and virus transmission are of particular concern because they can occur even when a whitefly population is small. In general, the later the infection with gemini viruses or the later the onset of plant disorders, the less damage to the crop, so preventive action is critical. Prevention is also crucial in managing whiteflies in highly cosmetic crops such as ornamental plants, where even low numbers of whiteflies can affect marketability.

Whitefly management in a given crop will depend greatly on the severity of damage caused in that crop and the number of whiteflies required to inflict this damage. Very few w[illegible] are required to transmit viruses, so where this is the major concern, the grower will want to avoid even small numbers of whiteflies. A combination of selected cultural practices, intensive chemical treatments or physical controls, and/or the development of host plant resistance, may be most effective. Where low levels of whiteflies are tolerable, other methods such as biological control can be more effective.

Biology of the Sweetpotato Whitefly

There are several types of whiteflies in the Lower Rio Grande Valley of Texas in addition to the sweetpotato whitefly. These include the banded-winged whitefly (*Trialeurodes abutilonea* Haldeman) and greenhouse whitefly (*Trialeurodes vaporariorum* Westwood). Banded-winged whitefly adults, as the name implies, have dark bands across white wings. The greenhouse whitefly adult looks similar to the sweetpotato whitefly, except that it holds its wings horizontally at rest. It is important to be able to distinguish the sweetpotato whitefly because its susceptibility to control measures is quite different from that of the other whiteflies.

The sweetpotato whitefly adult is small, about 0.9 to 1.2 mm in length. At rest it holds its solid white wings roof-like over its pale yellow body (Photos 1 and 2). Immature stages begin with a pointed, oblong, yellow egg (0.2 mm) which darkens at the apex just before hatching (Photo 15). The first instar or crawler (0.2 to 0.3 mm) is a flattened, oval nymph which attaches itself to the underside of a leaf near the empty egg. It remains there through three more molts. Late third and fourth instars begin to develop distinctive eye spots and are often referred to as red-eyed nymphs (Photo 16). The last instar, or "pupal stage" (0.7 to 0.8 mm), has very prominent eye spots and is oval and flat with a rounded outside margin, tapering toward the leaf surface as viewed from the side. In contrast, the pupae of *Trialeurodes* species have distinctly ridged outside margins with flat, vertical surfaces and waxy projections at the tops of the ridges as viewed from the side.

The life cycle (Figure 1) from egg to adult requires 2 to 3 weeks in warm weather, but may take as long as 2 months under cool conditions. The number of eggs produced per female is also [illegible]rm weather than in cool weather. The rates of reproduction for both strains of sweetpotato whitefly vary with the host plant, but the average is 160 eggs per female (range of 50 to 400), of which about two-thirds are female. This high reproductive potential explains in part how whitefly populations can increase so rapidly (1 female → 100 females → 10,000 → 1,000,000—approximate number of adult females resulting from three generations assuming no mortality occurs).

Monitoring Whitefly Populations

Methods of monitoring for whiteflies include the use of sticky traps, leaf inspection, vacuum sampling and others. The movement of whitefly adults can be monitored with yellow sticky traps. This method also can provide a relative measure of (1) general population trends for an extended area, (2) immigration rates into fields prior to planting, and (3) potential dispersal of adults from certain crop situations. Adults can both fly short distances within the plant canopy and be carried long distances on air currents. Some migrating adults can stay suspended for more than an hour and can be carried great distances. **Even so, whitefly adults are usually more concentrated close to the ground and close to the source of infestation.** Adults emerge from pupae during the morning and become more active as temperature increases. Thus, movement is greatest from mid-morning to mid-afternoon. Adults tend to settle randomly after a long-distance flight, but are able to perceive color at short distances and will preferentially select yellow/green objects.

