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BITTER PIT INVESTIGATIONS IN GRANNY SMITH APPLES

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SUMMARY

The effects of calcium nitrate foliar sprays on the incidence of bitter pit in Stanthorpe-grown Granny Smith apples are compared for trees of two different ages together with time of harvest and direct and delayed storage.

The incidence of storage bitter pit was considerably higher in fruit from younger trees irrespective of harvesting date and also in fruit harvested in late February when compared with fruit harvested from the same trees in mid March. Five calcium nitrate sprays throughout the season commencing in December had no effect on the incidence of tree bitter pit and gave only a slight reduction in the incidence of storage bitter pit in all fruit. Calcium nitrate sprays applied the day before harvest tended to increase storage bitter pit incidence.

I. INTRODUCTION

The use of preharvest sprays of calcium salts for the control of bitter pit in apples is becoming a standard orchard practice throughout the world. However, a number of sprays are required throughout the year and only partial control has been achieved. At Stanthorpe, in south-eastern Queensland, Stevenson and Carroll (1963), using both calcium nitrate and calcium chloride over a 3-year period, found that almost as much control could be exercised over the development of bitter pit by adjusting the time of harvest as by spraying with calcium salts.

Jackson (1962) showed that a single spray of calcium nitrate prior to harvest could significantly reduce the incidence of bitter pit. Sprays late in the season tended to be more effective than earlier ones. Nevertheless, the most effective treatment was a schedule of applications at fortnightly intervals. In the Stanthorpe district bitter pit is of minor importance during most seasons and a reduced schedule of applications would therefore be of special interest.

Colhoun, McElroy, and Ward (1962) showed a delay between harvesting and cool storage would increase the susceptibility of the fruit to storage bitter pit. In most experiments with bitter pit there is a delay of only 1 day between harvesting and storage and this is at variance with commercial practice.

The current work was undertaken to investigate the effects of various schedules of calcium nitrate applications and also time of harvest and harvest-to-storage delay interval on the occurrence of bitter pit in Granny Smith apples in the Stanthorpe district.

II. MATERIALS AND METHODS

Two separate though identical experiments were carried out during the 1963-64 season, one on young trees and the other on old trees. Each experiment consisted of randomized blocks involving four spray treatments with 2-tree plots and five replications. Subsequently a split-plot technique was used providing two harvest dates and two storage treatments.

Suitable trees were available on the Granite Belt Horticultural Research Station near Stanthorpe. Young trees (trial I) were 12-year-old Granny Smith on Merton 793 rootstock. Old trees (trial II) were 24-year-old Granny Smith on Malling XIII rootstock.

Four different schedules of calcium nitrate spray applications were applied:

(1) Five sprays of calcium nitrate at 8 lb/100 gal applied on December 6, December 24, January 16, February 6 and March 3 respectively.

(2) One spray of calcium nitrate at 10 lb/100 gal applied on February 24, the day before the first harvest, and a further spray at 10 lb/100 gal applied on March 18, the day before the second harvest.

(3) One spray of calcium nitrate at 10 lb/100 gal applied on March 18, the day before the second harvest only.

(4) Control—no treatment.

Treatments were applied with a high-volume power spray with hand-operated lances at a pressure of 250 lb/sq in. Complete coverage of the tree with a minimum of runoff was aimed at.

Two harvest dates were selected to correspond with a normal and a delayed harvest for export fruit of the variety in this area. The first harvest was made on February 25 and the second on March 19. At each harvest 100 fruit were selected at random from each tree and fruit from the two trees in each plot were combined.

Two delay intervals between harvest and storage were investigated. For direct storage, fruit was placed in cool storage within 24 hr of harvest. For delayed storage, fruit was held at room temperature for a week after harvest and prior to cool storage. All fruit was then stored at 32°F until 8 weeks after harvest. A sample of 50 fruit was placed under each set of conditions.

