Texas Agricultural Extension Service
The Texas A&M University System

UC-031

APHID MANAGEMENT

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Over 250 species of the superfamily Aphidoidea feed on agricultural and horticultural crops throughout the world (Blackman & Eastop 1984). Pest aphids tend to have a wider host range than economically unimportant species. The green peach aphid, Myzus persicae, has an extremely wide host range of over 100 plants including a wide variety of vegetable and ornamental crops (Baker 1982). Most aphid species are relatively host-plant specific, although they may occasionally be found colonizing certain plants or 'reserve hosts' with which they are normally not associated. The Aphidoidea are predominately a north temperate group (North America, Europe, Central Asia). Almost all major pest aphids are introduced species (Table 1).

Fig. 1. Aphid nymph and winged adult.

Recognizing aphids. Aphids range in size from 1.5 to 3.5 mm. in length although the largest aphid in northeastern America, the giant bark aphid (Logistigma caryae) is 6 mm. long (Borror et al. 1976). Aphids are pear-shaped, globose, ovate, spindle-shaped or elongate in shape and vary greatly in their body markings and color (black, grey, red, orange, yellow, green, brown, blue-green, white-marked, wax-covered, etc.). Single species may have several color forms and variable shapes. Aphids may be winged (alate) or wingless (apterous). Winged forms are usually triggered by environmental changes (i.e. decreasing photoperiod or temperature, deterioration of the host plant or overcrowding).

The body is distinctly segmented and the head and prothorax are usually separate. The head bears a pair of 5- to 6-segmented antennae and mouthparts modified for sucking plant juices. On the back of the fifth abdominal segment, a pair of tube-like structures called 'siphunculi' or 'cornicles' are present on most aphid species. These structures secrete a defensive fluid. The back end of the body (posterior) bears the cauda, and anal plats. The shape, size and hairs (setae) associated with these structures are important characters for aphid species identification.

Generalized aphid life cycle. The life cycle of aphids is rather unusual and can be complex. Most aphids reproduce sexually and develop through gradual metamorphosis (overwintering diapause egg, nymphs and winged or wingless adults) but also through a process called 'parthenogenesis' (the production of offspring without mating, asexually). Sexual reproduction involves gene recombination while parthenogenesis does not. The life cycle (development to sexual maturity) for most aphids is 5 to 6 days. Under greenhouse conditions the cotton aphid may complete a maximum of 51 generations a year, with each adult producing about 85 young. Sexual maturity is reached in 4 to 10 days and the reproductive period is about three weeks. The average length of life of an adult is about one month (Little 1972). Parthenogenic green peach aphid females, Myzus persicae, can produce three to six fully formed young per day for several weeks (Johnson & Lyon 1988).

Cyclical parthenogenesis (the alternation of sexual reproduction and a phase of parthenogenetic reproduction) is common in aphids. Loss of the sexual phase occurs or it may not be triggered in certain environments. In some cases, eggs and males of aphid species are unknown. In Aphididae, parthenogenesis is combined with viviparity (giving birth to living offspring that develop within the mother's body) in which embryos can start development even before the birth of the mother. The result has been a shortening of generation time, overlapping generations, increased reproductive potential (Blackman & Eastop 1984) and an increased rate of development of resistance to insecticides.

Host alternation is common in aphids. Often, aphids use one host plant as the 'primary host' for reproduction and another plant (perhaps a distantly related plant) as a 'secondary host' for parthenogenetic reproduction. In Aphidinae, migrants returning to the primary host are winged males and winged parthenogenic females which produce egg-laying sexual females. Later on, winged parthenogenic females return to the secondary host (herbaceous plant). Some species have lost their host-alternating behavior and only have a complete life cycle on a herbaceous plant. In these species, males produced may be winged, wingless or both. Both parthenogenesis and host alternation have enabled aphids to exploit their food plants, particularly short-lived herbaceous plants such as most agricultural crops. However, most of the cosmopolitan species are able to live all year round parthenogenetically on crop hosts, and some have spread to areas where their primary hosts do not occur (Blackman & Eastop 1984).

