DECAY CONTROL OF ORANGES WITH BENOMYL BY THREE METHODS OF POSTHARVEST APPLICATION

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Abstract. **Three methods of postharvest application of benomyl were evaluated on 'Hamlin', 'Pineapple', and 'Valencia' oranges during the 1973-74 season. These methods were: (1) application of an aqueous suspension prior to waxing; (2) incorporation in water wax; and (3) incorporation in solvent wax. Effective control was obtained by all 3 methods, in comparison to standard fungicide treatments. However, the latter method was slightly less effective, especially in controlling stem-end rots. Green mold was not controlled by any method when thiobendazole-benomyl-resistant strains were present.**

In recent years, researchers (3, 5, 7) have shown that benomyl effectively controlled diplodia and phomopsis stem-end rots, green mold (Penicillium), and other decays of Florida citrus fruits. In February 1974, benomyl was approved by the Environmental Protection Agency (EPA) for preharvest and postharvest use on citrus fruits and a residue tolerance of 10 ppm was established (4). For 2 seasons prior to this approval, benomyl was regulated by EPA experimental permits. However, due to the restriction that prohibited processing treated packinghouse-rejected fruit, benomyl had found only limited use in commercial packinghouse trials.

As regulated by the Florida Citrus Commission, benomyl can be applied either as an aqueous suspension, aqueous emulsion, or dissolved in organic solvents (1). In a packinghouse operation, benomyl could be applied as (1) a water suspension after washing but before waxing, (2) incorporated as a suspension (emulsion) in water-base wax, or (3) dissolved in solvent wax. A residue of at least 0.1 ppm but not more than 10 ppm must result from the application, according to the regulation.

The tests reported here were conducted during the 1973-74 season to determine the effectiveness of these 3 methods of application for decay control in comparison with other approved fungicides now in general use.

Materials and Methods

In these tests conducted at the Horticultural Research Laboratory, Orlando, Florida, the fruits used were 'Hamlin', 'Pineapple', and 'Valencia' oranges (*Citrus sinensis* (L.) Osbeck) harvested from commercial groves in Orange County, Florida. Fruit for sucecssive tests were picked from the same trees.

'Hamlin' oranges requiring degreening were treated with about 5 ppm ethylene at 85° F (29.4° C) and 92% relative humidity for periods up to 48 hr, depending on the natural color break of the fruit. 'Pineapple' and 'Valencia' oranges were not degreened. The fruit were washed, dried, and randomized into samples of 100+ fruit for each treatment on the day after harvest, or on removal from the coloring room. The treatments evaluated in these tests are listed in Table 1, together with their common or trade names and concentration used. Sodium orthophenylphenate + hexamine (SOPP+hex) was applied by recommended procedures (2). Thiabendazole (TBZ) (treatment #3) and benomyl (treatments #5 and 6) were applied as well-agitated suspensions by spraying on fruit travelling over a roller conveyor; fruit were not rinsed following application. After treatment, all samples were dried in a warm-air drier and those not previously waxed were waxed with a non-fungicidal solvent-wax. The fruit treated with the benomyl in solvent wax (treatment #7) were waxed separately, using the same equipment.

The samples were held at 70° F (21.1° C) and inspected weekly for decay and rind breakdown. Decays were classed according to the causal fungi: *Phomopsis citri* Faws., *Diplodia natalensis* P. Evans, *Penicillium digitatum* Sacc., and other miscellaneous fungi, e.g., *Geotrichum, Alternaria, Colletotrichum*, etc. Causal organisms were isolated to confirm identification of decays.

Results and Discussion

The 3 methods of benomyl application in comparison with TBZ were evaluated in 3 tests conducted from mid-November to early December, using 'Hamlin' oranges requiring a 40- to 48-hr ethylene-degreening treatment. Development of decay was effectively reduced by all 3 methods of application (Fig. 1). After 2 weeks, total decay incidence was 34% in the untreated controls and

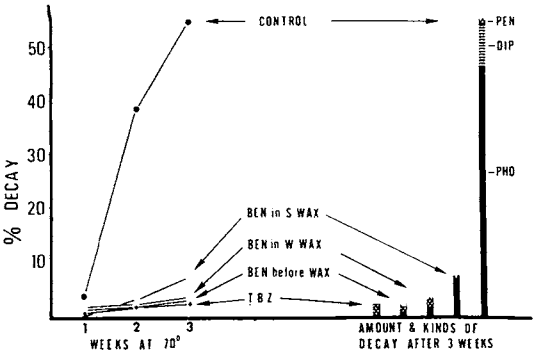

Fig. 1. Effect of several fungicide treatments on decay of 'Hamlin' oranges (3 tests).

