Monitoring aphid infestations on broccoli

John T. Trumble □ Henry Nakakihara □ William Carson

Aphids cause substantial economic losses to California's broccoli industry in three ways: by inserting their hollow beaks into plant tissues and removing sap, by transmitting viruses, and by contaminating the marketed product. Since California produces 95 percent of the broccoli grown in the United States, costs of pesticides, application equipment, and the labor associated with aphid control cause considerable loss of income.

Aphid feeding often results in stunting, curling, or yellowing of broccoli; severe infestations may kill plants. Leaves distorted by aphid feeding or virus infection provide areas sheltered from pesticides, and survivors can immediately reinfest the plants.

Once broccoli heads begin to form, some aphid species migrate to and thus contaminate the marketable portions. Pesticidal suppression of established populations is nearly impossible when aphids are shielded by the tight, umbrella-shaped flower buds. Unfortunately, biological control agents, such as hover flies (Syrphidae) and parasites, follow their hosts into the heads and cause additional contamination. Although washing the crop after harvest may reduce losses from contamination, parasitized aphids, or "mummies," are often firmly attached to the plant, so that repeated rinsings are required to dislodge them. Since much of the fresh market broccoli grown in California is packed for shipment in the field and cannot be readily cleaned, pesticides are used to maintain an insect-free crop.

The objectives of the study reported here were to determine which aphid species are economically important and to document when and where each occurs on the plant. Based on this information, an efficient, reliable sampling plan could be developed. We collected the experimental data in 1980-81 from three successive 0.4-hectare (1-acre) plantings of 'De Cicco' broccoli at the University of California's South Coast Field Station in Santa Ana, and two successive plantings at the Agricultural Operations property at the University of California, Riverside. At least 60 plants in each crop, which were selected using a stratified random design, were monitored for aphids and parasites each week between thinning and head formation. Counts from the youngest, highest, and oldest leaves were recorded separately from entire-plant counts so that locational preferences could be determined.

Green peach aphid

The green peach aphid, *Myzus persicae* (Sulzer), was the most common species in this study (fig. 1). These aphids are pale green to yellow, and the winged form (alate) has an irregular black pattern on the upperside of the abdomen. Some plant damage occurred when populations reached extremely high levels, but green peach aphids were primarily a problem because of their ability to transmit viruses.

Winged females transmit viruses during migrations, moving rapidly from one potential host to the next, probing each in search of suitable feeding sites. Transmission takes place when virus particles adhering to the mouthparts or contained in the salivary glands are injected during feeding. Thus, a single green peach aphid can infect many plants.

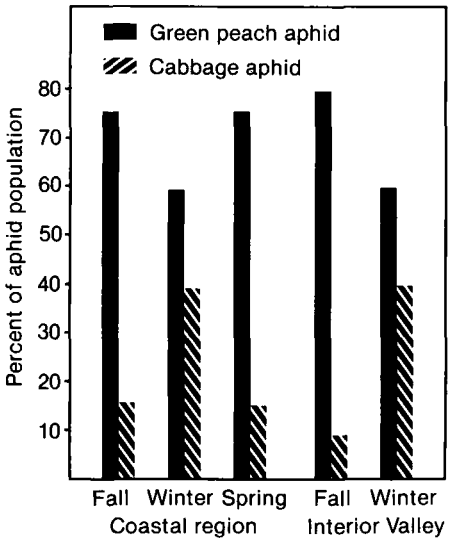


Fig. 1. Occurrence of primary aphid species on broccoli grown in valley and coastal areas of California.

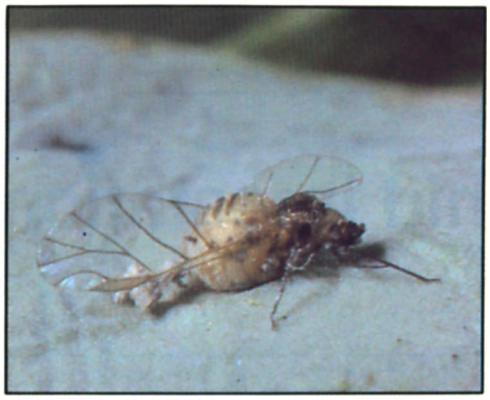
Throughout most of California, the green peach aphid produces a sexual generation in the fall, and females lay eggs that overwinter on peach trees. In the spring, winged adults leave the peach trees and migrate to a variety of weed and vegetable hosts, including broccoli. Offspring from these adults reproduce parthenogenetically (nonsexually), so that populations may expand quickly. In warmer areas like southern California, parthenogenetic reproduction may occur throughout the year without need for a sexual generation.

Cabbage aphid

Cabbage aphids, *Brevicoryne brassicae* (L.), were easily distinguished from green peach aphids because of their gray color and white waxlike covering. These aphids were gregarious, occasionally gathering in colonies of several thousand. Such large groups were quite destructive, often stunting the plants and seriously reducing yields.

