An Israeli perspective on Irrigation with treated wastewater, and why an avocado grower should care

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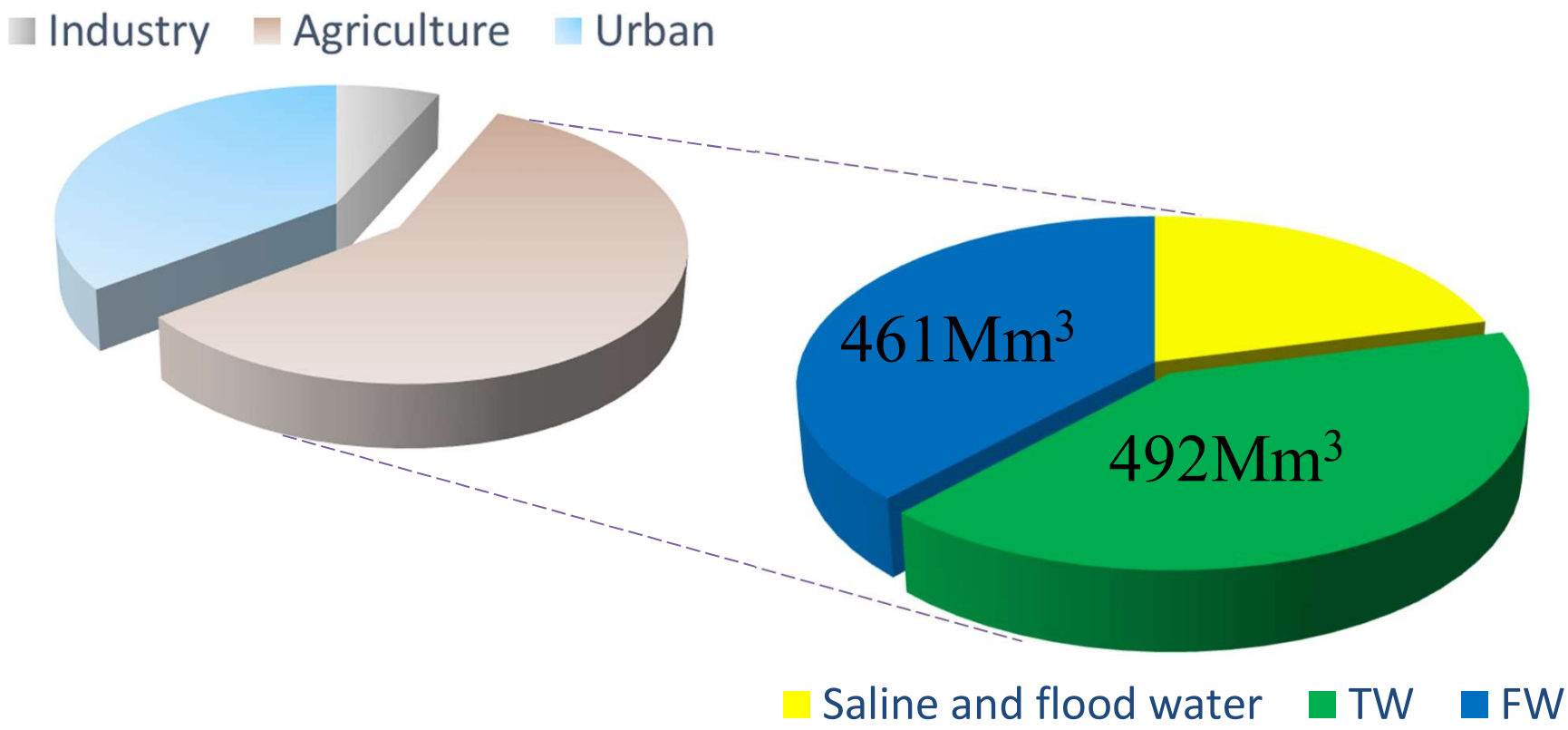
האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

Treated wastewater in Israel

Water consumption in Israel 2013 (total of 2076 Mm^3)



www.water.gov.il

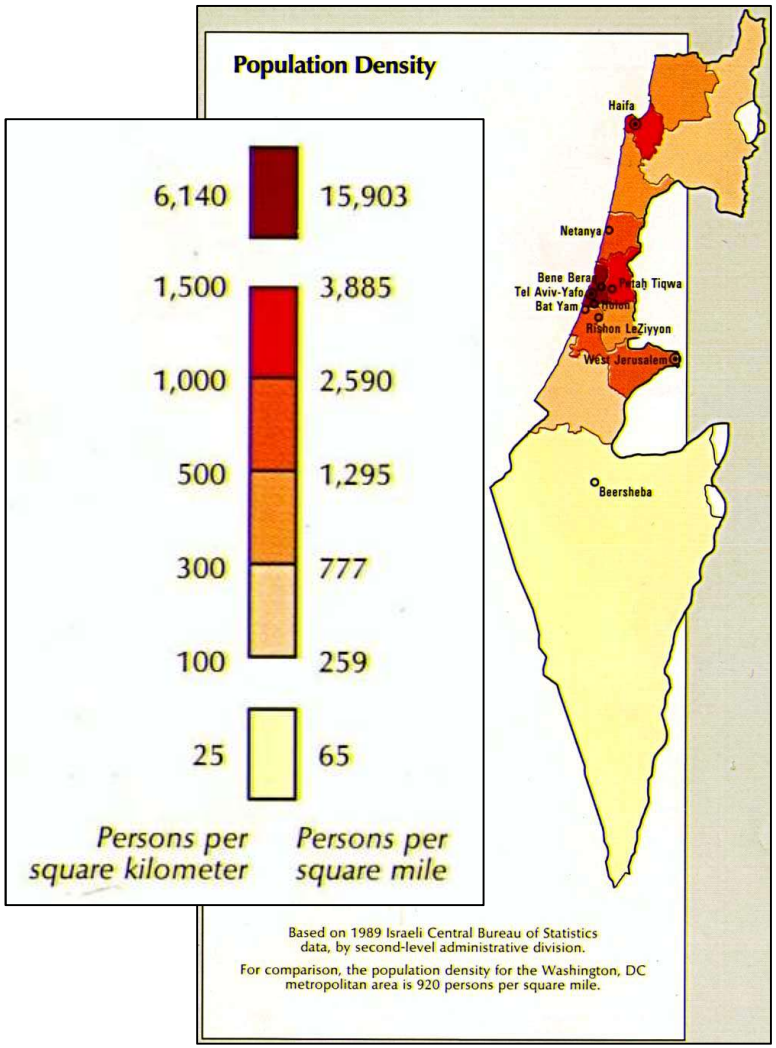
Treated wastewater in Israel

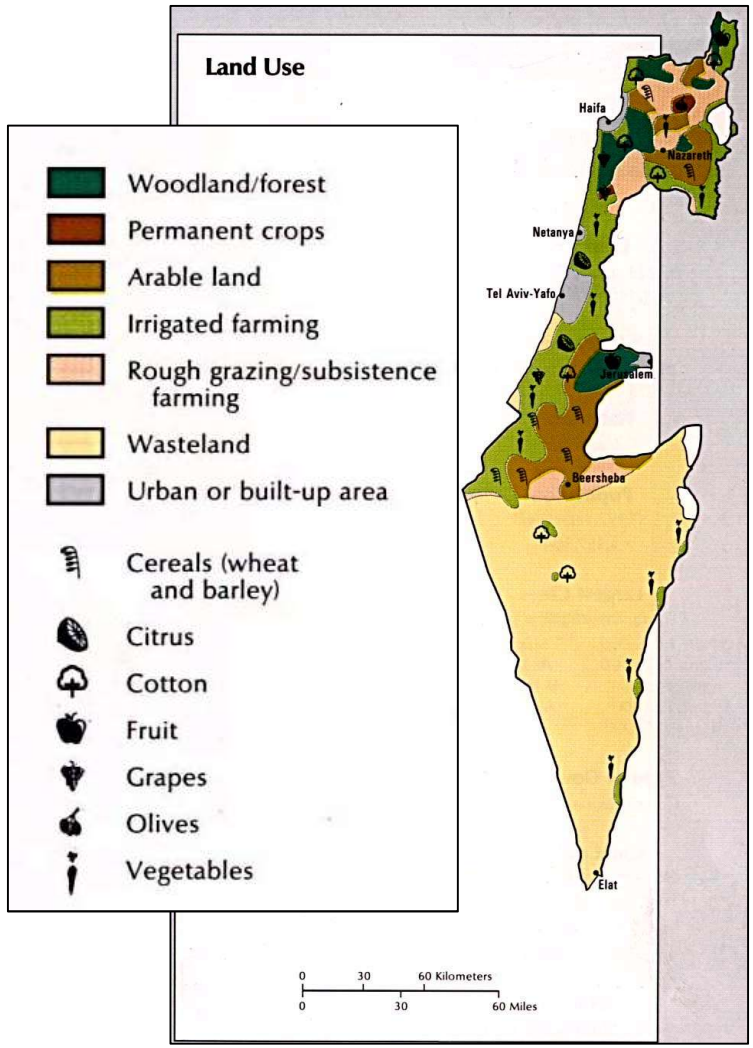
Israel recycles more than 80% of it's wastewater

