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**Cooperative Extension
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THE EFFECTS OF TEMPERATURE, TIME, AND AMENDMENT OF SOIL WITH BROCCOLI RESIDUES ON THE INFESTATION OF MELON (*CUCUMIS MELO* L.) BY TWO ROOT-KNOT NEMATODE SPECIES

Antoon T. Ploeg, U. C. Riverside, and James J. Stapleton, U. C. Kearney Agricultural Center

Introduction

The root-knot nematodes *Meloidogyne incognita* (Kofoid and White) Chitwood and *M. javanica* (Treub) Chitwood are the most damaging nematodes to cantaloupe melons (*Cucumis melo* L.). Because very low nematode levels at planting can cause serious yield losses (Ploeg & Phillips, 2001), and because there are no nematode-resistant melon varieties, current recommendations consist of preplant soil fumigation when any root-knot nematodes are found before planting. Methyl bromide is among the most effective soil fumigants for control of nematodes, weeds and soil borne pathogens, and up to recently was still widely used in California (105,000 acres [259,350 ha] treated with 15 million pounds [33.1 million kg] in 1999; DPR pesticide usage data). The current legislation calling for a complete ban on the importation and production of methyl bromide in the U.S. in 2005 has already resulted in increased costs of methyl bromide. As a result, the use of methyl bromide may no longer be an option, and interest in alternative methods for nematode control is

increasing. The incorporation of root-knot nematode resistant crop varieties (e.g. tomato, cotton), and non-host cover crops into cropping regimes are among the most promising nematode management strategies. Another method to manage nematodes and other soil borne problems is a combination of biofumigation and soil solarization.

Biofumigation occurs when compounds with pesticidal properties are being released into the soil during decomposition of plant or animal material. *Brassica* species (e.g. broccoli) release a number of toxic products (thiocyanate, isothiocyanate) during decomposition and have been used to suppress nematodes, weeds and soil-borne pathogens (Angus *et al.*, 1994; McFadden *et al.*, 1992; Spak *et al.*, 1993). Several plant-parasitic nematode species were also controlled by soil solarization, but success with root-knot nematodes was variable. Combining both methods was much more effective than either method alone for the control of fungi. Recent studies showed that this was also true for the root-knot nematode *M. incognita* (Stapleton & Duncan, 1998). As it is likely that levels of control depend on soil temperature and the time that the temperature can be maintained, our goal was to study the effects of soil temperature and time on levels of nematode control in broccoli-amended and non-amended soil. This report is a summarized version of an article that will shortly appear in Nematology, by the same authors.

Materials and methods

Soil infested with eggs of *M. incognita* or *M. javanica* was thoroughly mixed with steam-sterilized sand (ratio 1:9). The nematode infestation level of second stage juveniles (J2) was determined from five 100g samples of the nematode-infested soil mixture after a 5 day incubation period.

Leaves of mature broccoli cv. Liberty plants were cut into approximately 1 cm² pieces and thoroughly mixed with the *Meloidogyne*-infested soil (2% w/w). One hundred fifty containers (145 ml) were filled with 150 g of the broccoli-amended *Meloidogyne*-infested soil. An additional 150 containers were filled with 150 g non-amended *Meloidogyne*-infested soil. The containers were closed with plastic lids, and placed in constant temperature waterbaths at 20, 25, 30, 35 or 40°C (± 1°C). Twenty-five containers with broccoli and 25 without broccoli were placed in each waterbath. Five containers with, and five without broccoli were removed from each waterbath 1, 3, 10, 15, and 20 days later and placed on a

greenhouse bench. A melon seed, cv. Durango, was sown in each container 48 h later, and the melons were grown for 5 weeks. Plants that were dying during the 5-week period were removed from the containers, and if the root systems were severely galled they received a galling index of 10. After 5 weeks, the remaining melon plants were carefully washed from the containers, the root systems were weighed and inspected for galling. The severity of galling was indexed on a scale from zero (no galling visible) to 10 (100% of root system galled, plant dying) as described by Bridge and Page (1980). The egg masses on the root systems were subsequently stained and counted. The experiment was done twice, with the *M. incognita*- and the *M. javanica*-infested soils.

