3. Davis, P. L. 1973. Intermittent warming of grapefruit to avoid rind injury during storage. *Proc. Florida State Hort. Soc.* 86:280-283.
4. Dull, G. G. 1971. The pineapple: general. p. 303-324. *In* A. C. Hulme (ed.) The Biochemistry of fruits and their products. Vol. 2, Acad. Press, London and New York.
5. Miller, E. V. and R. L. Marsteller. 1953. The effect of parachlorophenoxyacetic acid on physiological breakdown of the fruits of the pineapple [*Ananas comosus* (L.) Merr.]. *Food Res.* 18:421-425.
6. Pantastico, E. B., W. Grierson, and J. Soule. 1967. Chilling injury in tropical fruits: I. Bananas. *Proc. Trop. Region, Amer. Soc. Hort. Sci.* 11:82-91.
7. ————, J. Soule, and W. Grierson. 1968. Chilling injury in tropical and subtropical fruits: II. Limes and grapefruit. *Proc. Trop. Region, Amer. Soc. Hort. Sci.* 12:171-183.
8. Scott, K. J. and E. A. Roberts. 1968. The importance of weight loss in reducing breakdown of Jonathan apples. *Austral. J. Expt. Agr. & Animal Husbandry* 8:377-380.
9. Teisson, Cl. 1972. Etudes sur le brunissement interne de l'ananas. *Fruits* 27:603-612.

HortScience 11(6):588–590. 1976.

Ethylene Degreening of 'Bearss' Lemons[1]

C. R. Barmore and T. A. Wheaton[2]
Agricultural Research and Education Center, University of Florida, Lake Alfred, FL 33850
A. A. McCornack[3]
Florida Department of Citrus, Agricultural Research and Education Center, Lake Alfred, FL 33850

Additional index words. Citrus limon, decay control, thiabendazole, benomyl, ethephon

Abstract. **The time required to degreen Florida 'Bearss' lemons can be greatly reduced by the use of 1 to 10 ppm ethylene at 25 or 30°C. Degreening was accomplished in 2 to 3 days instead of the 2 to 3 weeks required with the current commercial practice of cool coloring at 15° without ethylene. Applications of a benzimidazole fungicide (thiabendazole, benomyl) prior to degreening adequately controlled decay. Rapid degreening with ethylene at higher temperatures (25° or 30°) eliminates the need for cool coloring storage and brings lemon availability more nearly in phase with consumer demand.**

'Bearss' lemons grown in Florida to be marketed as fresh fruit are commercially degreened by cool coloring at 15°C under high humidity and without ethylene until an acceptable color develops (8). This procedure can require as long as 3 weeks. The 3-week delay limits marketing potential since harvest begins in midsummer when market demand is at its peak.

The use of ethylene for degreening of Florida-produced lemons has been avoided because it reportedly increased stem-end rot (1, 2, 5). Recently, postharvest applications of ethephon and storage at 15° has been suggested as a means of reducing the degreening time (9). The time is only reduced 30 to 50% with this method, and refrigerated storage is still required.

Florida lemons generally start maturing when the summer demand for lemons is maximal. Therefore, when juice content is adequate i.e. over 30% v/v, harvest and rapid degreening using ethylene at temp of 25 or 30°C would improve marketing by bringing lemon availability more nearly in phase with consumer demand. The effectiveness of thiabendazole (TBZ) and benomyl (Benlate) against the stem-end rot fungi, *Diplodia natalensis* P. Evans and *Phomopsis citri* Fawc., made the use of ethylene for degreening appear feasible. The purpose of this study was to determine the optimum temp and ethylene concn for degreening and to evaluate thiabendazole and benomyl for decay control on lemons degreened with ethylene.

'Bearss' lemons used in degreening studies were hand washed and graded for color and size. The laboratory procedure described by Wheaton and Stewart (11) for preparing fruit for color measurements was used. Ten fruit were placed at 15, 20, 25, and 30°C and exposed to ethylene concn of 0, 0.1, 1, and 10 ppm (± 5%) in a continuously flowing system. An additional 10 fruit were treated with 1,000 ppm ethephon and stored at 15° without additional ethylene. Ethylene concn was verified daily with a gas chromatograph equipped with a flame ionization detector. Color change was measured at intervals of 1 to 2 days with a Hunterlab D25 Color Difference Meter. An a/b value of −0.20 was considered as optimum greenish-yellow color acceptible for lemons to be used commercially.

