Irrigation design and scheduling influence the ripening patterns of avocado fruit

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ABSTRACT
Previous results have indicated that water stress conditions at the time of harvest influence the postharvest ripening of avocado fruit. During the 2013 season, a trial was performed in an alternately planted experimental 'Hass'/'Maluma' orchard in the Schagen area. Fifty plots containing one pair of heavy bearing 'Maluma' and 'Hass' trees each were selected. In order to compile the ripening profiles of the fruit, 20 fruit per tree (thus a total of 1000 'Hass' and 1000 'Maluma' fruit) were sampled and ripened directly after harvest at 16°C. The results indicated that fruit from trees located in the center of the orchard ripened faster and more evenly than fruit from trees located on the edges of the orchard. Micro-sprinkler delivery rate measurements revealed that the center of the orchard received more water than the edges. It further indicated that the slope also influenced the delivery rate of the micro-sprinklers. The present study confirms our hypothesis that the uneven ripening regularly recorded by artificial ripeners in Europe may be induced by variations in orchard soil moisture content. It further infers that sub-optimal irrigation design and scheduling may contribute towards the problem.

INTRODUCTION

Previous research (Kruger & Magwaza, 2012; Kruger *et al*., 2013) has shown that water stress conditions at the time of harvest may influence the postharvest ripening of avocado fruit. There were also some indications that plant nutrition, particularly soil phosphorous status, may play a role. The present study aimed to establish to what extent irrigation design and scheduling influences avocado fruit ripening.

MATERIALS AND METHODS

The trial was performed in a 'Hass' orchard in the Schagen area in which the bottom eight rows were alternately inter-planted with 'Maluma' trees. Fifty plots containing one pair of heavy bearing 'Maluma' and 'Hass' trees each were selected for the study (Fig. 1).

The mean maturity of the fruit from each tree was determined, using ten individual fruit per tree. Mineral analyses were thereafter performed on the pooled dried pulp samples. Soil mineral analyses were also performed using six pooled 600 mm core samples per plot.

In order to compile the ripening profiles of the fruit, 20 fruit per tree (1000 'Hass' and 1000 'Maluma' fruit) were sampled and ripened directly after harvest at 16°C (direct ripening at a low temperature was selected to amplify variation).

RESULTS AND DISCUSSION

The summary statistics for the two cultivars are

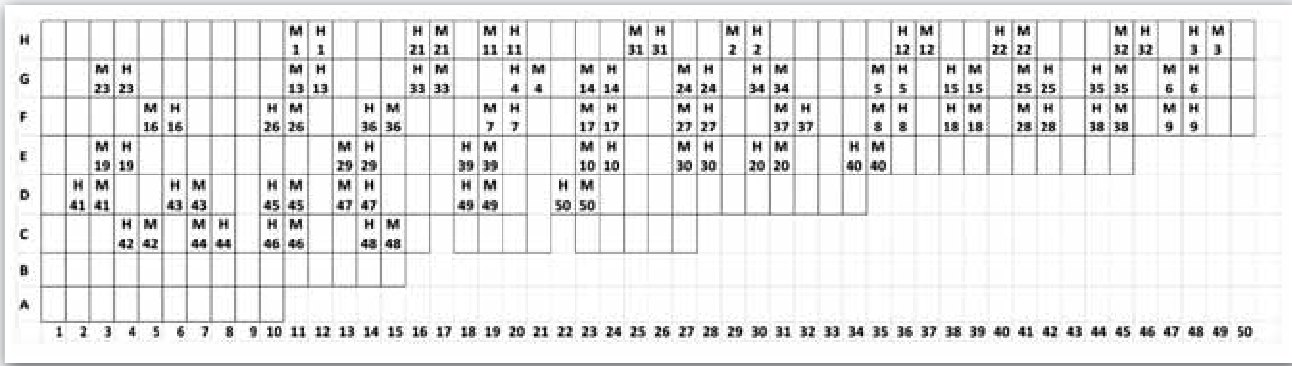

Figure 1. Location of the 50 experimental plots containing one 'Hass' and one 'Maluma' tree each.

shown in Table 1. As may be deduced from the table, the 'Hass' fruit were smaller and more mature than the 'Maluma' fruit and ripened at a slower rate.

The ripening profiles of the fruit are shown in Figure 2. The first 'Hass' fruit reached the ready to eat stage on day 13 and the last on day 22. A single peak occurred on days 17 to 18 during which approximately two thirds of the fruit ripened. The 'Maluma' fruit ripened between day 9 and day 22. Two distinct peaks occurred, one on day 11 and the other on day 17.

