Table 6. Valencia orange—irrigated study most profitable nitrogen rate.[z]

Price of nitrogen	On-tree value of fruit/lb. solids	Total yield lb. solids/acre	Gross return/ acre	Gross return/ acre less N cost	Most profitable N rate lb./acre[y]
$ .25	$ .85	1785	$1517	$1462	220
.25	.95	1785	1696	1641	220
.25	1.05	1785	1874	1819	220
.25	1.15	1785	2053	1998	220
$ .50	$ .85	1775	$1509	$1414	190
.50	.95	1775	1686	1591	190
.50	1.05	1775	1864	1769	190
.50	1.15	1775	2041	1946	190

[z]With nitrogen prices of $ .75, $1.00 and $1.25 per lb. on-tree fruit prices at least of $2.25, $3.00 and $3.75 respectively would be necessary before 220 lbs. of nitrogen per acre would be profitable.
[y]Refer to Table 5.

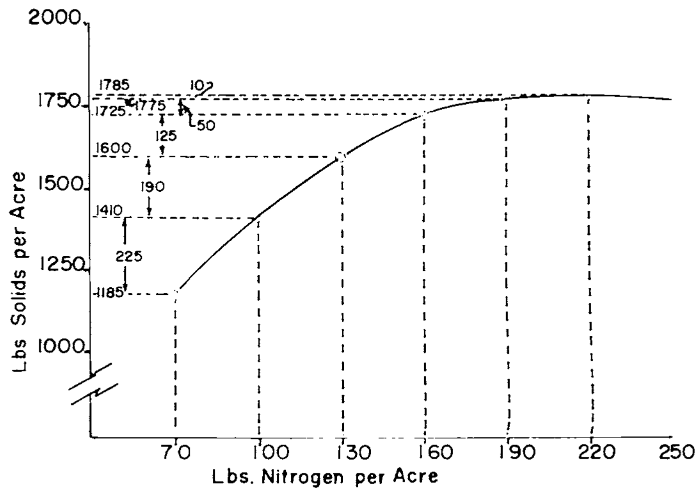

Fig. 3. Yield response of irrigated-nitrogen (irrigated to 65% of field capacity to 60") Valencia orange in lb. solids per acre to nitrogen fertilization 1973-74 to 1976-77 from research by Dr. R. C. J. Koo, IFAS Agricultural Research and Education Center, Lake Alfred.

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FRUIT SET AND DROP OF FLORIDA NAVEL ORANGES

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Abstract. **Fruit drop of navel oranges** [Citrus sinensis **(L.) Osbeck] following June drop was extensive in the 1978-1981 seasons. Blossom-end yellowing (BEY) during early summer, and stylar-end decay, fruit splitting and branch collapse during late summer and early fall all contributed to fruit drop. Sprays of 2,4-D alone or in combination with gibberellic acid suppressed BEY and reduced summer drop. However, these growth regulators did not affect summer-fall drop. Sprays of malathion and benomyl were ineffective in reducing summer or summer-fall drop.**

Inadequate fruit set and extensive fruit drop are major causes of low yields of navel oranges in Florida (8, 9). In addition to the postbloom and June drops, navels lose significant numbers of fruit during the period between the end of the June drop and legal maturity (13). Preharvest drop, defined as fruit drop after legal maturity, has not been extensive in recent years since many navels are harvested soon after reaching legal maturity.

Many attempts have been made to increase navel orange fruit set. Studies in Florida, however, have not resulted in practical solutions to the problem (1, 8, 9, 14). Girdling of the trunk during bloom was successful for increasing fruit set of 'Orlando' tangelo and navel orange (7). However, few growers currently girdle citrus trees in Florida because of unwilling or unreliable labor. Cross-pollination reportedly increases yields in Egypt (2) and South Africa (11); although, this practice has not been proven to increase yields in Florida (8, 15). Intermittent overhead misting or the application of an antitranspirant increased navel fruit set under experimental conditions (1). However, these methods have not been tested on a large scale.

Application of gibberellic acid (GA) to branches, inflorescences or individual fruits during bloom or shortly after consistently and significantly increased navel fruit set (9). Whole-tree sprays during the same period, however, produced inconclusive results. More recently, sprays of GA alone or in combination with 6-benzylaminopurine (BA) and/or $Ca(H_2PO_4)_2$ were found to increase navel fruit set through June drop (14). However, there is no evidence that GA increases yields of navel orange in Florida. As a result, not enough information is available to recommend GA sprays as a practical, reliable means of increasing navel fruit set and yields at the present time.

