Effects of salinity and water stress on vegetable crops

Stress tolerance varies by crop :

Crop	Level above which growth is affected		
	EC_e (dS/m)	Boron (PPM)	Available soil moisture depletion (%)
Lettuce	1.3	< 2	< 20
Cantaloupe	2.2	2-4	30-50
Tomato	2.5	5-6	30-50


2003-04 Lettuce salt tolerance study
Cahn & Ajwa, UCCE Salinas

Salinity treatments :

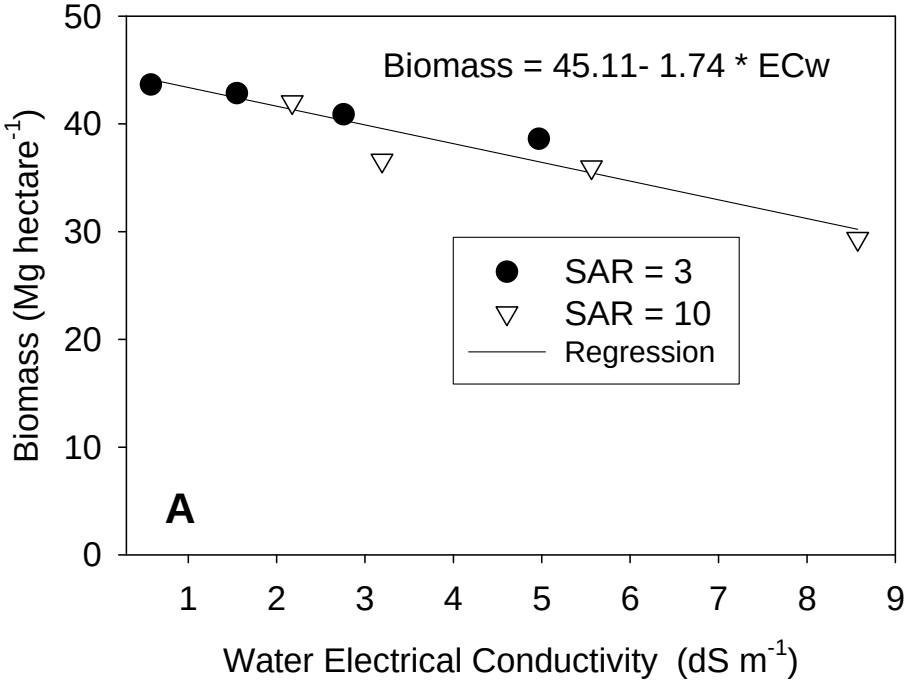
treatment	description	EC (dS/m)	SAR
1	well water	0.6	3
2	low salinity	1.5	3
3	low salinity	1.5	10
4	medium salinity	2.5	3
5	medium salinity	2.5	10
6	high salinity	5	3
7	high salinity	5	10
8	very high salinity	8	10


Foliar symptoms only in the highest EC treatment

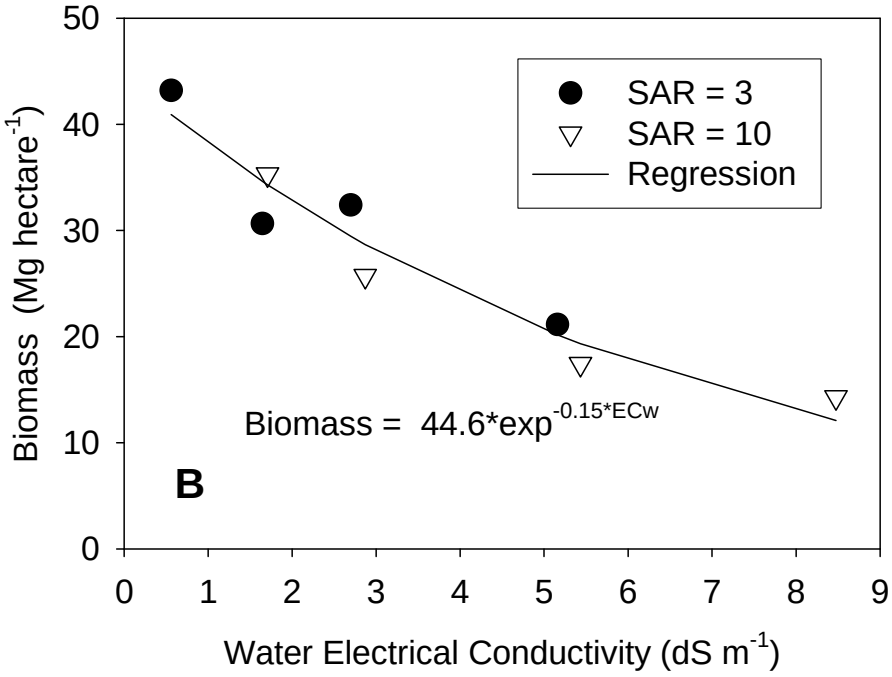
Biomass Yield vs ECw

(Salinas and Sniper Varieties)