Plant Damage. Aphids draw sap from plant (phloem) tissue using mouthparts modified for piercing and sucking. Some aphids feed on foliage while others feed on twigs, limbs, branches, fruits, flowers or roots of plants. Some species inject toxic salivary secretions into plants during feeding. If left unchecked, aphids can stunt plant growth, deform and discolor leaves and fruit or cause galls to form on leaves, stems and roots (Hamman 1985). As aphid populations develop, infestation sites become littered with cast skins.

Many aphid species secrete a sticky substance called 'honeydew' which is similar to sugar water. This energy-rich anal secretion falls on leaves and other objects below the infestation. A black-colored fungi called 'sooty mold' colonizes honeydew-covered surfaces. As a result, sunlight is unable to reach the leaf surface, restricting photosynthesis that produces the plant sugars. Honeydew also attracts ants, flies and other insects. Some species are heavily dependent on ants for survival and dispersal. The honeydew-loving ants 'tend' the aphids and prey upon natural enemies of aphids and otherwise unhealthy aphids. Ants also carry aphids to uninfested parts of plants. Some ants (Lasius spp.) even harvest and overwinter the eggs of the corn root aphid, Aphids maidiradicis (Borror et al. 1976).

Aphids are important vectors of plant diseases, particularly viruses. The cotton aphid is known to transmit over 50 plant viruses and the green peach aphid, over 100 (Kennedy et al. 1962).

Suppression tactics for managing aphid infestations. Most aphid populations are moderated by natural controls that include environmental stresses (high winds, heavy rains, extreme temperatures, etc.) and natural enemies (lady beetles, green lacewings, syrphid fly larvae, damsel bugs, braconid and chalcid wasps and parasitic fungi). However, any aphid may be considered a potential pest when conditions are favorable for reproduction. The reproduction rate of aphids is dependent upon food quality, host plant species and temperature. Food quality can be controlled to some extent by applying fertilizer and other chemicals.

A listing of biological control agents, non-chemical methods and insecticides for suppressing aphid infestations on ornamental plants is presented in Table 2. Chemical control of certain aphid species has become extremely difficult due to resistance to insecticides, particularly organophosphate, carbamate and pyrethroid insecticides. Ffrench-Constant (1988) suggested that pyrethroids may actually exacerbate a green peach aphid problem by stimulating the production of nymphs. Insecticides can also cause aphid populations to dramatically increase following application, a result of the destruction of natural enemies and failure to control the target pest (Oetting 1985).

Even within species of certain aphids, strains may show differences in insecticide susceptibility. For example, the cotton aphid occurs on chrysanthemum and cucumbers in British glasshouses, but aphids from chrysanthemums will not colonize cucumber, and vise versa - although both can be reared on cotton. The chrysanthemum aphid-living form has acquired resistance to organophosphate and carbamate insecticides, the cucumber-living form has not (Blackman & Eastop 1985). Consequently, results of bioassays or efficacy studies conducted historically, on other crops or at remote locations may be of limited value. Growers are encouraged to carefully monitor (using aphid counts from randomly-selected leaves or yellow sticky cards) the results from insecticides applied and stay informed as to what compounds perform well in their areas and crops.

In recognizing the potential for insecticide resistance in aphids, insecticide use in plant production systems must be developed with a 'resistance management' strategy. For cotton production, the Texas A&M University Cotton Aphid Task Force has suggested the management practices listed below (Tex. Agric. Ext. Serv. 1992). Several of these suggestions may be applied to horticultural crop production.