Since June 1991, 3-inch by 3-inch yellow sticky cards have been used to monitor the activity of migrating whitefly adults in Hidalgo and Cameron Counties. Since there is a diurnal change in the number of adults captured on traps, sampling has been conducted over 24-hour periods in order to minimize daytime variation and focus on differences between locations. Increases of whiteflies occurred in a similar pattern in 1991, 1992 and 1993, with a measured peak in late July (Figure 2). By late August in both years, adult numbers were drastically reduced. This rapid increase, peak and decline in activity of migrating adults correlates with the maturation and defoliation of the cotton crop. A should be sampled. Sampling 100 leaves per field (one leaf on each of 100 randomly selected plants) can provide a very good estimate of the average whitefly population density in the field, but fewer samples are usually needed to make a control decision.

The location on the plant of the various stages of the sweetpotato whitefly follows the development of the plant. Eggs and early instar nymphs are found on the young leaves and larger nymphs are usually more numerous on older leaves. For exam-ple, large nymphs are more noticeable at the sixth to eighth node from the growing point than on younger leaves in melons and tomatoes (Figure 3). On cabbage, higher concentrations of large nymphs occur on the oldest leaves (frame leaves). Thus, the age of leaves inspected affects the observed number of nymph stages. In general, large nymphs are the easiest of the immature stages to sample because they can be counted with the unaided eye. The advantage of sampling for nymphs is that it provides a better measure of actual whitefly population density in the field. This sampling method also can be used to measure percent parasitism, which may be critical in a biological control program. The disadvantage is that an infestation may become well established prior to the detection of nymphs.

Action thresholds are levels of pest populations at which control should be implemented to avoid significant damage to the crop. Action thresholds help producers determine both the need for control actions, such as insecticide applications, and the proper timing of such actions. Unfortunately, there is little data with which to establish thresholds for the B-strain of sweetpotato whitefly on most crops. In cucum-

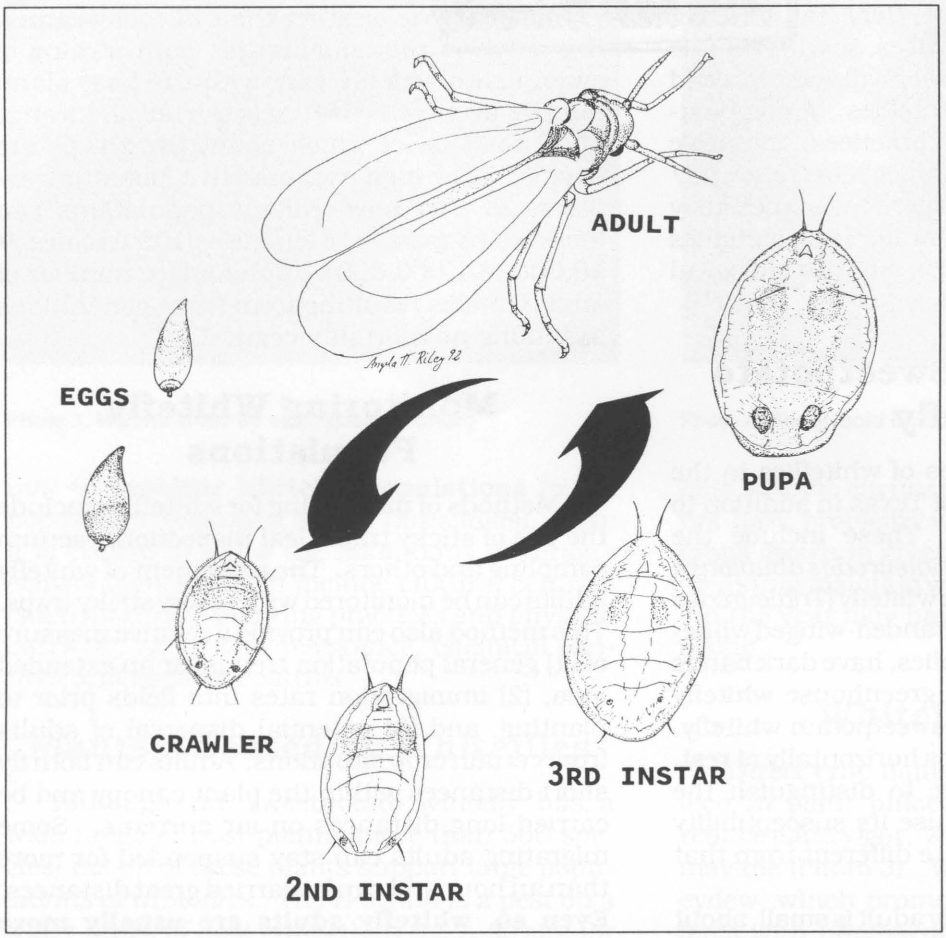

Figure 1. The life cycle of the sweetpotato whitefly (approximately 18 days at 86 degrees F).

