

cultivars with high doubling potential produced many doubles. In general, as the trees matured and began to spread, more limbs became exposed to direct sunlight, resulting in higher doubling percentages.

Cultivars in this test fell into three categories for doubling tendency (see table). The high-potential group averaged over 10 percent doubles for the test period, but during high doubling years, these cultivars frequently produced 30 percent or more double fruit. The moderate potential group averaged 4 to 10 percent doubles, but occasionally some cultivars produced 20 to 25 percent in high doubling years. The low potential group averaged less than 2 percent for the test period, and only a few of these cultivars exceeded 5 percent even in the worst years.

We conducted a limited test comparing the standard planting (20 by 20 feet) with a hedgerow planting of 7 by 15 feet. With most cultivars the closer spacing reduced the amount of fruit doubling (but did not eliminate it), presumably because limbs were shaded during bud differentiation. However, in the hedgerow, fruit maturity was delayed and yield reduced, probably also as a result of shading.

Some producers are interested in growing sweet cherries outside the traditional areas of adaptation in California. It should be noted that the cultivars Bing, Royal Ann, Early Burlat, and Van, which now make up over 90 percent of the sweet cherry acreage in California, all have high doubling potential. Therefore, if commercial cherry production is to be attempted in the warmer locations of the Central Valley, a change in cultivar selection should be considered.

Although the low potential group in this test included some cultivars generally considered unsuitable for commercial production (Black Republican and Black Tartarian), others within the group have commercial possibilities. The number of sweet cherry cultivars tested was limited, but this study points out the necessity for evaluating commercially promising cultivars for doubling potential under warm growing conditions before extensive plantings are made in such areas as the southern San Joaquin and Sacramento valleys of California.

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Damage to processing tomato caused by tomato fruitworm, *Heliothis zea*.

## Monitoring lepidopterous pest damage to processing tomatoes

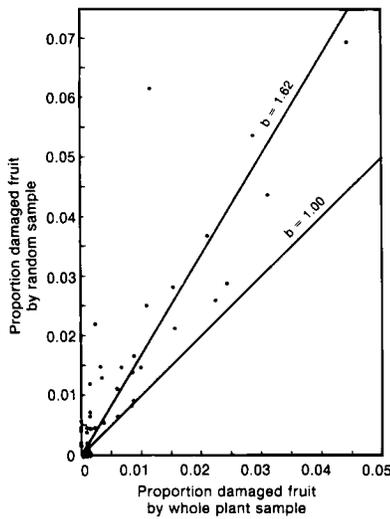
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**F**ew quantitative procedures exist for monitoring lepidopterous pests in processing tomatoes, yet reliable, cost-efficient sampling techniques are essential for the implementation of an integrated pest management program. These sampling techniques must be of such intensity as to predict the amount of damage with a given degree of reliability, yet sufficiently time-efficient to be useful to growers or crop consultants. Without such procedures, assessing a pest's status is subjective and may result in unnecessary control actions. Reliable control decision criteria are especially important in processing tomatoes, where thresholds for damage are set by government or industry standards, and exceeding damage thresholds can result in rejection of the crop.

Two lepidopterous pests are perennial problems in the San Joaquin and Sacramento valleys of California: the beet armyworm, *Spodoptera exigua*

(Hübner), and the tomato fruitworm, *Heliothis zea* (Boddie). The larvae of both species can enter the fruit, but tomato fruitworm is especially important, because it contaminates fruit with excrement. Such fruit often remains unhealed and becomes unmarketable.

During the summer of 1981, three commercial fields in Sutter and Yolo counties were monitored weekly for fruit damage by two techniques at 36 predetermined sites in each field. We took a "whole-plant" sample at each site by uprooting two plants and recording the numbers and proportion of damaged fruit. The whole-plant method provided an absolute estimate of lepidopterous pest activity, and was a standard upon which to base comparisons. The second method consisted of selecting 30 fruit at random from plants at each site. Some pest control advisors use a random procedure to assess damage, often without regard to adequate sample size. In both

