Implications

The grapefruit supply/demand projections suggest that a potential imbalance will exist in the decade ahead, with Florida having record-level crops to market. Significant shifts in production by variety and marketing district are also anticipated. Both white and pink seedless production are forecast to increase, with pink seedless accounting for a major portion of the production increase.

Given U.S. consumer preference for pink grapefruit, an increase volume of pink grapefruit is expected to enter fresh market channels and reduce the white seedless market share. This shift would mean an increase in the volume of white grapefruit available for processing unless the export market for white grapefruit is expanded.

The expected larger volume of pink grapefruit in Florida in combination with a recovery of the grapefruit industry in Texas could reduce returns on grapefruit substantially from current levels. The expected production trends suggest the need for increased emphasis on fresh market development and expansion with continued efforts to insure acceptability of Florida fruit in the export market.

In addition to increased competitive pressure in the fresh fruit market, increased production is likely to impact even more dramatically on the processed product prices and returns. The demand estimates suggest only modest growth in the U.S. market for grapefruit juice over the next decade. Sales are not expected to return to the historic high levels observed during 1977-78 and 1978-79 even if prices moderate to 1982-83 levels in real terms. The expected increase in grapefruit juice sales in the U.S. market is not forecast to absorb the potential supply increases. Liberalization of the grapefruit juice quota in Japan could allow expansion of the market in the years ahead. Markets are, however, not developed overnight. The expected larger crops in the future suggests a need for increased attention to development and expansion of additional markets as well as attention to expansion of the domestic market.

Demand expansion is only part of the equation. Informed planting decisions will perhaps keep supply in line with expected increases in the market. The modest increases expected in grapefruit juice demand and the fresh grapefruit market situation suggest a need for only modest supply increases if prices are to be maintained. If growers continue recent planting trends, production will probably increase faster than demand unless markets, particularly export markets, can be expanded.

Literature Cited

1. Florida Crop and Livestock Reporting Service. 1985. Citrus, October forecast (and previous reports), Orlando, Fla.
2. Florida Crop and Livestock Reporting Service. 1985. Citrus tree census, Orlando, Fla.
3. Florida Crop and Livestock Reporting Service. 1984. Commercial citrus inventory 1984 (and previous reports), Orlando, Fla.
4. Florida Crop and Livestock Reporting Service. 1984. Florida agricultural statistics, citrus summary, 1984, Orlando, Fla.
5. Florida Department of Citrus. 1985. A. C. Nielsen food index annual summary 1984. Market research report. Lakeland, Fla.
6. Gunter, D. L. and M. G. Brown. 1985. Florida citrus outlook 1985-86 season, Working paper 85-12, Econ. Res. Dept. Fla. Dept. Citrus, Gainesville, Fla.
7. Gunter, D. L., M. G. Brown, and G. F. Fairchild. 1985. Long-run supply/demand forecast for Florida citrus 1985 through 1995, CIR 85-1. Econ. Res. Dept. Fla. Dept. Citrus, Gainesville, Fla.

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SUBMERSION OF FLORIDA GRAPEFRUIT IN HEATED WATER TO KILL STAGES OF CARIBBEAN FRUIT FLY, *ANASTREPHA SUSPENSA*

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Abstract. **Florida grapefruit, (*Citrus paradisi* Macf. cus. Florigold Golden and Marsh), infested with laboratory-reared Caribbean fruit fly, *Anastrepha suspensa* (Loew), eggs (3 days old) and larvae (1-2 days old and mature) was submerged in water (120° F, 10-30 minutes to kill eggs; 120° F, 10-40 minutes to kill eggs and 1 to 2-day old larvae; and 120° F, 10-30 minutes, 130° F, 10-40 minutes, and 135° F, 10-30 minutes to kill all stages from eggs to mature larvae). None of the treatments produced probit 9 security. Noninfested grapefruit submerged in water at 120° F for 20 minutes exhibited severe scalding and pitting of the epidermis and produced off-flavors compared with control grapefruit submerged for 40 minutes in water at 80° F. Based on the results, submersion of Florida grapefruit in water at 120° F or warmer for 20 min or longer is not recommended as a quarantine treatment to kill stages of *A. suspensa* in Florida grapefruit.**

Grapefruit (*Citrus paradisi*) grown in Florida is susceptible to infestation by Caribbean fruit fly (*Anastrepha suspensa*) and must be treated to prevent spread of the fly to Texas, Arizona, California, Hawaii, and Japan. The approved postharvest treatments for disinfesting grapefruit are cold temperature storage (3) and methyl bromide fumigation (4). Herein, I report on submersion of grapefruit in hot water to kill *A. suspensa* eggs and larvae.