www.ehf.org.il

Treated wastewater in Israel

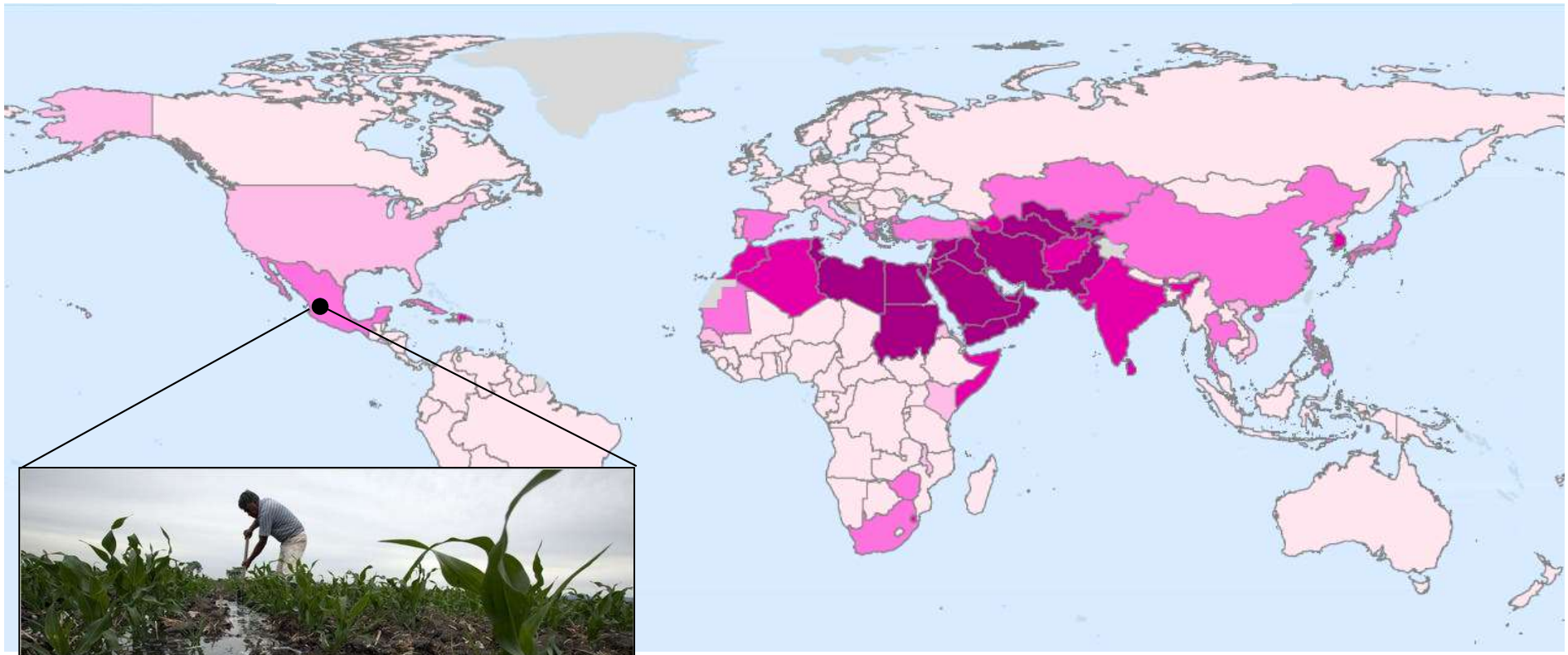
A convenient solution





World water stress drives wastewater reuse

Proportion of Renewable water for agriculture (FAO,2015)

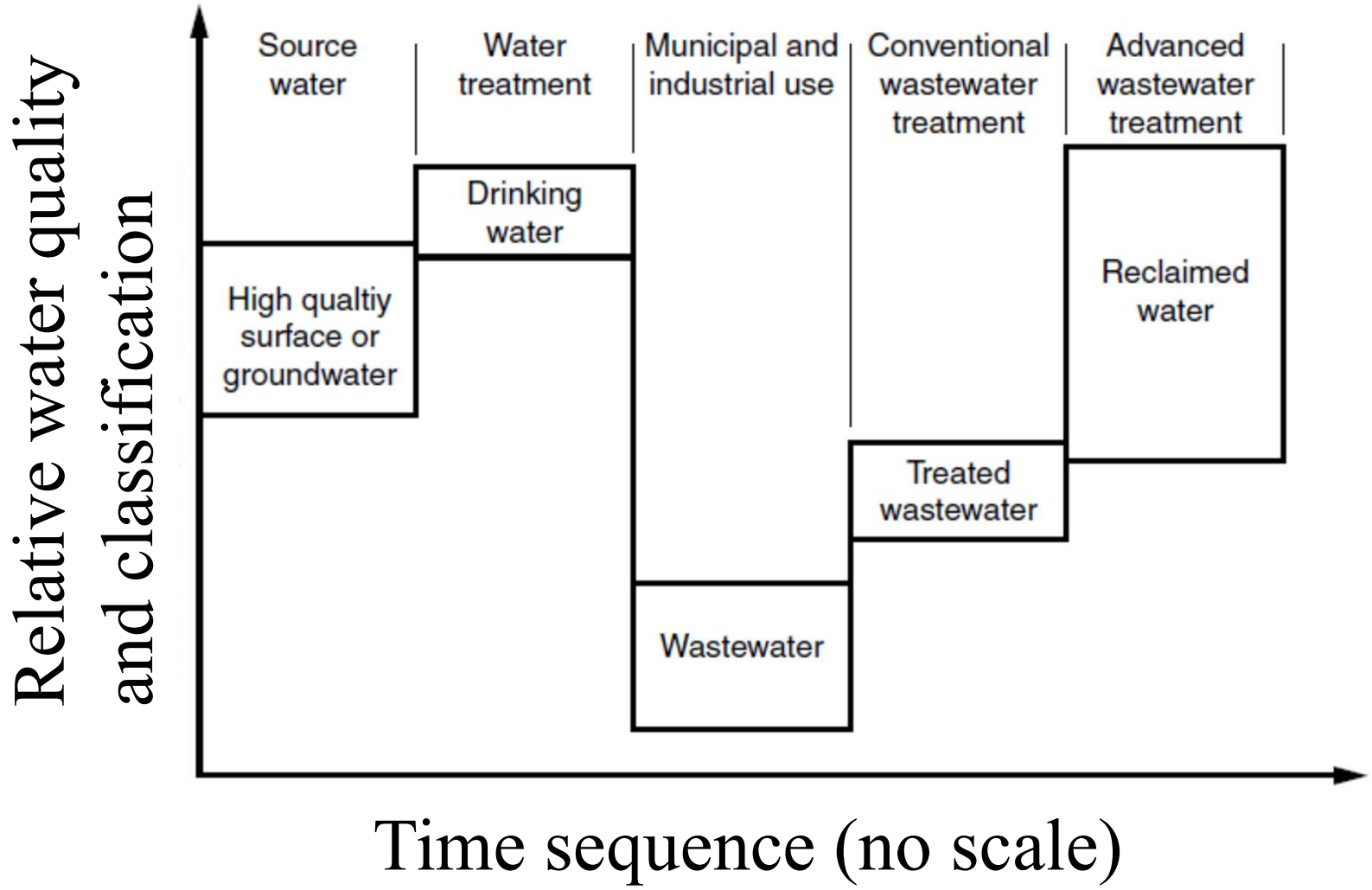


Janet Jarman; New York Times

Treated wastewater **Quality**

Treated wastewater quality

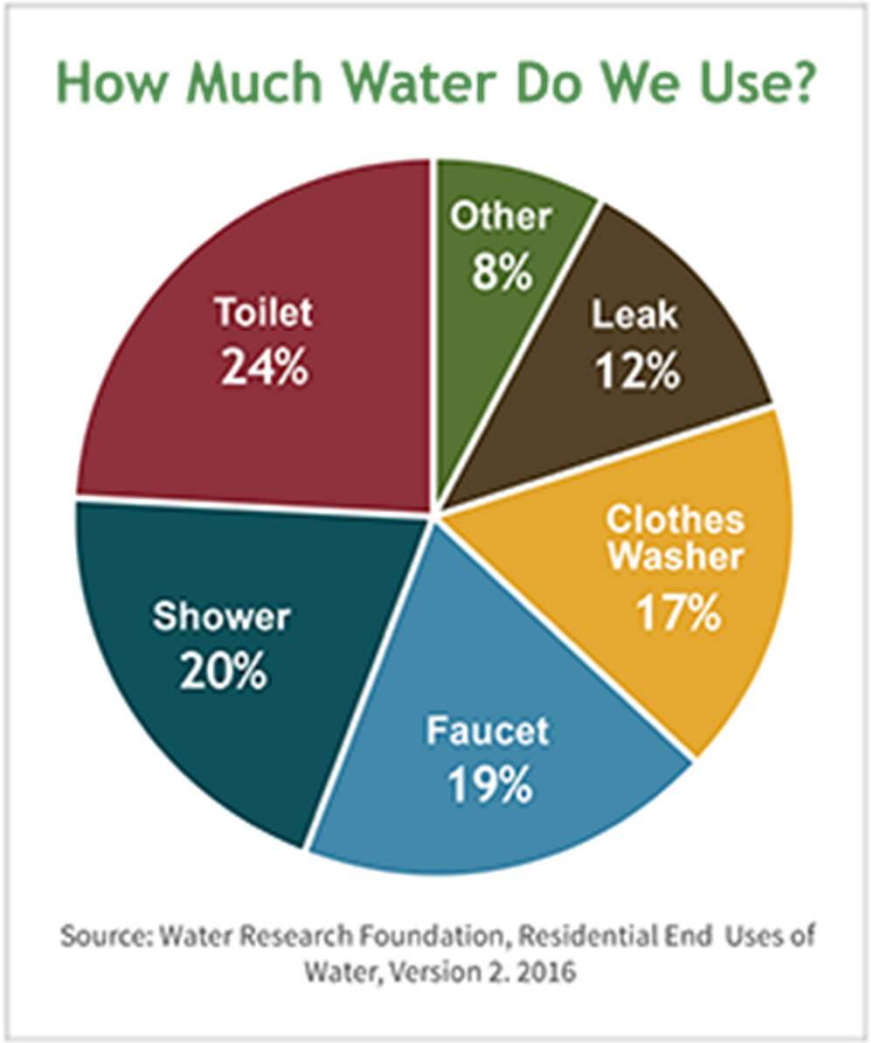
The water quality pathway



Asano et al., 2007

Treated wastewater quality

Water quality at the source



www.epa.gov

Treated wastewater quality

So, what is in our **wastewater**?!

