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POST-HARVEST TREATMENTS AND BITTER PIT OF GRANNY SMITH APPLES

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SUMMARY

A comparison is made of the effects of post-harvest dips of calcium nitrate, calcium chloride and a number of other materials on the incidence of bitter pit in cool-stored Granny Smith apples. The incidence of bitter pit was considerably higher in fruit from young trees than in fruit from old trees irrespective of treatment. Calcium nitrate at all concentrations increased the incidence of bitter pit while calcium chloride and paraffin wax emulsion (10%) reduced it. A delay of 1 week between harvesting and dipping and cool storage gave a significant increase in the incidence of bitter pit.

I. INTRODUCTION

It has been established in some localities that preharvest sprays of calcium salts will reduce the incidence of bitter pit in certain varieties of apples. However, a number of sprays are required throughout the year and only partial control is achieved. Stevenson and Carroll (1963), using both calcium nitrate and calcium chloride over a 3-year period, found that at the level of bitter pit incidence recorded, calcium sprays were of little benefit in the Stanthorpe district of Queensland.

Jackson (1962) showed that, while the most effective treatment for bitter pit control was a schedule of calcium applications at fortnightly intervals, late-season sprays were more effective than early sprays and bitter pit incidence could be reduced by a single spray the day before harvest or even by post-harvest sprays of calcium nitrate. Post-harvest application, although not the most effective method for bitter pit control, may be of value for some varieties which commonly received post-harvest sprays for scald prevention.

In the current work, various strengths of calcium nitrate and calcium chloride, as well as other materials, were used as post-harvest dips. These dips were tested on fruit from both young and old trees with both immediate and delayed dipping and immediate and delayed storage.

II. MATERIALS AND METHODS

Two separate though identical experiments were carried out during the 1963-64 season, one on fruit from young trees and the other on fruit from old trees. Each trial consisted of a 12 x 3 factorial with two replications for each treatment and five replications for untreated controls. Fifty fruit were used in each treatment.

Fruit used in this experiment was taken from trees on the Granite Belt Horticultural Research Station, near Stanthorpe, which had received no calcium sprays for bitter pit control prior to harvest. Young trees (trial I) were Granny Smith on Merton 793 rootstock 12 years old at the time of the current experiment. Old trees (trial II) were Granny Smith on Malling XIII rootstock 24 years old at the time of the current experiment.

Fruit was harvested from both trials on February 25, 1964. In each trial, samples of 50 bitter pit free fruits were used for dipping treatment.

Dipping was carried out by completely immersing the fruit in the solutions for a period of 1 min. To each solution X.77 non-ionic spreader activator (80% w/v alkylarylpolyoxythylene glycols) was added until the solution formed a thin film over a test sample of fruit. After dipping, the fruit was allowed to drain in plastic-coated wire baskets and then packed in half-bushel boxes with paper liners ready for storage.

Dipping treatments were as follows:—

(1) 1·0% calcium nitrate
(2) 2·0% calcium nitrate
(3) 3·0% calcium nitrate
(4) 4·0% calcium nitrate
(5) 0·5% calcium chloride
(6) 1·0% calcium chloride
(7) 1·5% calcium chloride
(8) 2·0% calcium chloride
(9) 10% paraffin wax emulsion
(10) 1·25% white oil
(11) C.O.S.—10% in alcohol (C.O.S. = 1 part castor oil to 1 part wax-free shellac).
(12) Control—no treatment.

Three treatments involving times of dipping and cool storage after harvest were also investigated:

(*a*) Immediate dip—immediate storage. Fruit was dipped and cool-stored on February 26, 1964.

(*b*) Immediate dip—delayed storage. Fruit was dipped on February 26, 1964, and allowed to stand at room temperature before being placed in cool storage on March 5, 1964.

(*c*) Delayed dip—delayed storage. Fruit was allowed to stand at room temperature until March 5, 1964, when it was dipped and placed in cool storage.

Fruit was stored at 32°F. All fruit was removed from cool storage on May 1, 1964, and allowed to stand at room temperature for 6 days before being examined for incidence of storage bitter pit.

III. RESULTS

The results are summarized in Tables 1 and 2.

Fruit from trial I was more susceptible to storage bitter pit than fruit from trial II. Where post-harvest dip treatments had not been applied, fruit from trial I had a storage bitter pit incidence of 15·0%, while fruit from trial II had an incidence of only 3·0%. This trend was consistent irrespective of post-harvest treatments. The difference cannot be explained directly from these trials, but, from the findings of other workers, e.g. Nyhlén (1954), it is highly probable that it is due to a difference in tree age. The trees in trial I were much younger than those in trial II.

The effect of post-harvest dips on the incidence of storage pit in both trials is shown in Table 1. Calcium nitrate generally increased the incidence of storage bitter pit. The increase was apparent irrespective of the time of dipping or the time of cool storage and the incidence of bitter pit increased with the concentration of the calcium nitrate solution.

Calcium chloride was slightly more variable in its effects, but in fruit from young trees it significantly reduced the incidence of bitter pit at concentrations of 1·0% and greater. Paraffin wax emulsion gave a highly significant reduction in bitter pit incidence in both trials, while white oil did not have a significant effect in either trial. C.O.S. gave a significant reduction in trial I.

Delayed dip with delayed cool storage gave more bitter pit than immediate dip with either direct or delayed storage. This difference was highly significant in both trials. With the immediate dip, the time of storage had no significant effect on the incidence of bitter pit.