smaller peak in migration activity has been observed at the end of the spring melon crop. Those periods during the year when large acreages of host crops are removed tend to produce the largest migrations and subsequent crop infestations. Cotton defoliation, for example, causes a large migration of whitefly adults to other crops. Cotton stalk destruction in the fall contributes to a regional decline of whitefly numbers, as do cooler temperatures and a fall build-up of natural enemies.

Eggs are laid and immature stages of sweetpotato whitefly develop on the undersides of leaves on most crops. Adults congregate on younger leaves in most crops and oviposition is heaviest on these leaves (Figure 3). Adult population densities within many susceptible vine or bush crops can be determined by counting the number of adults per fully expanded leaf (by gently turning over a leaf at the third or fourth node from the tip). In cabbage, older leaves

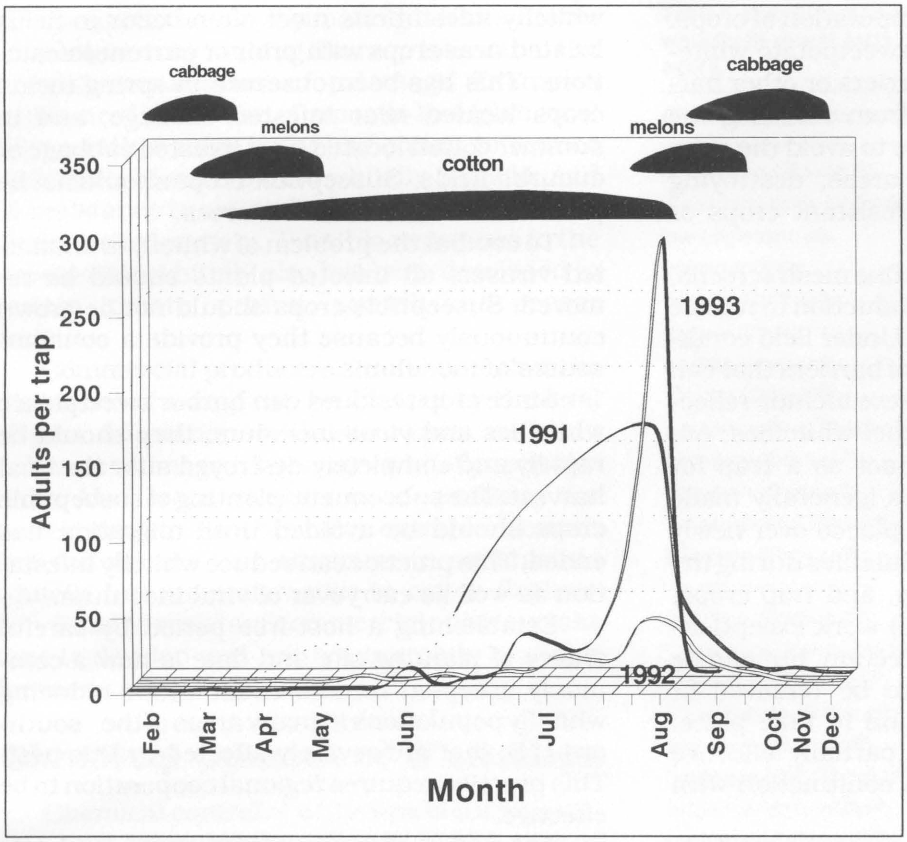

Figure 2. Population dynamics of the sweetpotato whitefly in the Lower Rio Grande Valley of Texas (measured by yellow sticky traps) relative to cropping sequences.

