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AVOCADO PESTS

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The California avocado grower is fortunate in having fewer pest problems than the grower of some other subtropical fruit crops. A considerable number of pest species are present, particularly in the coastal areas, but serious injury is sporadic and localized. Ordinarily the many natural enemies are effective in keeping the pest populations so low that treatment is not justified.

In recent years the "avocadoworms" appear to have caused a greater cullage and degrading of fruit than other pests. The avocadoworms are primarily the larvae of three species of moths: the omnivorous looper **(Sabulodes caberata),** the amorbia **(Amorbia essigana)** and the orange tortrix **(Argyrotaenia citrana).** The present paper deals primarily with this group of insects, although some data are incidentally included regarding the latania scale **(Hemiberlesia lataniae)** and the greenhouse thrips **(Heliothrips haemorrhoidalis).**

Experiments at Santa Paula

In June, 1952, experiments were begun in the avocado groves of J. N. Thille (Grove A) and Albert Thille (Grove B) near Santa Paula, in cooperation with the Department of Biological Control, University of California, Riverside. Although these groves never had pest infestations of economic importance, plots of 16 trees each were annually sprayed with 8 pesticides, increased by 2 more in 1955. The object of the experiment was to determine the effect of the annual application of pesticides where pest populations in untreated trees never rise to economically important levels. In other words, an attempt was made to create a pest problem by distributing the balance between the pests and their natural enemies, thereby adding to our knowledge of the role of natural control factors. The application of the sprays and the checking on the insect pests was to be the responsibility of the writers, while the checking on the mite pests and on the populations of natural enemies was to be the responsibility of the Department of Biological Control. Dr. C. A. Fleschner of that department was in charge of this phase of the cooperative project.

The pesticides were applied by means of conventional power sprayers, both the equipment and the labor being supplied by the owners of the groves, but the application was supervised by the writers. The sprays were applied in June of each year and the effectiveness of the treatments was determined by counts made about half a year later.

From 5 to 20 gallons of spray have been applied per tree, depending on the size of the tree. Thoroughness of application was somewhat less than for the average application for scale control on citrus trees.

The pesticides and concentrations were as follows: 50% DDT wettable powder at 2 lbs. to 100 gallons; 50% dieldrin W.P. at 1 lb. to 100; 25% parathion W.P. at 2 lbs. to 100; 25% malathion W.P. at 2 lbs. to 100; 15% Aramite W.P. at 2 lbs. to 100; 50% Ovotran W.P. at 1 lb. to 100; wettable sulfur at 2 lbs. to 100; and light medium spray oil at 1%. In 1955 two plots were added: (1) 50% DDT W.P. at 2 lbs. plus 50% Ovotran W.P. at 1 lb. to 100 and (2) basic lead arsenate at 4 lbs. to 100.

Beginning in 1954, counts were made annually to determine the relative population densities of the two insect pests that appeared in appreciable numbers, the omnivorous looper and the latania scale. As a criterion of the density of the populations of omnivorous loopers in the various plots, the number of areas of foliage injured by this insect were determined while slowly walking around each tree. As an estimate of the relative numbers of latania scales in the various plots, 20 mature leaves were picked at random, 5 from each quadrant of the tree, and the number of scales in all stages of development was determined for each leaf.

The results of counts made in 1954, 1955 and 1956 are shown in Figures 1 and 2. The omnivorous loopers were sufficiently abundant to make possible an adequate comparison of plots only in 1954, so Figure 1 shows only the results of the counts made in 1954. Figure 2 shows the average results of counts of latania scale made in 1954, 1955 and 1956.

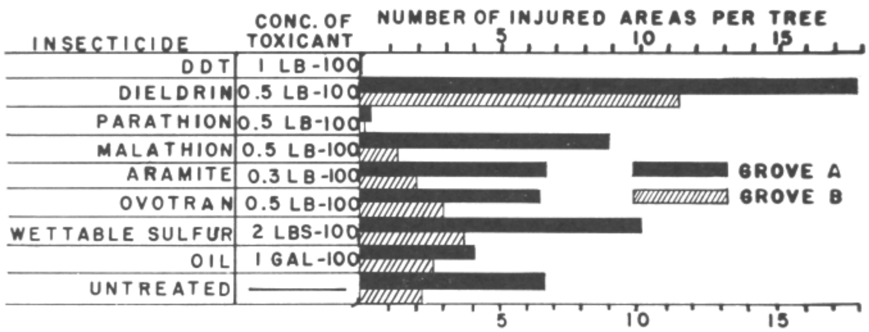

Fig. 1. Relative effect of 8 pesticides on the population density of the omnivorous looper in an avocado grove in Santa Paula in 1954.

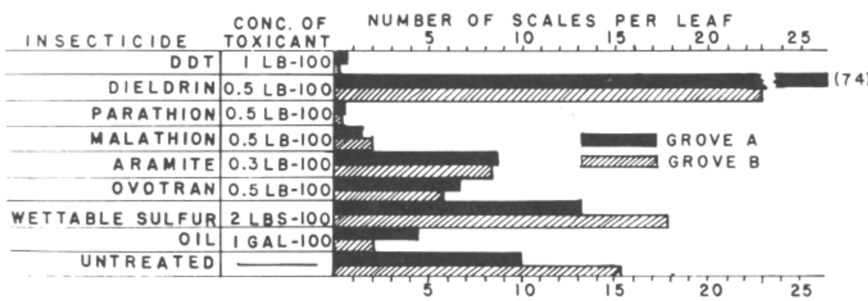

Fig. 2. Average relative effect of 8 insecticides on the population density of the latania scale in an avocado grove in Santa Paula for a 3-year period, 1954 to 1956, inclusive.

Figure 1 shows that in 1954 the relative populations of omnivorous loopers in the different plots were similar in Groves A and B. However, for all treatments, as well as for the untreated check, the population density of the loopers was less in Grove B than in Grove A. The trees in Grove B were younger and smaller, and that in itself should result in a decrease in the number of injured areas per tree. However, it is known from experience in other areas, that the density of omnivorous loopers and other avocadoworms is ordinarily much greater, per unit of tree volume, in large trees. The large trees provide a more sheltered and shaded area for the development of these insects. This is shown by the fact that the percentage of fruits injured by avocadoworms is ordinarily much greater in large trees, particularly with those of interlacing branches making a continuous canopy of dense foliage, than in smaller trees.

Comparing the plots within each grove, those sprayed with dieldrin and wettable sulfur were the only ones with significantly more looper injury than that which was found in the untreated check. Apparently these two insecticides had a strikingly adverse effect on the natural enemies without a corresponding insecticidal effect against the loopers. Dieldrin had an especially detrimental effect as far as the infestation of loopers was concerned. However, there was no tendency for dieldrin and wettable sulfur to increase the intensity of their effects over the three-year period that the counts were made.

DDT and parathion were outstandingly effective in controlling both avocadoworms and scales. DDT and dieldrin both had the effect of increasing the populations of avocado brown mites, **Oligonychus punicae**, to high levels, but that aspect of the problem will be considered by Dr. C. A. Fleschner in another paper.

Figure 2 shows that dieldrin and wettable sulfur are also the only insecticides that resulted in increased populations of the latania scale, dieldrin being particularly detrimental in that respect. The latania scale population remained approximately constant in the various plots during the three-year period of our observations and the ratio of the scale population between the dieldrin-or-wettable-sulfur-sprayed plots and the untreated check also was approximately constant.

DDT, parathion, malathion and light medium oil were able to decrease the latania scale population over the three-year period, the first two being particularly effective.

It is of interest to note that although dieldrin had a striking effect in increasing the looper population in 1954, when these insects were relatively abundant, it had no significant effect in that respect in 1955 and 1956, when conditions were apparently unfavorable for the development of omnivorous loopers. The average numbers of looper injuries per tree in the dieldrin-sprayed plots in 1955 and 1956 were, respectively, 0.5 and 0.6, as compared to 0.7 and 0.8 for the untreated plot. The looper injuries in the DDT-or-parathion-sprayed plots were never above 0.1 per tree during these two years.

On June 23, 1955, 2 new plots were added to the series in Grove A: one was sprayed with 2 Ibs. of 50% DDT wettable powder plus 1 Ib. of 50% Ovotran wettable powder to 100 gallons and the other was sprayed with 4 Ibs. of basic lead arsenate to 100 gallons. By 1956 these treatments had decreased the population of omnivorous loopers to 12% and 25%, respectively, of that of the untreated check and had decreased the latania scale population to 15% and 24%, respectively, of that of the untreated check.

The ability of lead arsenate to decrease the population density of the latania scale was verified in another avocado grove in Encinitas, San Diego County, where 3 months after the second annual treatment with lead arsenate, the population of scales was only 23% as high in the lead arsenate-treated plot as in the untreated check. It appears to cause no mortality of the scales or even an appreciable decrease in the ability of the crawlers to settle and develop, but in some insidious manner it appears to cause the tree to be a less favorable environment for the scales if treatments are continued for at least a two-year period.

Varietal Differences

Great differences were found in the susceptibility of the three varieties of avocado trees found in every plot to both the omnivorous looper and the latania scale. The average populations of omnivorous loopers were found to be 49% as great on the Hass variety and 28% as great on the MacArthur variety as on the Fuerte variety. For the latania scale the corresponding percentages were, for the Hass, 39, and for the MacArthur, 47. In the case of the omnivorous looper, at least, the lower degree of infestation on the Hass and the MacArthur varieties appears to be, at least in part, owing to the less favorable growth habits of these varieties for the omnivorous looper. Observations indicate that there is a similar difference in these varieties with respect to their susceptibility to infestation by the orange tortrix.

Experiments in Encinitas

In two groves containing the varieties Anaheim, Wurtz and Hass, standard or basic lead arsenate and parathion were compared as to their long-term effectiveness in depressing populations of omnivorous loopers and greenhouse thrips, at long periods after treatment, as based on the percentage of scarred fruit of the Wurtz variety. As shown in Table 1, all the insecticides had the effect of substantially decreasing the percentage of scarring from omnivorous loopers, but lead arsenate had no effect on the greenhouse thrips in Grove A. In Grove B this pest did not occur in appreciable numbers and no counts were made of fruit scarred by thrips.

Lead arsenate, even though it may appear to be relatively low in initial effectiveness against the omnivorous looper, has the advantage of remaining on the tree surface for long periods as an effective residue, but without interfering with the natural enemies. If used at sufficiently high concentrations, it can be applied after the fruit is picked as an insurance against a heavy infestation of loopers for the following year's crop. Residues left by lead arsenate on fruit would be in too high a quantity and would persist too long for consideration in the spraying of avocados with fruits any larger than the size of an egg. The amount of residue remaining on the fruit would be far greater than that which is allowed in the tolerance set for lead and for arsenic by the Federal Food and Drug Administration.

Table 1. Effect of three insecticides on the population densities of the omnivorous looper and the greenhouse thrips at long periods after treatment.

Grove	Insecticide[1]	Concentration of actual toxicant	Date of application	Date of counts	Per cent of scarred fruit Looper	Per cent of scarred fruit Thrips
A	DDT, 50% W.P.	½ lb. - 100	7-6-54	8-12-55	6	0
A	DDT, 50% W.P.	1 lb. - 100	7-6-54	8-12-55	5	0
A	Basic lead arsenate	4 lbs. - 100	7-6-54	8-12-55	3	36[2]
A	Untreated	----------------	----------	8-12-55	11	34
B	DDT, 50% W.P.	2 lbs. - 100	10-27-55	5-14-56	6	----
B	Parathion, 25% W.P.	2 lbs. - 100	10-27-55	5-14-56	3	----
B	Standard lead arsenate	3 lbs. - 100	10-27-55	5-14-56	7	----
B	Untreated	----------------	-------------	5-14-56	18	----

[1]*In every treated plot, Ovotran at 1 lb. and zinc at 1 lb. to 100 gallons were added to the spray, the Ovotran to control the avocado brown mite and six-spotted mite.*
[2]*Thrips were found on only a few trees bordering an older portion of the orchard in which thrips were abundant.*

In a section of Grove A the trees are older and much larger than those in the remainder of the grove. Their branches interlace and form a continuous canopy of foliage. Here the omnivorous loopers were so abundant that one could stand in the grove at night and hear the excrement of the larvae fall on the dry leaves under the trees with a sound similar to that of a light shower of rain. In this section of the orchard, 31% of the harvested Wurtz avocado fruits were scarred by omnivorous loopers and 63% by greenhouse thrips. In the remainder of the grove, 11% of the fruits were scarred by loopers and there was practically no scarring from thrips except for a few trees adjoining the older section of the grove in which the thrips were so abundant.

Large, interlacing trees provide a particularly favorable environment for omnivorous loopers and greenhouse thrips, and, as will be shown later, for the orange tortrix.

Experiments in Leucadia

The orange tortrix, **Argyrotaenia citrana**, is one of a family of moths known primarily as "leaf rollers." This name derives from their habit of rolling leaves and webbing them together, then feeding inside of this protective roll. They will, however, feed in other sheltered areas, such as under "nests" of debris built by the larvae or where two fruits or a fruit and a leaf come together, just as another leaf roller on avocados, the amorbia. The omnivorous looper also feeds in such places, but will also crawl out of its hiding places at night and feed on uncovered fruit surfaces.

The orange tortrix has been known to be present in California at least since 1885 and was already causing considerable damage to oranges in certain areas of southern California at the turn of the century. It was known for many years as a pest of importance only on citrus, but during the last decade it has become a serious pest of deciduous fruits, berries, and ornamental trees and shrubs in the Pacific Coast states. In 1949 it was found to be doing a limited amount of damage to avocados by feeding on green twigs and fruit. Since then it has gradually increased its depredations on the avocado until it may now cause important damage to the crop of certain varieties in some orchards in the coastal areas.

Description and biology. The adult moths are about 4/10 inch long, brownish, and usually with a chevron of a darker shade across the folded wings (Fig. 3, left). When the moth is at rest the folded wings flare out a little at the tip like a bell. The moths lay their masses of pale-green or cream-colored eggs on the leaves or smooth green bark of the avocado. These egg masses may be distinguished from those of the omnivorous looper and the amorbia in that the eggs overlap one another like shingles or fish scales.

There are 5 to 7 larval instars. When full-grown, the larvae are about ½ inch long, and may be straw-colored, light tan, greenish, or rather smoky-colored (Fig. 3, right). Like the larvae of the amorbia and other leaf rollers, they are very active when uncovered, and will wriggle about violently and attempt to drop to the ground. There are probably about three overlapping generations a year on avocado trees in the coastal areas.

Injury. Orange tortrix larvae cause the following types of injury to avocado trees: (1) feed on the bark of green twigs, sometimes girdling them (Fig. 3, right); (2) feed on terminal buds and foliage, after webbing the leaves together; (3) feed at the bases of the terminal clusters of twigs, causing a typical "rat-tailing" (Fig. 4); (4) feed under the tape of newly budded trees, destroying the inserted buds; (5) the smallest larvae may feed inside the flowers or farther down on the stems; and (6) feed on the fruit (Fig. 5). The feeding on the fruit, resulting in cullage or reduced grade, has been the most important type of injury caused by the orange tortrix to date.

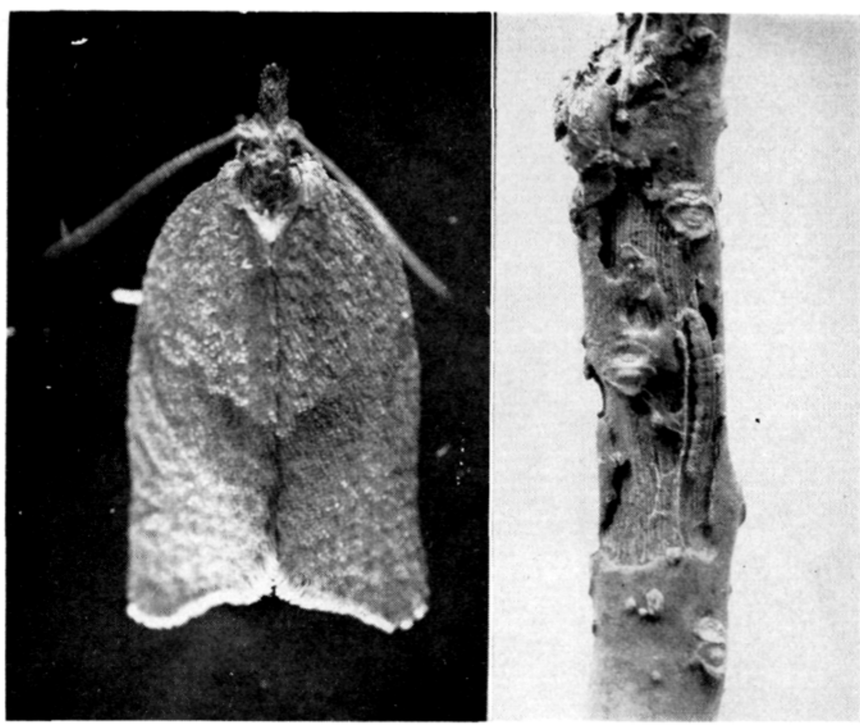

Fig. 3. The orange tortrix. Left, adult moth; right, larva revealed by removing a "nest" from a green twig.

