Managing Salinity in Florida Citrus

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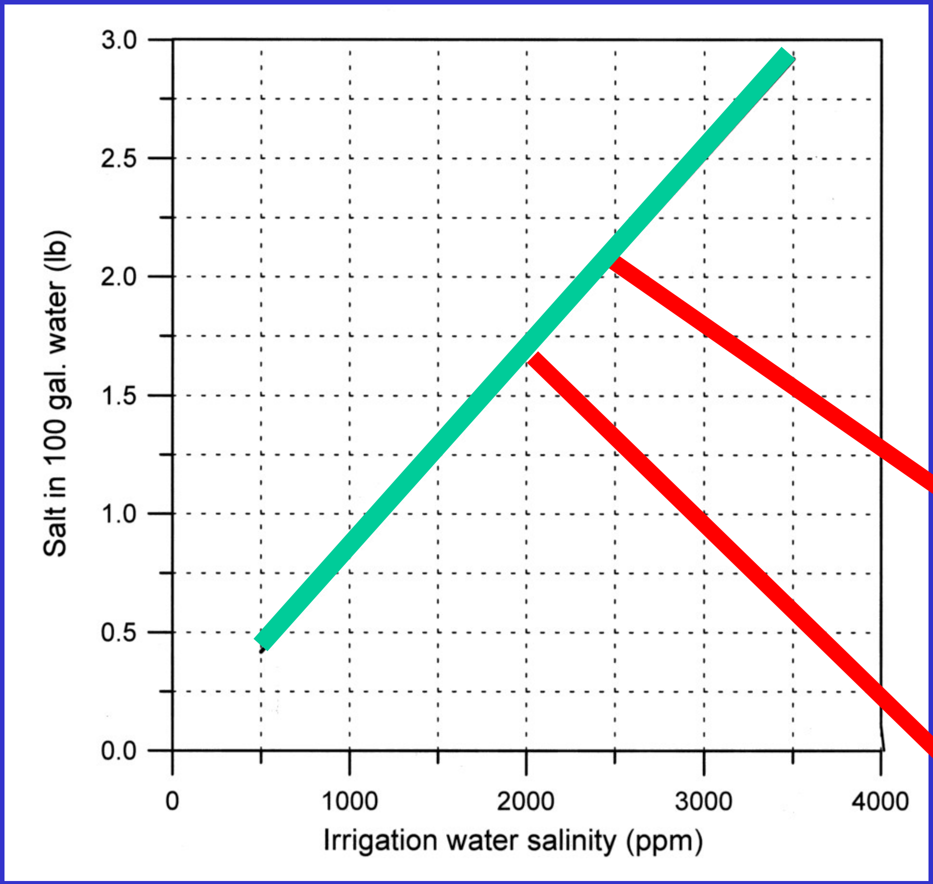
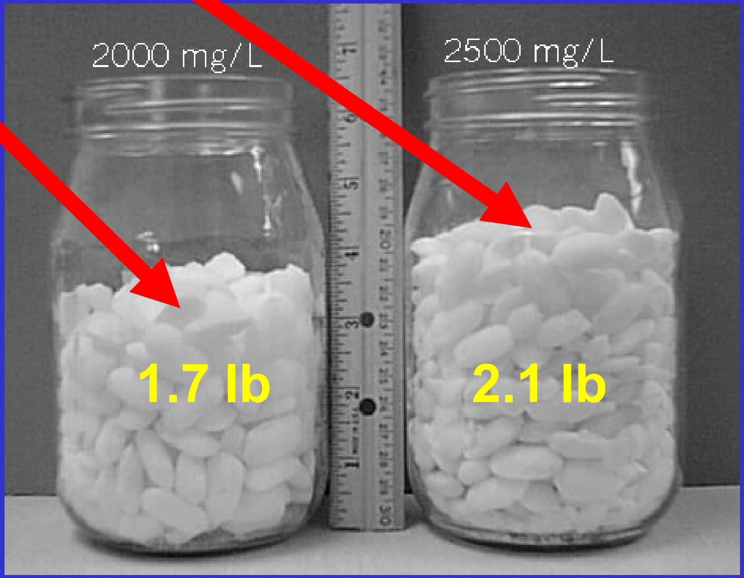
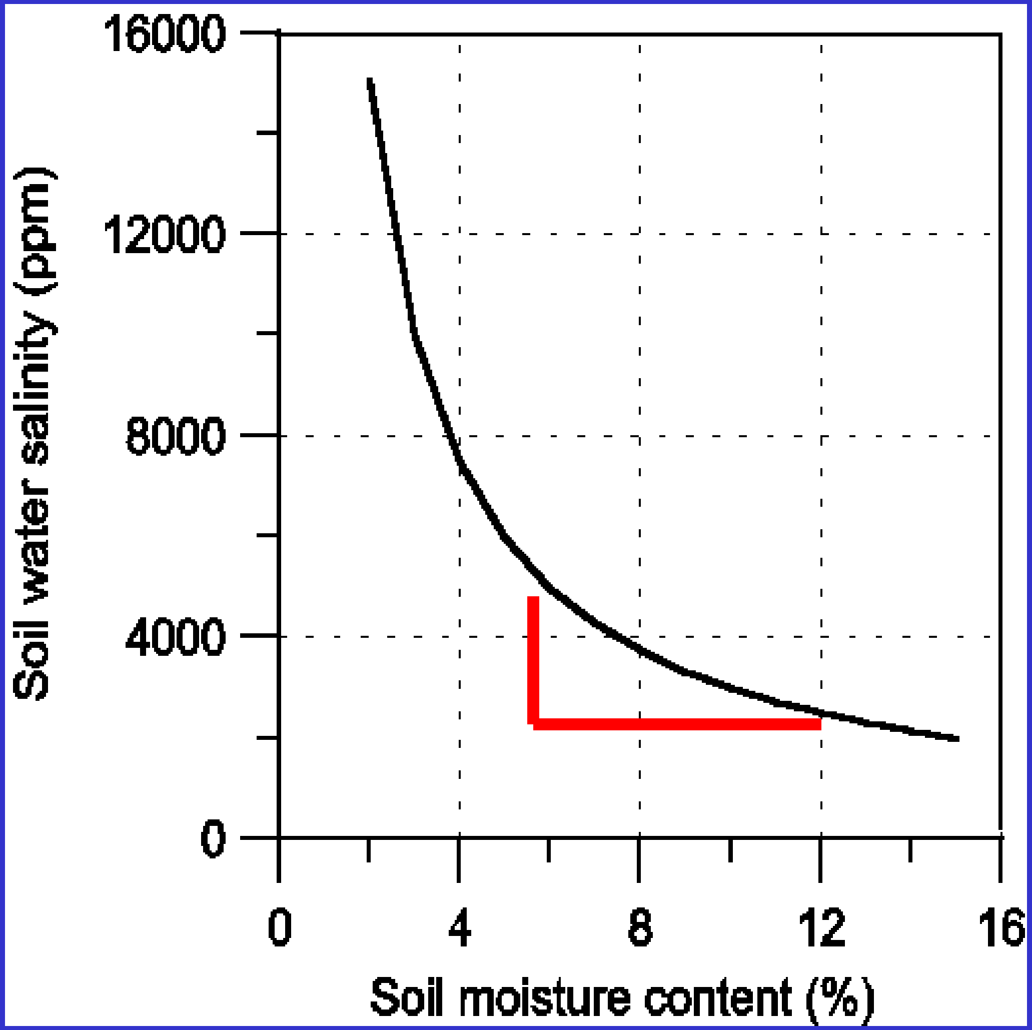
Salt Load in Water





Trees receiving 40 gal/day of 2000 ppm water will receive **4¾ lb** of salt per week



Evaporation

- Pure water ↑
- Salts accumulate at surface

Concentration

- As soil dries, ppm in water increases ↑

Removal

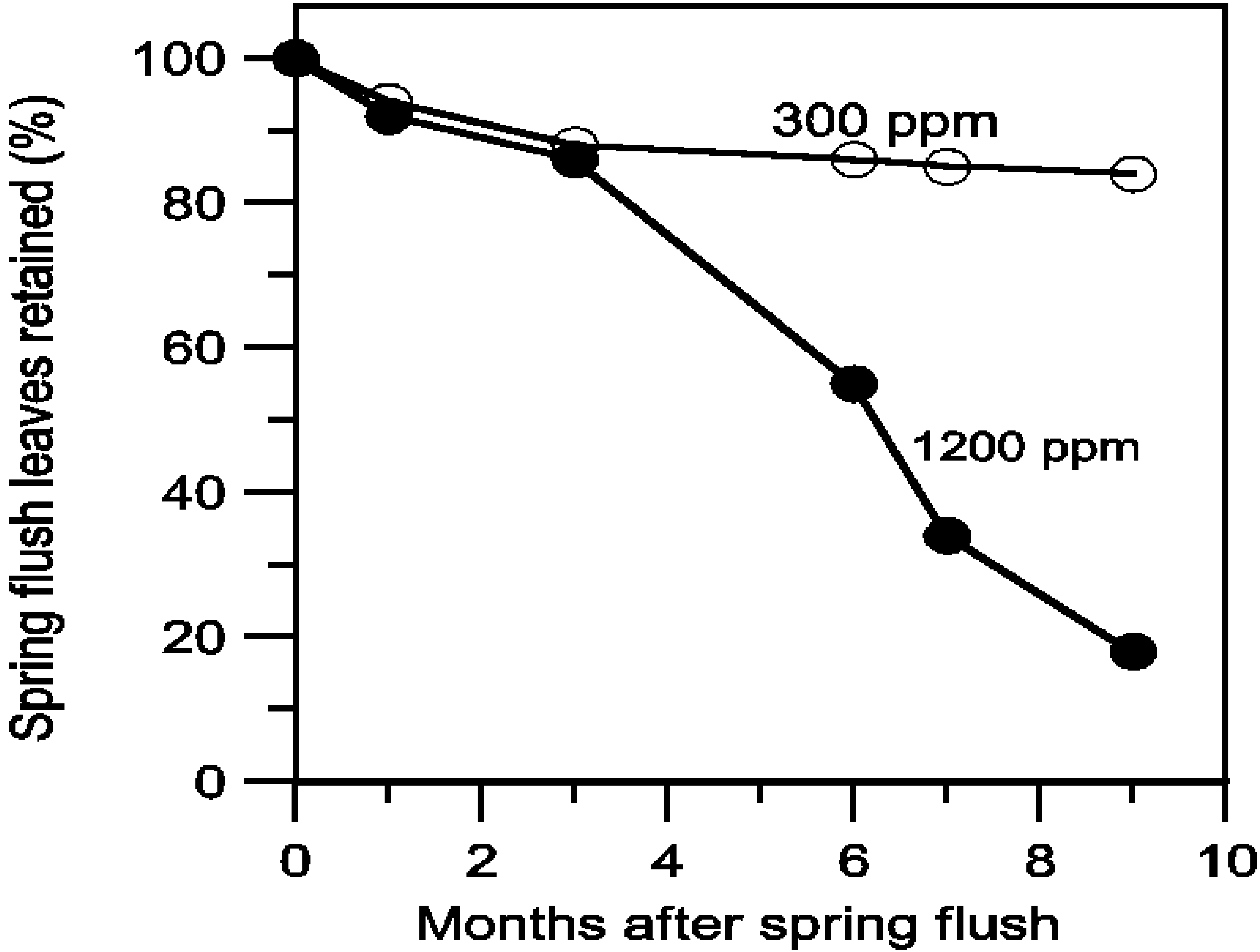
- Leaching only way to remove ↓

- Canopy thinning
- Leaf drop at extremities
- Delayed flush & bloom

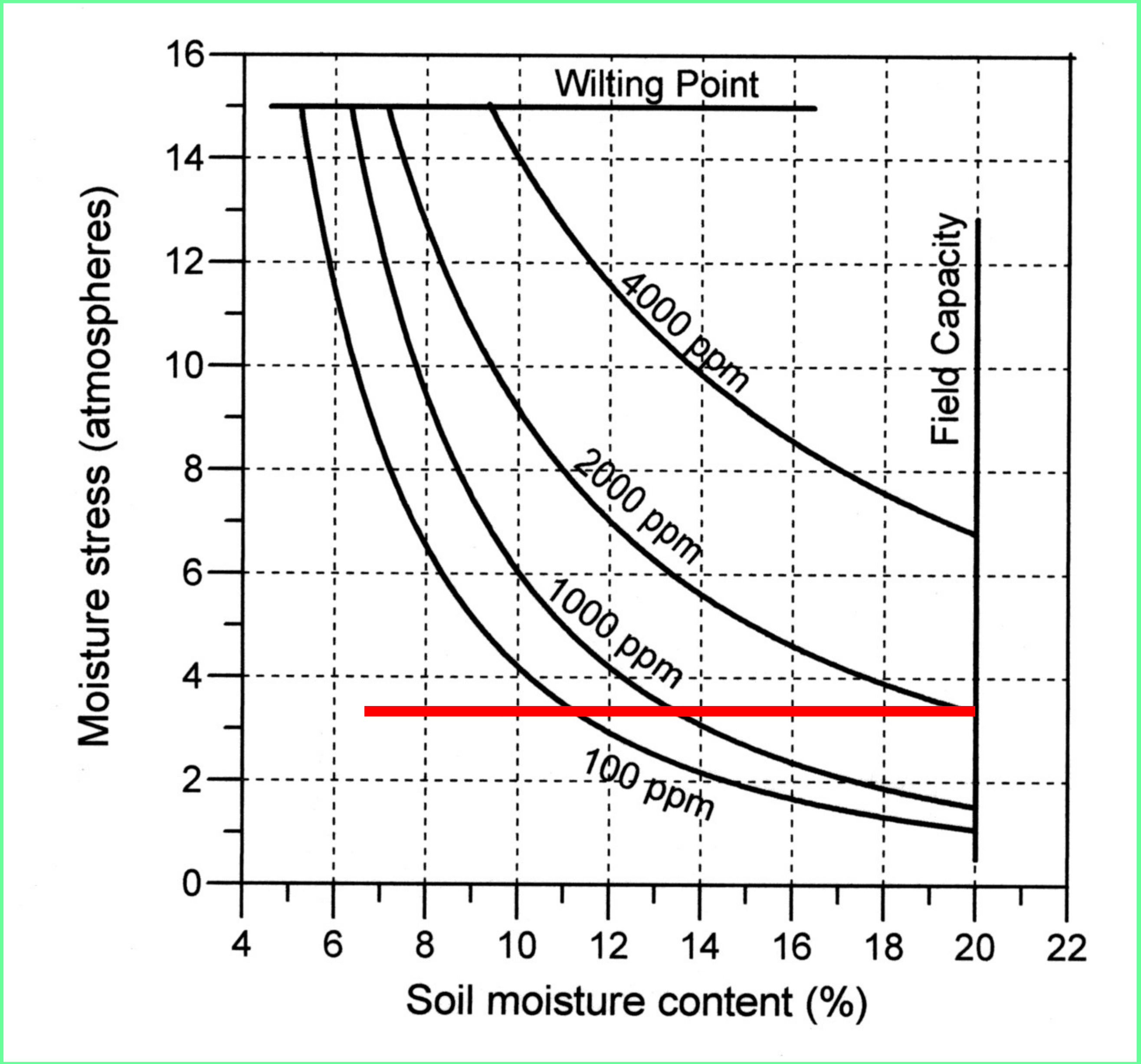
- Burn on edges of leaves
- Bronzing of leaves
- Twig dieback
- Small leaves
- Bark burn on young trees
- <u>Small fruit</u>

Leaf Burn

- Wetting foliage can cause severe leaf damage
- Cl and Na in lower leaves can be much higher
- Leaf burn can occur at about 0.25% Na or Cl
- Accumulation depends on evaporation rate, which results in increased salt concentration of the water film on the leaves.
- Damage greater from intermittent than continuous wetting - nighttime irrigation preferred

