AN INVESTIGATION INTO THE EFFECTS OF PRE-HARVEST SPRAYS OF CALCIUM-CONTAINING FORMULATIONS IN REDUCING POST-HARVEST ROTS IN 'HASS' AVOCADOS

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ABSTRACT

Calcium levels in fruit have been shown in several studies to be related to ripe fruit quality of 'Hass' avocados. Increased calcium levels play a role in reduced susceptibility to body rots. The aim of this trial was to determine whether calcium foliar applications would increase fruit calcium levels and thereby improve fruit quality, particularly regarding rots. Several calcium formulations were evaluated in two field trails. Foliar applications in these trails did not increase fruit calcium contents, either in the peel or in the flesh. Similarly it was not possible to demonstrate any benefit in terms of fruit quality. However, due to the ripe fruit assessment methodology employed in one trail, a potential benefit of foliar applications cannot be entirely eliminated.

INTRODUCTION

Fruit exported from New Zealand to the USA during the 1999/2000 season exhibited a high degree of post-harvest body rots, creating an industry concern about a loss of market confidence and the viability of future exports. Excessive rots have also been reported from the Australian market from time to time, especially in January 2000 (Everett & Pak, 2001). The poor quality season in 1999/2000, therefore prompted a major review of production systems throughout the industry. Emphasis was placed on evaluating any options for the reduction of fungal rots.

The extent to which a fungal pathogen is able to establish an infection is affected by numerous pre-harvest factors. The nutritional status of the trees, in particular the calcium content plays an important role in determining ripe fruit quality. Thorp *et al.* (1997) showed that low fruit calcium levels were associated with vascular browning. In a survey of several orchards Everett (2000) found that higher calcium contents were correlated with a reduced level of rots. Recent Australian research has also strongly implicated high fruit calcium levels with lowered rot levels in 'Hass' avocados (Willingham *et al.*, 2001; Hofman *et al.*, 2002).

In South Africa a number of foliar calcium formulations had been tested on the 'Pinkerton' variety in an effort to reduce internal physiological disorders

associated with that cultivar (Penter and Stassen, 2000). An unexpected beneficial effect of some treatments, was that anthracnose was significantly reduced compared to the control, with the product 'Calcimax' yielding the best results. In this study a significant benefit from Calcimax applications was shown in two out of the three years for which the trail ran.

Calcimax is described by the South African manufacturers 'Plaaskem', is a liquid organic calcium, with the calcium chelated to a carbohydrate and containing 100 g/l calcium and 5 g/l boron. They also reported that it is widely compatible with other spray products and very safe from a phytotoxic point of view. Phytotoxicity was tested locally on avocados in New Zealand prior to implementing a grower trail. No phytotoxic symptoms were observed on trees sprayed at 10 times the recommended concentration and at high water rates

In the light of the perceived threat that rots held for the local industry, it was felt that trailing the product in New Zealand had merit, especially since it is not a pesticide and would therefore not require lengthy and expensive registration procedures. Other calcium products were included in the trial for comparative purposes.

MATERIALS AND METHODS

Trials were located at Ken and Helen Littlejohn's and Bill and Jean Poole's orchards at Mangawai and Katikati respectively. At both trial sites, trees were 4 years old. Four trees per treatment were sprayed at the times recommended for 'Calcimax' applications and at the label rates recommended for all products. The recommended times of application for Calcimax during the early period of fruit development (when fruitlets are about pea sized and repeated 2 –3 weeks later).

Trees in Trial 1 were sprayed on 23rd November 2000 and again on 15th December 2000 with each the calcium products listed in Table 1. Trees in Trial 2 were sprayed on 17th November 2000 and again on 8th December 2000 with the calcium products listed in Table 1. All trees were sprayed by hand with an AR30 pump+turbogun portable sprayer at 2067 kPa using a 1.5 mm nozzle.

In November 2001, fruit were harvested from each trial site, packed through commercial packhouses at Aongatete and Golden Mile and coolstored for 30 days to simulate a sea voyage, overseas storage and transport to the customer. Fruit were left to ripen at room temperature and then evaluated for rots by the Quality Controller in each shed responsible for library tray evaluation. In Trial 2 all fruit were assessed on the same day and in Trial 1 treatments were assessed sequentially over a period of 4 days due to the larger sample size, with ripe fruit being held in coolstore until assessed.

Table 1. Products and application rates (per hectare and per 40l) of each of the treatment in Trials 1 and 2.

Treatment	Product	Rate/ha (L)	Rate/40l (mls)
Trial 1			
Untreated	-	-	-
Calcimax	calcium chelate	10	200
StopitN	calcium nitrate	5	100
StopitN	calcium nitrate	10	200
Caltrac 400	calcium+urea	5	100
Panda Headland	calcium oxide	5	100
Norplex		13.3	266
Norplex+duWett		13.3	266+10
Trial 2			
Untreated	-	-	-
Calcimax	calcium chelate	10	200
StopitN	calcium nitrate	5	100
StopitN	calcium nitrate	10	200
Caltrac 400	calcium + urea	5	100
Caltrac+Nufilm	calcium +urea	5	100+25
Headland Panda	calcium oxide	5	100

Additionally, fruit from each treatment and each site, was sent to Hill Laboratories in Hamilton for calcium analysis of peel and flesh. Sample size for the calcium analyses consisted of 4 replicate samples of 5-pooled fruit per treatment in Trial 1 and a single pooled sample of 5 fruit per treatment for Trial 2.

