



Whitefly Management on Desert Melons

Introduction

Melon production in the southwest occurs primarily in the desert growing areas of Arizona, and southern California. Cantaloupes, *Cucumis melo*, and watermelons, *Citrullus lanatas*, are the predominant melon types cultivated, but Persian, honeydew, crenshaw, and casaba melons, *Cucumis melo*, are also grown on a limited scale. These crops require irrigation throughout their production cycle and are planted during two distinctive growing seasons. Fall melons are typically planted from July-September, whereas spring melons are planted from January-March.

Melons in the desert are grown in very diverse cropping systems, where a variety of vegetable, agronomic and seed crops are cultivated concurrently throughout the year. Numerous insect species can be found on melon plants, but only a few have been determined to be economically important. The most damaging pest found on melons is the silverleaf whitefly, *Bemisia argentifolii*. It is polyphagous (feed on multiple plants) and migrates into melons from surrounding crops and weed hosts. Consequently, cultural management practices can have a measurable impact on pest population dynamics, but control with insecticides is often necessary to prevent reductions in yield and quality. Discussed below is a description of the silverleaf whitefly, its population dynamics, and several tactics commonly used to manage infesting populations.

Silverleaf Whitefly

The production of vegetables and melons in Arizona has increased dramatically over the past 10 years, and almost concurrently, the silverleaf whitefly has become the primary economic pest of most crops we grow. Prior to 1991, whiteflies were an occasional pest, predominately because of their ability to transmit viruses to lettuce and melons. However, with the emergence of the new whitefly species/strain, whiteflies began to cause direct damage to lettuce, cole crops, and melons by removing plant sap during feeding. The potential for whitefly transmitted virus disease still exists. Growers were then faced with the challenge of managing whiteflies populations to prevent yield

reduction and loss of quality of their crops. In the past several years, researchers, growers and the Agrochemical Industry have worked cooperatively to address the issues of short and long term management of the whitefly problem. This report attempts to summarize what we presently understand about factors that influence the seasonal abundance of whiteflies in southern Arizona cropping systems. Management approaches that have been developed by researchers and implemented by the agricultural communities are also discussed.

In the past few years, the silverleaf whitefly has shifted from a position as a secondary pest (virus vector) to being the primary pest in fall vegetables, melons and cotton in the southwest. This shift in pest status is thought to have occurred due to the development of a new strain of the sweetpotato whitefly (*Bemisia tabaci*, B-strain), or as many now believe, the emergence of the species, silverleaf whitefly, *B. argentifolii*. This whitefly can complete 2-3 generations in spring melons and can complete their life cycle on melons in 16 days during fall growing conditions.

Although the silverleaf whitefly has a wide host range, one of its most preferred hosts is cucurbits. It has become a serious pest on melons because of its high reproductive capability, wide host range, high

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rate of feeding, exudation of sticky honeydew and habit of feeding on the undersides of leaves where they are partially protected from insecticide sprays. Adults and nymphs feed on melon leaves by inserting their tubular mouthparts into vascular tissue and extracting plant assimilates (carbohydrates and amino acids). They also injure developing plants by destroying chlorophyll and reducing the plants photosynthetic activity. Heavy populations on young plants can cause desiccation of leaves and plant death. Whitefly populations cause serious economic damage to melons crops by reducing fruit quantity and size. Fruit quality is impacted by the lowering of soluble sugars in the fruit and by the contamination of fruit with honeydew which gives rise to sooty mold. In addition, heavy populations stress plants and lower the plants tolerance to disease infections from organisms such as *Monosporascus cannonballus*.