2003

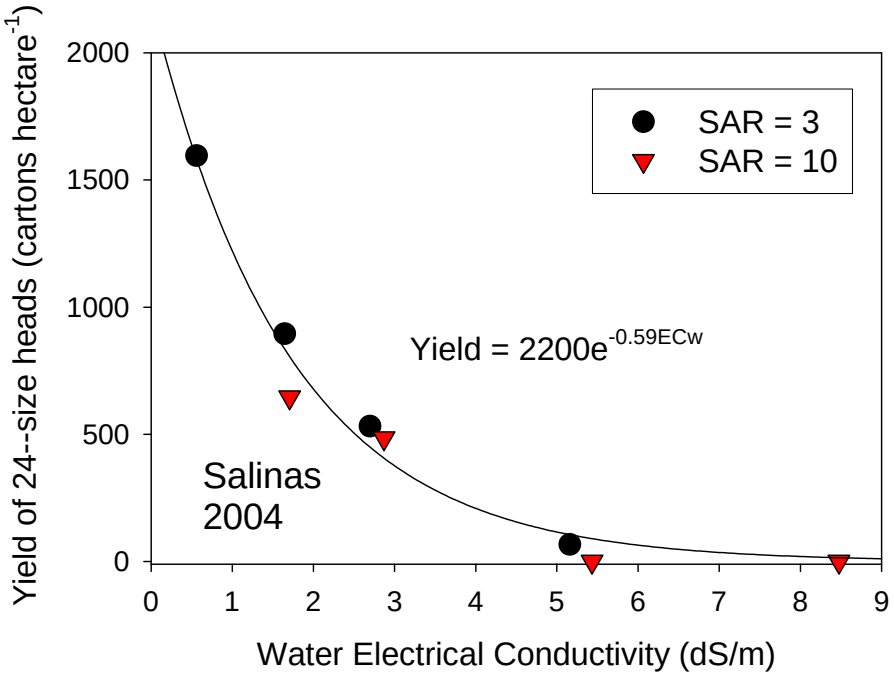


2004

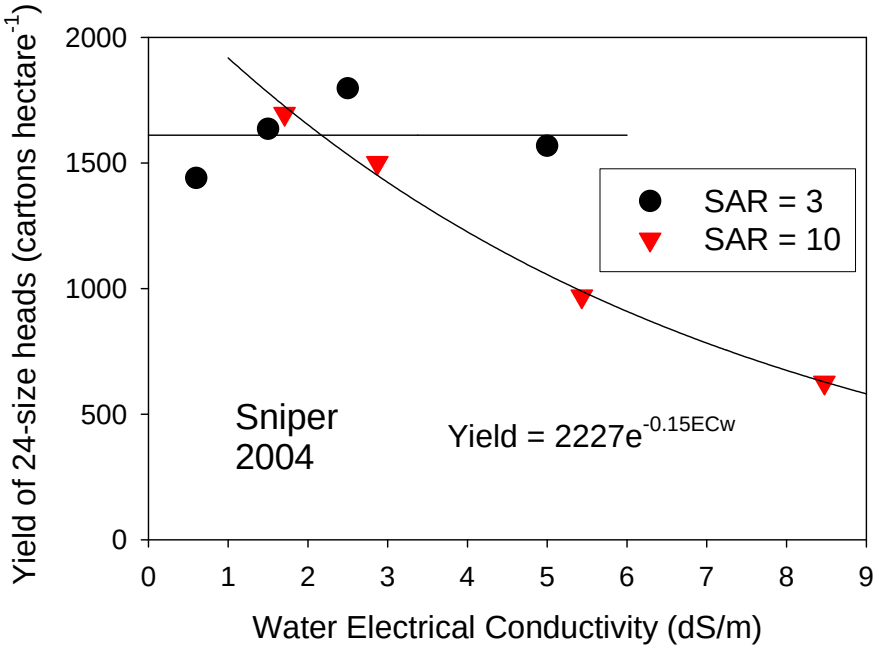


