Quantifying the Influence of Physiological Processes on Crop Water Status and Consumption

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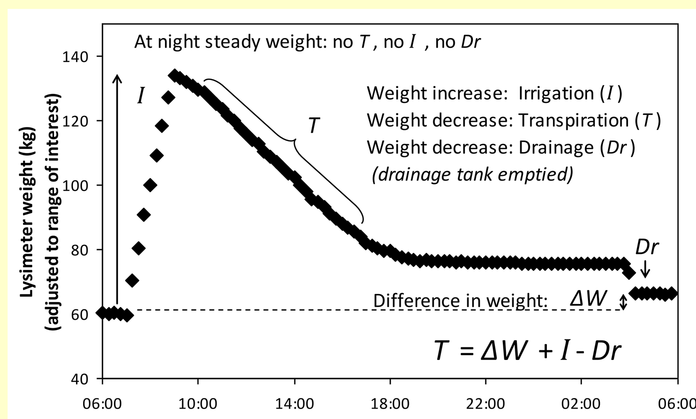
Case study: Effect of fruit load on olive trees

I. Whole plant water balance

- 2.5 m^3 free-standing drainage-weighing lysimeters
- "Barnea" trees 4 years old
- Irrigated and fertilized optimally (excess)
- Daily water balance:

ET = Irrigation - Drainage ± Δ Storage



- Tree and leaf scale monitoring of direct and indirect water status/stress
- Drought events

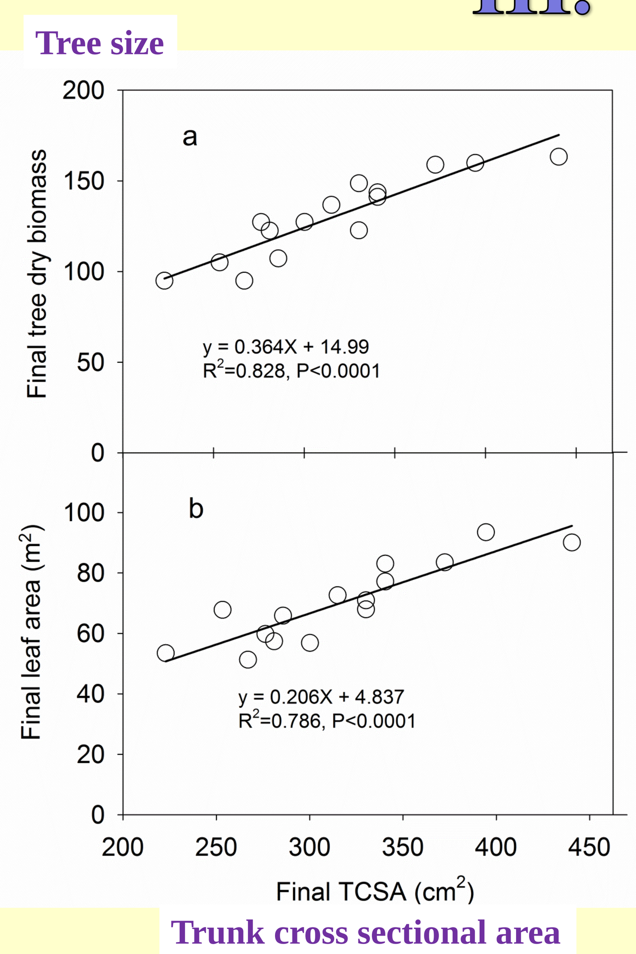
II. Fruit load manipulation

Tree #	Treatment	Experimental periods I	II	III	IV
2	Control HY	17793	17793	17793	17793
5	Control HY	36301	20133	20133	20133
8	Control HY	18794	18794	18794	18794
15	Control HY	26851	16842	16842	16842
9	OLY	3433	0	0	0
10	OLY	5610	5610	5610	5610
14	OLY	5744	5744	0	0
4	EFR	13338	6744	6744	6744
6	EFR	53796	0	0	0
13	EFR	29625	0	0	0
3	MFR	28260	28260	0	0
12	MFR	45718	45718	0	0
1	LFR	21365	21365	21365	0
7	LFR	25692	25692	25692	0
11	LFR	25620	25620	25620	0

- HY high yield (>10000 fruits)
- CHY (>10000 fruits throughout season)
- LY low yield (<10000 fruits)
- OLY (<10000 fruits throughout season)
- EFR early fruit removal (after fruit set 23 May)
- MFR mid-season fruit removal (7 July)
- LFR late fruit removal (7 Sept)

Blue and green shaded cells indicate HY and LY trees, respectively.

