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THE RELATIONSHIP BETWEEN OPP RESIDUES, FRUIT CONDITION, AND DECAY RATES OF ORANGES AND LEMONS

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Abstract. **The postharvest fungicide o-phenylphenol (OPP) has been used in citrus packinghouses as a sanitizer and decay control agent for nearly 3 decades. The efficacy of the treatment and desired residue levels have been disputed since the antifungal properties and penetration of OPP into the intact rind have not been adequately quantified. Some California shippers have contended that minimum residue levels are mandatory to prevent decay during transit and marketing. Oranges and lemons were mechanically injured and treated with OPP at levels of 1.0, 1.5 and 2.0%. Mechanical injuries and higher concentrations of the treatment solution yielded higher residues but did not improve decay control. These residues were concentrated at the injury site. No significant relationship could be drawn between residue level and decay control. Application rates above 1.5% were found to have the negative effect of increasing the likelihood of chemical injury.**

For nearly 30 yr solutions of sodium o-phenylphenate (SOPP) have been used to control postharvest diseases of citrus fruit (2, 11). The o-phenylphenate ion, which is formed in highly alkaline solutions, is unable to permeate the intact waxy surface of the citrus fruit. However, it does diffuse selectivity into ruptured oil cells at injury sites where it is hydrolyzed to o-phenylphenol, which is lethal to microorganisms (2, 3).

Previous studies indicate that there is no correlation between OPP residues and decay control (2, 3, 4, 7, 8). The purpose of treating with OPP is to sanitize the wash brushes and surface of the fruit and deposit a residue in harvest-related injuries to help prevent infection (2, 3, 10). It has no effect on injuries sustained after treatment (5).

In actual practice OPP is applied to the fruit by means of a spray, soak tank, or foam washer. This allows penetration of the OPP into injured areas. Excess OPP is removed by a fresh water rinse (1, 6). Therefore, fruit in good condition, with few damaged oil cells, would not be expected to have a high OPP residue. Unless subsequent injuries occur, that fruit would also not be expected to decay (5, 10).

The purpose of this study was to investigate the relationships among OPP residues, decay control, and phytotoxicity. Also desired was the establishment of the level at which OPP treatment is no longer improving decay control and begins to increase burn risks.

Materials and Methods

Navel oranges (*Citrus sinensis* (L.) Osbeck) from the San Joaquin Valley and 'Eureka' lemons (*Citrus limon* (L.) Burm.) from Ventura County were randomized into 7 lots of 300 fruit, 150 each of lemons and oranges.

Each lot was injured in a distinct fashion. The first lot was not injured and served as the control lot. Lot B was dropped 1 m onto a concrete surface with an impact velocity of 4.43 m/sec. Lot C received a 1 mm x 2.5 cm scratch along the vertical axis between the calyx and stylar ends. Lot D was given one 4 to 5 cm stroke with 120 grit sandpaper. Lot E was dry run twice over a packingline (approximately 50 m) including belts, *roll elevator, and* brushes. Lot F was rolled on 50/50 Durasof horsehair brushes (typical wax brushes purchased from L. A. Brush Co., Los Angeles, CA) for 2 min. The final lot, G, had the button (peduncle, receptacle, and calyx) removed.

Within 2 hr after injury, all lots were dipped for 30 sec in suspensions of *Penicillium digitatum* Sacc. spores. Spores for the navel orange suspension were collected by brushing decaying San Joaquin Valley navel oranges and then diluting to approximately 57,000 spores/ml. Spores from decayed lemons from Ventura County were collected in the same manner and then diluted to 42,000 spores per ml.

Fruit were left at room temperature for 20 hr and then divided into 3 subplots of 100 fruit, 50 each of lemons and oranges. Each sublot was treated by dipping in a solution of 1, 1.5, or 2% SOPP (Deccosol® 125, Pennwalt Corp.) then drained and air dried on paper towels for approximately 2 hr.

Residues from 5 fruit from each lot were analyzed by gas chromatography for OPP. A modified Nielson-Kryger steam distillation apparatus (9) that provides exhaustive distillation of OPP was used. The apparatus provides a continuous and simultaneous extraction of the distillate by a small volume of organic solvent. Final analysis of the sample was done using a gas chromatograph equipped with a flame ionization detector and glass column packed with 3% OV-1 (Supelco, Bellefonte, PA). The remaining fruit were placed in a storage room at 21°C and 80% relative humidity.