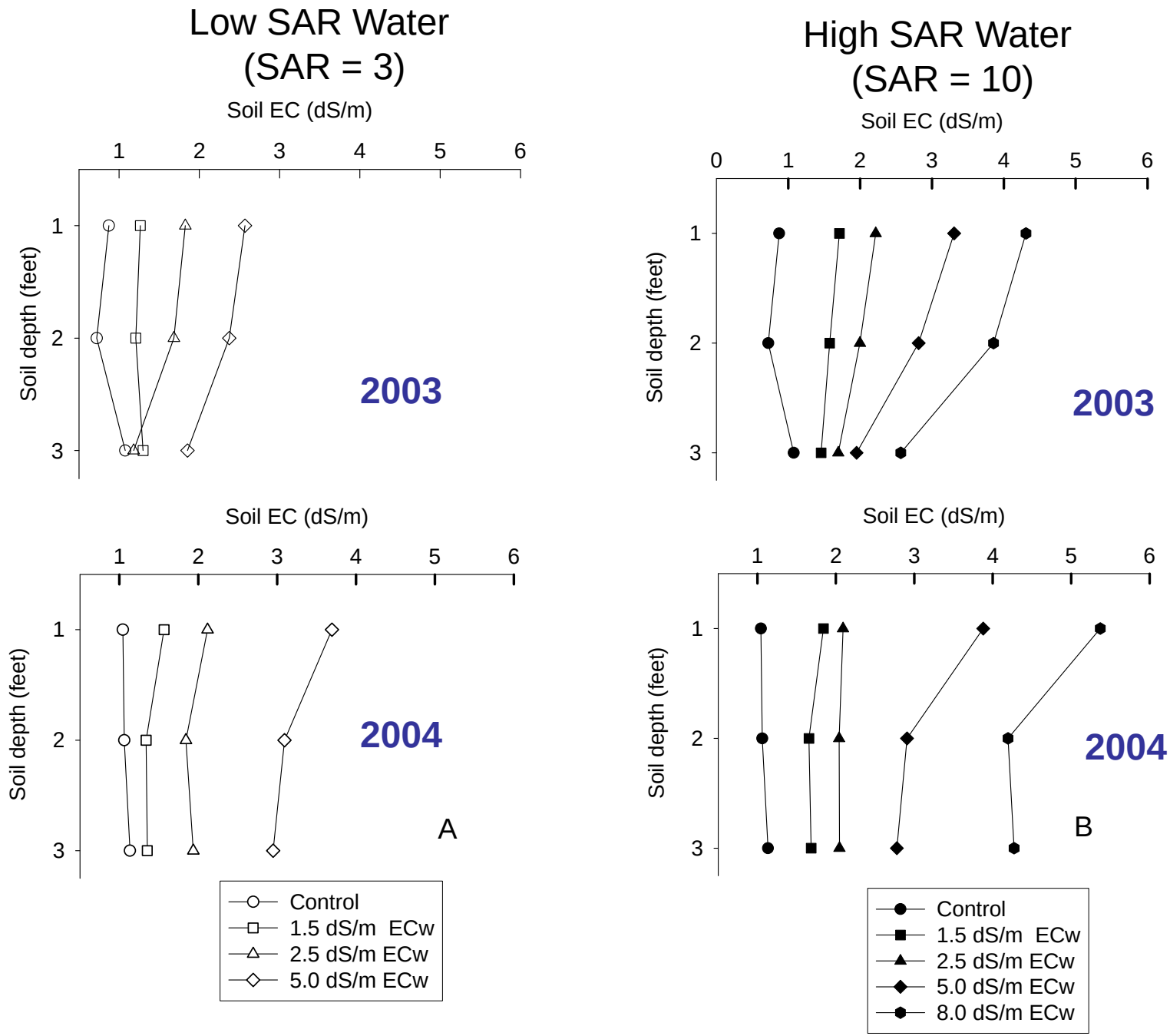
Carton Yield of 24-size heads (2004)

