Comparison of the black cold damage sensitivity and ripening uniformity characteristics of the Maluma and Hass avocado cultivars

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ABSTRACT

This project aims to develop suitable storage and ripening regimes for the Maluma cultivar. During the 2014 season, the incidence of black cold damage was determined after storing 'Maluma' and 'Hass' fruit for a period of 30 days at 4 temperature settings during, respectively, the beginning, middle and end of the season. 'Maluma' was found to be slightly more susceptible to black cold damage than 'Hass'. However, at this stage the preliminary results do not warrant the export of 'Maluma' at higher temperature regimes than 'Hass'. In terms of ripening, 'Maluma' ripened at a faster and more uniform rate than 'Hass'. It was also shown that the firmness of the skin (non-destructive) and the pulp (destructive) correlated to a greater extent in 'Maluma' than in 'Hass'. It was further noticed that, under certain conditions 'Hass', but not 'Maluma' fruit, ripened at a slower rate when stored at higher, non-black cold damage inducing temperatures compared to lower, black cold inducing temperatures.

INTRODUCTION

'Maluma' is a new Hass-like cultivar on which relatively little postharvest research has been done to date. One aspect that is of particular importance is the development of appropriate storage temperature regimes for the cultivar. The current project has the following aims:

- Black cold damage related aspects:
  - ◇ To determine the susceptibility of 'Maluma' fruit of increasing maturity to black cold damage.
  - ◇ To establish whether current step down temperature regimes used for 'Hass' will suffice for 'Maluma'.
  - ◇ If necessary, to use the above information to formulate appropriate maturity-related storage temperature regimes for 'Maluma'.

- Ripening related aspects:
  - ◇ To compare the ripening rate and uniformity of 'Maluma' with that of 'Hass'.
  - ◇ To determine what affect the storage temperature has on the ripening profiles of the fruit.
  - ◇ To compare the synchronisation between the externally measured firmness of the skin (non-destructive) with that of the pulp (destructive).

MATERIALS AND METHODS

Fruit from one 'Hass' orchard and two 'Maluma' orchards located in the Schagen area were used for the first set of trials.

The 'Hass' orchard was eight years old and grafted onto 'Velvic' seedling rootstocks. The first 'Maluma' orchard was eight years old and grafted onto 'Bounty' clonal rootstocks. The second was two years old and top-worked onto 27 year old 'Martin Grande' trees.

One hundred and thirty fruit per orchard were sampled on three dates (Table 1) during the 2014 season. On each date 10 fruit were used for moisture content analyses (Table 1). The balance of 120 fruit was divided into four samples of 30 fruit each that were stored at four temperature settings. The settings for the first trial were 3, 4, 5 and 6°C. During

Table 1. Moisture content of one population of 'Hass' and two populations of 'Maluma' avocado fruit sampled on three dates during the 2014 season.

Sampling dates	Moisture content (%)		
	'Hass'	'Maluma' 1	'Maluma' 2
16 April	75.2	79.1	79.9
21 May	69.9	75.2	74.3
3 June	67.8	73.6	73.6

the second and third trials, settings of 2, 3, 4 and 5°C were employed.

The avocados were stored for 30 days after which they were ripened at room temperature. Upon removal from cool storage each fruit was scored for black cold damage on a scale from 0 to 3, nil being a fruit with no black cold damage and 3 a fruit with severe damage.

Since research on the synchronisation between external colouration and firmness is a high SAAGA priority at the moment, each sample was photographed on a daily basis. During Trial 2 this was done over an 18 day period. In the case of Trial 1 and Trial 3 the photographs were taken over a 3 to 4 day period only. After this, a comparison was made between the externally measured firmness of the fruit (non-destructively determined with a bench-top Sinclair meter) and the internal density of the fruit (destructively measured with an automated Guss penetrometer).