ber, an average of 30 nymphs per square inch of leaf completely stunts growth. In poinsettia, more than two to five immatures per square inch of leaf is considered a damaging level. In Arizona cotton, after satisfactory control measures pupae were reduced to between one and 14 per leaf and adults to 10 to 12 per leaf. Data collected in 1992 at the Texas Agricultural Experiment Station at Weslaco suggest that an average of one large nymph per square inch of leaf at the sixth leaf node is a potentially damaging level in cantaloupe (resulting in approximately 10 percent yield loss). The action threshold in melons is currently estimated at an average of three adults per leaf. Sampling of adults is simpler and often more acceptable to growers than counting nymphs. Having samples of both adults and nymphs can help determine if the infestation is recent (adults present, but no nymphs) or established (nymphs present). With the limitations in available chemical treatments, the use of economic thresholds is essential for efficient whitefly management and economical production of susceptible crops.

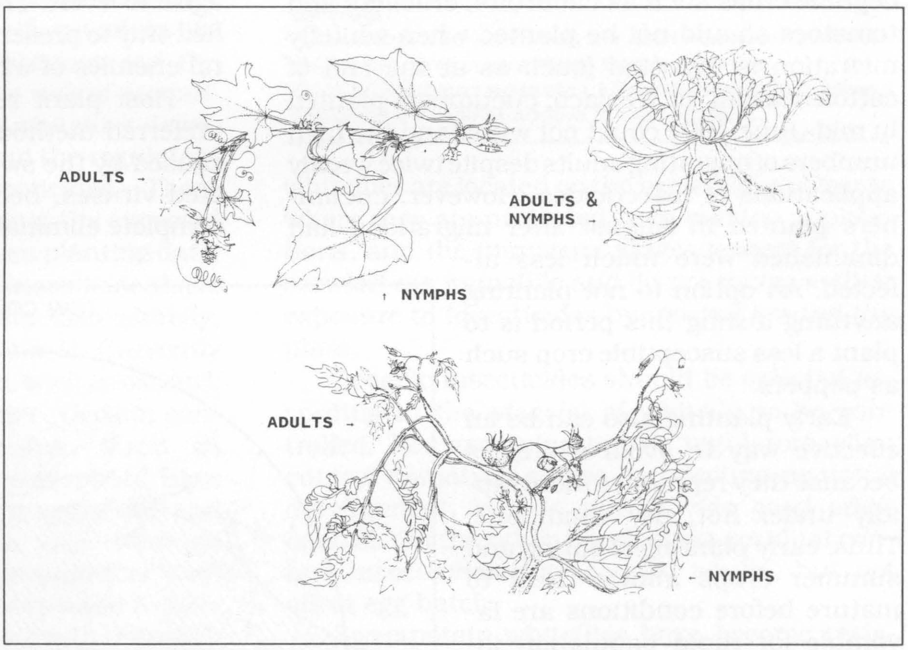

Figure 3. Typical concentration of sweetpotato whitefly adults and large nymphs relative to the plant structure on melons, tomato and cabbage.

Cultural Control of Whiteflies and Host Plant Resistance

One solution to any pest problem is to prevent or avoid it through cultural manipulation of crops. Cultural control options for sweetpotato whitefly include using physical barriers or other barriers that prevent the pest from reaching the crop, adjusting planting dates to avoid the pest, planting in low infestation areas, destroying crop residue and selecting resistant crops or cultivars.

Physical barriers, such as fine mesh screens, can be used in greenhouse production to reduce the potential for infestation. Under field conditions, there are several types of barriers that can reduce whitefly problems. These include reflective mulches that tend to repel whiteflies, oil-coated yellow mulches that act as a trap for whiteflies, floating row covers (generally made out of a light fiber mesh and placed over newly planted crops) that exclude whiteflies during the vegetative growth of the crop, and trap crops. Floating row covers (Figure 4) work exceptionally well for early-season protection, but can be expensive and often have to be removed at flowering for proper pollination to take place. Other barriers may be only partially effective and should be considered in conjunction with other control tactics.

