Table 5. Effects of irradiation, storage temperature and storage duration on color specification of light-colored Temples.

Trichromatic coefficients	Storage Days							
	24				35			
	Storage Temperature							
	35 F		50 F		35 F		50 F	
	Dose (krad)							
	0	200	0	200	0	200	0	200
x	.425	.423	.402	.419	.416	.406	.410	.407
y	.387	.398	.355	.390	.359	.381	.355	.379
Purity (saturation)	.506	.553	.349	.474	.415	.412	.370	.434
Y (brightness)	48.8	53.6	49.2	50.8	45.7	54.1	43.5	52.2
Dominant wavelength (hue)	585	582	588	582	590	582	589	583
Color[1]	YO-0	YO	0	YO	0	YO	0	YO

[1]Color: YO = yellowish orange, 0 = orange

LITERATURE CITED

1. Ahmed, E. M., and R. A. Dennison. 1966. Effects of irradiation on Satsuma oranges and lemons. 63rd. Ann. Proc. Assoc. Southern Agricultural Workers, Inc., p. 171.
2. Committee on Colorimetry, Opt. Soc. Am., The science of color, Ch. 7, T. Y. Crowell Co., N. Y., Publisher.
3. Curl, A. L. 1953. Application of countercurrent distribution to Valencia orange carotenoids. J. Agr. Food Chem. 1: 456-460.
4. Dennison, R. A., and E. M. Ahmed. 1966. A review of the status of irradiation effects on citrus fruits. In press. Paper presented at the International Symposium on Food Irradiation, Karlsruhe, Germany.
5. Dennison, R. A., M. S. Merkley, E. M. Ahmed, and G. D. Kuhn. 1965. Effects of low level irradiation upon the preservation of food products. Ann. Rept. USAEC AT-(40-1)-3097, TID22509.
6. Mathur, P. B. 1963. Low-dose gamma irradiation of fresh fruits. Food Irrad. 4: A26-28.
7. Maxie, E. C., I. L. Eaks, N. F. Sommer, H. L. Rae, and S. El-Batal. 1965. Effects of gamma radiation on rate of ethylene and carbon-dioxide evolution by lemon fruit. Pl. Phys. 40: 407-409.
8. Maxie, E. C., N. F. Sommer, and I. L. Eaks. 1963. Radiation technology in conjunction with post harvest procedures as a means of extending the shelf-life of fruits and vegetables. Ann. Rept. USAEC AT(11-1)-34.
9. Miller, E. V. 1946. Physiology of citrus fruits in storage. Bot. Rev. 12: 393-423.
10. ..... . 1958. The physiology of citrus fruits in storage II. Bot. Rev. 24: 43-59.
11. Oberbacher, M. F. 1962. Effect of temperature and handling practices on the degreening rate of green colored grapefruit intended for the European market. Proc. Amer. Soc. Hort. Sci. 80: 308-311.
12. .... Fla. Citrus Commission, Lake Alfred, Fla. 1966. Personal Communication.
13. Varner, J. E. 1961. Biochemistry of senescence. Ann. Rev. Pl. Phys. 12: 245-264.

THE POSSIBILITIES OF USING ETHYLENE GAS TO PRODUCE CITRUS FRUIT ABSCISSION UNDER FIELD CONDITIONS

WILLIAM C. WILSON[1]

ABSTRACT

Research workers have found that chemicals which increase abscission increase the production of ethylene by the abscission zones. Administering ethylene in concentrations as low as 1.5

[1]Assistant Plant Physiologist, Florida Citrus Commission, University of Florida Citrus Experiment Station, Lake Alfred.

Florida Agricultural Experiment Stations Journal Series No. 2549.

ppm produced complete abscission of citrus fruit explants within 24 hours, which was twice as rapid as with iodoacetic acid under similar conditions. 'Valencia' oranges were loosened successfully and no leaf drop was observed when a polyethylene tent was placed over a tree and ethylene injected under it for a period of time not exceeding 2 hours. The injection of ethylene into the soil showed some promise as a means of treating large citrus trees. After being taken up, the gas produced leaf drop and some loosening of mature 'Valencia' oranges with negligible loss of young fruit. Treated trees dropped mainly older leaves, became slightly yellow in color, and remained dormant for prolonged periods. Tests on early and midseason varieties and on specialty fruits are in progress. Various materials are being evaluated as carriers of ethylene in tests of spray applications. Ethylene is exempt from tolerance regulations of the Food and Drug Administration and, if found to be practical, could immediately be used by growers.

