The cause of the yield difference associated with the 2 concn of Release was not apparent. The 375 ppm concn of Release did, however, cause noticeably more defoliation than did the 250 ppm concn. No chemical damage was noted on any of the young fruit of the sprayed trees for either concn.

In summary, the 375 ppm concn of Release resulted in more preharvest fruit drop and higher percentage fruit removal with the air shaker than did the 250 ppm concn, even when rain followed the spray application within 4 to 6 hr. The 375 ppm concn of Release significantly reduced subsequent yields when compared to 250 ppm. The overall harvest efficiencies of the air shaker at 2 mph ground speed were 80% with 250 ppm and 78% with 375 ppm concn of Release.

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UPTAKE AND DISTRIBUTION OF "RELEASE" IN 'VALENCIA' AND 'HAMLIN' ORANGES[1,2]

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Abstract. **Uptake and distribution of Release[3] (^{14}C-labeled 5-chloro-3-methyl-4-nitro-1H-pyrazole) in 'Valencia' and 'Hamlin' orange peel was followed. Little lateral or polar movement of Release was observed. Seventy-eight to 94% of the recovered ^{14}C-labeled material was found in the flavedo, less than 1.5% in the pulp and the remaining activity in the albedo tissue. Uptake and distribution of ^{14}C-Release varied between tree and laboratory treated oranges. Humidity and tmperature are major factors in uptake and biological effectiveness. Rain during the first eight hours after application of Release removed 70% or more of the applied ^{14}C-Release, but a 24-hour rainless period resulted in up to 66% recovery of ^{14}C. Implication from the data for field applications of Release for fruit loosening will be discussed.**

Release has been found to be an effective abscission accelerating agent for oranges when applied as a spray to the entire tree. It is believed that the effectiveness of Release is directly related to the amount of active chemical actually contacting and penetrating the orange peel (4). Abscission of the orange from the peduncle occurs across a separation zone of only 4 or 5 cell layers in width at the base of the orange (3), thus the possible translocation of Release, as well as most abscission chemicals applied to orange trees, has not been investigated and is important.

The effectiveness of Release offers good potential for use in mechanical harvesting of 'Valencia' and 'Hamlin' oranges. These 2 cultivars mature at different seasons of the year, hence uptake and effectiveness of Release may be affected by highly variable environmental conditions, particularly temperature and humidity. Good abscission activity has been observed after evening spraying of groves but little abscission occurred when application was followed later in the day by rain.

The objectives of this research were to trace the uptake by flavedo, albedo and pulp and distribution of ^{14}C-labeled Release in oranges treated under field and laboratory conditions; determine under field conditions the amount of radioactive Release absorbed by the peel before natural or simulated rain occurred; and investigate effects of temperature and humidity on uptake of ^{14}C-Release from peel application.

Materials and Methods

Peel Distribution. 'Valencia' oranges were brought into the laboratory on May 5, 1975, stems cut to 50mm, and placed to a depth of 25mm in water for the duration of the experiment. Oranges treated under field conditions were from the same tree from which the detached samples were taken. An aqueous solution (100μl) of 300 ppm Release containing approximately 19,356dpm of ^{14}C-Release (1ppm) was applied to a 1 x 4cm area at the equatorial plane of each of the 12 oranges. Two oranges were harvested after 1, 3, and 7 days from both treatments under laboratory and field conditions. Each orange was frozen and then sectioned into 23 sampling units. Flavedo sections were carefully separated from the albedo. Pulp sections were taken immediately below the flavedo/albedo sections and consisted of septum material and juice vesicles.

Simulated rain after ^{14}C-Release treatment. Four 'Valencia' oranges per Release concentrations of 100, 300, 1000 and 10,000 ppm per time period were treated under field conditions on May 25, 1975 with 25μl of ^{14}C-Release on a 1 x 4cm strip around the center of the orange. Approximately 250 ml of water from a wash bottle was used to simulate rain at 2, 4, 6, 8, and 24 hours after treatment with ^{14}C-Release. Additional data was obtained when a natural rain occurred during the first experiment. The oranges were frozen after 2 days and the amount of ^{14}C remaining in the peel (flavedo and albedo combined) was determined.

