DECAY CONTROL OF FLORIDA CITRUS WITH 2-AMINOBUTANE[1]

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INTRODUCTION

The importance of decay control procedures to reduce losses in Florida citrus fruit after picking cannot be overemphasized. An experimental material, 2-aminobutane, has shown considerable promise for Florida citrus fruit decay control, especially when combined with Dowicide A-hexamine (4). Much of the experimental work was done with Hamlin and Valencia oranges. 2-aminobutane was also used as a decay control treatment on tangerines, Marsh grapefruit, and Pineapple oranges with encouraging results. Eckert and Kolbezen (1, 2, 3) working in California, have found 2-aminobutane to be a good fungicide for control of citrus molds. Smoot and Melvin (5) have shown 2-aminobutane to be of value for controlling decay of Florida citrus fruit.

Much of the fresh fruit decay losses of Florida citrus are caused by stem-end rot fungi, *Diplodia natalensis* Evans and *Phomopsis citri* Faw. that seldom naturally infect California citrus fruit. A smaller percentage of citrus fruit loss in Florida is caused by green mold, *Penicillium digitatum* Sacc. Blue mold, *Penicillium italicum* Wehmer is not a common cause of citrus fruit decay in Florida but does occur occasionally.

EXPERIMENTAL METHODS

All experimental lots of fruit were handled in essentially the same manner except for specific treatments. Each lot consisted of 135 to 150 fruit for tangerines, 100 fruit for Hamlin oranges, 80 to 90 fruit for Valencia and Pineapple oranges, and 56 to 60 fruit for Marsh grapefruit. Treatments were made on different dates during the regular harvesting period for each variety. Fruit, as received from the grove, was distributed at random into the desired number of lots. 2-aminobutane, unless otherwise noted, was applied to washed fruit as a 1 percent dip for 2 minutes at room temperature, followed by a water rinse. When 2-aminobutane was combined with Dowicide A-hexamine, enough 2 aminobutane to make a 1 percent solution was stirred slowly into the previously prepared Dowicide A-hexamine solution. Treatment was then the same as for 2-aminobutane.

After treatment, the fruit was dried and polished on horsehair brushes and waxed with non-fungicidal Flavorseal. All lots were packed in ventilated 4/5 bushel telescope-type fiberboard cartons. Packed cartons were held at 70° F, except for tangerines which were held at 60°F. Inspections for decay were made 1, 2, and 3 weeks from the picking date with the exception of four experiments which, in addition, were inspected 4 weeks from the picking date before being discarded.

Dowicide A-hexamine and diphenyl were used to check the comparative value of 2-aminobutane for decay control. Their use in this series of experiments followed standard commercial practices (4). Decay was classified as either stem-end rot or mold.

RESULTS AND DISCUSSION

Hamlin Oranges.—2-aminobutane was first tried in the fall of 1962 as a dip treatment on degreened Hamlin oranges with excellent decay control. In a similar series of four experiments with degreened fruit in the fall of 1963, there was a much higher percentage of decay in all lots of fruit, including the check. 2-aminobutane alone did not result in effective decay control of either degreened or non-degreened Hamlin oranges in the 1963-64 season but did give some reduction in total decay (unpublished data).

The combination of 2 percent Dowicide A-hexamine and 1 percent 2-aminobutane gave much better decay control than did Dowicide A-hexamine or 2-aminobutane alone (Table 1). In this series of experiments, 2-aminobutane reduced mold decay from 11.9 percent in the check to 1.5 percent but did not reduce loss from stem-end rot.

