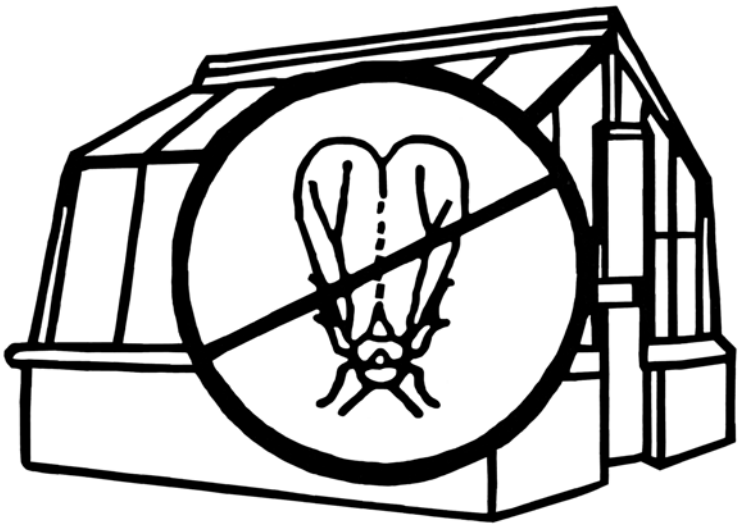
Whitefly Control in Greenhouses and Interior Plantscapes



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Whitefly Control in Greenhouses and Interior Plantscapes

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The most common and perhaps most difficult to control insect pests in greenhouses and interior plantscapes are whiteflies. Three common species of whiteflies, the greenhouse (GHWF), silverleaf (SLWF) and bandedwing (BWWF), are potential pests on a wide variety of crops. They attack a wide range of plants including bedding plants, cotton, strawberries, vegetables, and poinsettias. In addition to attacking many different crops, whiteflies are difficult to control. The immature stages are small and difficult to detect. Growers often buy plants and are not aware of the whitefly infestation present. Once inside a greenhouse, whiteflies develop and when adults emerge, they quickly become distributed over an entire crop or move to other available host plants. In addition, chemical control programs directed at the pest often have limited success. Two life stages, the egg and pupa, are tolerant of most insecticides. Control procedures are also complicated by the insects' clinging on to the underside of foliage, making them difficult to reach with chemical sprays.

Identification: The First Step

To the untrained eye all whiteflies may look alike. However, it is important to recognize and know the life cycle of these species to develop the most effective control program. All whiteflies develop from the egg through four nymphal instars before becoming adults (Figure 1).

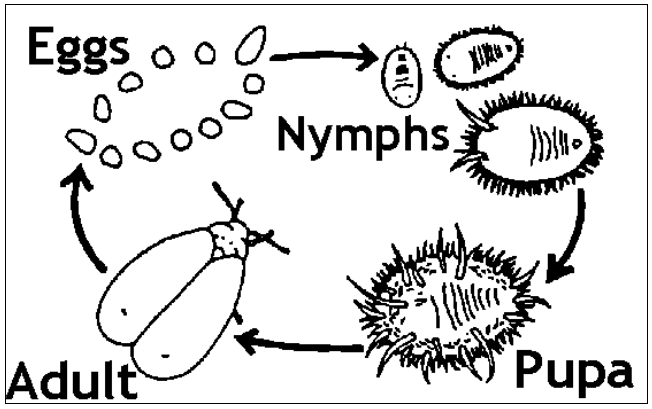

Figure 1. Whitefly Life Cycle.

Eggs are deposited on the undersides of leaves and are often found in a circular or crescent-shaped pattern. The "crawler" hatches from the egg, moves a short distance and then settles and begins feeding. The remainder of the nymphal development is spent in this sedentary condition. The adult whitefly emerges from the pupal case and has the capability of flying to other host plants to lay eggs and begin the cycle again. Fourth instar nymphs (called pupae) and adults are most frequently used to distinguish one species from another.

Greenhouse Whitefly

Adult GHWF are slightly less than ⅛ inch long. When they first emerge they are pale green or yellow, but quickly secrete a white, waxy coating (Figure 2). They hold their wings roof-like over the body, with the wings held almost parallel to the leaf surface.

