Facultad de Agronomía e
Programa de Doctorado en Ciencias de la Agricultura

Effect of the soil water-to-air ratio on water status, leaf gas exchange and biomass of avocado trees

Efecto de la relación agua/ aire del suelo en el estatus hídrico, intercambio gaseoso de la hoja y biomasa del palto.

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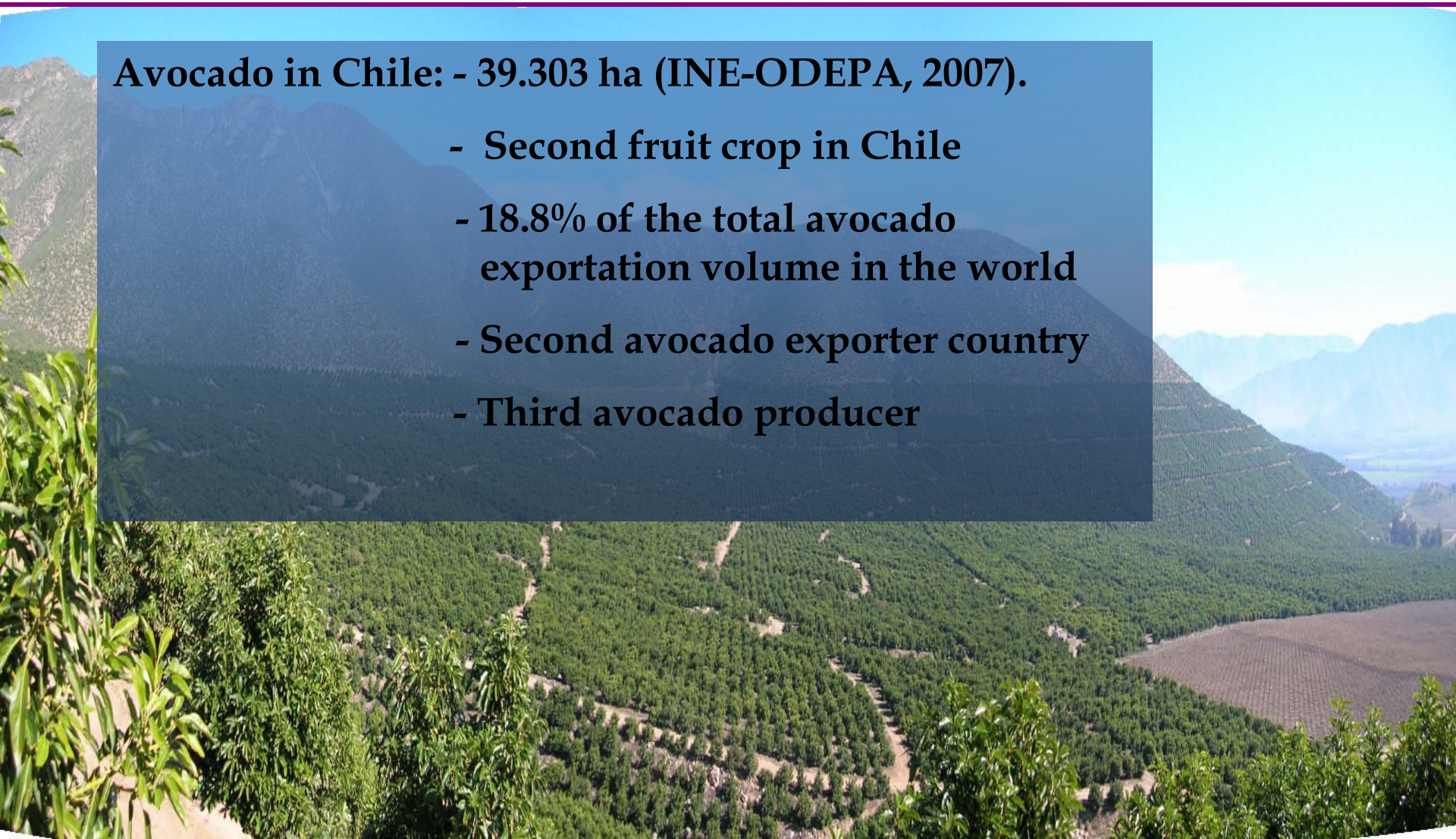
VII WORLD AVOCADO CONGRESS 2011
VII CONGRESO MUNDIAL DEL AGUACATE 2011
CAIRNS - AUSTRALIA