After 14 days all lots were then evaluated for Penicillium decay and OPP burn. Burn was given a rating from 0 to 5 with 0 as no burn and 5 as severe burn.

Results

Fruit were not rinsed after the SOPP treatments but allowed to air dry on paper towels before being transferred to fresh cardboard boxes for storage. Because of this noncommercial practice, residues were high and therefore were normalized against the orange control (no injury) lot.

A comparison of % decay and OPP residue (Fig. 1) shows that there is no positive relationship. Fruit with a normalized residue of 3.0 had as much as 30% decay while fruit with a normalized residue of 1.0 had as little as 0% decay. The results were the same for lemons and oranges even though the lemons tended to have higher residues overall than the oranges.

Fruit that were scratched and sandpapered were from lots that had 20 to 30 ppm OPP residues, yet still decayed completely except at the injury sites. The OPP appears to have concentrated in the injuries which is to be expected due to OPP's lipophilic nature (Fig. 2).

The highest residues on both lemons and oranges were obtained on the scratched samples (Table 1). Lowest residues excluding the control were on lots that were rolled on brushes. Treatment (Lot E) over an entire packinghouse line including rollers, washer and waxer brushes, belts, and delivery drops resulted in less severe injury and

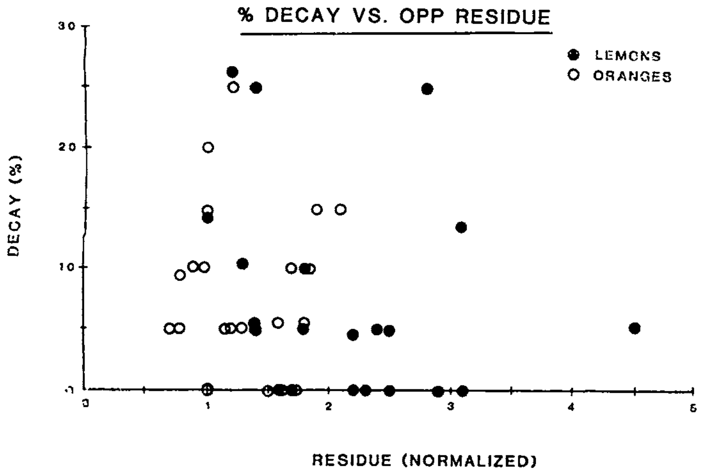

Fig. 1. Relationship between OPP residue and decay of navel oranges and lemons.

Table 1. Effects of various pretreatments on decay and residue of navel oranges and lemons.

Pretreatment	Orange residue[z]	Decay (%)	Lemon residue[z]	Decay (%)
A. None	1.7a[y]	6.7ab	1.4a	6.8a
B. Dropped	1.8a	13.6a	1.3a	5.0a
C. Scratched	2.9b	3.4ab	1.5a	8.3a
D. Sandpapered	2.5ab	1.7b	1.3a	16.7a
E. Line treatment	2.2ab	14.3a	1.2a	10.2a
F. Rolled/brushed	1.8a	9.1ab	1.1a	8.5a
G. Buttons removed	2.4ab	5.0ab	1.4a	5.0a
Overall average	2.2	7.7	1.3	8.6

[z]Residues are normalized against the orange residue at the 1% SOPP treatment level.
[y]Mean separation in columns by Duncan's multiple range test, 5% level or (for percentages) by Chi-square methods ($1 - \alpha = 0.95$).

lower overall residues than lots that were scratched, sandpapered, or had their buttons removed.

No correlation was found between percent decay and residues. For lemons, the line treatment (Lot E) with a normalized residue of 2.2 had 14.3% decay while the rolled/brushed lot (F) with a 1.8 normalized residue had only 9.1% decay. Normalized residues were similar for oranges with levels from 1.1 to 1.5, yet decay ranged from 5.0 to 16.7%.

Increasing concentrations of SOPP resulted in increased residues (Table 2). Concentrations of 1.5% gave better decay control than those at 1.0%. However, treatment at 2.0%, although increasing residues, did not decrease decay rates.

Table 2. Effect of SOPP concentration on residue, burn, and % decay of navel oranges and lemons.

