The Interaction Between Phytophthora Root Rot and Salinity

Can We Reduce Root Rot by Using Control Measures for Salinity?

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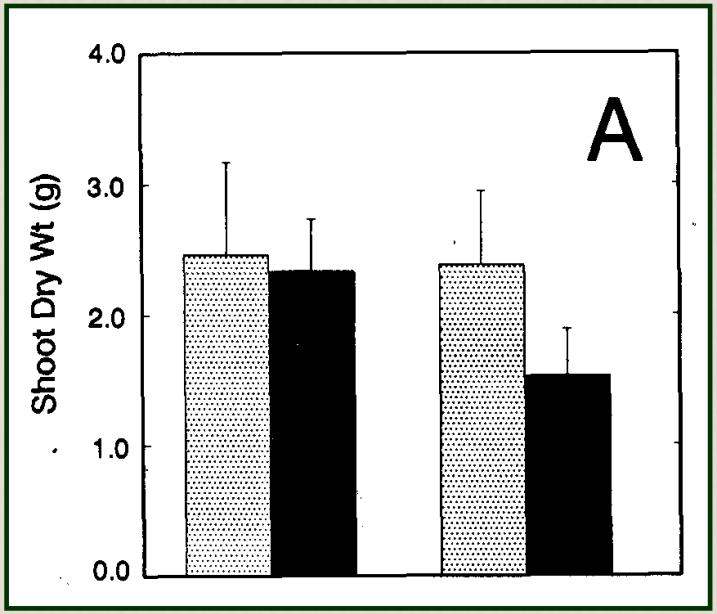
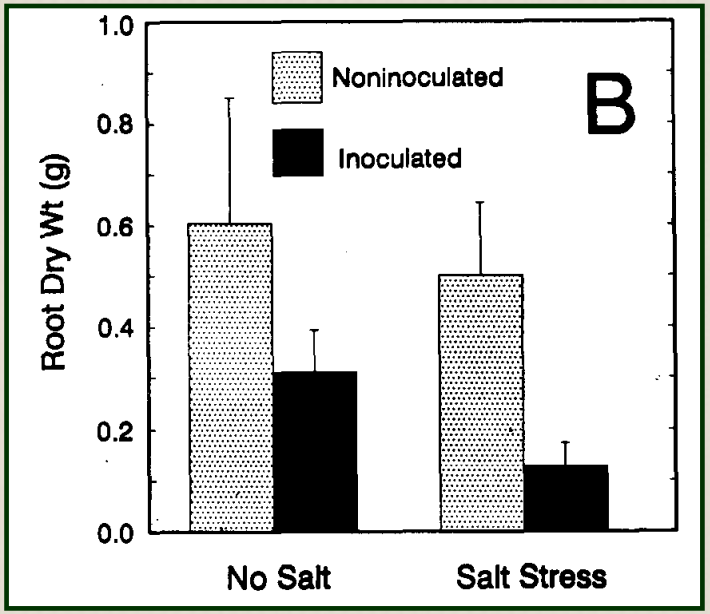
- Avocado is very sensitive to many soil stress factors, among which salinity, lime, exchangeable sodium, non−aerated soil, root−rot and dryness, each one by itself or in combination with others, limits the planting possibilities and cause damage and degeneration in existing orchards. Ben Ya'acov and Michelson 1995.

Is there an interaction between salinity and Phytophthora?

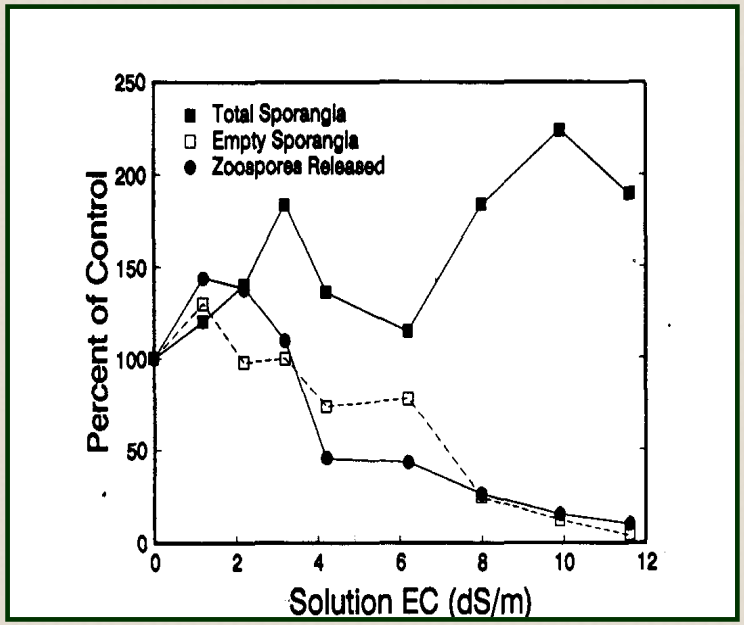
There is in tomatoes.