Factors involved with navel fruit drop after June drop have only been characterized recently (13). Two distinct waves of drop have been observed, the summer drop, which occurs mainly in June and July, and the summer-fall drop, which occurs from late August until October. Fruit abscission at these times is particularly disconcerting to growers and may be of more importance than previously realized (13).

The objectives of this work were to determine some possible causes of summer and summer-fall fruit drops, and to attempt to ameliorate these problems through the use of growth regulator, insecticide and fungicide sprays.

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Materials and Methods

Grove locations. Navel fruit drop was studied from 1978 to 1981 in groves located near Mount Dora, Umatilla and Eustis, Florida. These ranged from 12- to 25-years old. All were 'Washington' type navel oranges (*Citrus sinensis* (L.) Osbeck) budded on sour orange rootstock (*Citrus aurantium* L.). Experiments were designed as randomized blocks with 2 to 10 treatments arranged into 4 to 5 blocks.

Fruit drop evaluation. Fruit drop was evaluated using tagged fruit, and whole tree counts (13). Tagged fruit were uniformly distributed around the trees in a 3 to 6 ft (1 to 2 m) height range. Whole-tree counts were made by counting the number of fruit under each tree at a given time. Fruit were then removed and the next drop period begun. Tagged fruit and whole-tree counts were made at 1- to 3-week intervals throughout the experimental period.

Spray treatments. Materials were applied as dilute sprays at 10 to 20 gal (38 to 76 l) per tree. Chemicals and concentrations utilized were as follows: 21 oz (595 g) active ingredient (a.i.)/100 gal (379 l) malathion; 2.4 oz (68 g) a.i./100 gal (379 l) benomyl; 20 ppm GA; 20 ppm (except at petal fall, 10 ppm) 2,4-dichlorophenoxyacetic acid (2,4-D); and 1000 ppm Promalin (GA_{4+7} plus N-phenylmethyl-1 H-purin-6-amine). An adjuvant, X-77, was added as needed to the spray mixture at 0.03% to 0.06%.

Results and Discussion

Summer drop was caused by a condition referred to as blossom-end yellowing (BEY). BEY results from the abscission of the secondary fruit, the navel, from the primary fruit (12). The navel then becomes yellow and senesces inside the primary fruit finally causing the drop of the latter. BEY seems to be caused by physiological factors rather than by insects or micro-organisms. Fungi isolated from affected tissue were also recovered from healthy fruit and reinoculation of the navel with pure cultures of the most prevalent fungi, *Alternaria* spp. and *Gloeosporium* spp., failed to induce BEY (14). In addition, benomyl sprays did not significantly reduce summer drop in 2 seasons (Tables 1 and 2). A few insect species were observed near the senescing secondary fruit, but only sap beetles (Coleoptera: Nitidulidae) were found consistently. Sap beetles were also associated with fruit which had fallen due to other causes, and are considered to be secondary pests of many decaying fruits and vegetables (4). Moreover, malathion sprays failed to reduce fruit drop in 1979 (Table 1). The fact that navel oranges with BEY symptoms show no signs of insect or fungi attack at an early stage, that BEY can be induced by girdling fruit stems 2 to 10 cm away from the base of the fruit during early summer, and that the problem was ameliorated in 2 seasons by growth regulator sprays (Table 2), all support the idea of a physiological, rather than a pathological or insect-related cause.

Summer drop was less severe in 1980 than in the other 3 seasons studied (Table 3). Observations revealed certain differences between 1980 and the other 3 seasons, viz., a much heavier June drop, and below normal summer flush. In addition, many fruit that dropped during the 1980 June drop had an abscised secondary fruit. It seems possible that the summer drop represents a continuation of the June drop in seasons with a lighter than normal June drop and a less pronounced summer flush.

Fruit abscised during the summer-fall period due to 3

Table 1. Effect of benomyl and malathion sprays on navel orange fruit drop, 1979.