Fruit was examined for incidence of tree bitter pit immediately after harvest and only fruit free of bitter pit was used for storage treatments. Upon removal from store, fruit was allowed to stand for 5 days at room temperature before storage bitter pit incidence was recorded.

III. RESULTS

The results of statistical analyses are summarized in Tables 1–6.

The incidence of tree bitter pit in both young and old trees (Table 1) was low, with fruit from young trees showing 2·0% and fruit from old trees 1·0%. At this level of incidence there were no significant differences due to treatments and accordingly no detailed data are presented.

TABLE 1

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

Data combined from direct and delayed storage and various calcium nitrate schedules

Tree Age	Percentage Storage Bitter Pit				Necessary Difference for Significance Transformed Mean		Significances
	B1 1st Harvest 25.ii.64		B2 2nd Harvest 19.iii.64		5%	1%	
	Transformed Mean	Equivalent Mean	Transformed Mean	Equivalent Mean			
Young trees (Trial I)	0·411	15·9	0·248	6·0	0·053	0·072	B1 ≫ B2
Old trees (Trial II)	0·182	3·3	0·091	0·8	0·056	0·076	B1 ≫ B2

Fruit from trial I was more susceptible to storage bitter pit than fruit from trial II. Trial I trees had an average storage bitter pit incidence of 11·0% and trial II trees an incidence of only 2·0%. The trend was consistent irrespective of time of harvest, storage delay or calcium nitrate spray programme. 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.

Storage bitter pit incidence was lower at the second harvest than at the first (Tables 1 and 4). This overall difference was highly significant for fruit from both young and old trees (Table 1) and in general was significant when considered in relation to the calcium nitrate schedules (Table 4). However, the difference between harvesting dates did not reach statistical significance for "2 applications" and "no treatment" in old trees.

Overall, fruit from old trees with direct storage had significantly less storage bitter pit than fruit with delayed storage and the same trend was apparent in fruit from young trees (Table 2). The difference between direct and delayed storage was more pronounced at the first harvest than at the second harvest (Table 3).

TABLE 2

EFFECT OF DIRECT AND DELAYED STORAGE ON INCIDENCE OF STORAGE BITTER PIT IN FRUIT FROM YOUNG AND OLD TREES

Data combined from normal and delayed harvest and various calcium nitrate schedules

Tree Age	Percentage Storage Bitter Pit				Necessary Difference for Significance Transformed Mean		Significances
	C1 Direct Storage		C2 Delayed Storage		5%	1%	
	Transformed Mean	Equivalent Mean	Transformed Mean	Equivalent Mean			
Young trees (Trial I)	0·294	8·4	0·365	12·8	0·078	0·110	N.S.D.
Old trees (Trial II)	0·094	0·9	0·178	3·1	0·054	0·076	$C_2 \gg C_1$

Where storage bitter pit was at its worst, with delayed storage of fruit from young trees, calcium nitrate sprays reduced its incidence provided that the application was not made immediately prior to harvest (Tables 4–6).

Where a spray was applied just priod to harvest (treatment A2, Tables 4–6, and treatment A3, Table 6), there was a tendency to a slight though non-significant increase in pit. Responses due to the calcium nitrate spray applications tended to be greater with delayed storage than with direct storage and at the second harvest as compared with the first harvest.

IV. DISCUSSION

The levels of tree bitter pit and storage bitter pit encountered in these trials (1·5 and 7·0% respectively) reflect the relative importance of the two problems in the Stanthorpe district. Marketing of susceptible fruit before the development of storage pit will therefore avoid most fruit losses. This involves recognition of factors predisposing fruit to pit.

In the current work, tree age was probably the most important factor governing the susceptibility of fruit to storage bitter pit. It is therefore essential that fruit from trees of different ages be kept separate and that only fruit from the older trees be used for long storage.