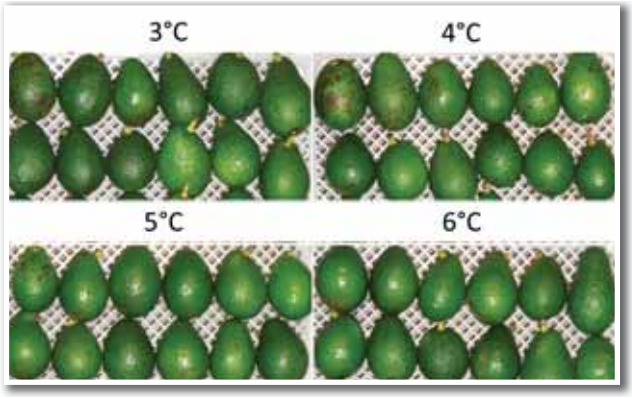

Figure 1. External appearance of 'Hass' fruit that were sampled on 16 April (moisture content 75.2%) and stored for 30 days at 4 temperature settings.

RESULTS AND DISCUSSION

Black cold damage incidence and intensity

The incidence and intensity of black cold damage recorded for the fruit harvested during the middle of April is shown in Table 2. All 'Maluma' fruit stored at 3°C had black cold damage lesions, albeit at relatively low intensities. The corresponding value for 'Hass' was 60%. The incidence and intensity of the disorder decreased as the storage temperature was increased. The 'Hass' and 'Maluma' 2 samples had no black cold damage when stored at 6°C while 16.7% of the 'Maluma' 1 fruit had low intensity lesions.

Photographic recordings of fruit with the most intense lesions are shown in Figure 1 ('Hass'), Figure 2 ('Maluma' 1) and Figure 3 ('Maluma' 2). In addition to the discernible differences between 'Hass' and 'Maluma', it is interesting to observe the difference in skin texture between the 'Maluma' fruit from Orchard 1 on the 'Bounty' rootstock (Fig. 2) and Orchard 2 on the 'Martin Grande' rootstock (Fig. 3).

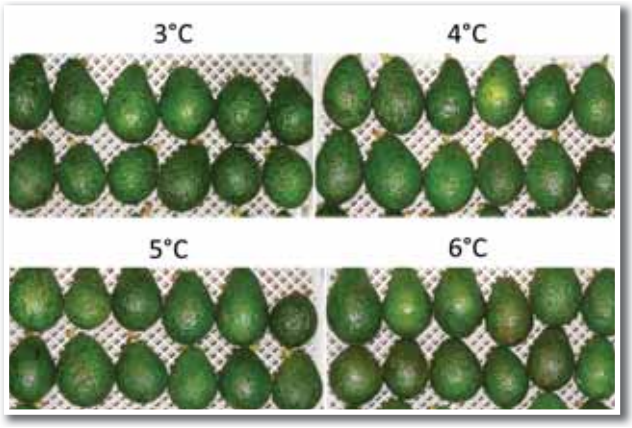

Figure 2. External appearance of 'Maluma' fruit from Orchard 1 (Bounty clonal rootstock) that were sampled on 16 April (moisture content 79.1%) and stored for 30 days at 4 temperature settings.

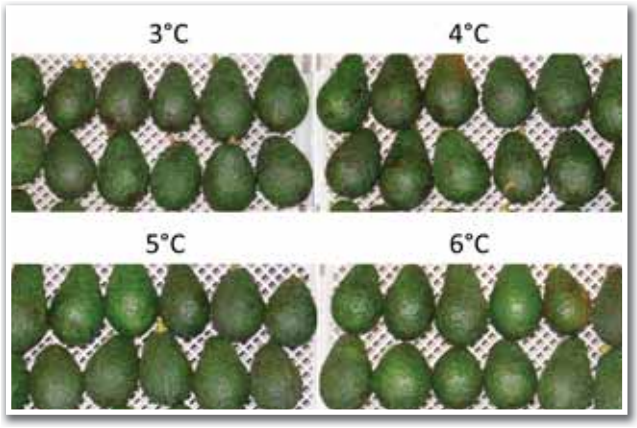

Figure 3. External appearance of 'Maluma' fruit from Orchard 2 (Martin Grande rootstock) that were sampled on 16 April (moisture content 79.9%) and stored for 30 days at 4 temperature settings.

Table 2. Black cold damage incidences and intensities recorded for one population of 'Hass' and two populations of 'Maluma' avocado fruit sampled on 16 April 2014 after storage at 4 temperature settings for 30 days.