Results

Average initial infestation levels were about 500 and 750 J2 per 100 g soil for *M. incognita* and *M. javanica* respectively. The results were very similar for *M. incognita* and *M. javanica*. Without broccoli, galling was very severe at soil temperatures of 20, 25, and 30°C, and many melon plants died within 3-4 weeks after sowing. Without exception, the roots of these seedlings were heavily galled, resulting in galling indices of 10. At 20°C, adding broccoli did not reduce galling of the melon roots. However, when the soil was kept at 25°C for at least 10 days, adding broccoli significantly reduced galling. Higher soil temperatures further reduced the period necessary for broccoli to take effect to 3 days at 30 and 35°C, and to 1 day only at 40°C. Very strong reductions in melon root galling occurred after adding broccoli and keeping the soil at 30 or 35°C for at least 10 days. Heating soil to 40°C for at least 10 days almost eliminated root galling, irrespective of whether broccoli had been added.

Adding broccoli also reduced the number of egg masses per gram of root. Even when root galling was similar, fewer egg masses occurred on melon roots grown in broccoli-amended soil.

Table 1. Effect of soil temperature, treatment period, broccoli amendment of *Meloidogyne incognita* infested soil on average (n = 10) root galling¹ of melon cv. Durango plants subsequently grown in these soils.

Temp. (°C)	Broccoli (2% w/w)	Treatment Period (days)				
		1	3	10	15	20
20	without	10.0 a ²	10.0 a	9.6 a	8.4 a	8.6 a
	with	10.0 a	9.5 a	9.5 a	9.2 a	8.5 a
25	without	9.9 a	9.7 a	9.8 a	9.5 a	9.5 a
	with	9.6 a	9.1 a	8.4 b	7.6 b	4.8 b
30	without	10.0 a	10.0 a	10.0 a	10.0 a	9.7 a
	with	9.9 a	8.0 b	3.5 b	0.0 b	0.1 b
35	without	9.7 a	10.0 a	8.4 a	6.3 a	4.8 a
	with	9.8 a	6.5 b	0.0 b	0.1 b	0.0 b
40	without	8.8 a	4.1 a	0.9 a	0.6 a	0.0 a
	with	4.5 b	0.4 b	0.1 b	0.0 a	0.0 a

¹Galling index 0 – 10; 0 = no galling; 10 = 100% of roots galled, plant dying

²Significant effects (95% confidence level) of broccoli-amendment for each different combination of treatment period and soil temperature are indicated by different letters.

Discussion and Conclusions

The effect of amending soil with broccoli on melon root-galling caused by *M. incognita* or *M. javanica* strongly depends on soil temperature. At 20°C, amending soil with broccoli did not reduce root galling. However, maintaining broccoli-amended soil at 30 or 35°C for at least 10 days dramatically reduced galling. In contrast, root-galling of melon grown in the non-amended soils that had been kept at 30 or 35°C for 10 days was severe.

Combining solarization with biofumigation may provide a way to increase the reliability and efficacy of root-knot nematode control, reduce the time necessary to achieve sufficient control and may make this a feasible strategy at locations or during periods where necessary soil heating cannot be realized through solarization. Furthermore, unlike some other non-chemical strategies that are specifically targeted towards nematodes (e.g. use of nematode suppressive crops, crop rotation) the combination of solarization with biofumigation has also been shown to control other soil borne diseases and weeds. Currently, studies are being done to evaluate the potential of this method under field conditions.

