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LARGE CHAMBER FUMIGATIONS WITH METHYL BROMIDE TO DESTROY CARIBBEAN FRUIT FLY IN GRAPEFRUIT[1]

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Abstract. **Commercial scale tests were conducted to confirm results with methyl bromide (MB) as a fumigant for Caribbean fruit fly** [Anastepha suspensa **(Loew)] infested grapefruit. Boxes of infested fruit were placed into a semi-trailer with 972 boxes of styrofoam balls. The loaded trailer was fumigated with 40 g/m³ MB for 2 hr in a 266-m³ chamber. A single pupa was recovered from 31,972 insects treated in fruit that was held at 75°F posttreatment, but no adult fly emerged from the pupa. Based on survival to the pupal stage, this represents a kill of 99.99687% or probit 9.01. In tests with fruit that was held at 60°F for 3 weeks following fumigation, no Caribbean fruit flies survived from a treated population of 45,664. Gas concentrations, monitored during fumigation, indicated a very uniform distribution of MB within the chamber. Residues of MB in fruit were calculated to reach 10 ppb and 1 ppb after 10 and 14 days respectively, when fruit was stored at 60°F following fumigation.**

Ethylene dibromide (EDB) has been used as a quarantine treatment against fruit flies for 30 yr. Several years ago, the impending loss of EDB prompted intensive investigation of methyl bromide (MB) as a possible substitute fumigant. The need for an alternate treatment became critical when the Environmental Protection Agency (EPA) set September, 1984 as the termination date for use of EDB on citrus. Our work at the Miami Station involved extensive fumigation studies with MB in 0.8-m³ chambers. The fumigant was tested against eggs and larvae of the Caribbean fruit fly, *Anastrepha suspensa* in Florida 'Marsh Seedless' grapefruit (1, 2).

Decisions were made that commercial scale (large chamber) fumigation tests would be required before MB could be considered for quarantine use. This paper describes fumigation tests conducted at the Miami, Florida, Subtropical Horticulture Research Station using a semi-trailer in a 266-m³ chamber (3).

Materials and Methods

'Marsh Seedless' white grapefruit used in this study was provided by the State of Florida, Department of Citrus. The fruit was commercially packed (36 per box) in 4/5 bushel export-grade fiberboard boxes including diphenyl pads. Procedures for infesting grapefruit with the Caribbean fruit fly were the same as previously reported (2).

The fumigation chamber was sealed to meet minimum requirements for gas tightness, and was approved by APHIS for these tests. The semi-trailer fully loaded contained 972-4/5 bushel citrus boxes or 18 chimney stacks. Styrofoam balls were used to fill the boxes in lieu of fresh fruit. In the chimney stack configuration, the boxes in each stack (9 per layer x 6 high) are arranged to leave an open space in the center of the stack. The rear doors, as well as 2 vents in the upper front corners of the semi-trailer were in the open position. At the rear of the trailer, a large centrifugal blower (171-m³ air/min) directed the air stream into the trailer.

Boxes of grapefruit infested with eggs and larvae of the Caribbean fruit fly were placed in the middle layers of a chimney stack in the center of the trailer. The number of boxes of fruit per fumigation varied from 18 to 27.

A dosage of 40 g/m³ MB was used in all tests. The fumigant (measured by weight on a scale) was introduced from a tank outside the chamber through a 0.94-cm copper tube extending through the chamber wall near the intake side of the blower. A 1.8-m length of 0.48-cm diameter electric heating cord wrapped around the copper tube was used to apply heat during delivery of the MB from the tank. A voltage controller (set at 30-40% capacity) regulated the heat produced in the cord so that the MB could be delivered slowly from the tank without freezing in the copper tube.

Two treatments, each repeated 3 times, were tested: 1) fumigation with MB followed by storage at 75°F and, 2) fumigation with MB followed by storage at 60°F for 3 weeks. The first procedure has application to domestic (short-haul) shipments where storage temperature during transportation is not a factor in fly kill. The second procedure applies to foreign (long-haul) shipments where refrigeration is required to preserve fruit in transit.

Fumigation time was 2 hr followed by aeration of the chamber for 2 hr before it was opened. The large truck-entrance door had to be sealed in order to make the chamber gas-tight. Therefore, the trailer could not be moved out of the building after each fumigation, as in commercial practice, and infested fruit had to be moved in and out by hand. The 2-hr aeration period was necessary to reduce the concentration of MB in air to zero before personnel could enter the chamber to remove the fruit.

