treatments in fruit harvested and degreened in November and December (Table 6). Decay caused by *P. digitatum* was not affected. Though residue analyses for Benlate were not conducted, mature fruit from all treatments were artificially inoculated after harvest with *P. digitatum* and *D. natalensis* to compare host susceptibility which could be influenced by translocation of this material into the fruit during formation. Fruit from all treatments were equally susceptible to decay by these two organisms. However, there was a tendency for fruit from the sprayed trees to develop symptoms less rapidly; and the effect was inverse to fungicide concentration, thus suggesting some fungitoxicity. Another perhaps more plausible explanation could again be that SER was reduced because Benlate suppressed sporulation of *D. natalensis* from the deadwood.

Preliminary studies to date indicate this to be true. Benlate has been shown to control brown rot (*Monilinia fructicola*) of peaches by suppressing sporulation from infected peach peduncles and mummified fruit (6).

Annual grove applications of Benlate for control of postharvest decay could possibly eradicate the SER fungi from the deadwood or at least reduce sporulation. Applications other than at preharvest for control of certain other citrus diseases may also be beneficial for the same reason. The activity of Benlate as an eradicant or antisporulant may, in some cases, be enhanced with the use of spray adjuvants such as Pinolene.

**LITERATURE CITED**


5. Florida Citrus Commission Regulation 105-1.43. 1968. Fungicide or fungistat treatment required for fresh citrus fruit.


were treated by several methods on the same day at the USDA laboratory. Results showed that all methods using TBZ were generally more effective in reducing decay than the standard sodium orthophenylphenate (SOPP) + hexamine treatment. The flood application was more effective than the spray or wax application, but the concentration of TBZ in the flood tank was difficult to maintain. No peel injury or other phytotoxic effects resulted from TBZ treatment. TBZ is approved by the Food & Drug Administration for postharvest use on citrus fruits.

INTRODUCTION

Experimental testing of TBZ in recent years by various researchers (2, 3, 4) has demonstrated its effectiveness in controlling postharvest decays of Florida citrus fruits. In 1969 TBZ was approved by the Food and Drug Administration (1) for postharvest use on citrus fruits, for which a residue tolerance of 2 ppm was established.

During the 1969-1970 season, eight to ten packinghouses in Florida began using TBZ as a postharvest fungicide for various citrus fruits destined for fresh market. Three months of application with slight variations were used. These were: (1) flooding with a recirculated TBZ suspension, 2) spraying with a nonrecirculated suspension, and (3) waxing with a water wax containing TBZ. The tests reported here were conducted to determine if these methods would give satisfactory results under commercial conditions and to compare the effectiveness and feasibility of the three methods.

MATERIALS AND METHODS

Fruit samples were collected weekly, beginning in November 1969 and continuing until April 1970, from five commercial packinghouses which used TBZ as a postharvest fungicide. TBZ was applied at approximately 1,000 ppm to washed and damp-dried fruit by nonrecirculating spray (houses A and B), recirculating flood (houses C and D), and TBZ in water wax (house E). The spray and wax treatments were applied in sufficient quantities to wet the fruit. The rate of application was in the range of 60 to 100 1 3/5 bushel standard boxes per gallon of fungicide. For each collection, a 1-bushel sample of fruit was removed from the packinghouse line prior to and another immediately following TBZ application. The collections were representative of the fruit the packinghouse was processing on the day the collections were made. Both samples were taken from comparable fruit. The samples were taken to the Horticultural Field Station, Orlando, where they were dried, graded, and waxed with solvent-base wax; those which received the TBZ in wax at house E were not rewaxed. Samples were held at 70° F. and inspected weekly for rind breakdown and decay. A total of 80 collections were made from the five packinghouses during the season; the kinds of fruit collected and the number of collections each are shown in Table. Some houses were not in operation every week during the test period.

In addition to the tests run on the weekly collections, three tests were conducted using Valencia oranges from a single source on March 26, April 16, and May 5, 1970. The fruit was picked, washed, and randomized into 200-fruit lots the day prior to treatment with TBZ (1,000 ppm) at the various packinghouses and with TBZ (1,000 ppm) and SOPP + hexamine (2% + 1%, respectively) at the laboratory, as indicated in Figs. 1, 2, and 3. The samples of fruit were handled and inspected in the same manner as fruit in the weekly collections. Since these tests were conducted during the latter part of the shipping season, some of the packinghouses had closed, and consequently their facilities were not available for the second and third tests.

