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Efficacy of Fungicides for Postharvest Treatment of Muskmelon Fruits

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Abstract. **Fruit of muskmelon (*Cucumis melo* L.) were treated with 0–10^4 mg/liter of the fungicides: benomyl (methyl-1-[butylcarbamoyl]-2-benzimidazole carbamate); etaconazole (1-{[2-(2,4-dichlorophenyl)-4-ethyl-1,3-dioxolan-2-yl]-methyl}-1 H-1,2,4-triazole); fenapanil (1-butyl-1-phenyl-1 H-imidazole-1-propanenitrile); imazalil (1-[2-allyloxyl-2-(2,4-dichlorophenyl)ethyl]imidazole); and prochloraz (1-{N-propyl-N-[2-(2,4,6-trichlorophenoxy)ethyl]}carbamoylimidazole). Damage from *Fusarium* rots, *Geotrichum* and *Rhizopus* soft rots, and *Alternaria* surface blemish was assessed. Fenapanil, imazalil, and prochloraz had the most useful range of fungicidal activities. Prochloraz was the most efficacious fungicide tested, expressed as disease control per unit concentration of active ingredient.**

Several fungicides have been found which, when applied as postharvest dips at room temperature, help to control disease in muskmelons. Three of these fungicides are imazalil (2), benomyl, and guazatine (7). When applied as dips at 57°C, captan (6) and sodium dimethyldithiocarbamate (1, 2) are also effective. The postharvest disease complex which affects muskmelons (7, 8) is not, however, readily controlled by any one fungicide. This fact has prompted the testing of many fungicides, often using conventional culture-plate testing techniques (e.g., 7). The limitations of culture-plate tests are well known (3), and tests should be made on disease-susceptible fruit at an early stage of the screening program. In this paper, we report the relative efficacies of 5 fungicides applied to muskmelons at room temperature. A rapid and economical test method was used which generated dosage/response curves for each treatment.

'Goldpak' muskmelons were harvested from a commercial crop at "full-slip" maturity (i.e., abscission crack between fruit and pedicel) and "western choice" ripeness (4) (fruit yellowish-tan in color). The melons were inoculated by dipping for 1 min in a suspension containing 10^4 spores/ml of *Fusarium* spp. (mixed isolates grown on melons and lesions excised from the fruit and blended to obtain spores). After incubation at ambient conditions for 16 hr, the melons were randomized and dipped for 1 min in solutions or suspensions of benomyl, etaconazole, fenapanil, imazalil, and prochloraz.

Each fungicide was tested at concentrations of 0, 100, 300, 600, 1000, 3000, and 10,000 mg a.i./liter. A non-ionic wetter (0.01% v/v) was added to each dip, and all dips were applied at ambient temperature. Each treatment was applied to a unit of 15 melons, so that 90 melons were treated with each fungicide.

Treated melons were drained, air-dried, packed in cartons, and transported 700 km to the laboratory. The severity of 3 types of disease was assessed after storage for 9 days at 25°C and ambient humidity. These diseases were *Fusarium* fruit rot, soft rots caused by both *Geotrichum* and *Rhizopus*, and surface blemish caused mainly by *Alternaria*. Melons were scored for severity of each disease (1 = no disease, 2 = trace, 3 = slight, 4 = moderate, and 5 = severe disease). Individual melons with a score of 2 were considered marketable without penalty, whereas a score of 3 would lead to downgrading in the market.