III. Data normalization

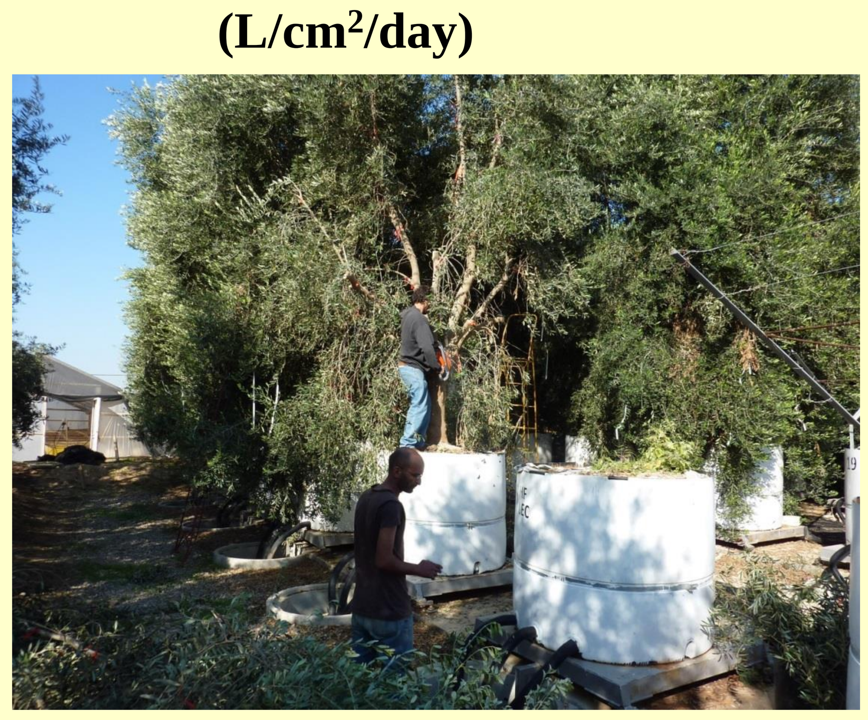


Relationship between trunk cross sectional area (TCSA), tree biomass (a) and leaf area (b) at time of tree removal after final fruit harvest in November 2011.

