Thresholds and sampling for aphids in strawberries

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Aphids occasionally cause substantial yield losses in California strawberries, usually as a result of honeydew accumulation from large populations of the pest. Honeydew deposits on the fruit permit development of sooty mold and attachment of the white skins shed by aphid nymphs; this contamination renders the fruit unmarketable. Many growers therefore apply pesticides regularly to prevent aphid population buildup. Viruses transmitted by aphids also can cause significant damage, but pesticide applications to reduce virus transmission are uneconomical.

Commercially grown strawberries are packed in the field; water rinses to remove contaminants are impractical, because moisture increases disease incidence and minimizes shelf life. One objective of the study reported here was to determine an economic threshold, or level at which treatment would be necessary, based on the relation between density of aphids per plant and occurrence of honeydew on the fruit. A second objective was to document which aphid species were the primary causes of contamination.

To develop sampling programs usable by growers, we investigated the distribution of aphids within strawberry fields. We also examined their distribution within the plant in an effort to reduce the time necessary to estimate accurately the aphid population density. Previous experiments on niche selection in broccoli had shown that aphids preferred the youngest or oldest leaves, which had high concentrations of nitrogen-containing compounds. Therefore, in this experiment, we recorded populations on the youngest and oldest leaves per plant separately from the whole-plant counts.

Aphid infestations were monitored on annual winter plantings of 'Tufts' strawberries at the University of California South Coast Field Station in Orange County during 1981 and 1982. Both plantings were transplanted the first week in November, plastic-mulched, and drip-irrigated. At each weekly sampling date from mid-January to mid-May in both years, all fruit were harvested and examined. Fruit were considered unmarketable when honeydew, cast skins, or sooty mold were present.

Aphid species

The strawberry aphid, *Chaetosiphion fragaefolii* (Cockerell), was the most common species present in either planting. These aphids are usually pale green to white in color, and are characteristically covered with hairs. This species was the primary cause of contamination and accounted for over 60 percent of the total aphid population.

The melon aphid, *Aphis gossypii* Glover, the second most common species, was also responsible for some contamination. These small, globose aphids vary from yellowish green to greenish black. Although melon aphids accounted for only 30 to 35 percent of the total aphid population, this species was the first to migrate into the field, and population densities equaled those of the strawberry aphid during the first month of sampling.

The green peach aphid, *Myzus persicae* (Sulzer), and the potato aphid, *Macrosiphum euphorbiae* (Thomas), were also present, but only at low densities (less than 5 to 10 percent of the total aphid population). However, inclusion of these species in our sampling program simplified sampling procedures by eliminating problems associated with identification. Including these aphids also increased the probability of a decision to apply control measures, thereby providing a conservative basis for our sampling program.

Aphid populations

Statistical analysis of a fast-growing aphid population (see details in accompanying box) showed that a group rather than an individual aphid was the basic unit of the population, and that the groups were aggregated in the field. This is logical biologically, because migrating adults reproduce rapidly, and each produces a cluster of aphids.

Our findings permitted the development of sampling plans based first on monitoring cumulative aphid numbers on the whole plant (sequential sampling). Later, when plants become too large for efficient whole-plant sampling, aphids can be monitored by a simple presence-absence (binomial) plan, whereby the need for control is determined by the percentage of plants infested on leaf subsamples, that is, the oldest trifoliate (three leaflets).

Under the sequential sampling plan, a decision to treat or not to treat is reached if the cumulative number of aphids counted is above the upper threshold line or below the lower threshold line, respectively, for a given number of plants sampled randomly.

In both years, aphid populations began to decline by the first week in April. Exact reasons for the decline cannot be specified, but a general increase in temperature and a corresponding change in plant physiology were probably more important than parasites, which accounted for less than 6 percent mortality at peak aphid populations.

By mid- to late-March, the strawberry plants were about 30 cm in diameter, and searching the entire plant became tedious and time-consuming. We compared data on leaf subsamples with whole-plant counts and found a linear relationship between the percentage of plants with aphids on the oldest trifoliate and the mean number of aphids per plant. Thus, at this stage, a presence-absence sampling plan accurately indicated the need for treatment.