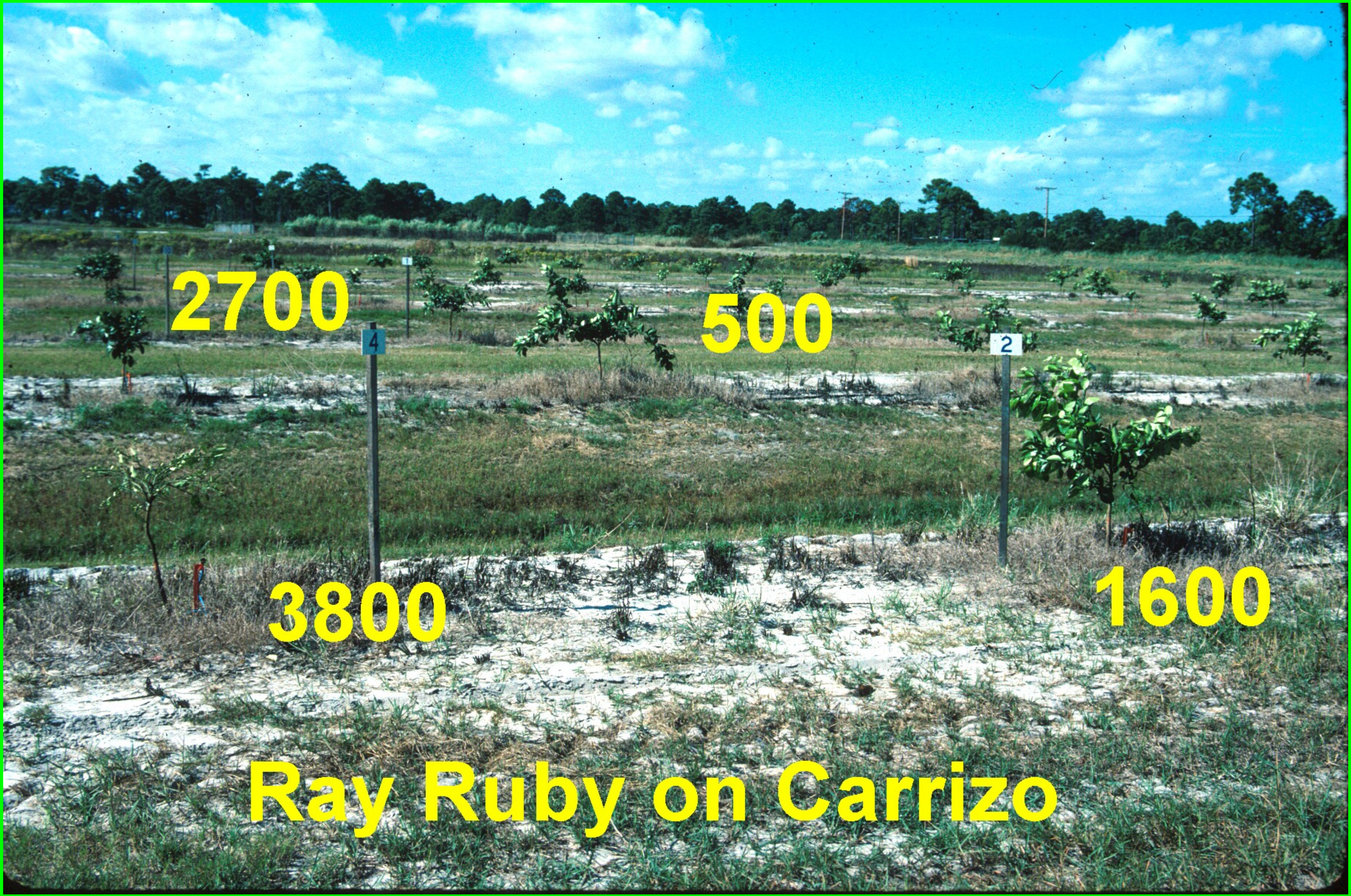


Spring flush leaves retained (%)
100
80
60
40
20
0
300 ppm
1200 ppm
0
2
4
6
8
10
Months after spring flush

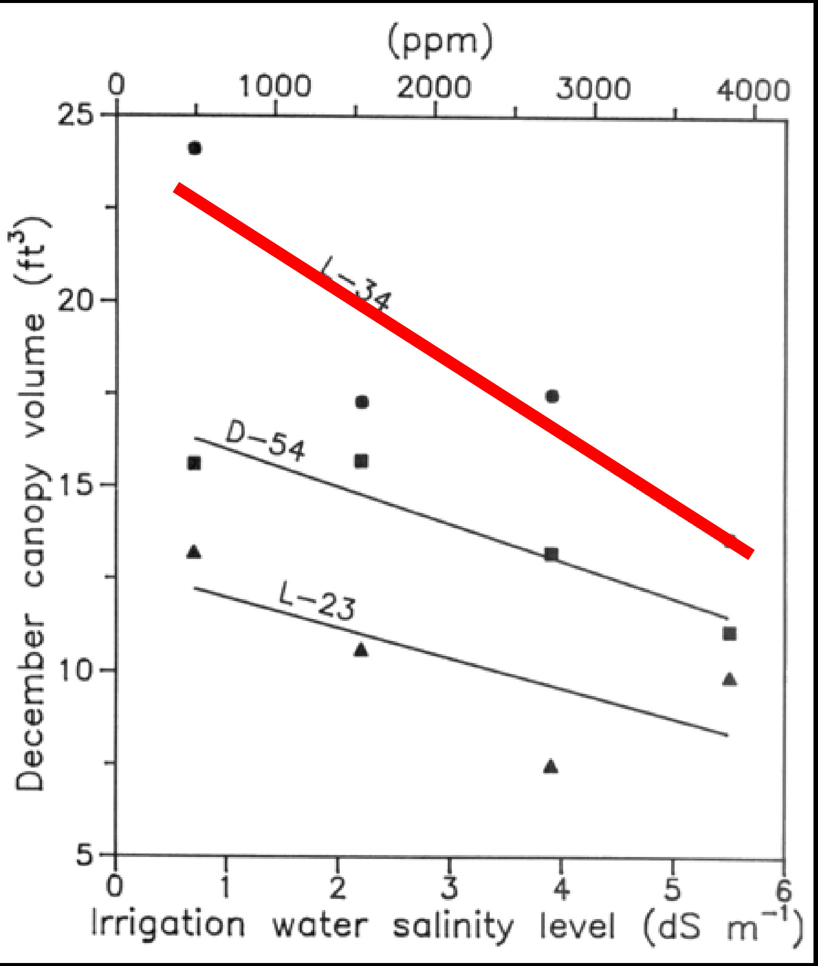


Osmotic Stress

- Salts reduces availability of free water through both chemical and physical processes.
- Roots cannot extract as much water from a solution that is high in salts
- Trees have to work harder to move water into the roots


2700
500
4
2
1
3800
1600
Ray Ruby on Carrizo

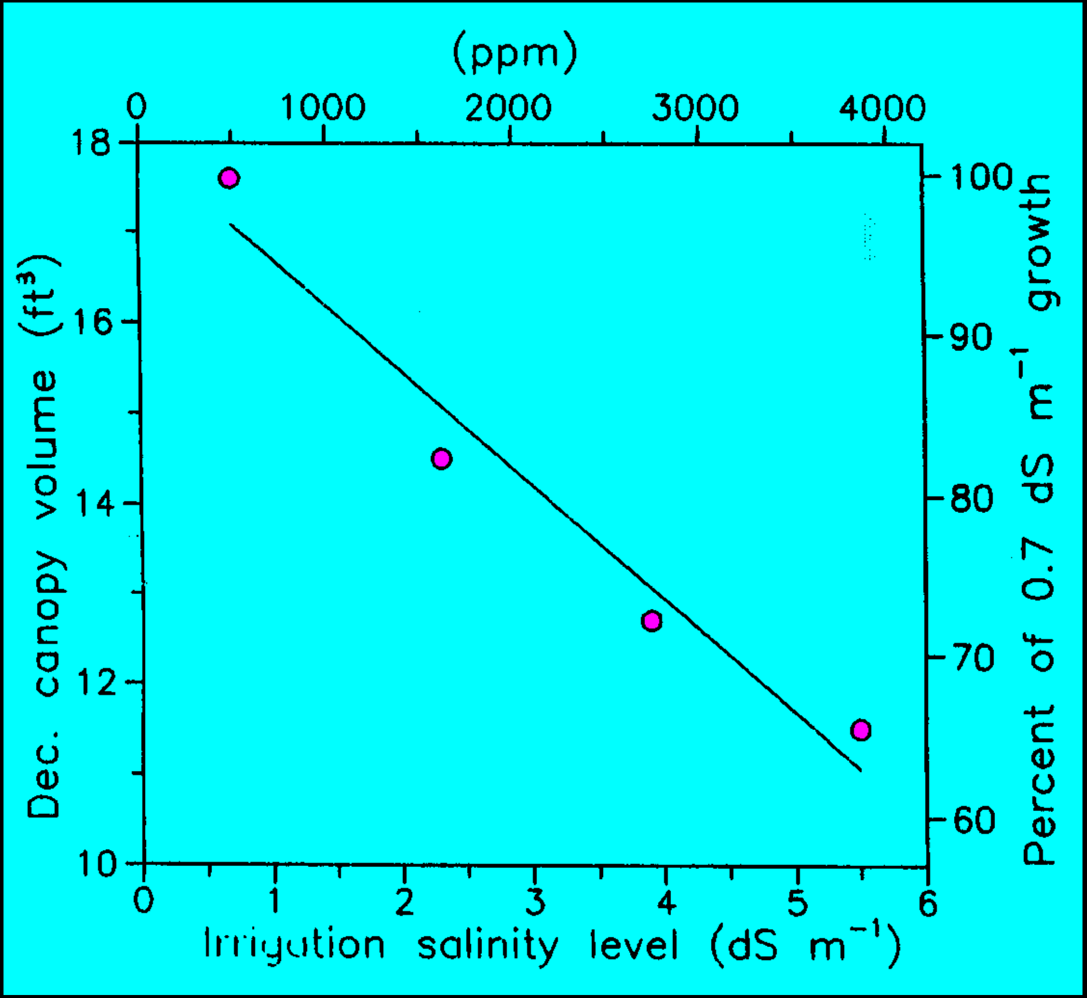
Young Trees



40 irrigations from June-Dec

D = 1 lb/tree 8-0-8 at 6-wk intervals (0.54 lb)

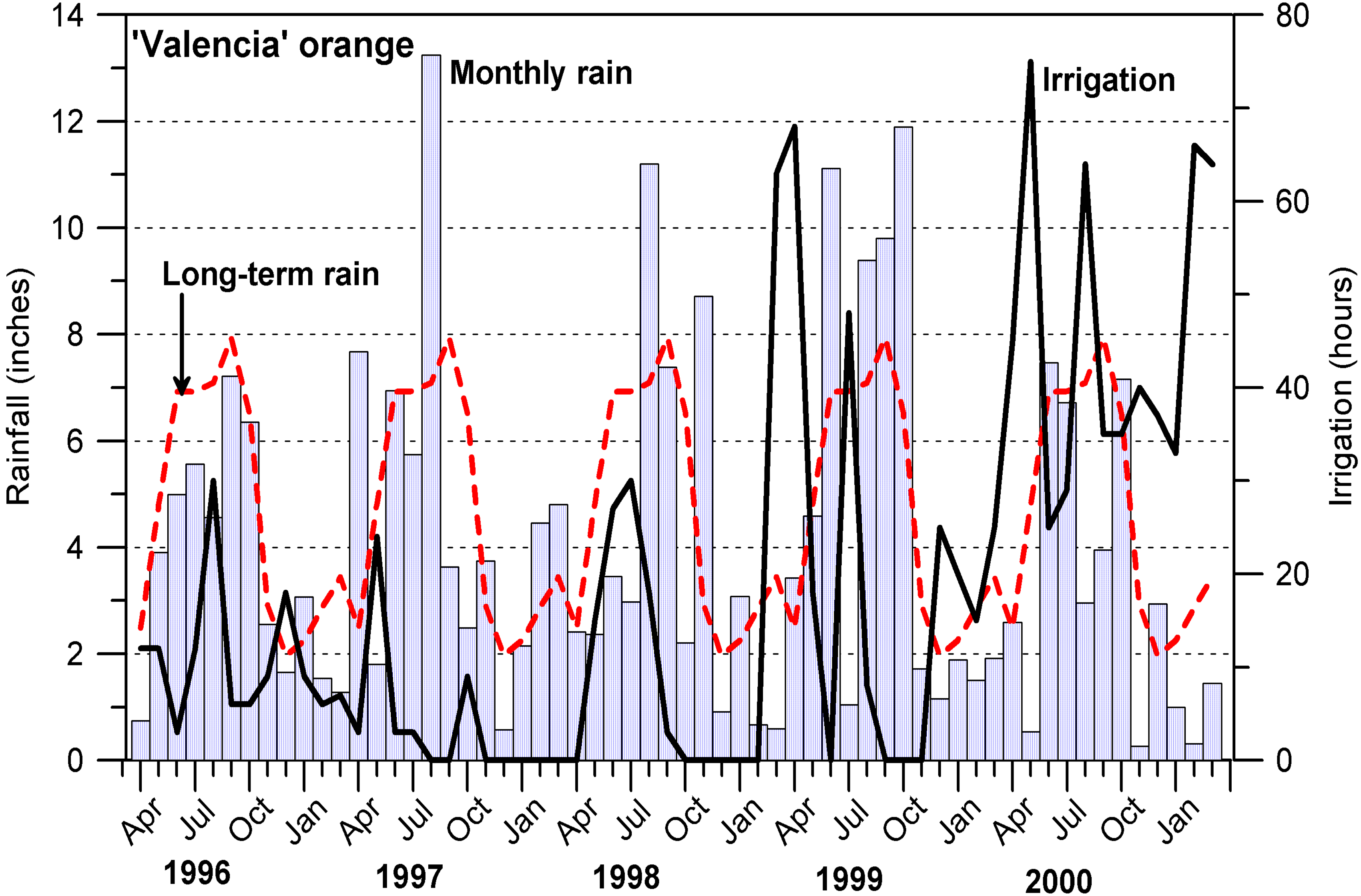
L = 19 fertigations at 1-wk intervals (0.23 or 0.34 lb)



10% growth reduction for each 1000 ppm

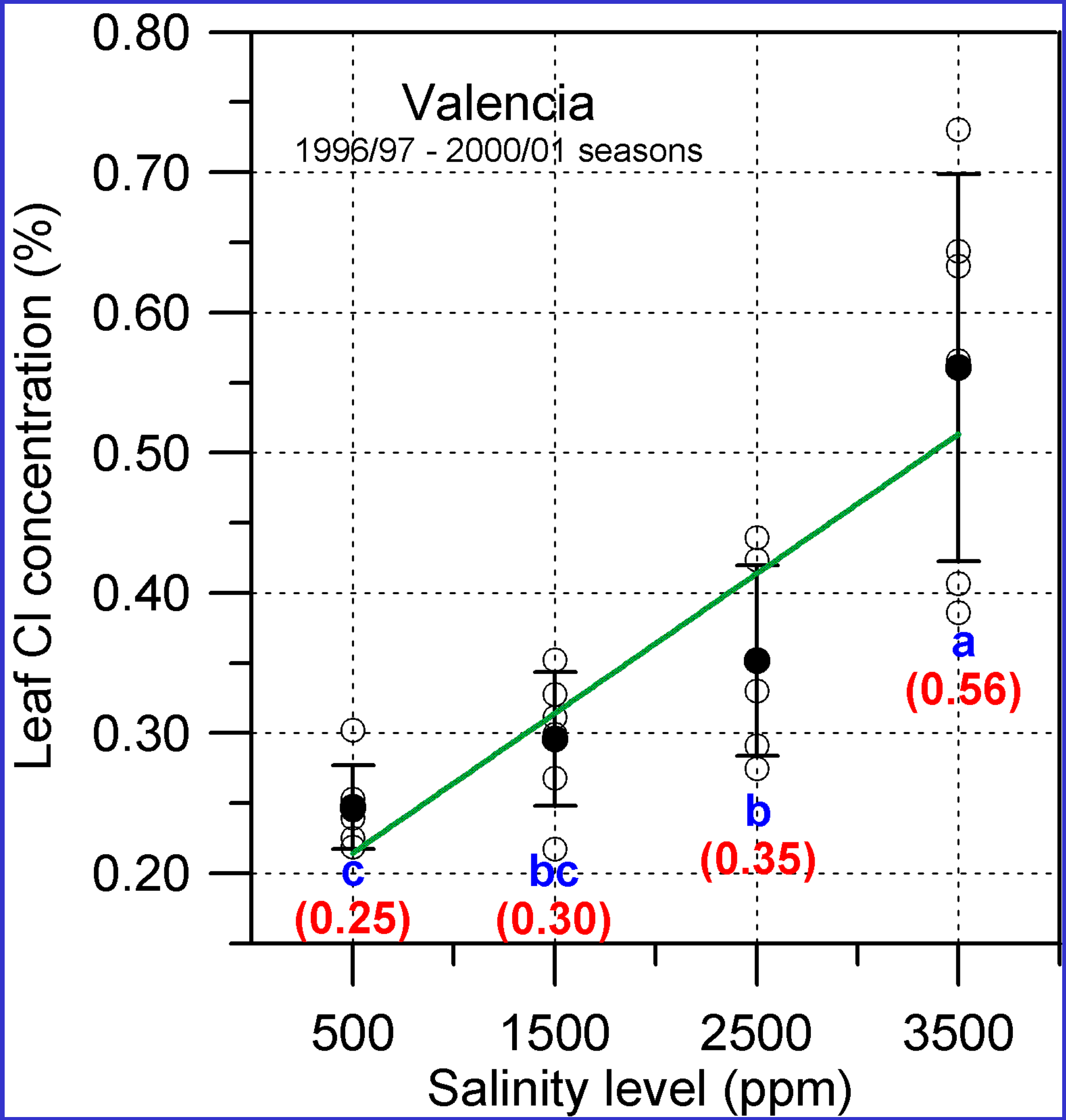
‘Valencia’ – rough lemon

- Planted in 1986
- Single beds – 15 X 30 ft (97 trees/ac)
- Oldsmar fine sand soil
- Microsprinkler – salinity began in 1996
  - 500, 1500, 2500 ,3500 ppm – proportional injectors
  - Brine from NaCl (55%), CaCl (34%), and KCl (11%)
- 6 trees/plot – 6 reps
- Blight problem – 2 trees/rep analyzed