Another way to avoid or reduce whitefly infestations is to adjust planting dates to avoid heaviest insect migration periods. Highly susceptible crops such as cucurbits, crucifers and tomatoes should not be planted when whitefly migration is expected (such as at the end of cotton season). In Weslaco, cucumbers planted in mid-June 1991 could not withstand the high numbers of migrating adults despite twice weekly applications of insecticides. However, cucumbers planted in August after migrations had diminished were much less affected. An option to not planting anything during this period is to plant a less susceptible crop such as peppers.

Early planting also can be an effective way to avoid whiteflies because they reproduce more rapidly under hot, dry conditions. Thus, early planting of spring and summer crops allows them to mature before conditions are favorable for rapid population increases.

Field location also can affect the potential for whitefly infestation. The earliest and heaviest whitefly infestations most often occur in fields located near crops with prior or current infestations. This has been observed in spring melon crops located near infested cabbage, and in summer cotton located near infested cabbage or cucurbit fields. Susceptible crops should not be planted near infestation sources.

To combat the problem of whitefly-transmitted viruses, all infected plants should be removed. Susceptible crops should not be grown continuously because they provide a constant source of inoculum.

Since crop residues can harbor sweetpotato whiteflies and virus inoculum, they should be rapidly and completely destroyed after the final harvest. The subsequent planting of susceptible crops should be avoided until migration has ended. This practice can reduce whitefly infestation as well as carryover of viral inoculum.

Establishing a host-free period by careful choice of planting site and date is now a commonly accepted recommendation for reducing whitefly populations in many areas of the southern U.S. that are severely affected by this pest. This practice requires regional cooperation to be effective.

Although these practices may not completely eliminate whitefly problems, they can help to reduce pest populations and damage to manageable levels. These practices should be modified only to preserve known populations of natural enemies of whiteflies.

Host plant resistance (HPR) is one of the preferred methods for minimizing the damage caused by the sweetpotato whitefly and associated viruses, because it does not require the complete elimination of the pest to be effective.

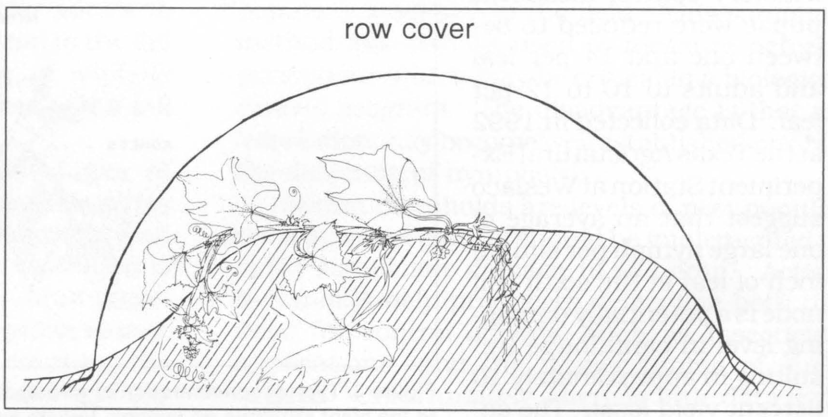

Figure 4. Floating row covers used as a mechanical barrier to insects (maintained over the crop from direct seeding to first flowering).

HPR protects the crop by making it less suitable for the pest or by making the crop tolerant to the pest. The result is less crop damage. Examples of this are (1) the use of smooth-leaf (glabrous) cotton rather than hairy-leaf cotton to reduce the impact of sweetpotato whitefly on yield, and (2) resistance to cotton leaf crumple virus in the 'Cedix' cotton variety. Possible resistance to the sweetpotato whitefly also has been developed in certain tomato, peanut, squash and pepper varieties.

Commercial producers should note that the resistance of a crop can be affected by the level of pest infestation, with even some resistant cultivars damaged by large whitefly populations. Also, crops resistant to one pest may not be resistant to another. For example, smooth leaf cottons are less attractive to sweetpotato whitefly but more attractive to cotton fleahopper. Finally, resistant commercial cultivars take time to develop and are not currently available for many crops.