INTRODUCTION



Avocado in Chile: - 39.303 ha (INE-ODEPA, 2007).

- **Second fruit crop in Chile**
- **18.8% of the total avocado exportation volume in the world**
- **Second avocado exporter country**
- **Third avocado producer**

Soils with low macroporosity

+ Wrong irrigation management (irrigation design, maintenance, programming)

+ High sensibility to root hypoxia

= ASPHYXIA SYNTOMS

→ Epinasty and/or leaves abscission

→Losses of fruit quality and production

→Death

Factors that affect air content in the soil:

Water content

Structure

Texture

Bulk Density

Soils with clay or loam clay textures, bad structure or mistakes in time, frequency and design of irrigation

→ Anaerobic condition → Affect plant physiology

<u>Previous studies:</u>

Hypoxia (flooding) → reduction in CO_2 rate assimilation (A), stomatal conductance (gs) and transpiration rate (T) in West Indian avocados (exacerbated by *Phytophthora cinnamomi*). **(Schaffer,1998, Schaffer et al., 1992, Schaffer y Ploetz 1989)**

- **Soil air contents (Ea) between 5 and 18% affect negatively gs in Hass avocado (Ferreyra et al., 2007).**

- **Ea lower than 17% restrict the O_2 diffusion rate (ODR) in less than 0.2 μg cm^{-2} min^{-1}. Those conditions were observed on soils kept with soil moisture of 10% above field capacity (Ferreyra et al., 2007).**

- **There exist few information concerning the effect of lack of air in the soil on photosynthesis, water relations, biomass, anatomy and phytohormones in avocado plants.**

- **It is possible to find different production ranges in avocado orchards with modern managements but in different types of soils → well irrigated soils can condition de avocado development and yield depending on their water-to-air ratio (W/A)??**

- **To know that information can be a useful tool to define the production potential of an orchard and thus the possible management to mitigate aeration problems in the soil.**

- **The W/A is a concept that integrate all the soil physical characteristics but also the water content which depend of the irrigation management.**