- Optimize planting date to escape times of the year with high aphid populations.
- Plant to ensure an adequate and uniform stand
- Avoid excessive nitrogen by fertilizing based on soil test
- Minimize the use of (nerve-active) insecticides early in the season, particularly aphicides (dicrotophos, methomyl and chlorpyrifos on cotton). NOTE: Since the cotton aphid has the ability to develop resistance to all classes of insecticides, maintaining effective insecticides through conservative use, rather than alternating insecticide classes, appears to be the most valuable approach.
- Delay insecticidal control of aphids until aphids exceed economic threshold levels (50 aphids/leaf in cotton)
- Use higher labeled rates of effective insecticides for aphid control
- When pyrethroids are applied for other pests an aphicide may be added
- Maximize insecticide coverage on lower plant parts

New approaches to managing aphid populations and insecticide resistance.

A few novel insecticides are under development. Trials conducted in Texas by Joe Daniel at Powell Plant Farm on bougainvillea (unpublished) demonstrated that imidacloprid (Bay NTN 33893 240FS) was an effective media treatment to suppress the green peach aphid for 10 weeks following application. Several entomogenous fungi (microbial insecticides, mycoinsecticides: Beauveria bassiana, Paecilomyces fumosoroseus) are under development for control of the sweetpotato whitefly, Bemisia tabaci, and may prove to have efficacy against aphid species. These products are not currently registered for use on aphid species.

G. T. Satoh and F. W. Plapp, Jr. at Texas A&M University have investigated the "use of juvenoid insect growth regulators for management of cotton aphid and sweetpotato whitefly populations". Results of their studies (in press) documented a delay in development of these insects treated with kinoprene, fenoxycarb or piperonyl butoxide. In addition, pre-exposure to these juvenoids increased sensitivity to organophosphate insecticides (diazinon). This approach, however, requires a different perspective since immediate high mortality can no longer be relied upon as an indicator of efficacy.

More likely than not, 'new' insecticides will be few and the number of registered aphicide products will become smaller in the future. Already in 1993, E. I. DuPont de Nemours and Company removed ornamental plants from methomyl and oxamyl product labels. Aphid resistance to insecticides will probably occur even to the 'new' insecticides developed. Consequently, growers must take the responsibility to use available products carefully, correctly and judiciously. By practicing sound resistance management practices, the useful life of currently available products can be extended.

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Table 1. Classification of Aphids and Nine Economically Important Species (derived from Blackman & Eastop, 1984). Hemiptera (Order)

- Homoptera (Suborder)
  - Sternorrhyncha (Series)
    - Aphidoidea (Superfamily)
      - Adelgidae (Family)(Conifer wooly aphids such as Adelgids, Pineus)
      - Phylloxeridae (Family)(Phylloxera, Moritziella, Viteus)
      - Aphididae (Family)
        - Aphidinae (Subfamily)
          - Aphis (Genus)
            - citricol (Species) - spiraea aphid, green citrus aphid
            - craccivora - black legume aphid, cowpea aphid
            - gossypii - melon aphid, cotton aphid
            - nasturii - buckthorn-Potato aphid
          - Macrosiphini
            - Aulacorthum solani - potato aphid, foxglove aphid
            - Macrosiphum euphorbiae - potato aphid
            - Myzus (Genus)
              - ascalonicus (Species) - shallot aphid
              - ornatus - violet aphid
              - persicae - green peach aphid, peach-potato aphid, tobacco aphid, spinach aphid
        - Anoeciinae, Chaitophorinae, Drepanosiphinae, Greenideinae, Homaphidinae, Lachninae, Pemphiginae (Other Subfamilies)

Table 2. Biological control agents, non-chemical methods and insecticides for suppressing aphid infestations on ornamental plants (derived from Drees 1992).

