Observations made during the 2016 season regarding certain factors that influence the ripening of South African avocado fruit

FJ Kruger, E Volschenk and GO Volschenk

Lowveld Postharvest Services,
PO Box 4001, Nelspruit 1200, SOUTH AFRICA
E-mail: fjkruger58@gmail.com

ABSTRACT

Previous observations we have made regarding variability in the ripening patterns of South African export avocado fruit have indicated that pre-harvest factors, such as irrigation and fertiliser practices, as well as orchard topography, may be responsible for a large proportion of the recorded variation. It was further noticed that the role played by storage temperature is more complicated than initially anticipated. It was postulated that storage temperature-related variations in ripening may be related to the phenology-dependent carbohydrate metabolism of the plant in general and specifically that of the fruit at the time of harvest. In the present report the above factors are further dealt with. Two sets of data pertain. The first concerns the ripening patterns of fruit from Nico Roets' stem xylem potential trial as recorded during the 2016 season. The second involves the SmartFresh holdback sample ripening patterns observed during the very dry 2016 season. The results from the stem xylem potential trial supported our previous observations that inadequate irrigation impedes expedient ripening. The outcomes from the SmartFresh holdback sample observations reiterated the complexity of the relationship between environmentally induced pre-harvest phenological factors and the effect that storage temperature has on ripening.

INTRODUCTION

A number of factors have thus far been identified in this project as influencing the ripening patterns of South African avocado fruit. These include climate, orchard topography, irrigation practices, fertiliser applications, SmartFresh practices and storage temperature regimes. The present report deals with observations made during 2016 regarding two of these aspects. The first involves Nico Roets' stem xylem potential trial (Roets *et al.*, 2015), while the second pertains to the SmartFresh holdback sample ripening patterns recorded during the 2016 season.

In the case of the stem xylem trials, the aim was to verify/disprove our previous observations that ripening of fruit from optimally irrigated orchards is faster and more synchronized than ripening of fruit from less well irrigated orchards (Kruger & Lemmer, 2014). In the case of the SmartFresh holdback trials, the aim was to further investigate the interesting relationship that exists between storage temperature and ripening rate, as reported by Kruger & Lemmer (2016).

MATERIALS AND METHODS

Stem xylem potential trial

The trial consisted of four treatments:

- Farm irrigation
- -10 to -25 kPa
- -25 to -35 kPa
- -35 to -45 kPa.

Each treatment had six replicates. Each replicate consisted of three adjacent trees, of which the centre one was used as a data tree. Due to the extremely dry conditions that prevailed during the study period, the trees yielded poorly and the size of the fruit was small. An attempt was made to pick one 4 kg carton of fruit from each tree. However, in many cases this was not possible due to a lack of fruit. The avocados were ripened at room temperature and the number of days required to reach the ready to eat stage was recorded for each fruit.

SmartFresh holdback sample ripening

Three sets of trials were performed with the fruit from 41 SmartFresh applications. The present report deals with seventeen of these applications that were conducted at one packinghouse from the end of April to the end of May.

After applying the SmartFresh, the fruit were stored at the following temperature regimes:

- 4°C for 30 days, or
- 6°C for 30 days, or
- 6°C for 28 days followed by 2 days at 1°C.

After storage, the avocados were ripened at room temperature. Upon reaching the ready to eat stage, the ripening period of each fruit was recorded, after which external and internal quality analyses were performed. The mean ripening period of each sample and the standard deviations were then calculated, listed and plotted.

RESULTS AND DISCUSSION

Stem xylem potential trial

The number of fruit that were sampled from each data tree is shown in Table 1. In many cases only a limited number of fruit were available, while three of the trees had no fruit at all. The ripening results are shown in Table 2. Due to the small number of fruit obtained from individual trees, an extra statistical analysis, where data from all the fruit from each treatment was pooled, is included. When interpreted in this way, the fruit from trees subjected to the lowest irrigation levels (-35 to -45 kPa) took approximately 15% longer to ripen that the fruit from the trees that were irrigated at the highest rate (-10 to -25 kPa). The standard deviations of the faster ripening treatments were also smaller than those of the slower ripening treatments. This corresponds with our previous observations that optimally irrigated orchards ripen faster and ripening of their fruit is more synchronised than fruit from less well irrigated orchards.

Table 1. Number of fruit sampled per tree.