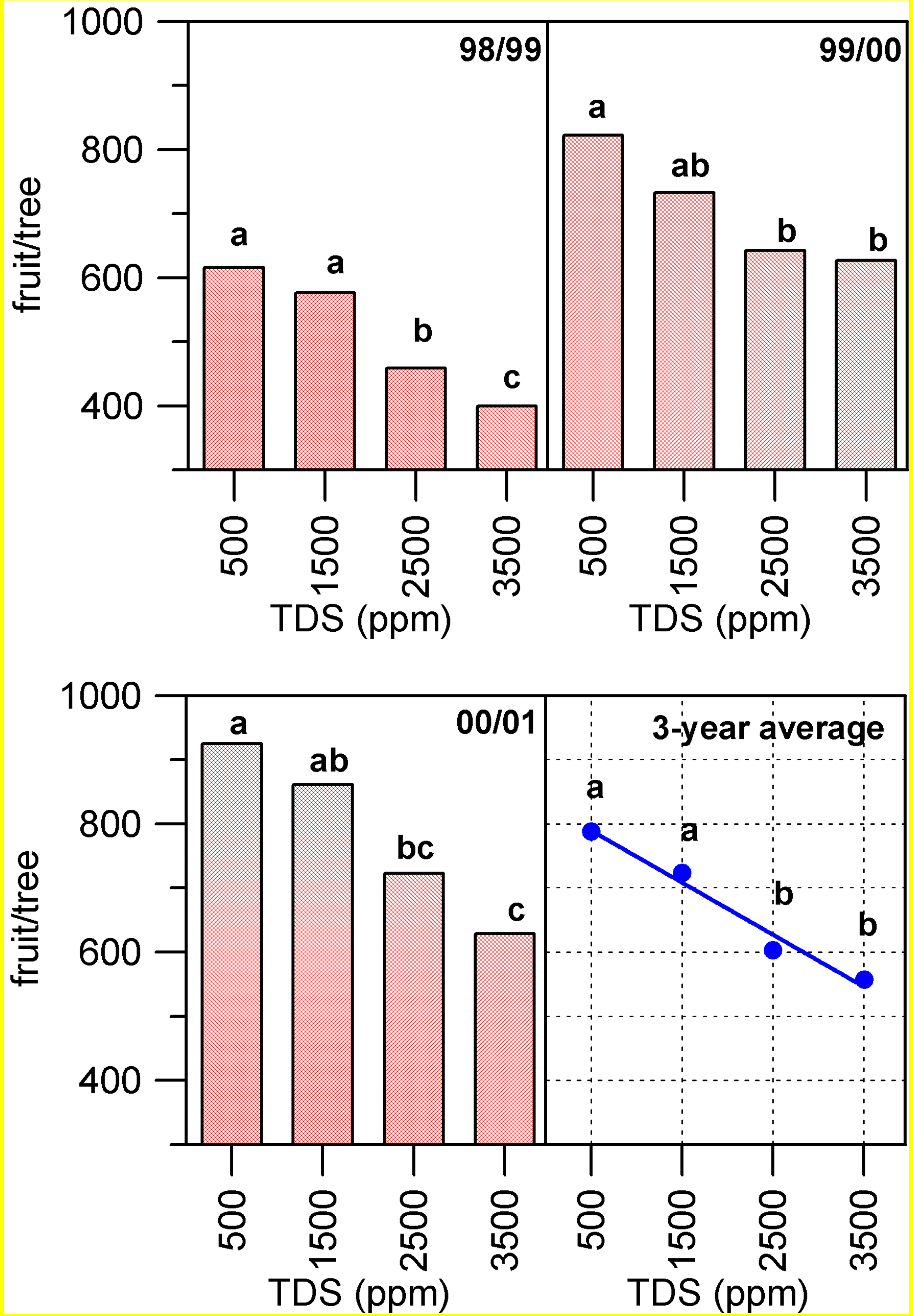


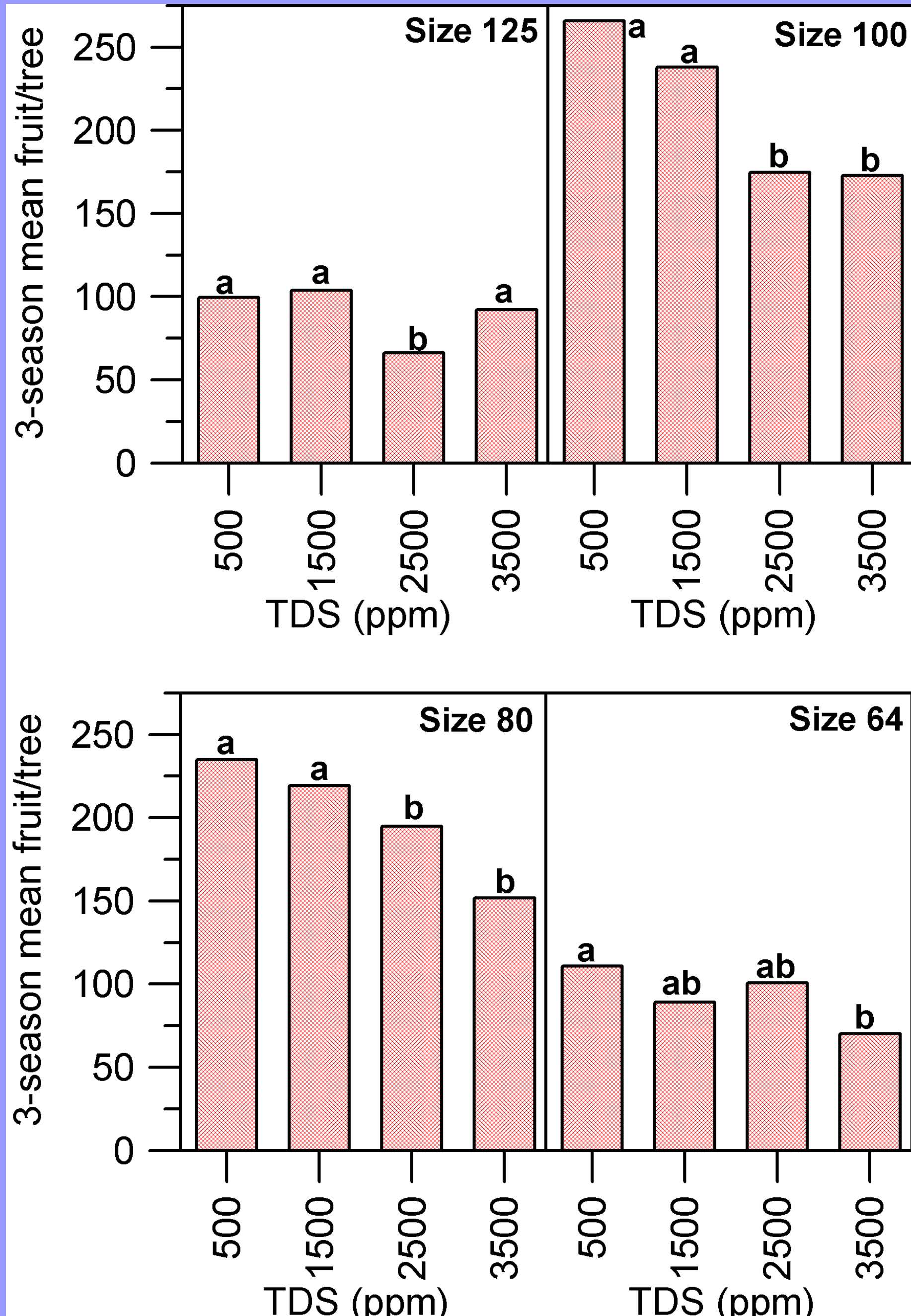
60% 20% 70% 103% 250% 221 hr avg

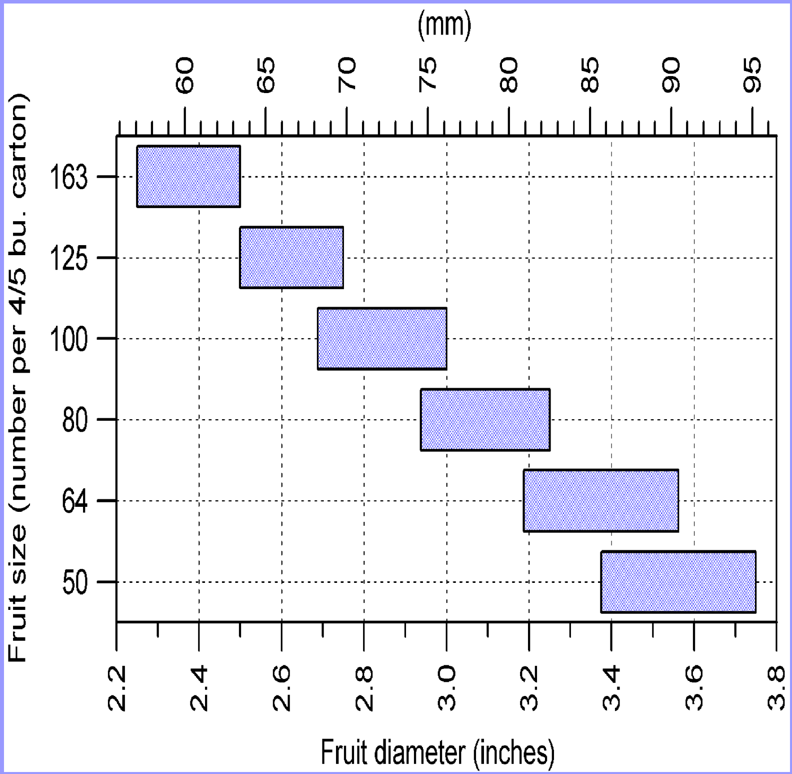
130 42 156 227 548 hours

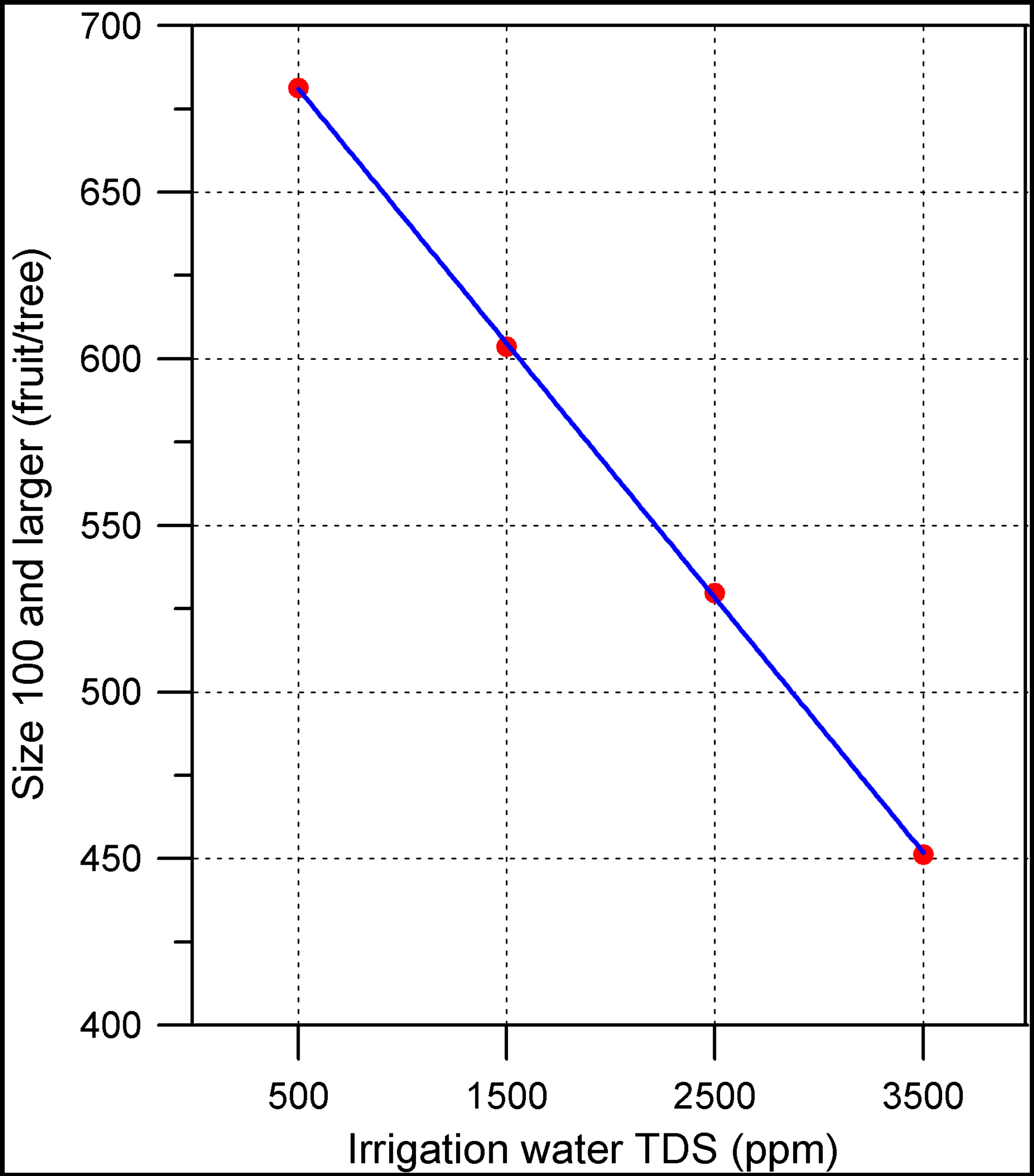


0.10% increase in leaf Cl for each 1000 ppm increase in salinity

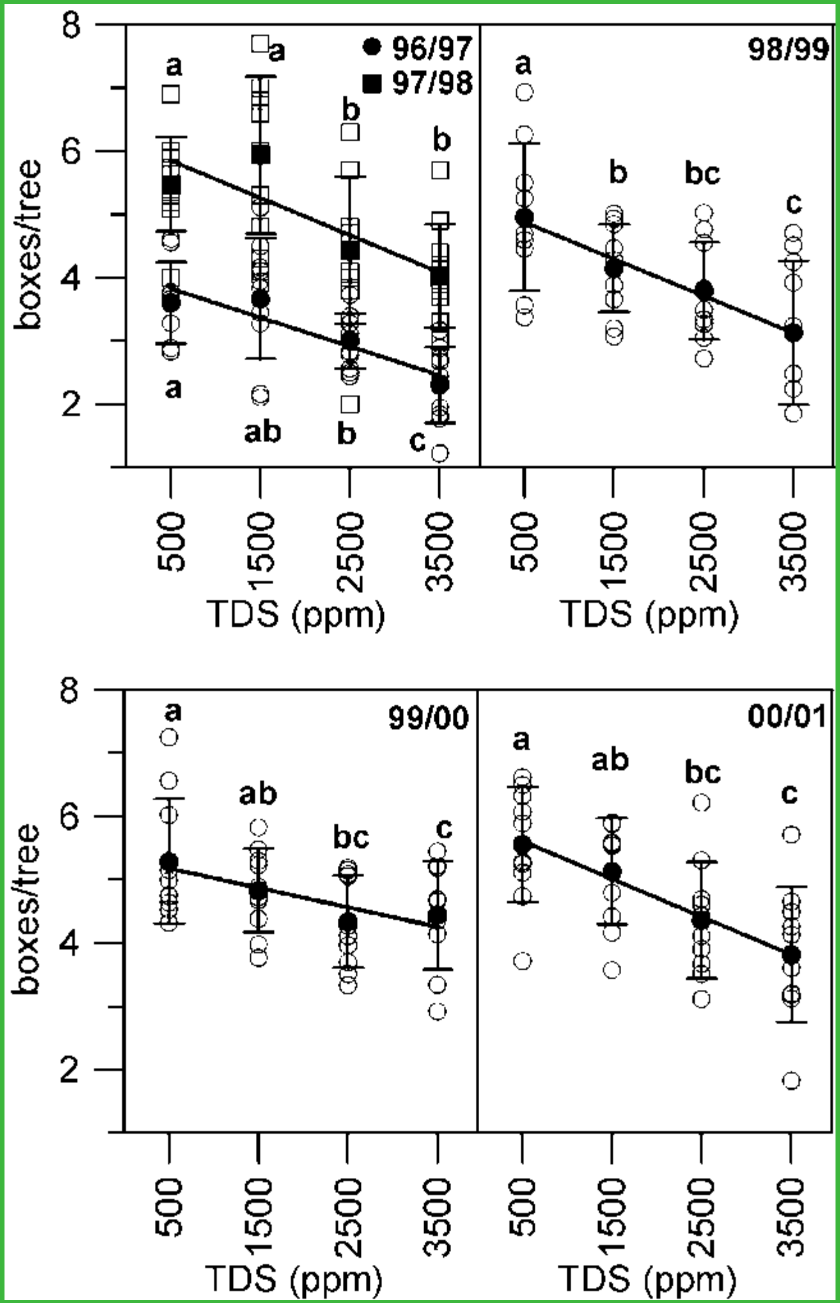

98/99
99/00
00/01
3-year average
fruit/tree
1000
800
600
400
a
a
b
c
a
ab
b
b
a
ab
bc
c
a
a
b
b
500
1500
2500
3500
TDS (ppm)


3-season mean fruit/tree
Size 125
Size 100
Size 80
Size 64
a
b
ab
0
50
100
150
200
250
500
1500
2500
3500
TDS (ppm)