Decay, primarily stem-end rot, as influenced by ethylene and fungicides, was evaluated in separate lots of 100 to 300 lemons. These fruit were cool

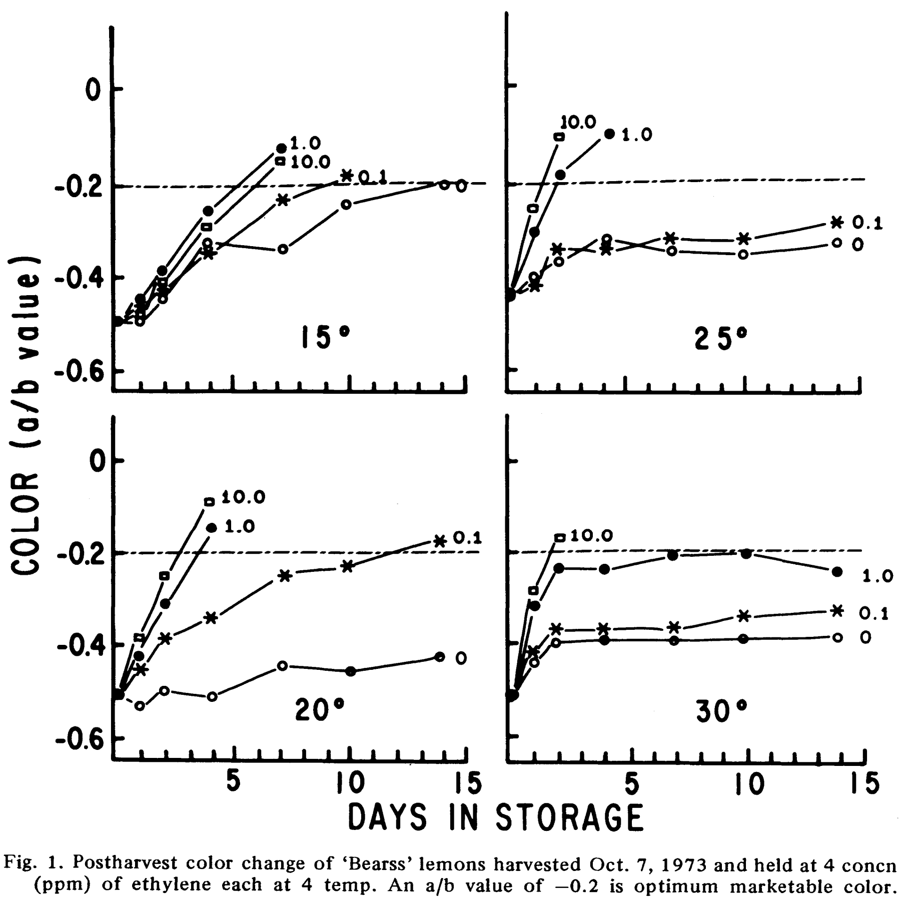

Fig. 1. Postharvest color change of 'Bearss' lemons harvested Oct. 7, 1973 and held at 4 concn (ppm) of ethylene each at 4 temp. An a/b value of −0.2 is optimum marketable color.

[1]Received for publication June 21, 1976. Florida Agricultural Experiment Stations Journal Series No. 6155.

[2]Assistant and Associate Professors of Horticulture, respectively.

[3]Food Technologist.

colored at 15°C without ethylene or degreened in degreening cabinets using standard commercial degreening conditions (10). The time required to obtain optimum marketing color was recorded. Fungicides were applied as nonrecovery sprays to unwashed fruit before degreening or cool coloring and to washed fruit after marketing color was obtained. All fruit were washed, waxed with Flavorseal, and packed in 4/5 bu cartons and stored at 21° for 6 weeks to evaluate decay.

The degreening response of 'Bearss' lemons to ethylene and temp (Fig. 1) was similar to that reported by Wheaton and Stewart for other citrus cultivars (11). Degreening was most rapid at 25° using 1 or 10 ppm ethylene and at 30° with 10 ppm ethylene. At lower temp, degreening was slower and lower ethylene concn were relatively more effective than at higher temp. Degreening at 15° without ethylene required 2 weeks and at 30° and 10 ppm ethylene, degreening time was reduced to less than 2 days. These results were confirmed in another experiment where greener fruit (a/b = −0.63), harvested August 28, 1973, required 27 days to degreen at 15° without ethylene and only 3.5 days at 25° with 10 ppm ethylene.

Degreening times at 15°C using low levels of ethylene (0.1) or 1 ppm) were similar to times required with ethephon (Fig. 2). Fruit degreened with ethylene were more uniform in color than those treated with ethephon. Postharvest applications of 250 to 1,000 ppm of ethephon and storage at 15° generally resulted in a 30 to 50% reduction in degreening time (3, 9). Our work also demonstrates that equivalent results in degreening time can be obtained with 0.1 or 1 ppm ethylene.