Cultivar	'Hass'		'Maluma' 1		'Maluma' 2	
Temperature (°C)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)
3	60 d	1.4 e	100 e	1.4 de	100 e	1.7 e
4	60 d	1.5 e	56.7 cd	1.7 e	100 e	1.4 de
5	16.7 b	1.3 cd	50 c	1.1 bc	20 b	1.5 e
6	0 a	0 a	16.7 b	1 b	0 a	0 a

By the third week of May, the black cold sensitivity of the two 'Maluma' orchards was fairly similar to that of 'Hass' (Table 3). When stored at 5°C, around 16% of the 'Hass' and 'Maluma' 2 fruit were affected, albeit at a low intensity (level 1). The 'Maluma' 2 sample was clean at this temperature setting. Significant black cold damage occurred in all three samples stored at temperatures lower than 5°C.

Around two thirds of the fruit from both cultivars harvested during the first week of June developed black cold damage when stored at 2°C (Table 3; Figs. 8-10). This dropped to under 50% when stored at 3°C. When stored at 5°C, ten percent of the 'Maluma' fruit in both samples still developed black cold damage lesions while the 'Hass' fruit was clean.

From the results it would appear that the two cultivars are quite similar in so far as their susceptibility to black cold damage is concerned. If anything, 'Maluma' may be slightly more sensitive than 'Hass'. However, it is our preliminary recommendation that current 'Hass' temperature regimes be used for the Maluma cultivar.

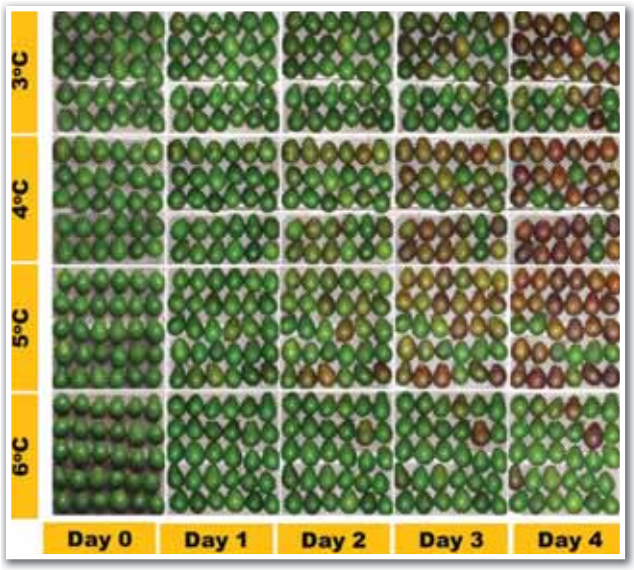

Figure 4. De-greening rate of 'Hass' fruit that were sampled on 16 April (moiture content 75.2%) and stored for 30 days at 4 temperature settings.

External colour / ripening

The rates at which the fruit skin de-greened are shown in Figures 4-12. In the case of Trial 1 (Figs. 4-6), the 'Hass' was photographed on the first 5 days of the shelf life phase and the 'Maluma' during the first 4 (the fruit were hereafter used for the hereunder reported firmness evaluations). With Trial 2 (Figs. 7-9), the colour of all three samples was recorded over a 19 day period. During Trial 3 (Figs. 10-12) both cultivars were again photographed for 4 days only.

Some interesting trends emanated from the photographic recordings. During the first two trials, the bulk of the 'Hass' fruit stored at the highest temperature (6°C in Trial 1 and 5°C in Trial 2) ripened at a slower rate than the fruit stored at the lower temperatures. However, a couple of individual fruit ripened at a faster rate. This resulted in uneven ripening. Although the fruit stored at the lower temperature settings took longer to ripen, they ripened more evenly. The trend was reversed during Trial 3, during which the complete sample stored at the highest temperature setting ripened the fastest. From the results it would appear that the response of 'Hass' to storage temperature is influenced by pre-harvest factors such as maturity, climate and