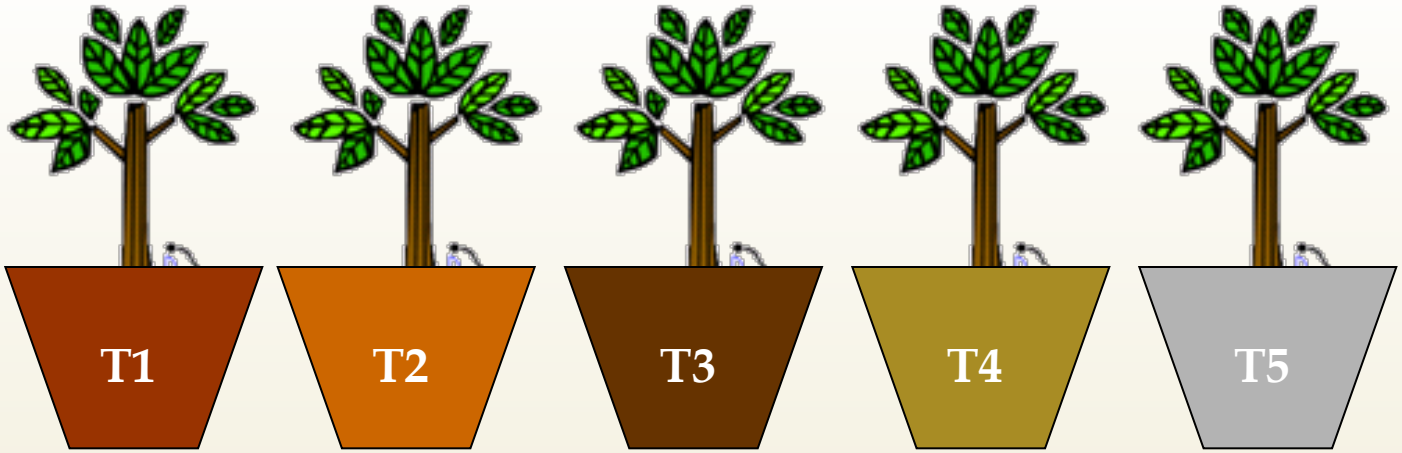
Methodology

Objective of the study:

To determine the effect of soil W/A in the plant water status, CO_2 assimilation and biomass of avocado plants.

- **Plant material: 2-year-old Hass avocado plants, grafted onto Mexicola rootstock. Plants on 200 Lt, open pots.**
- **Place: Experimental field of INIA CRI V Region, la Cruz, V Region, Chile.**
- **Irrigation system: 16 drippers/plant (0,5 l/h). High frequency rate of irrigation (keep soil moisture near to field capacity).**
- **Completely Randomized Blocks, 5 replications.**

Treatments

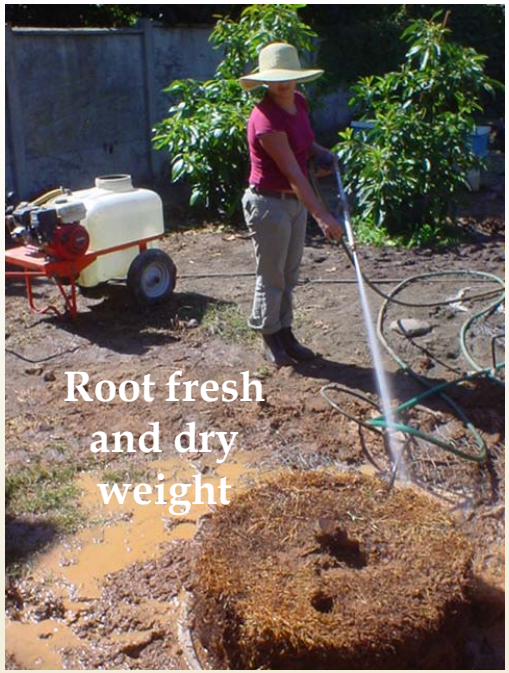


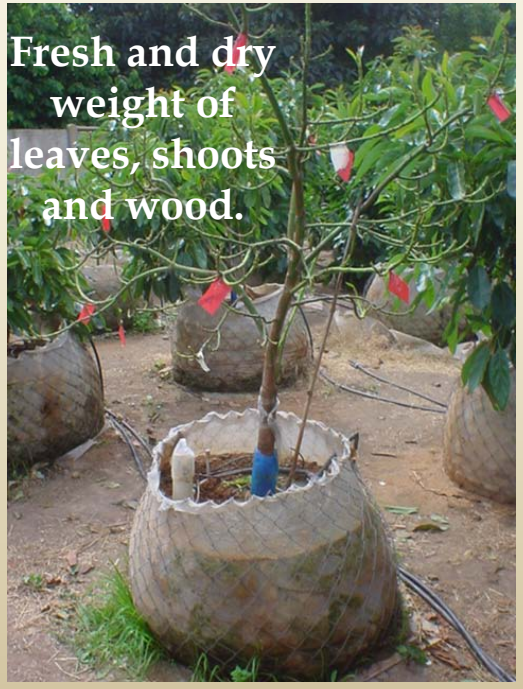
T1	T2	T3	T4	T5
FA	FA	FA	Fa	a
Da= 1.43	Da= 1.49	Da=1.14	Da=1.45	Da= 1.38
W/A = 1.7	W/A = 1.3	W/A = 0.6	W/A = 0.4	W/A = 0.3