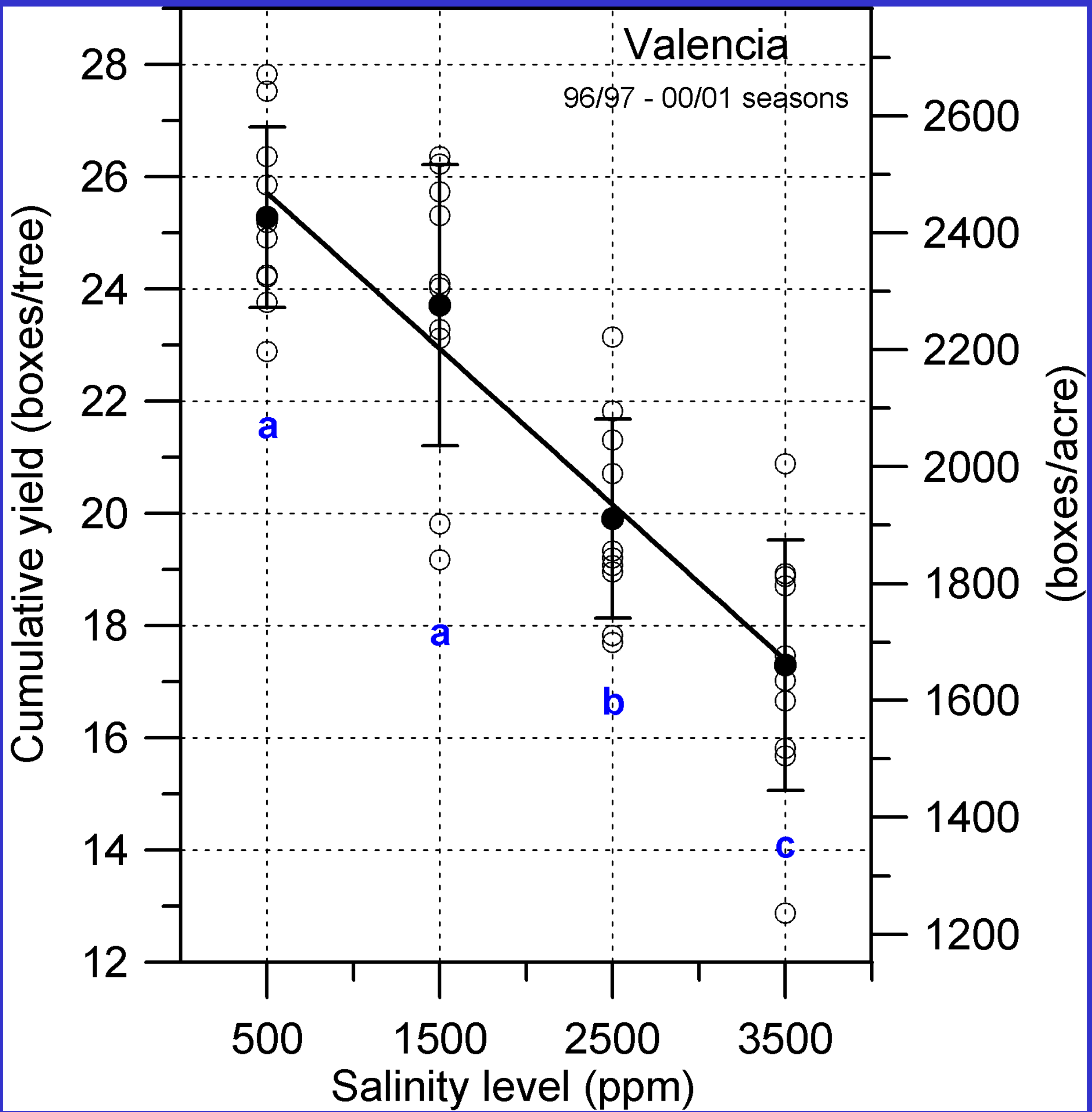

(mm)
60
65
70
75
80
85
90
95
Fruit size (number per 4/5 bu. carton)
163
125
100
80
64
50
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Fruit diameter (inches)



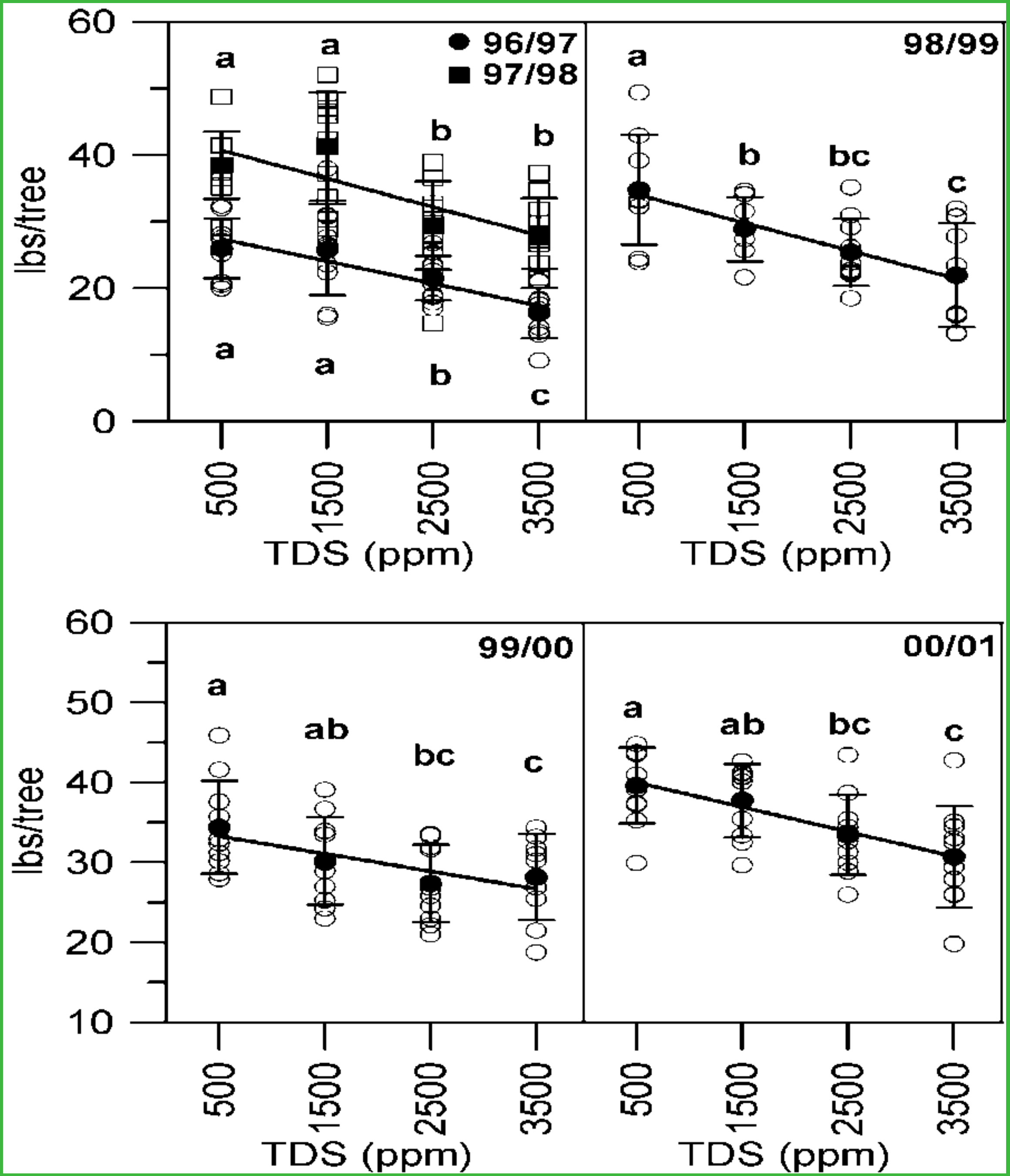
Average number of fruit size 100 and larger for 1998/99 through 2000/01 seasons



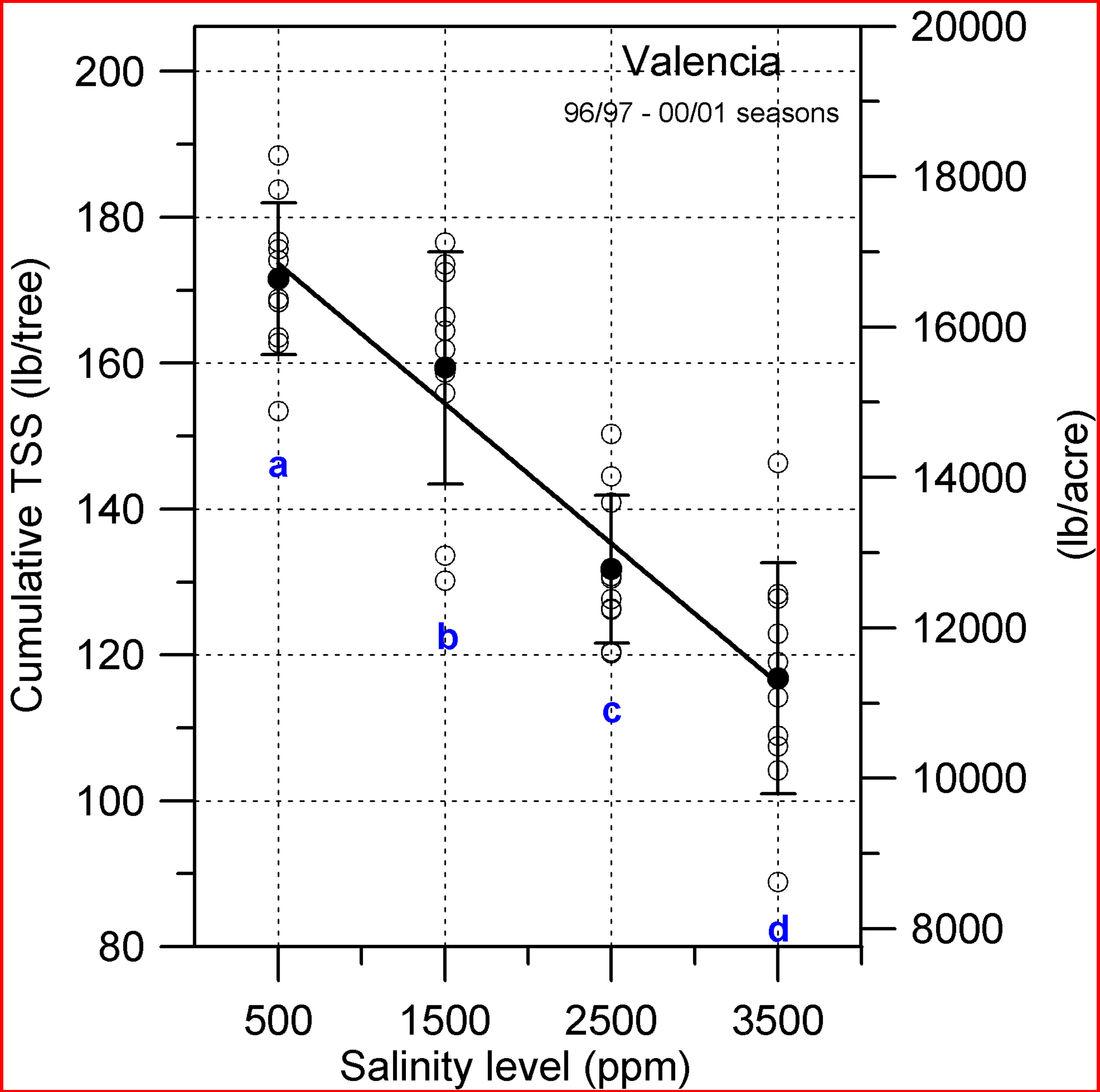
Yields for 1996/97 through 2000/01 seasons



Valencia
96/97 - 00/01 seasons
Cumulative yield (boxes/tree)
(boxes/acre)
Salinity level (ppm)
28
26
24
22
20
18
16
14
12
2600
2400
2200
2000
1800
1600
1400
1200
500
1500
2500
3500
a
a
b
c