Introduction

Mechanization of citrus fruit harvesting is not only imperative, but must be implemented with all possible haste. One big problem encountered by the agricultural engineers in developing mechanical harvesting devices was the bonding force between the stem and the citrus fruit. An effective chemical for loosening the fruit by lowering the bonding force is needed as soon as it can be effectively developed.

Hendershott (2, 3) found that iodoacetic acid (IOAC) was an effective abscission agent for early and midseason oranges although it had certain drawbacks. Possibly clearance for IOAC by Federal Food and Drug (FDA) would have to be obtained, which might take several years. Therefore, work is also underway to attempt to find a material which is effective and can be used immediately.

Ethylene production by plant tissue is reported to be responsible for the abscission process in plants (1). Wilson[2] found that ethylene production by citrus fruit abscission zones was greatly stimulated by known abscission agents, iodoacetic acid and mannitol. Wilson[2] in laboratory experiments also found that no chemical produced as rapid abscission of citrus fruits as ethylene. Because commercially produced ethylene can be obtained, is inexpensive in bulk quantities, and is cleared for use by FDA, it is a logical chemical to explore for field abscission studies.

Ethylene is currently available in Florida only in small steel cylinders, and is used primarily to degreen fruit. Elsewhere in the country, vast amounts are used as a chemical intermediate in the manufacture of plastics, ethyl alcohol, ethylene glycol, and other chemical compounds. It is available from several sales sources.

Ethylene is used commercially to produce flowering of pineapples in Hawaii (4). The gas is pressurized in the spray tank, and activated charcoal is used as a carrier. A particular charcoal (Nuchar C 190-N), manufactured by West Virginia Pulp and Paper Company, was found to be the most effective.

Materials and Methods

A tent was constructed of polyethylene plastic, placed over small 'Valencia' orange trees, and ethylene gas was injected until there were approximately 2,000 ppm under it. The trees were left covered for various periods of time. Fruit samples were later taken, and pull tests were made as described by Hendershott (2).

Soil injections were made using a small stainless steel probe as shown in Figure 1. Gas was injected into the soil at the rate of 300 to 400 liters per tree. Various injection depths and placements were tried.

Results

Placing a tent over a tree and injecting ethylene under the canopy produced some loosening of the fruit (Table 1), but the bonding force again approached normal after 120 hours (5

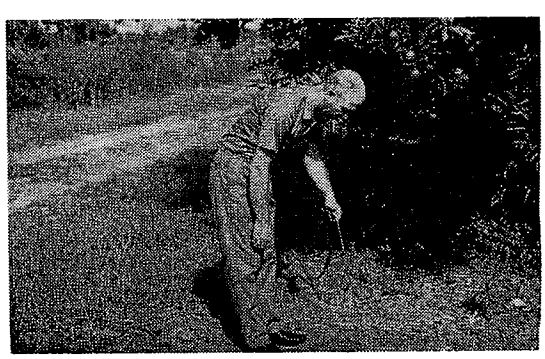

Fig. 1.—Procedure used to inject ethylene gas into the soil. Under moderate pressure, the probe is easily worked into the soil to a depth of about 2 feet.

[2]Unpublished data, Florida Citrus Commission.

Table 1. Force needed to remove fruit from 6-year-old 'Valencia' orange trees after being subjected to approximately 2,000 ppm of ethylene under a tent.

Duration of application	Lbs. force after treatment	
	48 hrs.	112 hrs.
0 minute	16.90	17.10
5 minutes	13.90	15.70
15 minutes	14.92	15.40
30 minutes	14.17	15.20
1 hour	8.76	13.10
2 hours	8.14	13.50

days). Small potted calamondins, when placed in degreening rooms for 24 hours, always dropped mature fruit very quickly (often within 24 hours), but leaf drop varied up to complete defoliation. Old leaves and mature fruit appeared to be more sensitive than younger leaves and green fruit to ethylene in the surrounding atmosphere.

Preliminary studies with injection of ethylene gas into the soil indicated the treatment is more effective on deep, light soils with very low organic matter content than on the slightly darker and heavier soils of central Florida. Tests of several citrus varieties on soils of the Blanton or Blanton-Plummer series have not been nearly as successful as those on the well-drained Lakeland fine sands. No studies have been made as yet on the shallow East Coast and flatwoods soils, but these are contemplated for the near future.

