LITERATURE CITED

1. Harding, P. L., J. R. Winston, and D. F. Fisher. 1940. Seasonal changes in Florida oranges. U. S. Dept. Agr. Tech. Bull. 753.
2. Huggart, R. L. and F. W. Wenzel. 1954. Measurement and control of color of orange concentrate. Proc. Fla. State Hort. Soc. 67: 210-216.
3. MacDonnell, L. R., E. F. Jansen, and H. Lineweaver. 1945. The properties of orange pectinesterase. Arch. Biochem. 6: 389-401.
4. Rouse, A. H. and C. D. Atkins. 1955. Pectinesterase and pectin in commercial citrus juices as determined by methods used at the Citrus Experiment Station. Fla. Univ. Agr. Exp. Sta. Tech. Bull. 570.
5. Rouse, A. H., C. D. Atkins, and E. L. Moore. 1962. Seasonal changes occurring in the pectinesterase activity and pectic constituents of the component parts of citrus fruits. I. Valenia orange. J. Food Sci. 27: 419-425.
6. Rouse, A. H., C. D. Atkins, and E. L. Moore. 1964. Seasonal changes occurring in the pectinesterase activity and pectic constituents of the component parts of citrus fruits. II. Pineapple oranges. J. Food Si. 29: 34-39.
7. Rouse, A. H., E. L. Moore, and C. D. Atkins. 1965. Characteristics of oranges from three-year-old trees. Proc. Fla. State Hort. Soc. 78: 283-288.
8. Savage, Z. 1964. Orange tree movement eighth highest of 35 seasons. Citrus Ind. 45: (5) 16, 20, 22.
9. Savage, Z. 1965. Hamlin tree movement exceeds Valencia for first time. Citrus and Veg. Mag. 28: (6) 18.
10. U. S. Department of Agriculture. 1959. U. S. standards for grades of chilled orange juice. Agr. Marketing Service, Washington, D. C.
11. U. S. Department of Agriculture. 1964. U. S. standards for grades of frozen concentrated orange juice. Agr. Marketing Service, Washington, D. C.

CHEMICAL ABSCISSION STUDIES OF CITRUS FRUIT[1]

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ABSTRACT

Ethylene gas tested in field trials produced abscission of citrus fruits, but use of the gas was found impractical. Soil injections caused too many undesirable side effects, and ethylene was not sufficiently soluble in water to be applied as a spray or through an overhead irrigation system. Trapping the gas in a foam might be a a feasible method of application, but no available foam will last sufficiently long to be effective.

Over 300 chemicals were tested on explants in pan test studies to evaluate their potential as abscission producing chemicals. More than 50 of these have shown sufficient activity to warrant testing in large quantities.

In field tests with 'Hamlin' and 'Pineapple' oranges, little difference in abscission activity was noted among iodo-, chloro-, and bromoacetic acids, but iodoacetic acid was probably the best in overall performance. Several chemicals submitted by commercial companies also showed promise. In tests with 'Valencia' oranges, only 1 coded material showed abscission activity, but its results were inconsistent.

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INTRODUCTION

The abscission project is concerned with "loosening" fruit by chemical means. Loosening fruit would enhance the operation of mechanical harvesters, improve the rate of hand picking, and possibly eliminate clipping of tangerines and tangelos.

There is much emphasis on abscission research nationwide. Previous research in Florida showed that iodoacetic acid would loosen early and mid-season oranges (2), and ethylene was proposed as a possible abscission agent for citrus fruits (4). Under Florida conditions, little success has been achieved with the 'Valencia' variety which does not respond to most chemical treatments in the same manner as the early and mid-season varieties (2). This variety also has an acute additional problem due to the presence of young fruit of the next year's crop at the time of harvest.

METHODS AND MATERIALS

The methods of applying ethylene to trees under a tent or with a soil probe have been previously described (4). In these experiments, ethylene gas was applied under a tent at a concentration of 1000 ppm, and soil injections of ethylene were made at varying concentrations up to 300 liters per tree. In addition, spray applications of ethylene were applied using 2% charcoal[2], 1% spray oil, and 5% ethyl alcohol

[2]Nuchar C 190-N manufactured by West Virginia Pulp and Paper Company.

as carriers. Ethylene was also injected into overhead irrigation lines and mixed with air, water, and detergents to produce foams for application to trees. Gas chromatographic analysis was used to determine the quantity of ethylene dissolved in aqueous solutions.

Citrus fruit explants were used in screening chemicals for abscission purposes as described by Wilson and Hendershott (5). Whole trees were sprayed with various chemicals and pull tests were made on the fruit as described by Hendershott (2). Ratings of effectiveness were based on the ability of the chemical to reducing the bonding force between the stem and the fruit. A substantial drop of the bonding force to 7 pounds or less was classified as "good"; from 7 to 12 pounds "fair"; and "no effect" means essentially not different from the control. Normally, 3 or more trees were sprayed with a given chemical. However, Abscisin II and most of the "HS" chemicals were available in very limited quantities, so that only single trees were tested with these compounds except for HS-4.

The halogenated acetic acids (chloro-, bromo-, and iodoacetic acids) caused considerable rind scarring. Therefore, in 1 series of experiments, tung or Wesson oils at up to 1% were incorporated into spray applications with these chemicals to determine if fruit scarring could be eliminated or greatly reduced.

