To differentiate between the effects of gallonage versus concentration, an additional test was conducted (Table 3). This test strongly indicated that most of the improved response from the sprays was a function of increased concentration rather than increased gallonage, although increasing gallonage of a given concn of PIK-OFF does reduce FRF and increase fruit drop somewhat (Table 2). Attempts to split applications (one-half applied one day, the second one-half the following day) proved not beneficial.

Table. 3. The effect of varying spray gallonages and split application sprays on the performance of PIK-OFF with 'Valencia' oranges. Split application sprays were applied May 25, 1978. Single sprays were applied May 26, 1978. FRF was taken May 30, 1978.

Qts/acre	Gal/acre	FRF (lb) & SD	Fruit drop (avg)	Rank
3	500	9.90 ± 5.00	57	5
3	1000	13.49 ± 4.35	25	7
5[z]	500	7.20 ± 5.10	159	2
5[z]	1000	9.63 ± 4.37	89	4
10[y]	1000	3.74 ± 3.46	412	1
1.5 + 1.5	500 + 500	12.06 ± 5.68	26	6
2.5 + 2.5[z]	500 + 500	8.31 ± 4.81	93	3
Control	—	14.40 ± 3.78	0	8

[z]Maximum allowable chemical per acre according to label recommendations.
[y]Exceeds label recommendations. Applied by hand sprayer.

In the central citrus producing area of Florida, many older citrus groves have trees ranging upwards from 18 ft (5.5 m) in height unless hedging and topping are practiced. The growth habit of orange trees also is such that these trees develop expansive canopies. Field experience with abscission chemicals has demonstrated that adequate spray coverage of these trees is often not accomplished with present machinery.

PIK-OFF is currently labeled for use with a maximum of 5 qts (18.9 l) (1 lb (0.454 Kg) active glyoxime per gal) per acre (1). With large trees, it is difficult to obtain adequate spray coverage at a rate of 500 gal (1892 l) per acre. Results of these tests strongly indicate that increasing gallonages to 750 (2839 l) or 1,000 (3785 l) with corresponding concn of 7.5 (7.1 l) and 10 (9.46 l) qts might reduce the poor performance of PIK-OFF on these larger trees. However, increasing the amount of material applied is impossible without state or federally allowed label changes.

In the original request for temporary tolerance to the federal Environmental Protection Agency (EPA), it would appear that total tree area was not adequately considered when computing maximum allowable chemical per acre. Since chemical residue on fruit appears to be a function of total tree area covered rather than ground area, increasing concn and gallonages for citrus groves with large trees should not produce excessive fruit residues.

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INCREASING THE EFFECTIVENESS OF RELEASE®[1] AS A HARVEST AID FOR CITRUS FRUITS[2]

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Additional index words. Citrus sinensis (L.) Osbeck, abscission, growth regulators, regreening, cuticle, cycloheximide, surfactants, adjuvants, harvesting, uptake, absorption.

Abstract. **Uptake of Release® in 2- and 3-way combinations with Sweep®,[4] Acti-aid®[5] and other adjuvants were tested on 'Valencia' orange (Citrus sinensis (L.) Osbeck). Immature, green oranges had the highest levels (65-84%) of uptake with decreasing amounts of ^{14}C recovered from December to May (43 to 49%), irrespective of additives. Adjuvants may be beneficial in causing spray retention on the orange under conditions of field application but did not increase uptake compared to the water control when runoff was eliminated, demonstrating that the critical parameter is surface retention. The data indicated that 1 ppm Acti-aid results in sufficient tissue changes to stimulate active uptake by as much as 34 percent, whereas 20 ppm inhibited uptake. Sweep combined with Release significantly increased uptake of Release by 20 percent on "regreened" or non-responsive oranges, and also significantly increased uptake of Release in the 3-way combination with Acti-aid. The patterns of uptake can be used to increase field reliability in using chemicals to aid in fruit harvest.**

[1]Release is a trademark registered by Abbott Laboratories.
[2]IFAS Journal Series No. 1538.
[3]A portion of this work was done under a contract from the Florida Department of Citrus, Harvesting Research and Development Committee, to Drs. R. H. Biggs and S. V. Kossuth and was also supported by National Science Foundation Grant #DEB 76-04150 to Dr. Hellmers for the Duke University Phytotron.
[4]Chlorothalonil and Sweep are trade names for formulations registered by Diamond Shamrock Corporation.
[5]Acti-aid (cycloheximide) is registered by Upjohn Company.