Commercial use of ethylene for degreening lemons must be weighed against its effect on decay, primarily stem-end rot (SER). The decay data presented in Table 1 agrees with the findings of others (2, 5) that ethylene increases decay in lemons. Significant increases in SER on other citrus cultivars as a result of ethylene treatment is usual (4, 7). Table 1 also shows that a fungicide application both before and after degreening was consistently effective in controlling decay. Smoot and Melvin (7) have shown that TBZ application before degreening is superior to application after degreening. Altogether, the evidence indicates that a single application before degreening effectively controls decay. Preliminary experiments suggest that a preharvest benomyl application (1-2 kg/ha ai) could be used successfully if a postharvest application prior to degreening is not feasible.

In summary, use of 1 to 10 ppm ethylene at 25 or 30°C to degreen mature lemons is feasible when preceded by a treatment with a benzimidazole fungicide. Extensive use of benzimidazole fungicides only for control of decay should be followed with caution. Development of benzimidazole-resistant strains of *Penicillium digitatum* in Florida packinghouses have been reported by Smoot and Brown (6). The use of ethylene can effectively reduce the degreening time of the currently used commercial method by as much as 90%. Degreening at concn as low as 0.1 or 1 ppm ethylene at 15° was comparable to the effect of a postharvest application of ethephon, but the fruit degreened with ethylene are more uniform in color than those treated with ethephon. The reduction in degreening time not only reduces cost but also allows earlier marketing of lemons to meet the seasonal summer demand.

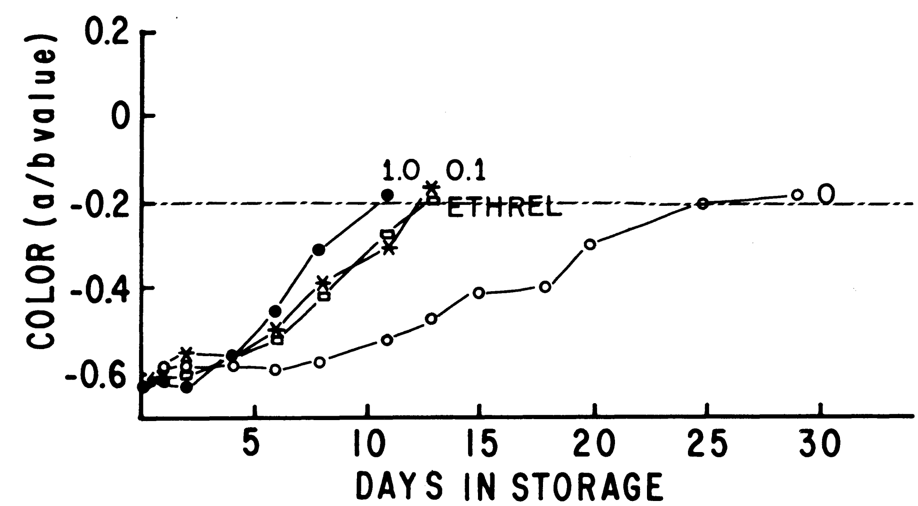

Fig. 2. Postharvest color change of 'Bearss' lemons harvested July 28, 1975 and held at 3 concn (ppm) of ethylene and 1,000 ppm ethephon at 15°C. An a/b value of −0.2 is optimum marketable color.

Table 1. Percentage decay of 'Bearss' lemons during storage (21°C) following various degreening and fungicide treatments.

Harvest date	Degreening: Ethylene (ppm)	Degreening: Temp (°C)	Degreening: Time[x] (days)	Fungicide[y]: Pre	Fungicide[y]: Post	% decay: 2 wk	% decay: 4 wk	% decay: 6 wk	% decay: 8 wk
Sept. 8, 1969	0 0	15	13		TBZ	–	1	1	1
	0	15	13	TBZ	TBZ	–	0	1	2
	5	30	2.5		TBZ	4	9	16	20
	5	30	2.5	TBZ	TBZ	1	1	1	2
Sept. 23, 1970	0	15	11		TBZ	1	13	16	23
	0	15	11	TBZ	TBZ	0	1	1	2
	5	30	3		TBZ	33	49	51	56
	5	30	3	TBZ	TBZ	0	2	3	3
Oct. 13, 1970	0	15	13		TBZ	–	7	28	37
	0	15	13	TBZ	TBZ	–	1	7	15
	5	30	3		TBZ	23	50	54	60
	5	30	3	TBZ	TBZ	2	5	9	11
	5	30	3	Ben.	Ben.	0	0	0	0
Sept. 12, 1972	0	15	15		TBZ	–	1	3	17
	0	15	15	TBZ	TBZ	–	0	2	4
	5	30	2		TBZ	6	11	13	17
	5	30	2	TBZ	TBZ	1	1	1	3
						1 wk	2 wk	3 wk	
July 28, 1975	0	15	12	Ben.	Ben.	0	0	1	
	1	15	4	Ben.	Ben.	0	0	1	
	5	30	2	Ben.	Ben.	0	0	1	
	5	30	2		Ben.	1	2	2	
	Ethephon[z]	15	12	Ben.	Ben.	0	0	0	