	Fruit drop (%)[z]				
		Spray applications			
Drop periods	Unsprayed	PB,J,S,SF[y]	PB,J,S	S,SF	SF
Postbloom (Mar. 29-Apr. 27)	50.3[x]	48.6	49.6	55.8	49.8
June (Apr. 28-June 8)	43.2	48.8	48.9	50.9	49.1
Summer (June 9-Aug. 15)	7.8	4.8	4.9	7.6	9.5
Summer-fall (Aug. 16-Oct 23)	6.5	8.6	6.5	6.9	8.7
Total fruit drop (Mar 29-Oct 23)	75.7	77.1	77.1	81.0	78.9

[z]Mean of 50 tagged fruit/tree, 19 trees/treatment. % = 100 x fruit dropped during period/no. of remaining fruit at the beginning of the period.
[y]PB, postbloom (Apr. 4); J, June drop (May 3); S, summer (June 11 and August 20); and SF, summer-fall (Sept. 20). PB and J sprays: 2.4 oz a.i. benomyl per 100 gal; S and SF sprays, 2.4 oz a.i. benomyl + 21 oz a.i. malathion per 100 gal.
[x]Mean within rows are not statistically different at the 5% level.

Table 2. Effect of chemical sprays on navel orange fruit drop in 1980 and 1981 seasons based on whole-tree counts.

		Fruit drop (no./tree)[z]					
			1980			1981[w]	
Spray dates	Treatments[y]	S[x]	SF	T	S	SF	T
Petal fall	no spray	—	—	—	101a[v]	75b	176b
(1981, Mar. 20)	GA	—	—	—	123a	114a	237a
	2,4-D	—	—	—	18b	109a	127c
	2,4-D + GA	—	—	—	27b	128a	155bc
5-8 wk after	no spray	9a	57a	66a	101a	75a	176a
petal fall	GA	8a	42a	50ab	93a	93a	186a
(1980, May 31;	2,4-D	2b	45a	47ab	18b	76a	96b
1981, May 01)	2,4-D + GA	3b	33a	36b	5b	77a	82b
	Promalin	4ab	49a	53ab	—	—	—
	benomyl	7a	45a	52ab	—	—	—
10-12 wk after	no spray	5a	50a	55a	76a	75a	151a
petal fall	GA	—	—	—	87a	71a	158a
(1980, Jun. 17;	2,4-D	1b	33b	34b	34b	88a	122a
1981, Jun. 26)	2,4-D + GA	—	—	—	31b	69a	100a

[z]Mean of whole-tree counts based on 4 to 5 trees per treatment.
[y]20 ppm GA, 20 ppm (except 10 ppm at petal fall) 2,4-D, 1000 ppm Promalin and 2.4 oz a.i. benomyl per 100 gal.
[x]S, summer; SF, summer-fall; T, total fruit drop.
[w]SF and T drop data are incomplete for 1981.
[v]Mean followed by unlike letters indicate significant differences within each column for each application time by Duncan's multiple range test, 5% level.

Table 3. Causes of summer and summer-fall fruit drops in navel oranges during 3 seasons based on whole-tree counts.

Drop period and causes	Fruit drop/tree[z] 1979 (no.)	(%)	1980 (no.)	(%)	1981[y] (no.)	(%)
Summer						
Blossom-end yellowing	63	42	8	12	101	57
Summer-fall						
Stylar-end decay	50	34	12	18	21	12
Splitting	15	10	27	42	13	7
Sound fruit[x]	16	11	9	14	33	19
Others[w]	5	3	9	14	9	5
Total (summer-fall)	86	58	57	88	76	43
Total	149	100	65	100	177	100

[z]Mean of whole-tree counts based on a sample size of 4 to 30 trees.
[y]Data were collected only through September 26. Final fruit drop will be greater.
[x]Mostly due to branch collapse. No fruit damage was apparent.
[w]Mostly due to brown rot (*Phytophthora* spp.).

major causes, stylar-end decay (SED), fruit splitting and branch collapse. SED produced a softening within 1 or a few fruit segments, starting near but not affecting the secondary fruit. Fruit splitting was more frequent during and following rainy days. Fruit affected by either SED or splitting were morphologically distinctive, generally being larger and having larger secondary fruit and stylar-end apertures (Table 4). Fruit with such characteristics are known to be more susceptible to SED and splitting (13).

