

## Impact of Certain Pesticides on Avocado

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### Introduction

Historically, the production of quality avocados has required little, if any, usage of pesticides. Growing costs have been restricted to those directly related to tree vigor (water and fertilizer) or cultural and harvesting practices. More recently, however, outbreaks of certain destructive pests have necessitated the registration and use of certain pesticides either to reduce populations of insects and plant feeding mites or to control or limit the spread of cinnamon fungus (*Phytophthora cinnamomi* Rands), the causal organism of avocado root rot.

Clearly, in the latter case, there is a need for fungicidal or other chemical intervention by the grower if trees are to remain productive and introduction and/or spread of this destructive disease is to be minimized. As is the case with many plant diseases, grower awareness and thorough sanitation programs for the crop are necessary to achieve economic control. Moreover, the potential for financial losses due to avocado root rot is well documented and the expense of containment and eradication is easily justified.

With insect and mite pests of avocados, however, other considerations come into play. Currently, periodic outbreaks of omnivorous looper, Amorbia moth, thrips, avocado brown mite, and the six-spotted mite are increasingly more frequent throughout avocado producing areas in California. Because of the sporadic nature of these pests, researchers have had difficulty determining the relationship between pest numbers and the corresponding economic losses resulting from infestations. Additionally, the feeding of most avocado pests is limited to foliage and usually is not injurious to fruit until their populations reach extremely high levels. The principal effect of low populations would probably be to reduce functional leaf area. These effects frequently do not become apparent until harvests of subsequent years. Owing to the lack of good correlative information available to the grower, decision making with respect to pesticide applications is at best difficult, and encourages so-called "insurance" treatments in groves with very low pest populations. This practice not only removes beneficial organisms from the groves, which may result in further outbreaks of pests, but also adds significantly and unnecessarily to growing costs.

Aside from the impact of insecticides on target pest populations and the beneficial complex present in the grove, the insecticide product may have deleterious effects on the tree itself. The term "phytotoxicity" denotes injury to plants by chemical products

applied for pest control or growth regulating purposes. Typical reactions of plants to phytotoxic materials include leaf yellowing, irregular growth, blossom burn or drop, or almost any malformation in normal development. However, studies by these authors and others have indicated that the effects of pesticides are frequently more subtle, and may not be evident following treatment. In the case of annual crops, reductions in important physiological processes and growth rates have been observed following applications of commonly used pesticide materials. This results in a delay in harvest and adversely affects yield quality, both of which can occur without any visible symptoms commonly associated with phytotoxicity.

This study was undertaken to assess the impact of currently used and experimental materials on important physiological processes of avocado.

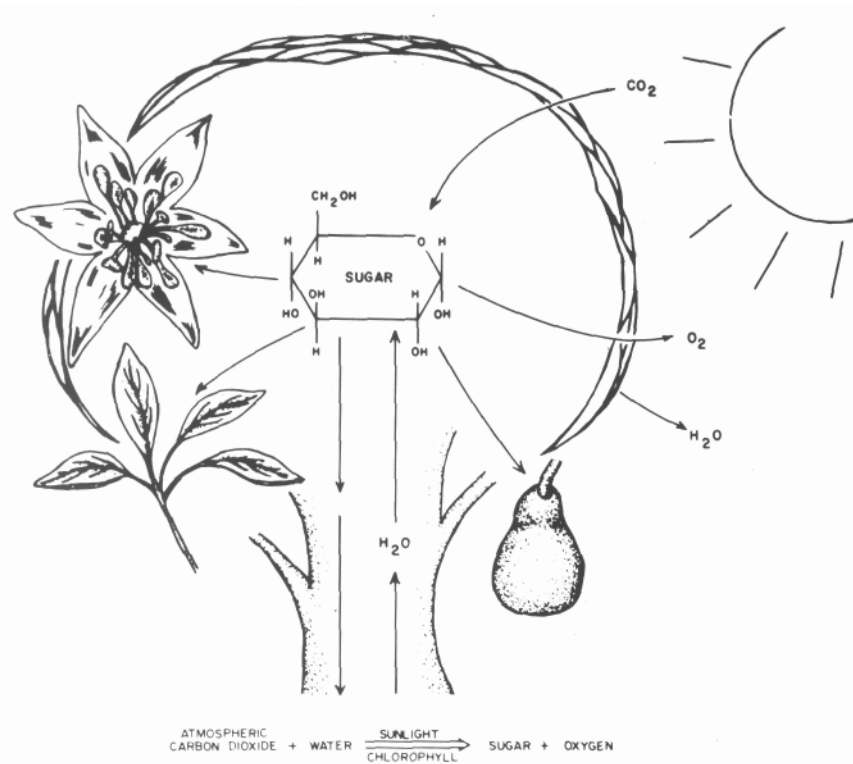


Figure 1: Schematic representation of avocado photosynthesis and carbohydrate distribution.