[z]Ethephon 1,000 ppm.

[y]Thiabendazole 1,000 ppm; benomyl 500 or 600 ppm; Pre-applied before degreening; Post-applied after degreening.

[x]Time to reach marketable color.

Literature Cited

1. Brown, G. E. and W. Grierson. 1966. Stem-end rot fungi in Florida fresh lemons. *Plant Dis. Rptr.* 50(11):860-861.
2. Grierson, W. and S. V. Ting. 1960. Florida lemons for fresh and cannery use: Variety selection and degreening methods. *Proc. Fla. State Hort. Soc.* 73:284-289.
3. Jahn, O. L. 1974. Degreening of Florida lemons. *Proc. Fla. State Hort. Soc.* 87: 218-221.

4. McCornack, A. A. 1971. Effect of ethylene on decay of Florida citrus fruit. *Proc. Fla. State Hort. Sci.* 84:270-272.
5. Oberbacher, M. F. and W. Grierson. 1960. Handling methods for fresh Florida lemons: Low temperature curing studies with the Sicilian variety. *Proc. Fla. State Hort. Soc.* 73:263-240.
6. Smoot, J. J. and G. E. Brown. 1974. Occurrence of benzimidazole-resistant strains of *Penicillium digitatum* in Florida citrus packinghouses. *Plant Dis. Rptr.* 58:933-934.
7. ________ and C. F. Melvin. 1972. Decay of degreened citrus fruit as affected by time of washing and TBZ application. *Proc. Fla. State Hort. Soc.* 85:235-238.
8. Tucker, D. H. and W. F. Wardowski. 1973. Lemon production and utilization in Florida. *Fla. Ext. Bul.* 184.
9. Wardowski, W. F., C. R. Barmore, T. S. Smith, and C. W. DuBois. 1974. Curing Florida lemons with ethephon. *Proc. Fla. State Hort. Soc.* 87:216-218.
10. ________ and A. A. McCornack. 1973. Recommendations for degreening Florida fresh citrus fruits. *Fla. Agr. Ext. Ser. Cir.* 389.
11. Wheaton, T. A. and I. Stewart. 1973. Optimum temperature and ethylene concentrations for postharvest development of carotenoid pigments in citrus. *J. Amer. Soc. Hort. Sci.* 98:337-340.

HortScience 11(6):590–591. 1976.

Pressure Trunk Injection Promising for Pecan and other Trees[1]

R. E. Worley, R. H. Littrell, and S. G. Polles[2]
University of Georgia College of Agriculture Experiment Stations, Coastal Plain Station, Tifton

Additional index words. zinc, magnesium, Rhodamine dye, *Carya illinoensis*

Abstract. **Pressure trunk injection of Zn sulfate solutions rapidly increased leaf Zn levels of Zn deficient trees in pecan (*Carya illinoensis* (Wang.) K. Koch). Injection of 2270 g/tree killed foliage and twig terminals within one week. New foliage growth appeared normal but was high in Zn. Injected Rhodamine B dye indicates that solutions move rapidly to the extremities of the tree. Injected wood preservative "Osmose" killed trees within 10 days.**

Nutritional deficiencies of pecan are often slow to correct in eastern U.S. (21, 22), and Zn deficiency is practically impossible to correct through soil application on calcareous soils of the west (17). Foliar sprays are used to supply Zn to trees growing in these high carbonate soils. Some success has been reported with the use of trunk injections for application of P (4), Fe (8, 14, 15) and Zn (1) to trees. Growth regulators were effective in much smaller quantities when injected than when sprayed on foliage (13, 16), and some success has been attained by injection of pesticides to control certain tree diseases (2, 3, 5, 6, 7, 11, 12) and insects (9, 10, 18, 19). Advantages of an effective tree injection system include: 1) rapid delivery of chemical to target area; 2) low rates of chemical required; 3) little loss of chemical to drift, leaching or washing; 4) no pollution of atmosphere or soil; 5) low hazard to applicator; and 6) low equipment expense. Such a system, if feasible, would be ideal for the city grower with a few trees in the back yard. This paper reports some early results from the use of pressure trunk injection for pecans and other trees. Results from fungicide and insecticide injections are forthcoming.