With 30 aphids per plant as a threshold, and 90 percent confidence levels, the potential for contamination began when about 30 percent of the plants were infested with aphids on the oldest trifoliates. At population levels below 10 aphids per plant, the relationship between percent oldest trifoliates infested and aphid density per plant was no longer linear. However, at such low densities, no more than 20 percent of the plants had aphids on the oldest trifoliates, and either the presence-absence or the sequential sampling plan provided for rapid decisions.

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The strawberry aphid is the primary cause of unmarketable fruit.

Sampling and statistical analysis

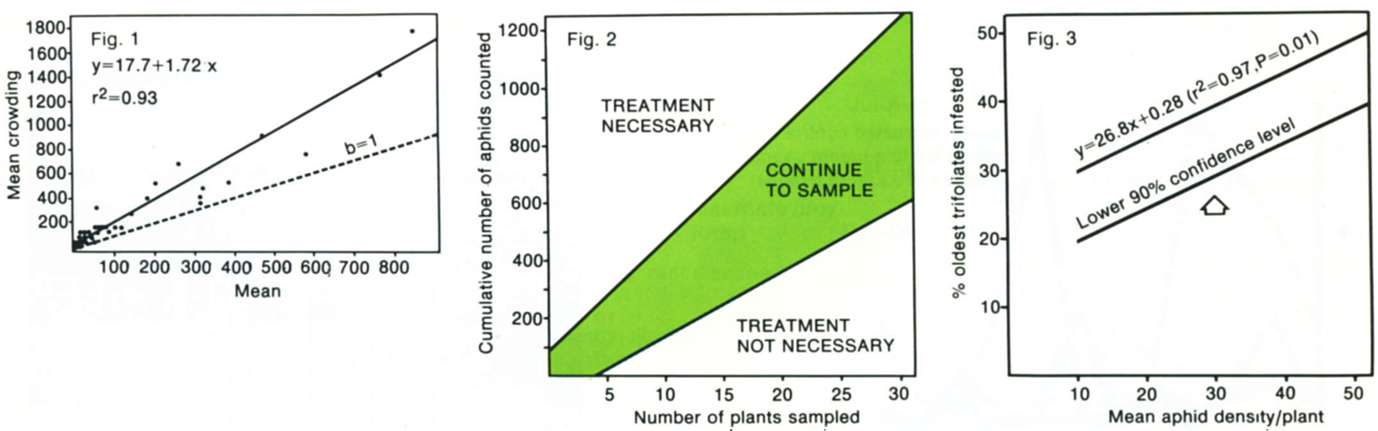
The strawberry plantings monitored consisted of 15 and 12 double-row, 60-meter-long beds in 1981 and 1982, respectively. In 1981, 144 plants were sampled each week in a stratified-random sampling plan. Data were not collected on May 21. In 1982, 118 plants per week were sampled from January 12 until March 2, and 72 plants per week from March 9 to May 11; data were not collected on March 16 or May 3.

To determine the within-field distribution of aphids, we used a statistical technique developed by the late Professor Iwao of Nagoya University in Japan, which basically called for a regression of mean crowding (=mean+[$\frac{\text{variance}}{\text{mean}}$]−1) on the mean.

This technique provided valuable information on whether an individual or a group of individuals was the basic unit of the population (from the y axis intercept), and how these units were distributed in the field (from the slope). Using data from a rapidly increasing aphid population (fig. 1), we determined that a group of aphids was the basic unit of the population. Also, these groups were found to be aggregated in the field, since the slope of the regression line in figure 1 was greater than one (see dotted line).

Fortunately, this technique also provides the foundation for a sequential sampling plan (fig. 2) (upper and lower threshold lines were developed at the 90 percent confidence level). This sequential sampling plan, which is based on the regression of mean crowding on the mean, has the advantage of including the concepts of a group or cluster of aphids, as the basic unit of the population, occurring in an aggregated fashion in the field.

When strawberry plants became too large to sample effectively with the sequential technique, our analysis showed that a simple binomial, or presence-absence, sampling plan (fig. 3) would accurately indicate when to start control measures.



Aphid distribution: Fig. 1. Regression of mean crowding on the mean number of aphids per plant for an increasing population. Fig. 2. Sequential sampling plan for aphids infesting strawberry plants. Fig. 3. Linear relationship between mean aphid density per plant and percentage oldest trifoliates infested. When about 30 percent of oldest trifoliates are infested (arrow), action must be taken to prevent fruit contamination.