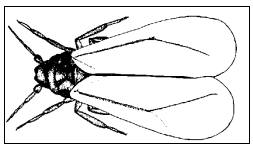

Figure 2. Adult GHWF

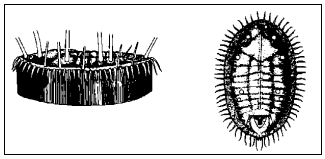

Figure 3. GHWF Pupae

GHWF pupae (Figure 3) from the side view appear cake-shaped with perpendicular sides. In addition, pupae have a fringe of short hairs or setae around the top edge and several long wax filaments projecting from the top surface.

Adult GHWF have a life span of 1 to 2 months and can produce 30-500 eggs. Egg laying begins 1-3 days after emerging from the pupa and occurs during daylight. Females usually lay the white to yellow eggs in a circular or crescent-shaped pattern. The first instar nymph, or crawler, hatches from the egg within 7-10 days. The crawler moves a short distance, inserts its siphoning type mouthparts into the plant and begins to feed. Within approximately one week, the crawler settles and remains stationary for the second, third and fourth instars. The second and third instar nymphs also feed on sap and are pale green and scalelike in appearance. Fourth instar nymphs feed initially, then feeding ceases before the adult begins

to form internally. Thus, fourth instar nymphs are considered pupae. After about 6 days, adults emerge from the pupal case. The entire life cycle may be completed in 32 days at temperatures of 65-75 degrees F. GHWF reproduce most effectively at temperatures averaging 75 degrees F.

Silverleaf Whitefly (formerly *sweetpotato whitefly*)

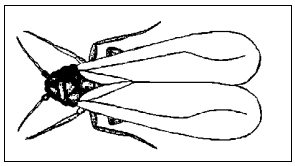

Figure 4. Adult SLWF

Adult SLWF, slightly smaller than the GHWF, measure approximately 1/16 inch long (Figure 4). They have a yellowish cast. SLWF adults hold their wings roof-like over their body at a 45-degree angle to the leaf surface and the wings are more narrow than wings of the GHWF.

SLWF pupae (Figure 5) viewed from the side are more dome-shaped and have sloping sides. They have no fringe of wax around the top surface and usually 8 or fewer setae or hairs projecting from the top surface.

SLWF adults begin laying eggs about seven days after emergence from the pupal case. These eggs are cigar-shaped and are deposited singly or in groups. After approximately 12 days the crawlers emerge and move about ⅛ inch, settle down, begin to feed and become stationary. They undergo three molts, with each nymphal instar taking about one week to mature. The pupae mature in approximately 6 days. The life cycle of the SLWF is completed in about 39 days at temperatures of 65-75 degrees F. They repro-duce most effectively at temperatures around 80 degrees F where the life cycle is completed in about 21 days.

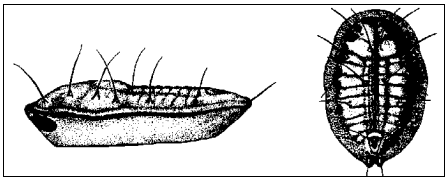

Figure 5. SLWF Pupae

Bandedwing Whitefly

Adult BWWF are similar in size to the GHWF. The adult BWWF can be distinguished from other species by the presence of two irregular and curved dark bands on the wings (Figure 6).

BWWF pupae are similar to the GHWF as they are cake-shaped with perpendicular sides. The BWWF pupa is light in color with a darker area running down the center of the back of the pupae. In addition, wax filaments on BWWF pupae are located near the margin of the pupae, but are not located in a fringe as on GHWF pupae (Figure7).

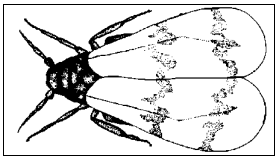

Figure 6. Adult BWWF

Depending on temperature, BWWF can develop from egg to adult within 16 to 35 days.

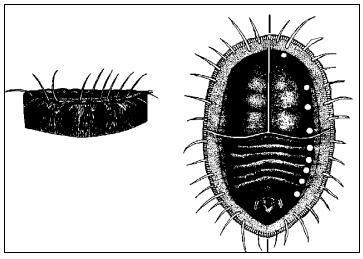

Figure 7. BWWF Pupae

Control Strategies

A good control program for whitefly begins prior to the arrival of a susceptible crop. Following are some specific practices that should begin before the crop arrives and continue until the crop is delivered.