Salinas



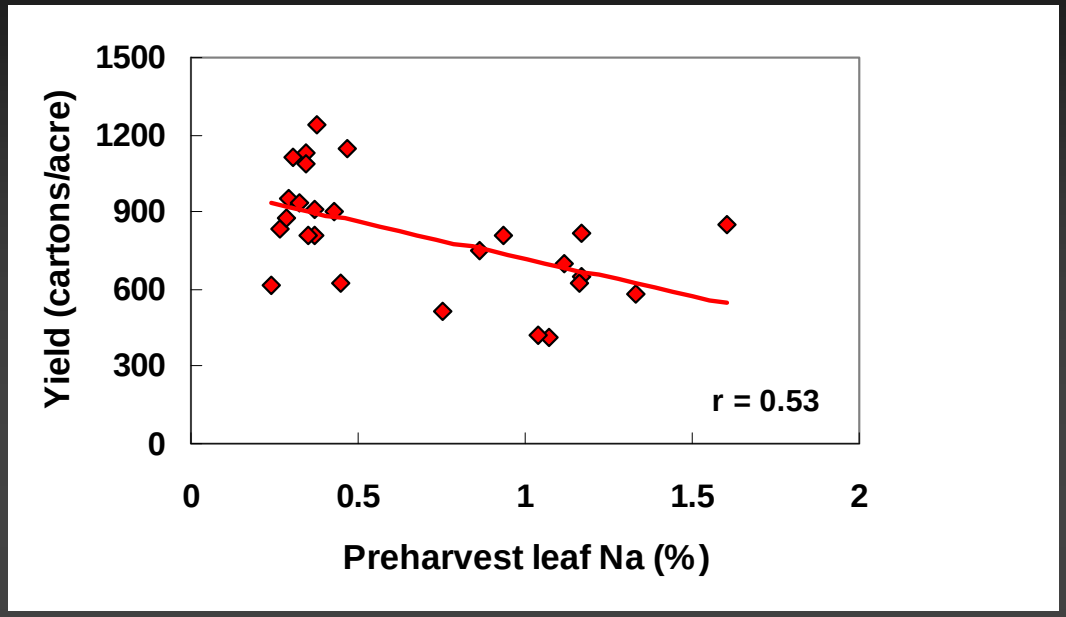
Sniper

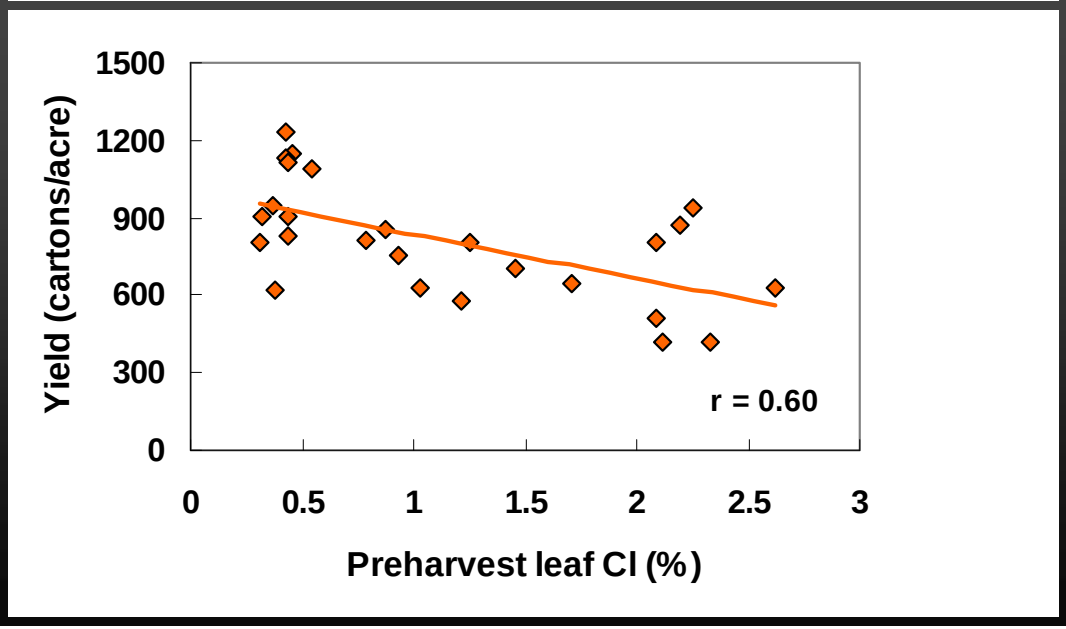



Low SAR Water
(SAR = 3)
Soil EC (dS/m)
1
2
3
4
5
6
Soil depth (feet)
1
2
3
2003
High SAR Water
(SAR = 10)
Soil EC (dS/m)
0
1
2
3
4
5
6
Soil depth (feet)
1
2
3
2003
Soil EC (dS/m)
1
2
3
4
5
6
Soil depth (feet)
1
2
3
2004
A
Control
1.5 dS/m ECw
2.5 dS/m ECw
5.0 dS/m ECw
Soil EC (dS/m)
1
2
3
4
5
6
Soil depth (feet)
1
2
3
2004
B
Control
1.5 dS/m ECw
2.5 dS/m ECw
5.0 dS/m ECw
8.0 dS/m ECw

What about Na and Cl toxicity ?

2004-05 coastal lettuce field survey :





General limit of vegetable crop tolerance :

	Irrigation water content	
	Na	Cl
No restriction	< 115 PPM or 5 meq/liter	< 100 PPM or 3 meq/liter
Severe restriction	> 460 PPM or 20 meq/liter	> 350 PPM or 10 meq/liter

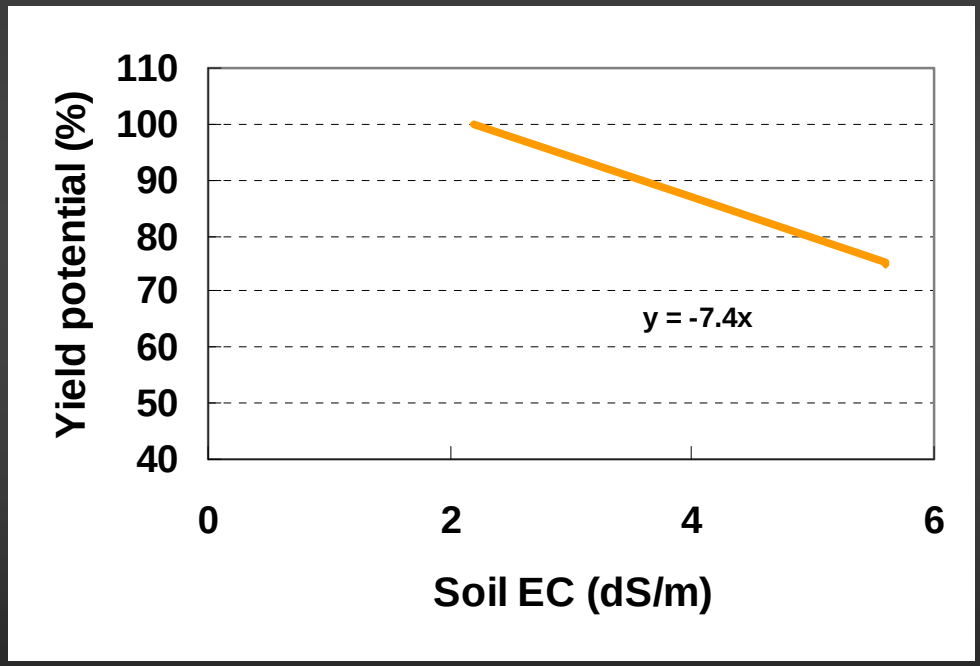
What about deficit irrigation ?