Fruit and air temperatures (not controlled) during treatment ranged between 75° and 85°F.

After treatment, all infested fruit was placed in holding cages over sand at 74-78°F and held for 5 weeks to recover any insects that survived the fumigation. Normally formed puparia were counted as survivors.

During the fumigation and aeration periods, gas concentrations were monitored with a Gow-Mac thermal conductivity gas analyzer. Readings were taken at 10 locations within the load and 2 locations in air outside the trailer (Figure 1). Teflon gas sampling tubes (0.31-cm diameter) extended from the control room to all sample locations. A small vacuum/pressure pump operated from the control room was used to circulate the fumigant-air mixture by drawing it from the sample site and returning it to the chamber. This was done with each sample tube just before readings were taken.

Single boxes of non-infested grapefruit placed at 4 different locations in the load were used for MB residue analyses (Fig. 1: S-1, S-2, S-3, S-4). This fruit was held at 60°F following fumigation. Fruits were taken from each box for residue assay at each sampling time. Eight samples (2/box) were taken for tests 1 and 3, and 12 samples (3/box) were taken for test 2.

[1]Mention of trade names, proprietary products, or commercial companies does not imply endorsement of that product by the U. S. Department of Agriculture over similar materials.

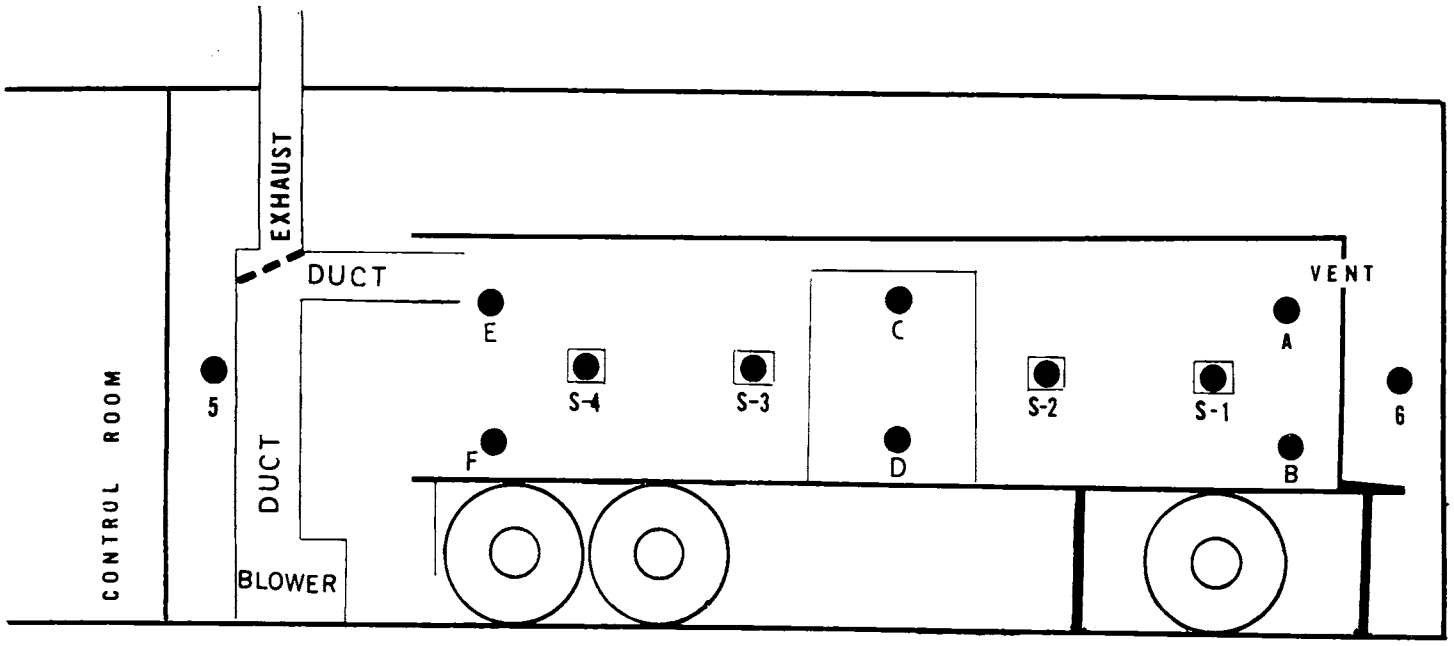

Fig. 1. Location of gas-sampling leads in the USDA 266-m³ fumigation chamber, Miami, FL.