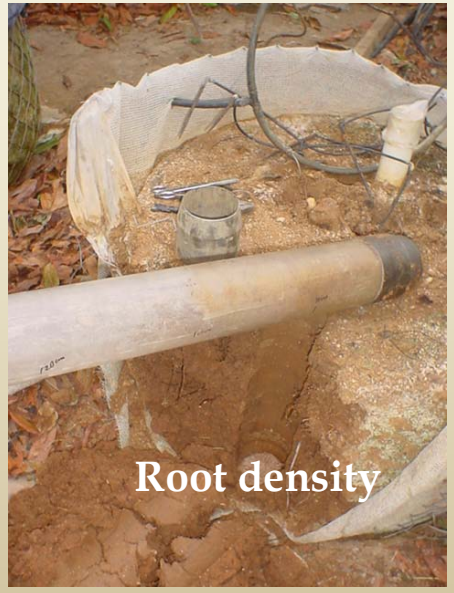
				2005/2006			2006/2007			2005-2007
Tmt	Porosidad %	Microporosidad [CC (θ)] %	Capacidad de Aire %	Humedad suelo (θ) (media ± SD)	Contenido de aire suelo (%) (media ± SD)	W/A (media ± SE)	Humedad suelo (θ) (media ± SD)	Contenido de aire suelo (%) (media ± SD)	W/A (media ± SE)	W/A
T1	46	28.6	17.5	27.47 ± 2.7	18.57 ± 2.7	1.5 ± 0.04	29.98 ± 2.1	16.02 ± 2.1	1.9 ± 0.04	1.7
T2	43.8	29.2	14.6	21.11 ± 4.8	22.66 ± 4.8	0.9 ± 0.05	27.59 ± 5.9	16.21 ± 5.9	1.7 ± 0.3	1.3
T3	57	23.8	33.2	18.40 ± 5.3	38.58 ± 5.3	0.5 ± 0.02	25.55 ± 10.6	31.45 ± 10.6	0.8 ± 0.09	0.6
T4	45.3	10.5	34.7	11.82 ± 2.5	33.46 ± 2.5	0.4 ± 0.01	13.18 ± 3.2	32.12 ± 3.2	0.4 ± 0.02	0.4
T5	47.9	16.5	31.4	8.99±1.9	38.93 ± 1.9	0.2 ± 0.01	13.45 ± 2.5	34.72 ± 2.5	0.4 ± 0.01	0.3

