# Relationship between fruit pulp mineral composition and the ripening profiles of South African 'Hass' avocado fruit

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**ABSTRACT**

The present report deals with observations made regarding the effect that orchard topography/management practices and the associated pulp mineral content of the fruit have on the ripening profiles of South African 'Hass' avocados. Two sets of data are concerned. The first involves the ripening of fruit collected from a stem xylem water potential trial. The second deals with the ripening of fruit from trees that received different rates of nitrogen in an attempt to reduce the incidence of black cold damage. The results generated by the first study implied that the ripening profile of a batch of fruit from a specific orchard may be influenced by the topography of the orchard, particularly the flow patterns of the runoff water. This ultimately influenced the potassium content of the fruit. Fruit with higher pulp potassium contents were found to ripen considerably faster than those with a lower content. The results from the second study indicated that insufficient nitrogen fertiliser applications may also retard ripening. Appropriate fruit pulp nitrogen levels were also found to improve ripening, especially in the presence of higher manganese levels which in turn are indicative of adequate water uptake.

## INTRODUCTION

In previous studies we have found inadequate irrigation practices to contribute towards poor ripening patterns in South African avocado fruit (Kruger & Lemmer, 2014). The present report deals with the effects that orchard topography and fertiliser-induced fruit mineral composition variability has on the ripening profiles of the fruit.

The observations were made during two studies. The first concerns the Roets *et al.* (2015) stem xylem water potential trial. The original trial was laid out in the Tzaneen area. However, it was later moved to a more homogenous orchard in the Levubu area. The present authors, nevertheless, continued to sample the fruit from the original orchard for ripening purposes. The current report deals with the ripening patterns of the fruit sampled from the Tzaneen orchard.

The second study concerns the results of a black cold damage mitigation trial during which supplementary nitrogen applications were made to 'Hass' trees in an attempt to reduce black cold damage (Magwaza *et al*., 2008). This study included detailed ripening rate recordings which were processed for the present report.

## MATERIALS AND METHODS

### Stem xylem water potential trial

Fruit from fifty trees were used in this trial. It included both pre-selected well-bearing trees from the Roets *et al*. (2015) trial as well as a number of additional high yielding non-data trees from the same orchard. Thirty fruit were sampled from each tree during September 2015 and immediately ripened at room temperature. The mean fruit ripening period for each tree was then calculated and plotted on the orchard plan.

During January 2016, an additional sample of 10 fruit each was collected from 15 well-bearing trees and the pulp mineral content (N, P, K, Ca, Mg, S, Zn, Cu, Mn, Fe, B, Na & Cl) of each sample determined.

In addition to the above, the delivery rate of the micro-sprinklers servicing each of the data trees was measured. A series of profile pits were also dug throughout the orchard and the soil type distribution plotted.

### Black cold damage mitigation trial

Magwaza *et al.* (2008) applied five different N formulations at two irrigation scheduling rates to two repetitions of seven trees each during 2007. This was followed by sampling 10 fruit per replicate on 10 separate days during the season. The fruit were stored at 1°C for 28 days in an attempt to induce black cold damage lesions. Upon removal from cold storage, the fruit were ripened at room temperature in the laboratory. The number of days to ripen each