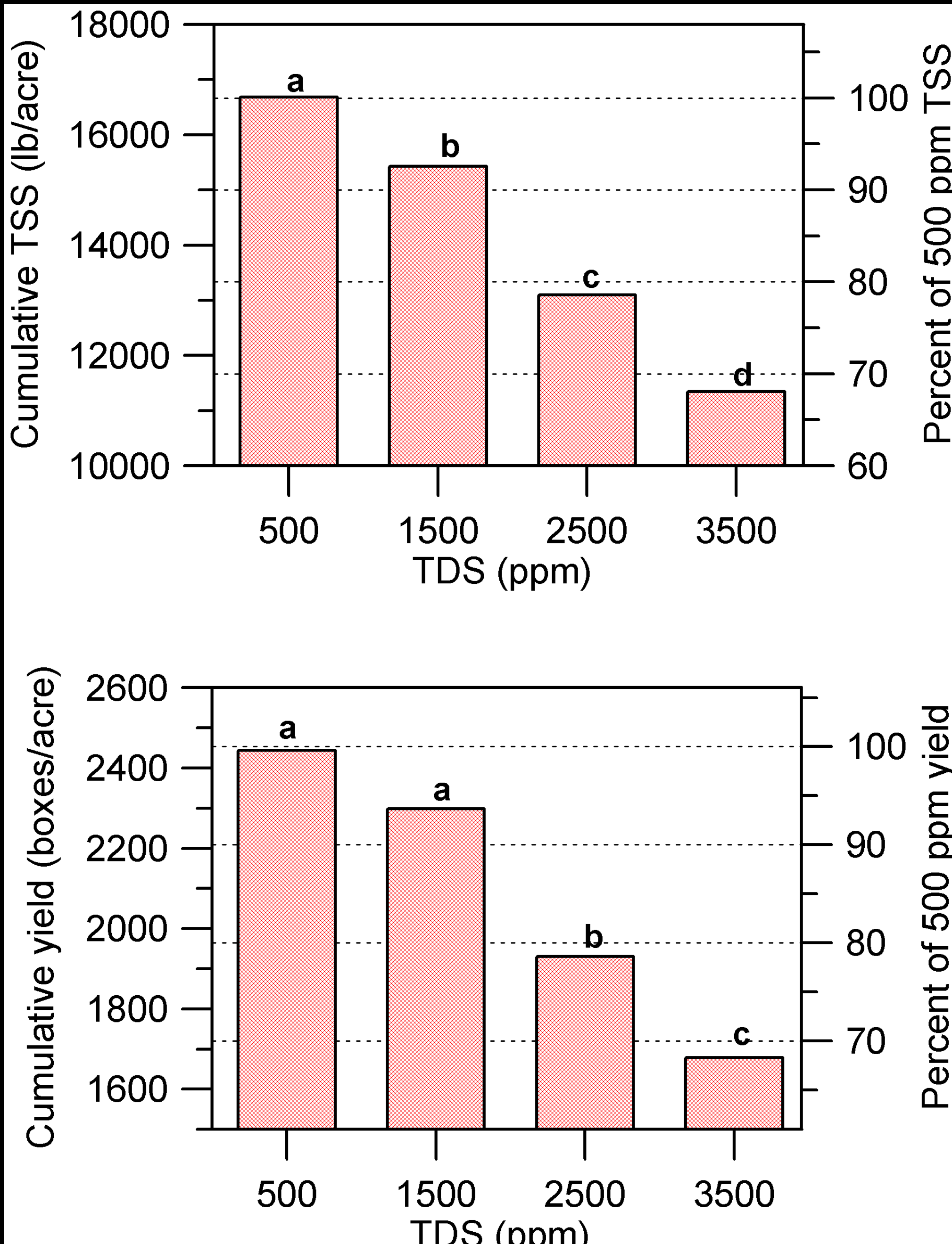


TSS for 1996/97 through 2000/01 seasons



3.8 lb TSS/tree per year reduction for each 1000 ppm increase in salinity

(370 lb/ac/yr @ 97 tree/ac)



5-yr Avg Yield: 490 box/ac/yr (500 ppm)

0.6 box/tree/yr reduction for each 1000 ppm salinity (11%)

60 box/ac/yr for each 1000 ppm @ 97 trees/ac

3340 lb TSS/ac/yr (500 ppm)

3.8 lb TSS/tree/yr for each 1000 ppm salinity (11%)

360 lb TSS/ac/yr for each 1000 ppm salinity @ 97 trees/ac

Little effect on internal juice quality

- •Differences masked by climatic swings (i.e. heavy rains, hot & dry to cool and wet)
- •No differences in solids/box or Brix:acid ratio at time of harvest
- •TSS averaged 6.7-6.8 lb/box for the 5 seasons
- •Ratio averaged 13.7, 13.9, 13.6, and 13.5 for 500, 1500, 2500, and 3500 ppm, respectively

Except for 97/98, salinity decreased both No. & fruit size

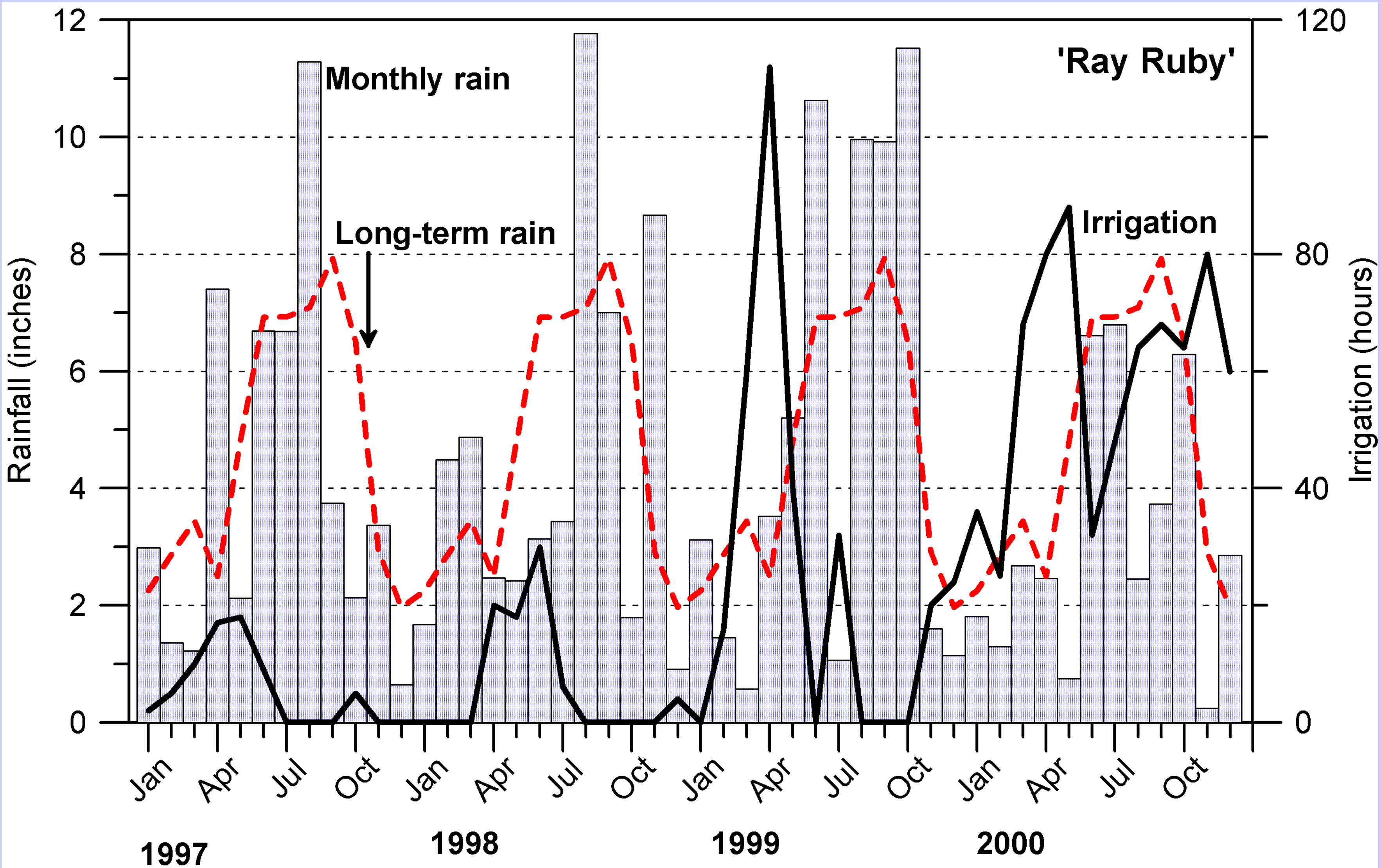
About 11% reduction in boxes and TSS for each 1000 ppm increase in TDS

Study period represents above, below, and average rainfall years

Detrimental effects could be greater with less management effort

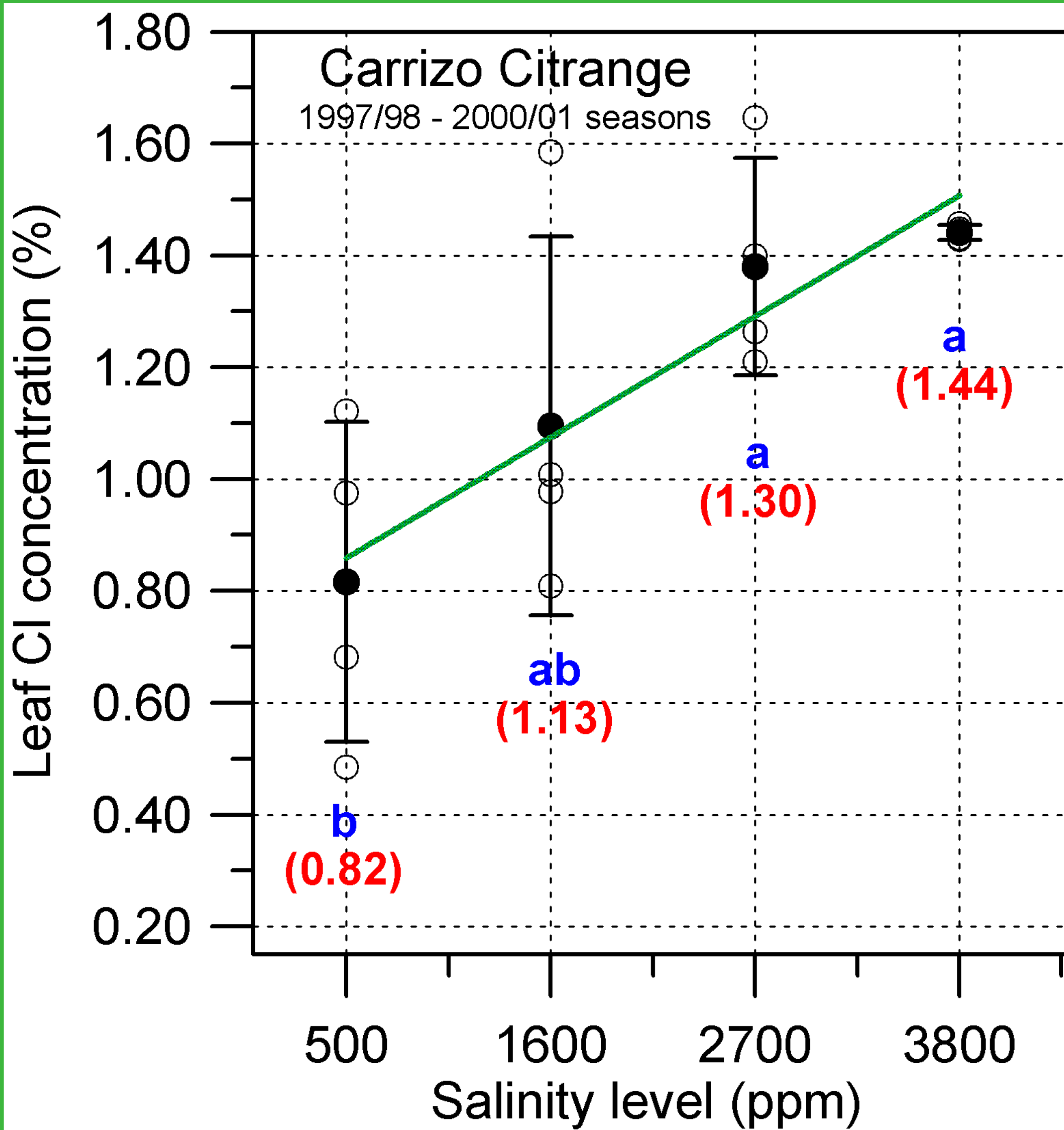
‘Ray Ruby’ Grapefruit

- Planted in 1990
- 50’ double beds – 15 X 24’ (116 tree/ac)
- Oldsmar fine sand soil
- Microsprinkler irrigation
  - 500, 1600, 2700 ,3800 ppm
  - Sea water mixed with surficial aquifer well water
- 4 trees/plot – 4 reps
- Fertilized Feb, May, Oct (140-150 lb N/ac)

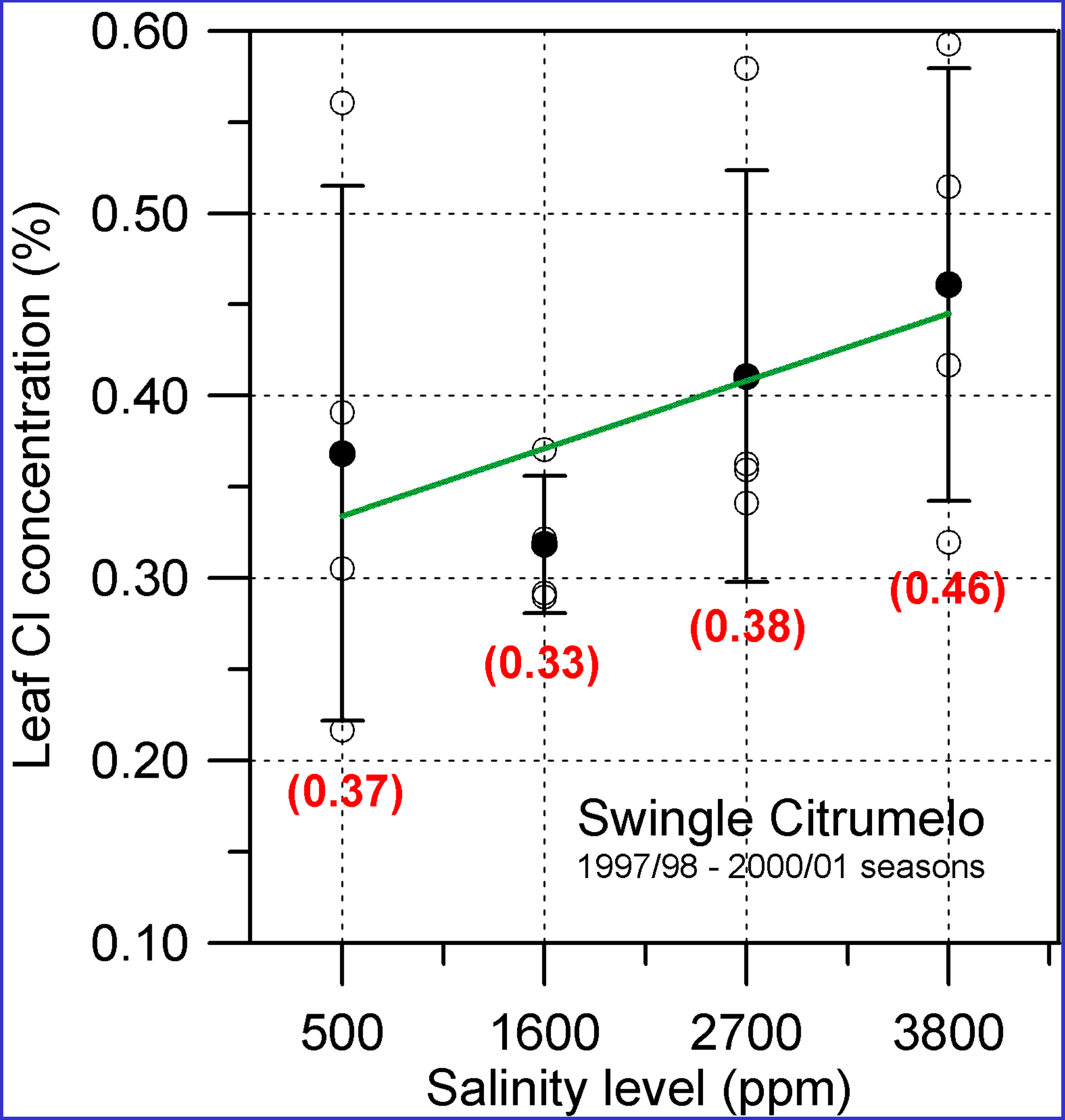


20% 27% 106% 250% (288 hr avg)

