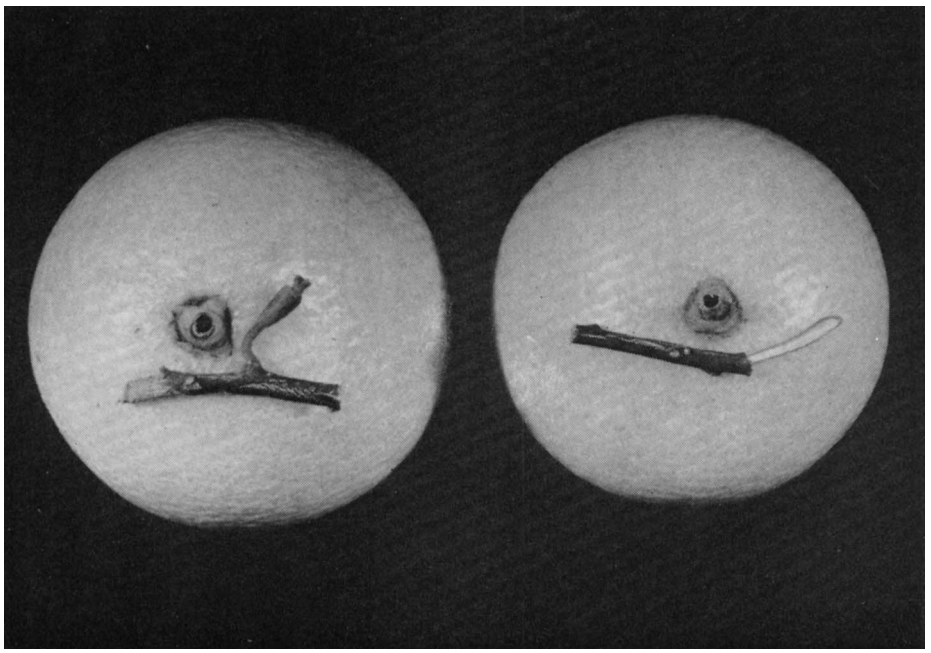
ORANGE



Valencia orange fruit showing stem-slip separation. Fruit at left is the most common type. Fruit at right shows less frequently occurring collar of bark above button and the longer bare slipped woody stem.

THE TRADITIONAL METHOD of harvesting citrus fruits in California is hand clipping the fruit stem flush with the fruit button. Increasing picking costs and large labor requirements of this operation have focused attention on the development of more economical methods of mechanical or hand removal.

Abscission, the loosening of the fruit at its natural separation layer, is desirable because it aids fruit removal with

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TABLE 1. COMPARISONS OF DETACHMENT FORCE AND STEM-SLIP SEPARATION FOR NAA-TREATED AND UNTREATED ORANGE FRUIT IN 1967 AND 1968

Variety	Number of trials	Detachment force			Number of trials	Stem-slip separation		
		Control	NAA	Signif.		Control	NAA	Signif.
		lbs	lbs	lbs		%	%	%
Navel	12	17.5 (14–21)†	16.9 (15–23)	NS*	16	9.7 (0–20)	27.3 (0–50)	4.86 A*
Valencia	9	14.7 (13–19)	14.5 (13–16)	NS	29	12.6 (0–50)	30.9 (0–100)	7.23 B

* NS indicates not significant, and A and B significance at 0.05 and 0.01 levels of probability.
† Numbers in parentheses indicate range.

TABLE 2. EFFECTS OF MARCH 28, 1968 SPRAYS WITH NAA ON NAVEL ORANGE FRUIT STEM SEPARATION

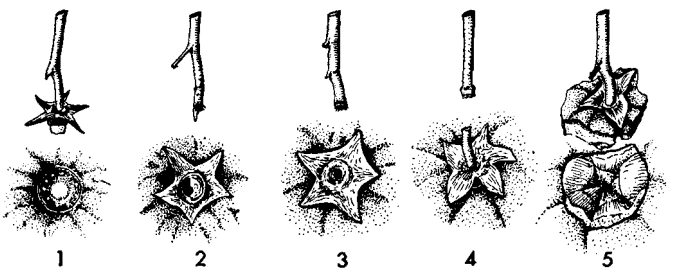
Days after treatment	Stem-slip separation			Significance †
	Check	NAA—ppm		
		100	1000	
	%	%	%	
3	6.7	6.7	13.3	
10	5.0	22.0	35.0	9.60 A*
17	13.3	11.7	15.0	NS

* A denotes significance at 0.05 level.