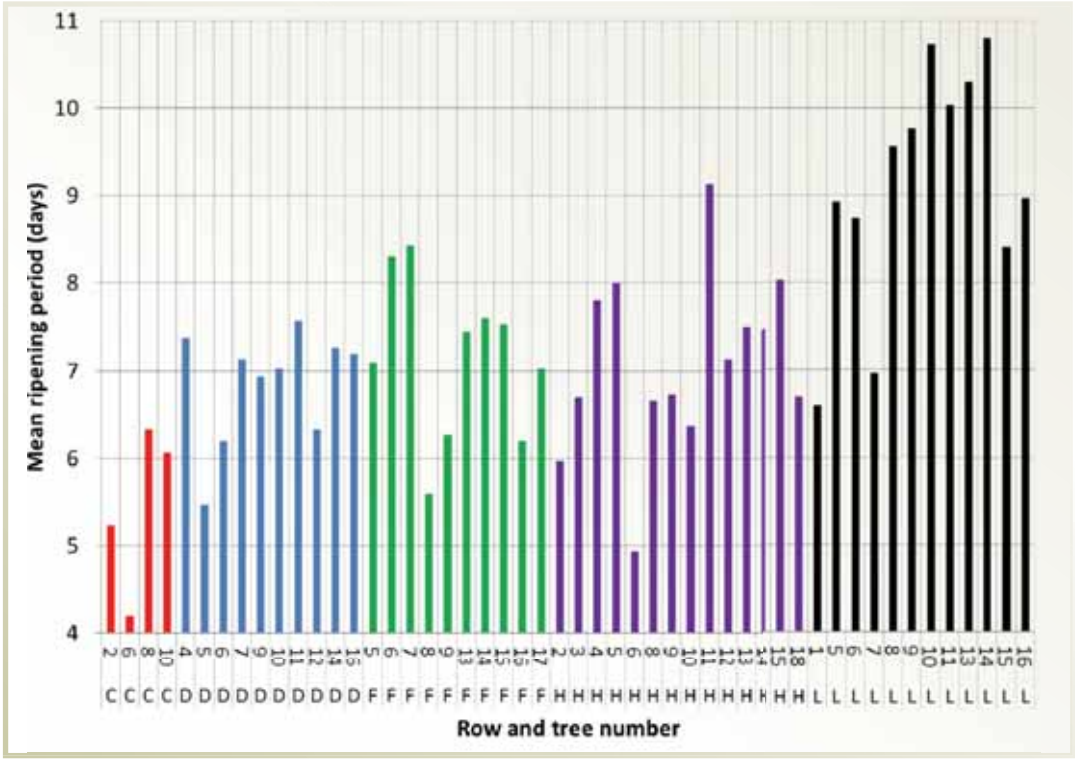


**Figure 1.** Mean ripening rates of 'Hass' fruit from 50 trees in the orchard used by Roets *et al.* (2015).

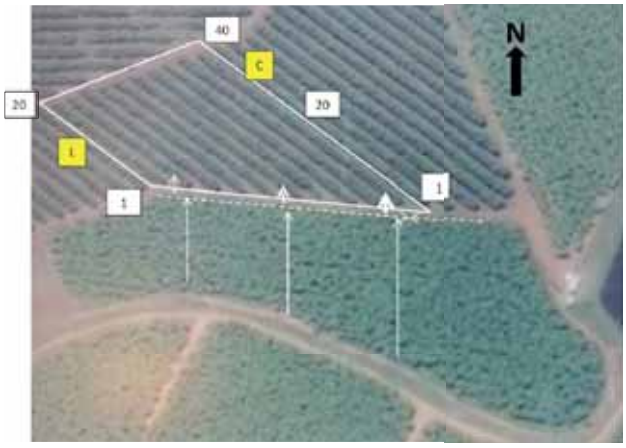


**Figure 2.** Orchard topography and water runoff patterns in the orchard used by Roets *et al.* (2015).

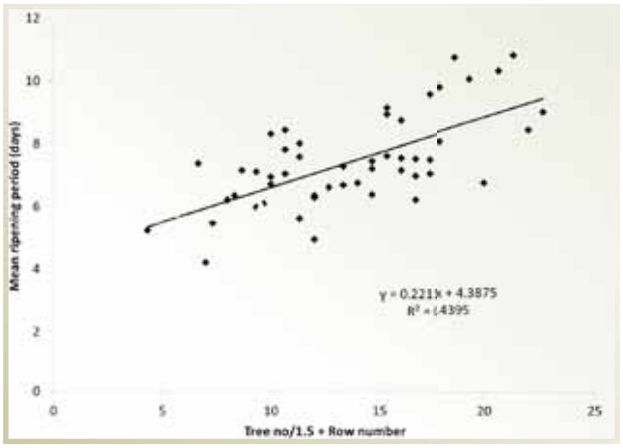


**Figure 3.** Relationship between mean ripening period and a transformed expression of orchard position used by Roets et al. (2015).

fruit was determined and the mean of each treatment calculated.