Component	Concentration
Dissolved solids	1055 mg/L
Suspended solids	419 mg/L
BOD	347 mg/L
COD	815 mg/L
Total Coliforms	$10^{8.03}$ MPN/100 mL
Fecal coliforms	$10^{7.09}$ MPN/100 mL

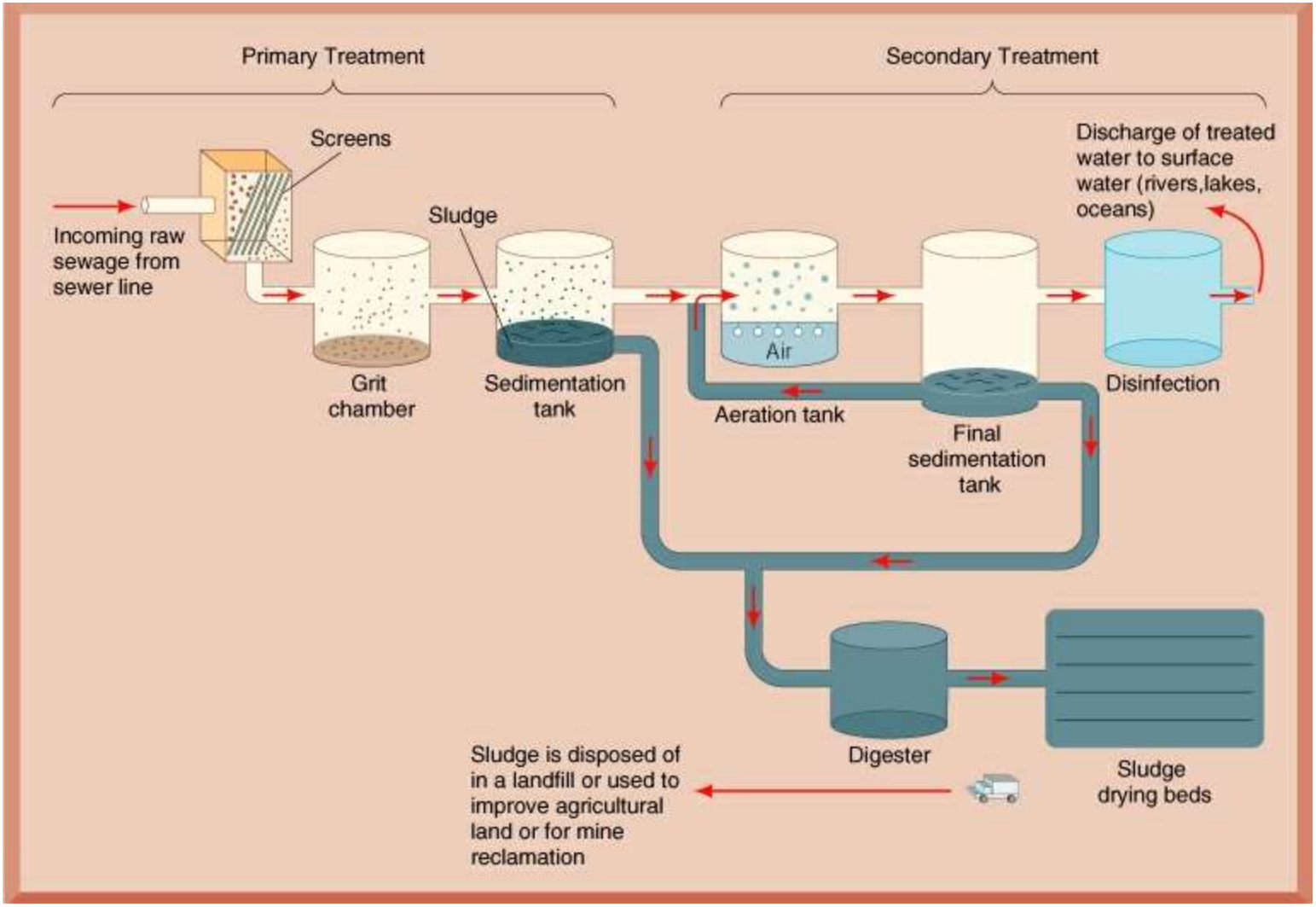
Component	Concentration (mg/L)
Nitrogen	63
Phosphorus	14
Potassium	30
Sulfate	82
Calcium	85
Magnesium	38
Chloride	286
Sodium	230
Boron	0.2

MPN - Most Probable Number

Data from Shafdan Icekson-Tal et. al., 2007

Treated wastewater quality

What does the treatment process do?



Treated wastewater quality

What does the treatment process leave?

Inbar regulations – maximum values for unlimited irrigation with treated wastewater

Component	Concentration
Dissolved solids	
Suspended solids	15 mg/L
BOD	15 mg/L
COD	150 mg/L
Total Coliforms	
Fecal coliforms	50 MPN/100 mL

Component	Concentration (mg/L)
Nitrogen	35
Phosphorus	7
Potassium	
Sulfate	
Calcium	
Magnesium	
Chloride	280
Sodium	200
Boron	0.5

MPN - Most Probable Number

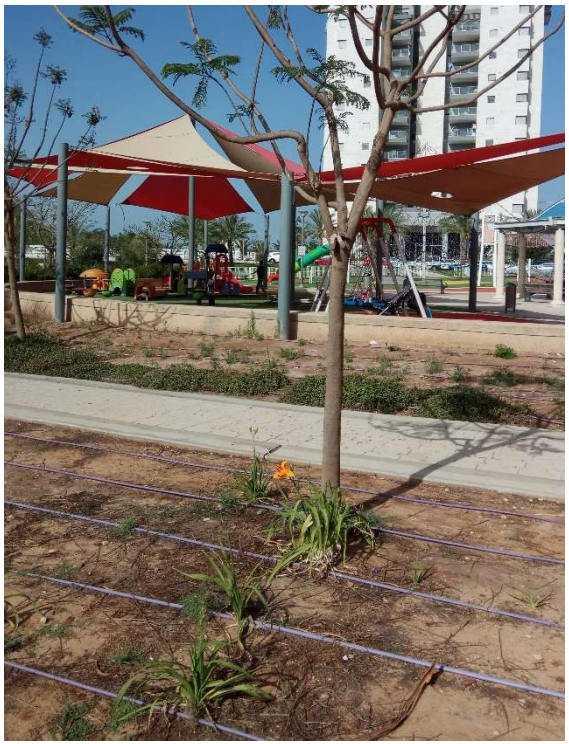
Inbar, 2010

Treated wastewater
Human safety

Is treated wastewater safe to consume?

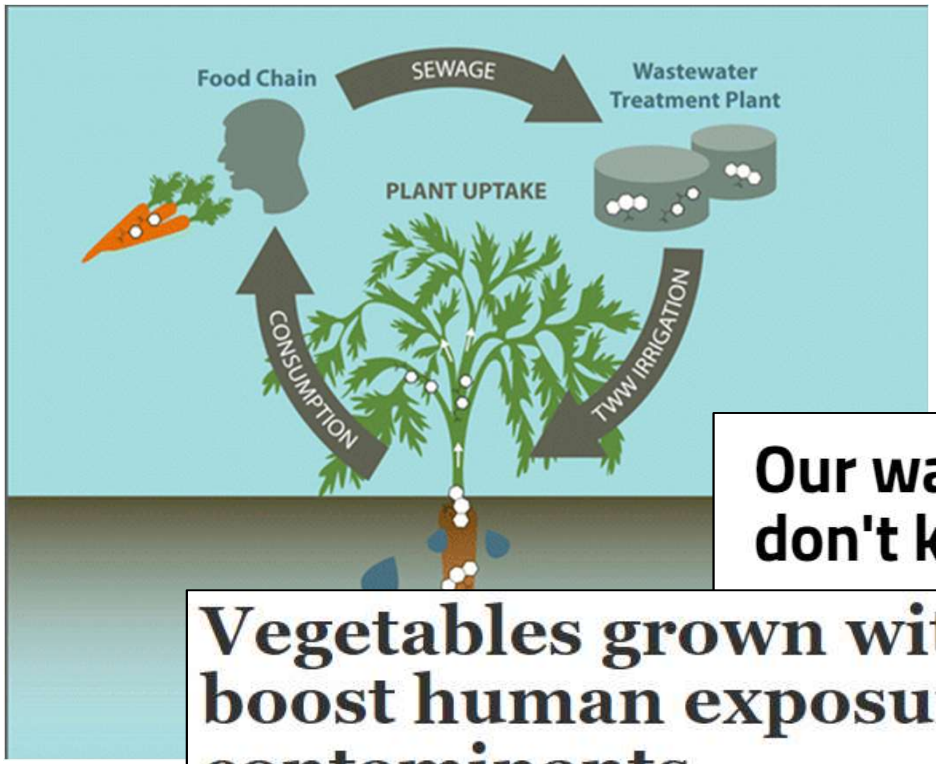
Number of barriers needed between treated wastewater irrigation and crops – ISO16075 (from Tarchitzky Jorge)

Type of treated wastewater quality	Private gardens and gardens landscape with unrestricted public access	Vegetables consumed raw	Vegetables after processing and pastures	Food crops other than vegetables (orchards, vineyards) and horticulture
Very high	0	0	0	0
High	1	1	0	0
Good	forbidden	3	2	1
Medium	forbidden	forbidden	forbidden	3
Extensively treated	forbidden	forbidden	2	2
Raw wastewater	forbidden	forbidden	forbidden	forbidden



Is treated wastewater safe to consume?

Contaminants of “emerging concern”, should we be concerned?!



Our water is full of drugs and we don't know their effects

Vegetables grown with treated wastewater boost human exposure to pharmaceutical contaminants

Consuming produce watered with reclaimed wastewater increased detectable levels of the drug carbamazepine in people's urine

by *Alla Katsnelson*

April 11, 2016

c&en CHEMICAL & ENGINEERING NEWS

Treated wastewater

Fertilizer?!

Plant nutritional value of treated wastewater

Examining the value of treated wastewater as a source of fertilizer using the 4 Rs as criteria

www.nutrientstewardship.com

Plant nutritional value of treated wastewater

Right source? What form of nutrients does TWW add?

Total N	Organic N	NH_4^+	NO_3^-	crop	Yield response	N content in leaves	Ref.
mg/L							
412	67	347	8	Bermuda – grass and Sorghum	+	+	Adeli and Varco, 2001
35	5	30		Grapefruit	+	+	Bar-Tal et al., 2004
35	5	30		Cotton and Corn	+	+	Bar-Tal et al., 2007*

Bar-Tal, 2010

Plant nutritional value of treated wastewater

Right Rate? How much does TWW add?

Nitrogen concentration $= 35 \frac{mg-N}{L} = 35 \frac{g-N}{m^3}$

Irrigation amount per year $= 5000 \frac{m^3}{ha}$

Nitrogen added per year $=$

$$35 \frac{g-N}{m^3} x 5000 \frac{m^3}{ha} = 175 \frac{kg-N}{ha}$$

Plant nutritional value of treated wastewater

Right Rate? How much does TWW add?