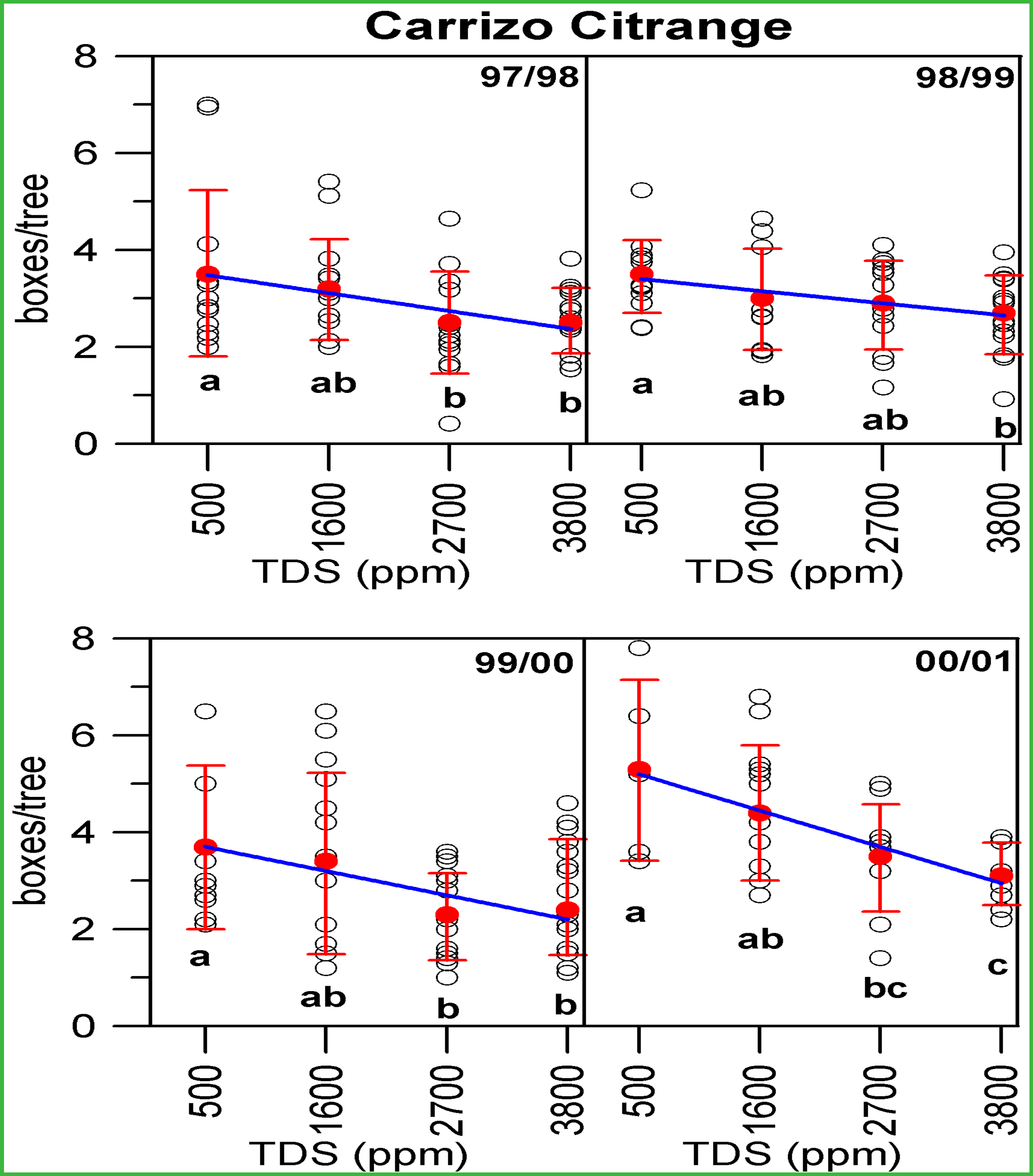
57 78 304 713 hours



0.2% increase in leaf Cl for each 1000 ppm TDS increase



0.03% increase in leaf Cl for each 1000 ppm TDS increase



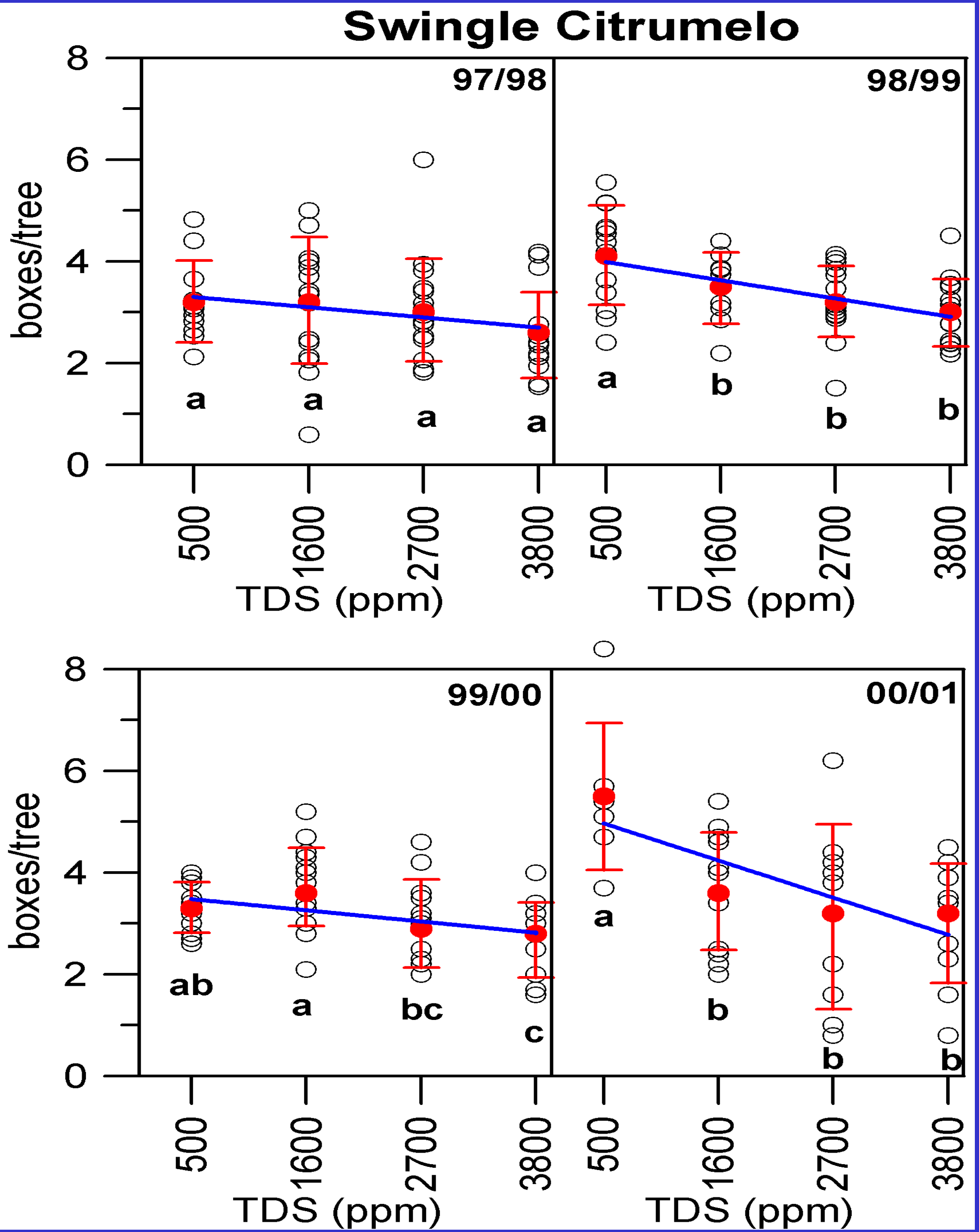
Yield reductions from 500 to 3800 ppm:

97/98 – 40%

98/99 – 30%

99/00 – 54%

00/01 – 91%



Yield reductions from 500 to 3800 ppm:

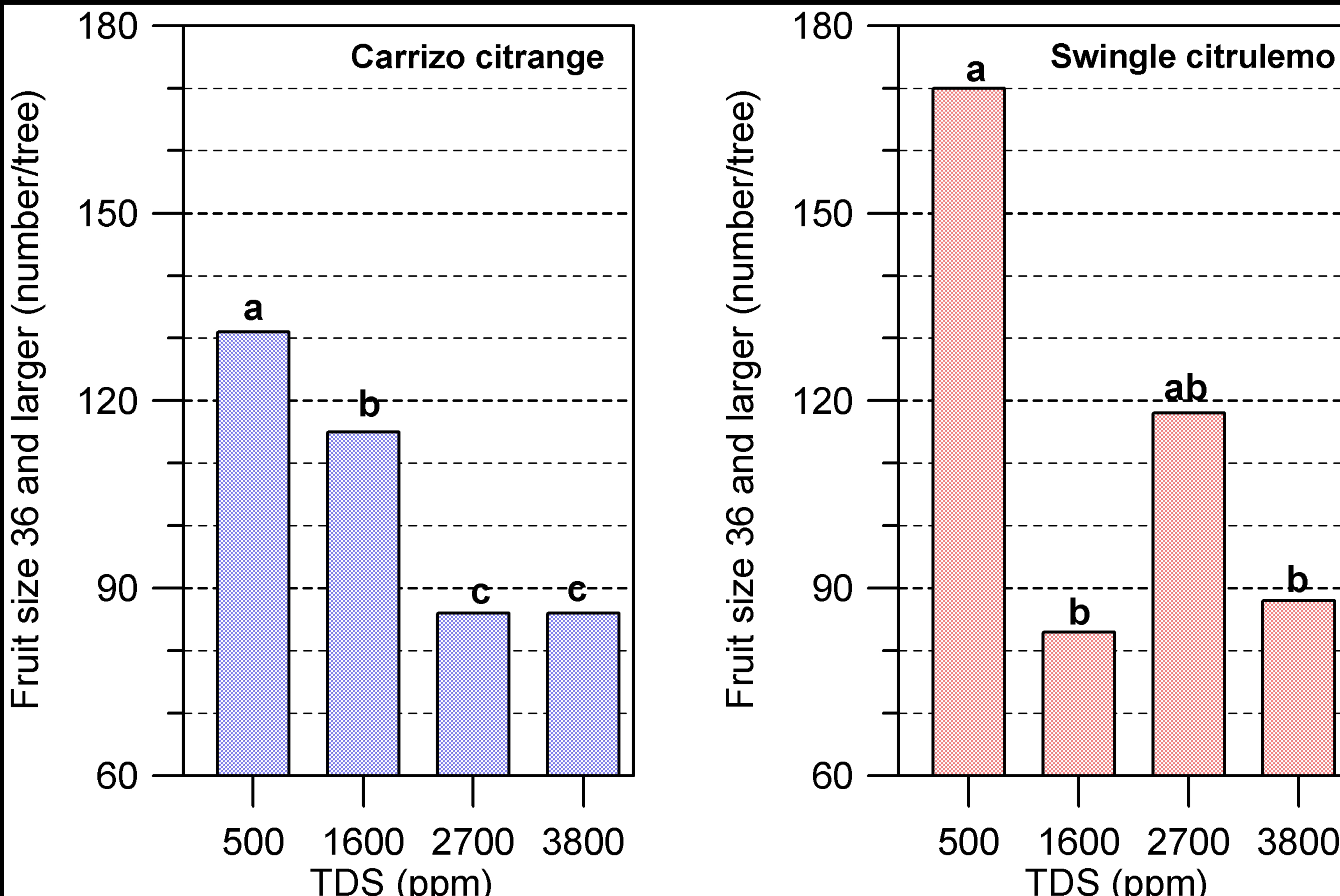
97/98 – 0%

98/99 – 37%

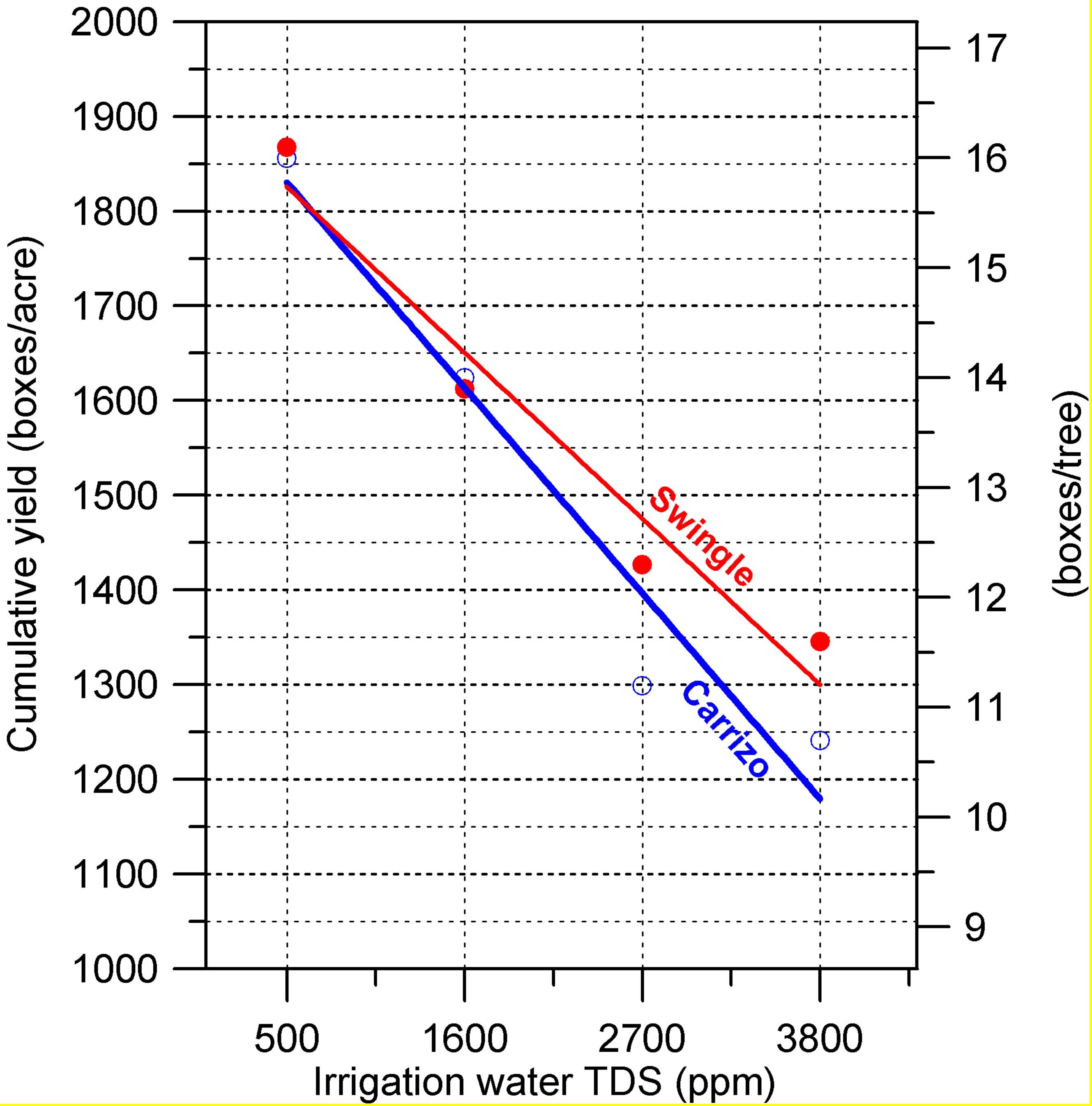
99/00 – 18%

00/01 – 72%

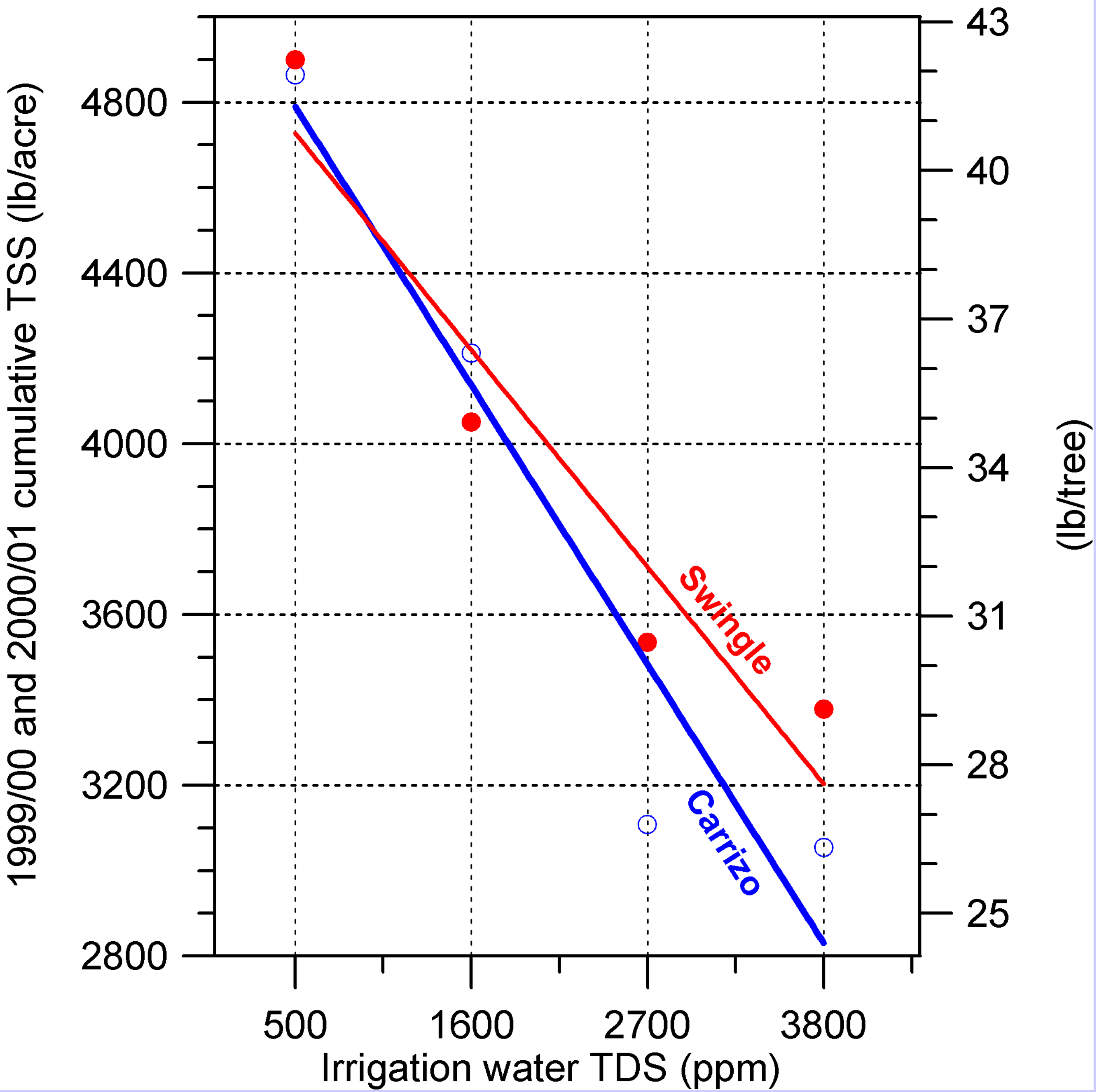
Fruit Size



Carrizo citrange
Fruit size 36 and larger (number/tree)
180
150
120
90
60
a
b
c
c
500
1600
2700
3800
TDS (ppm)
Swingle citrulemo
Fruit size 36 and larger (number/tree)
180
150
120
90
60
a
b
ab
b
500
1600
2700
3800
TDS (ppm)

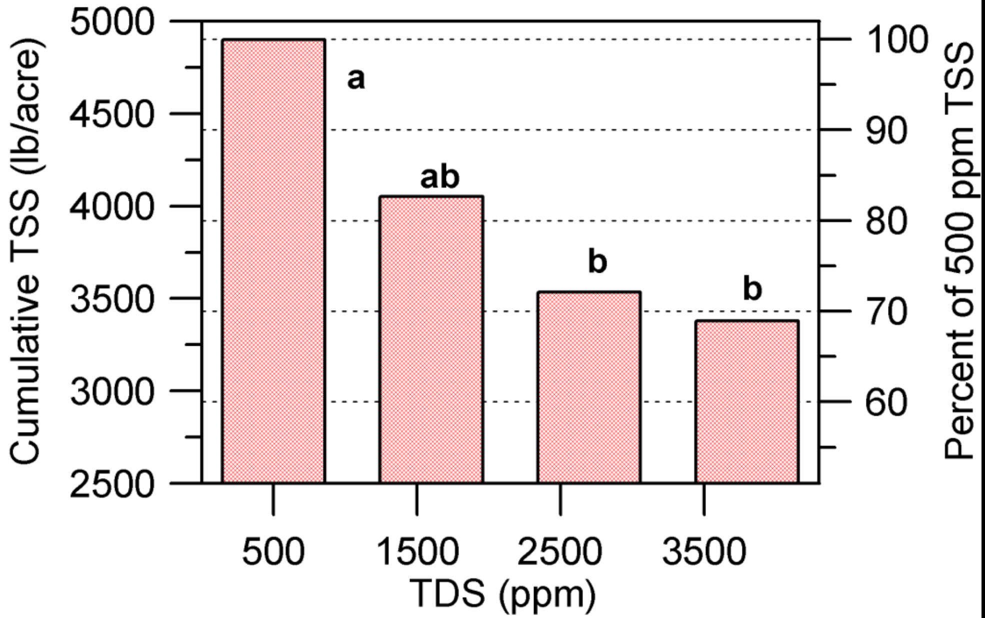


35 box/ ac/yr Swingle) to 45 box/ac/yr (Carrizo) reduction for each 1000 ppm increase in TDS



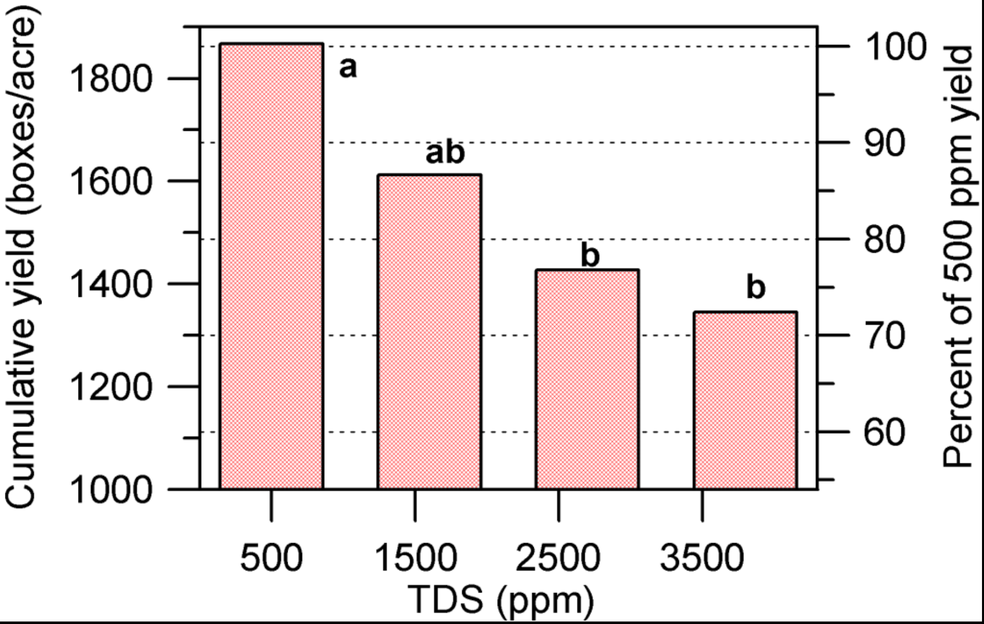
99/00 and 00/01 Juice Analysis

240 lb/ac/yr (Swingle) to 300 lb/ac/yr (Carrizo) reduction for each 1000 ppm increase in TDS (5-6%)



Carrizo: 300 lb TSS/ac/yr for each 1000 ppm TDS (6%)

Swingle: 240 lb TSS/ac/yr for each 1000 ppm TDS (5%)



Carrizo: 50 box/ac/yr for each 1000 ppm TDS (11%)

Swingle: 40 box/ac/yr for each 1000 ppm TDS (9%)

Little effect on internal juice quality

- Carrizo Ratio averaged 9.1, 8.8, 9.0, and 8.9 for 500, 1500, 2500, and 3500 ppm, respectively
- Swingle Ratio averaged 8.2, 8.5, 8.6, and 8.5 for 500, 1500, 2500, and 3500 ppm, respectively
- Solids/box averaged 4.7 lb for Carrizo and 4.9 lb for Swingle

5-6% (240-300 lb/ac) reduction in TSS and 9-11% (40-50 boxes/ac) reduction in boxes for each 1000 ppm increase in TDS

In 2000, CA w/ 500 ppm had 50% more size 36+ than 2700 or 3800 ppm while SW w/500 ppm had 1.5-2.0 times as many size 36+ as those with 1600 or more ppm

Study period represents above, below, and average rainfall years -- Detrimental effects could be greater with less management effort

Irrigation Management

Inches/day → gal/day

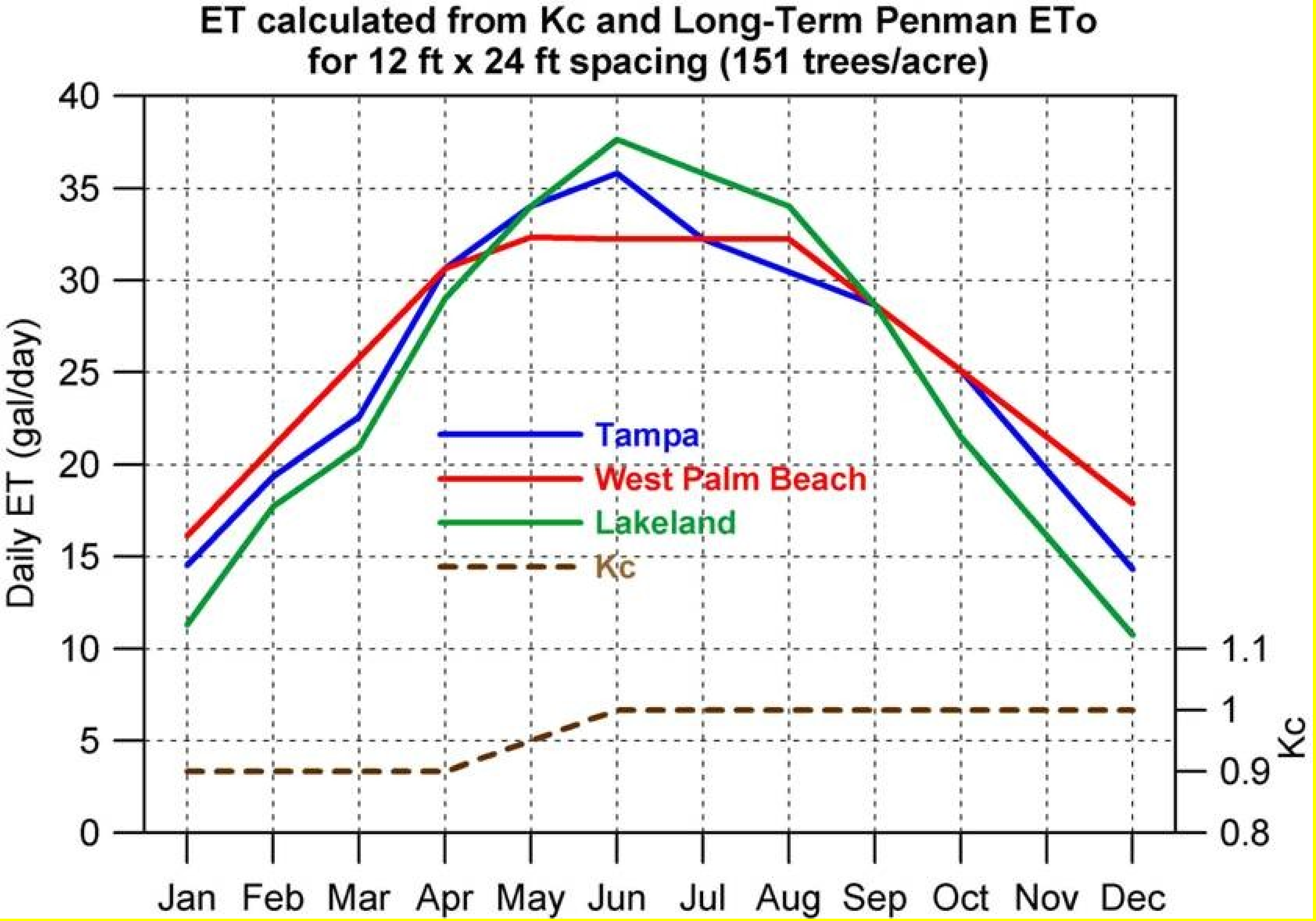
Gal/tree/day = ET x spacing x 0.622

For ET = 0.16 in/day

and 12 ft x 24 ft spacing:

Gpd/tree = 0.16 x 12 x 24 x 0.622

= 29 gal/tree/day


ET calculated from Kc and Long-Term Penman ETo
for 12 ft x 24 ft spacing (151 trees/acre)
Daily ET (gal/day)
40
35
30
25
20
15
10
5
0
Tampa
West Palm Beach
Lakeland
Kc
1.1
1
0.9
0.8
Kc
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Water use in gal/tree for various planting densities assuming equivalent per-acre water use.

ET (in/day)	Tree spacing (ft x ft)	Tree area (ft^2)	Tree density (trees/acre)	ET (gal/tree/day)
0.10	8 x 22	176	248	11
0.10	10 x 24	240	182	15
0.10	15 x 25	375	116	23
0.15	8 x 22	176	248	16
0.15	10 x 24	240	182	22
0.15	15 x 25	375	116	35
0.20	8 x 22	176	248	22
0.20	10 x 24	240	182	30
0.20	15 x 25	375	116	46

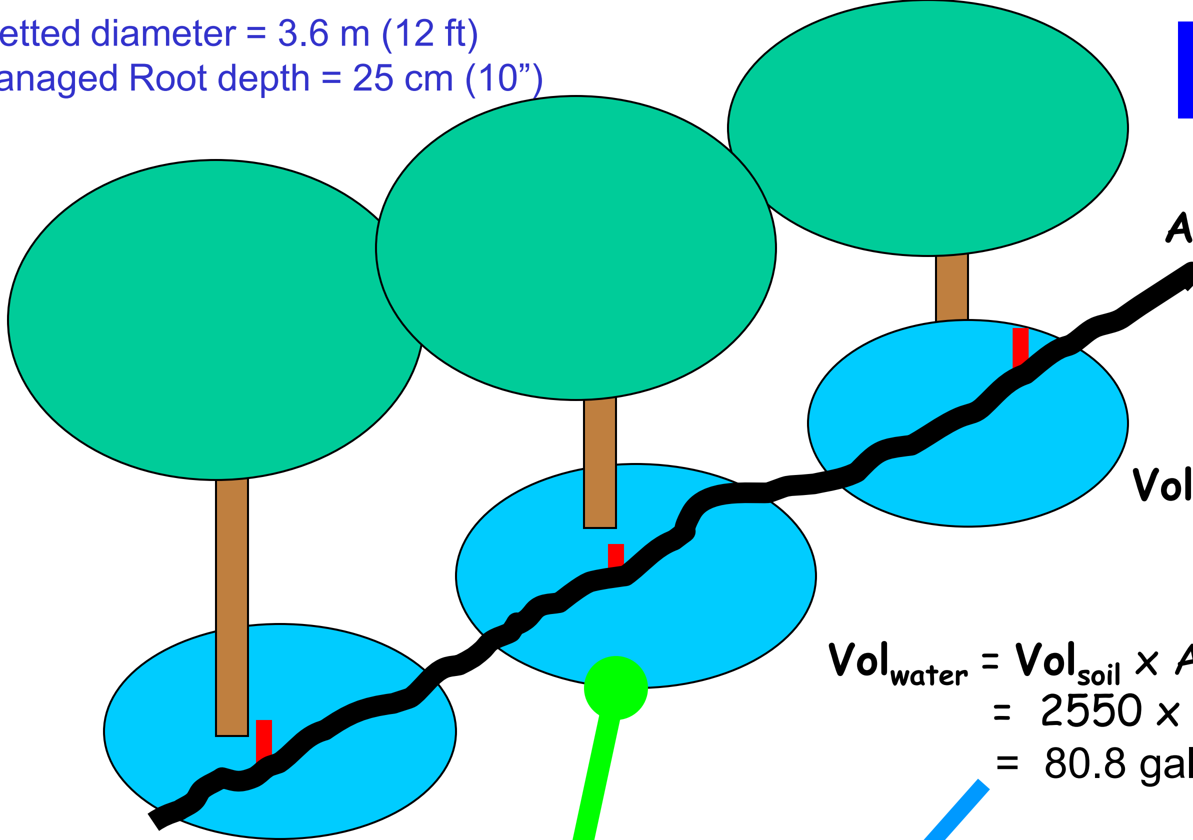



Root system most prolific in A horizon and lacking in overburden (Riviera series)

Source: Rootstock and Soil Interactions Project, Bauer, Castle, Boman, and Obreza

Wetted diameter = 3.6 m (12 ft)
Managed Root depth = 25 cm (10")

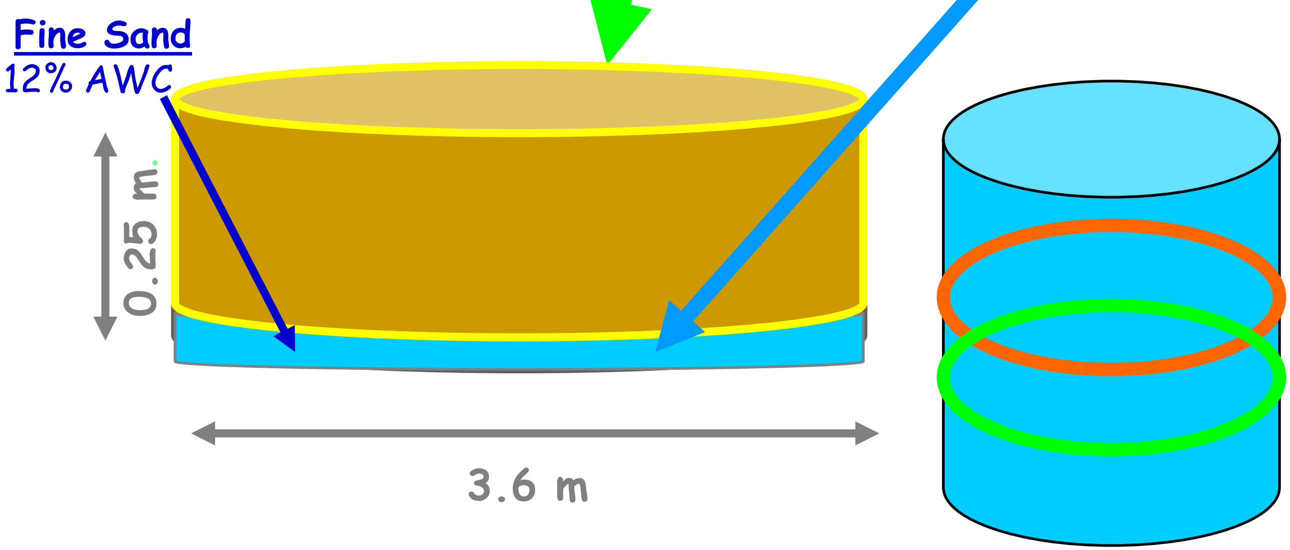
10 gal/hr emitter



$$\text{Area} = \frac{3.14 \times d^2}{4} = \frac{3.14 \times 3.6^2}{4}$$
$$= 10.2\ m^2 = 110\ ft^2$$

$$Vol_{soil} = \text{area} \times \text{depth}$$
$$= 10.2\ m^2 \times 0.25\ m = 2.55\ m^3$$
$$= 2550\ L = 90\ ft^3$$

$$Vol_{water} = Vol_{soil} \times AWC$$
$$= 2550 \times 12\% = 306\ L$$
$$= 80.8\ gal$$



Vol_{water} = 306 L (80.8 gal)

50% depl = 306 L x 0.5
= 153 L = 40.4 gal

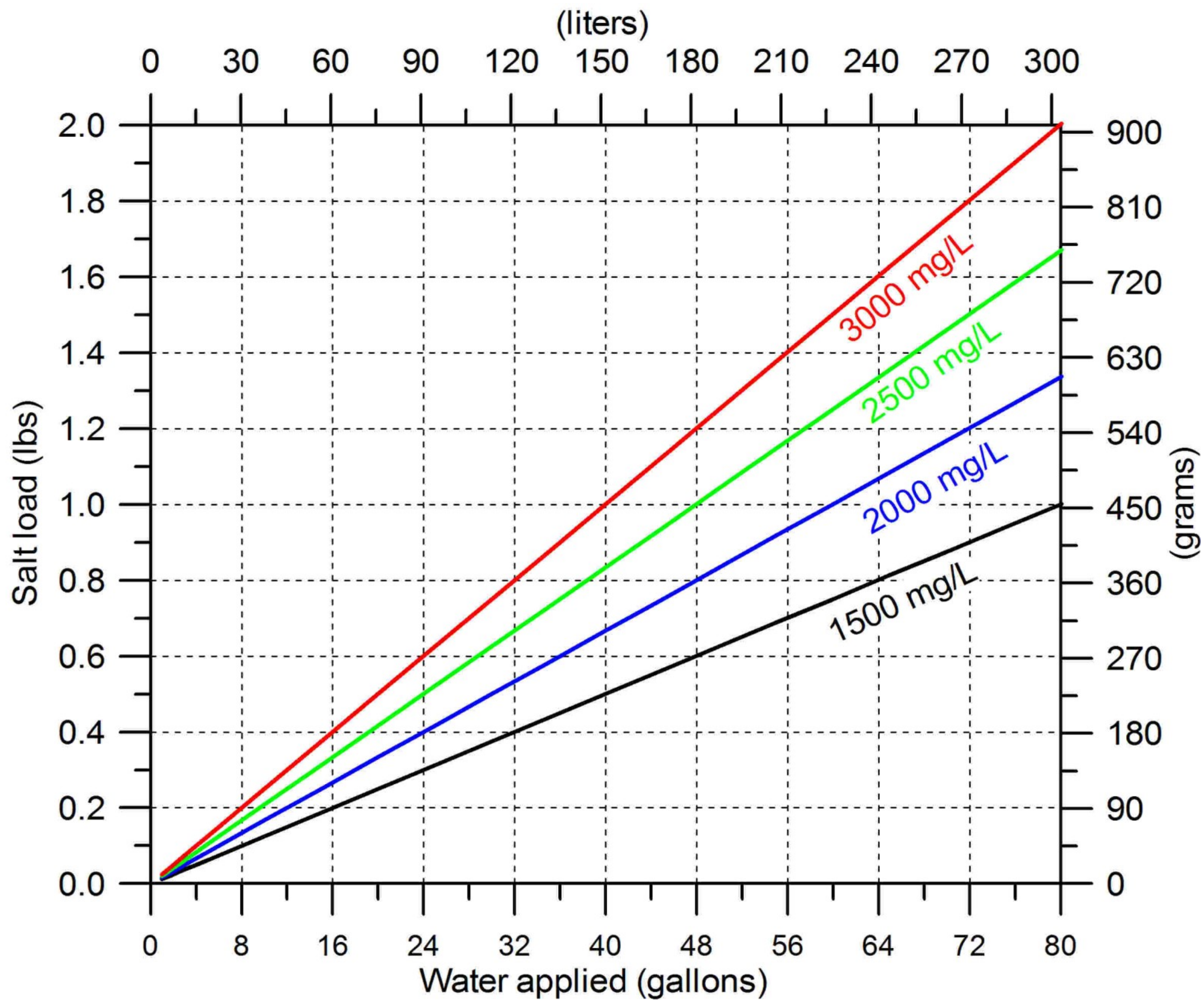
33% depl = 306 x 0.33
= 102 L = 27 gal

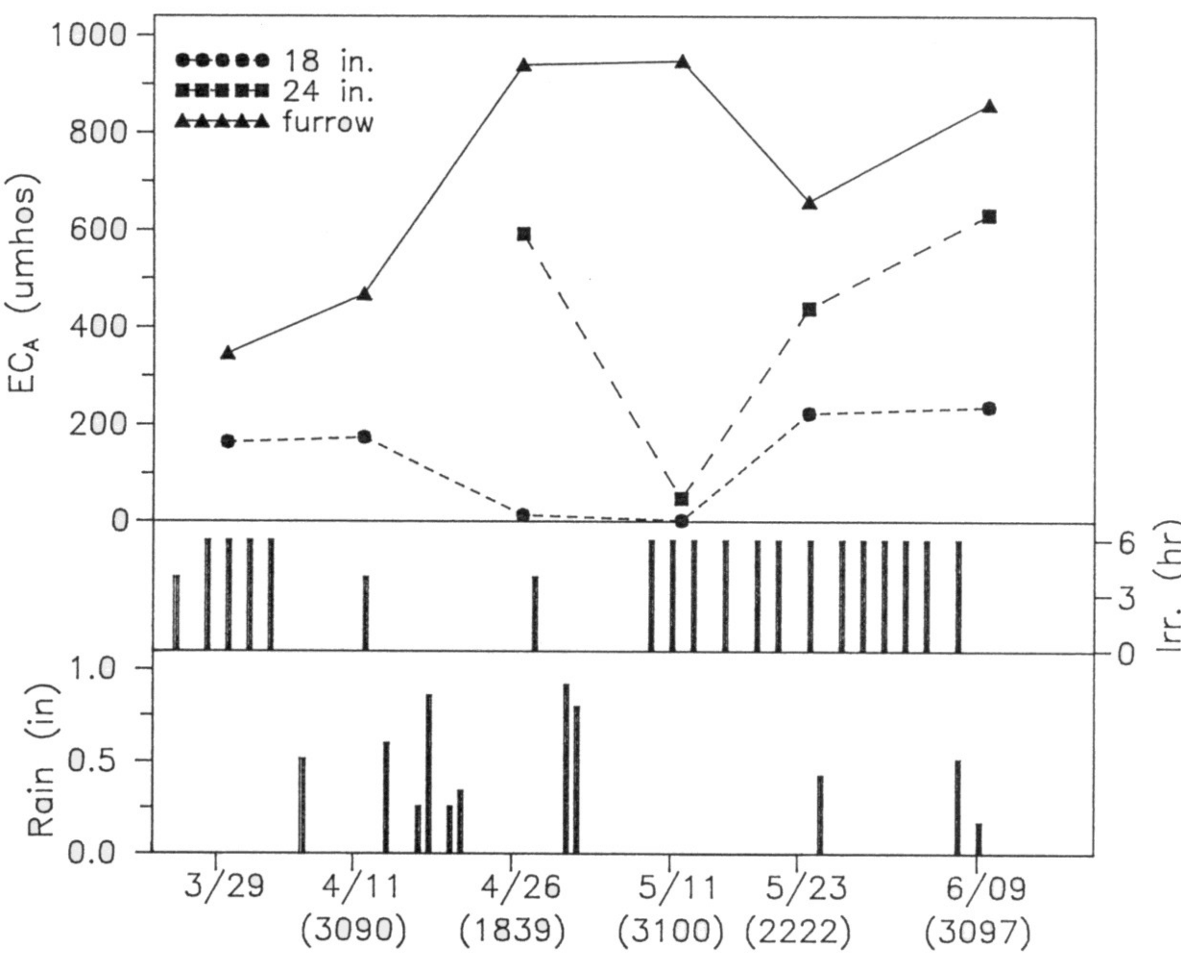
2:42 for 10 gph emitter

Flatwoods Soils

WHC of ~0.08 in/in is typical for most Flatwoods soils (exceptions: Winder, Chobee, soil mixing, etc.)

Root Depth	WHC	1/3 Depl.
9	0.72 in 79 gal	0.24 in 26 gal
12	0.96 in. 106 gal	0.33 in 35 gal
18	1.44 in 158 gal	0.48 in 52 gal


(liters)
0
30
60
90
120
150
180
210
240
270
300
Salt load (lbs)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
900
810
720
630
540
450
360
270
180
90
0
(grams)
3000 mg/L
2500 mg/L
2000 mg/L
1500 mg/L
0
8
16
24
32
40
48
56
64
72
80
Water applied (gallons)



- •Salts in sandy soils are flushed out fairly quickly following rainfall of 1+ inches
- •Salinity levels at a depth of 18 inches dropped to near zero following rains beginning April 13.
- •The rains on April 30 flushed out the salts from the 24 inch depth.
- •Salts were flushed from the profile and were found to build in the water furrow.
- •Irrigations every 2-3 days beginning on May 9 increased soil salinity at 18 and 24 inch depths.

Salinity Management

Salt concentration is higher in soil than in applied water

- Plant transpiration
- Soil surface evaporation
- Selectively remove relatively pure water

Salt accumulations removed only by leaching

Key is keeping a net downward flow in the root zone

Accumulation over years is not a problem in most cases

Salts in sandy soils leached out with the first 1” of rain

- Sensitivity to injury from direct foliar contact bears no relationship to general soil salinity tolerance.
- Trees on all rootstocks are about equally sensitive to injury through direct foliar contact.
- Young, tender shoots are especially vulnerable to salt burn

Young trees on Swingle are more susceptible to spray on their trunks, and often develop brown “blisters” of dead tissue on their trunks.

The frequency of injecting nutrients or applying granular fertilizer has a direct effect on the concentration of TDS in the soil solution.

- Frequent applications with relatively low concentrations of salts will normally result in less salinity stress than programs using only 2-3 applications per year.
- Controlled-release fertilizers and frequent fertigations are ways to economically minimize salt stress when using high salinity irrigation water.

Selecting nutrient sources that have a relatively small osmotic effect in the soil solution can help reduce salt stress.

- The Cl in KCl or Na in $NaNO_3$ materials add more toxic salts to the soil solution
- High rates of salt application can alter soil pH and thus cause soil nutrient imbalances
- Na displaces K, and to a lesser extent Ca, in soil solutions
    - Can lead to K deficiencies
    - In some cases, even Ca deficiencies
- Imbalances can compound the effects of salinity stress
- Problems can be minimized if adequate nutritional levels are maintained

Salinity Management

If TDS over 1200 ppm or Cl > 250 ppm, salinity management needs to be considered

- **Winter – most years there is little concern**
  - **Low ET**
  - **Least sensitive period**
- **Spring dry season**
  - **Irrigate daily in April - June**
  - **Apply enough water to wet entire root zone depth**
  - **Extra flushing every other week**
- **Summer/Fall - salinity management needed in some years**
  - **If successive irrigations are required, irrigate frequently with sufficient water to keep salts moving downward**

Summary

- Expect yield decreases of about 10% for each additional 1000 ppm increase in TDS
- Significantly smaller overall fruit size during years where irrigation is necessary
- Expect significant leaf loss due to Cl accumulation
- Frequent irrigations minimize effects of salinity
- Irrigation amount must be great enough to flush salts downward – water should seep into water furrow
- Monitor irrigation water salinity and soil moisture status during irrigation season
- Fertigation can be very effective during droughts

Resources

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Circular 1411

Managing Salinity in Florida Citrus[1]

B. J. Boman and E. W. Stover[2]

Introduction

The usual focus of citrus irrigation is to maintain water in the root zone in a range suitable for optimum crop growth. However in some areas, salinity management may become the major objective of irrigation management. Irrigation with high salinity water requires irrigations to be more frequent and of greater amounts than when good quality water is used. During extended droughts, salinity levels will dictate irrigation scheduling.

1900. More recently, problems with salinity have occurred in citrus groves in the Tampa Bay and Southwest Florida

In some coast
wells can be attrib
fresh water zone f
pumping rate in c
is illustrated in Fi
the effect of grour
intrusion. Salt wa
versus 1.0 for fres

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Pub. No. ABE 332

Outline for Managing Irrigation of Florida Citrus with High Salinity Water[1]

B. J. Boman and E. W. Stover[2]

Salinity Management

Salinity management is sometimes an important component of irrigation management. High levels of salts in irrigation water can compromise water relations in citrus trees, resulting in water stress even when soils have a relatively high water content. Irrigation with high salinity water requires more frequent applications and a greater volume than when

Typically, more salinity results in lower yields and growth. However, when water is below 1200 ppm, detrimental effects are likely to be minimal. More detailed information on effects of salinity on citrus management can be found in an IFAS Circular titled "Managing Salinity in Florida Citrus" located at: http://edis.ifas.ufl.edu/AE171.

Irrigation and fertilization interact in their effects on tree production and growth, and management of one should always consider the other. There are two

http://edits.ifas.ufl.edu

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