The use of abscission chemicals as aids to mechanical and hand harvest of citrus was limited at first to early- and mid-season fruit such as 'Hamlin', 'Parson Brown' and 'Pineapple' oranges (7, 8, 16, 28, 21). The difficulties with 'Valencia' orange, a late-season cultivar whose production makes up 45% of the Florida crop, were that Acti-aid (cycloheximide) and other abscission chemicals were erratic in performance or damaged young fruit, flowers or leaves at the time of harvest (19, 20). Release (5-chloro-3-methyl-4-nitro-1H-pyrazole) is an abscission chemical which can be used on 'Valencia' but it can give poor results in loosening the fruit at certain times of the year.

Irregularities in performance of abscission chemicals on 'Valencia' may have been due to the presence of physiologically less responsive oranges, a condition sometimes related to regreening of oranges, and to variable weather conditions (9, 20). Cooper and Henry (11) demonstrated that regreened 'Valencia' oranges unresponsive to abscission chemicals did not produce as much ethylene as non-regreened oranges treated similarly with Acti-aid (10). Wheaton et al. (17) repeated this experiment using Release rather than Acti-aid and obtained similar results.

The successful use of chemicals to accelerate abscission of citrus fruit by causing ethylene production from damaged peel tissue depends on penetration of the chemical through epicuticular waxes, the cuticle, the primary cell wall and plasmalemma. Albrigo (1, 2, 3, 5) examined developmental changes in wax composition and ultrastructure of 'Valencia' fruit and found a slow, but continuous accumulation of surface wax throughout fruit development. However, there were variations in rates of accumulation as related to environmental conditions. Changes in the number of stomata, number of oil glands, quantity and composition of cuticular wax, as well as epicuticular wax ultrastructure, may all play a part in efficacy in the entry of chemicals into the peel of citrus at different developmental stages.

This study was undertaken to determine if an interaction exists between absorption of Release, developmental stage of the fruit, certain formulations and environmental conditions and if regreened fruit have a different pattern of absorption of Release than non-regreened fruit.

Materials and Methods

The first experiment was a 2 x 4 factorial design with environmental conditions of 28° and 33°C each at 45%, 50%, 60%, and 65% relative humidity. The same experiment was repeated using fruit of different developmental stages collected April 22, July 3, December 18, 1976; January 13, February 22, April 8, and May 12, 1977. Treatments were made with an aqueous solution of 300 ppm Release containing 36,454 dpm/20 μl ^{14}C-Release. Ten oranges per condition were used, each with 2 treated rectangles per orange for a total of 1120 samples. Absorption was for 5 hours. The regreened fruit were those that had pronounced green peel color at the stem end.

The preparation and transport of 'Valencia' oranges to the Duke University Phytotron were as described earlier (12). Twenty μl of each treatment solution of radioactively labeled Release was applied evenly over a 1 x 4 cm scribed rectangle area of the peel. Treated sections were vigorously washed with a sponge and rinsed twice in water after the designated absorption period. Each section was cut from the orange and combusted in a Packard auto-oxidizer to yield water and carbon dioxide. Radioactive $^{14}CO_2$ from the ring-labeled Release was collected in a carbosorb, permafluor scintillation cocktail and radioactivity determined using a Packard Tri-carb liquid scintillation Spectrometer, Model 3385.

The second experiment was conducted concurrently with the first. The control was an aqueous solution of 300 ppm Release containing 36,454 dpm/20 μl ^{14}C-Release. Treatments were also 300 ppm Release with the addition of adjuvants, each at 250 ppm. The 6 treatments were, 1) 300 ppm Release (41,297 dpm/20 μl) + 20 ppm acti-aid + 250 ppm Sweep, 2) 300 ppm Release (39,260 dpm/20 μ) + 1 ppm Acti-aid + 250 ppm Sweep, 3) 300 ppm Release (35,105 dpm/20 μl) + 250 ppm X-77, 4) 300 ppm Release (39,971 dpm/20 μl) + 250 ppm Multifilm, 5) 300 ppm Release (36,982 dpm/20 μl) + 250 ppm Sweep, and 6) 300 ppm Release (33,513 dpm/20 μl) + 250 ppm X-100. Absorption was determined after 5 hours at 25°C and sixty percent relative humidity (RH). Ten fruit per treatment were used each time period for a total of 420 samples.