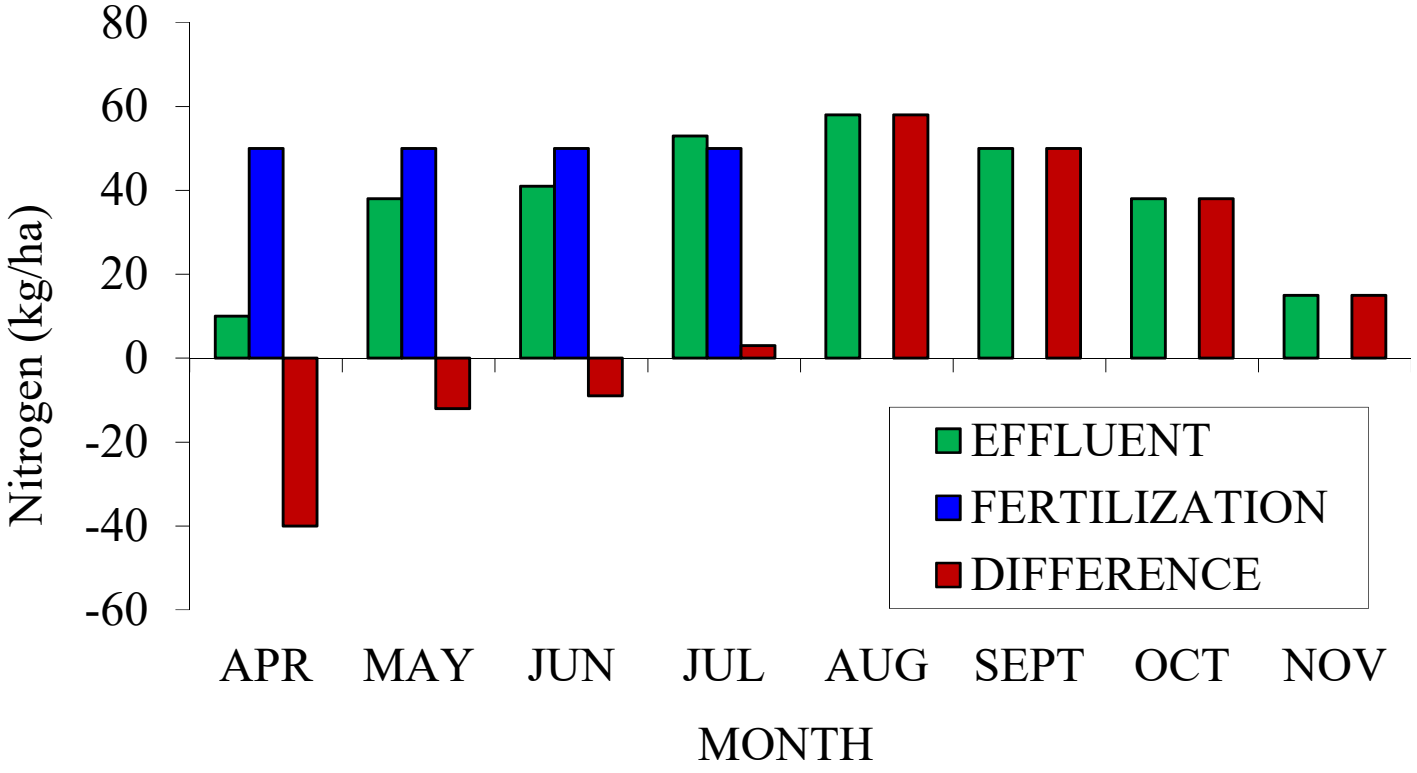
Irrigation (m^3/ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
3000	105	48	108
5000	175	80	181
7000	245	112	253
Avocado requirements (Haifa group)	150-250	57-90	205-350

- N and P content in TWW calculated based on the maximum allowed according to Inbar regulations
- K content according to the one found in the Shafdan Inlet

Plant nutritional value of treated wastewater

Right time? when does TWW add nutrients?

Schematic calculation for citrus in the western Galilee irrigated with secondary TWW - high N levels (source: Jorge Tarchitzky)



Plant nutritional value of treated wastewater

Examining the value of treated wastewater as a source of fertilizer using the 4 Rs as criteria

www.nutrientstewardship.com

Plant nutritional value of treated wastewater

What are the implications of applying too much and in the wrong time?

Consumption of high nitrate levels is detrimental to health - may cause “Blue baby syndrome”

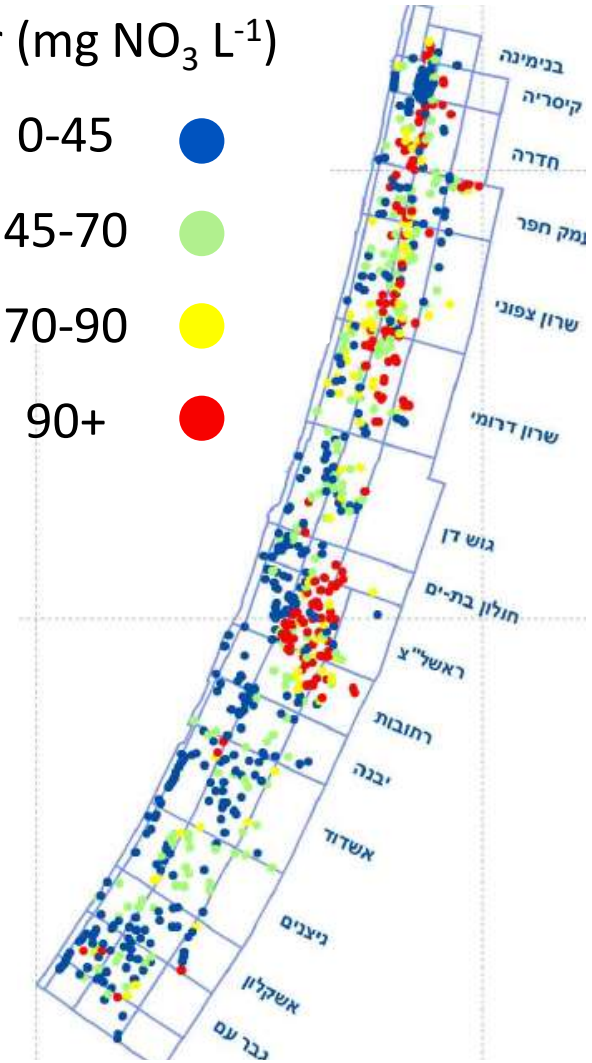
Nitrate concentration in ground water (mg NO_3 L^{-1})

0-45

45-70

70-90

90+



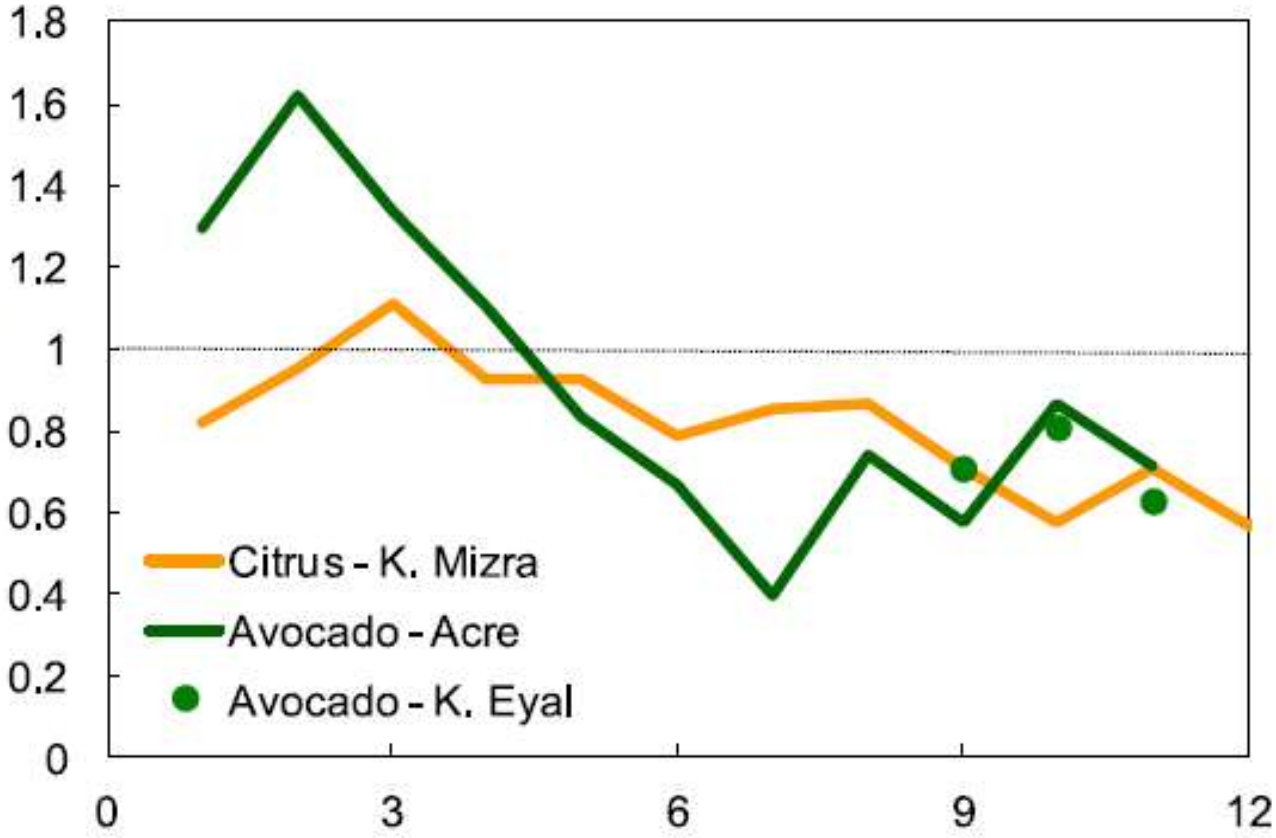
Treated wastewater

Effects on soil

And why an avocado grower should care!!!