Chemical Control of Whiteflies

Chemical control of whiteflies is both expensive and increasingly difficult. If the rate of whitefly re-infestation is great enough, as it was in June and July, 1991, the cost of effective insecticide treatments may be prohibitive. Besides the cost of treatment, other factors involved in chemical control decisions are the need for thorough coverage, the risk of secondary pest outbreaks, the risk of whiteflies developing insecticide resistance, and the regulatory restrictions on the use of insecticides. These factors have to be weighed against the expected returns for a given crop at a given planting date.

Many systemic and contact insecticides have been tested for control of sweetpotato whitefly, but few give effective control (Table 1). Currently registered systemic insecticides, such as oxamyl, have been only partially effective. Certain contact insecticide combinations, such as fenpropathrin or bifenthrin plus acephate, have provided excellent control in greenhouse and field studies as long as there was thorough coverage of the foliage. Other products with contact activity, such as oils, soaps and K-salts of fatty acids, can be very effective with thorough coverage, but in field tests they are often less effective because of poor coverage.

Good coverage of the foliage with contact insecticides is essential for best results. Most whiteflies are located on the undersides of leaves where they are protected from overtop applications, and the immature stages (except for the crawler) are immobile and do not increase their exposure to insecticides by moving around the plant.

Table 1. Some chemicals with activity against the sweetpotato whitefly in recent tests (1992), ranked alphabetically by category.[1]

Chemical common name[2]	Application	Category[3]
endosulfan (Thiodan®)	foliar 1.00 lb. AI/a	BR
K-salt fatty acids (M-Pede®)	foliar 1% to 2%	BR
low-phytotoxic oils	foliar 1% to 2%	BR +
neem products	(oil) 2%	BR
piperonyl butoxide	foliar 0.25 lb. AI/a	BR +
oxamyl (Vydate®)	foliar 0.50 lb./a	BR
amitraz (Ovasyn®)	foliar 0.25 lb. AI/a	LR
amitraz (Ovasyn®)	foliar 0.25 lb. AI/a	
+ endosulfan (Thiodan®)	foliar 1.00 lb. AI/a	LR
bifenthrin (Capture®)	foliar 0.08 lb. AI/a	LR
bifenthrin (Capture®)	foliar 0.08 lb. AI/a	
+ acephate (Orthene®)	foliar 0.50 lb. AI/a	LR
bifenthrin (Capture®)	foliar 0.08 lb. AI/a	
+ piperonyl butoxide	foliar 0.25 lb. AI/a	LR
cyfluthrin (Baythroid®)	foliar 0.50 lb. AI/a	
+methamidophos(Monitor®)	foliar 1.00 lb. AI/a	LR
fenpropathrin (Danitol®)	foliar 0.25 lb. AI/a	
+ acephate (Orthene®)	foliar 0.50 lb. AI/a	LR
buprofezin (Applaud®)	foliar 0.38 lb. AI/a	
+ endosulfan (Thiodan®)	foliar 1.00 lb. AI/a	NR
imidacloprid (Confidor®)	foliar 0.04 lb. AI/a	NR
imidacloprid (Confidor®)	furrow 0.1 lb. AI/a	NR
jojoba oil	foliar 1%	NR +

[1] The list is provided as a general reference and may not be complete.

[2] Always consult the label before use, and follow label instructions. Registered name in parenthesis for reference only.

[3] (In 1992) BR=broad registration, LR=limited registration, NR=not registered,+ = used as additive to other products.

Specific insecticides should be selected according to the stage(s) of whitefly to be controlled. For example, growth regulators often control immature stages by affecting nymphal development, but do not provide good adult control. On the other hand, short residual contact insecticides may control adults, but not affect egg hatch.

Sweetpotato whiteflies have become resistant to insecticides in parts of the U.S., and resistance could threaten traditional chemical control techniques in Texas. The effectiveness of the few currently registered insecticides could be lost if they are excessively and repeatedly applied. There are techniques for monitoring resistance to determine which insecticides are still active against whiteflies. Generally, if an insecticide treatment is properly made with sufficient coverage and yet is ineffective, then that whitefly population should be tested for resistance to the product.

There is a possibility that treating a resistant whitefly population with certain insecticides could actually accelerate population growth. This could be because more eggs are laid when the insect is under biochemical stress, or because beneficial arthropods are eliminated. To minimize this potential problem, insecticide applications should be used judiciously and combined with non-chemical control tactics.