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IMPACT OF GRAY FIELD ANT EXCLUSION FROM VINES ON GRAPE MEALYBUG ABUNDANCE, PARASITISM, AND INFESTATION: A PROGRESS REPORT

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Grape mealybug, *Pseudococcus maritimus* (Ehrhorn), was first described in 1900 from specimens infesting the roots of coastal buckwheat (*Eriogonum latifolium* Small) near Santa Cruz, California and was termed the ocean mealybug (Miller et al., 1984). It is considered native to North America (Ben-Dov, 1995) and has a wide host range which includes grape, pear, apple, apricot, alfalfa, walnut, ceanothus and citrus. Essig (1914) first described mealybug infestations in vineyards in central California, observing high mealybug densities in 1910 and 1911. Essig did not view the Fresno County infestation and mistakenly attributed the damage there to citrus mealybug, *Planococcus citri* Risso which, at that time, was commonly found infesting citrus in southern California. Again, in 1918, reference was made to grape mealybug being found frequently on grapes in Fresno, Kings, and Tulare counties and as far north as Red Bluff (Nougaret, 1918). Currently, grape mealybug has

become the key arthropod pest for California table grape growers (Geiger and Daane, 1999). It is also reported as a serious pest in Washington, Colorado and Oregon vineyards and pome fruit orchards.

Why table grape farmers are experiencing such severe infestations of grape mealybug is unclear but reduced parasitism appears to be a key factor. Clausen (1924) studied parasitism levels and reported >80% of sampled mealybugs parasitized by five species of parasitoids. Recent sampling has revealed much lower levels of parasitism, generally less than 50%. The primary parasitoid was *Acerophagus notativentris* (Girault). This species was recorded by Clausen and contributed the third highest level of parasitism behind that of *Zarhopalus covinus* (Girault) and *Anagyrus yuccae* (Coquette) in the 1924 study.

In 1999 a study was conducted to determine the effect of gray field ant (*Formica aerata* Wheeler) exclusion from vines and its influence on parasitism and subsequent infestation by grape mealybug. Results from the field study are presented here.

Procedures

The experiment was established at the Kearney Agricultural Center. A mature five-acre Thompson Seedless vineyard was divided into two treatments. These were bare ground and a common vetch (80%), Merced rye (20%) cover crop planted in November 1998 at the rate of 120 lb. per acre. Each plot was seven vine rows wide and 13 vines long. Buffer rows were four rows wide along the sides of the plot and six vines between ends of the plot. A total of six cover crop plots and six bare ground plots were established. Within three of the cover crop plots and three of the bare ground plots, "stickem" barriers were placed at the base of on each vine (approximately 6 inches above the ground) in the center three rows and on the wires at the end of the 13 vines. Vineyard stakes were also treated with stickem in the same manner as the vines. The stickem barrier was regularly renewed to prevent ant movement to the vines. The central three rows of vines in each of the plots were regularly trimmed back so runners did not touch the ground. The plots with the stickem barriers are termed exclusion plots as they physically excluded ants from moving onto the vine. This resulted in four treatments that are termed bare ground/no exclusion, bare ground/exclusion, cover crop/no exclusion, and cover crop/exclusion. The trial was designed as a randomized complete block with four treatments and

three replicates. The middle row of each plot was the sample row for data collection.

To determine the background level of grape mealybug, a spur sample was taken from each of the 12 plots (three per treatment) on 15 March 1999. Average number of mealybug crawlers per spur at that time was 1.6, 1.7, 0.7, and 2.4 for the stickem exclusion and cover crop, the stickem exclusion and bare ground, the cover crop alone, and the bare ground treatments. There were significantly more ($P < 0.10$, Fisher's Protected LSD) mealybugs in the plots (bareground/no exclusion) where ants had not been excluded the previous year (2.4 crawlers/spur). However, all of the plots had a relatively low level of crawlers emerging from winter hibernation. On 15 March 1999 additional spurs, collected in a heavily infested Delano vineyard, were seeded in the Kearney vineyard sample rows (four spurs per vine). These seeded spurs averaged 35.5 crawlers per spur (40-spur sample). The infestation ranged from 26.8 to 43.8 mealybugs per spur. The parasitoid *A. notativentris* was also found on the samples and averaged 1.6 per spur. Four mealybug-infested spurs were placed on the middle 10 vines of the central three rows. The treatment was done to equalize the resident mealybug population between plots.