Orchards planted in clayey soils are losing yield

$$\frac{\text{Yield TWW}}{\text{Yield FW}}$$



Assouline et al., 2015

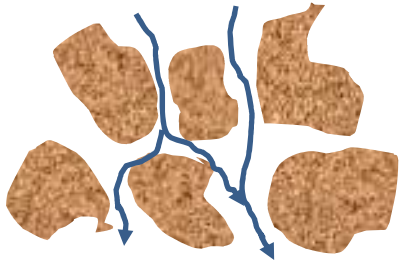
Effects of Na on the soil

High Sodium levels in the soil have impacts on soil structure.

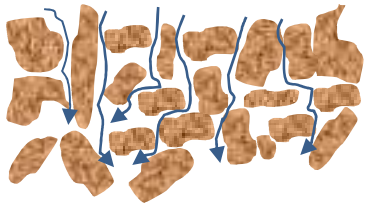
Schematic water infiltration into soil

Na increases the distance between the basic particles within the aggregates, creating a tight matrix with low water conductance

Soil with structure



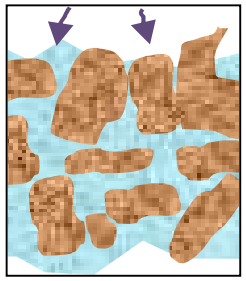
Soil with high sodicity



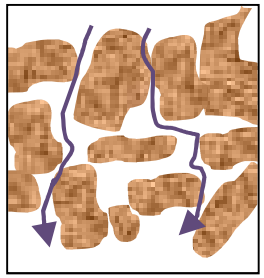
Water logging in pear orhard irrigated with TWW

Hypothesized effects of TWW on soil oxygen

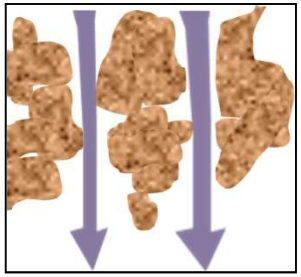
Saturated

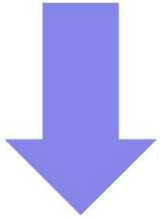


Micropores



Macropores





Oxygen supply

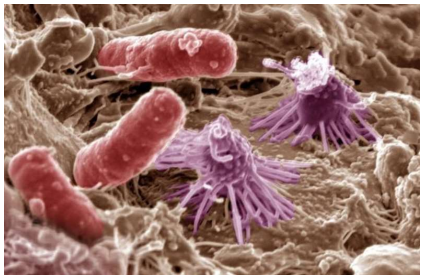
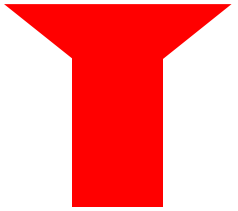


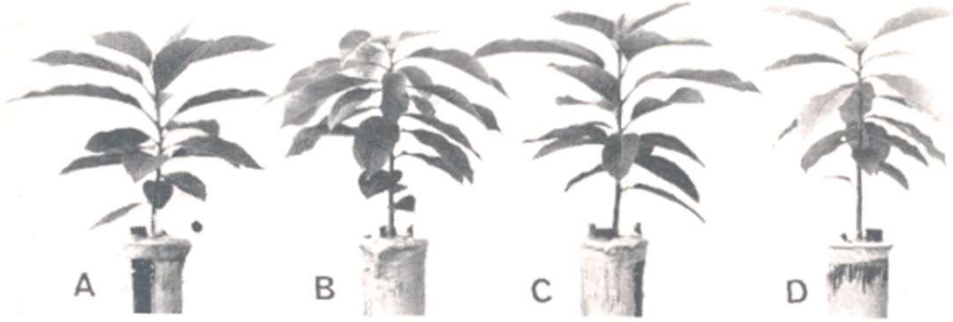
Image via Pacific Northwest National Laboratory



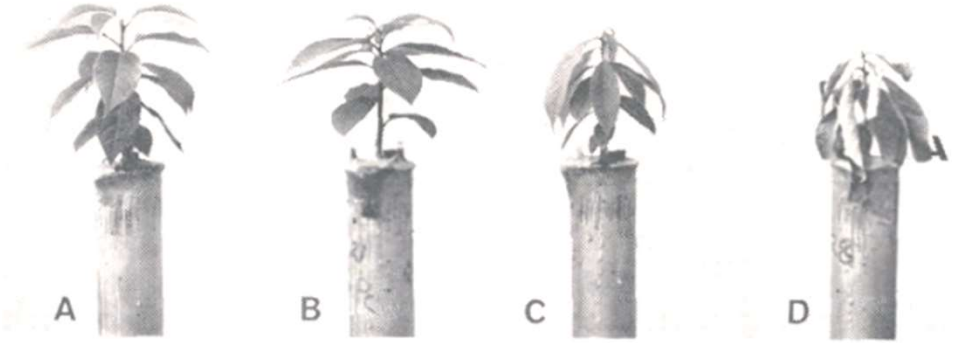
Oxygen demand

Plants need oxygen, especially avocado!

Increasing irrigation freq.



High oxygen supply



Low oxygen supply

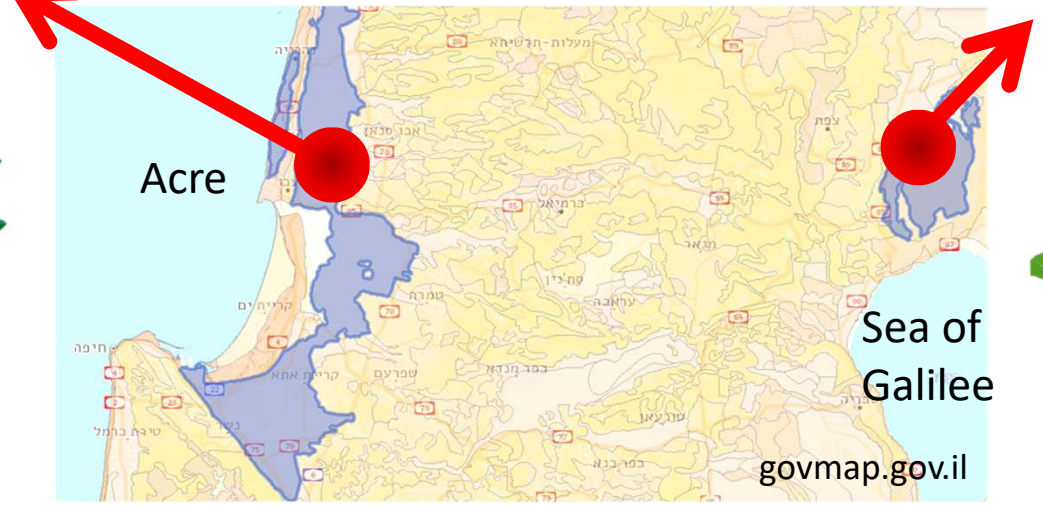
Virgil , Georgics book II, Planting A Vineyard (EST. 29 B.C.)

"…dig in porous stones or rough shell: then the water will slip between**, and the fine air steal in, and the sown plants will breathe."**

