Relationship Between Mode of Application of Thiabendazole and its Effectiveness for Control of Green Mold and Inhibiting Fungus Sporulation on Oranges

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The authors wish to thank M. Gottesman and Y. Gedassi for technical assistance.

ABSTRACT

A striking decrease was found in the effectiveness of thiabendazole in controlling green mold as a result of incorporation of the fungicide in wax as compared with a fungicidal spray only, or with a fungicidal spray followed by waxing. The correlation between levels of thiabendazole residues and effectiveness in decay control and inhibition of sporulation is discussed. Changes in packinghouse procedures are suggested.

Phytopathology 64:1477-1478

Additional key words: *Penicillium digitatum*, fungicide in wax, *Citrus sinensis*.

Thiabendazole, is a potent antifungal agent. However, because of its insolubility in water and frequent drop in concn due to precipitation with dust and dirt particles, formulations of it used nowadays in packing-houses for postharvest decay control are mainly incorporated in wax. Under laboratory conditions the effectiveness of different fungicides in the postharvest control of green mold in oranges is markedly decreased when compounds are incorporated into a water-emulsion wax (2). The present work describes the fungicidal and antisporulant effects of thiabendazole on fruit under packing-house conditions with different modes of application, and its relation to thiabendazole-residue levels.

Twenty-four hours before the chemical treatments, Shamouti and Valencia oranges [*Citrus sinensis* (L.) Osbeck], were artificially inoculated by inserting pins loaded with spores of *Penicillium digitatum* Sacc., the causal agent of green mold, into opposite sites of the fruit to a depth of 1.0-1.5 mm and incubating them at 18 C. The following day, the fruits were subjected to one of the three modes of application of 2-(4'thiazolyl)-benzimidazole, thiabendazole (supplied by S. Riesel, Tel Aviv, agent of Merck & Co., Inc., Rahway, New Jersey): (i) spray, (ii) spray followed by waxing, and (iii) application of wax into which the fungicide had been incorporated. Concentrations employed were 250, 1,000, and 4,000 μg active ingredient of thiabendazole per ml of water. The water suspensions of thiabendazole were prepared with a 60% active ingredient (a.i.) wettable powder formulation (Tecto 60), whereas a 100% wettable powder was incorporated into the water-emulsion wax formulation (Zivdar, a local brand of the "Citrashine wax"). Fruits handled similarly, but not treated with thiabendazole, served as controls. Four replicates of 50 fruits each were used per treatment and incubation was at 18 C.

While all control fruits decayed within one week, nearly

TABLE 1. Effect of different modes of application of thiabendazole on decay control, sporulation, and thiabendazole residues, in artificially inoculated Shamouti oranges

Method of application	Concentration of thiabendazole (μg/ml)								
	250			1000			4000		
	A[a]	B[b]	C[c]	A	B	C	A	B	C
Suspension in water	7.5	0	0.68	5.0	0.2	0.58	0	1.97	1.48
Ditto, followed by wax	4.5	0	0.78	5.5	0.14	0.64	2.0	1.77	1.21
Suspension in wax formulation	70.2	0	0.42	29.5	1.27	1.32	18.5	2.95	2.5

[a]Percent green mold after 33 days of storage at 18 C. Control = 100% decay.

[b]Inhibition of sporulation. Average of 30 fruits per treatment. Two or three days before the various fungicidal treatments, 0.1 ml of a heavy (1.8×10^7/ml) suspension of spores of *P. digitatum* was injected hypodermically into the inner part of the albedo and the resulting sporulation compared with that of inoculated, but untreated, control fruits. Index: 0 = No inhibition of sporulation (full coverage); 1 = slight inhibition (about two-thirds of each fruit covered with spores); 2 = strong inhibition (about one-third of each fruit covered with spores); and 3 = complete inhibition (no sporulation).

[c]Thiabendazole residues (μg/g). Average of ten fruits per treatment.

complete decay control was obtained with all three concns of thiabendazole in Shamouti orange provided that thiabendazole was suspended in water (Table 1). However, when thiabendazole was incorporated in Zivdar wax, a striking decrease in the antifungal effect was observed. Waxing of the fruit in itself slightly slowed down rot development and hampered somewhat the formation of mycelium and, subsequently, of spores. There was correlation between the concn of thiabendazole and its effectiveness in decay control.

When thiabendazole was incorporated in wax, complete inhibition of sporulation occurred only at 4,000 μg/ml (Table 1). Moreover, thiabendazole suspended in water at 4,000 μg/ml inhibited sporulation only partially. Thus, in contrast to the results of decay control, incorporation of thiabendazole into wax was more effective than the water suspension in controlling sporulation.

Fruits with a stronger inhibition of sporulation of *P. digitatum* (*e.g.*, treatment with thiabendazole incorporated in wax) were often covered with spores of an apparently resistant strain of *P. italicum* Wehmer, the causal agent of blue mold. *P. italicum* was not observed when sporulation of *P. digitatum* was not inhibited.

Fruits treated with thiabendazole incorporated in wax showed higher residue levels than those treated with thiabendazole suspended in water, apparently due to differences in viscosity and hence also in amounts of fungicides deposited (Table 1). When similar experiments were done on Valencia oranges, the effectiveness of thiabendazole in both decay control and inhibition of sporulation was less. For example, the incidence of decay following treatment with thiabendazole suspended in water at concns of 1,000 and 4,000 μg/ml amounted to 23.0 and 1.5% respectively in Valencia as compared with 5.0 and 0% in Shamouti. The index of sporulation at 4,000 μg/ml was 0.58 in Valencia oranges and 1.97 in Shamouti.

Packing-house data corroborate earlier findings in laboratory experiments (2), that thiabendazole suspended in water (with and without subsequent waxing) is more effective in the control of green mold than thiabendazole incorporated in wax. In similar experiments, Eckert and Kolbezen (1) and Smoot and Melvin (4) noticed lower effectiveness of thiabendazole in a wax formulation than in a water suspension.

The effectiveness of thiabendazole in wax, in controlling sporulation is explained on the basis of residue levels. Hence, to reach similar levels of thiabendazole residues, ensuring complete inhibition of sporulation, a much higher concn of thiabendazole in water will have to be used, approaching the 0.5% level suggested by Eckert and Kolbezen (1) and by McCornack and Brown (3).

We conclude that incorporation of thiabendazole in wax in packing-houses should be replaced by use of the fungicide as a suspension in water (with or without subsequent rinse), followed by waxing.

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