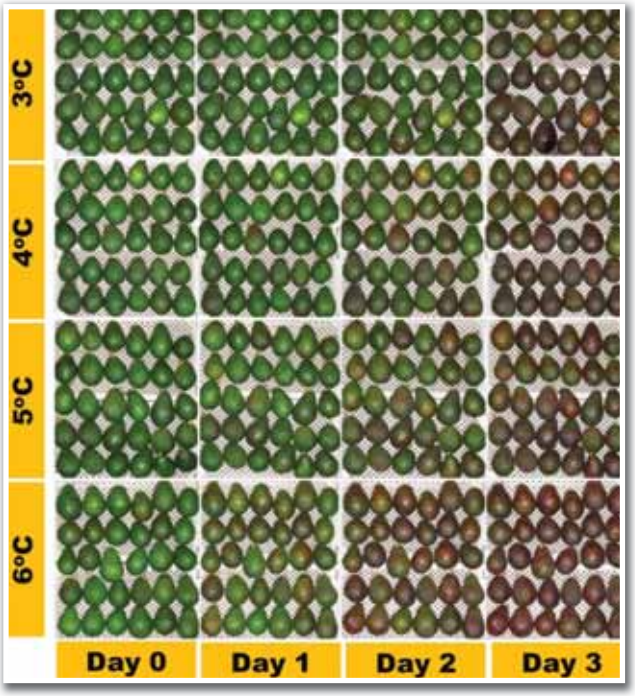

Figure 5. De-greening rate of 'Maluma' fruit from Orchard 1 (Bounty clonal rootstock) that were sampled on 16 April (moisture content 79.1%) and stored for 30 days at 4 temperature settings.

Table 3. Black cold damage incidences and intensities recorded for one population of 'Hass' and two populations of 'Maluma' avocado fruit sampled on 21 May 2014 after storage at 4 temperature settings for 30 days.

Cultivar	'Hass'		'Maluma' 1		'Maluma' 2	
Temperature (°C)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)
2	80 g	1.4 c	73.3 f	1.3 bc	70 ef	1.4 c
3	60 d	1.3 bc	70 ef	1.2 b	83.3 g	1.3 bc
4	50.3 c	1.2 b	66.7 de	1.2 b	66.7 de	1.4 c
5	16.3 b	1 a	0 a	1 a	16.3 b	1 a

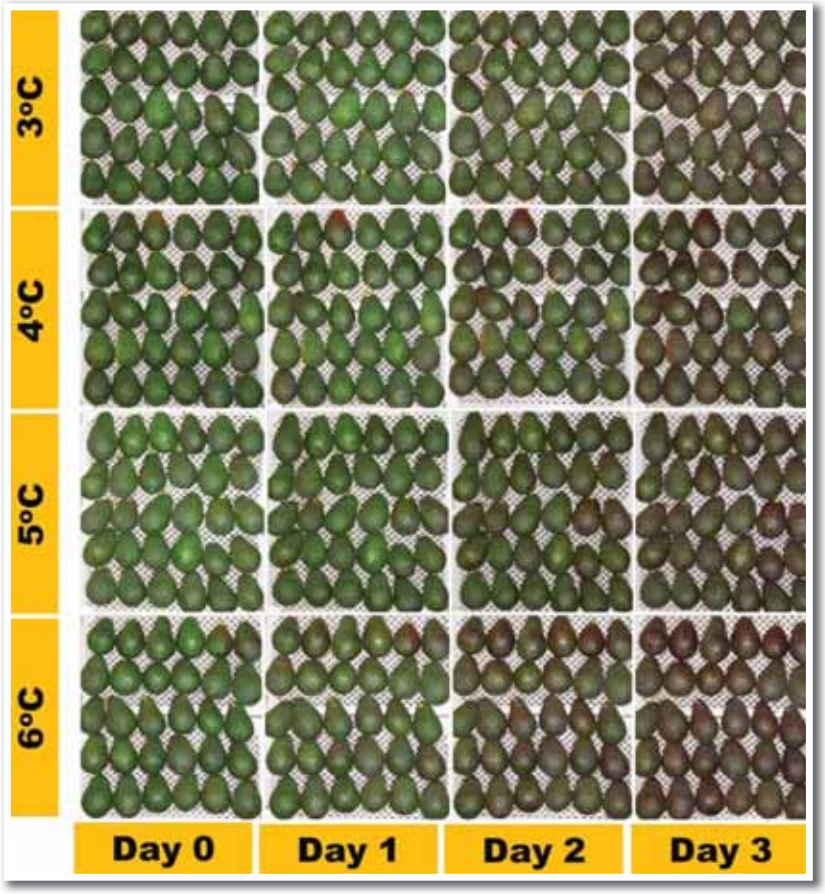

Figure 6. De-greening rate of 'Maluma' fruit from Orchard 2 (Martin Grande rootstock) that were sampled on 16 April (moisture content 79.9%) and stored for 30 days at 4 temperature settings.

orchard management practices. We are currently investigating this aspect.