Stolzy et al., 1967

Methods

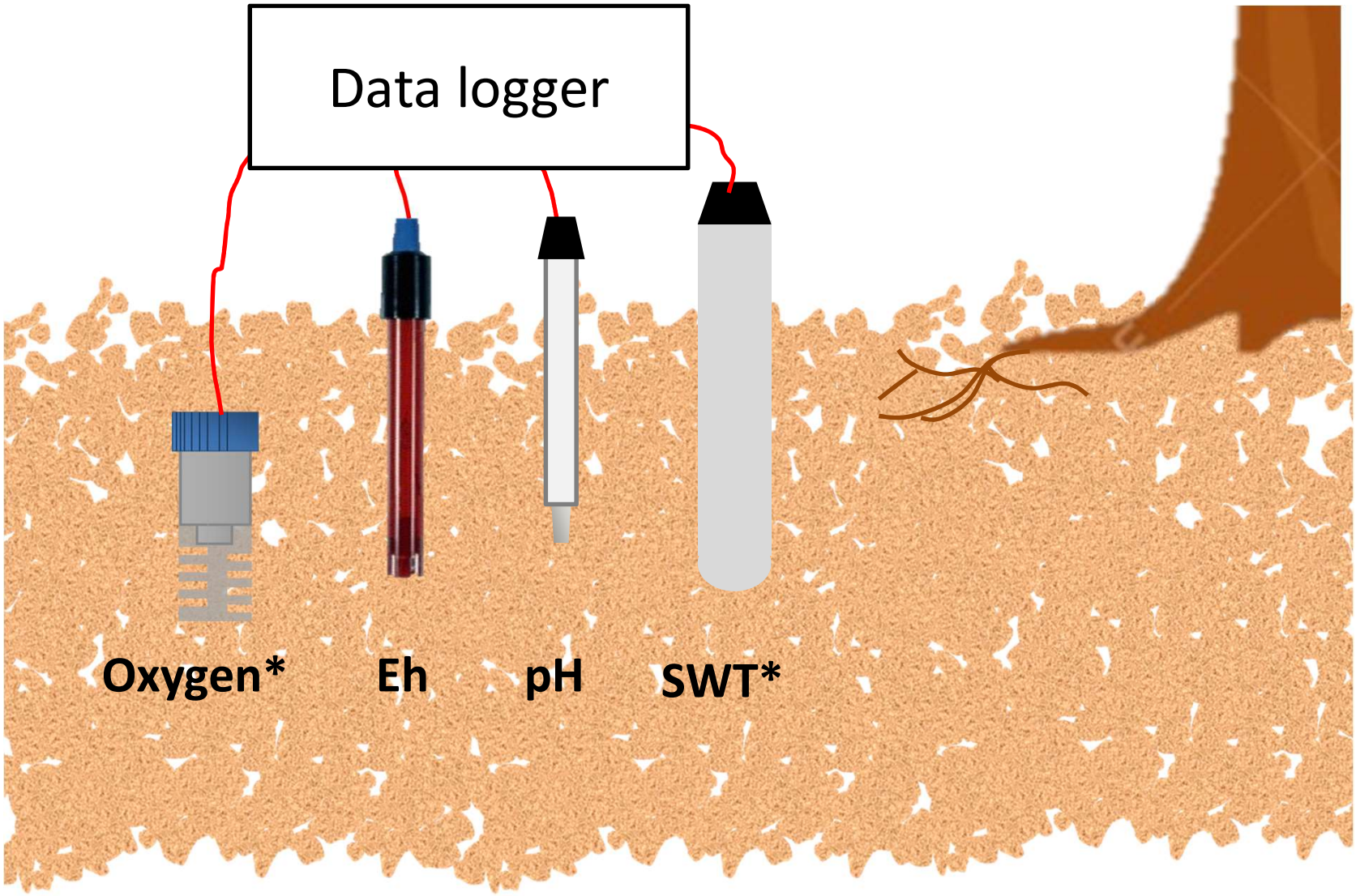
Acre Avocado



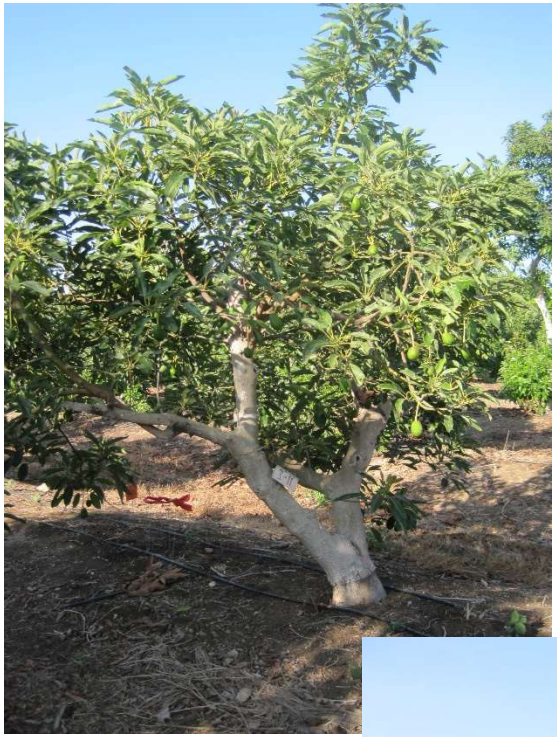
Rosh Pina pear

	Acre		Rosh-Pina	
	FW	TWW	FW	TWW
Clay (%)	60%		60%	
Soil EC (dS/m)	0.9	1.6	0.6	1.2
Soil SAR $(meq/L)^{0.5}$	0.5	3.5	0.6	2.3

Methods

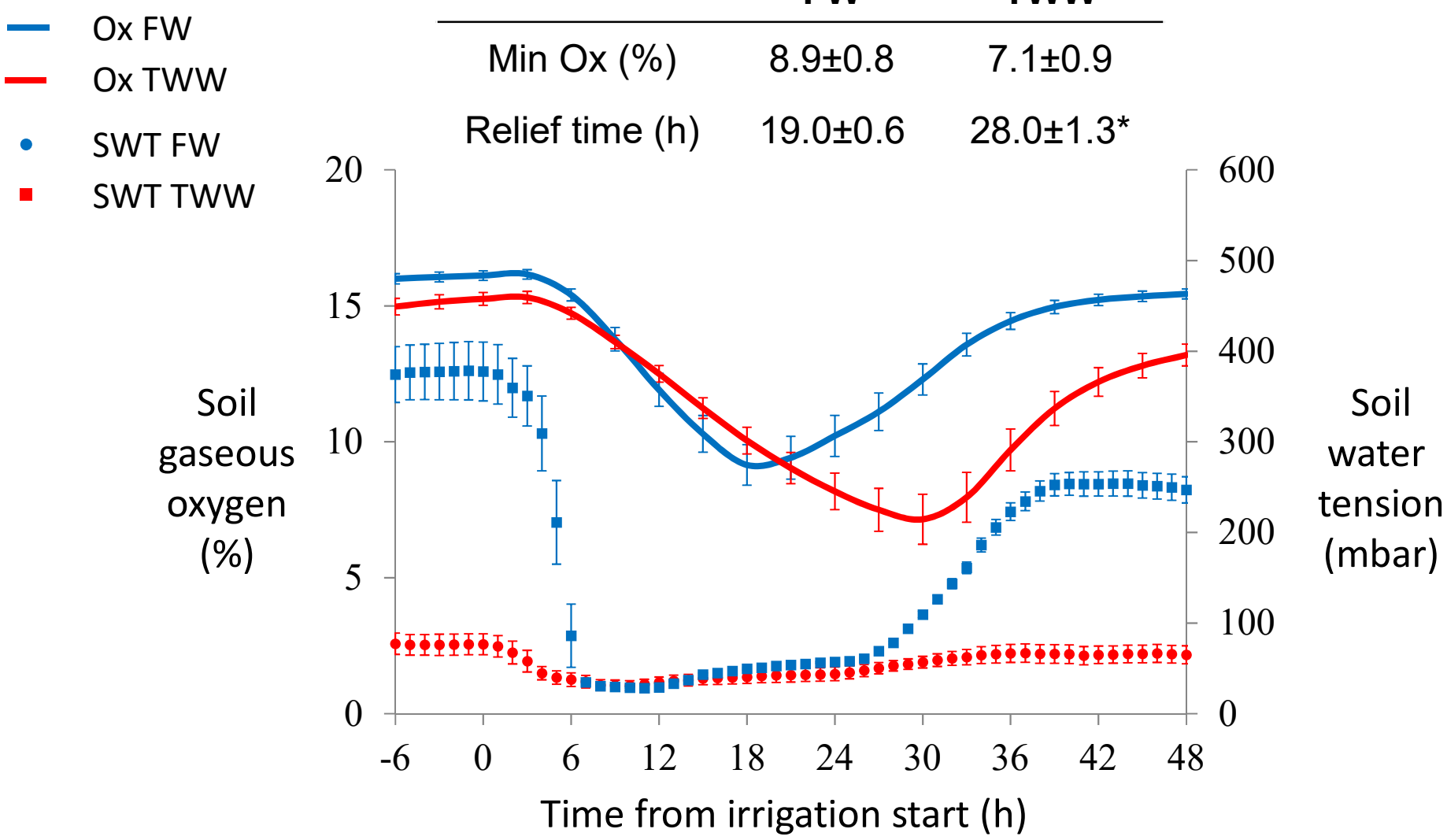


*Measurements performed by collaborators (Assouline, Narkis and Peres)



Oxygen and moisture dynamics

	FW	TWW
Min Ox (%)	8.9±0.8	7.1±0.9
Relief time (h)	19.0±0.6	28.0±1.3*

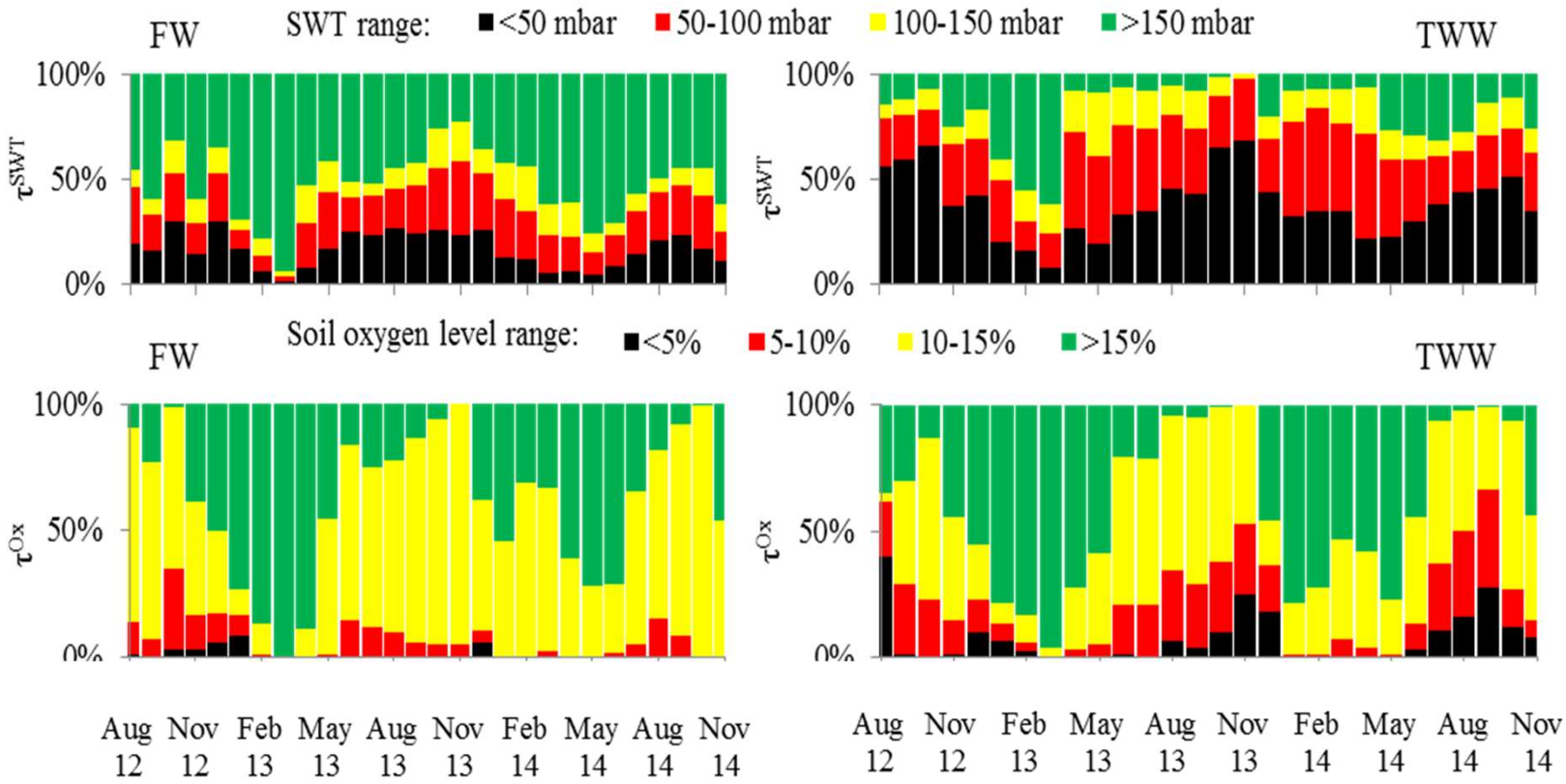


Average of four Sunday irrigations in three plots from each treatment (Aug-Sep 2013) 35 cm depth