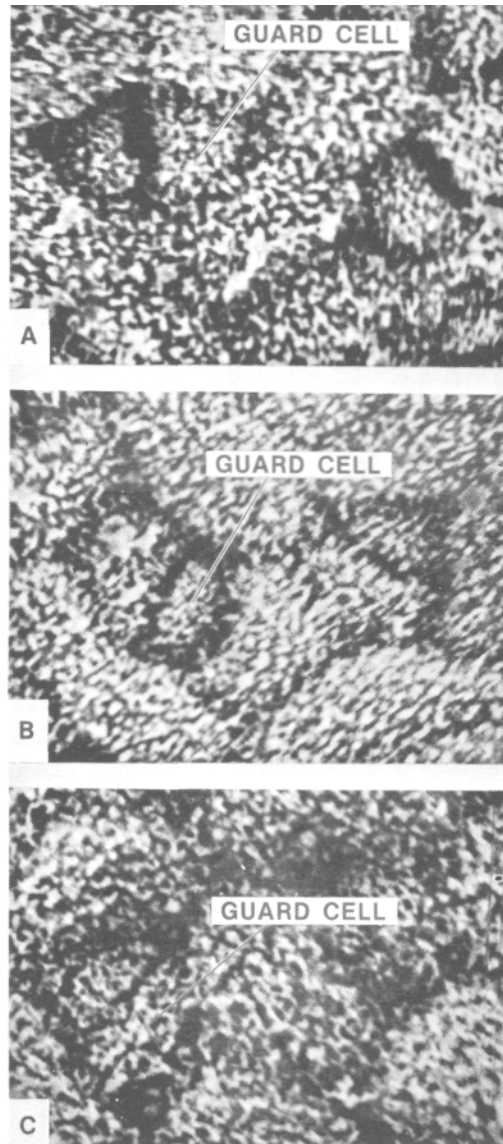


Figure 2: Scanning electron micrograph of avocado leaf stomata, A-open, B-partially open, and C-closed. (Photographed by L. M. LeBeck).

## Plant Physiology

Leaves of avocado and other green plants combine atmospheric CO<sub>2</sub> with water molecules to form sugars through the process of photosynthesis (Figure 1). This event occurs within the chloroplasts of leaf cells and is powered by solar energy absorbed by the pigment chlorophyll. Most of the required water is brought up from the roots through translocation, and the carbon dioxide enters the leaf through small closable apertures in the epidermis called stomata (Figure 2). Thus, the carbon dioxide and water molecules are combined to form carbohydrate molecules, with oxygen given off as a by-product. Open stomata facilitate movement of carbon dioxide into leaves, but as a consequence, large quantities of water are lost to the atmosphere through these openings by simple evaporation. This phenomenon of water leaving the moist internal tissues of leaves

through stomata is known as transpiration. When the rate of transpiration is high, as during warm dry weather, the rate of water loss by leaves may exceed the rate of water uptake by roots, and plants become stressed. When this occurs, stomata tend to close in response to water deficits and transpiration decreases until the plant recovers. Since stomata closure also limits diffusion of carbon dioxide into leaves, photosynthesis rates also may decrease with stomatal closure.

Sugars are the primary products of photosynthesis and they are actively distributed throughout the plant by translocation. These important carbohydrates form the building blocks for all other chemical constituents of the plant. New leaf and flower formation, fruit development, and root formation and growth all depend upon the availability of carbohydrates in the conductive system of trees. In addition, sugars are the source of food for plant cells, in that they are broken down chemically by respiration to supply energy for all plant functions. Sugars are also stored as complex carbohydrates, such as starch, frequently in the root system toward the latter part of the growing season. These reserves become important in early spring when they are mobilized and provide energy for bud breaking and new leaf initiation.

Thus, it is clear that the rate of photosynthesis influences many important plant processes. Factors which affect photosynthetic activity should be known so they can be optimized whenever possible. Nutrient availability, supply of water and carbon dioxide, temperature, sunlight, and the presence of toxic substances can all influence the rate of photosynthesis and, thereby, affect tree vigor and yields.