Swiecki and MacDonald. 1991. UC Davis

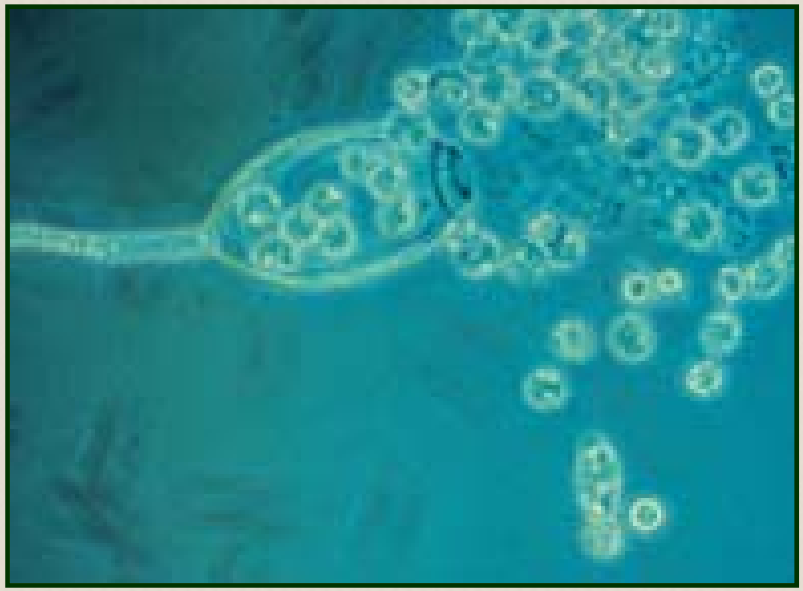




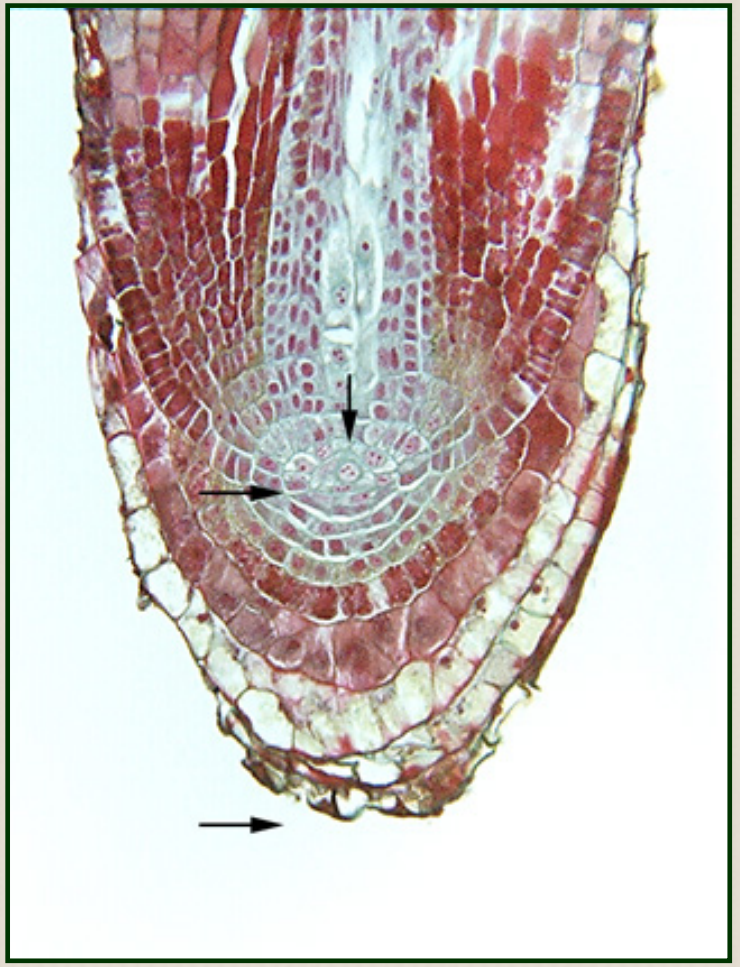
What about Sporangia and Zoospores?



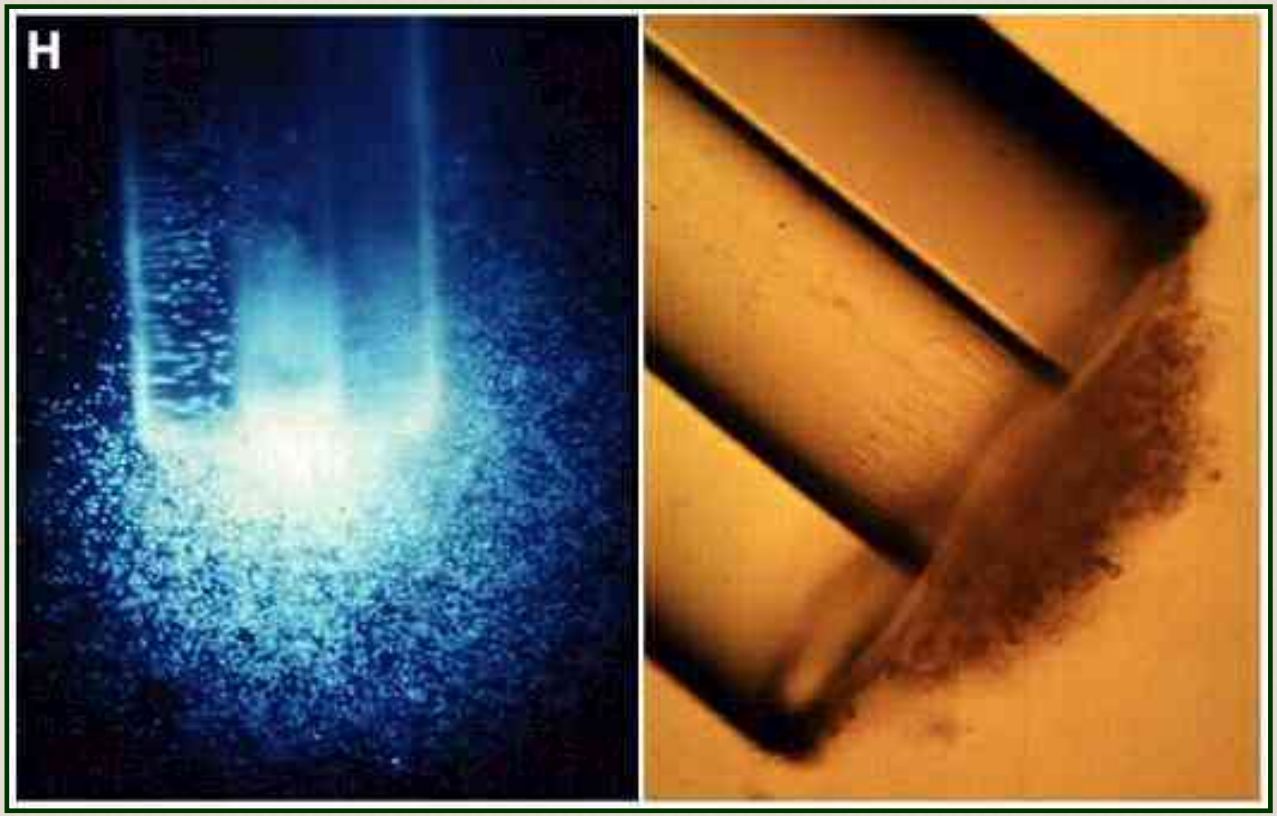
- Total sporangia increases with salinity
- Zoospore release peaks at an EC of 1-2



- Soil moisture just below saturation allows sporangia to form in 4-8 hrs and motile zoospores to be released in 10-60 min.
- Therefore, poorly drained or wet soils favor the pathogen.
- Zoospores infect feeder roots just behind the root cap.
- Cell walls are thin and leaky in this area and attract the zoospores.