IV. DISCUSSION

Tree age was the most important factor governing the susceptibility of fruit to bitter pit. Other factors were of secondary importance and applied treatments had only a modifying effect.

The increase in storage bitter pit incidence with post-harvest dips of calcium nitrate in the current work was unexpected and contrary to the findings of Jackson (1962). However, Martin, Lewis, and Cerny (1966) found that post-harvest dips of calcium nitrate alone or in combination with glycerol increased the incidence of bitter pit in cool-stored Granny Smith apples. If the action of foliage sprays of calcium nitrate in reducing bitter pit incidence is purely a chemical effect, this increase with post-harvest dips is hard to explain.

Stevenson (1967) found that fortnightly sprays of calcium nitrate and calcium chloride throughout the season reduced the incidence of storage bitter

TABLE 1

EFFECT OF POST-HARVEST DIPS ON THE INCIDENCE OF STORAGE BITTER PIT

Data taken from both immediate and delayed dip and immediate and delayed storage

Significance Greater or Less than Control	Young Trees (Trial I)			Old Trees (Trial II)		
	Dipping Treatment	% Storage pit		Dipping Treatment	% Storage pit	
		Trans. Mean	Equiv. Mean		Trans. Mean	Equiv. Mean
Significantly higher than control at the 1% level	4% calcium nitrate	0·653	36·9	4% calcium nitrate	0·418*	16·5*
	2% calcium nitrate	0·573	29·4	3% calcium nitrate	0·384	14·1
				2% calcium nitrate	0·297	8·5
Significantly higher than control at the 5% level	1% calcium nitrate	0·504	23·3			
Higher than control but not significant	3% calcium nitrate	0·490	22·2	1% calcium chloride	0·190	3·6
	1·25% white oil	0·413	16·1	C.O.S. (10% in alcohol)	0·190	3·6
	Control (no treatment)	0·401	15·3	Control (no treatment)	0·178	3·1
Lower than control but not significant	0·5% calcium chloride	0·346	11·5	1·5% calcium chloride	0·156	2·4
				1·0% calcium nitrate	0·116	1·3
				2·0% calcium chloride	0·115	1·3
				0·5% calcium chloride	0·105	1·1
				1·25% white oil	0·105	1·1
Significantly lower than control at the 5% level	1·5% calcium chloride	0·303	8·9			
	C.O.S. (10% in alcohol)	0·303	8·9			
Significantly lower than control at the 1% level	1·0% calcium chloride	0·216	4·6			
	10% paraffin wax emulsion ..	0·202	4·0	10% paraffin wax emulsion ..	0·047	0·2
	2·0% calcium chloride	0·175	3·0			

Necessary difference for significance transformed mean excluding control	5% 1%	0·107 0·142			0·097 0·130	
Necessary difference for significance transformed mean excluding control	5% 1%	0·092 0·123			0·084 0·113	

* Data for treatment 4 (old trees) is taken from delayed storage only. Corresponding means for control are 0·247–6·0 and necessary differences are:—5%, 0·106; 1%, 0·141.

TABLE 2

EFFECT OF HARVEST TO DIPPING AND HARVEST TO STORAGE DELAY ON THE INCIDENCE OF STORAGE BITTER PIT IN FRUIT FROM BOTH YOUNG AND OLD TREES

Data taken from all dipping treatments except control (treatment 12) and treatment 4 (4% calcium nitrate) for old trees only

Trial No.	Percentage Storage Bitter Pit						Necessary Difference for Significance (Transformed Mean)		Significant Differences
	(a) Immediate dip and storage		(b) Immediate dip, delayed storage		(c) Delayed dip, delayed storage				
	Transformed Mean	Equivalent Mean	Transformed Mean	Equivalent Mean	Transformed Mean	Equivalent Mean	5%	1%	
Young trees (Trial I) ..	0·353	11·9	0·326	10·2	0·461	19·8	0·056	0·074	c ⩾ a, b
Old trees (Trial II) ..	0·113	1·3	0·157	2·4	0·242	5·7	0·053	0·071	c ⩾ a, b

pit but did not significantly increase the calcium content of the fruit. He suggested that since these compounds are both highly hygroscopic their action in reducing bitter pit development may be purely physical.

The reduction in bitter pit incidence with paraffin wax emulsion is undoubtedly a physical effect. This treatment could be expected to reduce water loss by the fruit during storage. Even so, a definite relationship between water loss and bitter pit incidence has not been established. Stevenson (1967) reported that, in untreated fruit, increased weight loss was associated with an increase in bitter pit incidence, while in fruit that had received calcium treatments an increase in weight loss was associated with a reduction in bitter pit incidence.

The variable results that have been obtained from the application of calcium salts for the control of bitter pit do not give a clear picture of the action of these materials. Taylor and van den Ende (1968), using post-harvest dips of calcium nitrate and calcium chloride, got similar results to those in the current trials. It therefore appears that while calcium nitrate and calcium chloride have similar effects when applied as foliage sprays, they have opposite effects when applied as post-harvest dips. It is, therefore, difficult to give a purely chemical or purely physical explanation regarding the action of calcium salts in their controlling effect on bitter pit.

The current work indicates that post-harvest dips of calcium nitrate alone should not be used as a control for bitter pit. Calcium chloride, on the other hand, shows considerable promise and if post-harvest dips are used fruit should be dipped as soon as possible after harvest.

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