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SEASONAL VARIATION IN TOLERANCE OF FLORIDA 'MARSH' GRAPEFRUIT TO A COMBINATION OF METHYL BROMIDE FUMIGATION AND COLD STORAGE[1]

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Abstract. **Methyl bromide (MB) fumigation did not increase the incidence of decay or peel injury in grapefruit held at room temperatures of 70-80°F. (21-27°C.) posttreatment. When fumigation was followed by storage at 50°F. (10°C.) for 4 weeks, decay was generally higher than in fruit stored at room temperature. Decay was most prevalent in late season grapefruit harvested in April. Mid-season fruit harvested in January was the most tolerant to fumigation and/or cold storage. Peel injury was evident only in early season fruit harvested in October but it was severe. Cold storage at 50°F. alone caused substantial peel injury to early fruit and the addition of MB fumigation compounded the damage.**

Citrus destined for Japan must be fumigated as a quarantine measure against the Caribbean fruit fly, *Anastrepha suspensa* (Loew). While in transit on surface vessels, the fruit is refrigerated at below ambient temperatures to reduce spoilage during the 3-4 week journey. It has been reported by citrus researchers (2, 3, 5, 8) that grapefruit in particular varies in its sensitivity to cold storage. As a result, shipment temperatures are adjusted accordingly, with early season fruit requiring a higher storage temperature (60°F.) than mid and late season fruit (50°F.). Benschoter (1) in research on alternative fumigants, established dosage-mortality relationships for Caribbean fruit fly in grapefruit which was fumigated with methyl bromide (MB) then stored at room temperature (70-80°F.). This treatment caused no visible injury to grapefruit. The purpose of this study was to determine the seasonal variability in the tolerance of 'Marsh' grapefruit to MB fumigation followed by storage at 50°F.

Materials and Methods

This experiment represented a partial simulation of procedures used for export of citrus to Japan. The grapefruit was fumigated with MB dosages known to kill the Caribbean fruit fly (1). After fumigation the fruit was aerated for a time then placed in cold storage. The fruit used in these tests had been processed in packing houses and packed into 4/5 bushel (28.19 liters) export grade fiberboard cartons (avg. 40/carton). It was transported by truck from Ft. Pierce to the USDA-SEA-AR Miami station and placed at 55°F. (13°C.) for 5-7 days before testing. In preparation for treatment, the fruit was removed from the cartons and examined. Any decayed, scarred or blemished fruits which might confound the test results were replaced. The fruit was then completely randomized and repacked into the cartons (diphenyl pads included) ready for fumigation. Minimum (3 cartons) and maximum (12 cartons) fruit loads in 28 ft^3 ($0.8 m^3$) chambers were fumigated with 40 g/m^3 and 56 g/m^3 of MB respectively, for 2 hr. with continuous air circulation at 70-75°F. (21-24°C.). The cartons of fruit were then aerated for 4 hr. (an arbitrary time) and placed in cold storage at 50°F. for 4 weeks, which is about the maximum time required to transport citrus to Japan by surface vessels. Fumigated and nonfumigated grapefruit stored at ambient temperatures of 70-80°F. served as controls for computation of treatment effects. In order to assess injury, the symptoms were divided into 2 categories: 1. Scald or pitting of the peel and 2. decay. No attempt was made to classify or differentiate between the decay related microorganisms, but stem end rot and the penicillium molds were known to be involved.

Results and Discussion

Fumigation with MB did not increase the incidence of decay or cause peel injury in any of the lots of fruit held at ambient temperature (70-80°F.) posttreatment. When fumigation was followed by cold storage at 50°F., decay was generally greater than that in fruit stored at ambient temperature and percentage decay increased with the dosage of MB used. Cold storage alone resulted in only slight decay compared to fruit that had also been fumigated. The incidence of decay was rather uniform until late in the season when it increased sharply (Table 1). The data suggest that decay, whether chemically or cold induced, would be most likely in late season grapefruit. The fruit picked in January was most tolerant to these treatments compared to lots harvested earlier and later. This difference in tolerance may be due to gradual conditioning of the fruit on the tree to declining temperatures as the cold weather progresses. These results are in agreement with Chace et al. (2), and Schiffmann-Nadel et al. (8).

Table 1. Effect of MB fumigation + cold storage at 50°F. for 4 weeks on decay of grapefruit, 3 replicates.