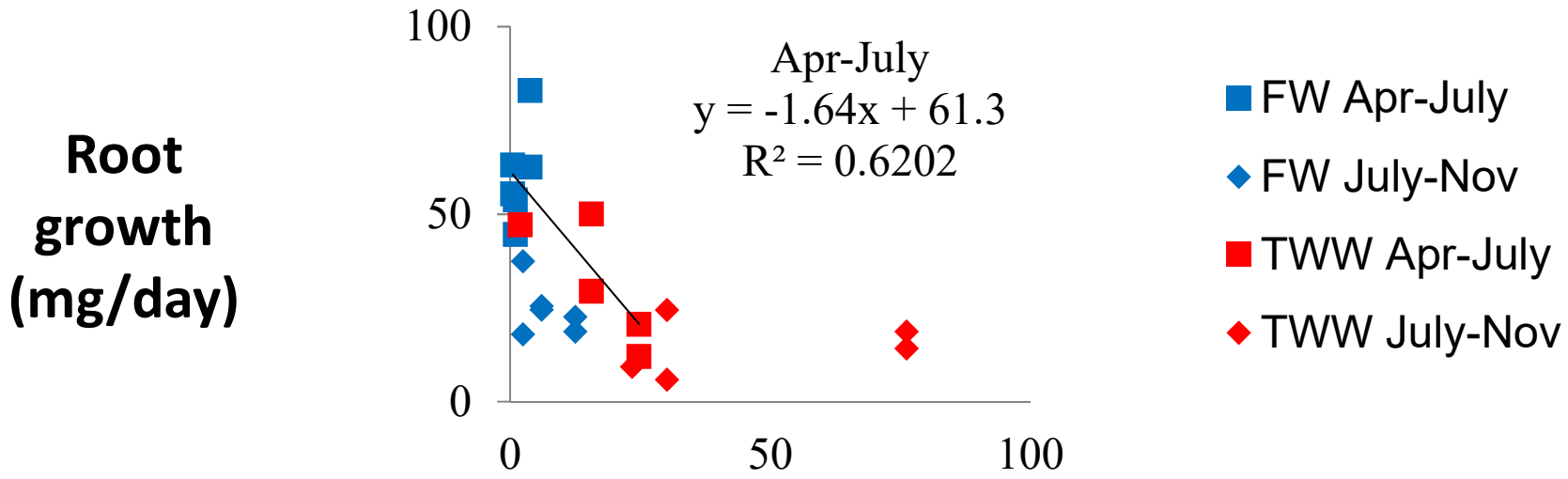
Overall effect on soil oxygen

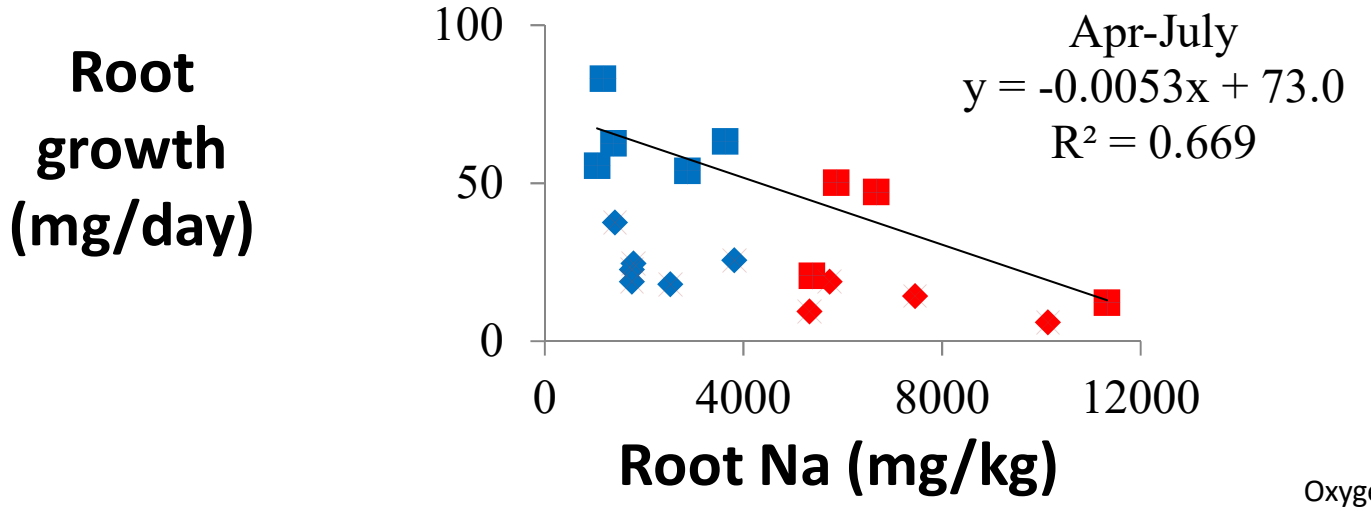
Soil water tension

Soil oxygen



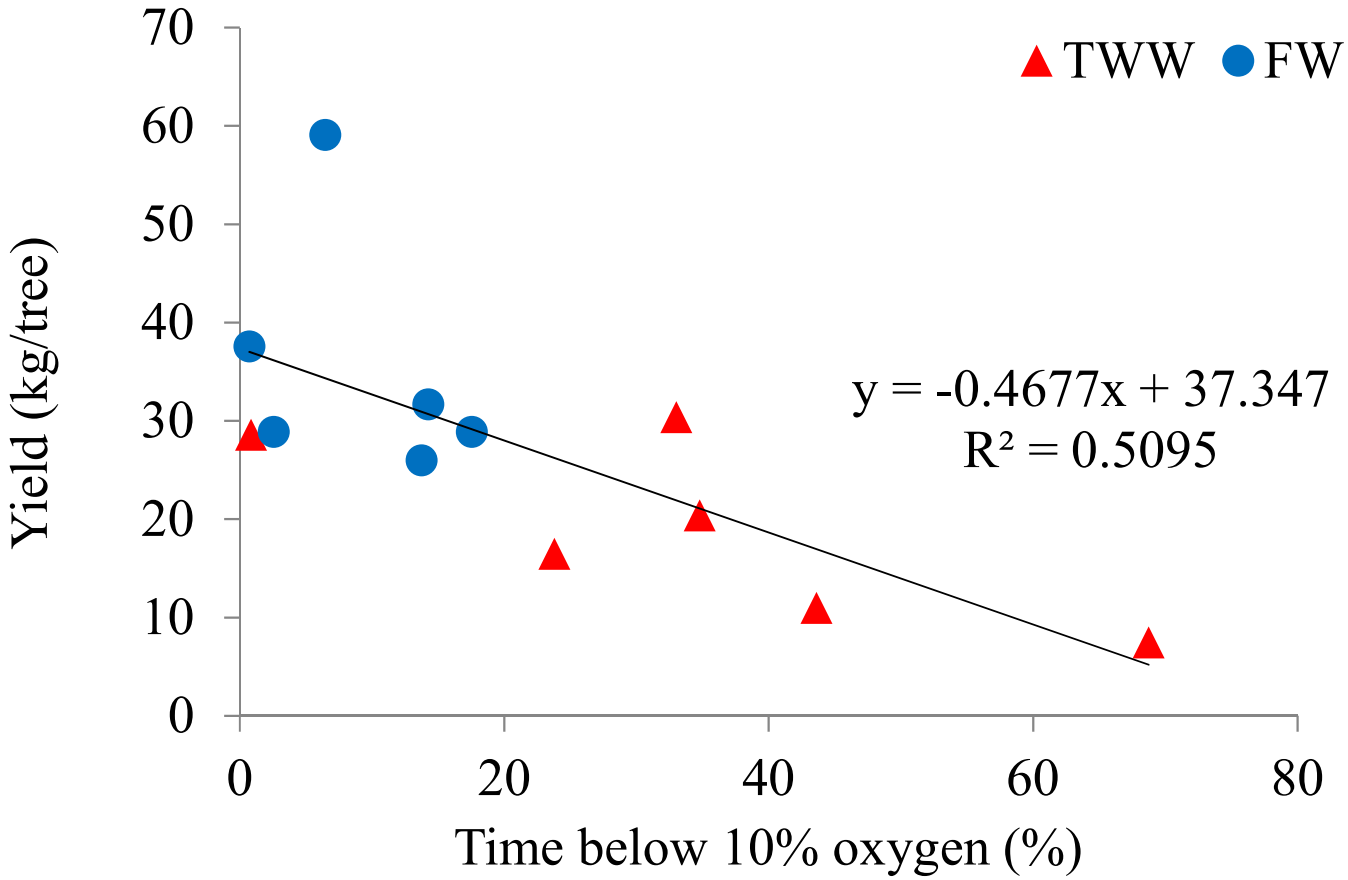
Yalin et al., 2017





Oxygen during months of growth,
Na in test after growth period

A link of oxygen and yield



Yalin et al., 2017

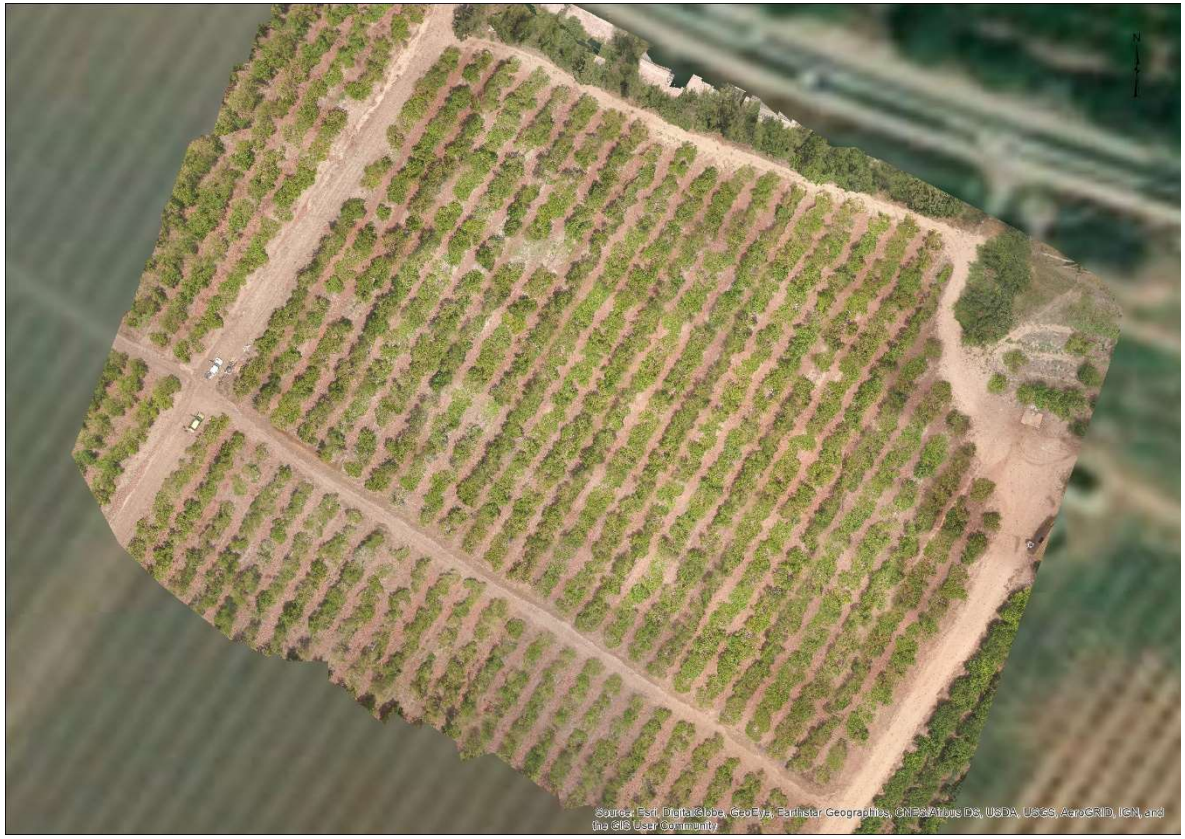
Prospects

Conversion to FW

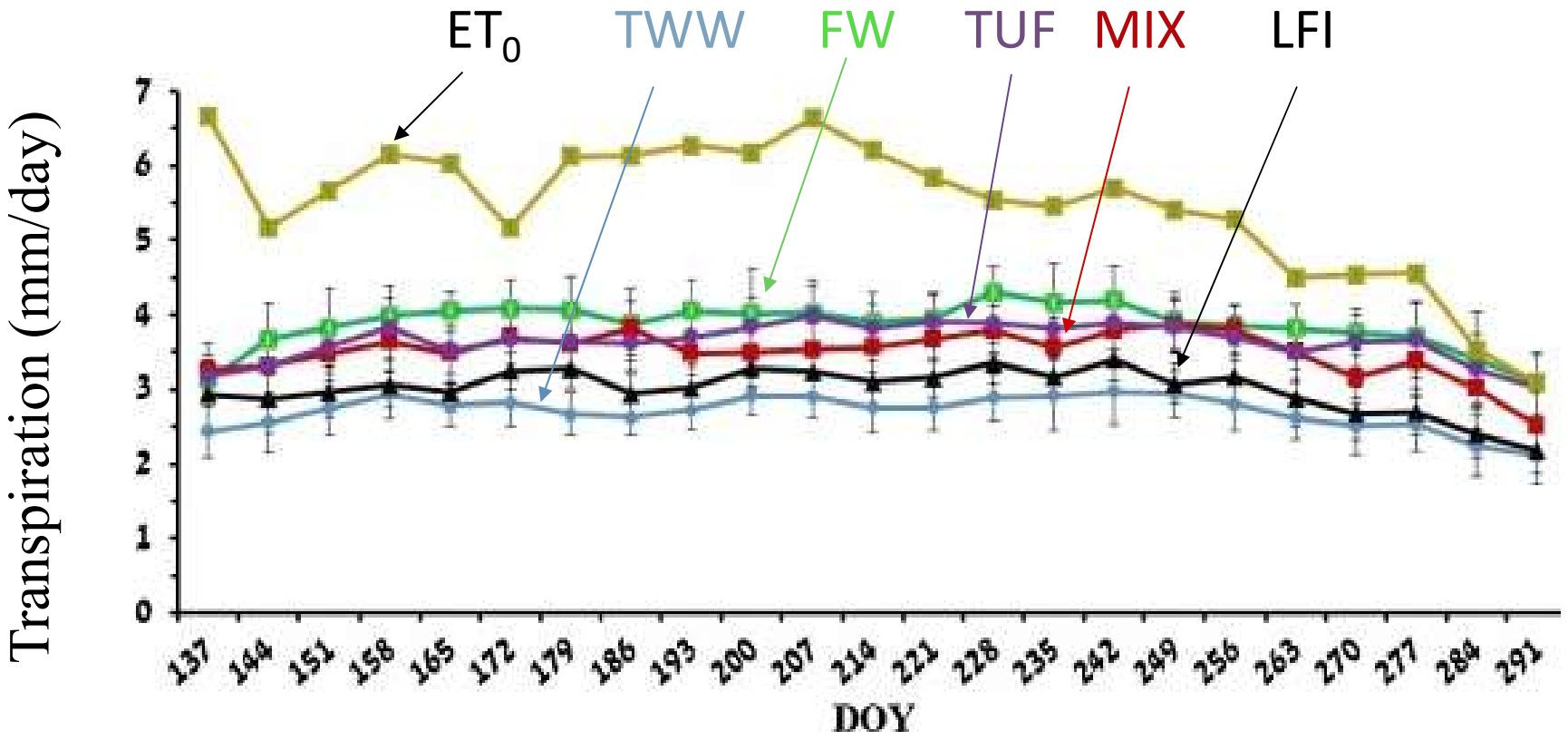
Low frequency irrigation

1:1 FW:TWW mix

Tuff filled ditches



Prospects

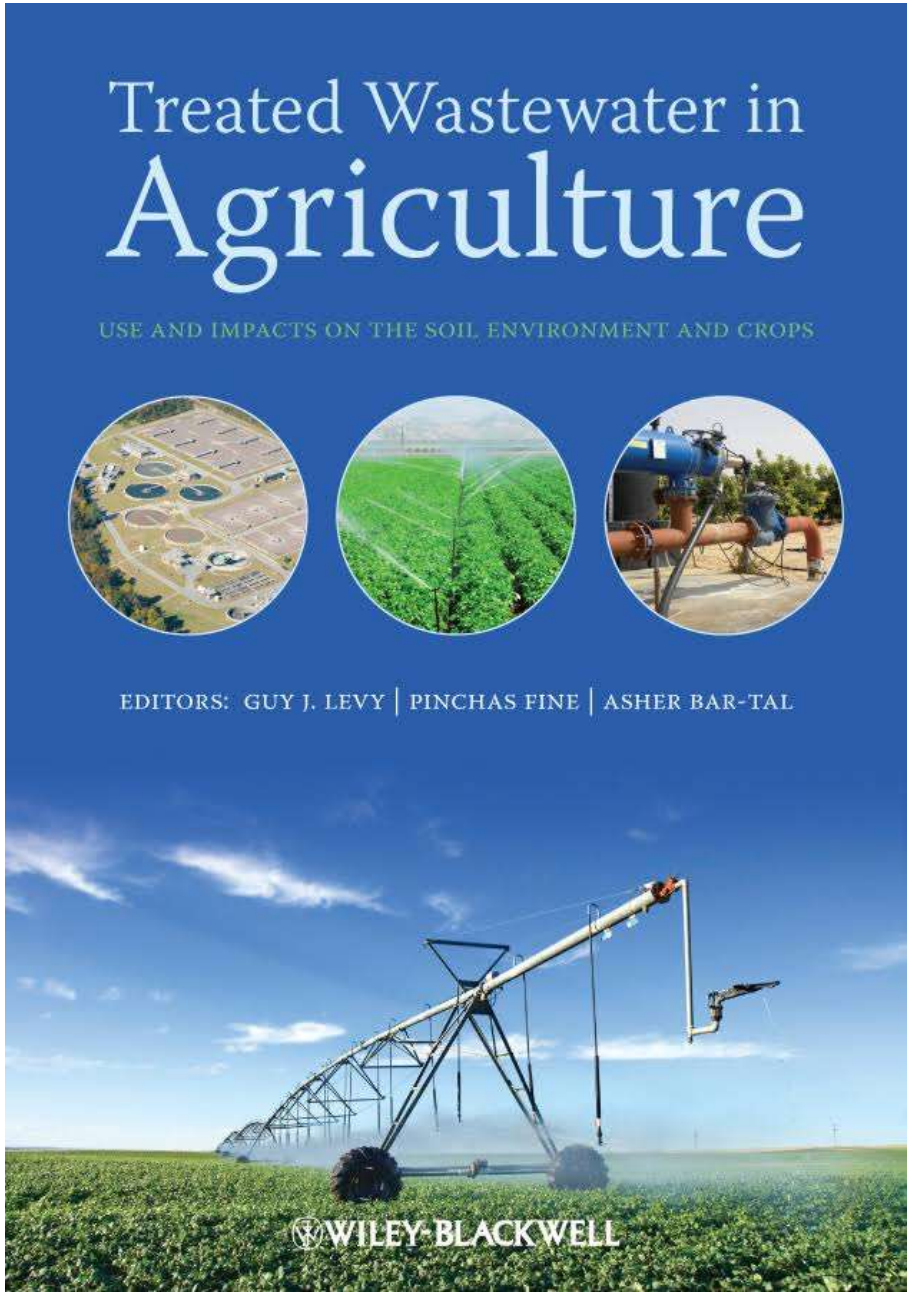

ET0
TWW
FW
TUF
MIX
LFI
Transpiration (mm/day)
0
1
2
3
4
5
6
7
137
144
151
158
165
172
179
186
193
200
207
214
221
228
235
242
249
256
263
270
277
284
291
DOY

Summary

Green Gold: A Global Demand for Avocados Leaves People Without Water in Chile

- Treated wastewater is widely used in Israel
- Treated wastewater adds N,P and K to plants which should be accounted for in fertilizer plans
- The high Na in TWW may affect aeration of the soil and cause damage to plants in this way

Treated Wastewater in Agriculture :
Use and impacts on the soil environments and crops
Editors:
Guy J. Levy, Pinchas Fine and Asher Bar-Tal



Thank you

- My family
- Moshe Shenker and Amnon Schwartz
- Collaborators – Tarchitzky J., Assouline S., Narkis K., Eshel A., Peres M.
- The Israel Ministry of Agriculture
- The Plants Production and Marketing Board