Timed ant counts (four minutes per vine) were taken on five vines in each plot, weekly, from March 10 through August 30. This involved searching the wood and canopy area above the crown for ants. Timed ant counts were also taken weekly on the cover crop and bare ground from 10 March until late June, when the cover was finally plowed. This involved counting ants moving on the ground or on the cover crop in three different areas of the plot. Each of the areas was 1/4 square meter and was examined for two minutes. Floral nectaries on the common vetch were evaluated for the presence of nectar in April and May. These counts were made from eight vetch flowers in each plot.

Timed mealybug counts were taken on 24 June 1999 on the vineyard vines. The counts were timed for 5 minutes per vine and taken from each of six vines in each of the plots. Also six adult mealybugs per plot were removed from vines which were not used for the harvest evaluation, but were within the treated plots. These specimens were placed in vials for parasitoid incubation. At harvest, infestation was rated by sampling 100 clusters from the 10 central vines of each plot. Any sign of mealybug classed the cluster as infested. Also, mealybugs were taken from the clusters and held for parasitoid emergence.

Results

Figure 1 shows the gray field ant count data on the vines. There were significantly more ($P < 0.01$, Fisher's Protected LSD) gray field ants found on vines (total of all the count dates) in the bare ground/no ant exclusion treatments than the other three treatments for the 18 readings between 10 March and 30 August. A peak of 13.7 ants per vine searched was found on 27 April on the bare ground/ no exclusion vines. The ant population on the vines became equal in all plots after the cover crop was plowed in July. This appears to coincide with the development of the second generation eggs and young crawlers, which are unable to produce honeydew in those two stages and, therefore not attractive to ants. Clearly, the presence of this cover crop as well as the stickem barrier kept ants from the vines, and from tending mealybugs on the vine. The season long total of ants per vine was 79, 4.5, 17 and 6.8 gray field ants in the bare ground/no exclusion, bare ground/exclusion, cover crop/no exclusion, and cover crop/exclusion respectively. The bare ground/ no exclusion plots resulted in significantly more ($P < 0.01$, Fisher's Protected LSD) ants than the other three treatments. There was no difference in population size found on the remaining treatments.

Figure 2 shows the ant count data from the middle ground between the vine rows. This data shows significantly more ($P < 0.05$, Fisher's Protected LSD test) ants on the cover cropped treatments than on the bare ground treatments, whether or not ants are excluded from vines by the use of stickem barriers. The analysis was performed for the total ant counts as was done for the ant counts on the vines. The increase in ant abundance, on the cover crop, begins in May and continues until the cover crop is plowed, in early July. During this period nectar is being produced by the vetch cover crop. Once the cover crop is plowed, ant populations in the middles and between vine rows are equal in each of the treatments.

Floral nectary counts were made on 16 April and 11 May. The percent of nectaries with nectar was 25% and 14%, respectively on the two dates. The quality of cover crop, as measured by the flower nectaries, was declining by mid June.

On 24 June, while the cover crop was still attractive, grape mealybug was counted on vines from each plot (Table 1). Each of six vines per plot was searched in the upper trunk and spur areas for 5 minutes by peeling back the outer bark. The results of that count are shown in

Table 1. An average of 15.33 grape mealybug or grape mealybug ovisacs were found in the bare ground/no exclusion treatment, 16 in the bare ground/exclusion treatments, 10.33 in the cover/no exclusion treatments, and 11 in the cover/exclusion treatments. There was no difference in mealybug abundance per six vines searched, based on treatments.

Table 1. The influence of four treatments on grape mealybug abundance, grape mealybug infestation, and, parasitized grape mealybug, Thompson Seedless, Parlier, CA, 1999

Treatment	Mealybug or ovisac/6vines**	% Parasitized**	% Infestation at harvest*
			June 24
Bare/no exclusion	15.33 a	16.7 b	18.67 b
Bare/exclusion	16.00 a	33.3 b	13.67 ab
Cover crop/no exclusion	10.33 a	33.3 b	2.00 a
Cover crop/exclusion	11.00 a	61.1 a	7.00 ab

* Numbers followed by the same letter are not significantly different ($P < .06$, Fisher's Protected LSD).

