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NOTA CIENTIFICA

SEASONAL WATER REQUIREMENTS OF AVOCADO TREES GROWN UNDER SUBTROPICAL CONDITIONS

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INTRODUCTION

The purpose of this investigation was to determine the seasonal water requirements of 'Fuerte' and 'Hass' avocados grown under subtropical conditions and to establish the effect of a water stress during certain fruit growth phases on yield and fruit size.

According to Lahav and Kalmar (1977) avocados grown under winter rainfall conditions in Israel need only 6680 $m^3 \cdot ha^{-1} \cdot annum^{-1}$. They are, however, only irrigating 8 months per year, unlike South Africa where irrigation is needed all year round. Gustafson *et al*. (1979) in California found that 6 yr old avocado trees needed 7875 $m^3 \cdot ha^{-1} \cdot annum^{-1}$ with micro irrigation and a maximum of 115 P $water \cdot tree^{-1} \cdot day^{-1}$ in summer. According to Adato and Levinson (1988) 'Fuerte' performed better with their drier treatment than the wetter treatment.

Robertson (1969) indicated the first 70 days after fruitset of 'Fuerte' to be the most critical for a water stress. A water stress during the second phase of fruit growth will result in smaller fruit. This was confirmed by Bower (1985) and he also stated that a soil matric potential of -55 kPa at 250 mm depth on a clayey soil should not be exceeded. Whiley *et al*. (1988) recommended that tensiometer readings of -40 kPa at 300 mm depth on a clay loam soil, during spring, should not be exceeded, whereas this value should be lowered to -30 kPa during the second fruit drop period (December/January). A study by Vuthapanich *et al*. (1995) showed that well watered 'Hass' trees (-20 kPa) on a clay loam soil had twice the yield of drier treatments (-40 and -70 kPa at a soil depth of 300 mm) due to more fruit per tree (no effect on fruit mass). Faber *et al*. (1995), using 'Hass' trees stated that different irrigation treatments only show an effect on accumulative yield in the fourth year. Their best treatment was 70 % of reference evapotranspiration (Eto) with the wettest treatment 111 % of Eto giving the largest trees, but the lowest yield.

From this short overview it can be seen that irrigation or a water stress had an effect on yield and sometimes also on fruit size of avocados. However, the matric potentials given are different for different textured soils, without relating it to the availability of water in the soil and referring mainly to the topsoil (0 to 300 mm depth). The applicability of these data are thus doubtful because the extent of water stress is not defined in terms of available water in the soil profile or root zone.

MATERIALS AND METHODS

'Fuerte' and 'Hass' trees on 'Duke 7' rootstocks were planted in two blocks during March 1998 at the Burgershall Experimental Station on a deep red clayey soil (35 % clay) with a planting distance of 10 x 5 m. Six treatments were applied to each cultivar with 4 replicates and 5 data trees per treatment with one guard tree between treatments in the row. Micro irrigation (strip wetting) was used with one spreader between two trees, delivering 35 P.h^{-1} with a radius of 2.75 m, giving a wetted area of approximately 7 m^{2}·tree^{-1}. Water applied per treatment was measured with an industrial flow meter. The season was divided into three phases (see Table 1) and each phase subjected to either a wet (short irrigation cycle) or dry (long irrigation cycle) treatment (Table 2). For the "wet" treatment, irrigation was done when an average tensiomenter reading of 30 kPa was recorded on two tensiometers placed at 300 and 600 mm depth in the rootzone. The "dry" treatment represents an average reading of 60 kPa. The volume of water applied per irrigation was calculated (see Results) to wet the soil to field capacity.

Table 1. Phases used in this experiment.

Cultivar	Phase	Description	Period
'Fuerte'	I	Resting phase	After picking to 15 Aug
	II	Flowering and fruit set	16 Aug to 15 Dec
	III	Fruit growth and ripening	16 Dec to picking (± May)
'Hass'	I	Resting phase	After picking to 15 Sept
	II	Flowering and fruit set	16 Sept to 15 Jan
	III	Fruit growth and ripening	16 Jan to picking (± June)

Table 2. Treatments since May 1994.

Treatment no	Phase I	Phase II	Phase III
1	Wet	Wet	Wet
2	Wet	Dry	Wet
3	Dry	Dry	Dry

Climatic data, including rainfall was measured in a nearby weather station.

Yield and fruit size were measured on a per tree basis and expressed as kg·tree^{-1} and percentage of fruit (mass basis) per count.

Water use was calculated on a monthly basis and expressed in m^{3}·ha^{-1}·day^{-1} for each treatment.

RESULTS AND DISCUSSION

The data reported are for the 1994/95 season only due to the fact that a hailstorm caused severe damage to the 1995/96 crop and excessive rain (Table 3) caused a large number of trees to die due to *Phytophthora* infection and drowning conditions. The experiment was than abandoned.

Table 3. Rainfall data (mm) for the Burgershall Experimental Station.

Month	Season		Long term ave.
	1994/95	1995/96	
May	3.1	13.5	17.5
June	0	0	8.0
July	0	0	11.7
August	4.5	33.6	16.3
September	15.0	0	36.8
October	87.5	87.9	72.5
November	22.2	337.9	130.0
December	131.5	185.1	162.1
January	174.8	266.7	160.6
February	90.6	717.1	164.5
March	81.6	153.8	127.5
April	76.3	108.3	53.8
Total	687.1	1903.9	961.3

Treatments

For irrigation purposes the term easily available water (EAW) is used in South Africa. This amount by definition is the water available in the rootzone (0-600 mm depth) between field capacity (FC) and a matric potential of -100 kPa. The “wet” treatment represents the extraction of 50% of EAW (see Figure 1) before the next irrigation and the “dry” treatment the extraction of roughly 80 % of EAW. From Figure 1 it can thus be seen that “wet” means to irrigate when 28 mm of water was extracted from the rootzone and “dry” when 44 mm was extracted. The difference between the two treatments therefore lies in a longer cycle length, with the dry treatment inducing more stress between irrigations.

Yield data

No significant yield differences between treatments were obtained (Table 4). This is in contrast to the work of Faber *et al*. (1995) showing their wet treatment to enhance tree growth and reduce yield. However, the “wet” treatments are probably not comparable in those two instances.

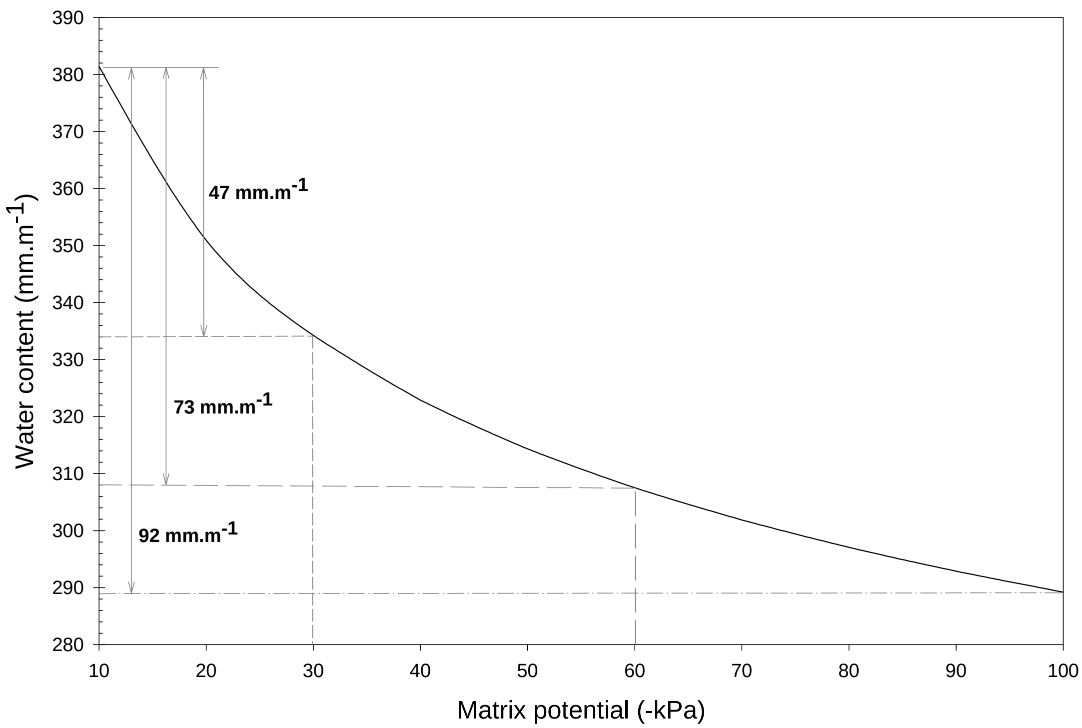

Fig. 1. Water retention curve of the soil with FC at -10 kPa and the limit of EAW at -100 kPa. (EAW = 92 mm.m^{-1}) The wet treatment represents an extraction of 47 mm.m^{-1} of water (28 mm from the rootzone) and the dry treatment 73 mm.m^{-1} (or 44 mm from the rootzone).

Table 4. Effect of the treatments on yield of 6 to 7 year old 'Fuerte' and 'Hass' trees.

Treatment	Cultivar (kg·tree^{-1})	
	Fuerte	Hass
Wet, Wet, Wet	25.3	26.9
Wet, Dry, Wet	32.3	32.5
Dry, Dry, Dry	27.9	19.2
LSD (P0,05)	NS	NS

Effect on fruit size

The effect of the three treatments on fruit size are shown in Figure 2 for 'Fuerte' and Figure 3 for 'Hass'. In the case of 'Fuerte' the WDW treatment tended to improve the fruit size although not significantly, whereas the wet (WWW) and dry (DDD) treatments show very little difference in fruit size distribution. 'Hass' was more reactive to a water stress, showing very small fruit with the WWW treatment and an improvement with both the drier treatments. These findings are in contrast to those of Robertson (1969) and

Bower (1985), but it must be kept in mind that the term 'stressed' is probably not comparable under these different conditions as was explained earlier.

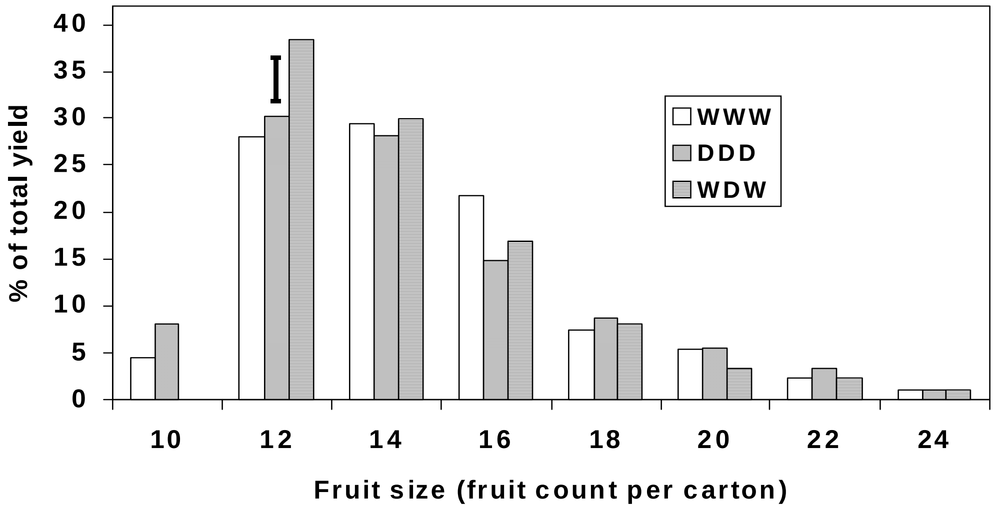

Fig. 2. The effect of the three treatments (WWW,DDD & WDW) on size distrubution of Fuerte fruit (%) of total yield. I = indicates signifigant difference at $P_{0.05}$)

Water use

The monthly water use was calculated as total water applied and effective rainfall received. Only precipitations larger than 5 mm at a time were considered, which means that for the months of May, June, July, August, September and November only irrigation water was used. For the other months (see rainfall figures, Table 3) 70 % of the rainfall was considered effective and calculated for the wetted area of 7 m^2 only. In a study by Mostert (1999) affectivity of rainfall for micro-irrigation of citrus for the same season was shown to vary between 32 and 45 %.

The seasonal water use pattern for the two cultivars are expressed as $m^3 \cdot ha^{-1} \cdot day^{-1}$ and shown in Figures 4 and 5. It is obvious that the water use for the two treatments shown (WWW and WDW) are very similar. In the case of 'Fuerte' maximum water demand is approximately 50 $m^3 \cdot ha^{-1} \cdot day^{-1}$ during mid summer (January) reaching a low of 15 to 20 $m^3 \cdot ha^{-1} \cdot day^{-1}$ in winter. For 'Hass' the maximum demand is slightly lower at almost 40 $m^3 \cdot ha^{-1} \cdot day^{-1}$ in December and also lower in winter at below 15 $m^3 \cdot ha^{-1} \cdot day^{-1}$. The total water use per season for the wet treatments were calculated from these graphs and amounted to 8900 $m^3 \cdot ha^{-1} \cdot yr^{-1}$ for 'Hass' and 10200 $m^3 \cdot ha^{-1} \cdot yr^{-1}$ for 'Fuerte'. These figures are higher than the 6680 $m^3 \cdot ha^{-1} \cdot annum^{-1}$ found in Israel by Lahav and Kalmar (1977) and the 7875 $m^3.ha^{-1}.annum^{-1}$ for 6 year old trees as indicated by Gustafson *et al*. (1979) for California.

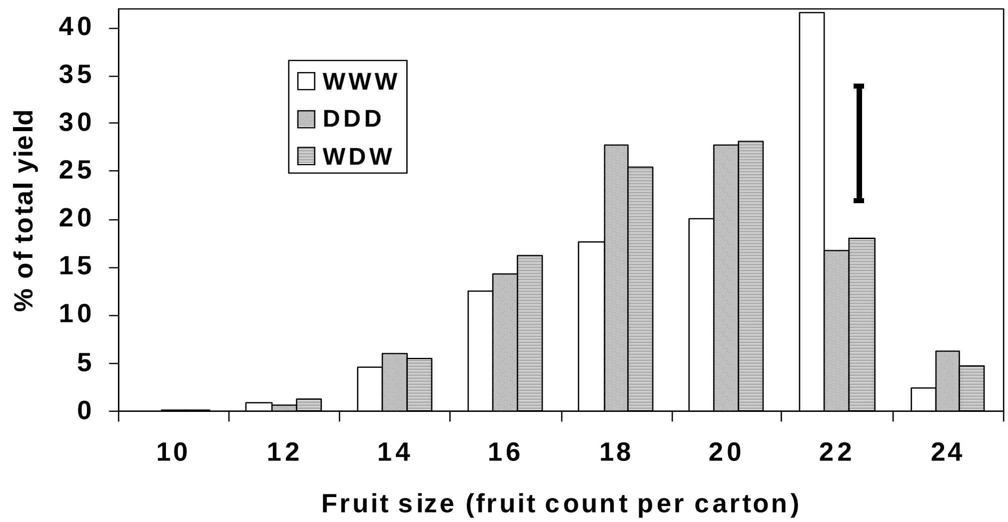

Fig. 3. The effect of the three treatments (WWW,DDD & WDW) on size distrubution of Hass fruit (%) of total yield. I = indicates signifigant difference at $P_{0.05}$)

CONCLUSIONS

These results show that the term “wet” and “water stress” should be very well defined to be of value to other researchers. Dry in this study referred to a longer cycle length only, therefore more water extracted between irrigations, with little difference between the annual amounts applied. Although no significant effect on yield was obtained the positive effect of a water stress during certain phases of fruit growth on fruit size seems promising. Further studies on the effect of deficit irrigation on improvement of fruit size of especially ‘Hass’ are necessary.

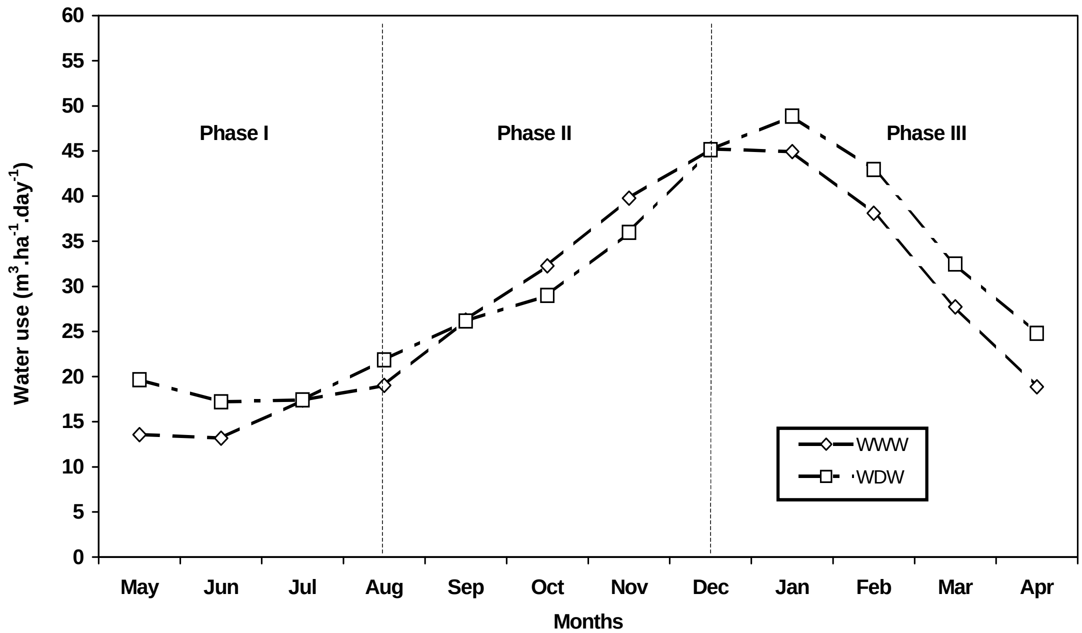

Fig. 4 Seasonal water use in $m^3.ha^{-1}.day^{-1}$ for Fuerte, indicating the three phases and two treatments (WWW and WDW).

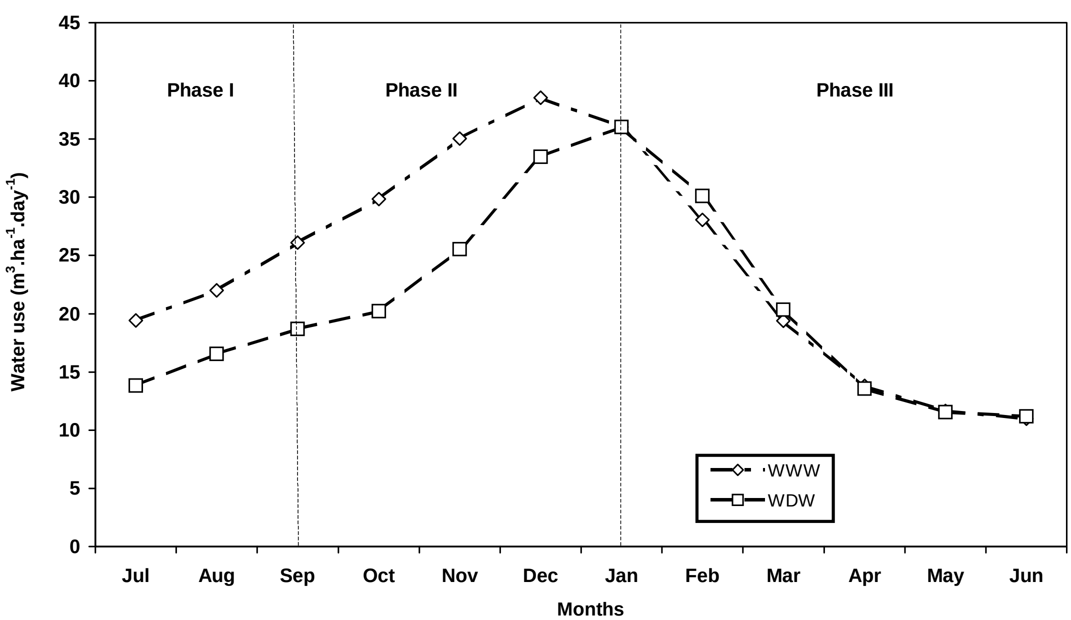

Fig. 5 Seasonal water use in $m^3.ha^{-1}.day^{-1}$ for Hass, indicating the three phases and two treatments (WWW and WDW).

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