Measurements

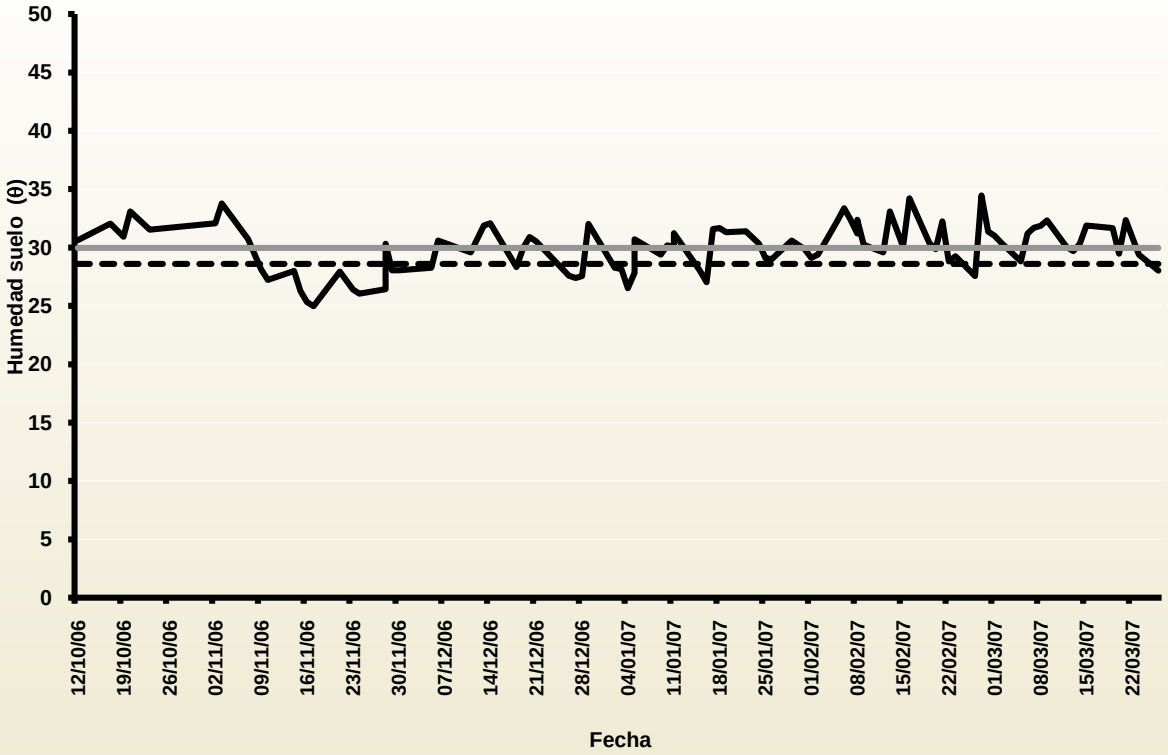
Measurements







Results

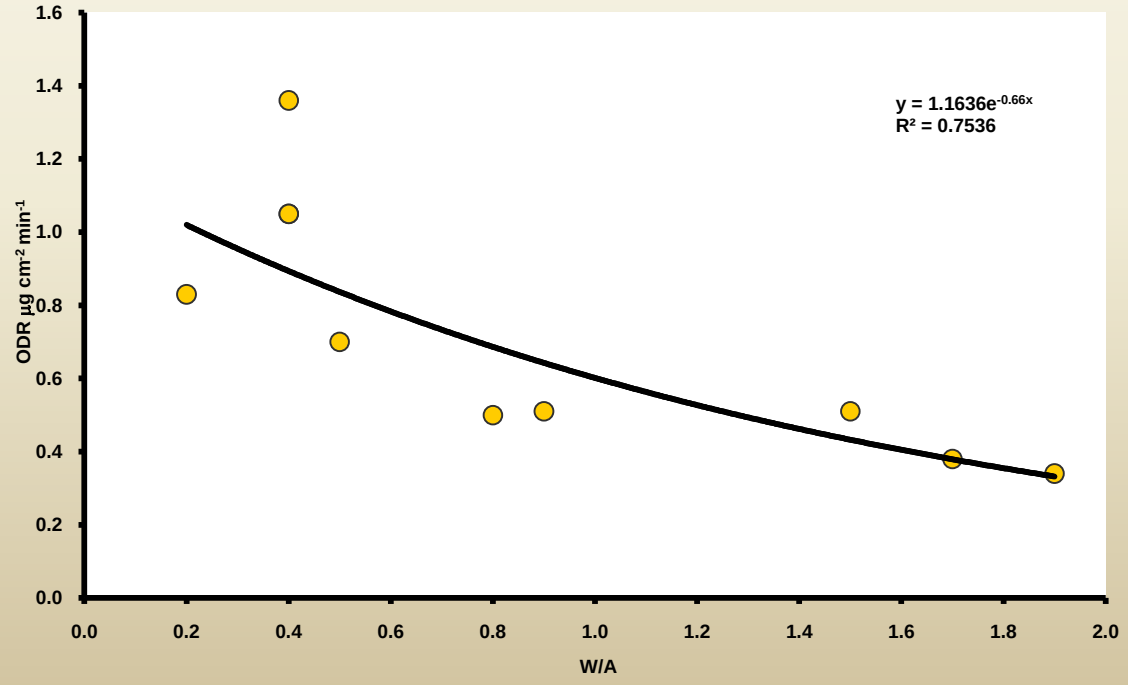


Tmt	% Días con Ea < 17% (mean ± SE)	
	2005/2006	2006/2007
T1	40.78 ± 19.18	54.89 ± 21.45
T2	18.78 ± 7.59	68.90 ± 8.41
T3	0.96 ± 0.96	15.16 ± 7.76
T4	0.00 ± 0.00	0.00 ± 0.00
T5	0.00 ± 0.00	0.00 ± 0.00

Oxygenation conditions in soil

Tmt	2005/2006				2006/2007			
	W/A	ODR ($\mu g\ cm^{-2}\ min^{-1}$)	CO_2 (%)	O_2 (%)	W/A	ODR ($\mu g\ cm^{-2}\ min^{-1}$)	CO_2 (%)	O_2 (%)
T1	1.5	0.51 c	0.83 ab	16.60 a	1.9	0.34 c	0.44 b	5.02 ab
T2	0.9	0.51 c	0.94 a	18.46 a	1.7	0.38 c	0.74 a	4.63 ab
T3	0.5	0.70 b	0.74 abc	16.60 a	0.8	0.50 c	0.41 b	3.35 b
T4	0.4	1.05 a	0.55 c	18.90 a	0.4	1.05 b	0.32 bc	5.32 a
T5	0.2	0.83 b	0.66 bc	17.36 a	0.4	1.36 a	0.16 c	4.47 ab

ANOVA, Waller-Duncan, $P \leq 0.1$



Plant physiology: Water relations

2005/2006