The 50 trees of each cultivar were hereafter ranked from the fastest to the slowest ripening. Remarkably, within the seven fastest ripening trees of each cultivar, five were from corresponding plots. In the case of the slowest ripening trees, the spread was somewhat wider in that five of the ten slowest ripening trees of each cultivar were paired. The ripening profiles of the five fastest and five slowest rip-

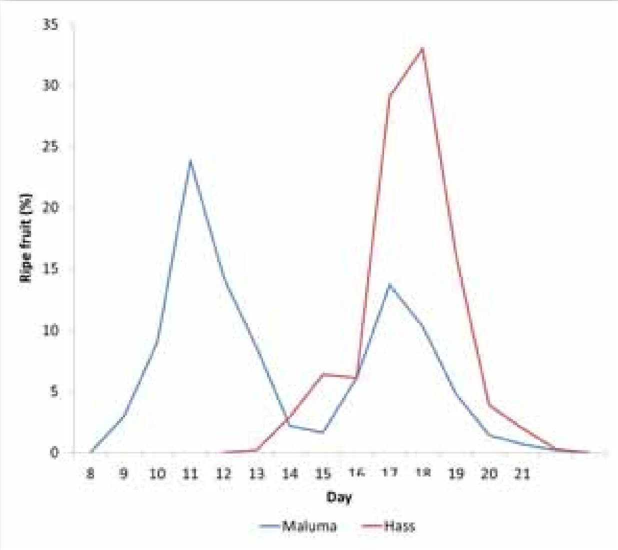

Figure 2. Ripening profiles of 1000 'Hass' and 1000 'Maluma' fruit ripened directly after harvest at 16°C.

Table 1. Moisture content and mean 'days to ripen' (DTR) of 1000 'Hass' fruit and 1000 'Maluma' fruit from 50 plots containing one 'Hass' and one 'Maluma' tree each. The fruit were ripened directly after harvest (no storage) at 16°C.

	Hass	Maluma
Fruit mass (g)	198.3 a	222.2 b
Moisture content (%)	70.4 a	74.5 b
Mean DTR (days)	16.6 a	12.8 b

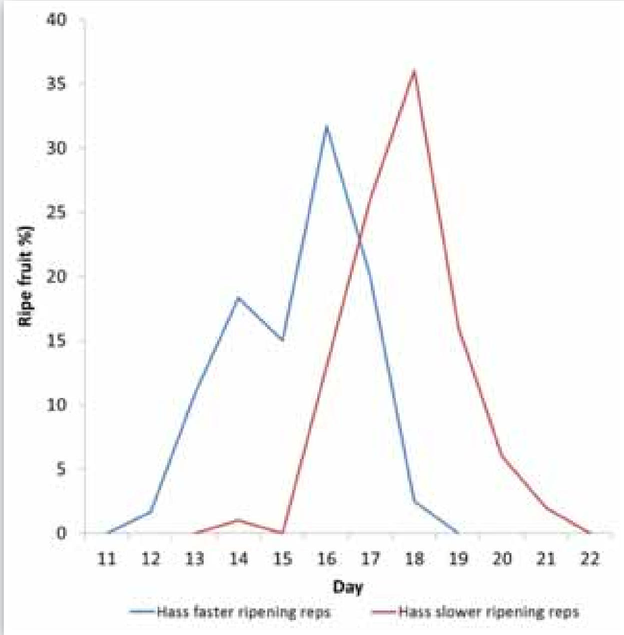

Figure 3. Ripening profiles of 'Hass' fruit from the five fastest ripening and the five slowest ripening paired plot repetitions. The fruit were ripened directly after harvest (no storage) at 16°C.

