

Since the last system involves three separate pieces of equipment and would require semi-skilled operators for each operation, it was not possible to calculate with any accuracy the economics involved. Fruit removal was excellent (98%) with 'Pineapple' but much less effective (74%) with 'Valencia'. Very little damage was noted following air harvesting of 'Pineapple'. With 'Valencia', however, leaves were shredded, removed, and some immature fruit was removed. Some of the remaining young fruit was scarred as a result of the air treatment. Anything less than thorough spray coverage of the tree could be easily detected after the air shaker was utilized.

A "mohawk" effect of fruit not removed could be observed. This same effect was noted by Whitney (8). The only observed effect attributable to hedging is a fruit load located in the upper third of the tree. It did allow for better spray penetration through the canopy and in turn allowed for somewhat better air harvesting.

CONCLUSION

Cycloheximide increased the rate of harvest regardless of the harvesting method utilized. A

significant reduction in fruit left on the tree and fruit plugged was observed in all tests where cycloheximide was utilized. Less than satisfactory results have been obtained with 'Valencia'. Additional research is needed.

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HORMONAL REGULATION OF CITRUS FRUIT AND LEAF ABSCISSION¹

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ABSTRACT

In an attempt to reduce the defoliating action of 2-chloroethylphosphonic acid (Ethrel), while maintaining its effectiveness as a fruit abscission promoter, 'Pineapple' orange leaf and fruit explants were administered the synthetic auxin

2,4-dichlorophenoxyacetic acid (2,4-D) 48 hr prior to treatment with Ethrel. Abscission was greater in fruit than in leaf explants after 120 hr incubation. However, when Ethrel was sprayed on 'Pineapple' orange trees 1 week after the application of 2,4-D, it caused about as much leaf abscission as did Ethrel alone while causing very little fruit loosening. N-dimethylamino-succinamic acid (Alar) did not influence abscission of leaf explants and did not greatly alter the abscission accelerating action of subsequently applied Ethrel.

INTRODUCTION

The use of chemical agents to promote abscission of citrus fruit can result in some de-

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gree of fruit, leaf, and sometimes wood damage. Cycloheximide (CHI), one of the most effective abscission accelerating agents, has been reported to cause rind pitting in mature 'Pineapple,' 'Jaffa,' and 'Valencia' oranges (6). Ascorbic acid sprays caused severe chemical burn to mature 'Hamlin' (17) and 'Valencia' oranges (16). Treatments with Ethrel, the ethylene evolving (15) and abscission accelerating chemical (10), did not damage fruit but caused excessive defoliation of 'Valencia' trees (6). Although acceptable for processing purposes, mechanically and chemically damaged fruit are unsuitable for the fresh fruit market. Ethrel is so far the only reported abscission-promoting chemical that causes no visible damage to fruit. For Ethrel to have potential as an abscission agent on citrus for the fresh fruit market, it would be essential to reduce its defoliating action.

MATERIAL AND METHODS

Petiole explants were prepared from mature, fully expanded, dark green 'Pineapple' orange leaves. Each explant consisted of 10 mm petiole and 3 mm leaf midrib tissues (12). Fruit explants consisted of mature, fully degreened fruit with 3 to 4 in. stem, trimmed to 2 in. prior to treatment. Field sprays were conducted on fully grown 'Pineapple' orange trees on rough lemon rootstock.

Treatment of leaf explants with Alar and Ethrel: Leaf explants were treated with 1,000 or 2,000 ppm Alar. Ethrel, at 400 ppm was applied to leaf explants, 24 hr after treatment with 2,000 ppm Alar. A mixture containing 2,000 ppm Alar and 400 ppm Ethrel was also applied to leaf explants. All chemicals were applied at the rate of 4 μ l/explant, 2 μ l on the distal end, and 2 μ l at the proximal end.

Treatment of leaf explants with 2,4-D and Ethrel: Leaf explants were treated with 44 ppm (2×10^{-4} M) 2,4-D, followed 48 hr later by treatment with 400 ppm (3.5×10^{-3} M) Ethrel. Fruit explants were also treated with similar 2,4-D and Ethrel solutions, but through the stem for 12 hr with a 12-hr duration in distilled water between the 2 treatments.