Seasonal Dynamics of Whitefly Populations

Much research has been conducted in the Yuma Valley over the past several years in an attempt to better understand the ecology and population dynamics of whitefly populations in desert cropping systems. The purpose of these studies was to determine how whiteflies develop on the numerous host-crops available and the environmental factors that influence their survival throughout the year. Based on much of this work, we now have a fairly clear understanding of the seasonal dynamics of whiteflies on vegetable crops in our multiple cropping systems. The relative whitefly abundance and seasonal cropping cycles of the primary whitefly host crops grown during the year are shown in Figure 1. It is important to note, that

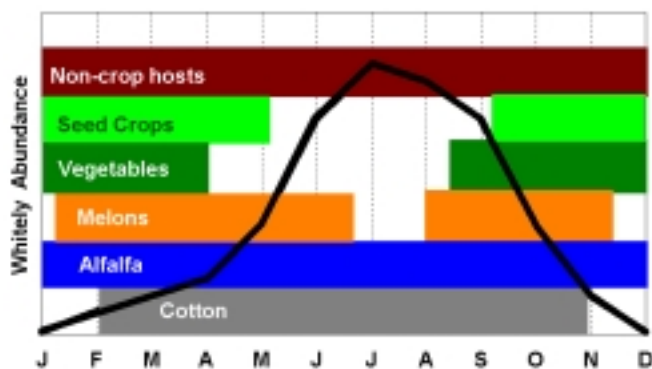


Figure 1. Relative whitefly population abundance and seasonal cropping cycles for whitefly host crops grown in Arizona.

whitefly numbers occurring on a given crop during the season will vary from year to year. However, it has been our experience that the relative abundance of whiteflies has followed this generalized pattern throughout the past several years.

Whitefly populations reach their highest numbers during July and August in cotton, where they have had the potential to increase rapidly under optimal weather conditions over a long growing season. Whiteflies are most abundant on lettuce, cole crops, and melons shortly thereafter in September and October when these crops are being planted. Newly emerged seedling can be inundated with high numbers of whiteflies migrating from defoliated cotton and newly cut alfalfa fields. Fall melons are particularly susceptible to whitefly feeding and appear to be preferred over other host crops.

Whitefly populations reach their lowest numbers during the winter months where cooler temperatures reduce movement and slow their development. Adults can be found inhabiting lettuce, cole crops, vegetable seed crops and several weed species during the winter. As temperatures increase in the spring, whiteflies begin to move into melon and cotton fields. Whitefly abundance will generally be greater on melon crops, but adults can be readily found on cotton fields adjacent to lettuce and cole crops. Colonization by immature whiteflies occurs at a fairly slow rate when crops are young, but rapidly begin to establish as temperatures increase into April and May.

Whiteflies begin to move out of melons onto cotton and alfalfa in May and June as melons begin to mature and /or adults become overcrowded on plants. Extended harvest periods (in-field and area wide) can prolong movement into cotton and alfalfa. During July when melons are not present, cotton and alfalfa are the primary whitefly hosts available. Most movement between crops during the summer can be attributed to alfalfa harvest and cotton termination. As cotton fields are terminated in August, the seasonal cycle begins again.

As noted above, whitefly densities on a given crop during the season will vary from year to year. Their abundance is influenced by several naturally occurring factors within the cropping system as well as management practices employed by growers. Weather patterns and seasonal temperatures probably have the largest natural influence in regulating abundance and population growth during the season. Natural enemies such as predators, parasites, fungal pathogens, etc also impact whitefly populations in crop and non-crop hosts. However, these factors alone are generally not capable of preventing economic damage from occurring on

melons in the desert. Rather, several fundamental management approaches in association with naturally occurring factors have allowed growers to economically produce melons in the desert over the past few years.

Management of Whitefly Populations

Preventing whitefly populations from colonizing plants is the key to successful management of whitefly populations in melon crops. This is achieved primarily by preventing the establishment of immature whiteflies, often through management of adult populations. If adults are allowed to oviposit on the undersurfaces of leaves, it becomes very difficult and often very expensive to avoid damage from the feeding nymphs. Presently, several effective management practices and control tactics are available that act against both adult and immature populations. In addition, because whitefly adults move between successive crops, management approaches must be employed in all crops within the area.

• *Non-Chemical Approaches*

There are three times during the seasonal cropping cycle when whitefly management is critical; during the winter when whitefly abundance is lowest, in late spring during the transition from melons to cotton, and in August/September during the transition between cotton/alfalfa to fall vegetable/melon plantings. These periods all involve the movement and colonization of adult populations. Below are several management practices that can help avoid problems with whiteflies before they have the chance to occur.