Two controlled environmental chambers were set up for the third experiment, to simulate an average day and a hot, dry day in Florida at the time 'Valencia' oranges are normally harvested. Ten oranges were equilibrated overnight at 18°C in each chamber and the temperature and relative humidity were programmed as indicated in *Table 1*.

Table 1. Temperature and relative humidity (RH) simulating a normal and dry Florida day during the 'Valencia' harvest season. Fruit were from the April harvest.

	Normal		Dry	
Time	RH (%)	Temp. °C	RH (%)	Temp. °C
0600	95	18	60	18
0900	70	18	55	20
1200	50	25	40	28
1500	45	30	35	33
1900	65	22	38	31
2200	95	20	55	20

Two sections per fruit (or 20 samples per treatment) were treated at 10 a.m. and harvested after 12 hours using techniques described above.

Data from the various tests were subjected to analysis of variance and Duncan's multiple range test.

Results

Overall absorption of ^{14}C-Release decreased from December 1976 to May 1977 (Fig. 1). Oranges tested in December were still quite immature and had significantly greater absorption than mature oranges of the same crop at a later stage of development. A complete analysis of the temperature vs. humidity effects can be found in a previous report (13).

Physiological age of the citrus fruit had a marked influence on the absorption of ^{14}C-Release and also adjuvants interacted at certain stages to alter uptake. Highly significant differences were found in the absorption of ^{14}C-Release due to treatment at all months except January (Table 2). X-77 resulted in higher absorption values than the control in the winter months.

Only the three-way combination of Release + 1 ppm Acti-aid + 250 ppm Sweep resulted in better absorption of Release than the control in April and May. Sweep + Release but without Acti-aid was the most effective combination tested on regreened fruit of the July 1976 harvest, but Sweep + 1 ppm Acti-aid was not used at this time so this comparison cannot be made. Treatments with Release + 20 ppm Acti-aid + 250 ppm Sweep had absorption values that were consistently lower than the controls.

Mean values of absorption of ^{14}C-Release on fruit in the chamber programmed for a normal day (Table 1) was 54.7 percent of that applied. This was significantly greater than the mean absorption of 46.9 percent for oranges in the hot, dry day chamber. These tests were conducted concurrently with the test of the April 1977 column of Table 2. Note that the simulated dry day conditions yielded less uptake than the Release-treated control fruit and the average day more uptake.

Discussion

The most immature fruit used in this study, Dec. 1976 harvest, had the greatest amount of ^{14}C-Release absorption. The next highest values were from regreened fruit collected