Some control of summer-fall fruit drop may be achieved by the use of navel cultivars with small secondary fruits. Cultivars with such characteristics are available and are being widely grown in certain citrus areas, e.g. 'Baianinha' in Brazil (5). Cultivars with reduced secondary fruits do not necessarily outyield those with pronounced navels; however, within a cultivar, summer-fall drop is less severe in fruit with smaller stylar-end apertures (13).

Table 4. Morphological characteristics of healthy navel oranges and those affected by stylar-end decay and splitting, October, 1980.

	Healthy	Stylar-end decay	Splitting
Diameter (mm)	78 ± 0.8	84 ± 1.0	82 ± 1.0
Secondary-fruit diameter (mm)	17.8 ± 1.5	—	22.5 ± 2.0
Stylar-end aperture diameter (mm)	7.1 ± 0.8	15.7 ± 1.1	22.5 ± 2.0
No. of segments	10.1 ± 0.2	—	10.9 ± 0.2
Peel thickness (mm)	3.6 ± 0.1	4.3 ± 0.2	4.0 ± 0.1
Presence of protrusions (%)	0	63	—

[z]Mean of 30 fruits ± SD.

Sap beetles were always present in SED-affected fruit. Species identified were *Carpophilus fumatus* (Boh.), *Carpophilus hemipterus* (L.), *Haptoncus luteolus* (Er.) and *Lobiopa insularis* (Cast.). In several instances, the beetles were observed inside apparently sound fruit or fruit with very early symptoms of SED. The insects had penetrated through the stylar-end cavity. Furthermore, adult insects are known to carry yeasts on their bodies and to prefer fermenting substrate for oviposition and feeding (4). As a result, sap beetles appear to be capable of attacking navel fruit as a primary pest. A cause-and-effect relationship between the beetles and SED, however, could not be substantiated.

Tissue protrusions or outgrowths from the central axis or the secondary fruit into primary-fruit locules, which have been associated with SED-affected locules (13), appear to be extra carpels which develop individually inside navel oranges. These structures were detected in approximately 3% of the healthy fruit, are present early in ontogeny, and are thought not to be caused by, but to precede SED. Protrusions usually have direct contact with both the outside of the fruit and the inside of fruit locules, possibly creating favorable conditions for insect or microorganism penetration.

Branch collapse differs from the dieback of twigs and branches reported in other citrus areas (6). Branches carrying fruits suddenly collapse and die during late summer and early fall. The last portions of the branch to die are the stems holding the fruit. This differs from twig dieback in which the branch dies from the fruit toward the trunk. The cause of branch collapse is *unknown.*

Sprays of 10 or 20 ppm 2,4-D alone or in combination with 20 ppm GA decreased summer drop significantly in 1980 and 1981 when applied at or within 10-12 weeks of petal fall (Table 2). These treatments generally decreased total fruit drop if applied at petal fall or 5-8 weeks later. GA at 20 ppm did not decrease summer fruit drop in either season.

Petal fall applications of 10 ppm 2,4-D, 20 ppm GA or their combination increased summer-fall drop in 1981. This effect resulted from an increase in splitting during late summer. Higher incidence of fruit splitting has been previously related to GA applications at petal fall (3, 10). As a result, total fruit drop was increased by GA treatment during 1981. In contrast, GA did not increase total fruit drop in 1980. However, summer and summer-fall drop were less pronounced during that season.

Spray applications more than 5 weeks after petal fall had no effect on summer-fall drop in 1981. However, 2,4-D did reduce summer-fall drop in 1980 (Table 2). Spray applications 14 to 18 weeks after petal fall had no effect on fruit drop (data not shown). Promalin had no effect on summer, summer-fall or total drop in 1980. Moreover, grower applications of Captan, sulfur, copper, Cytex or Temik at various times have been ineffective in preventing navel fruit drop.

The results of spray applications must be interpreted with caution. Experiments were not conducted over a long period of time and in some cases involved data from the 1980 season which showed very little summer drop and relatively smaller summer-fall and total fruit drop. In addition, no yield comparisons were made among treatments. Nevertheless, our findings indicate that considerable fruit drop occurs after the June drop period for navel oranges in Florida. Furthermore, at least 4 distinct causes of drop have been identified. Summer drop, which is caused by secondary fruit abscission, appears to be a physiological disorder which can be ameliorated by using 2,4-D at petal fall, or up to 8 weeks later. Summer-fall drop encompasses at least 3 separate problems and has not as yet been controlled by spray treatments.