Crop Management

It is important to utilize optimal growing practices to reduce the amount of stress on newly emerged seedlings. This would include proper management of irrigation, plant nutrition and salinity. Experience has shown that vigorously growing plants can better withstand external stresses. This is especially important for fall melons planted in August, a time of high temperature stress. Any additional stresses can delay growth and effect yield potential. Whiteflies have the competitive advantage because temperature at this time of the season are optimal for whitefly development.

Planting Scheduling

Careful consideration of crop sequencing, crop placement, and planting date can have significant impact on adult whitefly migration. When practical, it is recommended that growers avoid planting fall melons near other significant host crops such as alfalfa and cotton. Delaying fall planting until after termination or harvest can also reduce adult migration onto seedling crops. Early planting of spring melons and uniformity of planting in an area can reduce the impact of whiteflies as well.

Source Reduction

In preparing for the establishment a new crop planting, it is always important to be aware of adjacent crops and other natural habitat. Host-crops approaching harvest (vegetable seed, cotton, alfalfa) and weedy non-crop areas are the primary sources of adult migration. Sanitation and clean culture are perhaps the most important and practical cultural techniques that can be employed in on an area-wide basis. Rapid post-harvest destruction of host crops can reduce the magnitude and duration of whitefly movement in an area. It is also important to eliminate weed hosts in and around fields to be planted with melons, particularly in the winter where they can serve as overwintering reservoirs.

Natural/Biological Control

Presently, the augmentation of natural enemies (parasitoids/predators) for control of whiteflies is not practiced in desert melon production. It is unlikely that the use of biological control would have much impact in fall planted melons because of the overwhelming numbers of adults that migrate during stand establishment. Even under low whitefly densities, natural enemies may have a minimal impact because they are often eliminated by spray regimes used for control of lepidopterous larvae and leafminers. We have observed natural parasitism and predation occurring in spring melons. We have estimated as much as 20% control of whiteflies due to parasitism and predation, however, this was not enough to prevent economic damage to the melons. Although there have been several formulated foliar spray products containing fungal pathogens with efficacy against whiteflies, they have had only limited success in commercial melon production. This is due primarily to the requirement of high humidity for sporulation and the need for undersurface coverage for contact with immatures.

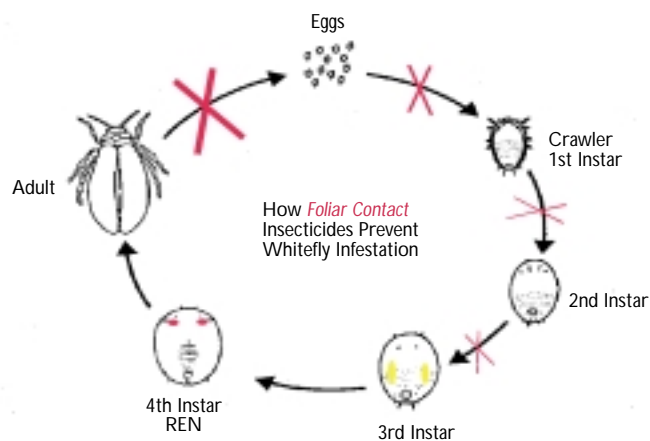
• Chemical Control Approaches

The most immediate and direct approach to control of whiteflies in vegetables is through the use of insecticides. Presently, growers can control whiteflies with chemicals in the following ways: a responsive approach using contact foliar applied insecticides or an insect growth regulator, a prophylactic approach using a soil applied systemic insecticide, or a combination of foliar and soil applied insecticides. These approaches are aimed at preventing adults from colonizing plants and depositing large numbers of eggs. Although mortality to nymphs from contact foliar sprays does occur, coverage with conventional application equipment is not usually adequate enough to control a large proportion of the nymph population, especially on lower leaves.

Responsive Approach

The use of foliar insecticides to suppress adult populations is dependant on several factors. First, the residual effectiveness of foliar insecticides is dependant on the duration of adult migration. If adults are continually moving into a field, repeated application may be necessary to prevent significant colonization. The residual of the insecticides and the rate at which the plant grows will also affect the performance of an individual application. In addition, good spray coverage is necessary even for activity against adult populations. Therefore, effective and timely application of foliar insecticides is important for control of whiteflies. The most effective contact insecticides presently used include combinations of pyrethroids (esfenvaluarate, bifenthrin) and endosulfan. These products work primarily against the adults, but with thorough coverage, can kill nymphs.