Zoospores encysting at the end of a capillary tube filled with asparagine (left) and malt extract (right).
Salt degrades the root tips allowing an increase in root exudates.



The result: infected avocado roots on the left, showing black-brown discoloration

Are we adding salt to our soils by irrigating?

How Much Salt is in Your Water?

1 Acre Foot = 1,233,000 Liters

X

TDS = 500 mg / Liter

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615 kg of TDS Salt

How Much Sodium Chloride is in Your Water?

1 Acre Foot = 1,233,000 Liters

X

Na - 54 to 101 mg/L

Cl - 71 to 96 mg /L

---

66 - 124 kg Na

87 - 118 kg Cl

---

153 - 242 kg NaCl

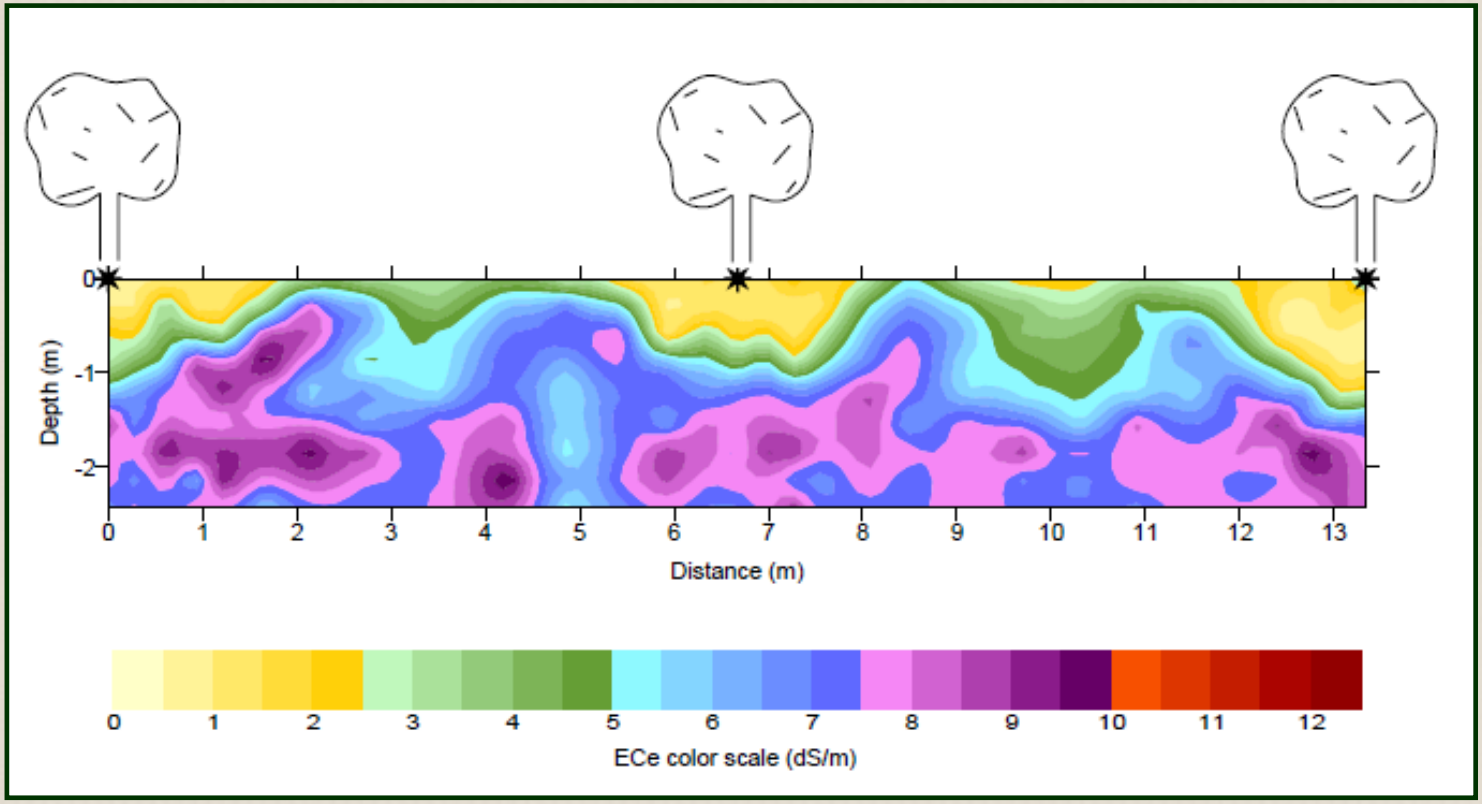
How Much Salt is in Your Water?