Tmt	W/A 2005/2006	AM gs (cm s^{-1})	AM T (µg cm^{-2} s^{-1})	AM SWP (MPa)	PM gs (cm s^{-1})	PM T (µg cm^{-2} s^{-1})	PM SWP (MPa)
T1	1.5	0.30 a	2.88 a	-0.11 a	0.31 c	4.98 c	-0.77 b
T2	0.9	0.37 a	2.84 a	-0.10 a	0.38 ab	6.48 b	-0.75 b
T3	0.5	0.30 a	2.42 a	-0.10 a	0.34 bc	6.08 b	-0.71 ab
T4	0.4	0.46 a	3.46 a	-0.10 a	0.42 a	7.24 a	-0.72 b
T5	0.2	0.42 a	3.23 a	-0.11 a	0.43 a	7.22 a	-0.61 a

ANOVA, Waller-Duncan, P ≤ 0.1

VPD= 1.7 KPa

VPD= 2.7 KPa

VPD $_{Max}$= 3.9 KPa

2006/2007

Tmt	W/A 2006/2007	AM gs (cm s^{-1})	AM T (µg cm^{-2} s^{-1})	AM SWP (MPa)	PM gs (cm s^{-1})	PM T (µg cm^{-2} s^{-1})	PM SWP (MPa)
T1	1.9	0.47 a	4.45 a	-0.62 ab	0.28 a	5.10 b	-0.91 a
T2	1.7	0.41 b	3.83 b	-0.65 b	0.28 a	5.24 ab	-0.88 a
T3	0.8	0.40 b	3.84 b	-0.55 a	0.26 a	4.91 b	-0.91 a
T4	0.4	0.44 ab	4.55 a	-0.59 ab	0.28 a	5.36 ab	-0.90 a
T5	0.4	0.47 a	4.74 a	-0.54 a	0.30 a	5.95 a	-0.83 a