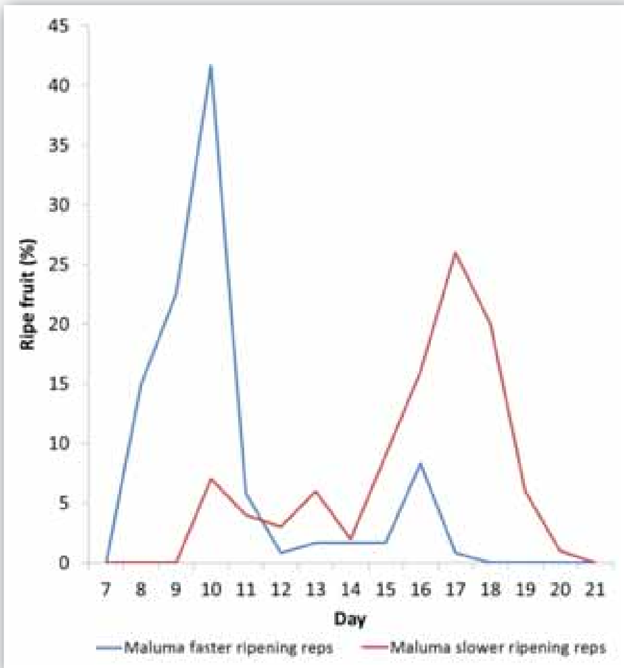

Figure 4. Ripening profiles of 'Maluma' fruit from the five fastest ripening and the five slowest ripening paired plot repetitions. The fruit were ripened directly after harvest (no storage) at 16°C.

Table 2. Mean 'days to ripen' (DTR) and fruit moisture content of the five fastest/slowest ripening paired plot repetitions. The fruit were ripened directly after harvest (no storage) at 16°C.

	Hass		Maluma	
	Mean DTR (days)	Fruit moisture (%)	Mean DTR (days)	Fruit moisture (%)
Five fastest ripening paired plot repetitions	**15.4 a**	**70.6 a**	**10.3 a**	**75.4 a**
Five slowest ripening paired plot repetitions	**17.8 b**	**70.1 a**	**15.7 b**	**73 b**

ening paired trees were hereafter drawn. In the case of 'Hass' (Fig. 3), the peak shifted from day 16 (five fastest ripening paired trees) to day 18 (five slowest ripening paired trees). However, in the case of 'Maluma' (Fig. 4), two distinct peaks occurred: one on day 10 (fastest ripening paired trees) and the other on day 18 (slowest ripening paired trees). The summary statistics for the fruit from the fastest and slowest ripening pairs of trees are shown in Table 2. The most important observation to be made from the table is that the fruit from the five fastest ripening pairs were not more mature than those from the five slowest ripening pairs.

Interestingly, the five fastest ripening plots were located in the center of the orchard, while the five slowest ripening plots were on the edges. Closer inspection of the spatial distribution of the individual 'Hass'/'Maluma' tree rankings revealed a distinct pattern. This applied to, especially, the top three rows containing 50 trees each. Fruit from trees located in the center of the rows had a lower (faster ripening) ranking than trees located to the edges of the orchard. Three distinct blocks of trees were discernable (Fig. 5). The two outside blocks had the highest (slowest ripening) mean rankings of respectively 32.2 and 33.3, while that of the center block was significantly lower (fastest ripening) at 15.5. It was noticed that the positioning of the three blocks more or less corresponded with the design of the irrigation system (Fig. 6). However, the block positioning was skewed in that the southern (left in the figure) block was larger than the northern (right in the figure) block. In an attempt explain this observation, it was postulated that the orchard is sloped from south to north (Fig. 7). The water pressure and the sprinkler delivery rates are thus higher towards the southern end of the rows.

The next step was to measure the water delivery rates of the micro-sprinklers. The results clearly indicated that the center block received more water than the two outside blocks (Fig. 8). It further confirmed that the slope influenced the delivery rate of the micro-sprinklers. Interestingly, the regression line seemed to point out that, where the 20 mm irrigation pipes are replaced with 15 mm pipes, a higher pressure was attained, but only over a short distance.

The soil texture and soil mineral analyses as well as the fruit mineral analyses rendered inconclusive results.

The present study infers that the different ripening

Figure 5. Mean ranking of trees grouped according to their fruit ripening rates. Three clearly discernable blocks occurred in the upper three rows of the experimental 'Hass'/'Maluma' orchard (the tree with the fastest ripening fruit was ranked 1, while the tree with the slowest ripening fruit was ranked 50).

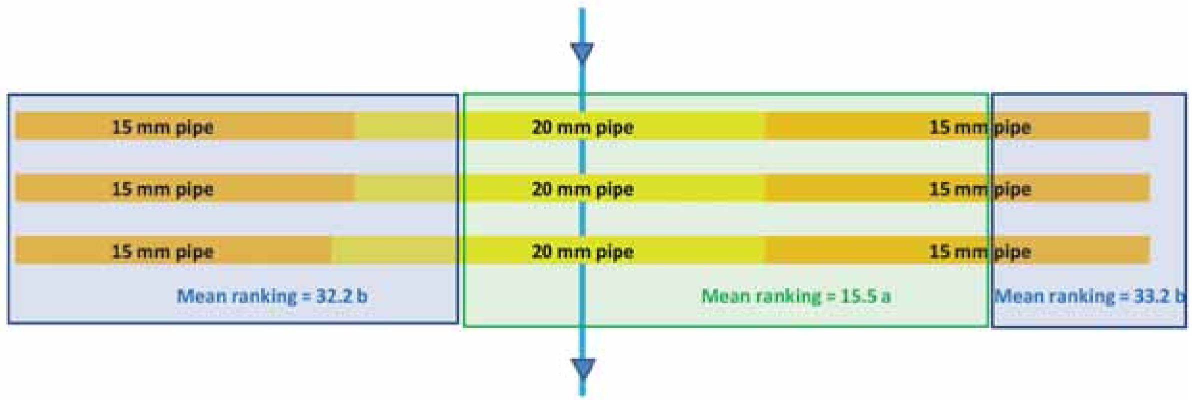

Figure 6. Location of the three blocks shown in Figure 5 in relation to the irrigation system outlay. The blue line represents the lateral pipe.

Figure 7. Cross sectional view through one of the rows shown in Figure 5. The blue circle represents a cross section through the lateral pipe.

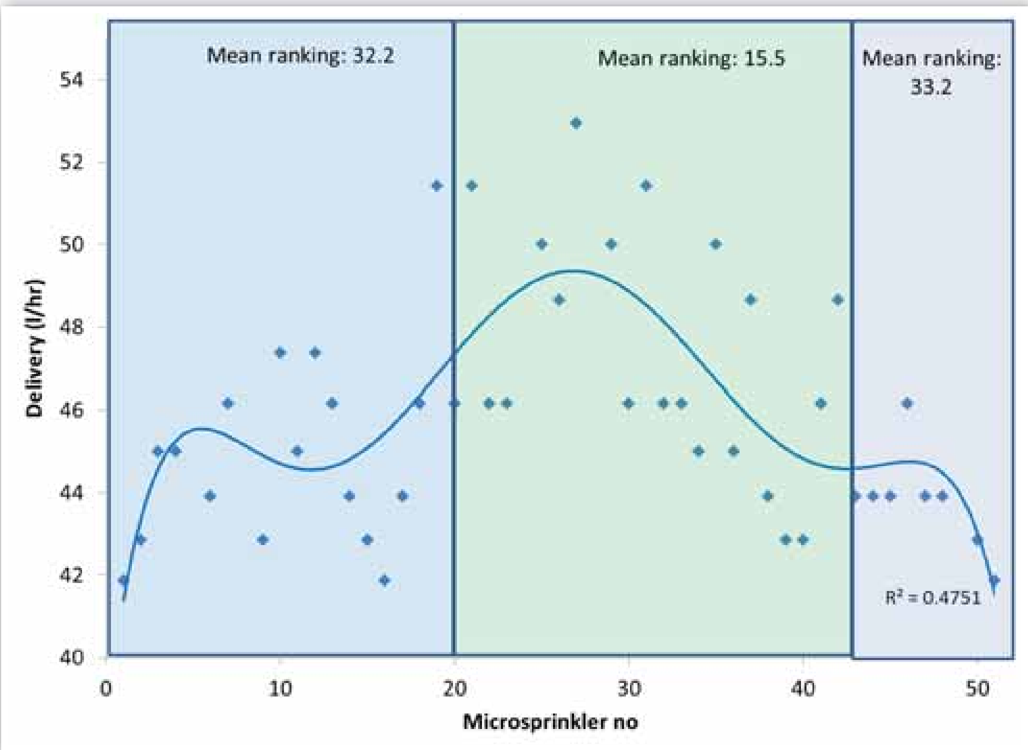

Figure 8. Micro-sprinkler delivery rates recorded in the top row of an alternately planted experimental 'Hass'/'Maluma' orchard in the Schagen area (three outliers with micro-sprinkler defects omitted). The mean ripening rate rankings of the fruit sampled from the three blocks are also indicated (ranking of the trees: 1 = fastest ripening tree of both cultivars; 50 = slowest ripening tree of both cultivars).

peaks regularly recorded by artificial ripeners in Europe may be induced by variations in soil moisture in the orchards the fruit originates from. It would appear that irrigation design and scheduling may significantly contribute towards uneven ripening. Further research on the topic is required to formulate appropriate irrigation design and scheduling recommendations.

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