SOPP (%)	Lemons Residue[z]	Lemons Burn index[y]	Lemons Decay (%)	Oranges Residue[z]	Oranges Burn index[y]	Oranges Decay (%)
1.0	1.6	1.7	12.9	1.0	1.8	12.1
1.5	1.9	2.7	2.9	1.3	2.5	7.1
2.0	2.2	3.5	7.2	1.7	3.5	6.6

[z]Residues are normalized against the orange residue at the 1% SOPP treatment level.
[y]SOPP chemical burn: severe = 5; moderate = 3; slight = 1; none = 0.

Increased concentrations of SOPP and residues caused a greater amount of chemical injury (Table 2). Fruit treated at 1.0% showed slight symptoms of burn while those treated at 2.0% exhibited severe chemical injury.

Discussion

Residue levels obtained in this experiment were much higher than would be expected in a typical OPP treatment. In spite of this, some fruit still completely succumbed to Penicillium mold. These fruit completely decayed except for the area which was intentionally injured. This lends support to the statement that OPP does not penetrate the intact rind but concentrates in injuries (11).

The SOPP application is made early in the packingline during the wash process. After treatment the fruit must still cover the rest of the packingline before being placed in cartons for shipment. Although packingline treatment used in this experiment did not result in severe injury to the fruit, commercial lines may cause less desirable results. Injuries can be caused by sharp corners, long drops, twigs

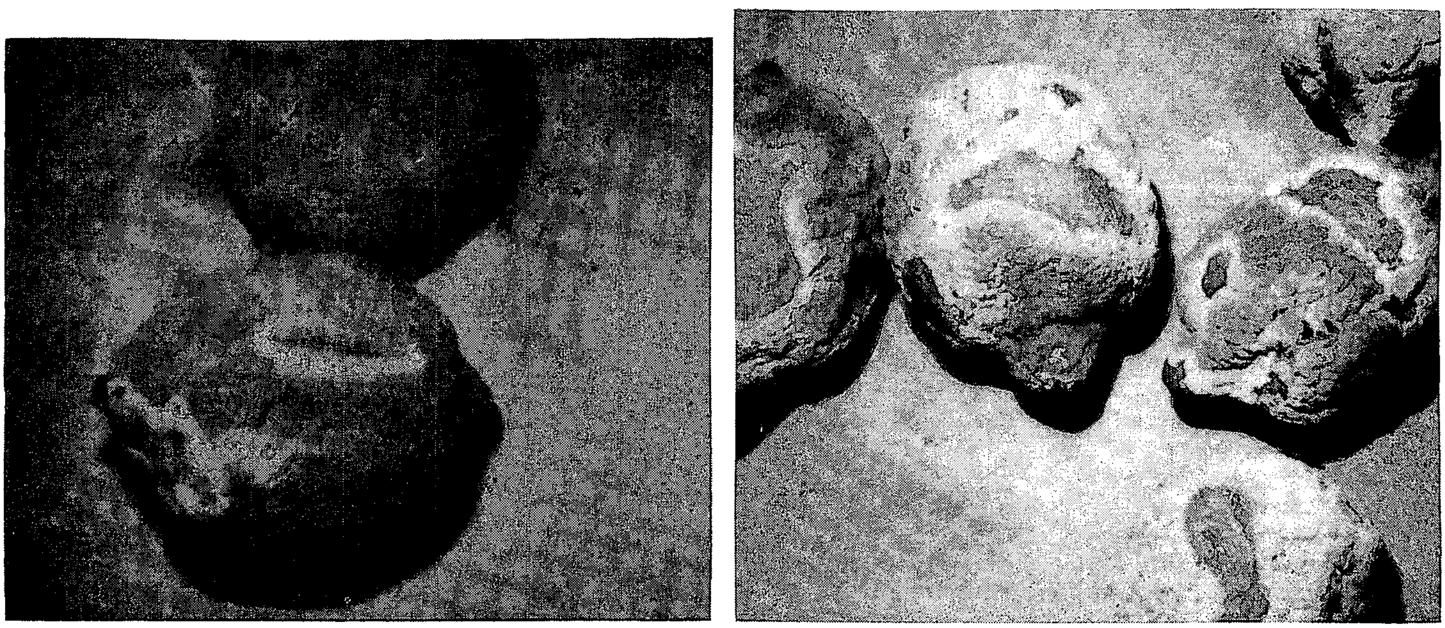

Fig. 2. *Penicillium digitatum* on lemons that were scratched (left) and sandpapered then dipped in 1.5 and 2% SOPP, respectively. Note the concentration of SOPP in the wound area.

caught in shears, and brushes. Long peduncles from improper clipping and buttons stuck in donut rolls or in wax on delivery boards can also cause severe injury and decay that OPP treatment could not control.

