characterized by a progressive increase in deformation under a constant load. After load removal this deformation gradually decreases to a set deformation. Tests were carried out, based on these results, on 'Valencia' oranges.

The fruit selected was of even size (65 min ± 2 mm diam) and had been subjected to the usual packing plant treatments of washing, disinfection, waxing, sorting and grading. The fruit was loaded by a simple loading machine, using a displacement transducer (LVDT) and x-y recorder to measure and record fruit response to an applied constant load of 2 kg (8).

A typical creep and recovery curve obtained with the loading machine on 'Valencia' oranges is shown in Fig. 1. Each numbered point on the curve represents the mean of 64 fruits measurements replications and corresponds to the stages of mean fruit deformation as a time function. The sudden application of the constant load results in an instantaneous elastic response (Point 0-1 in Fig. 1). This is followed by a delayed elastic response and viscous flow (Point 1-2) and a further continued viscous flow (Point 2-3). When the load is removed, the instantaneous elastic response is recovered immediately (Point 3-4). The delayed elastic response is gradually recovered (Point 4-5), leaving a permanent deformation (Point 6-0) on the fruit. This value of permanent deformation is a reliable indicator of the degree of the fruit's firmness as it indicates the fruit's ability to maintain its original shape when exposed to external forces. Let $\overline{x}_1$ denote the mean value of the 64 fruits' measurements at point 1 in Fig. 1 and $\overline{x}_6$ the mean value at point 6. It was found that $\overline{x}_1 = 4.82$ mm and $\overline{x}_6 = 5.02$. Using a t test lead to rejection of the test hypothesis of a difference between the means, thus showing that the value of permanent deformation is almost identical to the measured values of the initial deformation. These results are in agreement with those reported by Nahir & Sarig[3], who indicated that in a creep test made on 'Valencia' oranges, the permanent deformation value is very similar to the measured value of the initial deformation. This characteristic of fruit response would enable us to propose to test initial deformation only, thus establishing measureable values and providing a rapid method for measuring fruit firmness.

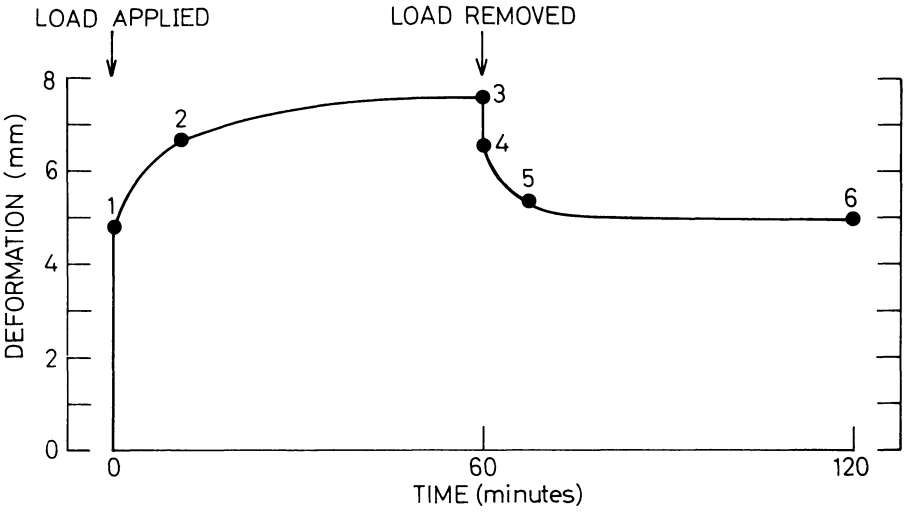

Fig. 1. Creep and recovery curve for 'Valencia' oranges under constant load of 2 g. (Each numbered point on the curve represents the mean of 64 fruit replications.)

The method is applicable during all parts of the season, as it was found that deformation of citrus is not influenced by time of harvesting (8). Since most agricultural products behave as viscoelastic materials, it is probable that this method is applicable to other varieties and should be verified by subsequent tests. A citrus fruit tester could be developed, based on the described method which would find large commercial application in a wide field of fruit handling such as predicting vital physiological factors for storage probability, storage period, or keeping quality of shipped fruits.