Dosage/response equations for each fungicide and disease combination were calculated by quadratic regression analysis, and the coefficients of determination were tabulated (Table 1.) The equations were then used to predict the concentration of each fungicide required to reduce disease to an economically acceptable level, which was defined as a disease score of 2.0 (Fig. 1). *Fusarium* rot was reduced by all fungicides; less than 100 mg/liter of benomyl or prochloraz was needed to give a disease score of 2.0. Soft rots were

Table 1. Correlations between fungicide concentration and disease score for several diseases of muskmelon[z]

	Coefficient of determination (r^2)		
Fungicide	Fusarium rots	Soft rots	Surface blemish
Benomyl	0.97**	0.87**	0.05
Etaconazole	0.93**	0.82**	0.28
Fenapanil	0.84**	0.80**	0.90**
Imazalil	0.86**	0.82**	0.91**
Prochloraz	0.97**	0.88**	0.86**

[z] $y = a + bx + cx^2$, where y is disease score (1–5 scale) and x is $\log_{10}$ fungicide concentration (mg/liter).
**Significant at 1% level.

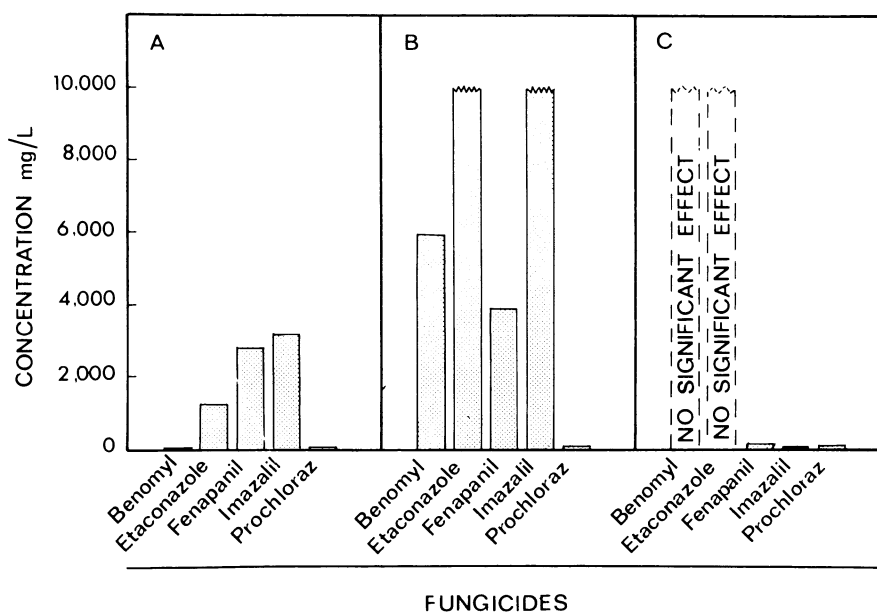

Fig. 1. Predicted fungicide concentrations required to reduce muskmelon diseases to an acceptable level (i.e. disease score = 2.0). A = Fusarium rots; B = Soft rots; C = Surface blemish. A break at the top of a bar denotes a predicted concentration > 10,000 mg/liter.

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reduced by all fungicides, but fungicidal efficacy was low except for prochloraz. In previous experiments, benomyl, imazalil, and fenapanil had no effect on the growth of *Rhizopus oryzae* on culture plates, and little effect on *Geotrichum candidum* (7). It is doubtful if the fungicides tested in the present study, other than prochloraz, exerted more than an indirect effect on soft-rot organisms. The incidence of soft rots was low where primary *Fusarium* infections were controlled, suggesting that the soft rots were secondary infections. Surface blemish was reduced by fenapanil, prochloraz, and imazalil; less than 100 mg/liter of these fungicides gave a disease score of 2.0.

The experimental technique used in this work has several novel properties. Each fungicide was tested over a 10^4-fold concentration range, and the resultant responses were described conveniently by quadratic equations. This treatment of the data is appropriate, since the scoring system used is an ordered classification (5). The technique enables fungicides to be tested on fruit, while requiring a minimal amount of experimental material, and with minimal recourse to artificial inoculation (inoculation was by surface contact, not deep wounding). The wide concentration range studied was deliberately chosen so that fungicides with high effective doses (ED_{50}) would not be arbitrarily discarded. We recognize that at dip concentrations of 10^3–10^4 mg/liter, surface residues of some fungicides may have reached saturation, and calculations of the dip concentration to give a particular disease score, such as those made for soft rots, may be artificial. Suffice it to say that the resultant estimates will have relative meaning—i.e., the estimated 6000 mg/liter of benomyl to give an apparent soft-rot score of 2 means that benomyl is not very effective.