During April, the pulp contents of 10 fruit from each replicate was pooled and the mineral content determined as above. The relationship between the mineral contents of the samples and the mean ripening rate, as recorded on the 10 dates, was plotted.

## RESULTS AND DISCUSSION

In Figure 1 the mean ripening rates of 50 trees located in the Roets *et al*. (2015) stem xylem water potential trial are plotted according to orchard position. Considerable variation occurred among trees. The mean ripening period of the fastest ripening tree's fruit (tree no 6 in row C) was just over four days. In contrast, the mean ripening period of the slowest ripening tree's fruit (tree no 14 in row L) was nearly 11 days.

The outlay of the trial orchard is shown in Figure 2. The following deductions can be made when comparing Figure 1 with Figure 2:

- The fruit sampled from trees on the western side of the plot tended to ripen faster than those sampled on the eastern side.
- The fruit sampled from trees on the southern side tended to ripen faster than those sampled on the northern side.
- In each row, fruit from certain trees between positions 1 and 8 ripened considerably faster than those from their neighbours.
- The above trends are mathematically depicted in Figure 3. (In order to generate the equation, the

row letters were converted to numbers and the tree number was divided by 1.5 so as to make their mathematical impact more comparable with those of the converted row numbers.)

The soil type was homogenous throughout the orchard and no discernable spatial orientation trend insofar as the delivery rates of the micro-sprinklers were found. These factors could thus not have influenced the orchard position related ripening rates of the fruit. The same applies to the Roets *et al*. (2015) stem xylem water potential treatments and the maturity (pulp moisture content) of the fruit.

After processing the above information, the orchard topography was studied and the (rainfall induced) water flow patterns plotted (white arrows in Fig. 2). The following deductions were made:

- The runoff water flows from south to north.
- The water enters the avocado orchard from the adjacent banana plantation located to the south of the avocado orchard.
- Most of the runoff water tends to flow from west to east (from row L to row C) in the service road between the avocado orchard and banana plantation (Fig. 4).
- To the east, the water runs from east to west (from row A to row C), which is the lowest lying point in the road (Fig. 4).
- In various places, flow marks were noticed, which indicated that the overflow water from the road tended to enter between the rows and accumulate under certain trees on the southern side of the orchard. Although it was not possible to corroborate with 100% certainty, there were indications that the water collected under the trees with the fastest ripening fruit (located between positions 1 and 8 in each row).
- The results imply that the ripening profile of a batch of fruit from a specific orchard may be influenced by the topography of the orchard, in particular the water flow patterns.

The mineral analyses results showed a very clear relationship between the ripening rate of the fruit and their potassium content (Fig. 5).

It is well known that potassium plays an important role in the (sometimes premature) ripening of banana fruit. The present study paves the way to explore the possibility of improving the ripening profiles of South African avocado fruit by means of appropriate potassium fertiliser applications.

Insofar as the black cold damage mitigation trial of Magwaza *et al.* (2008) is concerned, two minerals (nitrogen and manganese) showed a strong correlation between pulp content and ripening rate.

The relationship that existed between the mean ripening rates (10 dates) and the pulp nitrogen contents (measured during April) is shown in Figure 6. Fruit with a pulp content of 1% ripened approximately 30% faster than fruit with half a percent of nitrogen.

We have previously found high fruit pulp nitrogen content rates to be associated with soft landings and