In the case of 'Maluma', the fruit from both orchards ripened at a considerably faster and more even rate than 'Hass'. Furthermore, in contrast with 'Hass', the ripening rates were not influenced by the storage temperature.

Non-destructive versus destructive firmness measurements

The relationship between the external firmness of the fruit as measured with a bench-top Sinclair meter, and their internal firmness, measured with an automated Guss penetrometer, is shown in Figure 13.

In the case of 'Maluma', a linear relationship existed between the non-destructively measured external firmness of the fruit and their destructively measured internal firmness. This applied to both orchards. In contrast, 'Hass' showed considerably more variation and the relationship was polynomial.

During recent seasons, most European ripeners have done away with their non-destructive external firmness meters due to the poor correlation with pulp firmness. The present results elucidate that this is

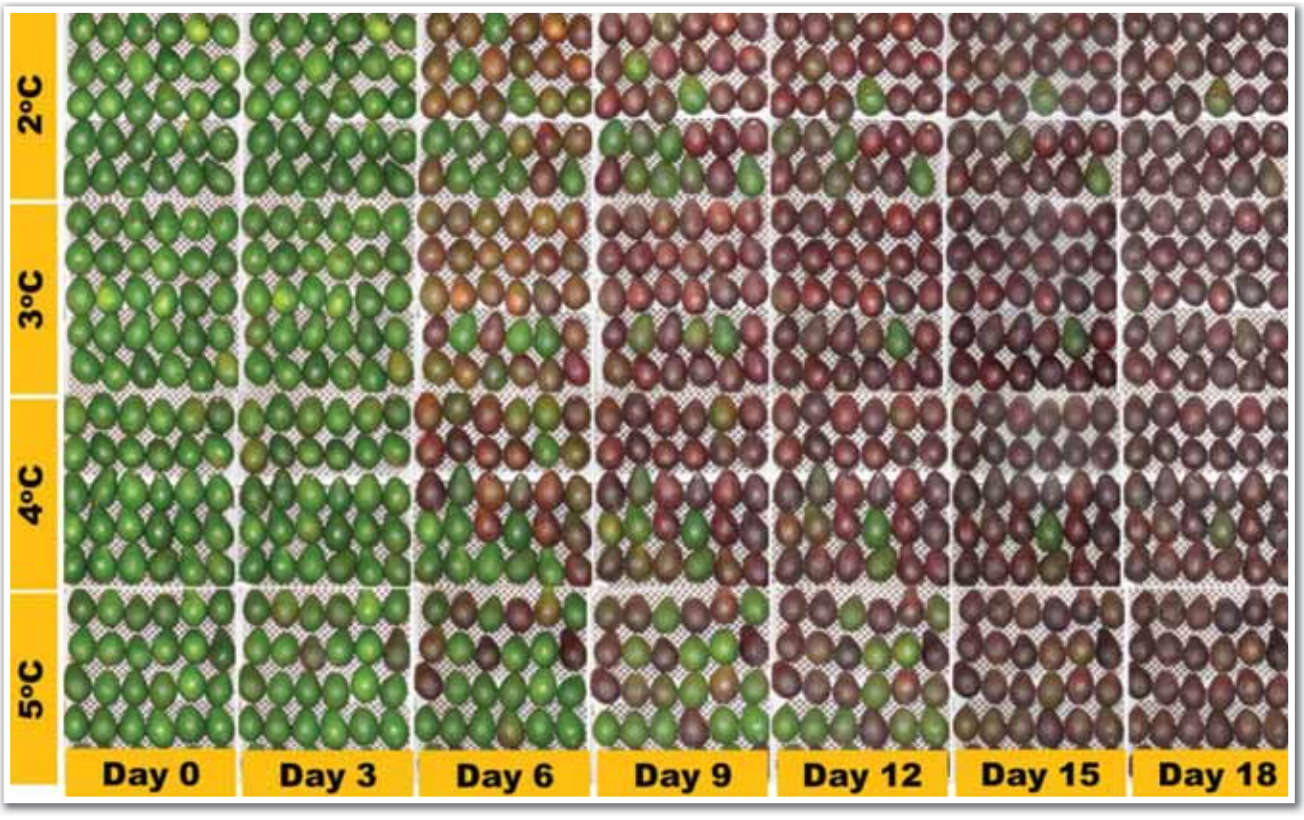

Figure 7. De-greening rate of 'Hass' fruit that were sampled on 21 May (moisture content 69.9%) and stored for 30 days at 4 temperature settings.