Injury to the fruit consists of two types: scarring of a limited area at the stem end of a fruit, usually accompanied by deep circular holes (Fig. 5, left) and a more extensive scarring of the side of a fruit with only occasionally a deep hole (Fig. 5, right). The feeding of the larvae at the stem takes place under "nests" of flower parts, bits of leaves, and other debris. This debris collects around the stem of the fruit and is webbed together by the larvae as a shelter under which to feed and eventually to pupate. If the nest covers a part of the stem, the larvae may feed on it also and may cause the fruit to drop. Feeding on the twigs also occurs under "nests" of debris; when these are removed, injured bark will invariably be found below.

Injury to the sides of the fruit is the most conspicuous and most common form of injury (Fig. 5, right). It may appear to be similar to injury caused by the omnivorous looper and the amorbia, but since the orange tortrix larvae are smaller than those of the other avocadoworms, the channels of injured tissue are on the average more narrow and they are also more serpentine. However, as in the case of the amorbia, the orange tortrix larvae must confine their feeding to the area covered by an adjoining leaf or fruit. Where there is a leaf next to the fruit, there is a particularly large protected area over which the larvae can feed. If a sufficient number are present, the typical serpentine channels of injured tissue will merge and result in a continuous injured area. Then either because they have run out of peel or because by that time they have become larger, the larvae will bore directly downward and form the round, deep holes that are characteristic of orangeworm injury, but not of the injury of other avocadoworms. The probable reason the holes are more prevalent at the stem end is that the available area for feeding is more restricted; the nests at the stem end of the fruit offer less protected feeding area than the leaves covering the side of the fruit.

Fig. 4. The "rat-tailing" of terminal twiglets caused by orange tortrix larvae feeding at their bases.

Factors favoring infestation. Serious infestations of orange tortrix have been noticed by the writers only in orchards in which the trees are large and interlacing. The continuously shaded environment in such orchards, and particularly the increased opportunity for the accumulation of debris for the construction of "nests," seem to be factors that greatly increase the populations of orange tortrix, as well as another "nest" builder, **Holcocera iceryaella**. As previously shown, the same conditions are equally favorable to another destructive avocadoworm, the omnivorous looper. The damage from orange tortrix and/or omnivorous looper will vary as much as from 50% in large, interlacing trees to 5 or 10% in smaller or more isolated trees in the same orchard. The Fuerte variety is particularly susceptible to attack by both the orange tortrix and the omnivorous looper. However, severe infestations are uncommon and have so far been confined to the coastal areas.

Control. In one Fuerte orchard in Leucadia, the orange tortrix was not suspected as the principal "avocadoworm" attacking the fruit until it was found that DDT, applied for the omnivorous looper and amorbia, had little effect in decreasing the percentage of fruits injured by "worms." DDT is known to be ineffective against the orange tortrix. Then combined insecticide and fungicide sprays were applied in a cooperative experiment with the Department of Plant Pathology of the Citrus Experiment Station on August 22, 1956. On February 13, 1957, over two thousand fruits were examined to determine the percentage scarred by orange tortrix. An examination of the fruits picked from 7 trees in a plot not treated with insecticide showed that an average of 37.8% were infested with orange tortrix. The per cent of fruit infested per tree ranged from 16.7 to 58.1. In the same row, with trees of approximately the same size, 6 trees sprayed with 28% TDE (also known as DDD) wettable powder and 15% Aramite wettable powder (for control of avocado brown mites), both at 2 pounds to 100 gallons, resulted in an average infestation of 10.6% of the fruits, with a range of 2.0 to 21.7%. Cuprocide applied for control of dothiorella rot appeared to have no effect on the orange tortrix population, as indicated by the fact that among 80 fruits picked from the remainder of the orchard, 41.8% had orange tortrix injuries. The degree of infestation in both the treated and the check plots was closely correlated with the size and density of the tree and the degree to which it was interlaced with adjoining trees. Untreated trees that did not interlace with adjoining trees, and therefore had sunlight on all sides throughout the day, and a minimum of accumulated debris, had a smaller percentage of injured fruit than treated trees with conditions favorable to the development of the orange tortrix. Trees next to a road, and consequently with considerable dust on the foliage, had much heavier infestations of orange tortrix than the trees farther from the road. Apparently the dust interfered with the activities of the parasites.