Exclusion

Make sure entry points to the greenhouse are properly fitted with screening that excludes whitefly from entering. In a large greenhouse range, consider using screening within the greenhouse to isolate certain areas and prevent potential spread of whitefly from one age crop to another or between different crops.

Sanitation

The first objective is to eliminate all possible sources of residual whitefly infestations. Totally eliminate all weeds and plant debris inside and immediately outside the greenhouse as they can harbor immature or adult whiteflies. Collect the weeds and debris in covered containers or seal them in plastic bags. Infested plant debris stored in open containers may continue to produce adult whitefly that may quickly migrate back onto crops inside the greenhouse.

Cultural Practices

If possible, allow the growing range to stand empty for one week prior to planting a new crop. If no host plants or weeds are present, one week provides

sufficient time for adult whiteflies to starve and ensures that you start with a whitefly free house. If it is not feasible to empty the greenhouse, scout the area thoroughly. If infested plants are found, discard them or remove leaves with eggs and nymphs, or move the infested plants to another area. Then, apply an insecticide treatment to remaining plants to eliminate any adults that may be present.

Scout and Monitor

When plants arrive, prior to their placement in the greenhouse, examine each and continue to scout and monitor the crop frequently for the presence of whitefly. Look for nymphs, pupae and eggs as well as the adults. Do not place infested plant material next to clean plants.

Once or twice a week systematically examine each greenhouse for developing whitefly populations. Examine the greenhouse in the same manner each trip. Look at the crop and note differences in color, size, or vigor of plants in each area. Next, select and closely examine several plants from each bench (10 plants per 1000 square feet should provide an adequate sample). Begin at the top of each plant and work to the bottom and examine both the upper and lower surfaces of each leaf for the presence of whitefly eggs, nymphs, or adults. The undersides of the lower leaves need to be examined more closely for immature whiteflies. If whiteflies are found, it may be useful to mark the leaf on the plant so that it can serve as an indicator plant for future monitoring trips. Indicator plants are useful in monitoring life cycle development as well as the efficacy of insecticide application.

Use yellow sticky traps throughout the crop as a tool to detect whitefly populations early. For best results in trapping whiteflies, hang one to four yellow sticky cards per 1000 square feet level with the crop canopy. The adults are attracted to the yellow and will stick to the adhesive surface of the card. Check each card during every scouting trip and note the number of whiteflies found. Develop a monitoring system so that you can keep a record of where whiteflies have been found and if the number of whiteflies trapped in each area is increasing or decreasing. Monitor whiteflies and replace traps as frequently as needed, but at least on a weekly basis. It is difficult to detect a population change on a sticky card that has an accumulation of insects.

Biological Control Agents

All three species of whiteflies have natural enemies that help keep their populations under control. In fact, several predators and parasites of whiteflies are commercially available for release into infested greenhouses or interiorscapes. Studies on fungal pathogens indicate some success in controlling both GHWF and SLWF, however these products are not yet commercially available. Reliable programs, based solely on biological agents, have not been developed. Biological agents have been successfully used to control whiteflies in areas such as interiorscapes where total elimination of whiteflies is not necessary. In commercial greenhouse production, biological control agents are best used in conjunction with properly timed insecticide applications.

Encarsia formosa, a small wasp that parasitizes whiteflies, is considered the primary natural enemy of GHWF, but will parasitize SLWF and BWWF. The wasp lays an egg inside a whitefly nymph and the developing wasp eventually kills the whitefly. Furthermore, the adult wasp destroys additional whitefly by probing her ovipositor into second stage nymphs and feeding on the whiteflies' excreted body fluids. **Encarsia** populations prefer temperatures above 72 degrees F for development. When temperatures are cooler, the whiteflies can reproduce faster than the parasite, so control of the whitefly population is not achieved. Research indicates that **Encarsia formosa** is not effective in controlling SLWF. Several parasitoids of SLWF have been studied and some species used in control of SLWF are **Eretmocerus** spp., **Encarsia transvena** and **E. pergandiella**.

A second beneficial organism, **Delphastus pusillus**, has a ravenous appetite for whitefly eggs, nymphs and adults. Studies indicate successful control of GHWF and SLWF has been achieved with the release of this small black lady beetle at a rate of 1 beetle per 15-50 square feet.

Prior to using a beneficial organism inside the greenhouse, consider the history of pesticide use inside the facility. Predators and parasites can be very sensitive to pesticides used in the past and even small quantities of pesticides that persist on foliage can be lethal to predators and parasites.