Effect of temperature and humidity on uptake of ^{14}C-Release. Water-saturated solutions of potassium acetate, potassium thiocyanate, sodium bromide, sodium nitrate, sodium chlorate and sodium phosphate were used to maintain 20%, 47%, 58%, 66%, 75% and 95% relative humidities (RH), respectively, in sealed glass chambers. Two glass chambers per humidity were placed in a growth chamber and the temperature maintained at 10, 15, 20, 25, 30, and 35C for each experiment. Relative humidity was monitored in each chamber using resistance cells. Four 1 x 4cm strips per orange were treated with 25μl of 300 ppm of ^{14}C-Release

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[2]A portion of this work was done under a contract from the Florida Citrus Commission, Harvesting and Handling Committee, to Drs. S. K. Murphy and R. H. Biggs.
[3]Release is a trademark registered by Abbott Laboratories.

containing 5000dpm. One orange was placed in each humidity chamber and temperature allowed to equilibrate. Treated areas of each orange were vigorously scrubbed with a sponge after an uptake period of 5 hours and each area sampled and analyzed separately.

All ^{14}C determinations were made by auto-oxidation of the samples on a Teledyne Intertechnique Instrument and the CO_2 trapped using a phenethylamine:permafluor-based scintillation solution. Radioactivity was determined using a Nuclear-Chicago Scintillation Counter.

Results

No significant lateral or polar movement of ^{14}C-Release was found on tree or laboratory treated peel sections (Table 1). Percentage recovery of ^{14}C applied increased with time, 71, 80 and 93% and 78, 89 and 99% for tree and laboratory treated oranges, respectively. The increase was found in the flavedo with tree-treated oranges, 77, 90, and 94% for 1, 3, and 7 days, respectively. However, the increased recovery in laboratory-treated oranges was equally distributed between the flavedo and albedo as reflected in similar recovery percentages in these tissues at 3 and 7 days, 81 and 79% in the flavedo and 17 and 18% in the albedo. A regreened orange was used in the 1-day laboratory harvest and could partially account for the high recovery of radioactivity in the flavedo. Less than 1.5% of the radioactivity recovered was in the pulp of any sample whether under laboratory or field treatments.

Increasing amounts of ^{14}C could be recovered from true or simulated rain-washed oranges (Fig. 1) in the field after a 4-hour ^{14}C-Release uptake time.

Appreciable uptake of the ^{14}C-Release did not occur until 8 hours after treatment, 19, 30, 29, and 25% recovery from 100, 300, 1000, and 10,000 ppm Release treatments, respectively. The greatest uptake occurred when the oranges were not washed for 24 hours, 65 and 60% recovery for 300 and 1000 ppm Release, respectively. The highest and lowest Release concentrations showed only 27 and 36% recovery for the same 24-hour treatment before simulated rain.

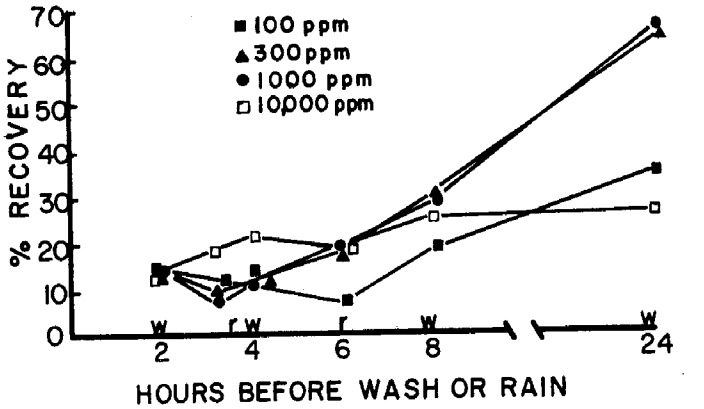

Fig. 1. Influence of simulated rain on the uptake of ^{14}C-Release by 'Valencia' orange.