**Figure 4.** Photograph of the service road between the banana plantation and the avocado orchard.

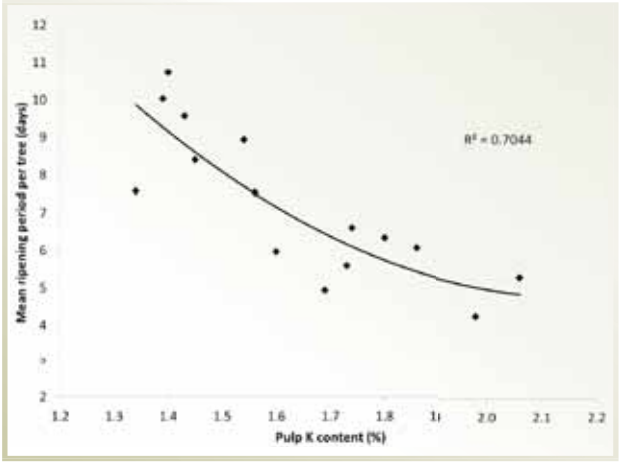


**Figure 5.** Relationship between the pulp potassium content and the mean ripening period of 'Hass' fruit from 15 well-bearing trees in the orchard used by Roets *et al.* (2015).

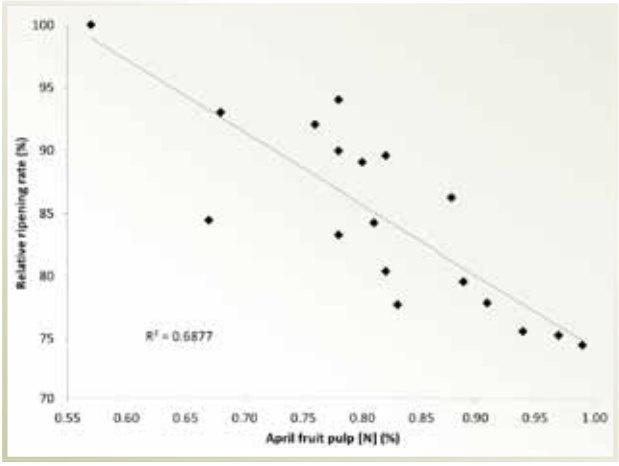


**Figure 6.** The relationship between relative ripening rates and the pulp nitrogen contents of 'Hass' fruit samples that were stored for one month at 1°C, before being ripened at room temperature. In each case the slowest ripening sample was designated a score of 100% and the faster ripening samples expressed as a proportion thereof.

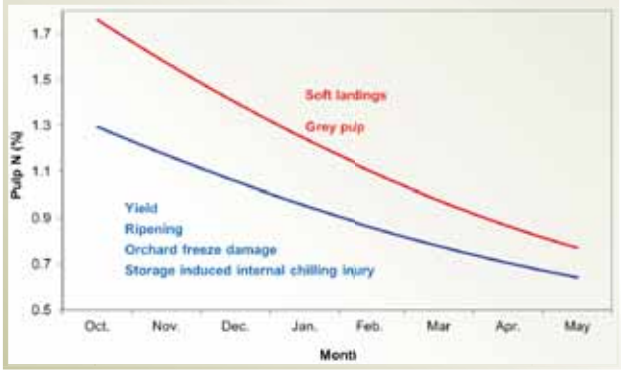


**Figure 7.** The current recommended maximum and minimum pulp nitrogen rates. The red line signifies maximum values proposed to control the disorders listed in red. The blue line indicates minimum values suggested for managing the aspects listed in blue. However, current results indicate that the plotted values require updating.

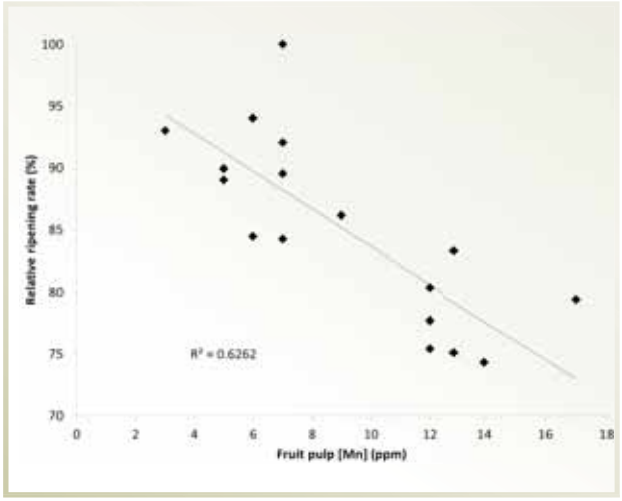


**Figure 8.** Relationship between the mean relative ripening rates (10 dates) and the (April) pulp manganese contents of 'Hass' fruit samples that were stored for one month at 1°C before being ripened at room temperature. In each case the slowest ripening sample was designated a score of 100% and the faster ripening samples expressed as a proportion thereof.