TABLE 3. EFFECTS OF A JUNE 28, 1967 SPRAY WITH NAA ON VALENCIA ORANGE FRUIT STEM SEPARATION*

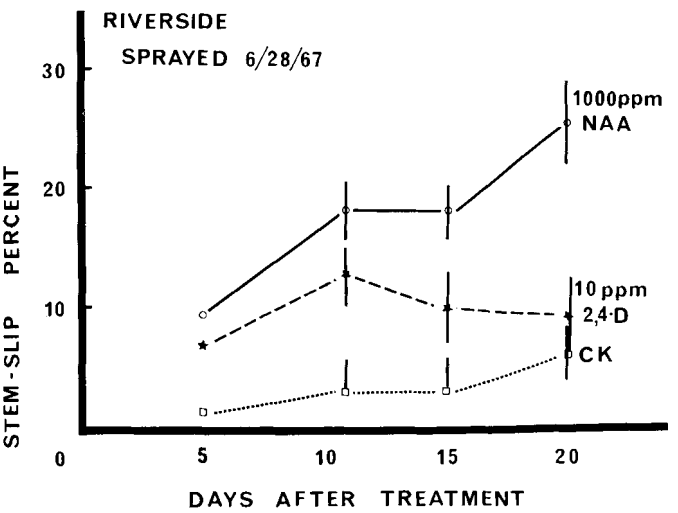
Days after treatment	Separation					
	Stem-slip			Rind tear		
	Check	NAA	Signif.†	Check	NAA	Signif.†
	%	%		%	%	
7	10.5	27.8	C	28.7	12.3	
12	10.5	36.0	B	33.9	13.4	B
14	12.9	34.1	B	67.1	32.9	B
19	12.3	19.8	A	26.9	20.3	

* Comparison on 17 paired trees. 8 fruit/treatment/date. Filmore location. NAA at 1000 ppm.
† A, B, and C denote significance at 0.05, 0.01, and 0.001 levels.



Fruit-stem separation categories: Class 1. Abscission. Vascular scars evident and no part of button remaining; Class 2. Separation with part of button remaining. Calyx may be missing with lower part of button covering vascular scars; Class 3. Stem-slip. Stem pulling from button leaving a stem size cavity. Stem end without bark and with uniform jagged end; Class 4. Stem break above button; Class 5. Plug. Any separation with a rind tear.

Increases in stem-slip separation of Valencia oranges resulting from NAA and 2,4-D sprays*



* Vertical bars through points show range of significance at 0.01 level.

FRUIT-STEM SEPARATION

. . . chemical influences

new harvesting procedures. Fruit loosening responses to chemicals are measured by the decrease in pounds of force needed to separate fruit and stem. A measurement of straight pull force has been used because a straight pull requires the greatest removal force and causes the highest frequency of undesirable types of detachment. The different types of fruit-stem separation are distinguished because of their influence on the market potential of the fruit. The chemicals are therefore evaluated under the most difficult removal conditions. The five categories of separation are shown in the sketch. While the hand clip method is used in current commercial harvesting, fruit with the separations shown in the sketch also occur because of deviations in a picker's use of the fruit clipper. Unclipped fruits in classes 1, 2, and 3 are not necessarily discarded. Fruits in class 4 are usually reclipped to remove the stems which could puncture the rind of other fruit. Class 5 fruits with rind tear separations are discarded because they are subject to decay.

Naphthaleneacetic acid (NAA) has been found to cause an increase in stem-slip separation (class 3) which was not related to fruit loosening. This influence was investigated to determine whether it might have value by assisting in a higher removal of marketable fruit under advanced harvesting procedures. All spray applications involved use of the ammonium salt of NAA unless otherwise specified.