Results and Discussion

Ethylene: Ethylene gas applied to a tree under a tent produced abscission of ripe fruits with negligible loss of leaves or young fruits, however optimum exposure time was found to be 5 to 6 hours. This long exposure time makes the method impractical.

Ethylene is not readily soluble in water. The various carriers which were tested increased the amount of ethylene absorbed in water, but none increased abscission. Moreover, charcoal coatings on trees would have numerous disadvantages.

Ethylene injected into a sprinkler irrigation system produced no fruit loosening, although measurable quantities of ethylene were obtained from the water. The presence of ethylene in water surrounding an abscission zone evidently does not react in the same manner as ethylene in the surrounding atmosphere.

Soil injection of ethylene did not successfully loosen 'Valencia' oranges (4). Fruit loosening was obtained with early and midseason oranges and tangelos from soil injection (Table 1), but subsequent injurious effects were noted, particularly heavy defoliation and dieback. During dry periods, severe tree injury occurred from soil application of relatively small amounts of ethylene. Observations of tree dormancy indicated

Table 1. Force needed to remove fruit from 'Orlando' tangelo and 'Hamlin' orange trees on Lakeland fine sand into which ethylene had been injected.

Variety	Treatment	Avg. lbs force 14 days after treatment
'Orlando' tangelo	Control	11.74
	200 liters of C_2H_4	3.78*
	300 liters of C_2H_4	2.56*
'Hamlin' orange	Control	13.25
	200 liters of C_2H_4	3.55*
	300 liters of C_2H_4	1.85*

*Numerous fruits and leaves had fallen to the ground.

that ethylene residues may persist in the soil for several months. None of the foaming materials available were successful as trapping agents for ethylene gas. A foam, to be effective, should last approximately 6 hours and cling to and cover a tree.

It was hoped that ethylene could be developed into a usable abscission chemical as a "stop GAP" measure until effective chemical sprays were available commercially. The results were not promising, but much was learned from experience with this chemical, and the "active double bond" concept of ethylene has opened a whole new class of chemical compounds for study, many of which show abscission activity.

Explant or Pan Test Screening Trials: The explant or pan test procedure of Wilson and Hendershott (5) was used to check the abscission activity of over 300 chemical compounds. Among the chemicals tested, a group of coded compounds appeared to be most promising. Larger quantities of a number of these compounds are expected to be available for field testing in the near future.

The pan test can be used throughout the fruit season as it gives consistent results on 'Hamlin,' 'Pineapple,' and 'Valencia' oranges (3), and requires only a small amount of chemical. When a particular chemical shows abscission activity in this test, it becomes a potential material for further testing on whole trees.

Field Tests with Abscission Chemicals: The results of field tests on 'Hamlin' and 'Pineapple' orange trees are shown in Table 2. Very little difference was observed among the halogenated acetic acids, but iodoacetic acid appeared to be the best in overall performance. The fact that these materials all caused foliage loss, fruit burning, and from past performance have proved to be ineffective on 'Valencia,' would seem to greatly restrict their commercial potential. The addition of tung and Wesson oils appeared to reduce fruit burning slightly, but did not reduce it sufficiently.

Most promising results were obtained from the "HS" series of coded materials. HS-4 was particularly effective, but only enough chemical was available in the early part of the season for application on a single 'Hamlin' orange tree. HS-19 and HS-42 were also somewhat effective in producing abscission. 2-Butyne-1, 4-diol produced some fruit loosening, but also caused fruit scarring and leaf drop. HS-66 acted as a fruit sticker and increased the pounds force necessary to pull the fruit from the tree.

The results of field tests with various chemicals applied on 'Valencia' trees are shown in Table 3. HS-4 was effective in 1 test, but 2 additional tests were negative. Potassium iodide showed slight loosening at very high application rates, but ascorbic acid and Abscision II were ineffective. The halogenated acetic acids were again ineffective on the 'Valencia' variety this year.

Ascorbic acid has been reported to loosen oranges (1). However, the application rates used were extremely high and fruit pitting resulted unless the chemical was washed off within 3 days. Such extreme rates of application for ascorbic acid or other chemicals would appear to be economically unjustified at the current price of fruit. Evidence is also currently accumulating that Abscisin II is incapable of penetrating the plant cuticle. Although much has been written about it from a physiological standpoint, practical horticultural uses of Abscisin II appear to be extremely limited.

The "HS" series of coded compounds has very low phytotoxicity and is believed to have very low mammalian toxicity. If an effective abscission agent is found in this class of compounds, the chances of FDA clearance and commercial application would be very promising.

Future Emphasis of the Abscission Work in Florida: Substantial progress in developing a suitable abscission chemical has been accomplished through chemical screening. This portion of the project will be continued and basic studies of the abscission zone and its metabolism will begin this year at the Citrus Experiment Station. In addition, the Fruit Crops Department at the University of Florida will continue its basic research program on abscission.

Although the abscission process is still not well understood, it is apparent that certain enzyme functions are affected by the known abscission-producing agents. From chemical structures it is possible, with some degree of success, to predict activity of a given compound. Therefore, commercial companies have been encouraged to furnish, from their laboratories, candidate chemicals for testing. Where abscission activity is noted, the company is further encouraged to manufacture larger quantities of the chemical, and to synthesize other chemicals related to the active chemical. Thus, even better materials