Monitoring and Sampling. To make appropriate decisions concerning pesticide applications, a reliable sampling scheme must be available. We have developed a sampling plan and action threshold for melons that take into account insect distribution and their impact on melon yields. This approach has been shown to offer economic control of whiteflies, particularly in spring melons. Currently, some control decisions are based on information generated from sticky traps. Sticky traps, although useful in certain situations, have not been found to accurately reflect population levels within melon fields. We have also found that trap catches near sprayed fields are artificially inflated following pesticide applications. Visual observations of adults on leaves provide more accurate and practical method for estimating field



populations. However several factors should be consider before initiating a sampling plan. Experimental evidence to date indicates that whitefly populations are relatively evenly distributed within in melon fields, but whitefly adults tend to primarily aggregate on the plant terminals (i.e., distally from the fourth node). Adults should be samples during early morning hours (within 2 hours of sunrise) by carefully turning leaves before adults are active

We have developed a presence-absence sampling scheme similar to those that have become popular in integrated pest management (IPM) programs because they minimize the time required for estimating populations. Presence-absence sampling involves counting the number of leaves with one or more whiteflies (i.e., are they there [present] or not [absent]) and relating these to the mean number of whiteflies per leaf across the field. For example, we recommend that a grower sample 50 leaves in a field (25 leaves from two separate areas in the field). If he finds greater than 50 percent of the leaves have at least one adult then he will know that the estimated level of infestation for the entire field is at least two to three whiteflies per leaf. The presence-absence sampling scheme for adults should not preclude monitoring the crown portion of the plant for red-eyed nymphs. Presence of these nymphs may indicate that adult numbers may increase rapidly in the near future.

Action Threshold. To prevent problems at harvest, it is necessary to minimize the establishment of whitefly colonies. Failure to do so may result in significant yield loss due to delayed maturity, and reduced fruit size and quality. Whitefly colonies have relatively lower densities during the early part of the growing season, but if left unchecked, can reach unmanageable levels at harvest. Experimental fields where whitefly populations reached 25 adults per leaf experienced a yield reduction of 52 percent, a 2 percent loss in total sugars and 50 percent of the fruit was excessively sticky.

On the basis of extensive field data, we recommend that whitefly populations not be allowed to exceed three adults per leaf. We believe that a control regimen based on this threshold would prevent large numbers of whiteflies from infesting plants later in the season. Thus using the presence/absence sampling plan above, the action threshold for adult whiteflies on melons is exceeded when adults can be readily found on greater than 50% of the leaves.

On fall melons, because plants are usually small when adults are migrating, a greater number of sprays are often needed. This is again dependant on the magnitude and duration of adult immigration. There are other limitations to use of foliar insecticides. First, there are a limited number of products available that are efficacious, such as the pyrethroid /organophosphate combinations. Other pests such as worms and leafminers also require treatment at various time so total pest control on a fall crops can often become quite expensive.

Prophylactic Approach

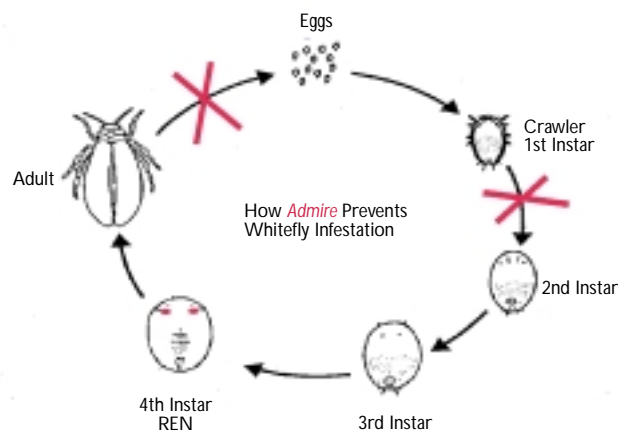
Presently, the use of a soil applied treatment of imidacloprid (Admire®) at planting is the industry standard for control of whiteflies in vegetables and melons. The product has been available since 1993 under a Section 18 registration and is now fully registered for use on melons in both Arizona and California. This product has consistently provided economic control of whiteflies. Admire belongs to a new class of insecticides called the chloronicotinyls. Its mode of action is unique from any insecticides currently available for use in field crops and vegetables. Admire is a nicotine mimic and acts by binding to the nicotinic receptor, thus simulating the action of acetylcholine. This action results in continual stimulation of the nerve cells and eventual death of the insect. Admire is very sensitive to ultra-violet light and has a half-life of about four hours in