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Effects of NAA and Sevin on the Structure of Apple Pedicels[1]

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Abstract. **Pre-June drop sprays of naphthaleneacetic acid (NAA) applied to apple trees increased the radial pedicel-xylem ratio, the % tracheary cells that were lignified, and the number of mature treacheary cells on the 7th day following treatment. No significant response for these characters were obtained with sprays of 1-naphthyl methyl carbamate (Sevin). Both NAA- and Sevin-treated pedicels had a higher percentage of sclereids that contained nuclei. Neither material affected pedicel diameter, width of phloem or xylem, size of newest lignified tracheary cells, number of immature secondary tracheary cells, or the radial xylem-phloem and pedicel-phloem ratios.**

The effects of NAA and Sevin, on the plant and pedicel have received only limited attention. Nitsch (8) reported that NAA sprays severely thinned pears and caused enlarged and mishaped pedicels on those fruit that did not abscise, inferring NAA affected their development. Jacobs and Morrow (4, 5) and Wetmore et al. (12, 13) showed that variations in auxin and sugar levels markedly influenced differentiation of vascular cells. In light of their findings and the fact that NAA sprays should augment plant auxin levels and did decrease reducing sugar in fruit (10) one might expect thinning sprays to alter pedicel structure. This study was conducted to determine if NAA or Sevin did have such an effect.

[1]Received for publication April 21, 1973. The investigation reported in this paper (73-10-45) is in connection with a project of Kentucky Agricultural Experiment Station and is published by permission of the Director.

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Bearing 'Staymared' apple trees growing on 'M7' rootstock were sprayed with NAA (25 ppm) or Sevin (209 ppm). Test 1 was applied May 1, 1970 (petal fall + 7 days), Test 2, May 14, 1970 (petal fall + 14 days) and Test 3, May 25, 1971 (petal fall + 19 days). Fruit were collected 2, 4, 7, 11 and 14 days after treatment and placed in FAA and held until they were to be dehydrated, using Johansen's (6) tertiary butyl alcohol schedule, prior to embedding in paraffin. The fast green and safranin staining schedule described by Johansen (6) was used. Transverse sections, 12 microns thick cut from the center portion of the pedicel, were studied with a compound microscope equipped with an ocular micrometer. Unless otherwise indicated data presented are from all observations on all collection dates from all three tests.

The data recorded for a single pedicel are the average of the following no. of determinations shown for each characteristic: pedicel diam, 2; radial width of phloem or xylem tissue, 5; size of two most recently lignified vessels, 10; and % sclereids containing a nucleus, 50. In addition, all nonlignified cells (immature) that appeared to be differentiating into secondary tracheary elements and the vacuolated, lignified primary and secondary tracheae (mature), were counted in a complete transverse section. At least 3 pedicels were examined from each treatment on each collection date. Xylem and phloem measurements reported are the radial width of the tissues since no differences in tangential or circumference characteristics were noted. Ratios of the tissue measurements were also calculated. All data on structural characteristics are the average of all 3 tests except % nucleate sclereids, which is an average of Tests 1 and 2.

In both treated and untreated pedicels schlereids continued to differentiate during these experiments. The sclereids appeared to differentiate from parenchymatous cortical cells adjacent to protophloem or protophloem fiber cells. There was no apparent difference in amount or rate of sclereid differentiation and lignification associated with treatment. However, a greater percentage of sclereids in pedicels from treated trees contained nuclei (Table 1) than did those from untreated trees. The implications of this response to treatment by both lignified and partially lignified sclereids are not known.

Diam of apple pedicels was not affected (Table 1) by the Sevin or NAA sprays. The NAA sprays which may reduce fruit size (10) might also be expected to cause a reduction in pedicel size. This expectation and our data differ from Nitsch's (8) report of malformed, enlarged pedicels in pear treated with NAA. Measurements of width of xylem and phloem tissue (Table 1) indicate that effects, if any, due to treatment were too small to be significant. The pedicel-phloem and xylem-phloem ratio data indicate no effect of sprays on relative amount of xylem and phloem tissue due to treatment. However, NAA increased the pedicel-xylem ratio (Table 1) even though the mean size of each was not significantly affected.