Harvest date	% Decayed fruit for indicated treatments[z]		
	Non-fumigated	40 g/m^3 MB[y]	56 g/m^3 MB[x]
Oct '77	4.3	0.0	13.9
Nov '77	1.7	8.4	21.9
Jan '78	0.0	0.0	14.7
Mar '78	1.8	11.7	19.8
Apr '78	20.0	45.0	58.8

[z]Readings made over a period of 2 weeks after fruit was removed from cold storage. Values corrected from non-fumigated fruit controls held at ambient temperature.
[y]3 carton load.
[x]12 carton load.

Peel injury was evident only in the first lot of fruit harvested in October but it was severe (Table 2). Cold storage alone caused 40% peel injury and MB fumigation increased this damage substantially. Therefore, peel injury whether chemically or cold induced would seem most likely in early season grapefruit. Again, our results agreed most closely with those of Chace et al. (2), and Schiffmann-Nadel

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et al. (8). Peel injury (pitting) in late season fruit (April) was not produced in our tests. Kawada and Grierson (5) demonstrated chilling injury of late fruit at a storage temperature of 40°F. (4.4°C.). At this same temperature, McCornack (6) clearly showed that diphenyl pads contributed significantly to peel injury of Marsh grapefruit harvested throughout the season and Norman et al. (7) demonstrated a causal relationship of diphenyl pads to chilling injury of fruit stored at 50°F. for 30 days. Grierson and Hatton (4) presented an excellent discussion of the multitude of pre- and postharvest factors that confound the problem of evaluating postharvest treatments of citrus fruits.

Table 2. Effect of MB fumigation + cold storage at 50°F. for 4 weeks on peel injury of grapefruit, 3 replicates.

Harvest date	% Peel injury for indicated treatments[z]		
	Non-fumigated	40 g/m^3 MB[y]	56 g/m^3 MB[x]
Oct '77	40.4	51.1	77.3
Nov '77	0.0	4.2	2.5
Jan '78	0.0	0.0	0.0
Mar '78	0.0	0.0	0.0
Apr '78	0.0	0.0	0.0

[z]Readings made over a period of 2 weeks after fruit was removed from cold storage. Values corrected from non-fumigated fruit controls held at ambient temperature.
[y]3 carton load.
[x]12 carton load.

Methyl bromide in our tests consistently produced more decay in the fumigations where chambers were filled to maximum capacity. The reason for this is not clear at present. The load-dosage relationship is not proportional. As the fruit load was increased by 4X (from 3 cartons to 12 cartons) the dosage of MB required to kill the Caribbean fruit fly in the fruit increased by only 1.4X (from 40 to 56 g/m^3) and yet considerably more decay developed in the larger load.

Although it was not the purpose of this paper to demonstrate such, the data suggest (from the amount of decay encountered) that MB would not be suitable as a treatment for grapefruit. However, results from our continuing research reveal that the MB dosages used in this study are larger than those needed to destroy fly infestations in grapefruit when fumigation is followed by cold storage. It is possible that amounts required to kill the Caribbean fruit fly might be reduced by as much as 8 to 16 g/m^3 when fumigation is followed by cold storage at temperatures of 45° and 50°F. Tolerances of grapefruit to these conditions have not yet been tested. All information we have at present however suggests that there will not be a wide margin of safety between the amount of MB required to kill the fly and that which will injure the fruit.

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PHYTOTOXICITY OF METHYL BROMIDE AS A FUMIGANT FOR FLORIDA CITRUS FRUIT[1]

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Abstract. **In 36 tests conducted during the 1977-78 and the 1978-79 citrus seasons, methyl bromide (MB) was found to be too phytotoxic as a fumigation treatment for grapefruit, orange and 'Temple' at dosages equal to or greater than that needed to eliminate the Caribbean fruit fly,** Anastrepha suspensa **(Loew). Increasing the exposure time or the fumigation rate invariably resulted in increased injury and subsequent decay. The injury manifested itself with a scaldlike appearance and/or in a few instances, discolored pitting of the peel. The scaldlike injury became water-soaked in severe instances. With orange and 'Temple' the development of symptoms was usually delayed and a general softening of the fruit was detected before symptoms of injury became visible. The symptoms were typified by a water-soaked appearance followed by excessive decay. Occasionally, an entire lot of fruit would escape MB injury after fumigation and during 4 weeks of storage (simulated transit), only to develop excessive decay after holding at 70°F (21°C) for 7 or 14 days; this was especially the case for orange and 'Temple'.**

The market value of fresh grapefruit exported to Japan will probably exceed $50 million in the near future (4). Over 30 million dollars' worth of Florida grapefruit (7.08 million cartons), as well as over 2 million dollars' worth of 'Valencia' oranges (431,000 cartons), were shipped to Japan during the 1978-79 season. All fruit must be fumigated with ethylene dibromide (EDB) to eliminate possible infestations

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