Efforts to increase OPP efficacy by raising the concentration of the SOPP solution or addition of SOPP to the wax are nonproductive. Residue levels may increase by use of such methods, but as shown in Fig. 1 a corresponding improvement in decay control should not be expected. Use of these overapplication methods use energy and money and may also increase the burn potential. Since burn does not usually show up for 24 hr or more, fruit can be packed into cartons before the burn is discovered leading to costly repacking or market complaints.

OPP is a sterilant and wound protectant. To prevent decay from packingline and handling injuries, a fungicide such as one of the imidazoles, which has some rind penetrating capabilities, should be used in addition to OPP.

Future experiments repeating this procedure but adding a fresh water rinse are recommended to more closely simulate packinghouse procedures and obtain data for comparison at normal treatment levels.

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IMPORTANT INSECT PESTS OF ANNONA SPP. IN FLORIDA[1,2]

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Abstract. **Two pests of** Annona **spp. in Florida are the seed borer,** Bephratelloides cubensis **Ashmead, (Hymenoptera:Eurytomidae) and the soft scale** Philephedra **n.sp., (Homoptera:Coccidae). Daily periodical occurrence of** B. cubensis **peaked at 1500 hr at an average temperature of 31-32°C. Ten to 20 times more adults were observed in August than during July or September 1984. Possible relation between fruit mummification and** B. cubensis **damage is discussed. Percentage of necrotic fruit that were infested with** B. cubensis **increased 4 times from early to late September.** Annona squamosa **L. was the preferred host for** Philephedra **n. sp., compared to** A. reticulata **L., and** Persea americana **Miller. Ethion + oil spray and methidathion provided a more acceptable control than oil spray or ethion alone.**

In recent years, the production of *Annona* spp. (*A. reticulata* L., *A. muricata* L., *A. cherimo'a* Hill) in Florida has escalated from backyard trees to commercial groves (1). This change has also increased the importance of insect pests attacking these crops. The insects that affect production of *Annona* spp. in Florida include major pests such as the seed borer, *Bephratelloides cubensis* (Ashmead), which reduces the marketability of fruit, the ambrosia beetle (poss. Xyleborus sp.) which reduces branch vitality, as well as secondary pests such as the scale *Philephedra* n.sp. which attacks leaves, young stems, and fruits. The impact incidental pests such as various Lepidopterous (*Sphingidae, Noctuidae*) larvae and some Hemipterans (*Acanthocephala femorata* (F) and *Leptoglossus phyllopus* (L.)) have on *Annona* sp. in Florida is unknown.

The seed borer is also considered to be an important pest of *Annona* spp. in the Caribbean (2). Another species, *B. maculicollis* Cameron, causes identical damage in Colombia (6), Venezuela (7, 8) and Surinam (3). A closely related species *B. ruficollis* Cam., has been identified in Panama and *B. paraguayensis* Crawford is found in Paraguay (2).

The scale, *Philephedra* n.sp. a pest of papaya and ornamentals, is found in Mexico, Texas, Colombia and recently was discovered in Florida.

In this preliminary study, the damage and diurnal activity of seed borer adults is described, evaluation of the possible relationship between insect presence and fruit mummification is made in order to properly assess the amount of loss due to this insect. To address the scale problem, investigations were also made of the damage, distribution and chemical control of *Philephedra* n.sp.

Materials and Methods

From July through September 1984, seasonal life history and damage studies of the seed borer *B. cubensis* were conducted at the Tropical Research and Education Center, Homestead, Florida. Ten custard apple (*Annona cherimola* x *A. squamosa*) trees, each 10-yr-old, spaced 5.4 m between trees and 6.3 m between rows, were selected for observation. A weekly count of the number of adults observed per tree was made. Daily adult activity was observed for 8 hr (800-1800 hr) during 5 consecutive days. Two evaluations were

[1]Florida Agricultural Experiment Stations Journal Series No. 5988.
[2]Chemicals used for research purposes only. No endorsements or registration implied herein.