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SLOW RELEASE PESTICIDE INSIDE TREE WRAPS FOR YOUNG TREE TRUNK PROTECTION FROM INSECT DAMAGE

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Abstract. **The practive of applying an insecticide to tree trunks when banking or wrapping has been less than satisfactory due to rapid loss of effectiveness of the pesticide from decomposition and dispersion by water. The slow release of Diazinon[1] vapors through the walls of packets formed from 5 mil thick, low density polyethylene film placed in semi-rigid tree wraps, has been found to produce a vapor concentration sufficient to repel or kill the insects that frequently damage the trunks of citrus trees, and to be effective over a relatively long period of time. The results of field tests are presented.**

It is common practice in many regions of the world and over most of the Florida citrus belt to insulate young citrus trees to protect them from loss due to cold (1, 2, 3). The material used to cover the tree trunks for this purpose almost invariably invites ants and other insects to take up residence in the protected area. Some of these insects such as ants, may chew on the bark near the base of the tree. Once a wound is created, the young tree is highly susceptible to *phytophthora parasitica* (foot rot). To protect the trunk from insect damage, insecticides are usually applied. Unfortunately, most insecticides either decompose upon exposure to moisture and soil or they are dispersed by water, or both, and lose their effectiveness in a period of time measured in days, or, at most, weeks. To add to the problem, few, if any, insecticides now enjoy regulatory approval for this use. This report presents the results of research into the use of insecticide vapors as a means of providing effective long term protection from insects.

Materials and Methods

For a vapor to be effective in insect control, it must be confined such that a concentration which is lethal or which is at least repellant to the insects in question is achieved within the confined area. A semi-rigid, insulating wrap with a central chamber surrounding the tree trunk was reported on previously (4). This wrap afforded the possibility of achieving a micro environment of insecticide vapors just as it produced a micro climate inside the central chamber by means of its heat releasing solution liners. This wrap is produced from expanded polystyrene (Styrofoam®), a closed cell material, the volume of its central chamber measuring about thirty cubic inches.

A number of insecticides were screened to find one that was effective against the insects to be controlled, had sufficient vapor pressure at grove temperatures to produce an effective vapor concentration and was environmentally acceptable. Diazinon appeared to meet these requirements being effective against a wide variety of insects including ants, roaches, crickets and wasps. It has a rather low vapor pressure at ordinary temperatures being only 1.8×10^{-7} atmospheres at 68°F and 1.4×10^{-6} atmospheres at 104°F. Others were also low. Chlordane for example, has a vapor pressure of 3×10^{-4} atmospheres at 68°F and 1.2×10^{-3} atmospheres at 104°W. Diazinon has been found to be safe in a number of applications, both residential and agricultural, giving it an advantage in this respect.

The insecticide was encased in packets of plastic film in all tests. There are a number of plastic film materials that are relatively impervious to liquid penetration, which is important here if hydrolytic loss of the insecticide is to be minimized, but which do transmit vapors. A wide selection of vapor transmission rates are available with ethylene vinyl acetate at the high end followed by low density polyethylene. Mixtures of these two may also be used. Lower transmission rates can be had by using a higher density polyethylene. The vapor concentration may also be varied by changing the thickness of the film to be used, and also by changing the surface area of the packet containing the insecticide. Low density polyethylene was selected for this study the film thickness used being five mils. The total surface area of each insecticide packet was about sixteen square inches, approximately half of this surface being open for unrestricted vapor transmission.

Initially, wraps with an insecticide packet in either one or both halves were tested singly on trees where insects were found or directly on ant nests. Since the point of entry by insects into the wrap is generally near the bottom it was reasoned that this should be the zone of highest insecticide vapor concentration. To accomplish this, the insecticide packets were placed near the bottom of the wrap in all tests.

A combination life and effectiveness test was initiated in November of 1980 involving 1200 Hamlin orange trees on Swingle citrumelo root stock planted in October of 1980. One group of trees were fitted with wraps as described

[1]Diazinon is the registered trademark of the CIBA-GEIGY CORP. for 0,0-diethyl-0-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate.