Effect of irrigation management on avocado ripening: Long term consistency would seem to be more important than short term variations

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ABSTRACT

During recent seasons a series of studies was conducted to establish what effect orchard management practices and climate have on avocado fruit ripening. The sources of information included specifically designed trials; ripening results obtained from experiments aimed at investigating certain horticultural (i.e. mulching) and postharvest (i.e. black cold damage) issues, as well as the analyses of ripening related feedback received from exporters. In the present article we report on the following three aspects: (1) preliminary results from a trial concerned with the relationship between midday stem xylem water potential (MSXWP) and ripening rate, (2) a trial dealing with the "drying out" of orchards prior to harvest, and (3) results from the SmartFresh holdback sample programme. The results indicated that long term consistency is more important than short term fluctuations in so far as ripening uniformity is concerned.

INTRODUCTION

The efficient ripening of avocado fruit, exported to Europe in particular, is of paramount importance to the South African industry. For this reason, SAAGA has commissioned a number of studies on the topic in the recent past. These studies clearly demonstrated the important role that climate (particularly rainfall) and horticultural practices (especially irrigation and soil P levels) play with regard to fruit ripening (Kruger & Magwaza, 2012; Kruger *et al*., 2013; Kruger & Lemmer, 2014).

An aspect requiring further attention concerns the relative importance of short and long term variations in climate and horticultural practices. In this article we report on the following three studies dealing with the ripening of:

- 'Hass' fruit from a midday stem xylem water potential (MSXWP) trial (preliminary results);
- 'Hass' and 'Maluma' fruit that were water starved over a three week period prior to harvest; and
- 'Pinkerton' fruit from the SmartFresh holdback sample programme.

MATERIALS AND METHODS

Midday stem xylem water potential (MSXWP) trial

This trial consists of four treatments with six repetitions each and is taking place in a 'Hass' orchard located in the Tzaneen area (Roets *et al*., 2014). The current researchers were tasked with evaluating the ripening of the fruit from all 24 repetitions. Unfortunately the producer started to harvest the orchard before sampling commenced and samples from only five replicates were obtained (Fig. 1). Each sample consisted of 30 fruit that were stored for 30 days and then ripened at 18°C. An additional 10 fruit per tree were used for moisture content analyses.

Water withholding prior to harvest

This trial was performed in a mixed 'Hass' and 'Maluma' orchard previously used for trials aimed at establishing what effect pre-harvest conditions have on postharvest ripening (Kruger & Lemmer, 2014). During the 2014 season the water supply to one row, consisting of 25 'Hass' and 25 'Maluma' trees each,

was turned off over a 20 day period prior to sampling. During this 20 day period, the rest of the orchard received two irrigation applications on respectively day 7 and day 14.

At the end of the 20 day water withholding period, 100 'Hass' and 100 'Maluma' single fruit replicates were randomly sampled from, respectively, the water starved row and the rest of the orchard. The fruit were stored for 30 days at 5°C and ripened at 18°C. The number of days to ripen each fruit was then recorded.

Ripening profiles of fruit from the SmartFresh holdback sample programme

Four cartons of fruit are routinely sampled during each SmartFresh application. Two of these are immediately ripened and the remaining two cartons are stored at 5°C for 30 days before being ripened at room temperature.

During the 2013 season, 12 SmartFresh applications were made to 'Pinkerton' fruit originating from two well managed farms in the Mooketsi area. The ripening results from the stored samples rendered quite interesting results and are included in the present report.

Table 1. Mean size and moisture content of 'Hass' fruit from the current midday stem xylem water potential trial (Roets *et al*., 2014).

Tree number	Mean fruit size (g)	Mean fruit moisture content (%)
1	207 a	69.9 a
2	215 a	69.1 a
3	229 a	69.9 a
4	205 a	69.1 a
5	211 a	69.1 a

RESULTS AND DISCUSSION

Midday stem xylem water potential (MSXWP) trial

A linear relationship existed between the mean MSXWP values (6 readings: one per month, January to June 2014) and the mean number of days to ripen each sample (Fig. 2). The mean ripening period of the fruit from the tree that was least water stressed throughout the season was less than 4 days, while that of the tree that was most water stressed was more than 7 days (Fig. 2). Interestingly, the fruit size and maturity were not affected by the irrigation treatments (Table 1).

The trial is continuing and it is anticipated that useful information will be generated during coming

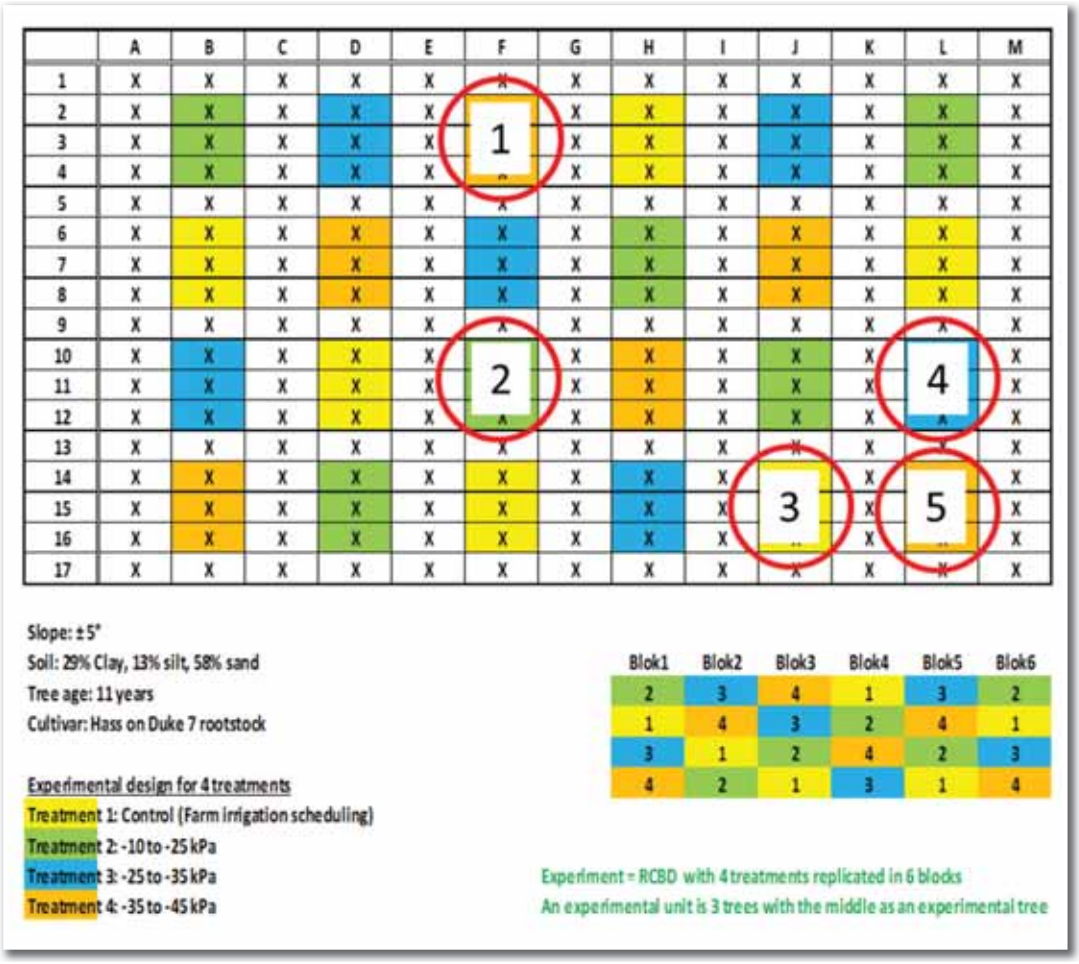

Figure 1. Trial layout of the midday stem xylem water potential (MSXWP) trial currently taking place in a 'Hass' orchard in the Tzaneen area (Roets *et al*., 2014). The circles indicate the repetitions from which fruit were obtained for ripening.

seasons when a full set of fruit will be evaluated. One aspect that will receive particular attention is the interaction between climate and ripening rate.

Water withholding prior to harvest

The mean ripening rates of the 'Hass' and 'Maluma' fruit samples are shown in Table 2. Interestingly, the mean ripening period for 'Hass' (both treatments) was approximately 9 days while 'Maluma's' mean was 3.6 days. However, with both cultivars there were no difference in ripening rate between the fruit from the normally irrigated rows and the row that was dried out for 3 weeks prior to harvest.

The ripening results were thus broadly similar to those recorded by Kruger *et al*. (2013), who compared the ripening profiles of fruit from the same (weekly irrigated) orchard before and after irrigation.

The mass and moisture contents of the fruit are shown in Table 3. The (short term) water withholding treatment did not affect the fruit mass. It did, however, affect the fruit moisture content. In the case of 'Hass' the dried out orchard's fruit moisture content was around two and a half percentage points lower than that of the control, while in Maluma it was three and half percentage points lower. This is the first time we have noticed this phenomenon and it certainly requires further investigation.

Ripening profiles of fruit from the SmartFresh holdback sample programme

The post-storage ripening profiles of nine 'Pinkerton' consignments from different blocks on the same farm

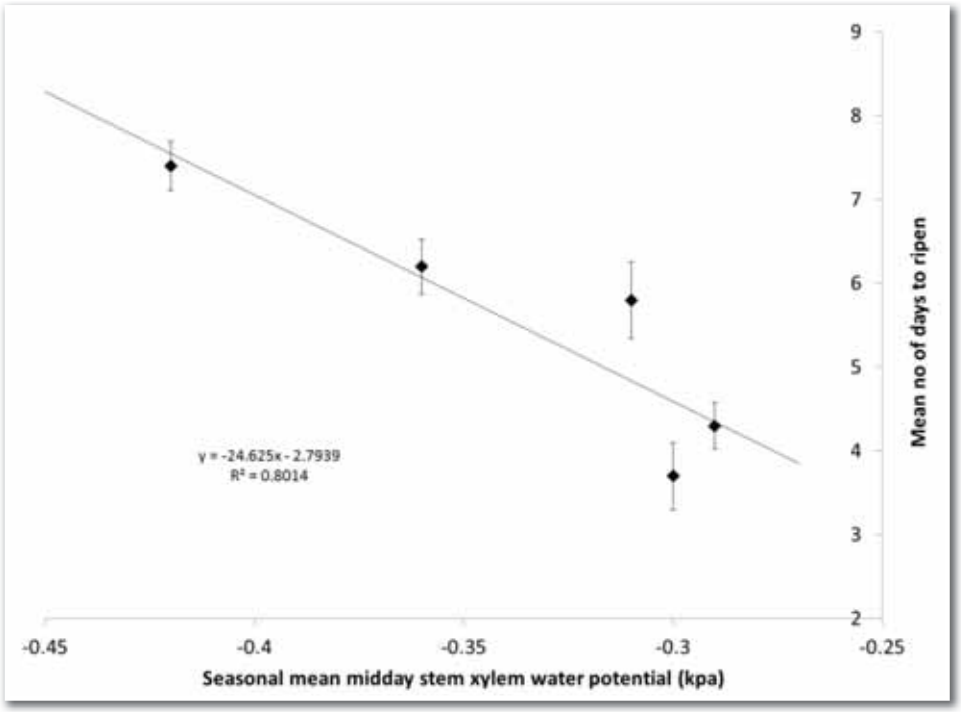

Figure 2. Mean ripening rates (with standard error bars) of the 5 repetitions shown in Figure 1.

Table 2. Mean number of days required to ripen 'Hass' and 'Maluma' fruit from trees that were irrigated on a weekly basis and fruit from trees that did not receive an irrigation treatment during the last three weeks before harvest.

Cultivar	Irrigation treatment	Mean no. of days to ripen
'Hass'	Normal irrigation	8.9 (+ 1) a
	Dried out last three weeks	9.1 (+ 2.2) a
'Maluma'	Normal irrigation	3.6 (+ 0.7) b
	Dried out last three weeks	3.6 (+ 0.7) b

Table 3. Mean fruit size and moisture content of 'Hass' and 'Maluma' fruit from trees that were irrigated on a weekly basis and fruit from trees that did not receive an irrigation treatment during the last three weeks before harvest.

Cultivar	Irrigation treatment	Mean fruit size (g)	Mean fruit moisture content (%)
'Hass'	Normal irrigation	233 a	69.9 a
	Dried out last three weeks	233 a	67.5 b
'Maluma'	Normal irrigation	289 p	73.6 p
	Dried out last three weeks	278 p	70 q

that received SmartFresh applications are shown in Figure 3A. The combined profile of the above treatments is shown in Figure 4A. As may be deduced from the graphs, a number of control fruit were already at the ready to eat stage upon removal from cold storage. The SmartFresh fruit generally started to ripen a day or two after the controls and usually ripened in a fairly condensed band. A soft landing would thus have been prevented, while the synchronised ripening profiles of the fruit would have been highly acceptable to artificial ripeners.

The ripening profiles of three SmartFresh treatments applied to poorly ripening fruit from a second farm are shown in Figure 3B. The combined profiles of the three treatments are shown in Figure 4B. As may be deduced from the graphs, the first control fruit only ripened on day 6 and ripening continued until day 13. The SmartFresh fruit ripened between days 11 and 20. The ripening profiles of the fruit would therefore have been completely unacceptable

A

			Ripe fruit (%)									
	Consignment	Treament	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
	1	Control	20	0	20	30	30	0	0	0	0	0
	1	SmartFresh	0	0	30	30	40	0	0	0	0	0
	2	Control	0	20	20	20	40	0	0	0	0	0
	2	SmartFresh	0	0	30	40	30	0	0	0	0	0
	3	Control	0	0	15	8	15	23	23	15	0	0
	3	SmartFresh	0	0	0	0	0	0	25	25	25	25
	4	Control	0	13	17	13	8	17	13	8	13	0
	4	SmartFresh	0	0	8	17	13	4	17	17	8	17
	5	Control	11	6	17	11	11	0	6	17	6	11
	5	SmartFresh	0	0	0	17	17	17	22	22	6	0
	6	Control	0	17	11	17	17	11	11	11	6	0
	6	SmartFresh	0	22	22	22	22	11	0	0	0	0
	7	Control	0	13	6	19	13	19	6	0	13	6
	7	SmartFresh	0	0	0	19	13	19	19	25	6	0
	8	Control	13	19	19	25	19	0	0	6	0	0
	8	SmartFresh	0	0	0	19	19	13	25	25	0	0
	9	Control	6	13	13	19	19	13	0	13	6	0
	9	SmartFresh	0	0	13	19	19	19	25	6	0	0

B

			Ripe fruit (%)																		
	Consignment	Treament	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20
	1	Control	0	0	0	0	0	0	0	13	13	19	19	19	19	0	0	0	0	0	0	0
	1	SmartFresh	0	0	0	0	0	0	0	0	0	0	0	0	14	9	9	9	14	23	14	9
	2	Control	0	0	0	0	0	0	0	0	19	25	25	25	6	0	0	0	0	0	0	0
	2	SmartFresh	0	0	0	0	0	0	0	0	0	0	0	13	13	25	13	19	19	0	0	0
	3	Control	0	0	0	0	0	11	33	39	6	6	0	0	6	0	0	0	0	0	0	0
	3	SmartFresh	0	0	0	0	0	0	0	0	0	0	11	11	28	17	17	17	0	0	0	0

Figure 3. Individual ripening profiles of (A) nine satisfactory ripening batches of 'Pinkerton' fruit from a farm in the Tzaneen area and (B) three unsatisfactory ripening batches of 'Pinkerton' fruit from a second farm in the Tzaneen area.

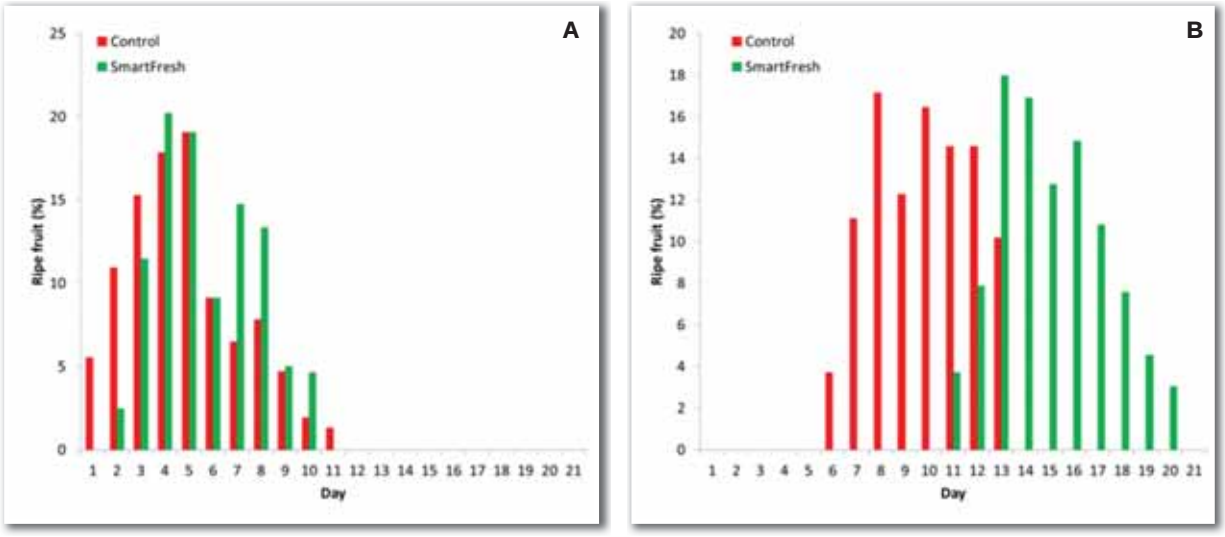

Figure 4. Combined ripening profiles of (A) nine satisfactory ripening batches of 'Pinkerton' fruit from a farm in the Tzaneen area and (B) three unsatisfactory ripening batches of 'Pinkerton' fruit from a second farm in the Tzaneen area.

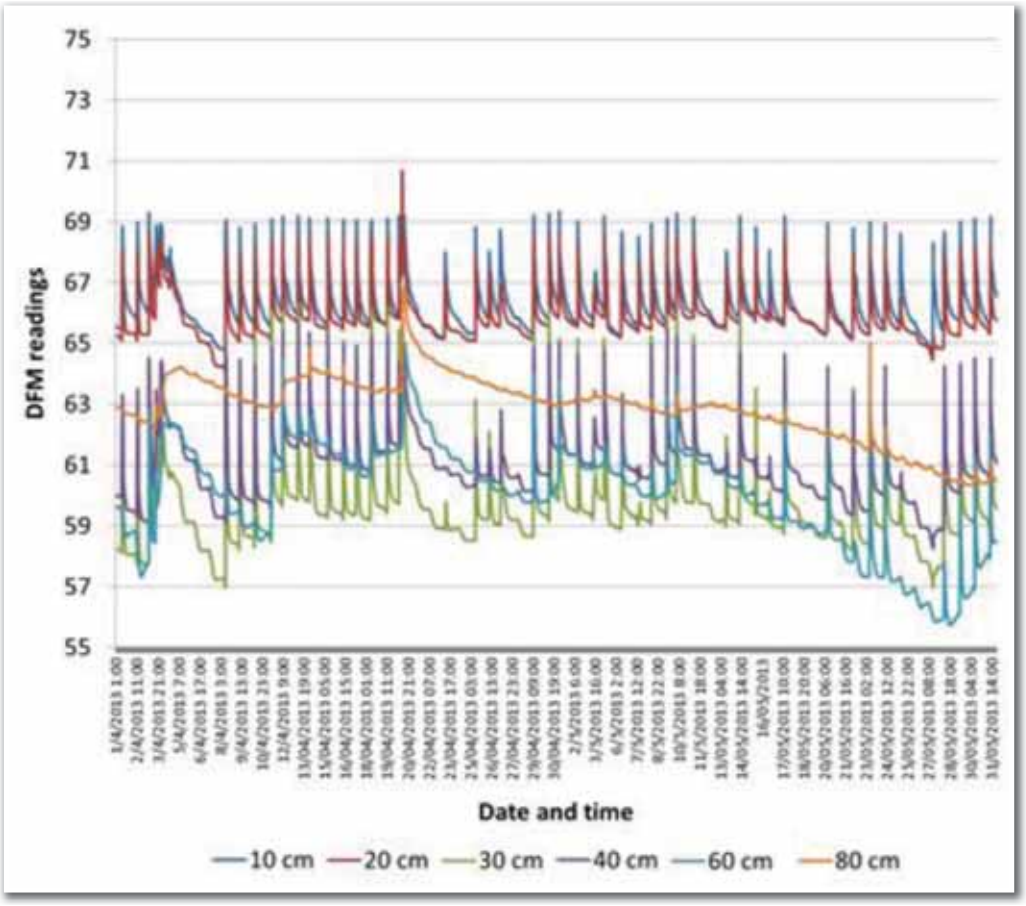

Figure 5. DFM readings taken in one of the orchards from which the satisfactory ripening fruit were obtained.

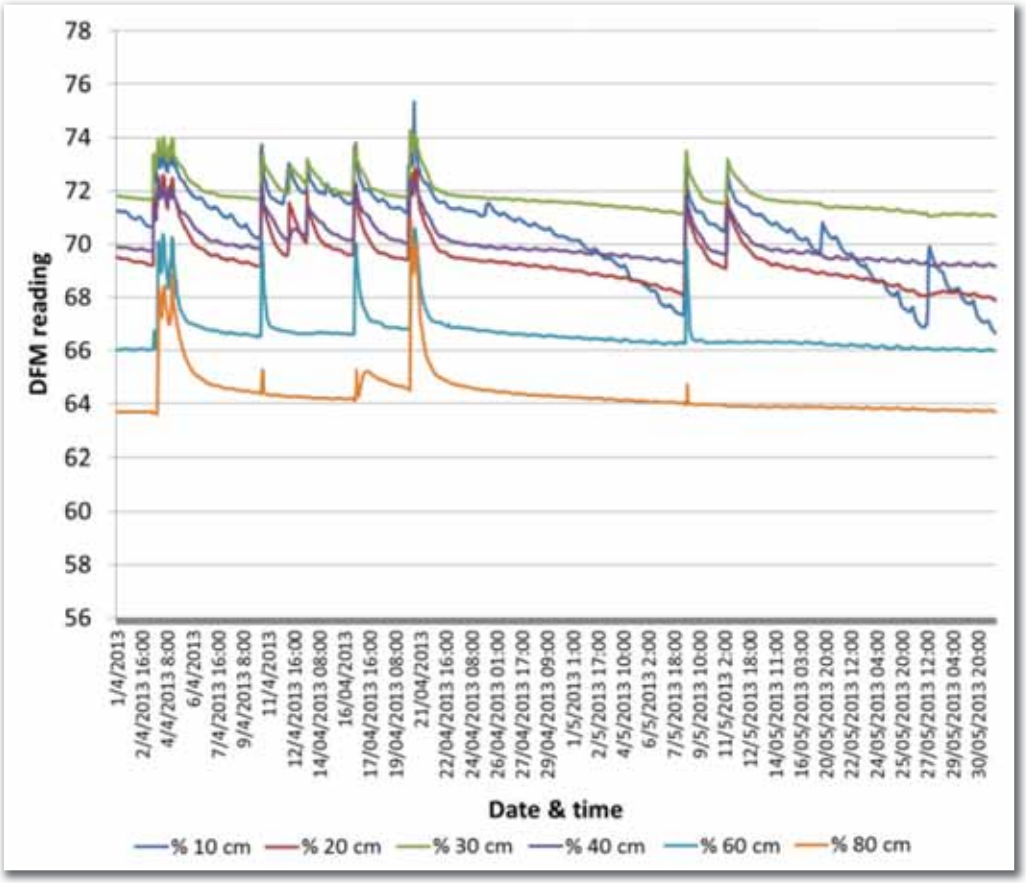

Figure 6. DFM readings taken in one of the orchards from which the unsatisfactory ripening fruit were obtained.

to artificial ripeners.

As DFM probes were installed on both farms, it was possible to compare soil water profiles at different depths. A DFM recording from one of the satisfactory ripening blocks is shown in Figure 5. The graph clearly shows that the trees were able to easily extract the water from soil depths between 10 cm and 60 cm. It also shows that the irrigation scheduling was such that the soil water was replenished at regular intervals at all depths.

A profile pit dug in one of the above (satisfactory ripening) blocks showed root development throughout the profile (Fig. 7). This explains the favourable extraction/replenishment curves found at all depths.

A DFM recording from one of the unsatisfactory ripening blocks is shown in Figure 6. The graph clearly shows that the trees only extracted water from the top 10 cm of soil. It also shows that the top 10 cm of soil was not adequately replenished at the correct intervals. Profile pits dug in these blocks (Fig. 8), showed root development in the top 10 cm of soil only. We are of the opinion that failure to keep the top 10 cm adequately watered throughout the season caused the poor ripening recorded in these orchards.

Figure 7. Profile pit dug in one of the orchards from which the satisfactory ripening fruit were obtained.

Figure 8. Profile pit dug in one of the orchards from which the unsatisfactory ripening fruit were obtained.

RECOMMENDATIONS

Pre-planting soil preparation is extremely important for root development and ultimately good avocado fruit ripening. It is very useful to dig profile pits in each orchard in order to gauge the root status. This will enable the formulation of appropriate management decisions regarding irrigation volumes and scheduling. Orchards with shallow root systems must be irrigated more regularly with lower volumes of water rather than less regularly with higher volumes of water.

FURTHER RESEARCH

We are currently investigating the ripening related advantages to be gained from the planting of orchards on well-constructed ridges.

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