I. BIOLOGICAL CONTROL AGENTS FOR AUGMENTATIVE RELEASES

A. Predators

1. **Chrysoperla carnea** (common green lacewing)
2. **Hippodamia convergens** (convergent lady beetle)
3. **Aphidoletes aphidimyza** (predatory midge)(Warkentin 1988)
4. **Coccinella septempunctata** (lady beetle)(Oetting 1985)
5. **Orius tristicolor** (minute pirate bug)(Oetting 1985)
6. **Aphidoletes aphidimyza** (gall midge larval predator)

B. Parasites

1. **Aphelinus abdominalis** (for potato aphid)(Koppert Biological Systems)
2. **Aphidius colmani** (Aphipar®, Koppert Biological Systems)
3. **Aphidius matricariae** (Aphidiidae, parasitic wasp)(Warkentin 1988)(IPM Laboratories)
4. **Ephedrus cerasicola** (Aphidiidae, parasitic wasp)(Oetting 1985)

C. Pathogens (see microbial insecticides below)

II. NON-CHEMICAL METHODS

A. **High pressure water sprays**
B. **Screen barriers**
C. **Resistant/tolerant plant species/cultivars/varieties**

III. INSECTICIDE CLASSES AND GENERAL PRODUCT INFORMATION

A. INSECTICIDAL SOAPS AND OILS - These materials trap and suffocate small, soft-bodied insects and impair the waxy layer on their exoskeleton, resulting in desiccation.

1. **Horticultural Oil** (SunSpray Ultra-Fine Spray Oil®)[1,2,3,5] - (unsulfonated residue of refined petroleum distillate)
2. **Insecticidal Soap** (Safer® Insecticidal Soap Concentrate, M-Pede®)[1,2,3,4] - (potassium salts fatty acids)

B. INSECT GROWTH REGULATORS - These materials affect developing insects only and do not kill adults.

1. Chitin synthesis inhibitors prevent the formation of the chitin, an important component of the exoskeleton, after a molt.
- a. **azadiractin** (Azatin® EC[1,2,3,4], BioNeem®)
2. Juvenile hormone analogs/mimics (juvenoids) produce a hormone imbalance in developing insects that results in abnormal development and/or death.
- a. **fenoxycarb** (PT® 2100 Preclude®) - not registered for aphid control
- b. **kinoprene** (Enstar® 5E, II)[3,4]

C. MICROBIAL INSECTICIDES (FUNGI, BACTERIA, VIRUSES)

1. **Cephalosporium lecanii** fungus (Vertalec® previously registered in the United Kingdom)(Warkentin 1988)

D. BOTANICALS - These plant-derived products have various modes of action.

1. **pyrethrins** (Pyrenone® Crop Spray Insecticide, X-clude Encapsulated Natural Pyrethrum PT[R] 1600A, Staffel's Pyrocide® Dust)[1,2,3,7]

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2. **nicotine** (Natural Guard Nicotine Sulfate, Nicotine Smoke Generator®)[1,2,7]
3. **rotenone** (Bonide® Rotenone 5 Organic Insecticide)[1,2]

E. DERIVATIVES OF PYRETHRINS - These products destabilize nerve cell membranes and quickly kill arthropods contacted, but are quickly deactivated and have little residual activity.

1. **resmethrin** (Resmethrin EC 26 Insect Spray, PT® 1200 Resmethrin)[1,2,3,4,7]
2. **sumethrin** (PT® 1400 Sumethrin)[7]

F. PYRETHROIDS - These products destabilize nerve cell membranes but are much more stable and can persist in the environment longer than pyrethrins and their derivatives.

1. **bifenthrin** (Talstar® 10 WP)[1,2,3]
2. **cyfluthrin** (Decathlon® Ornamental Insecticide, Tempo® 2 Ornamental Insecticide)[1,2,3]
3. **es-fenvalerate** (Asana® XL Insecticide)[1]
4. **fenpropathrin** (Tame® 2.4 EC Spray)[2,3]
5. **fluvalinate** (Mavrik® Aquaflow®)[1,2,3]

G. CHLORINATED ARYL HYDROCARBONS AND DDT RELATIVES (DIPHENYLALIPHATICS) - These materials destabilize nerve cell membranes, preventing them from transmitting nervous impulses.