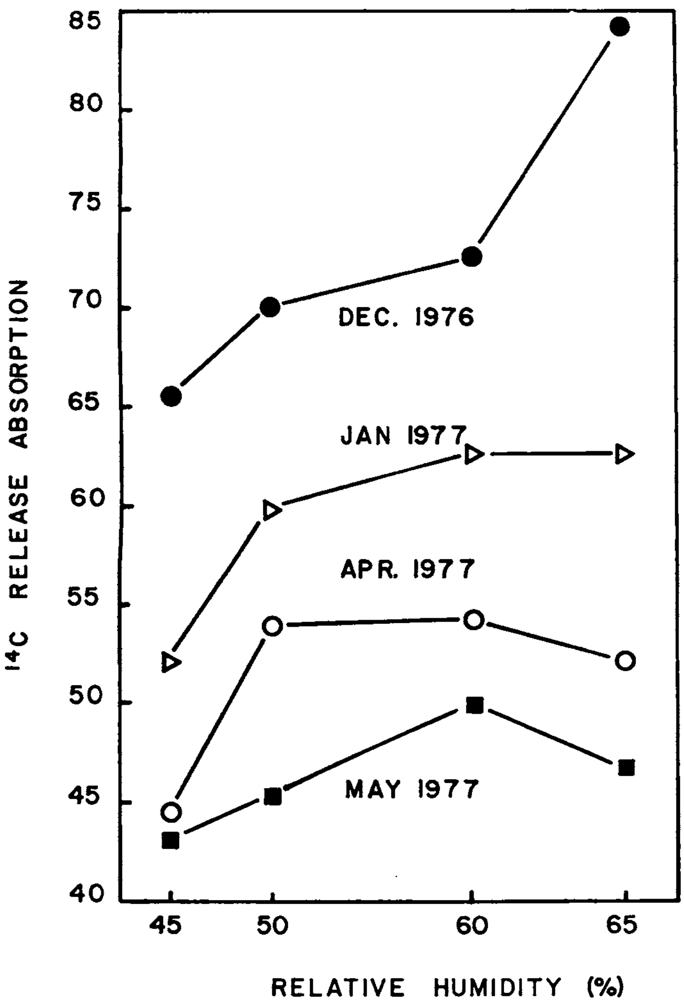

Fig. 1. Effects of physiological age and season of the year and humidity on percent absorption of ^{14}C-Release by 'Valencia' fruit.

in July. The same pattern was found by Wheaton et al. (17), who observed better uptake of ^{14}C-Release in immature fruit than in mature fruit with less responsiveness to abscission accelerating chemicals. Several physiological and structural factors may account for, or interact, to produce this result. For example, immature fruit of 'Valencia' orange have a thinner wax coating than mature fruit and a greater number of stomata per unit area (5). Albrigo (6) also noted qualitative differences in epicuticular wax composition and ultrastructure. Young 'Valencia' fruit have a smooth, soft wax surface. Later, the surface has platelet wax that becomes hardened with age. In addition, many stomata of mature fruit are covered and may be plugged with waxes (5). Absorption could be expected to be lower as was found if stomata are the port of abscission chemical entry.

Absorption of ^{14}C-Release on regreened fruit collected July 1976 was ten percent more than from the April 1977 fruit of the same trees. The Release plus Sweep combination on July collected fruit showed significantly greater ^{14}C-Release absorption than the control and other treatments. There could be an interaction between the particles of Sweep and the surface of regreened 'Valencia' oranges that results in higher uptake. Renewed cell division, greening of the peel and in general reversion to juvenile characteristics by these fruit is apparently also reflected in better absorption of Release. Wax quantity, quality or ultrastructure has not been determined for regreened fruit but additional wax production of the soft type and perhaps the smooth epicuticular ultrastructure of young oranges may account for the higher ^{14}C-Release absorption values. Mature fruit at 33°C can produce significant quantities of soft wax as shown by Albrigo et al. (6) under the same phytotron chamber conditions. Mature regreened and immature 'Valencia' fruit are also similar from the standpoint of abscission response. They both are less responsive to Release than the intermediate mature fruit state. This indicates that endogenous factors, i.e., metabolism, or possibly growth regulators, etc., may be modifying the abscission accelerating response.

Absorption during the harvest months was significantly increased when ^{14}C-Release formulations and Sweep were combined with 1 ppm Acti-aid. Conversely, absorption of the same combination with 20 ppm CYH was lower than that of the control. Kossuth et al. (13) demonstrated that high (10,000 ppm) and low concn. (100 ppm) of ^{14}C-Release showed less absorption than intermediate concn. (300 ppm). The higher concn. of ^{14}C-Release in the earlier work and Acti-aid in this study (20 ppm) that resulted in low absorption values may be caused by tissue damage with Release subsequently being leached during the washing of the fruit.

A working concept of the high absorption efficacy of the 3-way combination might be as follows: One ppm CYH acts as an efficient cellular metabolism altering agent which stimulates active uptake of more CYH and Release. The active ingredient in Sweep is an insoluble 1.5 micron size particle that surface absorbs the active abscission chemicals forming a 2-way (Release + Sweep or Acti-aid + Sweep) complex which adheres to the waxy surface of the peel. Reversible binding of the active agent in the complex(es) allows gradual exchanges that results in a slower uptake through the plasmalemma but over a longer period of time. This process is undoubtedly metabolically linked and would be expected to increase at higher temperatures. Advantages

Table 2. Mean absorption of ^{14}C-Release on 'Valencia' fruit as percentage ^{14}C-applied.