ANOVA, Waller-Duncan, P ≤ 0.1

VPD= 1.6 KPa

VPD= 3.03 KPa

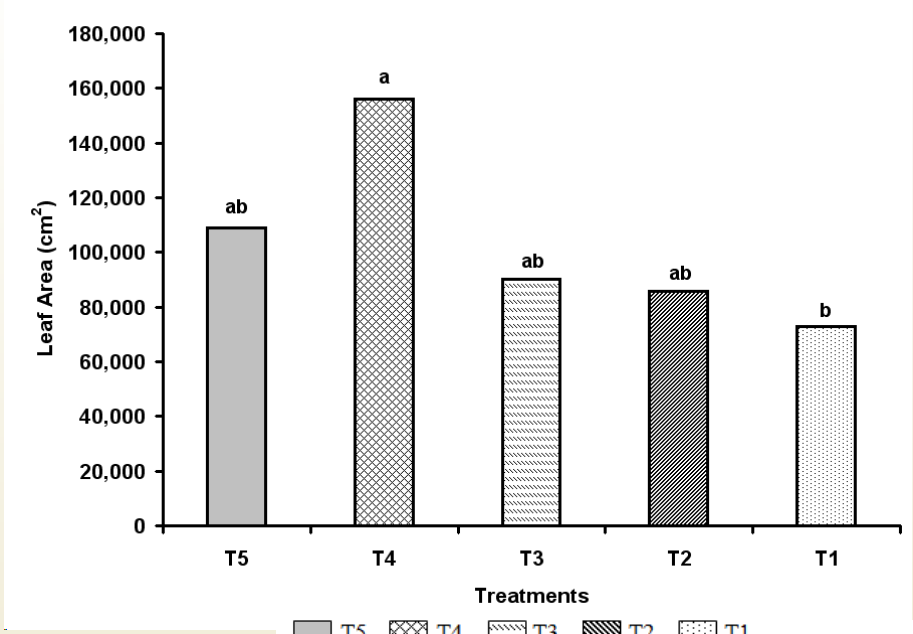
VPD $_{Max}$= 4.5 KPa

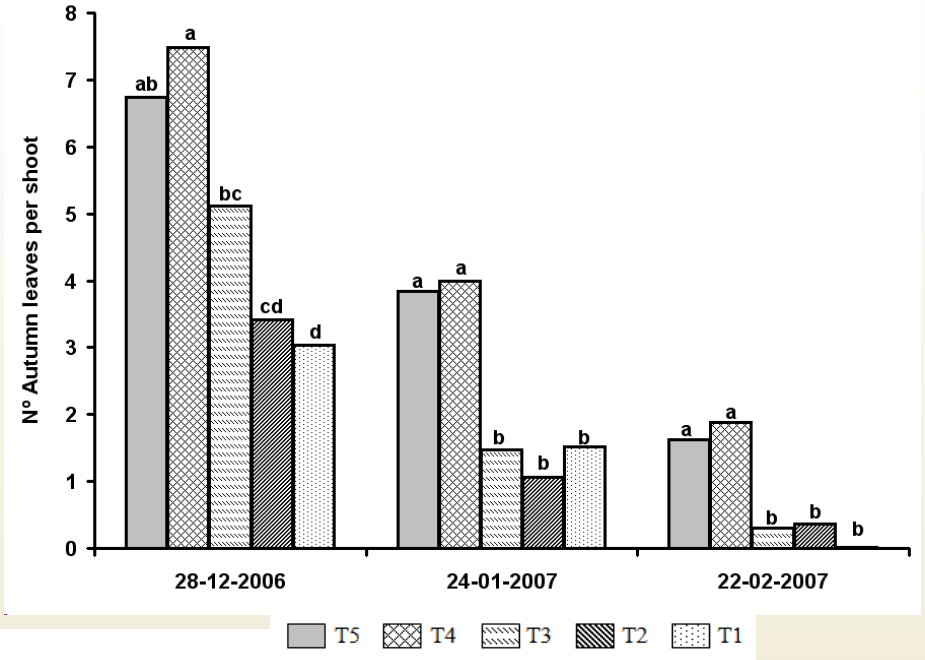
Plant physiology: CO_2 assimilation rate and WUE (b)