**Numbers followed by the same letter are not significantly different ($P < .10$ Fisher's Protected LSD).

Six mature female grape mealybug were collected per plot and held for parasitoid emergence. Only six were collected so as not to influence mealybug densities. These samples were taken from vines not evaluated for harvest infestation. Parasitism (*A. notativentris*) reached 61% in the cover crop plus stickem exclusion treatment and was significantly ($P < 0.10$ Fisher's Protected LSD) greater than that found in the other treatments. Parasitism in the cover crop and no stickem exclusion and the bare ground plus stickem exclusion treatment was 33%. Parasitism in the bare ground and no stickem exclusion reached only 16.7%.

Harvest samples, based on evaluating 100 grape cluster (ten clusters per vine and ten vines per plot) were taken on September 10 (Table 1). There was a significant ($P < 0.06$, Fisher's Protected LSD) difference in bunch infestation by grape mealybug due to treatments with the cover crop/no exclusion treatment being better than bare ground/no exclusion. The bare ground/no exclusion treatment averaged 18.67% infested clusters; the bare ground/exclusion treatment averaged 13.67% infested clusters, the cover crop/no exclusion treatment averaged 2% infested clusters, and the cover crop/exclusion averaged 7% infested clusters.

Discussion

The results of the 1999 study indicate that gray field ant can be effectively excluded from vines with a common

vetch and Merced rye cover crop; equal to that of a physical exclusion treatment using a sticky barrier. Counts made from the cover crop and vineyard floor also indicate a greater abundance of gray field ant on the cover cropped areas than on the bare ground. The purpose of the common vetch cover crop is to provide an alternative source of carbohydrate, in the form of plant sugar, to that produced by the grape mealybug. If this carbohydrate source is available, gray field ant would be more likely to visit the plant nectaries than the mealybug.

The limited number of mealybug adults collected (18 per treatment) in June did result in a higher parasitism rate ($P < 0.10$, Fisher's Protected LSD) within plots that had the cover crop plus the sticky exclusion. There was no statistical difference in parasitism rates between the bare ground and no exclusion, the bare ground and sticky exclusion, and the cover crop and no exclusion. The number of replicates and the number of collected mealybugs were too few to separate treatment effects based on ant exclusion techniques.

Harvest infestation by grape mealybug in the cover crop and no exclusion treatment (2% infested) was significantly different ($P < 0.05$, Fisher's Protected LSD) from the bare ground no exclusion (18.67% infested) treatment. The remaining two ant exclusion treatments had infestation levels that were not different from either the bare ground and no exclusion treatments or the cover crop no exclusion treatments.

Ant exclusion can aid in increasing grape mealybug parasitism levels. Preliminary results indicate that parasitism is increased and infestation is reduced. Further studies incorporating greater replication of exclusion and no exclusion treatments were conducted in 2000 that substantiate the results identified in the 1999 study. These will be reported in later issues of the Plant Protection Quarterly.

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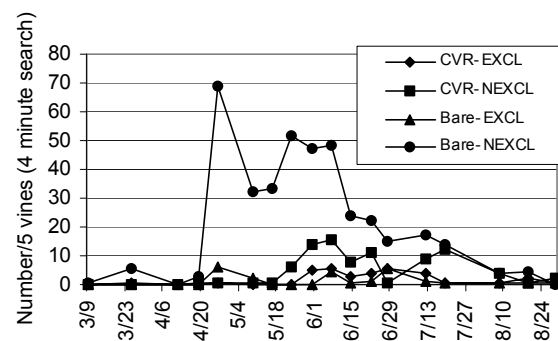


Figure 1. Gray field ant abundance on Thompson seedless grape vines, 1999

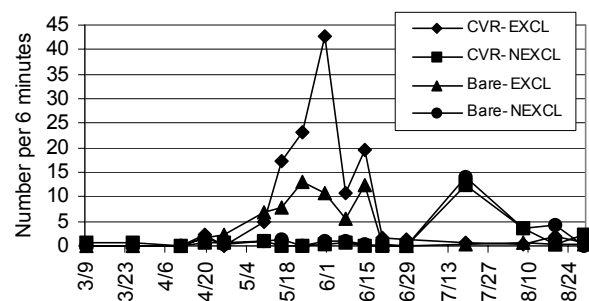


Figure 2. Gray field ant abundance on bare ground or cover crop between vines, 1999.