Lead No.	Location
A	Within trailer, in front, 2nd layer of boxes from top of stack
B	Within trailer, in front, 2nd layer of boxes from bottom of stack
*C	Within trailer, in center, 2nd layer of boxes from top of stack
*D	Within trailer, in center 2nd layer of boxes from bottom of stack
E	Within trailer, in rear 2nd layer of boxes from top of stack
F	Within trailer, in rear 2nd layer of boxes from bottom of stack
*S-1	Within trailer, in front 3rd layer of boxes from top of stack
*S-2	Within trailer, in front 3rd layer of boxes from top of stack
*S-3	Within trailer, in rear 3rd layer of boxes from top of stack
*S-4	Within trailer, in rear 3rd layer of boxes from top of stack
5	Outside of trailer, in rear, 5 ft above floor level (chamber air)
6	Outside of trailer, in front, 5 ft above floor level (chamber air)

*Accessible from side doors.

Grapefruit samples were assayed for residues of MB using a published headspace method (4). From each grapefruit, a 50-g sample was weighed into a 500-ml Eberback blending container, 50 ml of water were added, and the container was quickly sealed with a Teflon-lined cap which had been modified by use of a Swagelok union to incorporate a silicone rubber septum. The sample was blended, and after ten or more minutes, 5 ml of headspace gas were removed with a 10-ml syringe and injected into a 0.5-ml loop of the gas chromatograph equipped with a linear nickel-63 electron capture detector. A one-meter glass column (4 mm ID) packed with 100-120 mesh Porapak Q (Waters Associates) was used with the following GC conditions: detector, 300°C; oven 140°C; carrier gas, argon-5% methane at 60 ml/min flow. Non-fumigated fruit samples were spiked with MB at various levels to serve as standards.

Results and Discussion

Mortality data for the large chamber fumigations are presented in Table 1. A single pupa was recovered from 31,972 insects treated in the fruit that was held at 75°F post-treatment, but no adult fly emerged. Based on survival to the pupal stage, this is a kill of 99.99687% or Probit 9.01. In the tests with fruit held at 60°F for 3 weeks following fumigation, no Caribbean fruit flies survived from a treated population of 45,664. These results corroborate laboratory studies which indicated that fumigation with 40 g/m³ MB is adequate as a quarantine treatment against Caribbean fruit fly in grapefruit (1, 2).

Table 1. Mortality of *A. suspensa* eggs and larvae in grapefruit in a semi-trailer fumigated in a 266 m³ chamber with 40 g/m³ MB for 2 hr at 75-85°F.

Post-fumigation storage temp. (°F)	Boxes of[z] fruit fumigated	Treated fly[y] population (estimated)	Mortality (%)	Mortality (probit)
75	69	31,972 (1)	99.99687	9.01
60 for 3 wk	79	45,664	100	—

[z]Totals for 3 tests.
[y]Survivors in parentheses.

Gas concentrations in the chamber were monitored during fumigation and also for 2 hr of aeration after fumigation. Typically, the MB concentration in air dropped gradually from 40 g/m³ to about 30 g/m³ (25%) during the 2-hr fumigation. During the aeration period, the concentration of MB dropped rapidly to near 4 g/m³ within 1/2 hr, and reached zero concentration within 2 hours (Fig. 2). Within the load, gas concentrations were very uniform for all locations, differing by no more than 2 g/m³ for a given reading (Table 2). It should be noted that, although this chamber was minimally tight by APHIS standards, it produced adequate kill. This information may be helpful if commercial chambers are modified for use with MB.