Valencia Oranges.—Unwashed Valencia oranges from a commercial packinghouse were distributed at random into eight lots. Four lots were washed, treated, dried, polished, waxed, and

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[2]Retired.

packed within a few hours after picking. The remaining four lots were degreened with ethylene gas for 48 hours, then treated with the same fungicidal solutions and handled exactly as the first four lots. This experiment was replicated four times on different days. The summary of the results from these experiments are given in Table 2. The mixture of 2-aminobutane combined with Dowicide A-hexamine gave consistently good decay control in the degreened fruit for 3 weeks and the non-degreened fruit for 4 weeks from the picking date. Dowicide A-hexamine was effective in controlling decay for 2 weeks from the picking date. 2-aminobutane was not as effective in controlling decay as Dowicide A-hexamine for the first 2 weeks from the picking date but was more effective at 3 and 4 weeks.

A series of five mold inoculation experiments with Valencia oranges were handled as described below and in Table 3. Fruit for three experiments was from the Citrus Experiment Station groves, and unwashed fruit was purchased from a commercial packinghouse for the other two experiments. Fruit was washed and prepared for inoculation by puncturing the peel from 1/16 to 3/16 of an inch deep with 21 thumbtack points. The injured fruit was then submerged for 1 minute in water at room temperature containing fresh mold spores from moldy fruit. The inoculated fruit was allowed to stand 1 to 2 hours before being treated with the fungicides. The results from this series of experiments are summarized in Table 3.

Dowicide A-hexamine + 2-aminobutane gave the greatest reduction in mold decay in the inoculated fruit, followed by Dowicide A-hexamine. The 2-aminobutane treatment alone did not result in satisfactory reduction of mold decay in this series of experiments. Decay in the non-inoculated lots was effectively controlled by Dowicide A-hexamine for 2 weeks, whereas the Dowicide A-hexamine + 2-aminobutane treatment resulted in good decay control throughout the 3-week holding period.

Pineapple Oranges.—Two experiments with Pineapple oranges treated as described gave the following average percentage decay losses at 2 weeks from picking: check, 20.0 percent; Dowicide A-hexamine, 2.5 percent; Dowicide A-hexamine + diphenyl pads, 0.6 percent; Dowicide A-hexamine + 2-aminobutane, 1.9 percent; and 2-aminobutane, 6.9 percent. 2 aminobutane alone gave good control of molds but not of stem-end rot pathogens.

Tangerines.—Identical treatments were given to tangerines in eight experiments, four with degreened, and four with non-degreened fruit. After treatment, the fruit was held at 60° F. Two weeks after picking, the average decay loss of the degreened check lots was 17.5 percent, while loss from fruit treated with 2-aminobutane was reduced to 11.2 percent. Comparable results for non-degreened lots were 8.4 percent for the check lots and 4.1 percent for the 2-aminobutane treatment. 2-aminobutane gave better decay control than Dowicide A-hexamine on the degreened

Table 1. Treatments and decay control achieved with non-degreened Hamlin oranges at 70° F (average of four experiments).

		% Decay 2 Weeks from Picking		
No.	Treatment	Stem-End Rot	Mold	Total Decay
1	Check	18.4	11.9	30.3
2	Dow-hex	6.8	4.9	11.7
3	Diphenyl pads	9.0	2.2	11.2
4	Dow-hex* + diphenyl pads	1.3	0.0	1.3
5	Dow-hex* + 2-AB**	3.7	1.6	5.3
6	2-AB**	23.0	1.5	24.5

*Dowicide A-hexamine. **2-aminobutane.

Table 2. Comparison of decay loss and the value of fungicidal treatments with degreened and non-degreened Valencia oranges which were picked at the same time (average of four experiments).

No.	Treatment	% TOTAL DECAY - 70° F 2 Weeks	3 Weeks	4 Weeks
	Degreened			
1	Check	9.5	19.8	26.2
2	Dow-hex*	1.8	15.6	32.4
3	Dow-hex* + 2-AB**	1.0	5.1	14.6
4	2-AB	6.0	12.7	17.8
	Non-Degreened			
1	Check	6.3	13.0	21.0
2	Dow-hex*	0.8	8.5	20.2
3	Dow-hex* + 2-AB**	0.3	1.5	4.8
4	2-AB	3.8	7.5	10.2

*Dowicide A-hexamine. **2-aminobutane.

lots and was equal to Dowicide A-hexamine on the non-degreened lots. The value of 2-aminobutane in this series of experiments was due mostly to the reduction of mold decay.