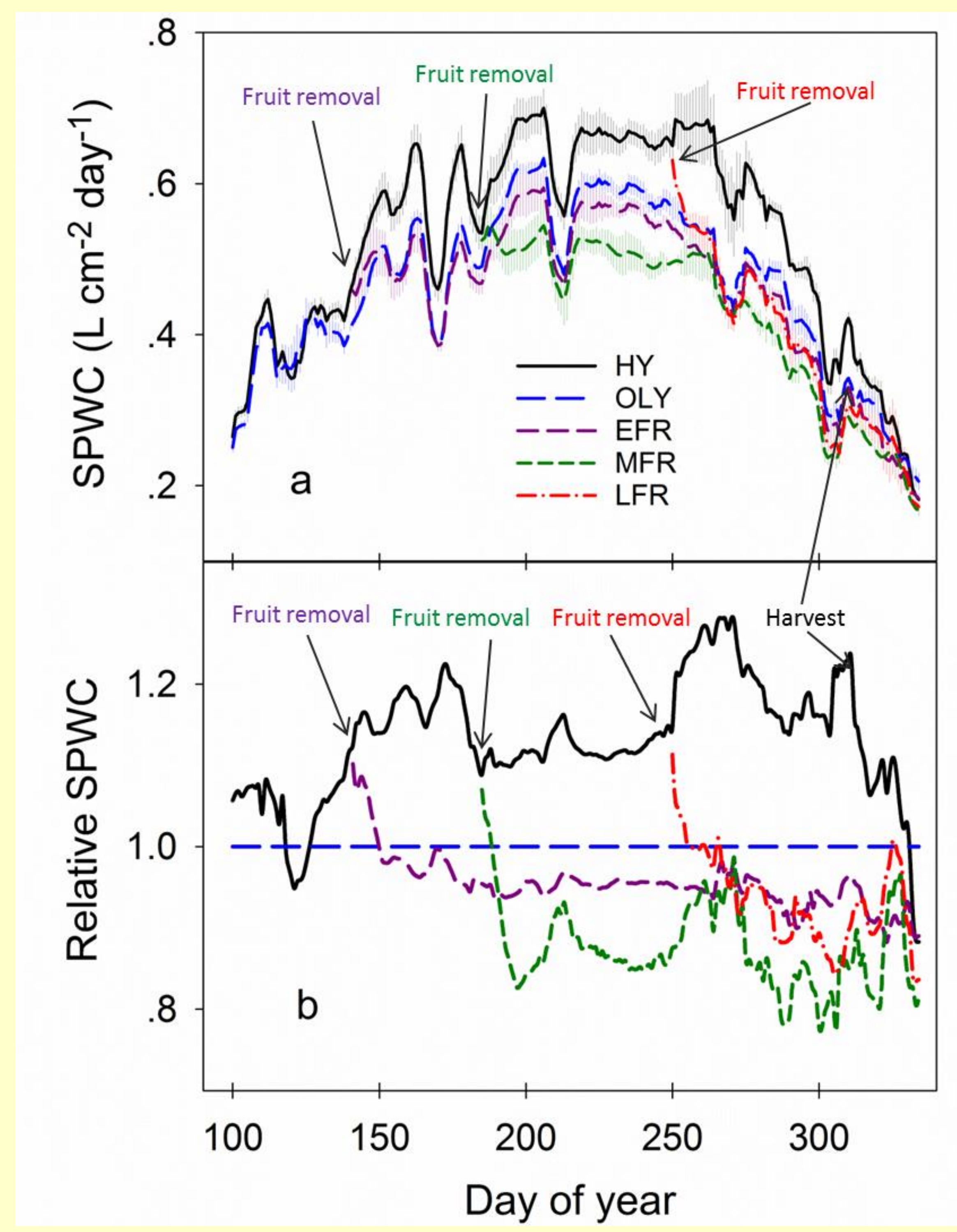
Specific Water Consumption

$$SPWC = \frac{ETa}{TCSA}$$

ETa = daily tree scale actual evapotranspiration (L/tree/day)
TCSA = trunk cross sectional area (cm^2)
SPWC = Specific water consumption ($L/cm^2/day$)