The residue data shown in Table 3 represent averages for all fruit in each test. As previously noted (4), the residue of MB decreases exponentially, and a plot of time vs

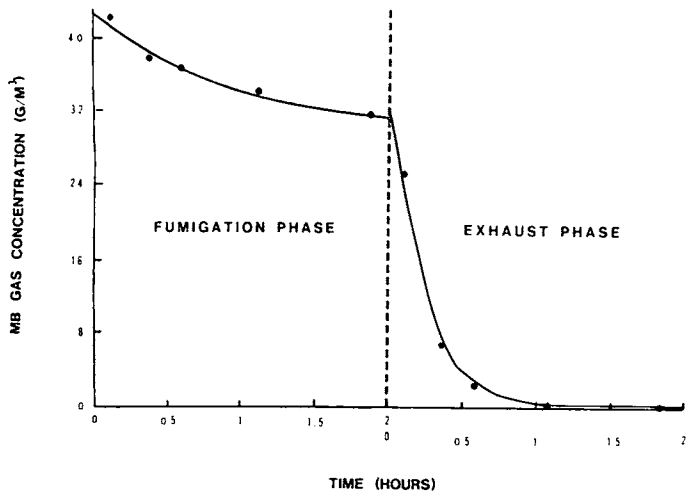

Fig. 2. Gas concentration readings taken during a typical methyl bromide fumigation of a semi-trailer load of grapefruit in a 266-m³ chamber. Dosage applied: 40 g/m³. Each point on the curve represents the mean reading for 12 sampling points. within the chamber.

Table 2. Methyl bromide (MB) concentrations during fumigation of a semi-trailer loaded with 972 citrus boxes (4/5 bushel) containing styrofoam balls (266 m³ chamber—40 g/m³ MB for 2 hr). Values cover 12 locations.

Sampling time (min)	Range in concentration of MB in air (g/m³)
0	40-43
15	37-38.5
30	36-37.5
60	34-35
120	31-33

the logarithm of the residue concentration is linear. When a linear regression calculation was applied to the data for 1 to 5 days, correlation coefficients of −0.993 to −0.997 were obtained for the 3 tests, indicating a good linear relationship. The half-life (time for the residue to decrease 50%) ranged from 1.12 to 1.15 days for the 3 tests. Extrapolation of the data indicates that levels of 10 ppb and 1 ppb would be reached in 10 and 14 days, respectively, for grapefruit stored at 60°F. These results indicate that MB residues would not be a problem for foreign shipments of grapefruit stored at 60°F during transportation.

Table 3. Methyl bromide residues in grapefruit after fumigation with 40 g/m³ MB for 2 hr at 75-85°F.[z]

Time (days)	MB residues (ppm)[y] Test 1	Test 2	Test 3
0	9.07 ± 1.38	10.74 ± 1.37	9.59 ± 1.44
1	2.85 ± 0.63	2.66 ± 0.35	3.35 ± 0.54
2	1.21 ± 0.53	1.21 ± 0.17	1.51 ± 0.32
3	0.68 ± 0.06	0.81 ± 0.14	—
5	0.24 ± 0.03	0.22 ± 0.06	0.27 ± 0.15

[z]Fruit stored at 60°F after fumigation.
[y]Average ± standard deviation based on 8 samples for tests 1 and 3, and 12 samples for test 2 (2 or 3 fruits from each of 4 boxes).

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POTENTIAL FOR THE EXPANSION OF THE TOMATO PROCESSING INDUSTRY IN FLORIDA[1]

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Abstract. **The purpose of this study was to evaluate the processing potential for Florida grown tomatoes. Production of tomatoes specifically for processing and the improved utilization of ripe tomatoes remaining from fresh market production were evaluated. Estimated costs and returns were developed for processing tomatoes under different production regimes and for fresh market tomatoes. Highest returns to the grower are from hand harvest of salvage tomatoes with no additional inputs after the last fresh market harvest. All systems dedicated specifically to the production of tomatoes for processing, at realistic yields and prices, resulted in negative returns. Estimated costs and returns were developed for processing tomatoes under different production regimes and for fresh market tomatoes. These are as follows: 1. production for fresh market; 2. production for processing, assuming low input levels; 3. production for processing, assuming high input levels; 4. salvage for processing, assuming no inputs after the last commercial fresh market harvest; 5. salvage for processing, assuming additional inputs after the last commercial fresh market harvest. Relative evaporation costs and concentrated product costs were estimated for processing tomatoes with various solids content. A table for tomato concentrates at 26% soluble solids was developed.**

According to the "Florida Agriculture in the '80's" report (4), "the Florida tomato industry is a dynamic and significant segment of the agricultural income of the state, representing approximately 30 percent of the total cash income from vegetables. In dollar value at the farm gate, tomatoes exceed $250 million and are worth almost $800 million in retail value. Florida is the major U. S. supplier for fresh market tomatoes during the late fall, winter and early spring marketing seasons."

"Florida tomato growers use the most intensive and sophisticated technology available in the production, harvest-

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