direct sunlight. Thus it should be applied soon after mixing. Admire undergoes microbial degradation in the soil and has a soil half-life of <150 days. In the soil, it is not very mobile, particularly in heavy soils with high cation exchange capacities.

This toxicant is taken up by the roots and distributed throughout the plant. Its primary activity is against feeding adults, but it also is known to repel adults and act as an anti-feedant. Consequently, colonization by immature whiteflies is avoided because of the reduction in egg deposition. Nymphs that do emerge usually die within a week from feeding on the treated plant. In fall vegetables, this has replaced the need for most foliar insecticide applications, but fall and spring melons generally still require foliar applications near or at harvest.

Admire has been shown to effectively control whiteflies when injected at 16 fluid ounces per acre (80 inch rows) 1.5-3 inches below the seed line (sub-seed furrow) just prior to planting. In commercial settings Admire has been effective at controlling whiteflies when applied immediately following seedling emergence through a low pressure drip irrigation system. When applying through a drip system, it is important that the emitters are positioned to deliver the material at the base of the plant to optimize root uptake. Admire should be injected during a normal irrigation timing and allow the material to uniformly distribute across to the last emitters before terminating injection. Although little research has been conducted regarding optimal application volume for maximum Admire activity, volumes of 5 to 20 gallons per acre have proven effective for sub-seed furrow applications.

Although Admire has demonstrated increased yields in lettuce, cole crops and melons through whitefly control, University of Arizona research has shown that Admire does not increase yield in the absence of whiteflies. Thus, Admire has no known plant growth regulator qualities. Immediately after crop emergence, it is not uncommon to find adult whiteflies and eggs on treated plants, particularly on the cotyledons. This is not necessarily indicative of an insecticide or application failure, but rather a delay in uptake of the material. Once the plants reach the one to three leaf stage, activity should be evident. However, because adults whiteflies may continually migrate into the field, do not base control on adult densities. If many adult whiteflies are present on treated plants, look closely around the base of the plants for adult whitefly cadavers. Also gently tap the plants against the soil surface and note whether or not the dislodged adults are alive or dead, and closely check the leaf tissue with a hand lens for the presence of eggs and immatures. At



thinning check the first couple of basal leaves. If plants treated with Admire contain high numbers of eggs or large nymphs, alternative control measures should probably be taken. To date there have been no reported whitefly control failures with Admire. It is a good idea to maintain a small untreated area in every field treated with Admire. These areas will provide growers and crop advisors with a check to evaluate how well the Admire is performing as the season progresses.

Because the use of Admire has been very successful in controlling whiteflies in vegetable and melon crops, the product has been used on most acres in the desert over the past few years. Although whiteflies populations in the Yuma area are potentially exposed to Admire during most of the year, to date neither field failures nor resistance in the laboratory has been observed. Furthermore, sustaining product efficacy is of great concern. Melon crops grown in the low desert area of Arizona where a multi-cropping system predominates can be categorized for risk of whitefly infestation on produce and melon crops. Populations at low-risk would be found on melons planted during early spring during cool temperatures. Populations at high-risk would be late spring and fall plantings. Whenever possible use a foliar alternative on melons where whitefly populations are at low-risk.