METHYL BROMIDE ALTERNATIVES: CDFA APPROVES AN ADDITIONAL TIME/TEMPERATURE SOLARIZATION TREATMENT TO ENSURE AGAINST NEMATODE PEST INFESTATION OF CONTAINERIZED NURSERY STOCK

J. J. Stapleton, T.S. Ruiz, M. V. McKenry, and L. Ferguson, UC Kearney Agricultural Center

The State of California requires specific soil treatments and handling procedures to ensure against nematode pest infestation of field and container, flat, and frame-grown nursery stock for farm planting (California Code of Regulations, Sections 3055-3055.6 and 3640). In addition to methyl bromide fumigation and steam treatments, a “double tent” solarization technique was approved by the California Department of Food and Agriculture (CDFA) in 1999 to ensure against nematode pest infestation of soil and other planting media used for container, flat, and frame-grown nursery stock for farm planting. The approved treatment stipulated, among other conditions, soil maintained at 70 °C (158 °F) for 30 continuous minutes (2) (Figure 1). Recently, we submitted laboratory and field data to the Nematode Study Committee of the CDFA demonstrating the destruction of phytoparasitic nematodes in soil subjected to 60 °C (140 °F) solarization for 60 continuous minutes, and proposed amending the existing regulations to allow this additional treatment option.

The proposal was accepted by CDFA, and wording of amended solarization treatment protocols for CDFA Nursery Inspection Procedures Manual (NIPM) Item #12 is as follows:

“Solarization of soil using a ‘double-tent’ setup until the temperature of all soil reaches a minimum of 158 °F (70 °C) that is maintained for at least 30 continuous minutes, or a minimum of 140 °F (60 °C) that is maintained for at least 60 continuous minutes. Soil must be either in polyethylene planting bags or in piles not more than 12 inches high. Soil in piles must be placed on a layer of polyethylene film, concrete pad, or other material, which will not allow reinfestation of soil, and covered by a sheet of clear polyethylene film. An additional layer of clear polyethylene film must be suspended over the first layer to create a still air chamber over the soil to be treated. Soil moisture content must be near field capacity. Soil temperature at the bottom center of the pile or bag must be monitored and recorded to ensure that the minimum temperature of 158 °F (70 °C) for 30 minutes, or 140 °F (60 °C) for 60 minutes is achieved.

Following treatment, the soil and containers shall be protected from reinfestation by nematodes.”

Apart from nematode control, the “double tent” solarization technique has been shown to provide soil and planting media free of weed seed (1). This information can be used by nursery operators and household gardeners alike.

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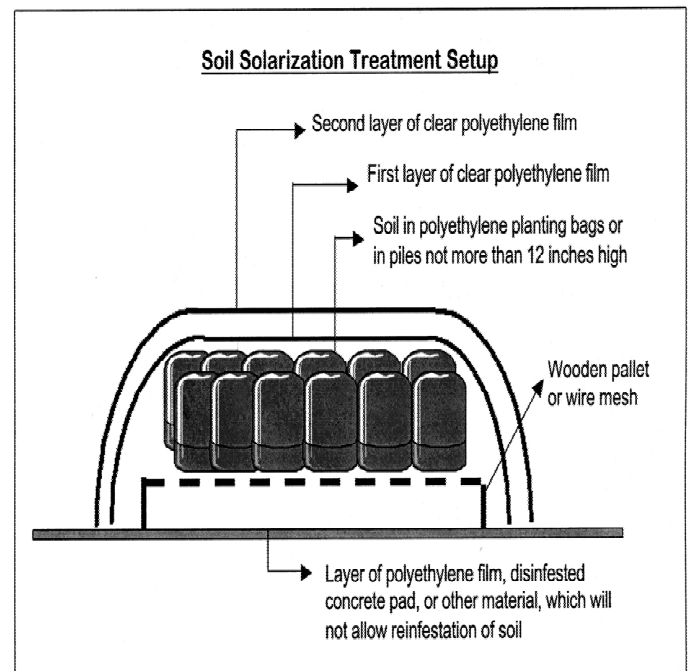


Figure 1. Soil solarization treatment setup (from CDFA, NIPM Item 12).