Figure 8. Degreening rate of 'Maluma' fruit from Orchard 1 (Bounty clonal rootstock) that were sampled on 21 May (moisture content 75.2%) and stored for 30 days at 4 temperature settings.

Figure 9. Degreening rate of 'Maluma' fruit from Orchard 2 (Martin Grande rootstock) that were sampled on 21 May (moisture content 74.3%) and stored for 30 days at 4 temperature settings.

Table 4. Black cold damage incidences and intensities recorded for one population of 'Hass' and two populations of 'Maluma' avocado fruit sampled on 3 June 2014 after storage at 4 temperature settings for 30 days.

Cultivar	'Hass'		'Maluma' 1		'Maluma' 2	
Temperature (°C)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)	Black cold damage: Incidence (%)	Black cold damage: Intensity of positives (1-3)
2	60 e	1.8 e	66.7 ef	1.8 e	70 f	2.1 f
3	40 d	1.7 de	46.7 d	1.4 cd	46.7 d	1.3 c
4	20 c	1 b	20 c	1 b	46.7 d	1.4 cd
5	0 a	0 a	10 b	1 b	10 b	1 b

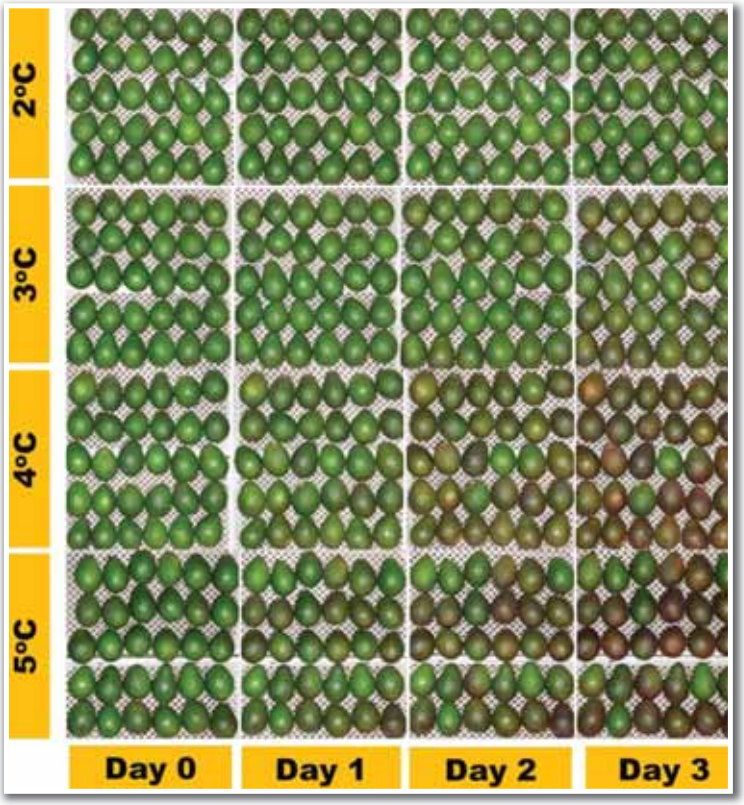

Figure 10. De-greening rate of 'Hass' fruit that were sampled on 3 June (moisture content 67.8%) and stored for 30 days at 4 temperature settings.