Fruit abscission was measured at various intervals by gently pulling the stem while leaf explants were checked by applying slight pressure against the midrib section of the explant.

Field sprays of 2,4-D and Ethrel on abscis-

sion response of 'Pineapple' orange trees: Fully grown, bearing 'Pineapple' orange trees were sprayed on December 15, 1969 with 22 ppm 2,4-D, 400 ppm Ethrel, or with 2,4-D followed by Ethrel a week later. Ortho spray sticker was used to insure coverage and 15 gal solution was applied per tree. The pull force required for detachment of fruit from stems was measured on 30-fruit samples with a Chatillon tensiometer at various intervals following the initial treatment as previously reported (8). Ethrel used in these experiments was of the AmChem 68-240 formulation containing 90% 2-chloroethylphosphonic acid (2).

RESULTS

Prior application of Alar at 2,000 ppm did not alter subsequent abscission of leaf explants in response to Ethrel administered 24 hr later (Table 1). Explants treated with Alar alone at 1,000 or 2,000 ppm abscised at a rate close to that of the controls, while Ethrel-treated explants exhibited higher rates of abscission (Table 1). However, a mixture of Alar and Ethrel caused higher abscission rate in leaf explants than obtained with either chemical alone.

Abscission was retarded by 2,4-D in both leaf and fruit explants (Table 2). 2,4-D also counteracted the abscission-accelerating activity of Ethrel. The extent of 2,4-D counteraction of abscission was apparently greater in leaf than in fruit explants as shown by the difference in

Table 1. Effect of Alar and Ethrel on the abscission rate of 'Pineapple' orange leaf explants.

Initial	Treatment *	% cumulative abscission			
		Time after initial treatment (hr)			
	After 24 hr	24	48	72	96
1,000 ppm Alar	Distilled water	0.0	10.0	66.7	86.7
2,000 ppm Alar	Distilled water	0.0	6.7	56.7	80.0
2,000 ppm Alar	400 ppm Ethrel	3.3	40.0	66.7	73.3
Distilled water	400 ppm Ethrel	0.0	36.7	66.7	83.3
2,000 ppm Alar & 400 ppm Ethrel mixture	None	3.3	53.3	80.0	90.0
Distilled water	None	0.0	6.7	53.3	73.3

*30 leaf explants were used in each treatment.

Table 2. Effect of 2,4-D ($2 \times 10^{-4}M$) and Ethrel ($3.5 \times 10^{-3}M$) on abscission rates in 'Pineapple' orange leaf and fruit explants.

Treatment*	% cumulative abscission				
	Hrs after initial treatment				
	24	48	72	96	120
Leaf explants					
Control	0.0	30.0	76.7	86.7	90.0
2,4-D + Ethrel	0.0	0.0	6.7	36.7	43.3
2,4-D + H ₂ O	0.0	0.0	6.7	23.3	33.3
Ethrel	0.0	50.0	80.0	93.3	93.3
Fruit explants					
Control	10.0	40.0	85.0	95.0	100.0
2,4-D + Ethrel	0.0	5.0	10.0	20.0	80.0
2,4-D + H ₂ O	0.0	0.0	0.0	5.0	20.0
Ethrel	75.0	95.0	100.0	100.0	100.0

* Fruit explants were administered 2,4-D and Ethrel through the stem, each for 12 hr. Leaf explants were administered the chemicals by applying 4 μ l/explant.

percentage of fruit and leaf explants abscised after 5 days.

Results of field application of 2,4-D followed by Ethrel are shown in Table 3. Ethrel alone hastened fruit abscission as indicated by the drop in pull force by 60.0% of the initial value within 2 weeks after spraying. This was accompanied by an estimated 5% leaf drop, but there was no sign of any rind damage on fruit. On the other hand, prior application of 2,4-D to 'Pineapple' orange trees negated the fruit loosening effect of Ethrel without reducing defoliation.

DISCUSSION

Despite the many reported effects of Alar on deciduous fruit trees (3, 4, 5), it has been shown to be virtually ineffective in retarding growth in citrus. Hield *et al.* (9) reported that 0.5 to 1.0% Alar is required to induce a slight

Table 3. Abscission response of 'Pineapple' orange fruit as affected by 2,4-D and Ethrel sprays.