When ethylene was injected into Lakeland fine sand at the rate of 200 liters of gas per tree (approximately ½ pound of ethylene), the effects of the gas were noted in the tree top after about 2 weeks. A general lightening of leaf color and some increase in leaf and young fruit drop were noted in June, but applications later in the summer produced no young fruit drop. When application rates of about 400 liters per tree were used, increased leaf drop and some slight loosening were noted on 'Valencia' oranges (Table 2). Tests with 'Hamlin' and 'Pineapple' oranges and 'Duncan' grapefruit indicated these trees have approximately the same sensitivity to ethylene as 'Valencia' orange. The possible effects on fruit loosening for these varieties will be tested this winter. All varieties which responded to ethylene showed a period of dormancy following soil injection. Excessive rates of ethylene produced tree defoliation, dieback, or death, depending upon the amount of gas applied.

Initial tests with charcoal used as a carrier for ethylene in sprays have been negative.

Discussion

The preliminary studies indicate that ethylene has potential as an abscission-producing or fruit-loosening chemical. The problem with ethylene is not that it will not produce abscission, but that it must remain (in small amounts) around the abscission zone for several hours. Hence, the problem is one of engineering as well as physiology.

The tent method of applying ethylene to a tree appeared to have considerable promise but required a long application period. Much time

Table 2. Force needed to remove fruit from 'Valencia' orange trees on Lakeland fine sand into which ethylene had been injected 3 weeks previously.

Treatment	Lbs. force after treatment
Control	17.77
300 liters	14.48
400 liters	14.70

and effort is involved in erecting, lowering, and moving a tent, and this procedure would not appear to be economical unless the application time could be greatly reduced.

The soil injection method of applying ethylene showed some promise of having practical horticultural use. It has been tried on a limited basis with 'Valencia' orange, but did not produce fruit abscission as had been hoped. Tests with early and midseason oranges, grapefruit, tangerines, and tangelos will be conducted during the and winter of 1966-1967.

The dormancy induced by soil injections of ethylene lasted over 2 months in some cases. This is not beneficial to 'Valencia' oranges during the normal summer growth period, but might be beneficial as a means of inducing dormancy of citrus trees in winter.

The use of charcoal as a carrier of ethylene in sprays has not been successful, but additional studies are planned. Future research will include injecting ethylene into overhead sprinkler system lines, and applying ethylene in foam materials of the type used for fire fighting.

LITERATURE CITED

1. Ables, F. B. and R. E. Holm. 1966. Evidence for an hormonal role of ethylene in abscission. Plant. Physiol. Meetings (1966): liii.
2. Hendershott, C. H. 1964. The effect of various chemicals on the induction of fruit abscission in 'Pineapple' oranges. Proc. Amer. Soc. Hort. Sci. 85: 201-209.
3. Hendershott, C. H. 1965. The effect of iodoacetic acid on citrus fruit abscission. Proc. Fla. State Hort. Soc. 78: 36-41.
4. Personal correspondence with Mr. John W. Hurdis, Superintendent, Experimental Department, Dole Corporation, Wahiawa, Hawaii.

PROCESSING QUALITIES OF NEW CITRUS FRUIT HYBRIDS

W. Clifford Scott[1] and C. J. Hearn[2]

Abstract

Lee, Osceola, and Robinson tangerines, Page orange, and a new tangerine hybrid (Selection 6-8-16) were processed and evaluated by comparison with Dancy tangerines. Color of Selection 6-8-16 was comparable to that of Murcott orange, and much deeper than any of the other hybrids. Next in order of depth of color were Robinson and Osceola tangerines, while colors of Page orange and Lee tangerine were approximately the same as that of Dancy tangerines. Off-flavors were developed in the processing and storage of all hybrids, but were reduced by the removal of volatiles by concentrating the juice. Concentrated juice of the darker varieties could be used in quantities up to 10% (single strength basis) to improve the color of better flavored orange juice products without deleterious effect on flavor. When added in this amount to lightly colored orange juice, Robinson juice raised the score from its original 36 points to 37 points, and Selection 6-8-16 to 38 points.

Introduction

The development of new citrus hybrids has been an important project of the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, for many years. Five new hybrids resulting from crosses made in 1942 have been released to the industry. In 1959 "Robinson," "Osceola," and "Lee' tangerine were released (4). "Page" orange was released in 1963 (5) and "Nova" tangelo in 1964 (6). These hybrids are now in various stages of production. Production and fruit characteristics are given in the above references with additional information given in an article by Rasmussen et al. (7). All of these hybrids, plus a new one not yet released but included in this study, are ¾ tangerine and ¼ grapefruit.

A cooperative plan has been initiated, under which new hybrids will be tested, as soon as they

[1]U.S. Fruit and Vegetable Products Laboratory, Winter Haven, Florida, one of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture.
[2]Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Orlando, Florida.
References to specific products of commercial manufacture are for illustration only and do not constitute endorsement by the U.S. Department of Agriculture.