Peel uptake of ^{14}C-Release was strongly affected by temperature and humidity. Between 15 and 20C the greatest uptake was found at 75 to 95% RH, 44 and 40% of the total radioactivity applied, respectively (Table 2). Maximum uptake was greater, 61 to 65%, at 25 to 35C, however, and occurred at a lower RH, 58 and 66%. The least amount of uptake occurred at 10C, 23 to 26%, with 58 and 75% RH.

Table 1. Percent ^{14}C recovered from field (on tree) and laboratory 'Valencia' oranges treated with radioactive Release.

Tissue	% recovery[y] 1 day Tree	1 day Lab	3 day Tree	3 days Lab	7 days Tree	7 days Lab
1. Treated area flavedo	75.8[x]	89.8	80.1	76.6	88.6	74.3
2. Treated area albedo	14.5	3.1	5.1	15.8	4.0	16.4
3. Treated area pulp	0.9	0.3	0.4	0.3	4.0	0.7
4. 2 x 2cm lateral total area—flavedo	0.9	1.8	4.8	1.4	1.1	0.9
5. 2 x 2cm lateral total area—albedo	0.2	0.2	1.6	0.9	0.3	0.7
6. 2 x 2cm lateral total area—pulp	0.1	0.2	0.2	0.1	0.1	0.2
7. 2 x 2cm² opposite treated area—flavedo	0.2	0.4	0.1	0.1	0	0.1
8. 2 x 2cm² opposite treated area—albedo	0.2	0.3	0.1	0.1	0	0.1
9. 2 x 2cm² opposite treated area—pulp	0.2	0.4	0.1	0.1	0	0.2
10. Abscission zone (5mm)	0.1	0.3	0.1	0.1	0.1	0.1
11. 2 x 2 cm stem end—flavedo	0.4	0.3	0.1	0.1	0.1	0.1
12. 2 x 2cm stem end—albedo	0.4	0.3	0.1	0.1	0	0.1
13. 2 x 2cm stem end—pulp	0.3	0.3	0.2	0	0	0
14. style end 2 x 2cm—flavedo	0.2	0.3	0.2	0.2	0.1	0.1
15. style end 2 x 2cm--albedo	0.2	0.1	0.3	0.1	0	0.1
16. style end 2 x 2cm—pulp	0.1	0.1	0.2	0.1	0	0.1
17. 2 x 2cm proximal to treated area—flavedo	0.5	0.4	1.1	1.0	0.1	0.9
18. 2 x 2cm proximal to treated area—albedo	0.1	0.4	0.3	0.5	0.1	0.5
19. 2 x 2cm proximal to treated area—pulp	0.1	0.1	0.2	0.1	0.1	0.1
20. 2 x 2cm distal to treated area—flavedo	0.3	0.3	3.7	1.7	3.9	2.9
21. 2 x 2cm distal to treated area—albedo	0.2	0.3	0.7	0.1	0.5	0.9
22. 2 x 2cm distal to treated area—pulp	0.1	0.1	0.3	0.4	0.6	0.4
23. stem	4.0	0.2	—	0.1	0	0.1
Total	100	100	100	100	100	100
% recovery of total	71.5	77.68	80.5	88.8	93.33	99.1
Sum (%) flavedos (Tissue #1, 4, 17, 20)	77.5	92.3	89.7	80.7	93.7	79.0
Sum (%) albedos (Tissue % 2, 5, 18, 21)	15.0	4.0	7.7	17.3	4.9	18.3
Sum (%) pulp (Tissue #3, 6, 19, 22)	1.2	0.7	1.1	0.9	1.2	1.4

[x]A mean of 2 oranges per treatment is shown. 100µl of 300 ppm Release with a calculated 19, 356 dpm radioactivity was placed on a 1 x 4cm area at the center of each orange.
[y]Percent recovery at designated times under laboratory or field conditions.

Table 2. Recovery (%) of ^{14}C-Release in the peel of 'Hamlin' orange 5 hours after peel application under various temperature and relative humidity (RH) regimes.