Materials and Methods

Florida grapefruit cultivars, 'Florigold Golden' and 'Marsh', were used in all tests conducted from Nov. 1984 to June 1985. Fruit was exposed in an outdoor cage to thousands of gravid, female Caribbean fruit flies which

This paper reports the results of research only. Mention of a trade name in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture.

were reared in the laboratory (6). Fruit was exposed for 3 days to obtain egg stages (eggs hatch in 72 hr at 79° F), 2 additional days to get 1 to 2-day-old larvae, and 12 more days to secure mature larvae. Then prior to heat treatment, fruit was randomized and submerged in heated water (7). Fruit infested with eggs and 1 to 2-day-old larvae was submerged in water at 120° F, 10-30 min to kill eggs and 10-40 min to kill eggs and 1 to 2-day-old larvae; also, fruit was submerged in water at 120° F, 10-30 min, 130° F, 10-40 min, and 135° F, 10-30 min to kill all stages from eggs to mature larvae. A control of 25% of the fruit was randomly selected from the total number of infested fruit used for each temperature test to estimate the larval population in the treated fruit. Treated and nontreated fruit separated into different holding towers (5) were kept for 5 weeks over trays containing sand in a room maintained at 70-80° F. Larvae that emerged from the fruit and fell into the sand were collected once per week. Normally-formed puparia were recorded as survivors. Data were subjected to probit analysis and analysis of variance. Also, fruit phytotoxicity tests were conducted. Noninfested grapefruit of both cultivars was submerged into water at 120° F, 10-40 min and water at 80° F for 40 min (control). All fruit was held at 78° F for 5 days and then evaluated for firmness, scalding, surface pitting, and flavor.

Results

The effect of hot water submersion of grapefruit on mortality of stages of Caribbean fruit fly is shown in Table 1. None of the treatments produced probit 9 security (1). This level of security provides 99.9968% mortality of the insect stages in the fruit and allows one survivor in 31,250 individuals treated. Effective time projected to kill various stages at each treatment temperature is given in Table 2. For probit 9 security, the fruit would require submersion in water at 120° F for almost 600 min to kill eggs, 267 min to kill 1 to 2-day-old larvae, and 143 min to kill mature larvae. None of the times and temperatures were feasible based on the procedures used in this study. Phytotoxicity tests revealed that noninfested fruit submerged in water at 120° F for 20 min developed severe scalding and pitting of the epidermis, loss of firmness, and off-flavors compared with control fruit whose only effect was that the epidermis appeared dull presumably because the wax coating was removed in water at 80° F.

Discussion

Submersion of 'Florigold Golden' and 'Marsh' grapefruit in water, from 120° F (10-40 min) to 135° F (10-30 min), did not produce probit 9 security and adversely affected fruit quality. Evidently the peel served as an insulator and was damaged by exposure to temperatures of 120° F or higher for 20 min. Perhaps peel and pulp would not be adversely affected at lower temperatures if longer submersion times were used. For example, submersion of grapefruit into water at 105-110° F for 6 to 8 hr might slowly increase pulp temperature to a level that kills infestations of Caribbean fruit fly but does not damage fruit. Such a procedure, if successful, could be a substitute process for vapor heat treatment for Florida grapefruit. Exposure of Texas grapefruit to water vapor at 109.9° F for 6 hrs was authorized in 1938 to kill infestations of Mexican fruit fly (2). The Japanese government prefers a vapor heat treatment over irradiation to kill Caribbean fruit fly infestations in Florida grapefruit. Submersion of grapefruit in water at 105° F or 110 ° F for extended time periods might serve as an alternative treatment. This type of treatment with grapefruit and fruit with thinner peels such as certain cultivars of oranges and tangerines, should be tested further.

Table 1. Effect of hot water treatment on killing stages of Caribbean fruit fly infesting Florida grapefruit.

Treatment						
Temp. (°F)	Time (minutes)	No. of fruit	No. of immatures treated[u]	No. of survivors	Percent mortality	Probit value
		Egg infestation[z]				
120	10	350	5751	1249	78.3	5.78
	20	350	5751	591	89.7	6.27
	30	350	5751	263	95.4	6.69
		Larvae 1-2 days old[y]				
120	10	280	5392	2135	60.4	5.26
	20	555	10567	2433	77.0	5.74
	30	555	10567	755	92.7	6.46
	40	275	5175	24	99.5	7.60
		Mature larvae[x]				
120	10	72	674	349	48.2	4.96
	20	72	674	170	74.8	5.67
	30	72	674	10	98.5	7.17
		Mature larvae[w]				
130	10	72	450	29	93.6	6.52
	20	492	4814	224	95.4	6.68
	30	492	4814	19	99.6	7.66
	40	420	4364	1	99.9	8.50
		Mature larvae[v]				
135	10	154	678	177	73.9	5.64
	20	154	678	11	98.4	7.14
	30	154	678	1	99.8	7.97

[z]5 replicates each at 10-30 min.
[y]4 replicates each at 10 and 40 min, 8 replicates each at 20 and 30 min.
[x]1 replicate at 10-30 min.
[w]1 replicate at 10 min, 7 replicates at 20 and 30 min, 6 replicates at 40 min.
[v]2 replicates each at 10-30 min.
[u]based on an equivalent yield from untreated controls.