RESULTS AND DISCUSSION

The percent decay control afforded by TBZ applied at the various packinghouses is shown in Table 1. The effectiveness of TBZ treatments in controlling decay was determined after holding the fruit for 2 weeks at 70° F. and is expressed as percent decay control.

\[
\text{Percent control} = \frac{\% \text{ decay in control} - \% \text{ decay in treatment}}{\times 100}
\]

Percent control varied from 100 in five collections of grapefruit and three collections of Valencia oranges to a low of 15 in one collection of Temple oranges. In the overall average, including all types of citrus fruits, best control was attained by the flood method in house C (74%) and house D (70%). The spray method resulted in 61% and 36% control in houses A
Table 1.—Control of citrus decay by thiabendazole in five commercial packinghouses in Florida
(1969-1970 season)

<table>
<thead>
<tr>
<th>Packinghouse and method of application</th>
<th>Decay control* after 2 weeks at 70° F.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grapefruit</td>
</tr>
<tr>
<td>A - Spray</td>
<td>100 (4)**</td>
</tr>
<tr>
<td>B - Spray</td>
<td>--- (-)</td>
</tr>
<tr>
<td>C - Flood</td>
<td>91 (4)</td>
</tr>
<tr>
<td>D - Flood</td>
<td>60 (3)</td>
</tr>
<tr>
<td>E - in wax</td>
<td>100 (1)</td>
</tr>
</tbody>
</table>

Average 87 (12) 69 (7) 49 (12) 47 (16) 83 (6) 46 (15) 49 (7) 80 (5) 60 (80)

* Percent control = \( \frac{\% \text{ decay in control} - \% \text{ decay in treatment}}{\% \text{ decay in control}} \) \times 100

** Figures in parentheses indicate number of collections made.

and B, respectively, while the wax application in house E resulted in 50% control. The average control in all tests was 60%. In considering the various kinds of citrus fruits treated, 87% control was obtained with grapefruit, 83%, 80%, and 69% with oranges, and 46% to 49% with tangerines and other mandarins. The types of decay encountered with grapefruit and oranges were primarily Diplodia and Phomopsis stem-end rot in addition to green mold (Penicillium digitatum). The mandarin fruit were affected also with sour rot (Geotrichum), Alternaria black rot, and anthracnose (Colletotrichum). The latter three decays are not effectively controlled by TBZ (3, 5), and this could account for the lower control obtained with the mandarins.

The data from the above tests are useful in regard to commercial applications of TBZ but are not directly comparable between houses or collections due to the heterogeneity of the test fruit with regard to variety, rootstock, production practices, weather conditions, etc. For this reason, the three additional tests were conducted using a uniform source of Valencia oranges.

Figures 1, 2, and 3 show the percent decay which developed after 1, 2, and 3 weeks at 70° F. in Valencia oranges that had received flood,
spray, or wax applications of TBZ the same day at the laboratory and at the available packinghouses. As with the packinghouse collections, of the three methods used, the flood application of TBZ was most effective in controlling decay. With the exception of the spray treatment in packinghouse A, all TBZ treatments gave good control and were superior to the standard SOPP treatment. No explanation can be given for the poor control obtained by this spray application of TBZ, since the applicator appeared to be functioning properly and it is assumed that the TBZ was applied at the rate of 1,000 ppm as indicated by the supplier. The decays which developed in these Valencia oranges were *Phomopsis* stem-end and green-mold rots. Physiological rind breakdown (aging and pitting) was not increased by the TBZ treatments over that observed in the SOPP-treated and control lots.

Throughout the season some inherent problems became evident in the systems for flood application. TBZ is not soluble in water at the rate required to effect decay control (1,000 ppm +); therefore, agitation of the suspension prior to and during use is required. Even with good agitation in the flood tank, precipitation occurs on the drain pans and in other poorly agitated areas. TBZ also adheres to metal surfaces including the inside of the piping, resulting in a reduction of the TBZ in suspension. No simple method has been devised for assaying the TBZ concentration in the flood tank at the packinghouse; thus frequent additions of the chemical or complete renewal of the treating suspension are required. For these reasons, the recirculating flood application may not be the best for commercial use, but since good results were generally obtained with nonrecirculating spray and wax applications (Figs. 1, 2, and 3), these methods are recommended for Florida conditions. Effective concentrations can be applied directly to the fruit by these methods, and formulations and application equipment are available from various manufacturers of packinghouse equipment.

**ACKNOWLEDGMENTS**

The authors express appreciation to the following for cooperation in these tests by supplying materials, equipment, and facilities: American Machinery Corporation, Orlando, Fla.; Brogdex Company, Orlando, Fla.; FMC Corporation, Lakeland, Fla.; and to the packinghouses where tests were conducted.

**LITERATURE CITED**