Treatment[x]	Time[z]					
	1976 July[y]	1976 Dec.	1977 Jan.	1977 Feb.	1977 April	1977 May
Control, 300 ppm Release	54.1b	69.9ab	58.0a	39.6b	48.5ab	47.9b
Release + 20 ppm Acti-aid + 250 ppm Sweep	34.5c			35.6b	42.5bc	42.5bc
Release + 1 ppm Acti-aid + 250 ppm Sweep					54.6a	64.4a
Release + 250 ppm Sweep	65.3a	57.7bc	55.3a	43.8b	35.6c	41.7bc
Release + 250 ppm X-77	52.6b	75.5a	58.0a	54.8a	41.4bc	38.2c
Release + 250 ppm X-100	49.2b					
Release + 250 ppm multifilm		51.7c	59.0a	42.3b	42.3bc	44.1bc

[z]Column means not followed by the same letter are significantly different at the 5 percent level.
[y]July fruit were chosen as regreened from their enlarged pericarp and green-colored peel at the stem end.
[x]Ten fruit per treatment.

to the system are that the cells are exposed to low concn. of the *chemical* abscission agents for a longer period of time. Such a binding and slower uptake would account for the sustained ethylene production observed by Holm and Wilson (14) when a similar 3-way combination that differed in concn. was applied to 'Valencia' oranges.

Uptake of ^{14}C-Release with Sweep was not any greater than the control in April and May, thus the use of other adjuvants in the 3-way combinations might have been just as effective. However, 3-way combinations with the others were not investigated.

This and earlier work indicates that a minimum of 4 to 8 hours without rain is required for good absorption of abscission chemicals for fruit loosening in the field. Rainless absorption time for Release for good efficacy is longer than for Acti-Aid (4, 15). High temperatures (33°C) and medium relative humidity levels (50 to 65%) result in the best uptake of Release during the months of harvest in April and May (13). Lower efficacy would be expected from spraying in the evening when temperatures drop and RH tends to increase, often resulting in dew which may collect and drip from the orange, thus removing the active chemical agent with it. Optimal times for spraying in April and May will probably fall between 10 a.m. and 3 p.m. during the day.

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SOME MOISTURE PROPERTIES OF DRIED CITRUS PEEL[1]

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Additional index words. cattle feed, moisture equilibrium.

Abstract. **Equilibrium moisture content of dried citrus pulp cattle feed was measured for different relative humidity (RH) levels at 25°C. Storage of dried pulp and pellets at 8.8% moisture in atmospheres between 30 and 100% RH resulted in re-equilibration of moisture contents from 6 to 29%. In a constant 52% RH atmosphere at 25°C, both loose pulp and pellets reached an equilibrium moisture content of 9 to 10% within 2 to 5 days. Drying rate curves at 100°, 130°, and 155°C were obtained for feed mill press cake and showed constant drying rates between 73 and 25% moisture. A falling rate was apparent from 25% down to about 3% moisture. Particle size distributions of press cake, fines, and dried pulp are also included. Particle size distributions were similar when comparing the press cake with the whole dried pulp. Both fractions had a significant proportion of particles distributed between 2.2 to 6 mm with a small proportion in the 1.5 mm range.**

Data from a Florida statistical report (10) indicated that over one million tons of dried citrus pulp and pellets were produced during the 1977 season. This important by-product is vital to the function of the Florida citrus processing industry and to many livestock producers worldwide.

Citrus peel residue, in its wet state, contains 80 to 85% water and is readily fermentable. The difficulty of handling this material necessitates dehydration to a low (10%) moisture content. But if proper precautions are taken to maintain dry conditions, the product may be handled, stored, and shipped in a manner similar to other dry feedstuffs.

Some physical properties of dried citrus pulp have been studied. Ross and Kiker (9) and Ross and Boots (8) measured bulk density, void space, moisture equilibrium, compressibility, and other properties in studies which reported design data for citrus pulp handling and storage facilities. An earlier study by Bissett and Veldhuis (1) reported the effect on citrus pulp moisture equilibrium caused by mixing different amounts of citrus molasses with the pulp.

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