In an isolated row of Fuertes, where a row of trees had been removed on either side, causing the remaining trees to be less susceptible to infestation by the orange tortrix, on 6 trees sprayed with 25% TDE wettable powder and 15% Aramite wettable powder, each at 2 pounds to 100 gallons, the percentages of tortrix-injured fruit ranged from 2.7 to 7.3, with an average of 4.4. On 6 trees in the same row sprayed with 1½ pounds of 25% parathion wettable powder and 2 pounds of 15% Aramite wettable powder to 100 gallons, the percentages of injured fruit ranged from 3.8 to 15.1, with an average of 8.5.

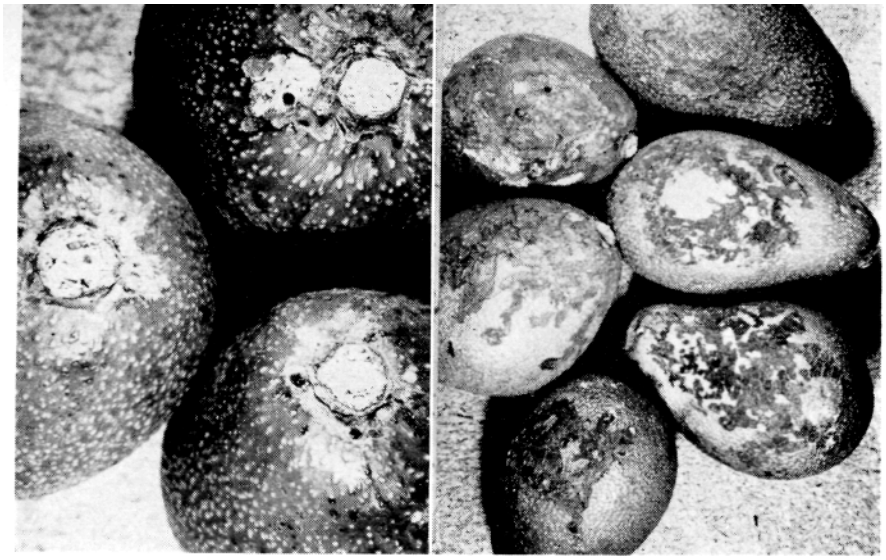

Fig. 5. Orange tortrix injury to avocado fruits. Left, injury to stem end of fruit showing typical holes; right, injury to sides of fruit, where they had been covered by foliage.

The above figures show that TDE and parathion, particularly the former, were effective in substantially decreasing the percentage of fruit injured by the larvae of the orange tortrix. No avocado brown mite problem developed in the treated plots, presumably because of the addition of an effective miticide to the sprays. The latania scale population was found to be the same in the TDE-sprayed plots as in the untreated plot and was greatly decreased in the parathion-sprayed plot. However, it was nowhere of economic importance.

Possibility of control by cultural methods. In view of the usual difficulties encountered by upsetting the balance of pests and their natural enemies, the few growers who suffer substantial losses from avocadoworms should consider all practicable means of utilizing cultural measures to combat these pests. As indicated above, damage from these pests can be decreased to a tolerable level by thinning out trees growing under excessively crowded conditions. This might be accomplished by removing every other tree and keeping the remaining trees open to sunlight by a certain amount of pruning, and particularly by removal of dead twigs and branches. Experience has shown that in orchards in which this has been done the production per acre can be expected to return to its original level in about 3 years. Over a more prolonged period the average production has often greatly exceeded that of the years preceding the correction of the crowded condition. However, a less drastic measure might be to cut every other tree back to the trunk and graft it to what currently appears to be the most desirable variety for the region in question. The Fuerte is not considered to be a particularly desirable variety in coastal areas because of its unpredictable bearing habits. The average yield is much lower than that of a number of other avocado varieties and also much lower than that of the Fuerte in inland areas. Varieties less susceptible to avocadoworms might be worthy of consideration if grafting is to be done.

Growers who plan to thin out their orchard in order to provide a less favorable environment for the avocadoworms should first consult the County Farm Advisor's Office for advice as to the best procedure.