The apparatus used consisted of an injection manifold, a solution tank, and a compressed air tank. The injection manifold consisted of 6 injector heads of a prototype developed by G. F. Gregory (personal communication) connected by flexible tubing and quick-fit connectors. A 1.0 cm (3/8 inch) hole was drilled into the trunk approx 2.5 cm deep and the end of the injector was inserted into the hole. Nails compressed the injector against a gasket placed in a smoothed area on the bark giving a tight seal. Compressed air from the air tank was metered into the solution tank at 2.1-2.8 kg/cm^2 and forced the solution (usually 8 liters) into the tree trunk. Time involved for injection ranged from 20 min to several hours, but true solutions usually were injected within one hr.

Preliminary trials to determine safe injection rates for Zn showed that rates of 0-40 g/tree of $ZnSO_4$ caused no visual damage when injected just after bud break in the spring to non-deficient pecan trees.

Leaf analysis (determined by atomic absorption spectroscopy) of middle leaflets of middle leaves of first flush growth indicated that all trees had leaves that were normal to high in Zn. Normal leaf Zn levels are 50-100 ppm (20), and visual Zn deficiency symptoms usually occur only when leaf Zn levels drop below 50 ppm.

Rates of 0-64 g/tree of $MgSO_4$-$7H_2O$ also caused no visual symptoms of damage. Trees ranged from 142-257 cm in circumference. A massive injection of 2270 g/tree (5 lb.) of $ZnSO_4$ killed all first flush leaves and twig tips on one tree (201 cm circum.). A larger tree (270 cm circum.) had a few small limbs that escaped injury. This damaged foliage contained over 5000 ppm Zn. Within 3 weeks, however, new shoots emerged from the limbs and contained normal foliage. Leaf analysis of middle leaflets of middle leaves of the new shoots collected June 17 as revealed by atomic absorption spectroscopy showed leaflet levels of 1360 and 565 ppm Zn for the small and large tree, respectively.

Studies in replicated trials on Zn deficient trees in the process of renovation at Hahira, Ga. showed that injection of 1 g $ZnSO_4$/2.54 cm trunk circum. on April 21 increased leaf Zn from 38 to 230 ppm as revealed by atomic absorption spectroscopy of middle leaflets of middle leaves of first flush foliage collected June 16. A sample of similar foliage on August 7 indicated leaf Zn levels of 39 and 100 ppm, respectively. All trees had received a uniform soil application of 2.7 kg $ZnSO_4$/tree the previous Feb., but it was apparent that this application was not yet reflected in increased leaf levels. Soil application of 104 g/tree of Zn as Na_2Zn ethylene diamine-tetraacetic acid (Na_2Zn EDTA, 14.2% Zn) on April 21 did not increase Zn levels the first year. Three sprays of N-Zn (5.5% Zn and 22% N, Allied Chemical Co.) at 3 ml product/liter to point of runoff at bi-weekly intervals significantly increased leaf Zn levels by June 16 (100 ppm) but not on August 7 (47 ppm). Tree size ranged from 61-135 cm.

Replicated trials in a similar orchard near Tifton revealed a 5-fold increase in leaf Zn levels by June 16 (125 vs. 25 ppm Zn) and almost a 4-fold increase still in effect by August 5 (91 vs. 25 ppm Zn) from an injection of only 40 g/tree (circum. avg = 139 cm). Three foliage sprays of N-Zn also significantly increased leaf Zn by June 16 (110 ppm), but the increase was not significant by August 5 (46 ppm). Trunk injection of 11 g Zn as N-Zn also significantly increased leaf Zn at both sampling dates.

Tests to determine rapidity of distribution of injected materials revealed that 1% Rhodamine B dye had moved to the top of a 16 m tall tree within one hr of the beginning of injection. The outer sapwood was stained throughout the tree.

The wood preservative "Osmose" (45.3% AS_2O_5, 19.3% CuO, and 35.35% CrO_3) injected readily into slash pine, oak, wild cherry, and pecan killing all trees within 10 days, thus demonstrating possible herbicidal use of

[1]Received for publication June 22, 1976.
[2]Departments of Horticulture, Plant Pathology and Entomology, respectively.