4 acre feet/acre/year:

612 - 968 kg NaCl

2464 kg total dissolved salt
= 5432 lbs salt/acre/year

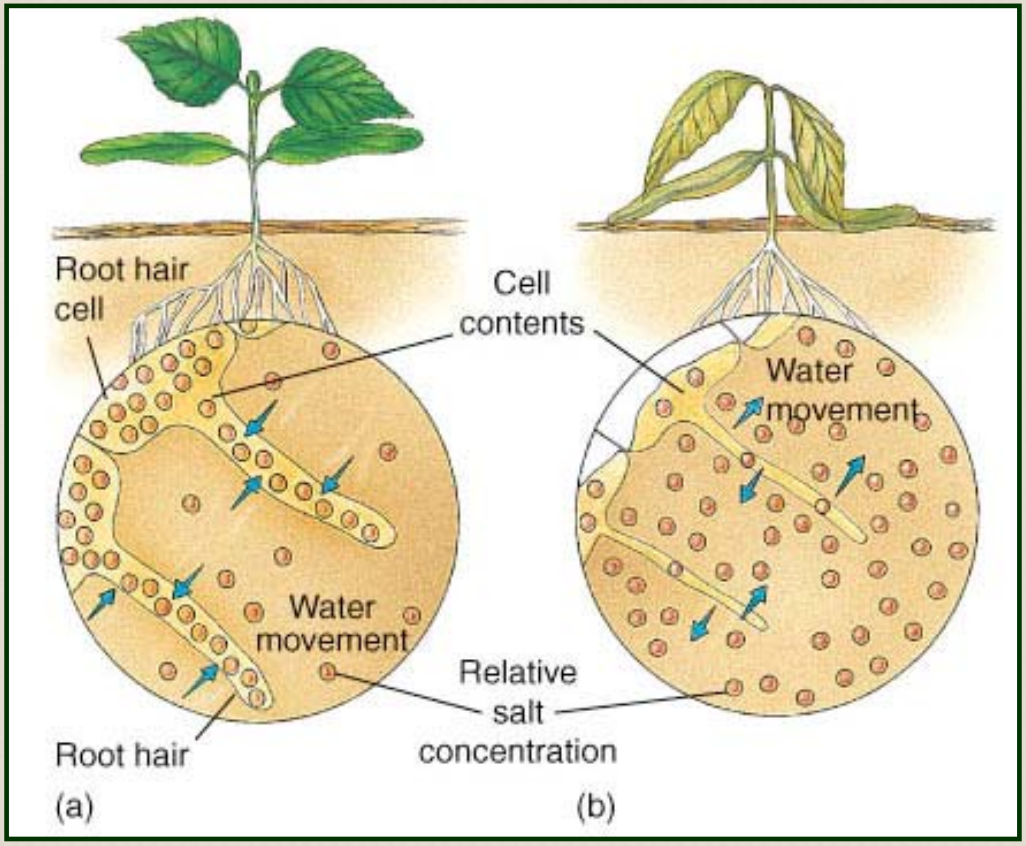
Salt Accumulation in Tree Crop Orchards Using Micro-Spray Irrigation



CDWR 2003

Soil Salinity Accumulation in Orchards with Drip and Micro-spray Irrigation in Arid Areas of California
http://www.itrc.org/reports/salinity/treecropsalinity.pdf ITRC Report No. R 03-005

The Problem with Total Dissolved Salt: High Salt Inhibits Plant Water Uptake



For avocado, this occurs at EC = 4 dS/m

Water enters the plant by osmosis

Salt in the soil sucks water out from the plant roots

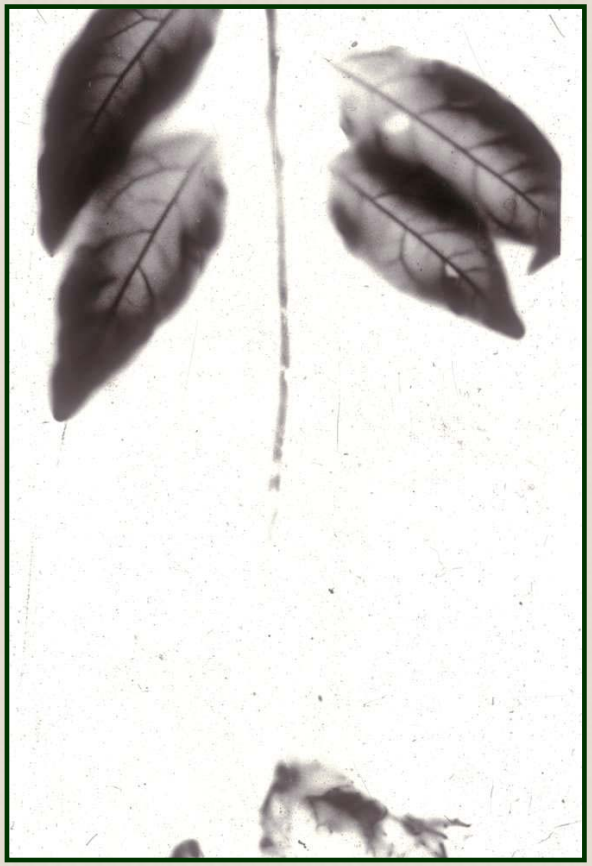
Water Stress after Fruit Set, Leading to Fruit Drop in July

Irrigation Water Salinity

Salts in irrigation water include toxic minerals:

Cations	Anions
Calcium Ca^{++}	Sulfate SO_4^{2-}
Magnesium Mg^{++}	Carbonate CO_3^{2-}
Sodium Na^{+}	Chloride Cl^{-}
Potassium K^{+}	

Uptake and Distribution of Radiolabeled Chloride and Sodium (Kadman ca 1960s, avocadosource.com)



Chloride

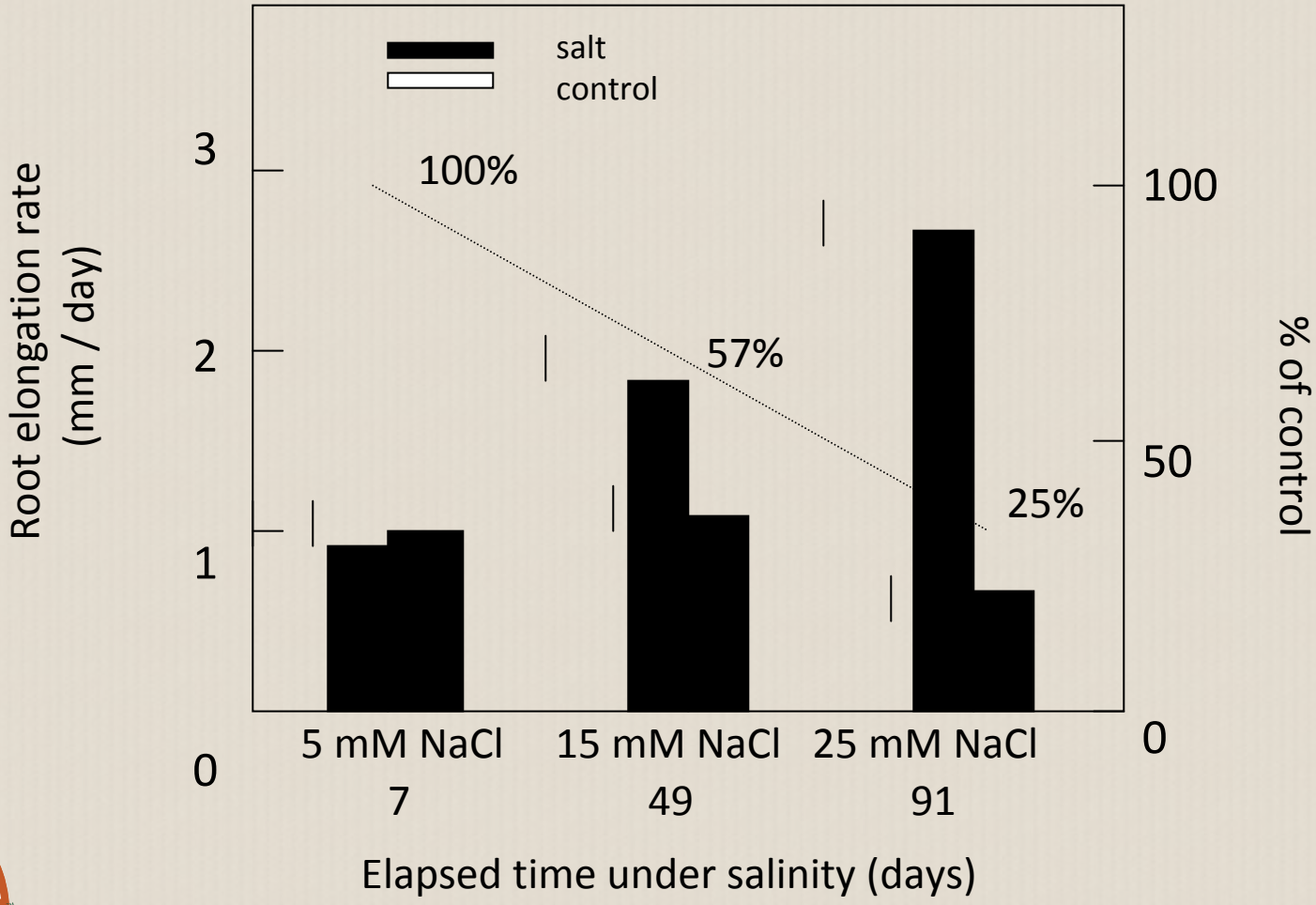
Sodium

Combined Effects of Chloride and Sodium Toxicity

Chloride 0.58%
Sodium 0.35%

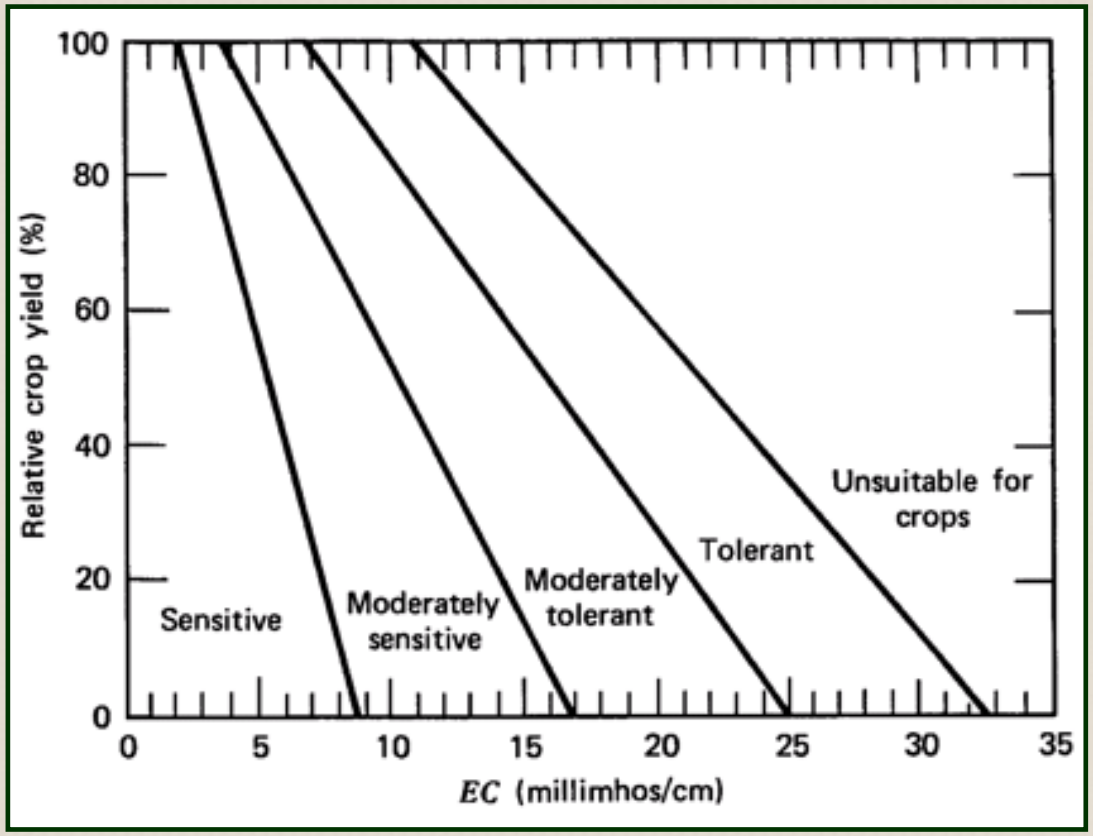
Chloride 0.61%

Effects of Chloride Toxicity on Root Growth



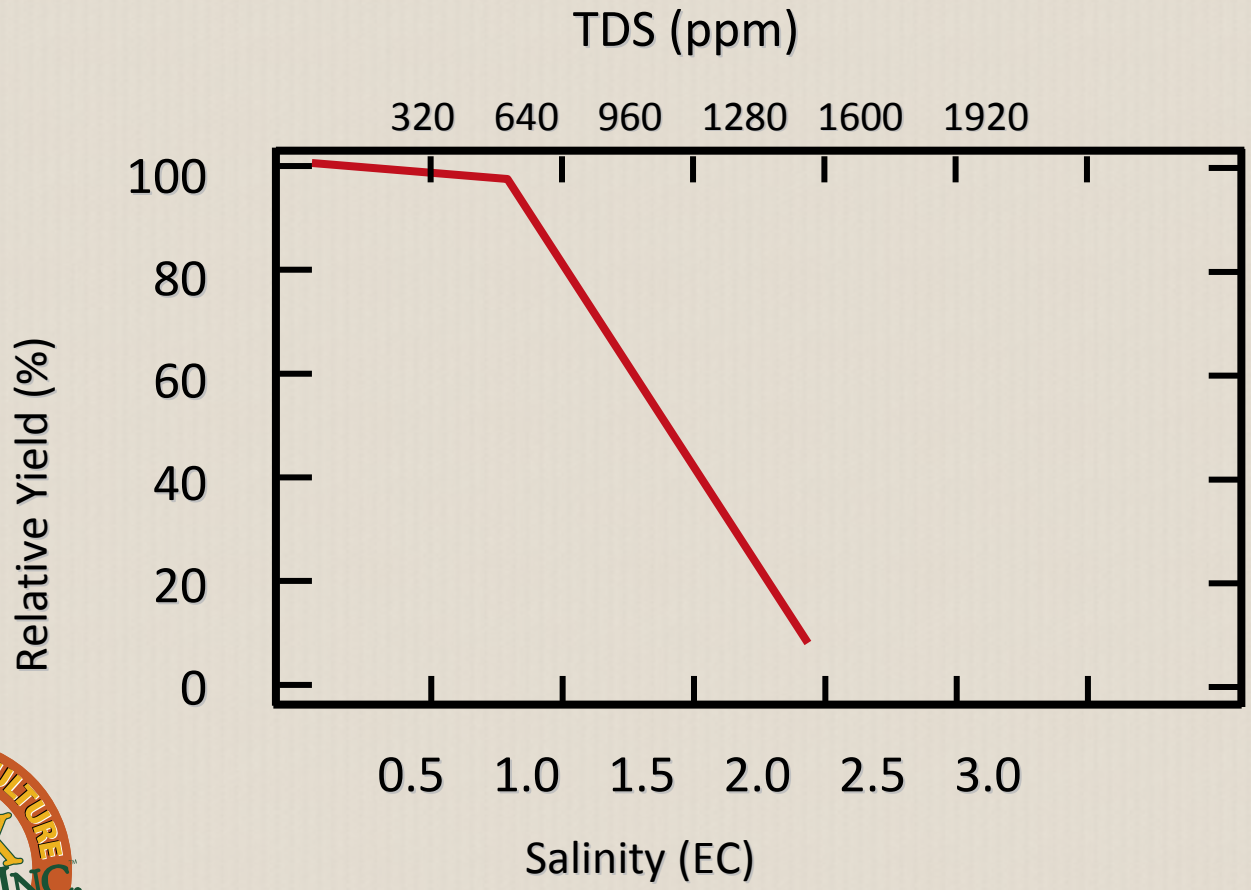
Berstein (Avocadosource.com)

Avocado is one of the most saline sensitive crops, and is subject to yield reduction when irrigated with saline irrigation water. This is due to a combined effect of dissolved solids (EC) and chloride toxicities.