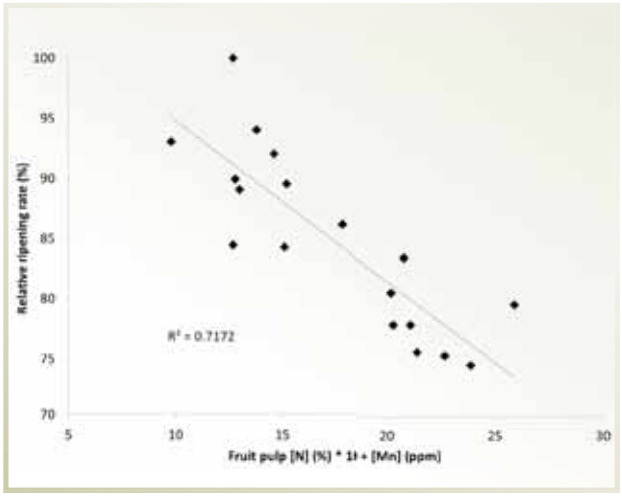


**Figure 9.** Relationship between the mean relative ripening rates (10 dates) and the (April) pulp nitrogen + manganese contents (transformed) of 'Hass' fruit samples that were stored for one month at 1°C before being ripened at room temperature. In each case the slowest ripening sample was designated a score of 100% and the faster ripening samples expressed as a proportion thereof.

grey pulp (Kruger & Magwaza, 2010). However, as the quality of the current fruit was acceptable, the slower ripening rates of the fruit with lower pulp nitrogen contents would seem to indicate that application rates were too low. From the present results it would appear that it is important that further research be conducted on the monthly fruit nitrogen norms (Fig. 7). The norms were initially introduced as a measuring tool to prevent soft landings and grey pulp due to elevated N levels. Maximum fruit N values were suggested for November and February. It has since been realised that the maximum norms need an upgrade and that the procedure shows potential to identify low N orchards that are susceptible to orchard cold/freeze damage, storage induced internal chilling injury and poor ripening. It will therefore be useful to have a full set of maximum and minimum fruit pulp N values from November to June.

The relationship that existed between the mean ripening rates, as recorded on the 10 dates, and the (April) pulp manganese content, is shown in Figure 8. We have previously found high Mn levels in the skin of mangoes to be associated with increased susceptibility to lenticel damage (Kruger & Fraser, 2004). We have also found high Mn rates in macadamia kernels to be associated with higher incidences of the onion ring disorder (Kruger *et al.* 2014). In both cases Mn did not cause the disorder but elevated levels were indicative of high soil moisture levels after good rains. In the present case the better ripening of fruit with high Mn levels may be due to the trees having higher, more favourable, soil moisture content levels. In an attempt to reveal the combined effect of N and Mn, the data points were transformed and plotted (Fig. 9). From the graph it would appear that a synergistic effect occurred between the 2 minerals.

In both the above studies copper showed a weak positive correlation and calcium a weak negative correlation with ripening. The observation regarding calcium is not surprising in context of the substantial literature on the effect that the element has on fruit quality, ripening and its inverse correlation with nitrogen. In terms of copper, the interpretation is more complex due to it being used as a spray application in the orchard.

Finally, we would like to draw attention to the fact that the pulp phosphorous levels of the fruit did not show a correlation with ripening. Kruger *et al.* (2013) found indications that higher soil P levels correlated with faster ripening. At the time the energy metabolism and root development functions of the element were cited as possible reasons. In light of the present results it would seem that the faster ripening of fruit from orchards with higher soil P values is most probably a function of good root development.

## FURTHER RESEARCH

During 2016 a trial will be launched to establish what effect soil ridging has on the ripening profiles of avocado fruit. The trial will be conducted in collaboration with soil scientists and a number of potassium treatments will be included.


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