Lettuce deficit irrigation sensitivity :

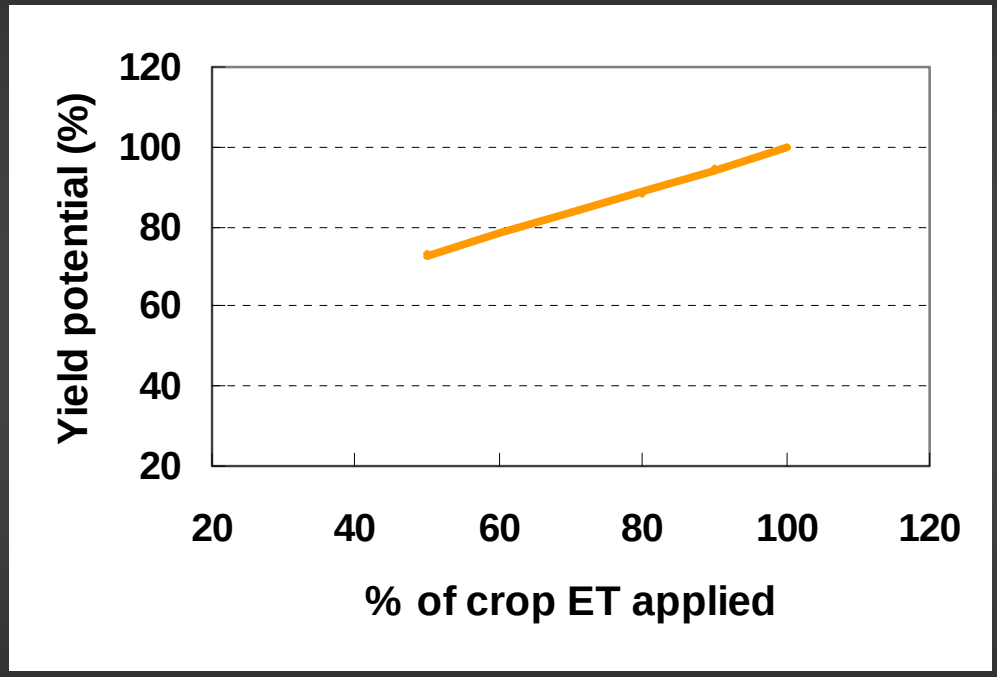
Last irrigation applied	Mkt. yield (tons/acre)	Soil moisture tension at harvest (cb)
1 day preharvest	14.7	13
5 days preharvest	13.3	23

Data from Cahn, mean of 7 romaine fields harvested for salad mix:

Melon salinity tolerance :



Melon tolerance for deficit irrigation:



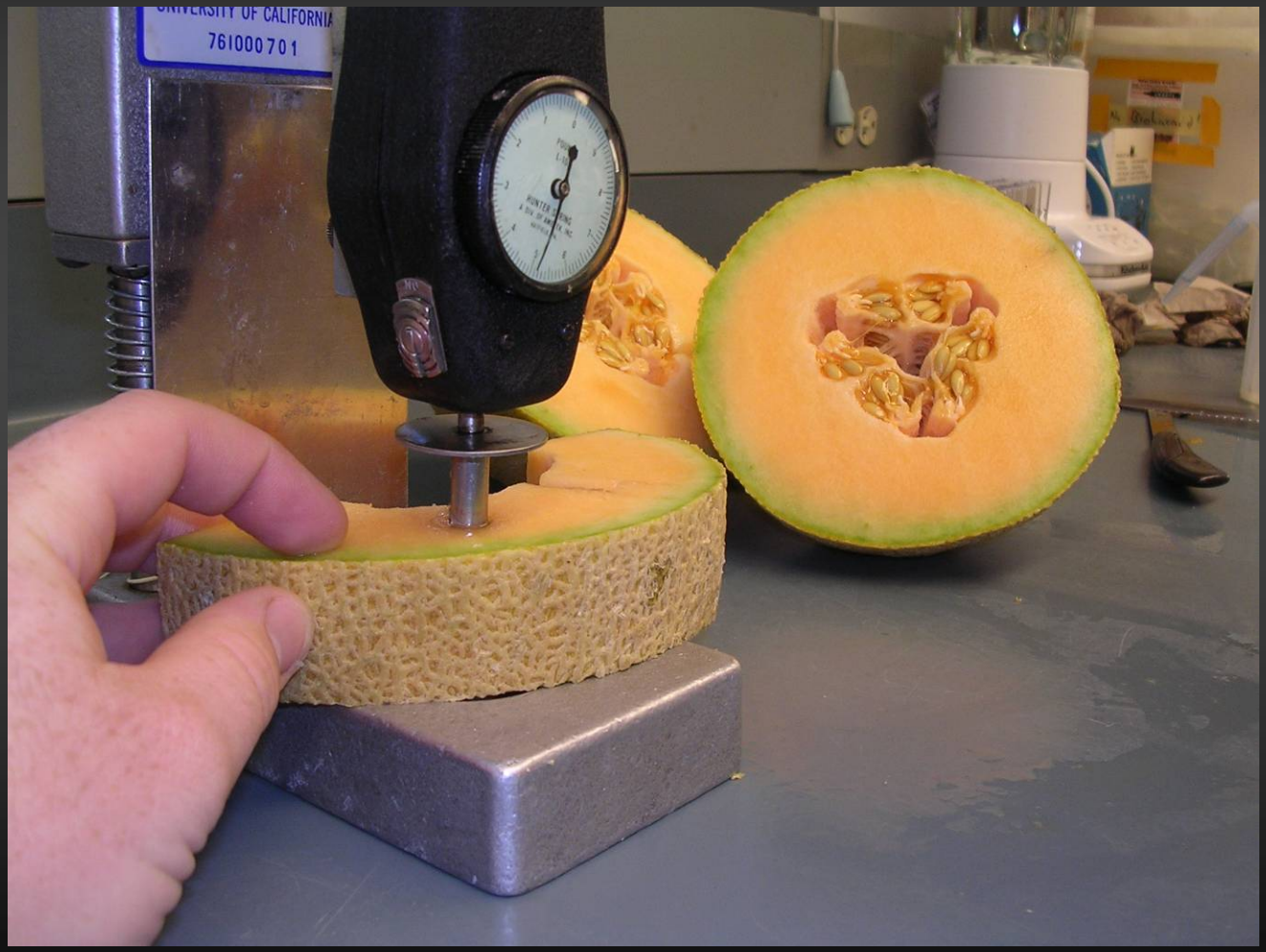
Adapted from Cabello et al. (2009) and Fabreiro et al. (2002); deficit applied across entire season

Tolerance to water stress increases through the season :

Irrigation treatment	Mkt yield (cartons/acre)
Full irrigation until harvest began	928
25% irrigation from 20-10 days preharvest, terminated 10 days preharvest	939

1994 UC Davis drip irrigation trial

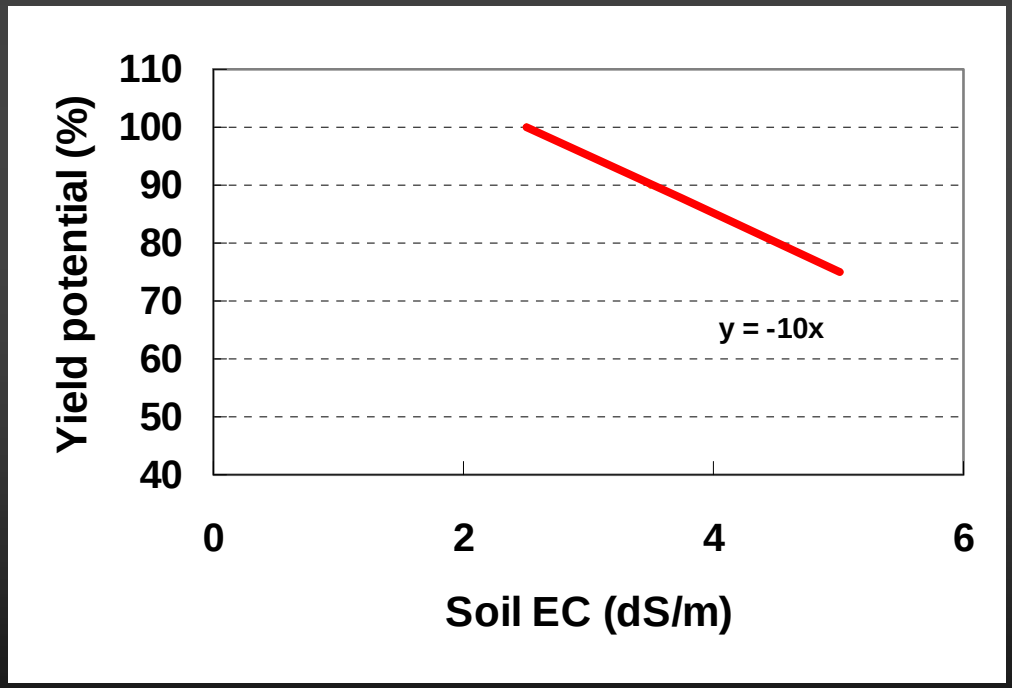
Silver lining to melon stress – improved firmness and soluble solids



Specific ion toxicities ?