Chemical Control

When choosing a pesticide to control whitefly, the first step is to identify the whitefly species and the life stages present. Select an insecticide from Table 1 that is effective against the most prevalent stages. Remember that pupae and eggs of all three species of whitefly are difficult to kill. Watch the population closely and apply the insecticide when first stage nymphs or adults have emerged. In heavy whitefly populations of mixed life stages, two to three applications per week may be necessary to bring the population under control with a contact insecticide.

Proper application of the insecticide is also a key component to a successful control program. It is necessary to deliver the insecticide to the undersides of leaves to achieve good control. As many greenhouse crops mature, a dense canopy of foliage forms that interferes with pesticide delivery. With these crops, it is necessary to control whiteflies prior to the formation of this canopy or to space plants so they can be treated adequately.

When making any pesticide treatment, the method of application is dependent on the formulation of pesticide used. Read and follow all application procedures carefully. All plant surfaces need to be thoroughly covered, especially the lower leaf surfaces, where whiteflies feed and reproduce.

Because whitefly populations can develop resistance to pesticides, it is best to rotate products used in a control program. To avoid the development of resistance, switch among products from different chemical classes (Table 1 lists products by the chemical classes, i.e. pyrethroids, organophosphates, carbamates, chlorinated hydrocarbons, insect growth regulators and miscellaneous). Avoid making more than two consecutive applications of any product classified as an organophosphate, carbamate or chlorinated hydrocarbon insecticide before switching chemical classes. Avoid the use of pyrethroid insecticides for more than one application before rotating to a product from a different chemical class. Insect growth regulators can be applied with greater frequency than organophosphate, carbamate, chlorinated hydrocarbon or pyrethroid insecticides. Imidacloprid (Marathon) is a systemic insecticide that can be applied as a granular or drench and will give residual control for eight to nine weeks. Therefore, it is best to apply the soil medium treatment two weeks after planting rooted cuttings or when the roots first reach the edge of the pot.

Acknowledgement: The authors thank Tong-Xian Liu for drawings of whiteflies used in this publication.

Table 1. Insecticides registered for control of whiteflies. Check pesticide label for registered crops, application information, rates and application frequency.

Chemical Class/Common Name	Brand/Formulation	Life Stages Affected
Pyrethroid and pyrethrum:		
bifenthrin	Talstar 10WP	nymph, adult
cyfluthrin	Tempo 2E*; Decathlon 20WP	nymph, adult
d-phenothrin	Sumithrin 2EC; PT 1400*	nymph, adult
fenpropathrin	Tame 2.4EC	nymph, adult
fluvalinate	Mavrik 2F*	nymph, adult
permethrin	Pounce	nymph, adult
resmethrin	SBP-1382; PT 1200	nymph, adult
pyrethrum	Pyrenone; PT 1100; PT 1600A*	nymph, adult
fenvalerate	Pydrin	nymph, adult
lambda - cyhalothrin	Scimitar 10WP	nymph, adult
Organophosphate:		
acephate	PT 1300*; Orthene TTO	nymph, adult
naled	Dibrom (vapor, smoke)	nymph, adult
sulfotepp	Plantfume 103 (smoke)	nymph, adult
chlorpyrifos	Dursban 50WP, Duraguard	nymph, adult
diazinon	PT 1500R Knox Out*	nymph, adult
Carbamate:		
methiocarb	PT 1700	nymph, adult
Chlorinated Hydrocarbon:		
endosulfan	Thiodan 2EC, 3EC, 50WP	adult
Insect Growth Regulators:		
kinoprene	Enstar 5E*	egg, nymph, pupa, adult
fenoxycarb	Preclude, Precision	egg, nymph, pupa
azadirachtin	Margosan-O, Azatin	nymph, pupa
pyriproxyfen	Distance	egg, nymph
Miscellaneous:		
insecticidal soap	M-Pede	nymph, pupa
horticultural oil	Sunspray Ultrafine; Saf-T-Side	nymph, pupa
oxythroquinox	Joust	nymph, adult
imidacloprid	Marathon, Merit*	nymph, adult
abamectin	Avid 0.15EC	nymph, adult
pymetrozine	Endeavor 50WG	nymph, adult
pyridaben	Sanmite 75WP	nymph, adult

* labeled for use in interior plantscapes.

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