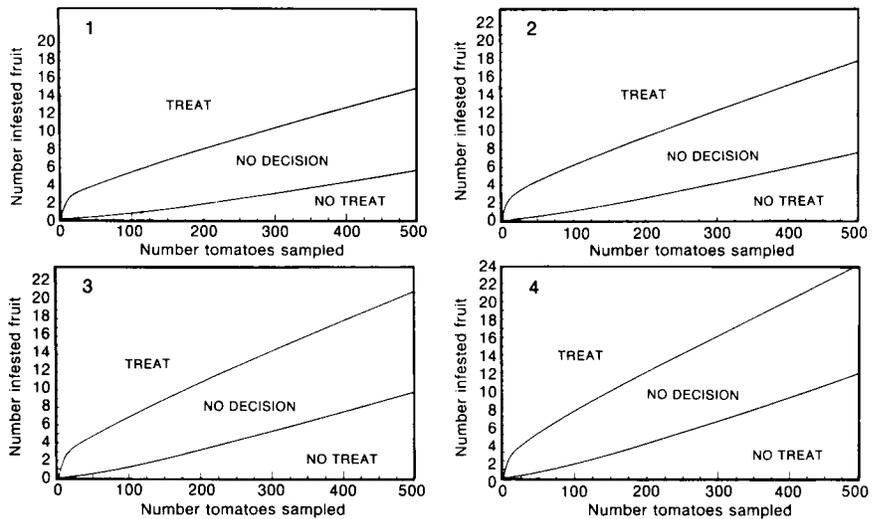


**Fig. 1. Random sampling procedure, compared with whole-plant sampling, predicts 62 percent greater injury than is actually present.**

sampling methods, a fruit was considered damaged when the wound had not healed by scar tissue.

We compared the relative efficiencies of the whole-plant and random-sample counts using regression techniques (fig. 1). The forced regression coefficient ( $b = 1.620$ ) indicates that the random sampling procedure provides a biased estimate of damage, predicting 62 percent greater injury than is actually present. However, the correlation between the sampling techniques was highly significant ( $r^2 = 0.76$ ;  $n = 43$ ). Therefore, although the random sampling procedure provides an inflated estimate of larval damage, actual damage can be calculated by using a correction factor. This becomes important when considering the time (cost) required to estimate the control action status with a given degree of reliability. In this case, the time required to sample 30 fruit at random after all fruit has been set is 4.9 minutes, whereas each equivalent whole plant estimate would require 11.0 minutes. Thus, the random sampling procedure is more time-efficient in the field.

Most beet armyworm and tomato fruitworm larvae occur in processing tomatoes during late August or early September, although some activity can be found as early as May and as late as November. Depending on when the tomato crop is planted and the number of larvae present, some fields may escape fruit injury almost completely and others may suffer economic damage. The best strategy for minimizing damage is to seed the crop as early as possible so that fruit is more likely to mature before either species becomes abundant late in the season. Spring rains and cool spring temperatures, farm-specific cultural constraints, and contractual obligations



**Fig. 2. Four sequential sampling rules are used with crop maturity date and growth stage (see table). Decision to treat or not to treat is made when number of infested fruit is equal to or greater than upper action line or equal to or less than lower line.**

**Sampling rules for tomato fruitworm based on stage of crop growth and for early, mid-, and late-maturing crops.\***

Fruit stage most common	$^{\circ}\text{D} > 10.0^{\circ}\text{C}$ from emergence†	Early crop (before 15 August)	Mid-crop (16 August-15 September)	Late crop (after 15 September)
Green <2.5 cm	<325	No treat	No treat	No treat
Green >2.5 cm	>325	2	1	1
Pink	525	3	2	1
25% red	625	3	3	2
50% red	750	4	4	4

\*Numbers 1 through 4 correspond to sequential sampling decision rules based on different treatment thresholds, which are shown in figure 2.

† $^{\circ}\text{D}$  = Degree-day, a measurement of development based on heat accumulation. As an example, at a constant  $30^{\circ}\text{C}$  and a  $10^{\circ}\text{C}$  threshold for tomato development,  $20^{\circ}\text{C}$  would accumulate in a day.

result in large acreages of late-maturing, and therefore susceptible, processing tomatoes every year. Further, damage becomes most serious as harvest approaches, because of injured fruit failing to drop before harvest and the probability of wounds remaining unhealed.

A dynamic threshold is therefore warranted that takes into account both the earliness or lateness of the crop and the associated likelihood of increased damage later in the season. These relationships are expressed in the table, where numbers 1 through 4 correspond to sequential sampling decision rules based on different thresholds.

The four sequential sampling lines (fig. 2) are to be used in conjunction with crop maturity date and crop stage presented in the table. A decision to treat or not to treat is reached when the number of infested fruit is equal to or greater than the upper action line, or equal to or less than the lower action line, or when an arbitrary upper limit of 500 fruit is reached. By this technique the maximum estimate of damage before harvest would be 2 percent, which corresponds to the current damage tol-

erance for California's processing tomatoes. These graphs can be converted to sampling forms for ease of field use.

The proposed control decision guidelines are provisional and allow for the implementation of a quantitative, albeit conservative, monitoring program. The actual damage threshold corresponding to 2 percent damage after harvest is probably higher because of natural fruit loss in the field, mechanical harvesting, and sorting during harvest. Further, the error rates used in developing the sampling decision lines ( $a = 0.10$ ;  $b = 0.05$ ) assign more importance to a conservative treatment approach. As relevant information becomes available on effects of the tomato fruitworm and the beet armyworm, the error rates as well as control decision thresholds will be adjusted to maximize net profits.

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