Our results are provocative since they deprecate the role of soft-rot organisms in primary pathogenesis and imply that control of *Fusarium* rots will curtail soft rots. Further work is needed to clarify this point. Fenapanil, prochloraz, and imazalil had the most useful range of fungicidal activities in this work; and prochloraz was the most efficacious fungicide, in terms of disease control per unit concentration of active ingredient.

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Chlorflurenol Interrupts Ovule Development of Muskmelon

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Abstract. **Application of 50 or 75 mg/liter chlorflurenol (methyl-2-chloro-9-hydroxy-fluorine) to muskmelon (*Cucumis melo* L.) 10 to 12 days prior to anthesis eliminated ovule development during later bud growth. The interruption of ovule development increased when chlorflurenol was applied 6–14 days prior to anthesis. Chlorflurenol did not interfere with pollination, pollen germination, or pollen tube growth.**

Chlorflurenol induces parthenocarpic fruit set on cucumbers and muskmelons (2, 3, 4, 5, 7, 8). Chlorflurenol can also improve fruit set of pollinated flowers and usually reduces the number of seeds per fruit (3, 4). This observation led Cantliffe to hypothesize that chlorflurenol interferes either with ovule or pollen tube development (3). This study was initiated to determine the validity of these hypotheses.

Chlorflurenol (Curbiset, EM Industries Inc.) at 50 mg/liter was sprayed to run-off onto 7 muskmelon lines (both cultivars and breeding lines) grown in the field. Pistillate flowers from treated and untreated plants were hand-pollinated 10 days after treatment and fixed in 8 ethanol : 1 formalin : 1 acetic acid (FAA) at intervals from 10 to 50 hr after pollination. Fixed flowers were rinsed, hand-sectioned, and hydrolyzed in 1 N NaOH at 60°C for 10 min and then rinsed and stained with 0.1% aniline blue in 0.1 N K_3PO_4. Pollen tubes were observed under ultraviolet light according to the methods of Martin (6). The quantity of pollen on each stigma, pollen germination, and ovule number per flower were rated on a scale of 0 (no pollen, germination or ovules) to 3 (sufficient pollination and germination or adequate ovule number). Extent of pollen tube growth was determined by visually assessing the location of the tube tip within the style or ovary. There were no statistically significant differences among the 7 muskmelon lines.

The relationship between ovary development at the time of chlorflurenol treatment and the number of ovules present at anthesis was investigated with 'Saticoy' muskmelon plants grown in a greenhouse during the late fall. Plants were treated as above with 0, 50, or 75 mg/liter chlorflurenol. Ovary lengths of pistillate flowers were measured at the time of treatment or as soon as buds were detected. Flowers were collected and fixed at anthesis. Differences for date of anthesis, ovary length, and ovule rating between the 50 and 75 mg/liter treatments were not statistically significant. Consequently, data for these 2 treatments have been pooled for presentation.

Application of chlorflurenol did not reduce pollination or pollen germination (Table 1).

Table 1. Mean pollination and pollen germination ratings on stigmas from chlorflurenol-treated and untreated muskmelon plants.

Treatment	Pollination rating[z]	Pollen tube germination rating[z]
Control	2.9	2.9
Chlorflurenol[y]	2.8	2.7
Significance	NS	NS

[z]Rating scale where 0 = no pollen or germination and 3 = abundant pollination (stigmatic surfaces nearly covered with pollen) or pollen germination (pollen tubes appeared to occupy most of the available space within the style or ovary).
[y]50 and 75 mg/liter combined.
NSNonsignificant, 1% level.

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