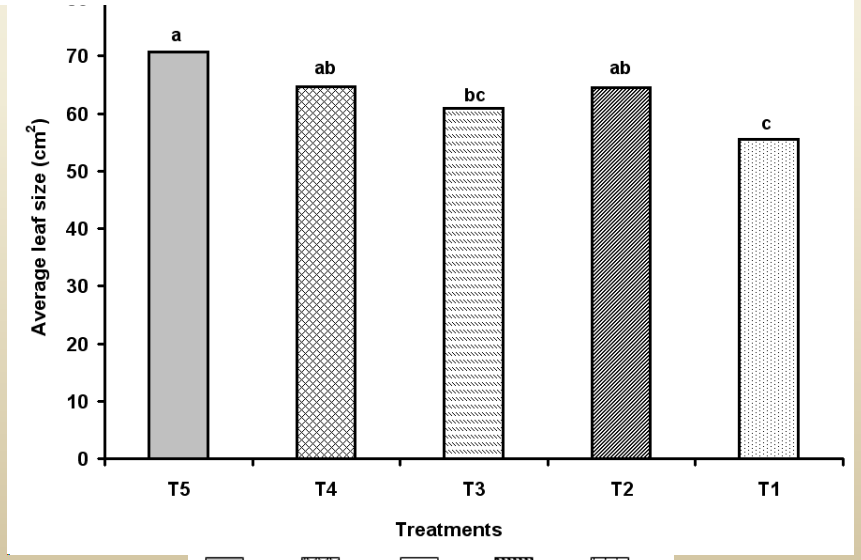
Tmt	A (µmol s^{-1} m^{-2})	WUEb (g L^{-1})
T1	4.71 ab	2.40 c
T2	4.44 b	3.23 b
T3	4.35 b	3.09 bc
T4	5.40 ab	3.99 a
T5	6.07 a	3.70 ab

ANOVA, Waller-Duncan, $P \leq 0.1$

Biomass







ANOVA, Waller-Duncan, $P \leq 0.1$

Biomass

	Dry weight (g/tree)					Biomass partitioning (%)			
	Wood	Shoots	Leaves	Roots	Total	Wood	Shoots	Leaves	Roots
T1	533.2 c	365.4 c	891.6 bc	848.1 c	2638.3 c	20.2	13.8	33.8	32.1
T2	994.0 ab	587.6 ab	1182.4 ab	1174.8 b	3938.7 ab	25.2	14.9	30.0	29.8
T3	766.9 bc	557.1 abc	883.5 c	1100.3 bc	3307.9 bc	23.2	16.8	26.7	33.3
T4	1061.5 a	691.2 a	1192.5 a	1592.4 a	4537.7 a	23.4	15.2	26.3	35.1
T5	801.8 b	491.9 bc	1255.0 a	1383.0 ab	3931.8 ab	20.4	12.5	31.9	35.2

ANOVA, Waller-Duncan, $P \leq 0.1$

Conclusions

- The W/A in non-*Phytophthora*-infested soils irrigated to near field capacity is an important factor that affects avocado physiology.
- In soils with low W/A, gs, T, SWP and A of avocado are higher than in soils with high W/A.
- During the first season after planting, avocado trees in soils with high soil W/A had lower gs and T than trees in soils with low W/A, but soil oxygen content was apparently not low enough in those soils to severely stress the trees.
- Trees in the T1 treatment could apparently acclimate to these high W/A during the following season.

- Soil physical characteristics influence soil water-to-air ratios, and thus root growth which results in greater biomass of the aerial portions of the plant.

- Taking into account that avocado production in Chile and other places in the world is expanding to areas with marginal soils that are often poorly drained and low in oxygen, soil water-to-air ratios should be an important consideration when assessing the potential productivity of an avocado orchard.

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¡¡¡¡GRACIAS POR SU ATENCIÓN!!!