TABLE 3

EFFECT OF TIME OF HARVESTING AND DIRECT AND DELAYED STORAGE ON INCIDENCE OF STORAGE BITTER PIT IN FRUIT FROM BOTH YOUNG AND OLD TREES

Data combined from various calcium nitrate schedules

Storage Treatment	Percentage Storage Bitter Pit							
	Young Trees (Trial I)				Old Trees (Trial II)			
	B1 1st Harvest 25.ii.64		B2 2nd Harvest 19.iii.64		B1 1st Harvest 25.ii.64		B2 2nd Harvest 19.iii.64	
	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean
C1 Direct Storage	0·369	13·0	0·219	4·7	0·111	1·2	0·077	0·6
C2 Delayed Storage	0·452	19·1	0·278	7·5	0·252	6·2	0·104	1·1
Necessary difference for significance 5%	0·075		0·075		0·080		0·080	
Necessary difference for significance 1%	0·101		0·101		0·108		0·108	
Significances	* B1C1 ≫ B2C1 B1C1 > B2C2 B1C2 ≫ B2C2, B2C1 B1C2 > B1C1				B1C2 ≫ B1C1, B2C1, B2C2			

* F value not significant

TABLE 5

EFFECT OF CALCIUM NITRATE FOLIAR APPLICATIONS ON INCIDENCE OF STORAGE BITTER PIT IN FRUIT FROM BOTH YOUNG AND OLD TREES UNDER DIRECT AND DELAYED STORAGE

Data combined from normal and delayed harvest

Calcium Nitrate Schedule†	Percentage Storage Bitter Pit							
	Young Trees (Trial I)				Old Trees (Trial II)			
	C1 Direct Storage		C2 Delayed Storage		C1 Direct Storage		C2 Delayed Storage	
	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean
A1 (5 applications)	0·309	9·3	0·286	8·0	0·102	1·0	0·165	2·7
A2 (2 applications)	0·289	8·1	0·430	17·4	0·092	0·8	0·218	4·7
A4 (No treatment)	0·284	7·8	0·379	13·7	0·089	0·8	0·152	2·3
Necessary difference for significance 5%	0·136		0·136		0·094		0·094	
Necessary difference for significance 1%	0·190		0·190		0·132		0·132	
Significances	* C2A2 > C1A2, C1A4, C2A1				* C2A2 > C1A1, C1A2, C1A4			

* F value not significant

† Treatment A3, affecting only 2nd harvest, not included

TABLE 4

Effect of Calcium Nitrate Foliar Applications on Incidence of Storage Bitter Pit in Fruit from Both Young and Old Trees at Two Harvest Dates

Data combined from direct and delayed storage

Calcium Nitrate Schedule†	Percentage Storage Bitter Pit											
	Young Trees (Trial I)						Old Trees (Trial II)					
	Data Combined from Both Harvests		B1 1st Harvest 25.ii.64		B2 2nd Harvest 19.iii.64		Data Combined from Both Harvests		B1 1st Harvest 25.ii.64		B2 2nd Harvest 19.iii.64	
	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean
A1 (5 applications)	0·298	8·6	0·392	14·6	0·203	4·1	0·134	1·8	0·204	4·1	0·063	0·4
A2 (2 applications)	0·360	12·4	0·426	17·1	0·293	8·3	0·155	2·4	0·177	3·1	0·133	1·7
A4 (No treatment)	0·331	10·6	0·414	16·2	0·249	6·1	0·120	1·4	0·164	2·7	0·077	0·6
Necessary difference for significance 5%	0·054		0·092		0·092		0·068		0·097		0·097	
Necessary difference for significance 1%	0·078		0·124		0·124		0·099		0·132		0·132	
Significances	* A2 > A1		* B1A1 ≫ B2A1, B2A4 B1A1 > B2A2 B1A2 ≫ B2A1, B2A2, B2A4 B1A4 ≫ B2A1, B2A4 B1A4 > B2A2				N.S.D.		B1A1 ≫ B2A1 B1A1 > B2A4 B1A2 > B2A1, B2A4 B1A4 > B2A1			