Replicate number	Number of fruit sampled per irrigation treatment			
	Farm irrigation	-10 to -25 kPa	-25 to -35 kPa	-35 to -45 kPa
1	24	21	26	14
2	30	15	27	10
3	0	8	24	0
4	25	22	5	25
5	22	18	5	30
6	22	0	30	27
Total no of fruit	123	84	117	106

SmartFresh holdback sample trials

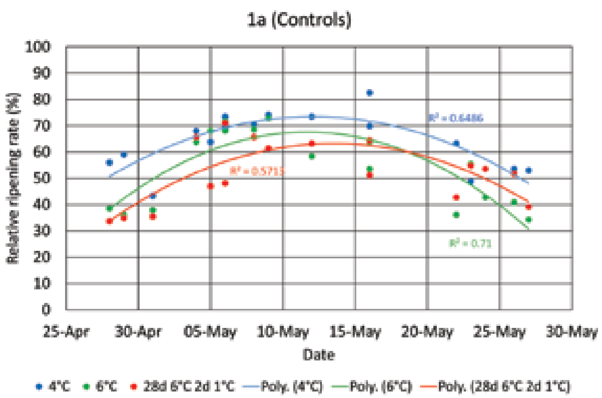
The relative ripening rates of the treatments are plotted in Figure 1a (controls) and Figure 1b (SmartFresh applications), while the relative standard deviations are plotted in Figure 2a (control) and Figure 2b (SmartFresh applications). Relative ripening rate and relative standard deviation were calculated by assigning a value of 100 to the overall longest ripening time/highest standard deviation for the entire trial (all storage temperatures/harvesting dates/Smartfresh treatments). All other (lower) values were expressed as a percentage of this highest value.

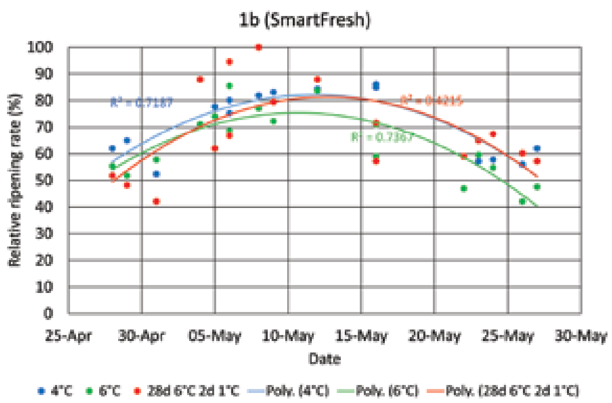
The convex seasonal ripening trend recorded for both the controls and the SmartFresh treatments (Fig. 1) is quite similar to that recorded for 'Hass' during, for instance, the 2009 season (Kruger & Magwaza, 2012). It is caused by the combined effect of the ambient ripening temperature and the maturity of the fruit.

The relatively small differences in ripening rate between the control and SmartFresh fruit corresponds with observations made during previous, similarly dry seasons (Kruger & Magwaza, 2012; Kruger *et al*., 2013).

Table 2. Mean ripening period recorded for fruit sampled from trees subjected to different irrigation treatments. Due to the low numbers of fruit sampled from certain trees, an additional calculation was made using all the fruit collected from all the trees in each treatment.

Replicate number	Mean (direct) ripening period per irrigation treatment (days)			
	Farm irrigation	-10 to -25 kPa	-25 to -35 kPa	-35 to -45 kPa
1	8,6	8,6	7,6	8,7
2	8,8	8,7	9,8	9,2
3		7,6	8,6	
4	8,6	9,6	9,0	10,7
5	9,2	9,1	9,0	12,1
6	9,2		11,4	9,2
Mean (per replicate)	8,9 a	8,7 a	9,2 a	10,0 a
Mean (all fruit)	8,9 a (±0.7)	9,0 a (±0.9)	9,5 b (±1.5)	10,4 c (±1.5)





Figures 1a & 1b. Relationship between the mean ripening rates (expressed as a percentage relative to the treatment that took the longest to ripen) and the sampling dates of control and SmartFresh-treated 'Hass' avocados. Fruit were collected from the end of April to the end of May 2016 from an avocado packinghouse and stored for 30 days at one of three different temperature regimes, before being ripened at room temperature.