Natural Control of Whitefly

Whiteflies are controlled by predatory insects such as green lacewing (Photo 9) or *coccinelid* larvae (Photo 10); by parasitic wasps such as *Encarsia* (Photo 11) or *Eretmocerus* (Photo 12) species; by mechanical injury; desiccation; diseases such as *Beauvaria, Paecilomyces* (Photo 13) or *Verticillium* species; and lack of host plant material. Personnel from the Texas A&M University System, USDA-ARS and USDA-APHIS are researching the use of natural enemies in field situations.

Parasites usually are more effective at low pest population densities, whereas predators are more effective at high population densities. Parasitism can be quantified by counting the number of empty whitefly pupal cases with a circular exit hole (created by the parasite) rather than a "T" shaped split (created by the normal adult whitefly emergence, Photo 14).

Pathogenic fungi can be applied as a spray treatment and are effective at any population density. Insect pathogens used for sweetpotato whitefly control must be applied with good coverage and under proper environmental conditions to be effective. These products are being tested in commercial production fields and commercial greenhouses, and the economic feasibility of their use has not yet been determined.

Management of Whiteflies

A combination of cultural, biological and chemical controls can be effective in managing sweetpotato whitefly and reducing the overall impact of this pest. Different strategies will be necessary for different production systems, growing conditions and geographical areas. Greenhouse growers can take advantage of the enclosed environment by using screens to exclude whiteflies and by releasing beneficial insects. In field situations, one general approach is to use: 1) cultural practices to avoid potential infestations; 2) biologically mild treatments such as insecticidal soaps or highly selective insecticides to suppress whiteflies while preserving beneficial insects; and 3) broad-spectrum pesticides only when necessary (based on action thresholds) in order to minimize detrimental effects on beneficial organisms.

When planning whitefly management in vegetable and field crops in the lower Rio Grande Valley, the following factors should be remembered: (1) the overall whitefly population begins with low numbers in the early spring, increases through the spring and summer and declines in the fall; (2) hot, dry weather favors rapid whitefly reproduction; (3) a decline of host crop quality, such as after harvest, increases the likelihood that whiteflies will migrate to adjacent crops; and (4) different crops and crop varieties can vary greatly in their susceptibility to whiteflies. Early planting of susceptible spring crops and the use of short-season varieties will help crops escape the greatest whitefly pressure. Following cotton, whitefly numbers in fall vegetables begin high and eventually decrease with time, presumably because of the smaller acreage of available host crops, cooler weather and greater numbers of natural enemies in the fall. Therefore, delaying fall planting until the threat of heavy migrations has diminished can help to reduce whitefly problems.

Working with these considerations in mind, a multi-tactic approach can be used to effectively manage the sweetpotato whitefly in agricultural situations.

Suggestions for Whitefly Management

1. Destroy old crop residues that harbor whitefly infestations unless large numbers of natural enemies of whitefly are detected.
2. Plant resistant varieties where available.
3. Plant earlier in the spring to avoid high infestations late in the season and use short-season varieties.
4. Avoid planting next to crops infested with whitefly and avoid carry-over from infested plant material.
5. Delay the planting of fall vegetables until whitefly migration has diminished; use physical barriers during heavy migration; or, plant tolerant crops during these periods.
6. Adopt spraying methods that improve coverage, especially underneath leaves.
7. Incorporate 1 to 2% oil, K-salts of fatty acid or soap mixtures in spray programs; however, avoid the use of phytotoxic materials.
8. Use insecticides selectively and in accordance with action thresholds to preserve beneficial insects and minimize the selection for insecticide resistant whiteflies.
9. Alternate insecticides used and/or use combinations to avoid or delay the development of insecticide resistance.
10. Consult the Texas Agricultural Extension Service for the effectiveness of chemical and nonchemical treatments.

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Photo 5. Silver leaf symptom of squash.

Photo 6. Irregular ripening of tomatoes caused by sweetpotato whitefly.

Photo 7. Gemini virus in tomatoes (transmitted by whitefly).