* F value not significant

† Treatment A3, affecting only 2nd harvest, not included

TABLE 6

EFFECT OF CALCIUM NITRATE FOLIAR APPLICATIONS ON INCIDENCE OF STORAGE BITTER PIT IN FRUIT FROM BOTH YOUNG AND OLD TREES UNDER DIRECT AND DELAYED STORAGE

Data from delayed harvest only

Calcium Nitrate Schedules	Percentage Storage Bitter Pit											
	Young Trees (Trial I)						Old Trees (Trial II)					
	C1 Direct Storage		C2 Delayed Storage		Average		C1 Direct Storage		C2 Delayed Storage		Average	
	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean
A1 (5 applications)	0·246	5·9	0·161	2·6	0·203	4·1	0·057	0·3	0·069	0·5	0·063	0·4
A2 (2 applications)	0·224	4·9	0·362	12·6	0·293	8·3	0·078	0·6	0·187	3·5	0·133	1·7
A3 (1 application)	0·262	6·7	0·284	7·8	0·273	7·3	0·090	0·8	0·028	0·1	0·059	0·3
A4 (No treatment)	0·187	3·4	0·311	9·4	0·249	6·1	0·097	0·9	0·057	0·3	0·077	0·6
Necessary difference for significance 5%	0·162		0·162		0·078		0·138		0·138		0·076	
Necessary difference for significance 1%	0·224		0·224		0·110		0·190		0·190		0·106	
Significances	* C2A2 > C1A4, C2A1				* A2 > A1		* C2A2 > C2A3				N.S.D.	

* F value not significant

The effect of varying time of harvest was apparent in both trials and mid March was suggested as a more suitable harvest time than late February. This supports the work of Allen and Torpen (1950) and Conway (1960), who showed that with increasing maturity fruit is less susceptible to storage bitter pit development. It contrasts to a degree with the results of Stevenson (1962) and Stevenson and Carroll (1963), who worked with the Granny Smith variety in the Stanthorpe district and found that in two out of three years fruit harvested in mid February developed less storage bitter pit than fruit harvested 10 days earlier or later. However, in their work harvesting did not extend past March 1 and storage bitter pit incidence was lower in all seasons than that recorded for young fruit in the current work.

The increase in storage bitter pit in fruit held for a week at room temperature prior to cool storage agrees with the findings of Colhoun, McElroy, and Ward (1962), who obtained the same result with Bramley's Seedlings. It emphasises the importance of placing fruit in cool store immediately after harvest. With fruit from old trees, delaying storage at the first harvest resulted in significantly more storage bitter pit than fruit from the second harvest under either storage treatment. In fruit from young trees, although the value of F in the analyses of variance was not significant, fruit from the second harvest under both direct and delayed storage had less storage bitter pit than fruit from the first harvest stored immediately. However, direct storage will reduce the incidence of storage bitter pit in fruit at both harvest dates.

The overall effect of calcium foliar sprays on the incidence of storage bitter pit was slight and was of much less consequence than the factors already discussed. These findings support those of Stevenson and Carroll (1963) for Stanthorpe-grown Granny Smith apples, in which the incidence of storage bitter pit in most seasons is low. The increase in storage bitter pit incidence with late-season calcium nitrate sprays is an unexpected result and contrary to the findings of Jackson (1962), who showed that late-season sprays of calcium nitrate would reduce the incidence of storage bitter pit in the Cox's Orange variety. This effect of late-season calcium nitrate sprays is supported by the unpublished results of other experiments by the author with post-harvest dips of calcium nitrate.

In the current experiments the low incidence of tree bitter pit precluded any sound conclusions. However, in a season of high tree bitter pit incidence, tree age, harvesting date and spray treatment may all have effects. Baxter (1960) found that the incidence of tree bitter pit could be reduced by calcium sprays applied 2-3 months before harvest.

It is concluded from the current work that a schedule of calcium nitrate foliar applications will reduce the incidence of bitter pit to a slight degree, but applications close to harvest tend to increase bitter pit severity. Tree age, time of harvest and cool storage delay are of overriding importance.

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