Grapefruit.—Four similar experiments with non-degreened Marsh grapefruit had the following average percent losses from decay: check, 7.6 percent; 2-aminobutane, 4.0 percent; Dowicide A-hexamine + 2-aminobutane, 3.4 percent; Dowicide A-hexamine, 1.3 percent; and Dowicide A-hexamine + diphenyl pads, 1.7 percent.

The decay control treatments used during the 1963-64 season are listed below in the order of their value in controlling decay, with the average percent decay loss 2 weeks from the picking date. The first two treatments resulted in exceptional decay control.

1. Dowicide A-hexamine treated fruit packed with diphenyl pads, 1.4 percent.
2. Dowicide A-hexamine + 2-aminobutane with a water rinse, 3.1 percent.
3. Diphenyl pads, 8.4 percent.
4. 1 percent 2-aminobutane, 2-minute dip at 118° F with a water rinse, 10.0 percent.
5. Dowicide A-hexamine, 10.5 percent.
6. 1 percent 2-aminobutane, 2-minute dip at room temperature without a water rinse, 10.5 percent.
7. 1 percent 2-aminobutane, 2-minute dip at room temperature with a water rinse, 12.5 percent.

Decay control, resulting from combining 2-aminobutane with Dowicide A-hexamine, was consistently better than either material alone and for a longer period of time. Dowicide A-hexamine + 2-aminobutane was tested on non-degreened Hamlin, Pineapple and Valencia oranges, Marsh grapefruit, and degreened Valencia oranges. Dowicide A-hexamine treated fruit placed in cartons with diphenyl pads resulted in slight but consistently better decay control than did Dowicide A-hexamine + 2-aminobutane.

2-aminobutane has been tested for several years by California workers who have reported good control of *Penicillium* mold decay (1, 2, 3). Experimental work at the Citrus Experiment Station at Lake Alfred has shown 2-aminobutane to be of value in reducing mold decay and to a lesser

Table 3. Treatments and decay control achieved with mold-inoculated Valencia oranges compared with non-inoculated fruit from the same experiments.

No.	Treatment	% TOTAL DECAY - 70° F		
		1 Week	2 Weeks	3 Weeks
	Non-Inoculated			
1	Check	1.0	18.4	34.8
2	Dow-hex*	0.4	3.0	25.4
3	Dow-hex* + 2-AB**	0.0	1.4	5.2
4	2-AB	1.4	14.8	25.6
	Mold-Inoculated			
1	Check	100.0[1]	--	--
2	Dow-hex*	29.4	43.8	68.2
3	Dow-hex* + 2-AB**	20.2	33.2[1]	51.8
4	2-AB	62.8	94.0[1]	--

*Dowicide A-hexamine. **2-aminobutane.

[1]Discarded after this examination.

extent, stem-end rot. In holding tests at 60° and 70° F, 2-aminobutane has been shown to be generally less effective than Dowicide A-hexamine for the first 2 weeks after picking but better when the fruit is held for longer periods. Additional work is needed to determine the comparative value of these two materials. When 2-aminobutane treatments were varied as to strength or temperature of solution, time of treatment, or whether given a final rinse, no one treatment was consistently better.

The water solution of 2-aminobutane has shown no evidence of rind injury and leaves no odor on the fruit. The necessary work to obtain a Food and Drug Administration clearance for the use of this material as a fungicide on citrus fruit is being done.

SUMMARY

The value of 2-aminobutane to the fresh fruit citrus industry is promising. It was demonstrated that 2-aminobutane was a good fungicide for the control of mold decay but of less value for the control of stem-end rot. When 2-aminobutane was combined with Dowicide A-hexamine in a single treating solution, the resulting decay control was consistently better than either fungicide used alone and resulted in decay control for a longer period, particularly with non-degreened citrus fruit.

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