Table 1. The effect of NAA and Sevin sprays on certain characteristics of 'Staymared' apple pedicels.[z]

Variable	Treatments		
	Control	NAA[y]	Sevin[x]
Diam (mm)	2.3a	2.4a	2.4a
Phloem width (μ)	112.0a	116.0a	114.0a
Xylem width (μ)	145.0a	141.0a	139.0a
Xylem/phloem ratio	1.3a	1.2a	1.2a
Pedicel/phloem ratio	21.3a	21.3a	21.5a
Pedicel/xylem ratio	16.5a	19.4b	17.7ab
% sclereid cells containing nuclei	39.0a	52.0b	50.0b
Width of lignified tracheary cells (μ)	11.9a	11.4a	11.0a
No. of non-lignified tracheary cells	45.0a	39.0a	40.0a
No. of lignified tracheary cells[w]	148.0a	152.0a	136.0a
% of tracheary cells lignified	76.0a	81.0b	77.0ab
No. of lignified tracheary cells[v]	101.0a	145.0b	102.0a

[z]Mean separation within rows by Duncan's multiple range test, 5% level.

[y]NAA 25 ppm.

[x]Sevin 209 ppm.

[w]Avg of all observation following treatment in all 3 experiments.

[v]Avg of observation on material collected the 7th day after treatment in all 3 experiments.

Observations of pedicel sections gave the impression that few secondary vessels were differentiating in pedicels from NAA-sprayed trees and that those differentiating after NAA treatment were smaller. Measurements and counts of these factors (Table 1) also suggest this possibility; however, differences were not significant. The no. of mature treacheary cells was not affected by spray treatments when the averages of all observation dates were considered. Even though the no. of mature and immature tracheary cells were not significantly affected by NAA sprays the percentage of those cells that were lignified was greater in NAA-treated pedicels than in the check (Table 1). This agrees with Barlow's (1) view that auxin tends to induce lignification and vacuolation of xylem cells. Observations of pedicel samples collected the 7th day after treatment show that there was an increased no. of mature tracheae (primary and secondary) in pedicels from NAA-treated trees (Table 1). This in agreement with Feucht's (3) finding of more vessels in IAA treated cherry shoots. A reduced no. of nontracheary xylem cells in IAA-treated shoots, as reported by Wareing et al. (11), along with the possibility of smaller secondary tracheary cells, can possibly explain how there could be more mature vessels in NAA-treated pedicels, 7 days after treatment, even though the xylem width at that time was not significantly greater than that of the check.

These data do not establish the point that the effect of NAA sprays on vascular development is the reason for its thinning effect since the abscission process, in the fruit about to abscise due to the NAA spray, had started by the time the effect of the NAA spray on the no. of xylem vessels in pedicels of non-abscising fruit could be detected. In light of the report of Luckwill and Whyte (7) that xylem is a major pathway for hormone translocation, it seems quite likely that the increased no. of mature vessels 7 days after an NAA spray and the previously reported (9) increase in IAA translocation 10 days after a NAA spray are more than casually related.

Thus the probable high auxin level, from exogenous NAA and the endogenous auxin, and the decreased reducing sugar (10) available to the fruit did affect vascular differentiation resulting in increased trachea in the pedicel 1 week after the NAA spray. This suggests that the NAA effect on differentiation may be dual; the increase in auxin level in the plant, and the indirect effect on sugar available to the fruit. The latter is apparently not due to an effect of NAA on sucrose translocation through the pedicel (9) but perhaps because the foliage of NAA-sprayed trees has sufficient auxin, for the development of foliar metabolic sinks, which compete with the developing fruit for available metabolites.

Sevin sprays that resulted in fruit abscission have not caused structural or physiological responses (9, 10) similar to those reported for NAA. Therefore, the mechanisms of the thinning action of NAA and Sevin appear to be different. This might be expected since Sevin inhibits rather than stimulates *Avena* coleoptile elongation (2).