KEY TO COMMON ALFALFA AND COTTON APHIDS IN CALIFORNIA

Charles G. Summers, Dept. of Entomology, U.C. Davis and Kearney Agricultural Center

Aphids attacking California alfalfa and cotton may be difficult to identify. The alfalfa aphids, pea aphid (*Acyrtosiphon pisum* (Harris)), and the blue alfalfa aphid (*A. kondoi* Shinji) are similar in appearance. Recently, the cowpea aphid, *Aphis craccivora* Koch has become a pest of alfalfa and has been found colonizing cotton in the San Joaquin Valley. *A. craccivora* on cotton can easily be confused with cotton aphid, *A. gossypii* Glover, at certain times of the year. Since economic thresholds have been developed for individual species, proper aphid management depends on proper identification. Presented here is a simple key to the most common aphids found in alfalfa and cotton. Not all species potentially found are covered.

While aphids appear to be very simple insects, they are really very complex, both in their biology and morphology. As with other insects, external morphological features are used to identify individuals to species. Figure 1 is of a “typical” aphid and shows a number of morphological features important in identification. This key pertains to adults and will not work to identify immature individuals. Links are provided (for the web version) to color photographs of the various species when ever possible.

Additional Reading: The following books are recommended for additional information and keys to aphids.

Blackman, R. L., and V. F. Eastop. 1984. Aphids on the world's crops. An identification guide. Wiley. New York. Keys to aphids based on host plant. Highly recommended but expensive.

Chaney, W. E., and M. A. Lee. 1992. Common aphid pests on vegetable crops in the Salinas valley. University of California, Monterey County Cooperative Extension Service, Salinas, California. Keys to common vegetable aphids. Excellent keys that work equally well for the San Joaquin Valley. Highly recommended. Contact Dr. Chaney regarding availability.

- | | |
|--|---------------------------------------|
| 1. Body pale green, pink or white..... | 2 |
| Body black, olive green or yellow..... | 7 |
| 2. Six to eight rows of spots on dorsal abdomen (Figure 2a)..... | Spotted Alfalfa Aphid |
| Dorsal abdomen without spots | 3 |
| 3. Frontal tubercles converging (Figure 2b)..... | Green Peach Aphid |
| Frontal tubercles diverging (Figure 2c)..... | 4 |
| 4. Legs, antennae, cornicles and cauda (Figure 2d) long, found in alfalfa..... | 5 |
| Legs, antennae, cornicles and cauda (Figure 2d) long, found in cotton..... | Potato Aphid |
| 5. Body pink..... | Pea Aphid ¹ |
| Body green..... | 6 |
| 6. Antennae uniform brown (Figure 2e)..... | Blue Alfalfa Aphid |
| Antennae with dark bands between light segments (Figure 2f)..... | Pea Aphid |
| 7. Body black (shiny or dull)..... | 8 |
| Body pale yellow, yellowish green or olive green | Cotton Aphid |
| 8. Cauda (Figure 1) bushy with many hairs (Figure 1); cornicles and cauda of equal length (Figure 2g)..... | Bean Aphid |
| Cauda (Figure 1) not bushy, with few hairs (Figure 1) cornicles longer than cauda (Figure 2h)..... | Cowpea Aphid |

¹A pink colored biotype of the Pea Aphid occurs in France, on the east coast and in several western states of the U. S. To date, it has not been found in California, but could appear at any time. Biologically, it behaves identically to the green form we have in California including its response to resistant cultivars.