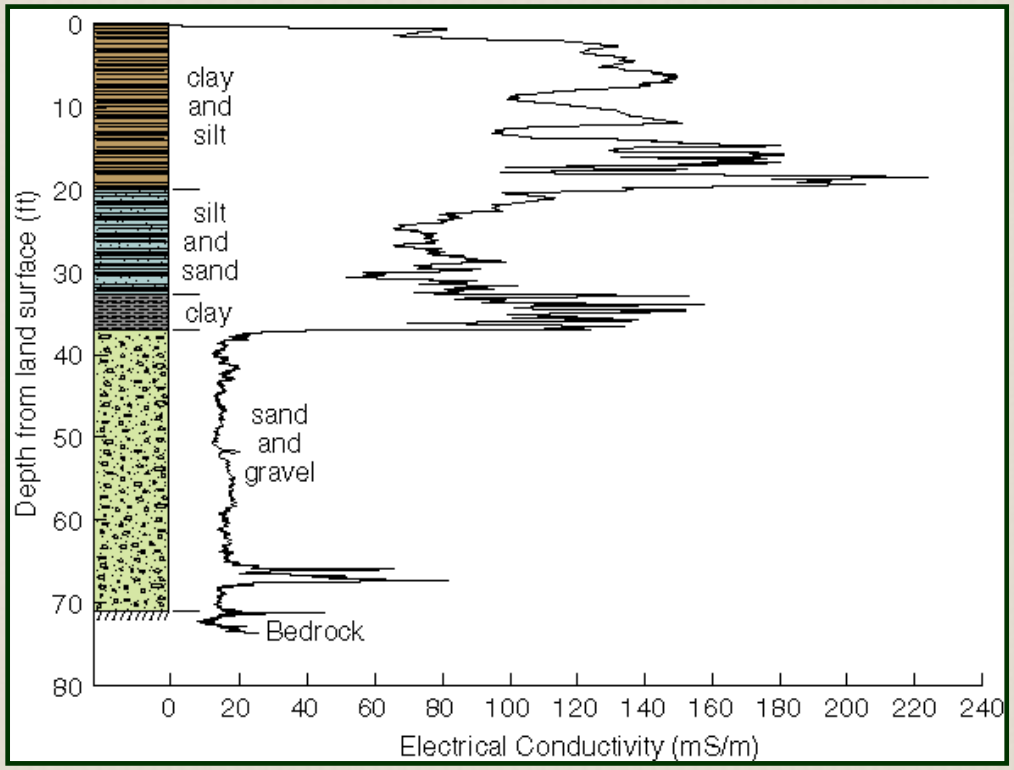


Avocado Yield Function for Irrigation Water Salinity

Oster and Arpaia, J. Am Soc. Hort Sci. 2007



Measuring Salinity: Electrical Conductivity

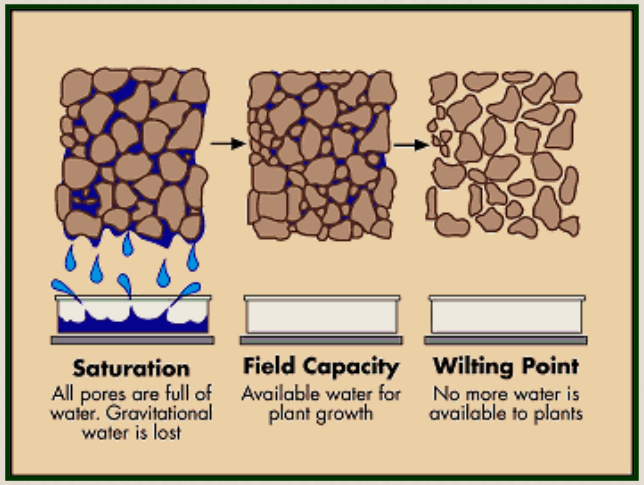


Units for measuring salinity, and conversion factors.

Conversion factors relating total dissolved salts or pure NaCl to an electrical conductivity (EC) of 1 dS/m (1 deciSiemen/metre) are given, along with equivalent units of various types, old and new.
The conversion of EC of 1 dS/m to total dissovled salts (640 mg/L) assumes a composition of salts that is common in groundwater across the world. The exact factor varies from 530 (if the salt is predominantly NaCl) to 900 (if the salts are formed predominantly from divalent ions).

Measurement and units	Application	1 dS/m is equal to:	Equivalent units
Conductivity (dS/m)	soils	1	1 dS/m = 1 mS/cm = 1 mmho/cm
Conductivity (µS/cm)	irrigation and river water	1000 µS/cm	1 µS/cm = 1 µmho/cm
Total dissolved salts (mg/L)	irrigation and river water	640 mg/L (approx.)	1 mg/L = 1 mg/kg = 1 ppm
Molarity of NaCl (mM)	laboratory	10 mM	1 mM = 1 mmol/L

Salinity Calculations for Soil At Different Moisture Levels



Irrigation water EC = 1
Assume no prior accumulation,
Then as soil dries:

Soil Status	Water Content	CentiBars	EC
Saturation	50%	0	1
Field Capacity	25%	3	2
Air dry	10%	40	5
Wilting point	<5%	>100	10

Leaching Fraction

$$LR = \frac{ECiw}{5*EC_{ts} - EC_{iw}}$$

For EC_{ts} 0.67 for avocado and EC 1 irrigation water

$$LR = \frac{1.0}{5*0.67 - 1} = .42$$

EC_{ts} = EC threshold sensitivity
EC_{iw} = EC irrigation water

Rhoades 1974

TDS/Conductivity/Salinity Pen

- Collect Soil Cores
  0-6”, 6-12”, 12-18”
- Prepare 2:1 Water:Soil Extracts
  Distilled Water
- Measure EC
  Multiply x 6 (to estimate soil ECw)
- If EC > 0.25 dS m^{-1} for 2:1 water extract then it is time to leach (equivalent to an ECw of 2.0 at field capacity)

Dealing with Salinity

- Proper Irrigation Management
- Gypsum
- Leaching
- Organic Matter
- Rootstock Selection

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Salinity-Chloride Interactions: Their Influence on Yields

David Crowley and Mary Lu Arpaia - Dept of Environmental Sciences,
University of California, Riverside, and UC Kearney Agricultural Center, Parlier, CA
Cooperating Investigators: Ben Faber and Gary Bender

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Typical Soil Water Analysis for Well Water San Diego County

SUBMITTED BY: CROWLEY, DAVID
DANR SECTION: AGF: ENV SCI, UCR

COMMODITY: Avocado Irrigation Water

WORK REQ #: 03W003
OF SAMPLES: 2
DATE RECEIVED: 07/08/02
DATE REPORTED: 07/26/02
DANR CLIENT #: CROX1
TURN AROUND TIME IN WORKING DAYS: 15

Sample Type: WATER Date Sampled: 24 Oct 01 & 18 May 02; Grower/Location/Project: Stehly/San Diego/ Stehly Salinity

SAMPLE #	DESC	EC [SOP 815] mmhos/cm	pH [SOP 805]	Ca (Soluble) [SOP 835] meq/L	Mg (Soluble) [SOP 835] meq/L	Na (Soluble) [SOP 835] meq/L	Cl [SOP 825] meq/L	HCO3 [SOP 820] meq/L	CO3 [SOP 820] meq/L	B (Soluble) [SOP 835] ppm	SAR [SOP 840]	Zn (Soluble) [SOP 835] ppm	Cu (Soluble) [SOP 835] ppm
1A	24-Oct-01	2.12	8.0	10.0	7.2	6.6	8.3	3.3	0.1	0.1	2	<0.02	<0.02
1B		2.09	8.0	9.8	7.0	6.6	8.4	3.3	0.1	0.1	2	<0.02	<0.02
2A	18-May-02	3.28	8.0	14.7	14.5	9.5	13.6	3.8	<0.1	0.1	2	<0.02	<0.02
2B		3.17	8.0	14.6	14.4	9.6	13.4	3.8	<0.1	0.1	3	<0.02	<0.02
Method Detection Limit:		0.01	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1	0.02	0.02
Blank Concentration:		-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.00	0.00
Standard Ref as Tested:		0.29	6.4	0.4	0.7	1.8	0.4	2.1	-	0.3	3	50	8.6
Standard Ref Acceptable:		0.29±0.04	6.5±0.4	0.4±0.2	0.8±0.2	1.7±0.2	0.3±0.2	2.3±0.4	-	0.4±0.2	2±2	50±6	8.7±1.2
Standard Reference:		UCD 005	UCD 004	UCD 005	UCD 005	UCD 005	UCD 005	UCD 005	-	UCD 005	UCD 005	UCD 155	UCD 155