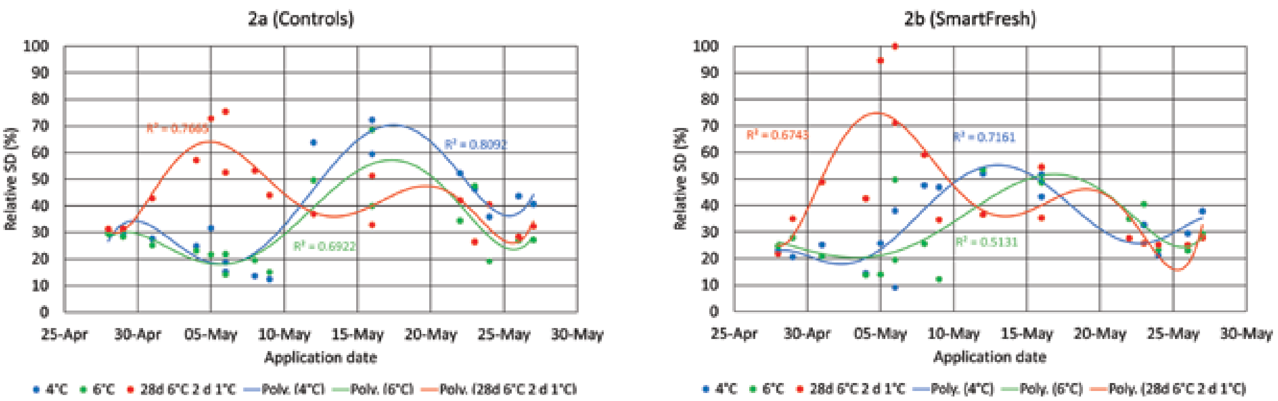


Figure 2. Relationship between the relative standard deviation scores (expressed as a percentage of the treatment that exhibited the most variation) and the sampling dates of control and SmartFresh-treated 'Hass' avocados. Fruit were collected from the end of April to the end of May 2016 from an avocado packinghouse and stored for 30 days at one of three different temperature regimes, before being ripened at room temperature.

This differed from that recorded during, for instance, the 2011 season when a significant deviation occurred during the middle of June (Kruger & Magwaza, 2012) or the 2012 season when the SmartFresh fruit took significantly longer than the controls to ripen (Kruger *et al*., 2013). At the time an explanation was offered based on the effect that climate may have on root growth/die-back and the subsequent uptake of water by the different sectors of the tree. The current results would seem to support this hypothesis.

Although the ripening rate differences between the different temperature treatments were relatively small in both the control and SmartFresh treatments, the standard deviations differed markedly from one stage of the season to the next (Fig. 2). The values recorded for both the 6°C and 4°C treatments were lower during the first and last thirds of the study period than during the middle part. The corresponding values recorded for the 6+1°C treatment were similar to the other two treatments during most of the period. However, from 5-10 May the standard deviation of the 6+1°C treatment increased drastically. The increase was quite significant in the control fruit and even more so in the SmartFresh treated fruit.

Our current hypothesis aimed at explaining the observed phenomenon concerns the carbohydrate metabolism of the fruit (Kruger & Lemmer, 2016). It was noticed that at specific times of season during certain years, fruit stored at a lower temperature ripened faster than those stored at a higher temperature and it was postulated that this may correlate with the carbohydrate related phenological cycle of the tree. Monosaccharides, from the *de novo* synthesis/catabolisation of starch reserves, are transported to the fruit where they may serve as an energy source or they may be converted into oil and/or starch – the latter of which may be converted back to monosaccharides when required. We suggest that the following may happen: if the monosaccharide level in the fruit is high at the time of harvest, it has enough reserves to sustain the fruit when stored at a relatively high temperature (e.g. 6°C) for a month followed by ripening. If the monosaccharide reserves are low during harvest (due to a demand from other plant organs), the fruit uses a high percentage of the available monosaccharides for respiration when stored at a high temperature. It then needs to convert the starch reserves in the fruit back to monosaccharides towards the end of the storage period and during subsequent ripening. This may take some time and lead to slower ripening in monosaccharide starved fruit that are stored at higher temperatures. This situation may be exacerbated when the storage temperature is drastically dropped at the end of the storage period, as happened with the 6+1°C treatment.

Acknowledgements

The authors would like to acknowledge SAAGA, Agrofresh, ZZ2, Afrupro and all other institutions and individuals who have contributed towards the study. We would also like to thank Mark Penter of the ARC-TSC for proofreading the manuscript.

REFERENCES

KRUGER, F.J. & LEMMER, D. 2014. Irrigation design and scheduling influence the ripening patterns of avocado fruit. *South African Avocado Growers' Association Yearbook* 37: 56-60.

KRUGER, F.J. & LEMMER, D. 2016. Intra-seasonal variation in the ripening rates of South African avocados stored at different temperatures. *South African Avocado Growers' Association Yearbook* 39: 119-125.

KRUGER, F.J. & MAGWAZA, L.S. 2012. Does orchard soil moisture content at the time of harvest influence the post-storage ripening pattern of 'Hass' avocado fruit. *South African Avocado Growers' Association Yearbook* 35: 47-53.

KRUGER, F.J., ROETS, N.J.R., VOLSCHENK, O., PIETERSE, P. & NZANZA, B. 2013. Further observations on the effect that rainfall, irrigation and fertilizer practices have on the ripening of avocado fruit. *South African Avocado Growers' Association Yearbook* 36: 9-16.

ROETS, N.J.R., SCHOEMAN, S.P. & MUROVHI, N.R. 2015. Calibrating soil-based irrigation norms of avocado using plant indicators. *South African Avocado Growers' Association Yearbook* 38: 60-65.