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Response of 'Starkrimson Delicious' Apples to Ethephon Application as Influenced by Spray Coverage[1]

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Abstract. **Ethephon [(2-chloroethyl)phosphonic acid] at 250 ppm + 20 ppm of fenoprop [2-(2,4,5-trichlorophenoxy)propionic acid] was applied to fruit only as a dip, to leaves only as a spray, and to fruit and leaves as a normal dilute spray. Fruit color was stimulated only when ethephon was applied to the fruit surface and a direct relationship existed between coverage and color response. A small increase in fruit soluble solids appeared following all applications, while fruit softening occurred only when materials were applied to both fruit and leaves. This softening response is apparently a combined ethephon-fenoprop response. These data imply that ethephon applications should be applied as a dilute spray, using sufficient water to cover all fruit on the tree as thoroughly as possible if maximum color response is to be achieved.**

We reported previously that a preharvest ethephon application on various 'Delicious' cultivars increased red color and resulted in a positive trend in soluble solids content (3). It has also been shown that it was necessary to apply fenoprop with ethephon for abscission control (1, 3). Another study utilizing 'McIntosh' indicated that 20 ppm of fenoprop might result in accelerated fruit softening in addition to preventing fruit abscission (2). The objective of this study was to study fruit responses to ethephon applied to fruit and/or leaf tissues and determine the influence of known total coverage to a normal dilute spray application.

At the start of the harvest season in 1971, 4 limbs were randomly selected on separate quadrants of 6 individual tree replicates of 15-year-old 'Starkrimson Delicious'. Three treatments, all utilizing ethephon at 250 ppm, fenoprop at 20 ppm and Tween 20 at 0.1%, were applied randomly to 3 of the 4 quadrants of each tree, the 4th served as check. Treatments were: fruit (including the lower part of the pedicel) dipped momentarily, leaves sprayed to run-off (fruit enclosed in bags and tied at the pedicel during application), and normal dilute hand gun application to fruit and leaves. Ten days after treatment a 25-fruit sample was harvested from each treatment-rep and evaluated in the laboratory. Solid red color was estimated visually on each fruit to the nearest 5%. Firmness was determined with a standard Magness-Taylor pressure tester and soluble solids were read on a hand refractometer from a filtered juice sample (Table 1).

Treatment applied only to the leaves did not increase red color development to a significant extent while applications to fruit alone or to fruit and leaves did significantly increase red color. This would indicate that color response is stimulated only by ethephon which was applied directly onto the fruit surface. This could be due to a lack of ethephon penetration into leaves, leaf tie-up of ethephon, or lack of translocation due to ethylene liberation and metabolism. A further comparison of dipped fruit vs. normal dilute spray shows a significant difference in favor of fruit dipped. Since one would expect that a dilute application would give "good" but not total fruit coverage, there is apparently a direct relationship between degree of fruit coverage and magnitude of ethephon color stimulation. Soluble solids data show no significant difference, however, there is the same consistent trend (P = .50 – .80) in favor of ethephon treatment as was shown in previous studies (3). Both fruit and leaf applications show this trend. There are several ways which these treatments might alter soluble solids. Perhaps the most plausible explanation is that the soluble solids is stimulated by lower concn of ethylene (such as could be supplied by translocation from the leaves).

Fruit firmness was unaffected by

Table 1. Quality of 'Starkrimson Delicious' apples as influenced by localized and normal dilute spray applications of ethephon plus fenoprop.

Ethephon @ 250 ppm + 20 ppm fenoprop	% solid red color	% soluble solids	Firmness (kg/lb.)
Control	46	10.2	8.66/19.1
Fruit dipped only	81**	10.7	8.75/19.3
Fruit covered & leaves sprayed	57	11.0	8.53/18.8
Normal dilute spray on fruit & leaves	63*	11.0	5.35/11.8**
LSD 5%	16	1.2	1.45/3.2
1%	26	1.7	2.00/4.4

*Significantly different from control at 5% level.
**Significantly different from control at 1% level.

[1]Received for publication April 13, 1973. Paper No. 4027 of the Journal Series of the North Carolina State University Agricultural Experiment Station, Raleigh. The use of trade names in this publication does not imply endorsement of the products named, nor criticism of similar ones not mentioned.

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