1. **endosulfan** (Thiodan® 3 EC, 50 WP)[1,3]

H. AVERMECTINS - These products affect the GABA-dependent chloride ion channel and inhibit this nerve transmitter.

1. **avermectin B_1** (Avid® 0.15 EC Miticide/Insecticide) - not registered for aphid control (Harris et al. 1988, Pinkston et al. 1988a & b)

I. CARBAMATES - These materials inhibit cholinesterase and prevent the termination of nerve impulse transmission.

1. **bendiocarb** (Dycarb®, Ficam® W 76% Wettable Powder Insecticide, Ficam® 2 1/2 G Insecticide)[2,3,4]
2. **carbaryl** (Sevin® SL, 4-Oil, 80 S, 50 W)[1]
3. **methiocarb** (Mesurol® 75% Wettable Powder Insecticide-Molluscicide, PT® 1700 Methiocarb)[1,2,3,7]
4. **methomyl** (Lannate® Insecticide, L Insecticide)[2,3]
5. **oxamyl** (Oxamyl 10% Granular, Vydate® L Insecticide/Nematicide Water Soluble Liquid)[1,2,3,8]

J. ORGANOPHOSPHATES - These products inhibit cholinesterase and prevent the termination of nerve impulse transmission.

1. Aliphatic derivatives of phosphoric acid
- a. **acephate** (Orthene® Turf, Tree and Ornamental Spray, PT® 1300 Orthene®, Acecap® 97 Systemic Tree Implants)[1,2,3,6,7]
- b. **dichlorvos** DDVP (Prentox® Greenhouse Spray)[7]
- c. **dicrotophos** (Inject-A-Cide® B)[6]
- d. **dimethoate** (Dimethoate 2.67 EC)[1,2]
- e. **disulfoton** (Di-Syston® 15% Granular Systemic Insecticide)[8]
- f. **malathion** (Malathion 5 EC)[1,2]
- g. **naled** (Dibrom® 8 Emulsive)[7]

- h. **oxydemeton-methyl** (Metasystox-R®, Inject-A-Cide®)[6,8]

2. Carbon cyclic derivatives of phosphoric acid
- a. **fenitrothion, sumithion** (Pestroy® 4 EC Broad Spectrum Insecticide)[1,2]
- b. **fenthion** (Baytex® 4 Emulsifiable Insecticide)[1,2]

3. Heterocyclic derivatives of phosphoric acid
- a. **azinphosmethyl** (Guthion® 2S Emulsifiable Insecticide)[1]
- b. **chlorpyrifos** (Dursban® 50 W, 4 E, Pageant® D F)[1,2,3,5]
- c. **diazinon** (D·Z·N® Diazinon® 4 E, AG 500, 50 W, PT® 1500R Knox·Out® Microencapsulated Diazinon, PT® 265 Knox·Out® 2 FM)[1,2,3,4,7]

K. MISCELLANEOUS COMPOUNDS AND MIXTURES OF INGREDIENTS

1. **acephate + fenpropathrin** (Orthene® plus Tame®)[2,3]
2. **pyrethrins + rotenone** (Green Light® Plus Organospray®, I-Bomb)[1,2,7]
3. **sulfotepp** (Plantfume 103 Smoke Generator)[7]

Registered uses (United States, only. Registrations may vary from state to state. Refer to product label for further restrictions and use instructions)

[1] Outdoor ornamentals, forest and shade trees and shrubs (woody ornamentals), foliar and trunk sprays
[2] Outdoor floral and foliage crops, bedding and non-food herbaceous plants and ground covers, foliar sprays
[3] Greenhouse, shadehouse and lath house floral and foliage crops, foliar applications
[4] Interiorscapes, plantscapes, foliar sprays
[5] Dormant sprays for outdoor tree and forest pests
[6] Trunk injections for outdoor tree and forest pests
[7] Aerosols, space sprays and fumigants fore sites listed on the product label
[8] Soil/media treatments for sites listed on the product label

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