## **Methods**

### *Pesticides*

The eight products tested include five pesticide materials commonly used on avocado trees and three experimental products of potential value on avocados in the future. These products, listed according to pesticide classification, target pests, and dosage, are shown as follows:

<u>Material</u>	<u>Classification</u>	<u>Target Pests</u>	<u>Dosage</u>
Fosethyl Al (Aliette)	organophosphate	cinnamon fungus	3,000 ppm (v/v)
Malathion	organophosphate	thrips	50% EC at ½ pint per acre
B. T. Formulation* (Dipel)	biological	omnivorous looper worms	50% WP at 4 lbs. per acre
Wettable sulfur	inorganic	avocado brown mite	80% micronized at 20 lbs. per acre
Frost Gard (TM)	proprietary	ice-nucleating bacteria	10% (v/v) solution at 2 gals. per acre
Methomyl	carbamate	worms	1.8 EC at 4 pints per acre
Acephate (Orthene)	carbamate	thrips, worms	75 SP at 1 lb. per acre
Permethrin	pyrethroid	worms	2 EC at 12.8 oz. per acre

\*(*B. thuringiensis*)

All materials were applied to labeled leaves of Fuerte and Hass trees in a randomized complete block design, with each tree comprising one replicate containing eight appropriately treated leaf terminals and an untreated terminal for a control. All treatment sites were selected for uniformity in age, coloration, and physiological condition in order to minimize between-treatment variation.

### *Physiological Measurement*

Physiological processes were measured with a dual isotope porometer utilizing two radioactive isotopes,  $^{14}\text{CO}_2$  and titrated water. Porometric measurements were taken three days following pesticide treatments. Sampled leaves were excised from the trees and taken to the laboratory for determination of radioactivity. From the amounts of isotopes in the leaf tissue the rate of photosynthesis and transpiration were calculated. In addition, values for stomatal conductance (related to stomatal opening) and internal leaf mesophyll cell conductance were obtained.

**Table 1.** Physiological responses of Hass and Fuerte avocado cultivars to spray applications of commonly used and experimental pesticides, San Diego County, 1982.

Pesticide Treatment	LEAF PHYSIOLOGY <sup>3</sup>					
	Stomatal Conductance <sup>1</sup>		Transpiration <sup>2</sup>		Photosynthesis <sup>2</sup>	
	Hass	Fuerte	Hass	Fuerte	Hass	Fuerte
Unsprayed Control	71.2a	47.0a	4.1a	2.7a	30.0a	22.9a
Fosethyl Al	55.6ab	32.5ab	3.2ab	1.9ab	27.3ab	18.4ab
Methomyl	60.4ab	30.5ab	3.5ab	1.8ab	24.0ab	17.0ab
Frost Gard	55.4ab	35.4ab	3.2ab	2.0ab	18.5bc	16.9bc
Acephate	50.5ab	31.0ab	2.9ab	1.8ab	20.3bc	14.7bc
Sulfur	43.0bc	24.4bc	2.5bc	1.4bc	19.4bc	14.4bc
BT Formulation	38.0c	13.2c	2.2c	0.8c	16.1cd	8.7cd
Permethrin	26.1cd	10.7cd	1.5cd	0.6cd	13.2d	7.0d
Malathion	3.8d	2.3d	0.2d	0.1d	1.9e	0.9e

<sup>1</sup> Conductance values are an index of stomatal opening. Low values indicate reduced stomatal opening. Units in cm/sec x 10<sup>2</sup>.

<sup>2</sup> Physiology of treated and untreated leaves measured simultaneously for photosynthesis and transpiration rates. Transpiration values in units of gms H<sub>2</sub>O lost/cm<sup>2</sup>/hr. Photosynthesis in units of mg CO<sub>2</sub> assimilated per dm<sup>2</sup> leaf area per hour.

<sup>3</sup> Actual values are means of 3 replicate trees per variety. Means in vertical columns followed by same letter not significantly different. Duncan's multiple range test, p<0.05.

## Test Results

All insecticide and fungicide products adversely affected photosynthesis, transpiration, and stomatal functioning, but differed in their relative effect and severity of injury (Table 1). Products having the greatest effect were malathion, permethrin, and the B. T. formulation, in that order. Compounds having the least acute effects on leaf physiology were Fosethyl Al (Alette) and Methomyl. Frost Gard, acephate (Orthene), and wettable sulfur were intermediate in their effects, although physiological values obtained from foliage treated with these products were statistically less than for untreated foliage.