- ✓ Reasonably high tolerance; damage is cumulative
  and likely to reach threshold too late in the season to be critical

Tomato is reasonably salt tolerant :



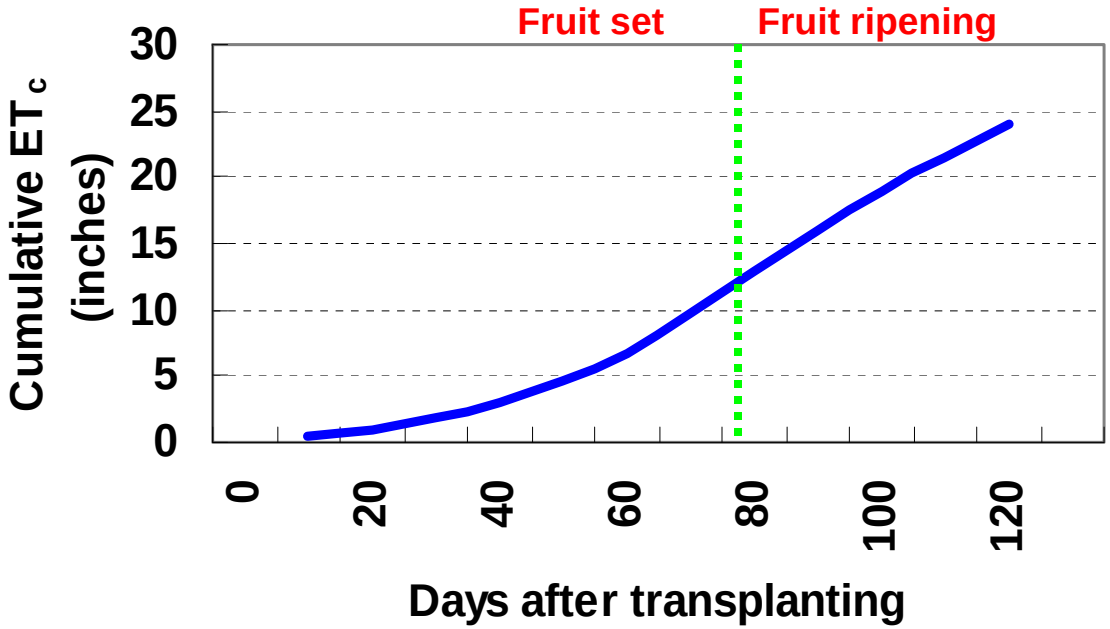
Using saline water :

In a 2 year study at Westside Field Station, irrigation with saline water (EC = 8.1 dS m^{-1}, begun after bloom initiation) was compared to conventional irrigation

	Control	Saline water
Yield (tons/acre)	39	40
Soluble solids (^{o} brix)	4.6 a	5.0 b
Brix yield (tons/acre)	1.8	2.0

Salt buildup a problem for the subsequent crop

How about deficit irrigation ?



Seasonal crop water use :
about 50% through fruit set,
50% during fruit ripening

Deficit irrigation during fruit set :

% of ET_o applied	Ton fruit / acre	Tons solids / acre
35	17	1.14
70	25	1.55
105	40	2.13

Source: Sanders and Phene, 1989

Deficit irrigation during fruit set :