IV. Fruit reduction/removal reduces water consumption

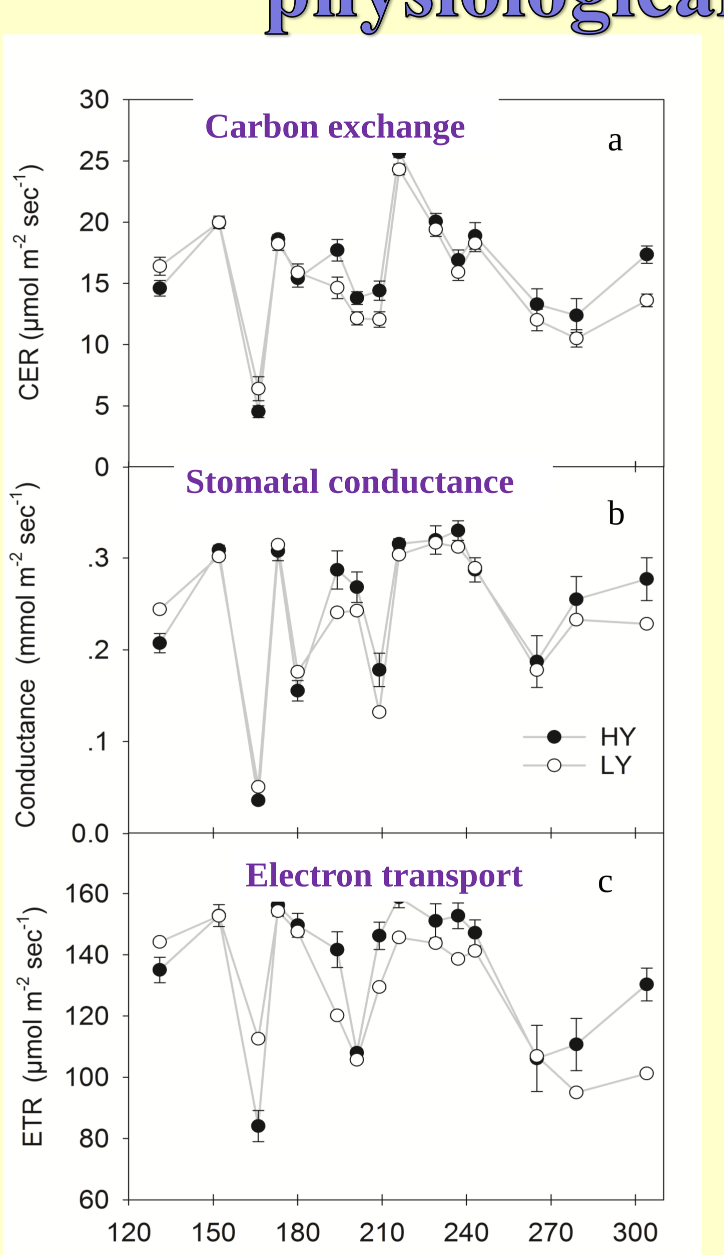


Time course of specific water consumption (SPWC) for olive fruit season in 2011 (a). SPWC

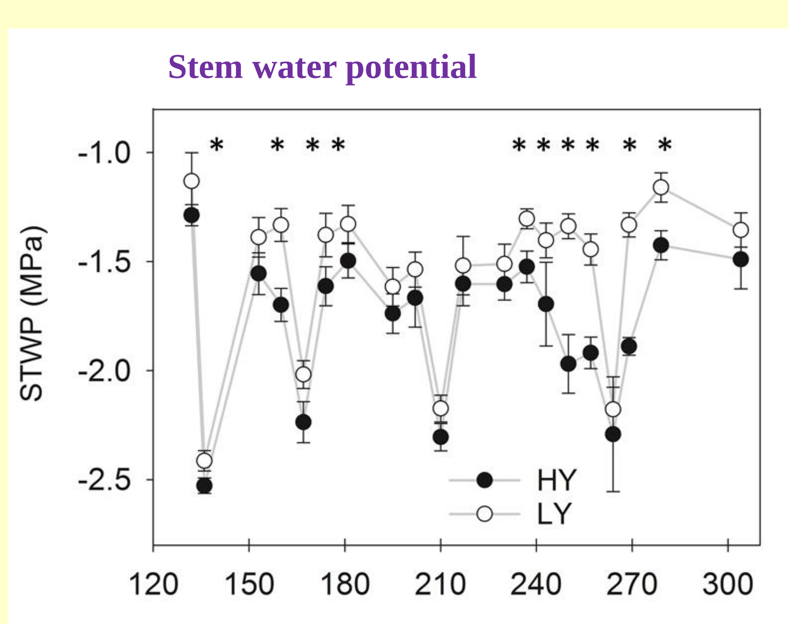
Treatment classes:
HY (high yielding) more than 10,000 fruits/tree
OLY (originally low yielding) less than 10,000 fruits/tree
EFR (early fruit removal)
MFR (mid fruit removal)
LFR (late fruit removal)

Relative SPWC (b) – SPWC normalized to the OLY group. Error bars are standard errors.

V. Leaf- and stem- scale physiological parameters



Leaf-scale carbon exchange rate (CER, a), stomatal conductance (g_s, b) and electron transfer rate (ETR, c). HY are high yielding (>10,000 fruits) and LY are low or non-yielding trees (<10,000 fruits), respectively. Error bars are standard errors.



Midday stem water potential (STWP) in olive trees grown in lysimeters with either current high crop load (HY, >10,000 fruits) or low/no crop load (LY, (<10,000 fruits). Error bars are standard errors. Stars indicate dates with significant differences between the treatments.

VI. Summary

- Removal of fruit brought about an immediate decline in tree water consumption, measured as transpiration normalized to tree size, which persisted until the end of the season.
- The later the fruit removal was executed, the greater was the response, indicating that factors such as fruit size or stage of development influence the governing of water consumption.
- The amount of water transpired by a fruit-loaded tree was found to be ~30% greater than that of an equivalent low- or non-yielding tree.
- The tree-scale response to fruit was reflected in stem water potential but was not mirrored in leaf-scale physiological measurements of stomatal conductance or photosynthesis.
- Trees with low or no fruit-load had higher vegetative growth rates. However, no significant difference was observed in the overall aboveground dry biomass among groups, when fruit was included.
- This case, where carbon sources and sinks were both not limiting, suggests that the role of fruit on water consumption involves signaling and alterations in hydraulic properties of vascular tissues and tree organs.
- Practical outcomes of the results include need for fruit-load / phenological specific crop factors or set points for irrigation scheduling.

More information? Contact us? bengal@volcani.agri.gov.il

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