RH (%)	Recovery (%)					
	10°	15°	20°	25°	30°	35°C
20	6	14	19	16	49	26
47	14	20	37	30	54	35
58	24	27	29	65	61	54
66	23	25	33	64	61	65
75	26	32	40	54	39	42
95	21	44	34	16	19	18

Discussion

Application of ^{14}C-Release to oranges under field and laboratory conditions was characterized by increases in uptake up to 7 days but the major fraction (76%) occurring the first day. A limited capacity of the flavedo tissue to accumulate and metabolize Release may explain the decreasing percent in time, as well as the absolute dpm's recovered in the albedo and increasing recovery in the flavedo tissue of on the tree oranges. This increase may have been due to an efflux of Release back to the oil glands of the flavedo where active accumulation may have been occurring but had been saturated after the initial peel treatment. The constant percent distribution of ^{14}C between albedo and flavedo with time for the laboratory oranges may be due to altered metabolism induced when an orange is detached from the tree. Diurnal fluctuations of xylem constituents and environmental conditions (temperature, humidity, wind, light, etc.) are absent when the oranges were brought under controlled conditions of the laboratory, although water was supplied. This difference in environment may have enhanced active and/or diffusionary uptake of ^{14}C-Release, giving the 6 to 9% greater recovery in laboratory treated oranges.

Peel uptake of ^{14}C-Release was not similar to that of cycloheximide (CHI), which has been widely used as an abscission accelerating chemical for oranges (1). The maximum uptake of radioactive CHI from 4-year-old greenhouse 'Valencia' oranges (after washing) was only 20% by the flavedo and 11% albedo after 7 days. This compares to 94 and 5% flavedo and albedo, respectively, for 'Valencia' oranges on the tree treated with ^{14}C-Release. CHI treatments effective in accelerating abscission of oranges may damage and kill more peel tissue than similarly effective Release concentrations, thus eliminating continued active uptake and metabolism of the chemical. Release concentrations used in the field are approximately 10 times those of CHI (2).

Data on the uptake of ^{14}C-Release after simulated or true rain shows that more than 8 hours was required for good uptake of Release at 300 and 1000 ppm. The low recovery values after simulated rain at 24 hours for 100 and 10,000 ppm may reflect this interaction if some degree of tissue-chemical interaction is required for uptake of Release. Good abscission activity on 'Valencia' oranges may be expected at Release concentrations greater than 100 and less than 1000 ppm if no rain falls for 24 hours after treatment. The data also suggest that 60 to 70% uptake, 100 to 1000 ppm, is sufficient for abscission activity from Release.

The effect of temperature-humidity on uptake of 300 ppm Release shows that treatment of 'Hamlin' oranges with Release at 25C or higher should be done when RH's are between 58 and 75%. Fifty-eight and 66% RH gave the maximum, 54 to 65%, uptake for 25 to 35C. This uptake in a 5-hour period would negate loss of activity due to rain after that time. Increasing RH only partially compensated for loss in uptake as the temperature was decreased to 15C, 44 and 40% uptake at 15 and 20C, 95 and 75 RH, respectively. Further studies are needed to identify the parameters, both environmental and physiological which influence uptake of Release. Optimal knowledge of the Release concentrations for the parameters encountered at the time of harvest for each variety of orange should result in application rates of Release with good abscission activity.

Conclusions

Better uptake (6-9%) of ^{14}C-Release can be obtained with 'Valencia' oranges in the laboratory than with those left on the tree. However, similar distributions of ^{14}C in time in the flavedo and albedo suggest arrested or altered peel metabolism under laboratory conditions. Continued accumulation of ^{14}C occurs in the flavedo of tree oranges as decreasing amounts were recovered in the albedo. These differences suggest that peel metabolism is different under the two conditions and that laboratory research should be corroborated with similar studies on oranges on tree under field conditions.

True or simulated rain removed enough Release for at least 8 hours after peel treatment of 'Valencia' oranges on the tree to render it ineffective in inducing abscission. However, this may have been due to the environmental and physiological conditions of the oranges at this time. The temperature-humidity data indicated that these parameters can drastically alter uptake of Release, being maximized at 58 to 66% RH between 25 and 35C. The amount of time for effective uptake of Release may be 5 hours under optimal conditions, as yet poorly defined; under less than optimal conditions a longer period of time is required.

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