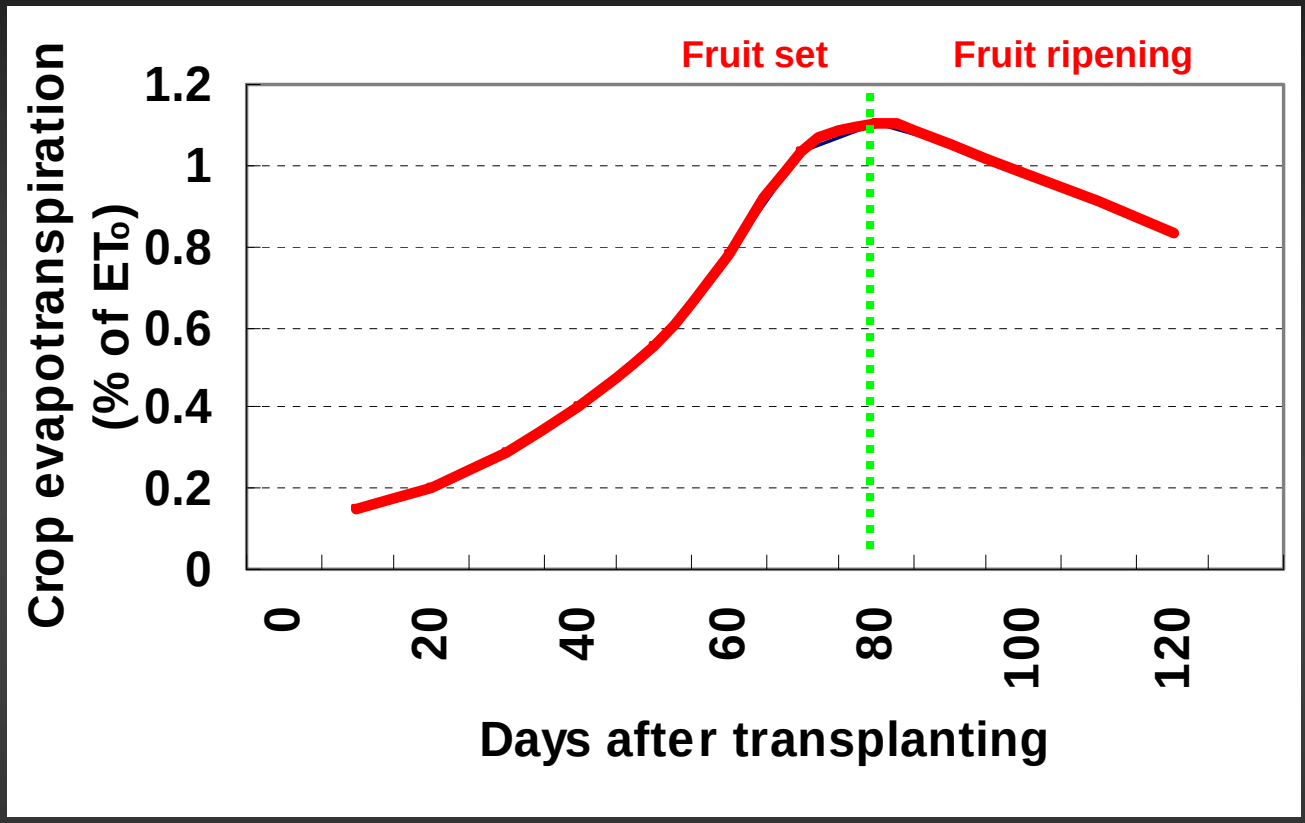
% of ET_o applied	Ton fruit / acre	Tons solids / acre
35	17	1.14
70	25	1.55
105	40	2.13

Source: Sanders and Phene, 1989

% of ET_o applied	Ton fruit / acre	Tons solids / acre
25	30	1.6
50	37	2.1
110	55	2.7

Source: May and Hanson, 1995

Deficit irrigation during fruit ripening :



Irrigation cutback starting at early red fruit saves water, maintains brix yield

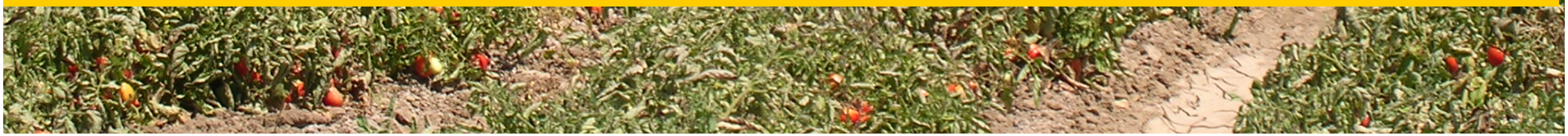
2002-04 Drip cutback trials :

- eight drip-irrigated fields
- compare ‘typical’ practice with more severe cutbacks

Irrigation treatment	% of ETo applied during fruit ripening	Mkt yield (tons/acre)	Brix yield (tons/acre)	Inches of water saved
'Typical'	58	55	2.9	
Reduced	26	53	2.9	3

In summary :

- vegetable crops differ in their sensitivity to salinity and water stress
- salinity is more a concern over seasons than within seasons
- specific ion toxicity a minimal threat in most cases
- water stress tolerance increases over the season



Crop	100 % Yield Potential		90 % Yield Potential	
	EC_{soil}	EC_{water}	EC_{soil}	EC_{water}
	----------dS/m----------			
Squash, Zucchini	4.7	3.1	5.8	3.8
Beet, Red	4.0	2.7	5.1	3.4
Squash, Scallop	3.2	2.1	3.8	2.6
Broccoli	2.8	1.9	3.9	2.6
Tomato	2.5	1.7	3.5	2.3
Cucumber	2.5	1.7	3.3	2.2
Spinach	2.0	1.3	3.3	2.2
Celery	1.8	1.2	3.4	2.3
Cabbage	1.8	1.2	2.8	1.9
Potato	1.7	1.1	2.5	1.7
Corn, Sweet	1.7	1.1	2.5	1.7
Sweet Potato	1.5	1.0	2.4	1.6
Pepper	1.5	1.0	2.2	1.5
Lettuce	1.3	0.9	2.1	1.4
Radish	1.2	0.8	2.0	1.3
Onion	1.2	0.8	1.8	1.2
Carrot	1.0	0.7	1.7	1.1
Bean	1.0	0.7	1.5	1.0
Turnip	0.9	0.6	2.0	1.3

FAO Irrigation and Drainage Paper 29, 1985