Photo 8. Gemini virus in peppers (transmitted by whitefly).

Photo 9. Green lacewing larva feeding on whitefly.

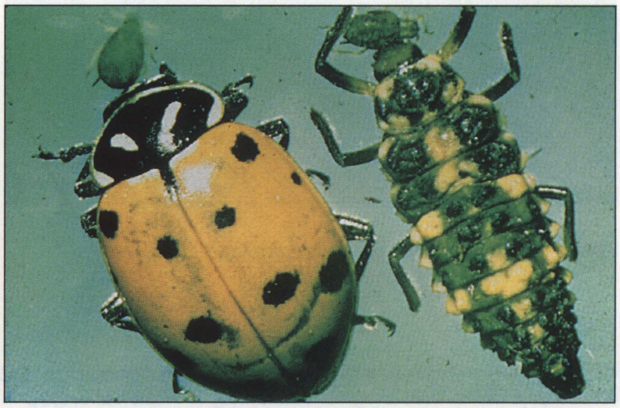

Photo 10. *Coccinelid* sp., predator of whiteflies and aphids.

Photo 11. *Encarsia* sp., parasite of whiteflies.

Photo 12. *Eretmocerus* sp., parasite of whiteflies.

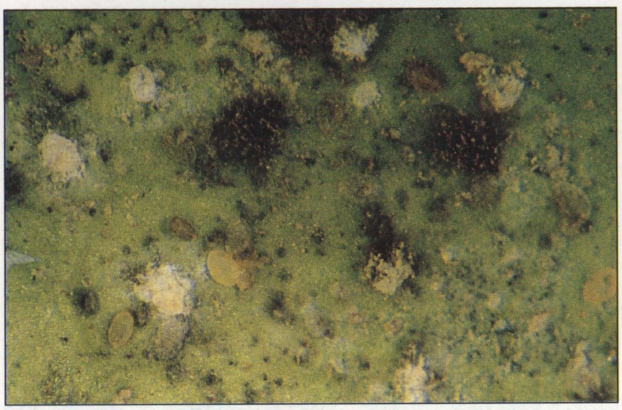

Photo 13. Insect pathogens of whiteflies.

Photo 14. Normal and parasitized whitefly pupal cases.

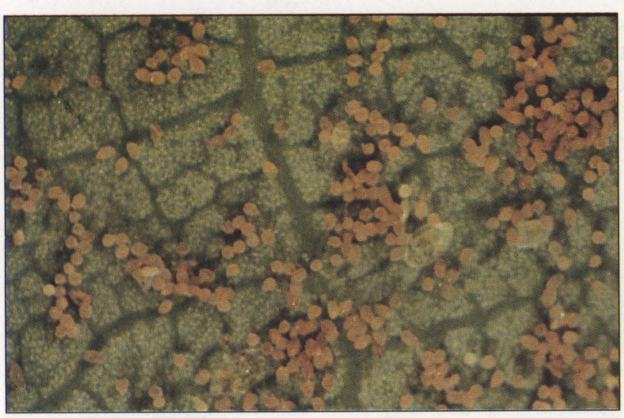

Photo 15. Sweetpotato whitefly eggs and crawlers.

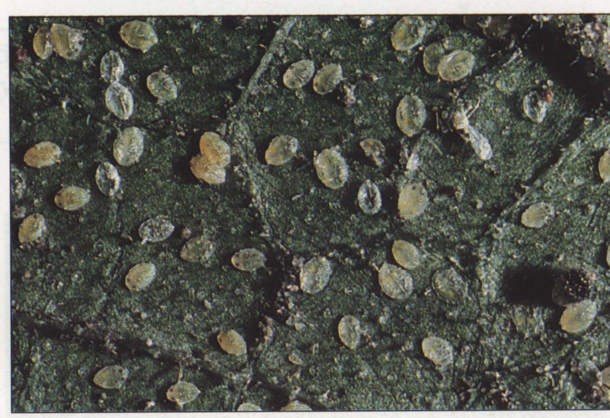

Photo 16. Sweetpotato whitefly large nymphs and pupae.

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