but when molasses is not added back, the citrus pulp is lower *in* nitrogen-free extract and higher in crude fiber.

The statistical analysis indicated significant differences among production sources, among years, and for source x year interaction ($P<.05$). The significant interaction indicates that the relative differences among production sources were not the same for each season. Although these relative differences existed, an examination of the data year-by-year indicated that many production sources were consistent in remaining within the same one-third (lower, middle, upper) of the source ranking throughout the 13 year observational period.

Literature Cited

1. Ammerman, C. B. 1973. Effect of processing on the nutritional value of dried citrus pulp. *In* Effect of Processing on the Nutritional Value of Feeds, National Academy of Sciences, Washington, D. C. Page 297.
2. ————, J. F. Easley, L. R. Arrington and F. G. Martin. 1966. Factors affecting the physical and nutrient composition of dried citrus pulp. *Proc. Fla. State Hort. Soc.* 79:233.
3. ————, F. G. Martin, and L. R. Arrington. 1968. Nutrient and mineral composition of citrus pulp as related to production source. *Proc. Fla. State Hort. Soc.* 81:301.
4. Association of Official Agricultural Chemists. Official Methods of Analysis. 9th Ed. Washington, D.C. 1960.
5. Association of Official Agricultural Chemists. Official Methods of Analysis. 10th Ed. Washington, D.C. 1965.
6. Becker, R. B. and P. T. Dix Arnold. 1951. Citrus pulp in dairy rations. *Fla. Agr. Exp. Sta.* Cir. S-40.
7. Chapman, H. L. Jr., C. B. Ammerman, F. S. Baker, Jr., J. F. Hentges, B. W. Hayes, and T. J. Cunha. 1972. Citrus feeds for beef cattle. *Fla. Agr. Exp. Sta. Bul.* 751.
8. Duncan, D. B. 1955. Multiple range and multiple F. tests. *Biometrics* 11:1.
9. Hendrickson, R. and J. W. Kesterson. 1966. Citrus pulp with and without seeds. *Proc. Fla. Sta. Hort. Soc.* 79:248.
10. Keener, H. A., N. F. Colovos and R. B. Eckberg. 1957. The nutritive value of dried citrus pulp for dairy cattle. *New Hampshire Agr. Exp. Sta. Bul.* 438.
11. Peacock, F. M. and W. G. Kirk. 1959. Comparative feeding value of citrus pulp, corn feed meal and ground snapped corn for fattening steers in dry lot. *Fla. Agr. Exp. Sta. Bul.* 616.
12. Schaibly, G. E. and J. M. Wing. 1974. Effect of roughage concentrate ratio on digestibility and rumen fermentation of corn silage-citrus pulp rations. *J. Anim. Sci.* 38:697.

Proc. Fla. State Hort. Soc. 89:170-171. 1976.

LARGE CHAMBER FUMIGATION OF GRAPEFRUIT INFESTED WITH THE CARIBBEAN FRUIT FLY, ANASTREPHA SUSPENSA (LOEW)

A. K. Burditt, Jr. and D. L. von Windeguth
13601 Old Cutler Rd.,
USDA, Agricultural Research Service,
Subtropical Horticulture Research Station,
Miami, FL 33158

Additional index words. citrus.

Abstract. **Grapefruit infested with eggs and larvae of the Caribbean fruit fly were packed in boxes that were loaded into a semi-trailer van which was placed in a 9000-ft³ (255 m³) chamber. After fumigation for 2 hours with 4.0 oz ethylene dibromide/1000 ft³ (4g/m³), 99.95% of the immature flies were dead. The estimated dosage necessary to obtain adequate security for quarantine purposes (99.9968% mortality) was between 6.5 and 8.0 oz ethylene dibromide/1000 ft³.**

During the 1974-1975 shipping season, grapefruit that was to be shipped to Japan was fumigated in semi-trailer vans at Fort Pierce or Lakeland or in large (ca. 9000 ft³) chambers at Gainesville or Lake Hamilton, Florida that were capable of holding a loaded semi-trailer. The methods used were developed by USDA in cooperation with the Florida Department of Agriculture and Consumer Services and the University of Florida, Institute of Food and Agricultural Sciences (2, 5). However, problems were encountered in making the vans gas-tight so plans were made to construct additional fumigation chambers in St. Lucie and Polk counties. Meanwhile, a pilot fumigation chamber (ca 9000 ft³) was constructed (in cooperation with the Florida Citrus Commission) at Miami so tests could be made of the fumigation procedures that would be used in the new commercial chambers.

The construction of the chamber at Miami was similar to that of the chambers being constructed at Fort Pierce and Wahneta, Florida. However, the Miami chamber had doors at the side and back to permit access by personnel involved in the research. For a test, a USDA semi-trailer van loaded with cartons of polystyrene balls (used to simulate the sorption properties of grapefruit (2)) and of infested fruit (placed at the center of the load) was placed in the chamber. Experiments were conducted to determine the dosage of gas needed for effective fumigation. Loading of the semi-trailer van, infestation of the fruit, fumigation, and post-treatment holding were as described previously (2). The resulting distribution and concentration of ethylene dibromide (EDB) gas are described elsewhere (3).

Results

The first two quasi-commercial fumigations in the Miami fumigation chamber (8 oz EDB/1000 ft³ for 2 hours) each resulted in the recovery of one immature fruit fly puparium. The subsequent investigation showed that the chamber was not gas tight, apparently because caulking had dried and doors had sprung during the tests. Additional caulking was therefore added to the chamber, and new gaskets were placed on the doors to insure that it would pass the requirements of the Animal and Plant Health Inspection Service (APHIS), USDA for gas tightness (1).