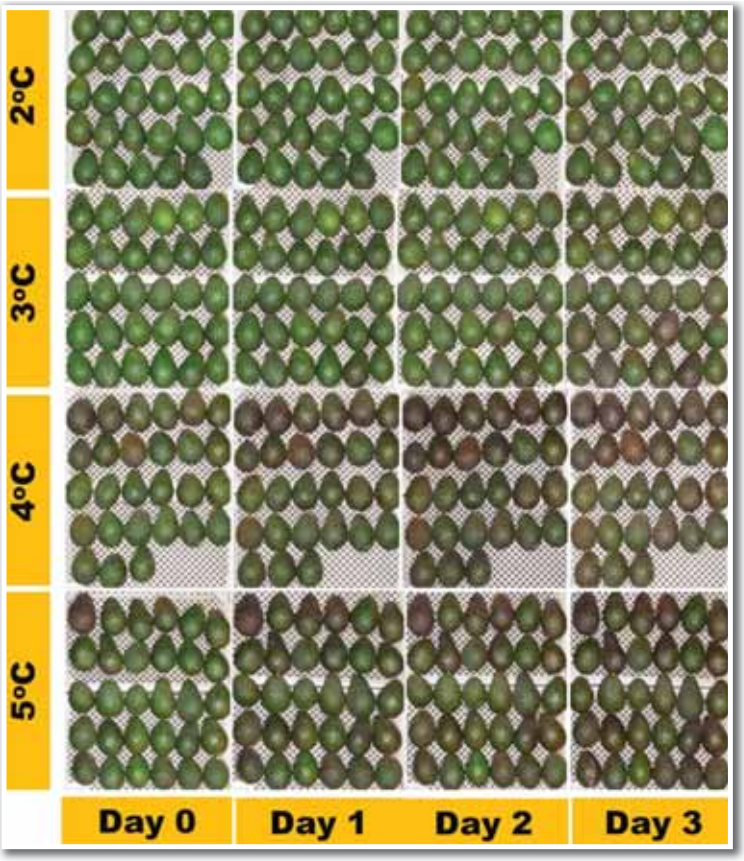

Figure 11. De-greening rate of 'Maluma' fruit from Orchard 1 (Bounty clonal rootstock) that were sampled on 3 June (moisture content 73.6%) and stored for 30 days at 4 temperature settings.

the case in so far as 'Hass' is concerned. However, in the case of 'Maluma' the results clearly show that non-destructive external firmness meters can be used very effectively. From the graph it is also clear that a considerably higher yield of marketable 'Maluma' fruit can be obtained if the timing is correct. We are presently investigating this aspect and are in the process of developing appropriate firmness parameters for the cultivar.

CONCLUSIONS

- It appears that 'Hass' and 'Maluma' are quite similar in so far as their susceptibility to black cold damage is concerned:
- 'Maluma' may be slightly more sensitive than 'Hass' at the lowest temperature setting during the early season (above the current regulation of 78%).
- It is our preliminary recommendation that current 'Hass' temperature regimes be used for 'Maluma'.
- The external de-greening of both 'Hass' and 'Maluma' was satisfactory.
- During the first two trials, the 'Hass' fruit stored at the highest temperature setting (6°C in Trial 1 and 5°C in Trial 2) ripened at a slower rate than the fruit stored at the lower settings.
- In all 3 trials the 'Maluma' fruit (both orchards) ripened/coloured more evenly than 'Hass'.
- The results regarding the relationship between the external firmness of the fruit, as measured with a bench-top Sinclair meter, and their internal firmness, as measured with an automated Guss penetrometer, showed important cultivar differences:
  - ◇ In the case of 'Maluma' a linear relationship existed between the non-destructively measured external firmness of the fruit and their destructively measured internal firmness. This applied to both orchards.
  - ◇ In contrast, the relationship was polynomial in 'Hass'. This cultivar showed considerably more variation in firmness.

The ripening research is being continued.