Table 2. Effective hot water treatment [dose ± se (min)] for mortality percentages for immatures of Caribbean fruit fly infesting Florida grapefruit.

Treatment temperature (°F)	Immature stages	Projected time (min ± se) for percent mortality			
		50%	95%	99%	99.9968%
120	Eggs[z]	4±0	30±1	72±4	595±78
120	Larvae 1-2 days old[y]	9±0	36±1	65±1	267±12
120	Mature larvae[x]	11±0	31±1	49±3	143±16
130	Mature larvae[w]	5±0	17±0	29±1	110±11
135	Mature larvae[v]	7±0	16±0	22±1	48±5

[z]5 replicates each at 10-30 min.
[y]4 replicates each at 10 and 40 min, 8 replicates each at 20 and 30 min.
[x]1 replicate at 10-30 min.
[w]1 replicate at 10 min, 7 replicates at 20 and 30 min, 6 replicates at 40 min.
[v]2 replicates each at 10-30 min.

Literature Cited

1. Baker, A. C. 1939. The basis for treatment of products where fruit flies are involved as a condition for entry into the United States. U.S. Dept. Agr. Cir. 551.
2. Balock, J. W., and D. F. Starr. 1945. Mortality of the Mexican fruit fly

in mangoes treated by the vapor-heat process. J. Econ. Ent. 38:646-651.
3. Benschoter, C. A. 1984. Low-temperature storage as a quarantine treatment for the Caribbean fruit fly (Diptera: Tephritidae) in Florida citrus. J. Econ. Ent. 77:1233-1235.
4. Benschoter, C. A., J. R. King, and P. C. Witherell. 1984. Large chamber fumigations with methyl bromide to destroy Caribbean fruit fly in grapefruit. Proc. Fla. State Hort. Soc. 97:123-125.
5. 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.
6. Burditt, A. K., Jr., D. L. von Windeguth, and R. J. Knight, Jr. 1974. Induced infestations of fruit by the Caribbean fruit fly, *Anastrepha suspensa* (Loew). Proc. Fla. State Hort. Soc. 87:386-390.
7. Sharp, J. L., and D. H. Spalding. 1984. Hot water as a quarantine treatment for Florida mangos infested with Caribbean fruit fly. Proc. Fla. State Hort. Soc. 97: 355-357.

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EFFECT OF FOLIAR APPLICATION OF PROMALIN ON SHOOT GROWTH OF CITRUS SEEDLINGS

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Abstract. **Foliar application of Promalin (GA_{4+7} and 6-benzylamino purino) in 1981 to 1½-year-old trifoliate (*Poncirus trifoliata,* Raf.) seedlings increased the total length of new shoot growth but not shoot number. Both the fresh and dry weights of new shoots of the sprayed plants were significantly greater than that of the control. However, the same experimental plants failed to have the new shoot growth increased to the succeeding application of Promalin in the following year of 1982.**

Since Promalin contains GA_{4+7} plus 6-benzylamino purine, it is expected that foliar application of this material to citrus seedlings would also increase the new shoot growth just as GAs do on that of other fruit trees. This study tested this hypothesis.

Experiments and Results

1981 Experiment. In Aug. 1981, 40 trifoliate seedlings about 1½ years old were potted in 2-gal pots in the field. Each plant was trimmed to a single stem about 1½ feet high. Twenty of these plants received foliar weekly applications of Promalin from Sept. to Nov. 1981 at a concentration of 25 ppm using a volume of 20 ml per plant. All newly growing shoots of the treated and control plants were cut off from the initial single stems on Jan. 1982 and total length, total number, and fresh and dry weights were obtained.

Fig. 1. Growth pattern of shoots of trifoliate seedlings sprayed with Promalin and the control.

Comparison of new shoot growth between the treated and control plants indicated that the treated plants had the total length of shoots significantly increased over the control, but the total number of new shoots were not increased. Also, the treated plants had increased fresh and dry weights (Table 1).

The growth pattern of shoots between the treated and the control plants were quite different. The control plants produced erect and sturdy shoots but the treated plants produced elongated shoots that were slender and soft in the early stage of growth (Fig. 1).

1982 Experiment. In 1982, ten pots of the same experimental plants, which had been sprayed with Promalin in the previous year were sprayed again at 10-day intervals from March to May. Ten pots of plants which had also

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Table 1. Comparison of new shoots on trifoliate seedlings sprayed with Promalin and control plants in 1981.

	Length (cm)	No. of Shoots	Fresh wt (g)	Dry wt (g)
Treated	74.55 ± 3.72	4.30 ± 0.21	5.31 ± 0.26	2.27 ± 0.11
Control	44.10 ± 2.20	4.00 ± 0.19	2.80 ± 0.13	1.22 ± 0.06
t value	7.04**[z]	1.07^{NS}	9.65**	8.75**

[z]** = significant at the 1% level.
NS = non significant.