In the cool northern regions of California, cabbage aphids overwinter in the egg stage on crop debris or weeds in the genus *Brassica*. However, warm winters in southern California permit parthenogenetic reproduction all year, and 15 to 20 generations may be produced annually. Cabbage aphids are more tolerant of cold weather than the other aphid species attacking broccoli; infestations generally occur in the winter in southern California and in the spring and fall in northern California.

Although they did not reach population densities as high as those of green peach aphids, cabbage aphids were of greater economic importance as a contaminant of broccoli. Approximately 20 percent of the harvested broccoli was contaminated in the fall and winter plantings, and cabbage aphids



Biological control agents, such as syrphid larva shown attacking cabbage aphid colony, may cause additional contamination of broccoli heads.

Green peach aphid, shown above right in parasitized state, is a problem mostly because it transmits virus diseases.

Parasitized cabbage aphids are often so firmly attached to the plant that repeated rinsings are required to dislodge them.

accounted for over 90 percent of the insects observed. Because cabbage aphids tend to move from the youngest leaves into the broccoli heads, they must be controlled before heading to ensure a marketable crop.

Other aphid species

The turnip aphid, *Hyadaphis erysimi* (Kaltenbach), and the potato aphid, *Macrosiphum euphorbiae* (Thomas), were occasionally found at low population levels but were not considered to be of major importance. Turnip aphids are generally yellow or green, with black heads. Although similar in appearance to cabbage aphids, they could be readily distinguished by the absence of a waxlike coating. The red biotype of the potato aphid was the dominant form during fall and early winter plantings, which greatly facilitated identification and separation of species. Throughout the remainder of the study the green biotype predominated. The relatively long cornicles (tubular structures projecting upward or backward from the rear of the abdomen) and legs, as well as the extended antennal tubercles (protrusions on the head to which the antennae are attached), aided in distinguishing this species.

Winged forms of *Macrosiphum ambrosiae* (Thomas), *Aphis spiraecola* Patch, and *Schizaphis graminum* (Rondani) were the most common aphids encountered that did not accept broccoli as a host. Therefore, we did not investigate the occurrence, distribution, and potential for virus transmission by these visitors.

Distribution and sampling

Approximately two weeks after broccoli thinning, the aphid species began to segregate by location on the plants. Cabbage aphids preferred the youngest and highest leaves; green peach aphids were most common on the undersides of the oldest leaves (fig. 2).

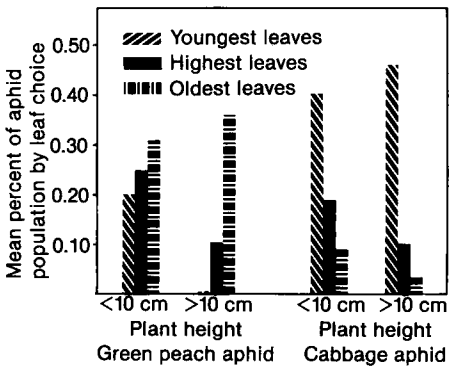


Fig. 2. Niche separation by green peach and cabbage aphids based on plant development.

These preferences appeared to be in response to nitrogen availability in the plants. The youngest and highest leaves near the apical meristem were rapidly growing and served as nitrogen "sinks." As the oldest leaves began to senesce, the nitrogen-containing compounds released by cellular breakdown were transported out of the leaves for use elsewhere in the plant, and substantial amounts of amino acids and nitrogen became available in a form suitable for aphids and other sap-feeding insects. The other aphid species were usually found on the intermediate leaves, unless one of the high-nitrogen niches was available. Earlier in the season, when plant height averaged less than 10 cm (4 inches) physiological differences between the leaves were minor and within-plant distributions of aphid species were not as well defined.

Based on this information, early-season monitoring should include aphid counts from entire plants. Once plants reach about 10 cm, sampling for the cabbage aphid is most efficient when only the youngest and highest leaves are sampled. The green peach aphid can be effectively monitored by checking just the underside of the oldest leaf. Researchers in both England and the United States have demonstrated an "edge effect" for aphid infestations; borders of fields tend to have larger populations. Therefore, presence-or-absence sampling should concentrate on these areas to minimize sampling time and maximize efficiency. This type of sampling is particularly important before heads begin to form, since aphids must be controlled at this time if a marketable crop is to be produced.

Previous research at U.C., Riverside, has shown that, in the absence of viruses, broccoli plants can tolerate at least 100 aphids per plant without significant yield loss. However, if viruses are prevalent, economic losses can occur at much lower population levels, and pesticide application may be required sooner. Since aphid populations were often distributed in clumps in the field, counts from just a few plants were not effective for determining the extent of an infestation. Samples collected throughout the field provided the best statistical picture of aphid density, but sampling from field borders (especially those downwind of fences or windbreaks) produced more conservative estimates and provided the earliest notice of aphid migrations.

John T. Trumble is Assistant Professor of Entomology, Henry Nakakihara is Staff Research Associate, and William Carson is Laboratory Assistant, Department of Entomology, University of California, Riverside, Calif. All photos by Max Badgley, Department of Entomology, U.C., Riverside.