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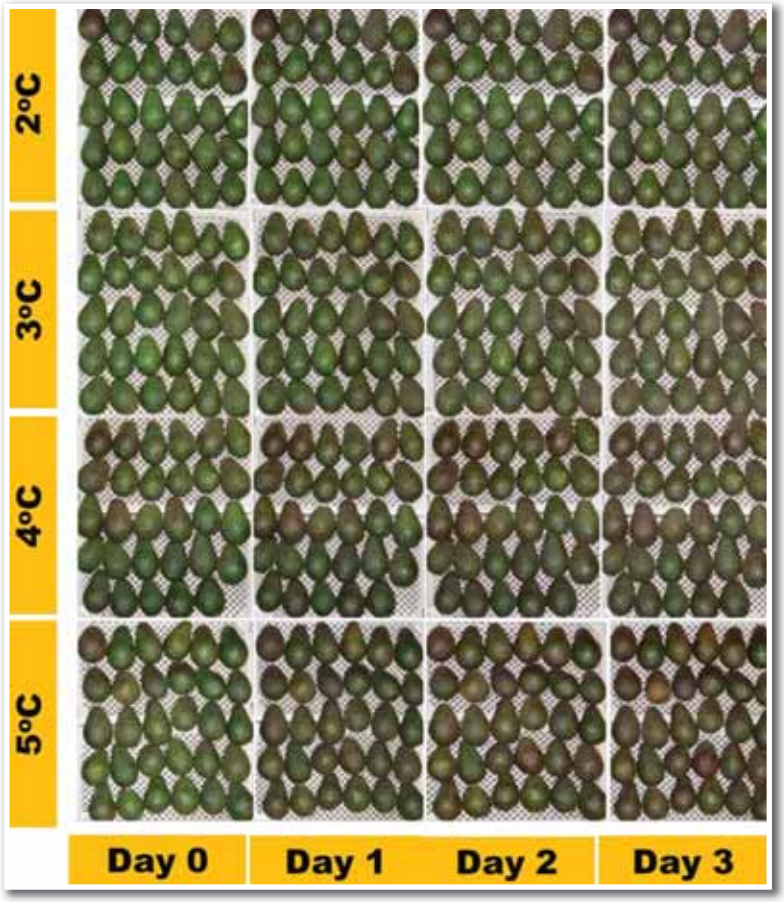

Figure 12. De-greening rate of 'Maluma' fruit from Orchard 2 (Martin Grande rootstock) that were sampled on 3 June (moisture content 73.6%) and stored for 30 days at 4 temperature settings.

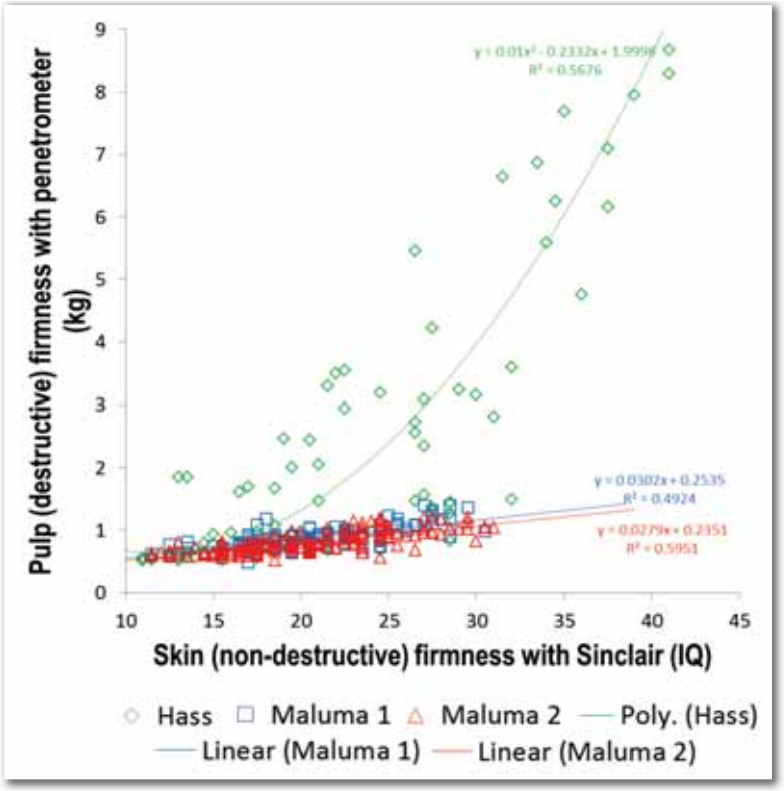

Figure 13. Relationship between the external firmness, as measured with a bench-top Sinclair meter and internal firmness, measured with an automated Guss penetrometer, of 'Hass' and 'Maluma' fruit during the ripening process.