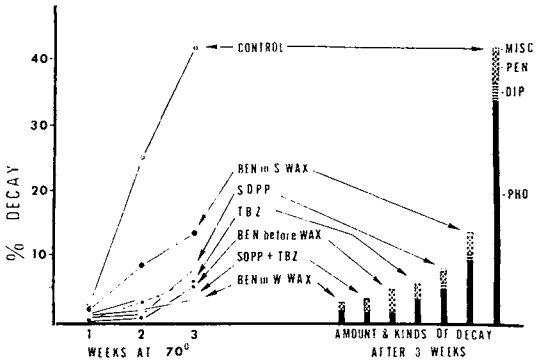

Fig. 2. Effect of several fungicide treatments on decay of 'Pineapple' oranges (4 tests).

less than 5% in treated fruit; and after 3 weeks, was 55% and 8%, respectively. Benomyl applied before waxing and in water wax was comparable to TBZ and slightly more effective than benomyl incorporated in solvent wax.

In the controls, the decay was primarily phomopsis stem-end rot with smaller amounts of diplodia stem-end rot and green mold rot *(Penicillium digitatum)*.

'Pineapple' oranges, which did not require ethylene degreening, were used in 4 tests from mid-January to mid-March to evaluate treatments (Table 1). After 3 weeks at 70° F, untreated controls had 42% decay, primarily phomopsis stem-end rot, with lesser amounts of green mold, diplodia, and miscellaneous other rots (Fig. 2). Effective decay control was attained by all of the treatments used. Benomyl in solvent wax and SOPP+hex alone were the least effective in suppressing both *Phomopsis* and *Diplodia*. Although green mold rot was not a serious decay, it was not effectively reduced or eliminated by any of the treatments.

In 6 tests with 'Valencia' oranges, conducted from mid-March to mid-May, results were similar to those obtained with the other 2 cultivars with respect to the relative effectiveness of the 6 treatments (Fig. 3). Benomyl in solvent wax and SOPP+hex alone were less effective in controlling both phomopsis and diplodia stem-end rots. Green mold was again not an important factor in the overall decay of the untreated controls, but it was not appreciably reduced by any treatment used.

Physiological rind breakdown (aging and pitting) was not increased by any treatment on the 3 cultivars used in these tests. All treated lots

Table 1. Postharvest fungicide treatments used.

Treatment	Concn used
1. Control (wash + wax only) (Flavorseal wax[z])	----
2. Sodium orthophenylphenate (SOPP) + hexamine (Dow-hex[zy])	2%+1%
3. Thiabendazole (TBZ[z]) (Mertec 260[z])	0.12%
4. SOPP + TBZ (Treatment #2 followed by #3[y])	----
5. Benomyl (Benlate[z])	0.06%
6. Benomyl in water wax (Sealbrite[z])	0.06%
7. Benomyl in solvent wax (Flavorseal[z])	0.4%

[z]Trade names are used for identification, and their use is not to be construed as an endorsement of the product by the U.S. Department of Agriculture.

[y]Treatments #2 and #4 were used for 'Pineapples' and 'Valencias' but not for 'Hamlins'.

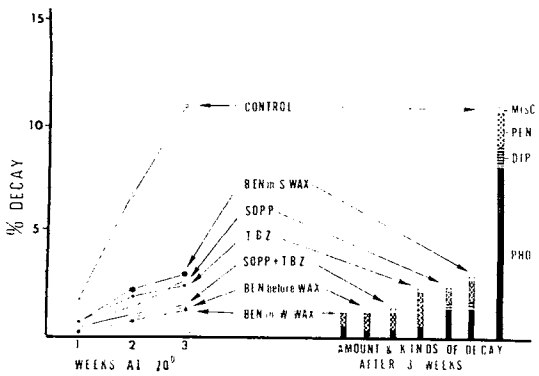

Fig. 3. Effect of several fungicide treatments on decay of 'Valencia' oranges (6 tests).

were equal in appearance to the untreated controls with the possible exception of the benomyl in solvent wax-treated lots. These oranges had slightly less shine when compared to the waxed-only controls in some tests.

These results demonstrate that good to excellent control of decay of oranges can be attained by benomyl using these 3 methods of application when compared to the standard treatments of TBZ and SOPP. The relative effectiveness of all the treatments tested was consistent throughout the season for the 3 cultivars. The benomyl in water wax and benomyl before waxing treatments were more effective than benomyl in solvent wax under the conditions of these tests. Analyses made by the Florida Fruit and Vegetable Inspection Laboratory of comparable test samples have shown that residues fell within the acceptable range (0.1 to 10 ppm); the highest was about 2.3 ppm for fruit treated with benomyl in solvent wax.

The occurrence of green mold-infected fruit in all of the treated samples may be explained by the fact that during the 1973-74 season, an outbreak of green mold resistant to TBZ and benomyl occurred at several packinghouses in the State and at this Laboratory (6). The accumulation of these resistant strains is found where TBZ- and/or benomyl-treated fruit are held or stored with adequate time for the fungus to sporulate and reinfect. Strict sanitation reduced the resistant-spore population at the Laboratory, but some limited resistant infections were found until late spring. No method of application or concn of benomyl will successfully control green mold that has become resistant to either thiobendazole or benomyl.

The combination treatment of SOPP+hex followed by TBZ has consistently given good results as illustrated in these tests with 'Pineapple' and 'Valencia' oranges. SOPP+hex may also be used in combination with either of the 3 benomyl treatments used in these tests. However, SOPP+hex must be applied and rinsed off prior to the application of benomyl. These treatments are not compatible as a tank mix.

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