Days after spraying	Pull force (lbs)*			
	Treatment			
	Control	2,4-D	Ethrel	2,4-D Ethrel
Initial	17.7	15.3	13.7	15.6
4	15.4	14.9	10.0	15.2
7	18.0	16.5	9.0	15.7
11	16.1	14.3	9.4	14.4
14	13.9	13.2	5.4	12.4
21	14.3	14.1	6.3	12.7

*Average of 30 fruit.

degree of growth inhibition in citrus. Pieringer and Newhall (13) reported some degree of vegetative growth stimulation in grapefruit seedlings treated with 1,000 ppm Alar. Higher concentrations resulted in inconsistent growth inhibition. Reports on the interactions between Alar and Ethrel are quite variable. Edgerton and Blanpied (7) reported that Ethrel can overcome the abscission-delaying effect of Alar on 'McIntosh' apples. On the other hand, Hield *et al.* (9) reported that Alar reduced abscission and delayed Ethrel-accelerated abscission in citrus for as long as 30 days. In the present work, Alar applied separately proved virtually inactive in hastening or delaying abscission of leaf explants. It also did not seem to interfere with the action of Ethrel on abscission of leaf explants. However, it caused some acceleration of abscission when combined with Ethrel. Thus, the possibility of using Alar on citrus for modification of Ethrel's excessive defoliating action seemed unproductive and was ruled out.

Retardation of abscission in citrus leaf and fruit explants by the synthetic auxin 2,4-D has been reported (10). It has also been shown to counteract the abscission-accelerating activity of ethylene (11). The application of 2,4-D to fruit and leaf explants resulted in retardation of their abscission, but fruit explants were more responsive to Ethrel than were leaf explants. Thus, it appeared that 2,4-D may have been more effective on leaf than on fruit explants. This may have been partly due to differences in physiological age of fruit and leaves from which the explants were excised. Preceding field application of Ethrel with 2,4-D did not promote the desirable preferential abscission of fruit. However, the magnitude of defoliation caused by Ethrel or by Ethrel preceded by 2,4-D seemed to be smaller than previously observed. This may have been partly due to the formulation of Ethrel applied. In this study, the Ethrel used was of the AmChem 68-240 formulation containing 90% 2-chloroethylphosphonic acid. In previous but unreported experiments on 'Hamlin' orange, the AmChem 66-329 formulation containing the acid, ester, and anhydride was used and resulted in heavy defoliation of branches.

The mechanism of action of 2,4-D in delaying abscission is not known. Its stimulation of ethylene production (1) does not explain its abscission-retarding activity. However, it seems to

retard or reverse some of the catabolic processes associated with senescence (13) which preceds abscission.

Presently it is not yet feasible to chemically induce and promote fruit abscission without causing some degree of fruit and/or leaf damage. It is important to know the immediate as well as the short and long-range effects of a chemical treatment aimed at fruit loosening to facilitate mechanical harvesting in order to determine the true economical value of an abscission promoting chemical.

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EFFECT OF BUDWOOD SELECTION AND ROOTSTOCK ON THE PEEL OIL CONTENT OF 'VALENCIA' ORANGES

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ABSTRACT

A comparison of peel oil content was made on 34 'Valencia' budwood selections budded to one type of rootstock. A significant difference in oil content was found. Oil content ranged

from 11.1 to 15.7 pounds per ton of fruit. The best selection gave an oil yield of 4.6 pounds greater than the poorest selection which possibly indicates the potential of budwood relation. A similar investigation on the influence of 19 different rootstocks was conducted which also showed differences of a significant magnitude. Some rootstocks tended to suppress oil yields while others increased it. Rootstocks did not appear to offer the potential for increased oil yields as did budwood selections.

When fruit yield and peel oil per fruit were jointly considered, it was calculated that 1.27 pounds of peel oil per tree or 111 pounds of oil per acre of trees could be recovered from the best 'Valencia' selection on 6-year-old Indian River trees.

By analyzing peel discs removed from differ-