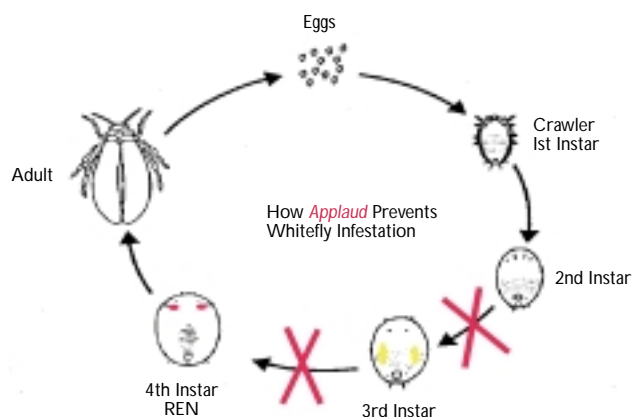
Population Regulation

Buprofezin (Applaud®) is an insect growth regulator (IGR) with selective activity against whitefly nymphs. The mode of action of Applaud involves the inhibition of chitin synthesis, and efficacy is dependant on precise timing of application. The compound works by disrupting the molting process between developing nymphal stages. In particular, it is most effective against the 1st and 2nd instar nymphs, preventing the developmental transition to the 3rd and 4th instars. Applaud does not have immediate knockdown activity against the adults, but suppresses egg deposition and can cause egg sterility. Applaud has very little translaminar movement in the plant, and intoxication works primarily through vapor inhalation and direct contact. Effective control of immatures requires about 7-10 days after application. Consequently, if applied properly, Applaud can effectively regulate population growth for several weeks. The keys to successful whitefly control with Applaud are: correct population assessment, proper spray timing, and application methods.

Population Assessment. Applaud applications should be aimed at immature whiteflies when populations are first becoming established on melon

plants. This involves an accurate assessment of nymph densities on leaves. However, visual observations of adults on leaves provide an estimate of the developing field populations. As adult populations increase, egg deposition and nymphal development on the underside of leaves near the crown portion of the plant should be monitored closely. Thus, samples should be taken from infested portions of the plant. Early season sampling (planting-first fruit set) should be focused primarily on crown leaves found on the primary vine (3rd - 4th leaf from cotyledon). From fruit set until harvest, sampling should be focused on the near the middle of the primary vine.

Spray Timing. Applaud applications should be initiated early in population growth when nymphs become visible on leaves. Visible nymphs include 3rd and 4th instar larvae and appear as flattened, egg-shaped scales on the leaf. The incidence of large nymphs correlates to a large build up of the susceptible nymphal instars. An action threshold of 1-2 visible nymphs per “quarter-sized” disk/ leaf has shown to provide good residual control of whitefly population in spring planted melons. The nymphs should be sampled within a “quarter-sized” disk wedged between the main leaf veins. The area of the leaf can be located by placing a quarter between the two major veins of the melon leaf. Additional factors to consider when timing Applaud applications include adult population status, anticipated pre-harvest interval, and harvest duration. If large numbers of adults migrate into fields before the nymphal threshold has been exceeded, an application with a foliar, contact insecticide (see #1) should be considered. Furthermore, the present pre-harvest interval for Applaud is 7 days and should be considered prior to use of this compound near harvest.



Application. Under the current section 18 registration for Applaud, only 1 application per season can be made to a spring or fall melon crop. Therefore, spray applications should be as precise as possible. Because Applaud is toxic to whiteflies primarily through vapor activity, residual activity is dependant on spray volume, deposition, coverage and temperature. Whenever possible, Applaud should be applied with ground application equipment in a minimum of 30 GPA to ensure coverage. Directed sprays should be made to ensure maximum deposition of spray droplets on leaf surfaces. Equipment that optimizes deposition on the undersides of leaves is desirable. If applied correctly, 3-4 weeks of residual control can be expected under spring growing conditions. Under higher temperatures (July-Sep), less residual can be expected. Although the compound has not shown negative effects on pollinating honey bees, the product should be applied a night whenever possible.

Applaud should be applied according to strict Section 18 label recommendations. The benefits derived from the availability and use of Applaud are that it offers an alternative chemistry to effectively control specifically the immature stage of the whitefly. It provides an alternative management approach that compliments the use of prophylactic and responsive approaches to provide season-long management. An additional benefit from the use of Applaud is the reduction of WF adults that may emerge and migrate to adjacent cotton in the late spring or to vegetable crops in the fall. Applaud is also easy on natural enemies such as lady beetles, lacewings, *Geocoris* spp., and *Orius* spp. that feed on whitefly immatures.

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