Checked and Approved: *{electronically signed by E. Sue Littlefield}*
E. Sue Littlefield, Lab Supervisor

Total Chlorides Range Measured in 2006: 8 to 13 mM, 300 – 560 ppm
(1 meq Cl x 35 = ppm)

Current Research

Salinity – Chloride Interactions and Their Effects on Avocado Yields

Objectives

- Examine salinity effects on the yields of avocado trees across the main production areas in Southern California.
- Compare salinity performance of the major rootstocks now being used for avocado production.
- Evaluate the specific ion toxicity effects of chloride and sodium on root growth.

Where are we with rootstocks?

- Mexican rootstocks are much more susceptible to salinity than West Indian rootstocks.
- "West Indian avocado rootstocks were very rarely used in California, although they are known in Israel and Texas to resist salinity much better than the Mexican rootstocks. The fact that the West Indian race is much more sensitive to low temperatures, inspired Halma's conclusion that the West Indian was too tender for California conditions." A. Ben-Ya'acov and E. Michelson, Avocado Rootstocks, 1995.

Where are we with rootstocks?

- In 2003 we planted ten rootstocks (replicated 20 times) with Hass scions at the Stehly Ranch in Valley Center. The salt content in the water was high (EC = 2.5, chloride content about 300 ppm).
- We used four of Ben-Ya'acov's selections from Israel (VC selections).
- A freeze destroyed our trial in 2007, but most of the grove was recovered and harvested in 2010.

Responses of Avocado Rootstocks to High Salinity Irrigation Water

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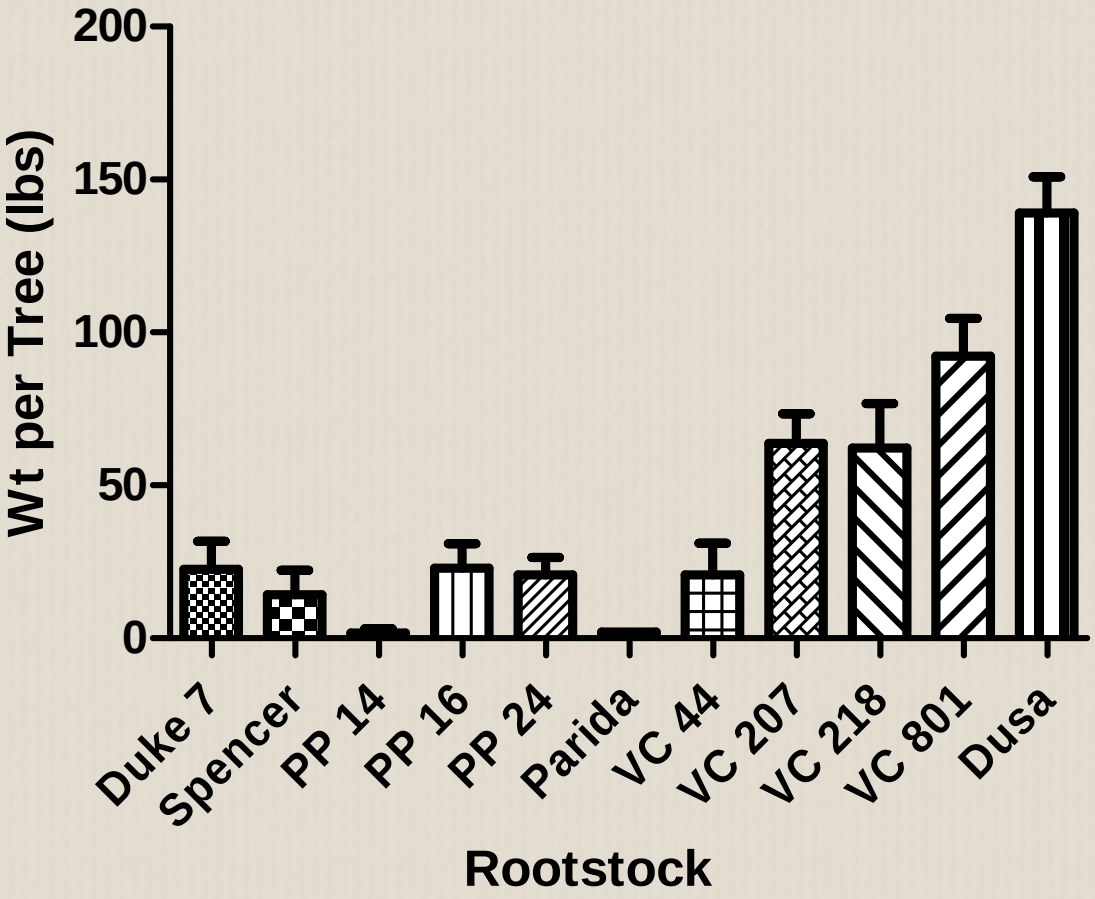
Salinity Rootstock Trial , Harvest 2010



We still have a lot more work to do!

"Rootstock selection is one of the best means of action when soil problems must be solved. But all around the avocado industries, there were only very few selection projects, and they were aimed only to solve a specific problem, like the root−rot problem in California" (Ben-Ya'acov, 1980).