Table 1 summarizes field experiments comparing NAA-treated oranges with nontreated fruit for stem-slip separation. Fruit attachment force was not influenced —the same amount of force was required for fruit removal. The stem-slip separation occurred more frequently as a result of the NAA treatment. This separation, which is the slipping of the woody stem from the bark, suggests an increased cambial activity in the region directly above the button. Most frequently a bare white stem tip remains on the tree with the small empty cavity occurring in the center of the button. Occasionally a short collar of pliable bark remains above the button as shown on the fruit at the right in the photo.

Citrus is less responsive to NAA than are some other tree crops. Therefore, high concentrations were tested to obtain a positive response and compensate for climatic influences on NAA. The effective concentration range was between 100 and 1000 ppm. Effects of the NAA treatments lasted from 7 to 20 days, with the maximum response during the second week after treatment.

The increase in stem-slip separation did not decrease the percentage of fruit in the class 1 or 2 separation classifications. Differences in other separation categories were less pronounced than the increase of class 3. However, there was a trend towards the reduction of stem-remaining and rind-tear separations with the NAA treatments. Table 3 shows that Valencia oranges pulled 12 and 14 days after application of NAA gave the greatest stem-slip response. There were also significantly fewer fruits with rind-tear separations at these intervals of testing. This NAA treatment significantly reduced the percentage of fruit separating with stems and tears when these two groupings were combined and compared during the 7- to 19-day interval after treatment.

A comparative study of removal of NAA-treated and untreated navel oranges by a limb shaker was conducted (table 4) in cooperation with the USDA and University agricultural engineers. The fruit pull force measurements and separation classifications were determined prior to spraying, and at 6, 10, and 12 days after treatment. It was again found that there was no significant difference in attachment force but there was an increase in the stem-slip type of separation. Fifteen days after treatment, 600 to 1,000 fruit remained, of which less than 1 per cent were not removed by the limb shaker. Examination of the fruit removed by the shaker showed a significantly greater percentage of fruit with a stem-slip separation. The NAA did not reduce the occurrence of class 4 (fruit with stems) separations. Less than 1 per cent of the fruit in either treatment had rind tears.

The increase in stem-slip separation has not been sufficient to be considered commercially important. Various other auxin type chemicals, as well as NAA forms other than the ammonium salt, have been tested. NAA in the methyl ester form was most active, followed in order by the salt form, and the acid form. The 4 thianaphtheneacetic acid was approximately twice as active as NAA salt. Indoleacetic acid was not active at 500 or 1000 ppm in water spray or 2000 ppm applied in alcohol. The comparative separation of navel orange fruit sprayed on January 5, 1967 with 10 ppm isopropyl ester 2,4-D or 1000 ppm NAA is given in graph 1. The 2,4-D-treated fruit gave more stem-slip detachment than untreated fruit at 11 and 15 days after application. The stem-slip separation of NAA-sprayed fruit was increased over both the 2,4-D-sprayed and the control at 11,15, and 20 days from treatment.

Chemicals which do not influence abscission may also be of value because of influence on other desirable types of fruit separation. In citrus it is possible that there will be an accompanying decrease in undesirable separations. The increase in the percentage of fruit separating by stem-slip has not been attained consistently at a high enough level to be commercially important.

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TABLE 4. EFFECTS OF NAA ON NAVEL ORANGE FRUIT REMOVED BY HAND PULL AND LIMB SHAKER

Days after treatment	Pull force		Stem-slip separation	
	Check	NAA	Check	NAA
	lbs	lsb	%	%
Pull 0	17.7	18.3	3.2	3.2
6	16.7	17.0	6.3	19.1
10	15.9	15.5	11.1	33.3
12	16.3	15.1	16.7	43.7
Limb shake 15*			4.7	12.1†

* 600–1000 fruit remaining per tree. 6 replications. Riverside location. NAA at 1000 ppm.
† Significant F value at 0.01 level.