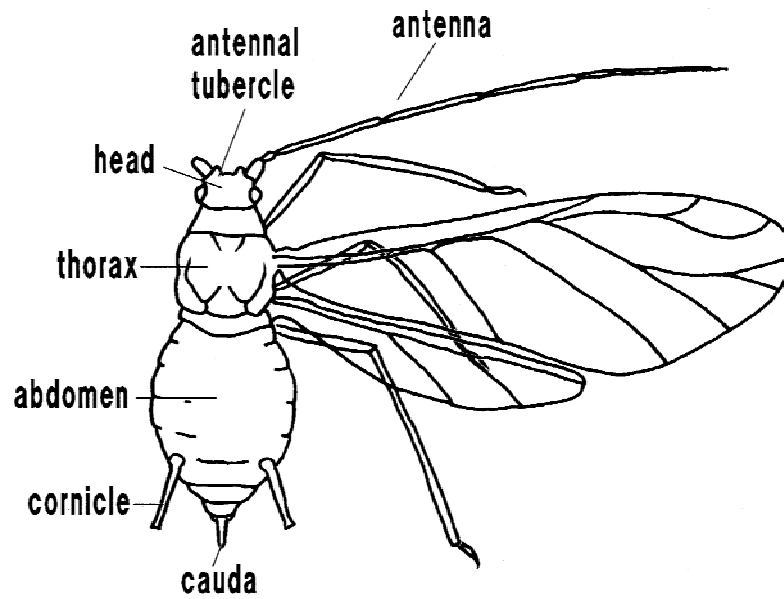


Figure 1. Diagrammatic drawing of a winged green peach aphid showing many of the important morphological features used in aphid identification.

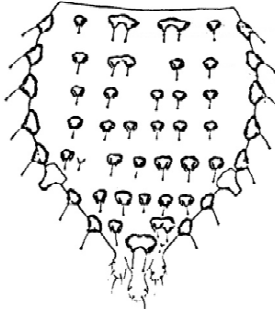


Figure 2a. Dorsal abdomen of a spotted alfalfa aphid showing rows of dark spots. These spots are actually raised tubercles.

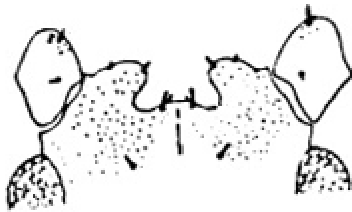


Figure 2b. Dorsal view of an aphid head showing converging frontal tubercles.

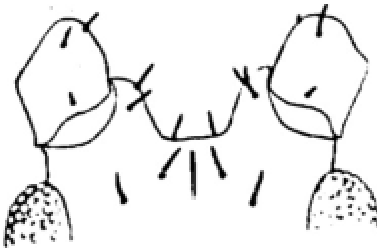


Figure 2c. Dorsal view of an aphid head showing diverging frontal tubercles.

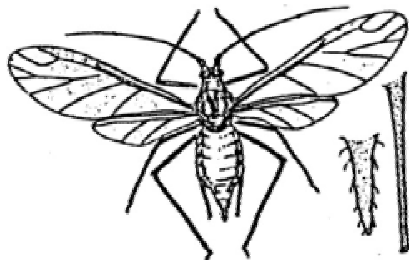


Figure 2d. Aphid with long legs, antennae, cauda and cornicles.

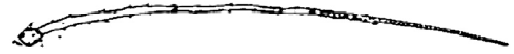


Figure 2e. Antennae of blue alfalfa aphid. Note uniform color.

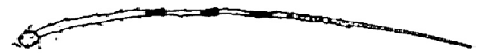


Figure 2f. Antennae of pea aphid. Note dark bands between segments.



Figure 2g. Cauda and cornicles (Figure 1) of bean aphid. Note bushy cauda that is equal in length to cornicles.

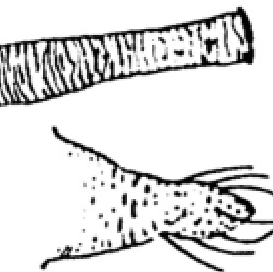


Figure 2h. Cauda and cornicles (Fig 1) of cowpea aphid. Note lack of hairs on cauda and equal length of cauda and cornicles.