In the tests made after the chamber was made tight, cartons of fruit that had been artificially infested with eggs and larvae of the Caribbean fruit fly, were substituted for cartons of polystyrene balls in the center of the load and exposed to two-hour fumigations with 0.25, 0.5, 1.0, 2.0, or 4.0 EDB/1000 ft³. These tests were replicated five times over a period of two months. Results are summarized in Table 1. The 4.0 oz dose gave 99.95% mortality. A dosage-mortality curve calculated from these data by using Daum's probit program (4) as modified for our Wang 2200 mini-computer, permitted us to estimate the dosage required to achieve adequate quarantine security. This curve (Fig 1) showed that 50% mortality of immature Caribbean fruit flies would be obtained at a dosage of 0.3 oz/1000 ft³ and that 95% mortality would be obtained

at 1.2 oz. However, a dosage of between 6.5 and 8.0 oz EDB/1000 ft³ was required for probit 9 security (99.9968% mortality).

Table 1. Recovery of larvae of the Caribbean fruit fly from grapefruit after fumigation with EDB.

Test Series	Control	Dosage of EDB (ounces/1000 ft³) 0.25 oz.	0.5 oz.	1.0 oz.	2.0 oz.	4.0 oz.
1	296*	150	33	34	3	1
2	135	41	35	44	0	0
3	52	209	31	1	2	0
4	135	102	44	12	0	0
5	1512	890	714	38	2	0
Total	2130	1392	857	129	7	1

*Number of larvae or puparia recovered from 4 boxes of cage-infested grapefruit.

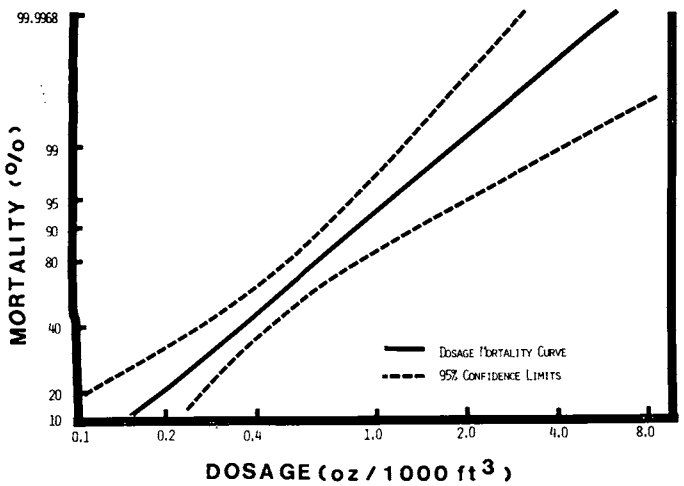

Fig. 1. Dosage mortality curve for large chamber ethylene dibromide fumigation of grapefruit infested with Caribbean fruit flies.

Discussion and Conclusions

For quarantine security in commodities subject to infestation by pests such as fruit flies of economic importance, treatments are strictly defined. The research described here was conducted in a semi-trailer van similar in size and configuration to most of these used for commercial treatments. Also, the chamber, blower fan, duct, and other equipment used were similar to those used commercially. However, we did substitute polystyrene balls for grapefruit in most of the boxes to save loading and unloading boxes of fruit and the expenditure of about $3,000/fumigation for purchase of 950 cartons of grapefruit. Also, we added an extension to the duct and a plywood baffle to improve ventilation and produce faster and more complete aeration after the fumigation was finished. (The most efficient aeration technique is to unload fumigated fruit into a warehouse at the port and use large fans to help desorb EDB from the cardboard cartons).

On the basis of a dosage-mortality curve calculated from the data we estimated that the dosage required for quarantine security (99.9968% mortality) would be a 2-hour fumigation with between 6.5 and 8.0 oz EDB/1000 ft³. Required conditions of the treatment would include: 1. A ca. 9000-ft³ chamber that would meet requirements for gas tightness similar to those of APHIS for fumigation of imported commodities (1). 2. A ca. 6000-CFM centrifugal blower fan with a nozzle extension that blows directly into the semi-trailer van, 3. A ca. 2000-ft³ van loaded with ca. 1000 boxes (4/5 bu capacity) of grapefruit uniformly loaded throughout the van, 4. Load restricted to 80% of the volume of the van, and 5. Fruit temperature in excess of 70°F. Adequate ventilation after fumigation is essential.

Literature Cited

1. Anonymous. 1973. Title-7. Agriculture. Chapter III, Animal and Plant Health Inspection Service, *U.S. Dept. Agric.* Part 319, *Foreign Quarantine Notices,* Subpart—Fruit and Vegetables. Code of Federal Quarantine Regulations. Rev. Jan. 1, 1973.
2. Burditt, A. K., Jr. and D. L. von Windeguth. 1975. Semi-trailer fumigation of Florida grapefruit infested with larvae of the Caribbean fruit fly, *Anastrepha suspensa* (Loew). *Proc. Fla. State Hort. Soc.* 88:318-323.
3. ———— and ————. 1976. Ethylene dibromide gas distributions during fumigation of grapefruit. *Proc. Fla. State Hort. Soc.* 89: 220-225.
4. Daum, R. J. 1970. A revision of two computer programs for probit analysis. *Bull. Entomol. Soc. Am.* 16(1):10-15.
5. Norman, G. G., W. Grierson, T. A. Wheaton and J. D. Dennis. 1975. Minimizing hazards from in-truck ethylene dibromide fumigation of carton-packed citrus fruit. *Proc. Fla. State Hort. Soc.* 88: 323-328.