Differences between cultivars tested and their relative susceptibility to pesticide treatments are also evidenced from the physiological measurements obtained. Data from Hass foliage, both untreated base rates and treated foliage, were consistently higher than those obtained from Fuerte. Hass exhibited a 24% higher base rate of photosynthesis and 34% higher transpiration. Moreover, the magnitude of the reductions in physiological rates by pesticide treatments also appear to vary with cultivar. Figure 3 illustrates the reduction in photosynthesis rates by each product as a percentage of the base rate obtained from the control for each cultivar. In the case of Permethrin and B. T. formulation, Fuerte showed significantly larger reductions by 13% and 16% respectively. This trend suggests Fuerte is more susceptible to injury of this kind; however, further experimentation is necessary for confirmation.

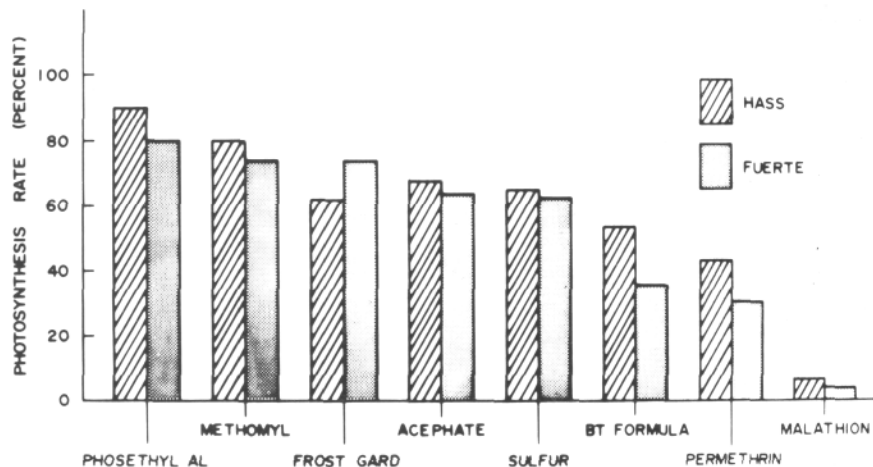


Figure 3: Photosynthesis of Hass and Fuerte as influenced by pesticide applications to foliage. Data are expressed as percentages of Base rates obtained from untreated leaves.

## Discussion and Conclusions

The results of this study indicate that some commonly used and experimental pesticides can adversely affect important physiological processes of the avocado. Since measurements were taken three days following treatment applications, these results are indicative of immediate effects; such effects probably subside after a period of time or following residue removal or degradation. This applies especially to the flowable-wettable formulations which leave a visible particulate deposit that could effectively obstruct or otherwise affect stomata opening and interfere with normal gas exchange. Spray deposits were particularly evidenced following application of sulfur and the B. T. formulation. These products produced a visible particulate residue on the leaf epidermis, and stomatal conductance values taken from these treatments were significantly lower than those for untreated foliage. Other products tested, notably Permethrin and malathion, also limited stomatal functioning, thereby causing significant reduction in photosynthesis and transpiration. In addition, these latter two compounds affected the mesophyll cells within treated leaves which resulted in significantly reduced assimilation of carbon dioxide and sugar synthesis. This implies that residues within leaf tissues may affect normal biochemical reactions and further impact processes not measured in this study.

These data reflect some fundamental differences between the two common avocado cultivars tested. Hass exhibited significantly higher base rates of photosynthesis and was more tolerant to pesticide sprays overall. Additionally, when consideration is given to the typically 25% higher yields obtained with Hass, the relationship and importance of photosynthesis rate and yield is further supported. The severity of the effects to Fuerte, particularly those of malathion, warrants further study. Knowledge of the duration of recovery from a depressed physiological condition would be necessary if multiple treatments for pest control with this product are utilized. This could allow either for plant

recovery or alternation with less injurious products before reapplication. Temperature, sunlight, and other environmental factors under which the product was applied may also influence how the plant will respond. These and other important factors must be clarified before conclusions can be drawn regarding the relative toxicity of these products on avocado. Such projects are currently under investigation by the authors and will be elucidated in future reports.

As more data are obtained on the effects of pesticides on plant physiology and non-target populations of insects and mites, the avocado grower will be better able to understand the ramifications and/or benefits of pesticide usage.