RESULTS

Calcium uptake

In Trial 1 there were no significant treatment effects of calcium applications in terms of either concentration of calcium in either the peel or the flesh of the fruit (Table 2). The mean overall levels of calcium in the fruit skins tended to be higher in Trial 2 (Table 3).

Fruit quality

In terms of ripe fruit quality in Trial 1 both treatment and date of assessment had significant effects on fruit quality (data not presented). However, there were also significant interactions between assessment date and treatment. Due to these confounding effects it is not possible to make valid comparisons based solely on treatments.

Table 2. Effect of calcium foliar applications in Trial 1 on both fruit peel and flesh calcium content. Four samples of 10 fruit were assessed for each treatment. Values are means and standard errors (s.e.).

Treatment	Calcium in peel (g/100g dry weight)		calcium in flesh (mg/100g fresh weight)	
	Mean	s.e.	mean	s.e.
Control	0.058	0.006	3.28	0.063
StopitN 5l/ha	0.043	0.005	2.68	0.354
StopitN 10l/ha	0.045	0.005	2.62	0.197
Calcimax	0.050	0.007	2.80	0.183
Panda	0.050	0.008	3.05	0.171
Caltrac	0.048	0.006	2.73	0.317
Norplex	0.043	0.005	2.75	0.253
Norplex + Dewett	0.048	0.003	3.10	0.108
Overall mean	0.048		2.87	

Table 3. Effect of calcium foliar applications in Trial 2 on calcium content of fruit peel. A single composite sample of 10 fruit was assessed for each treatment.

Treatment	Calcium in peel (g/100g dry weight)
Untreated control	0.07
Stopit N 5l	0.05
Stopit N 10l	0.05
Calcimax	0.08
Panda	0.05
Caltrac	0.11
Caltrac + Nufilm	0.06
Overall mean	0.067 +/- 0.008

Table 4. Effect of calcium foliar applications in Trial 2 on incidence (%) and severity (%) of fuzzy patches on green fruit, stem-end rots, vascular browning and body rots.

Treatment	Fuzzy patches		Stem-end rots		vascular browning		Body rots	
	Inc	Sev	Inc	sev	Inc	sev	Inc	sev
1	41.7	3.8	6.3	0.7	29.2	8.7	33.3	7.9
2	33.3	3.0	6.3	1.3	37.5	7.3	20.8	3.0
3	45.8	10.3	4.2	0.4	35.4	9.6	37.5	8.5
4	37.5	3.6	14.6	1.1	43.8	11.8	35.4	7.7
5	33.3	2.4	6.3	0.8	39.6	6.0	18.8	3.0
6	41.7	4.2	16.7	1.4	35.4	10.3	37.5	4.1
7	33.3	2.2	10.4	1.4	25.0	4.1	27.1	4.9
significance	ns	P<0.01	ns	ns	ns	ns	ns	ns

Foliar calcium applications had no influence on ripe fruit quality in Trial 2, other than the StopitN at 5 l/ha treatment which had significantly more fuzzy patches on green fruit than the other treatments (Table 4). Regression analysis between treatment means for ripe and green fruit quality parameters and the mean calcium contents for each treatment did not indicate any significant treatment differences.

DISCUSSION

The combined results from the two trials indicate that the lack of treatment effects on fruit quality reflects the lack of treatment effect on calcium contents. Treatments were applied during the period of most rapid calcium uptake. Witney *et al.* (1990) showed that calcium uptake is most rapid in the first 6 weeks following fruit set. At this stage the fruits are strong 'sinks' for calcium accumulation. As the vegetative shoot growth increases with the spring flush, these shoots outcompete the developing fruit for calcium.

The lack of treatment effect may in part be due to calcium levels being sufficiently high as to not limit quality. Both Thorp *et al.* (1997) and Everett and Pak (2001) indicate that beyond a given threshold level there is likely to be reduced benefit from increased calcium levels.

The higher peel calcium contents in Trial 2 may reflect differences in soil calcium levels between the two trail sites or differences in rootstock efficiency of calcium uptake. Willingham *et al.* (2001) showed that rootstocks can have a significant impact on post-harvest antracnose susceptibility in 'Hass'. This effect was due partially to differences in concentrations of antifungal dienes, but also in part to differences in mineral nutrients in leaves and fruit. They attribute this to graft incompatibility when 'Hass' is grafted to a Mexican rootstock ('Duke6', 'Duke 7') compared with a Guatemalan rootstock ('Velvick').

SUMMARY

There is good evidence in the literature demonstrating the benefits of increased calcium levels in fruit on improved quality in 'Hass' avocados, particularly for body rots and vascular browning. In this study, there was no demonstrable increase in calcium content, either in the peel or in the flesh, as a result of foliar calcium applications. Similarly, it was not possible to demonstrate any benefits in terms of fruit quality.

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