Crop response to high salinity well waters

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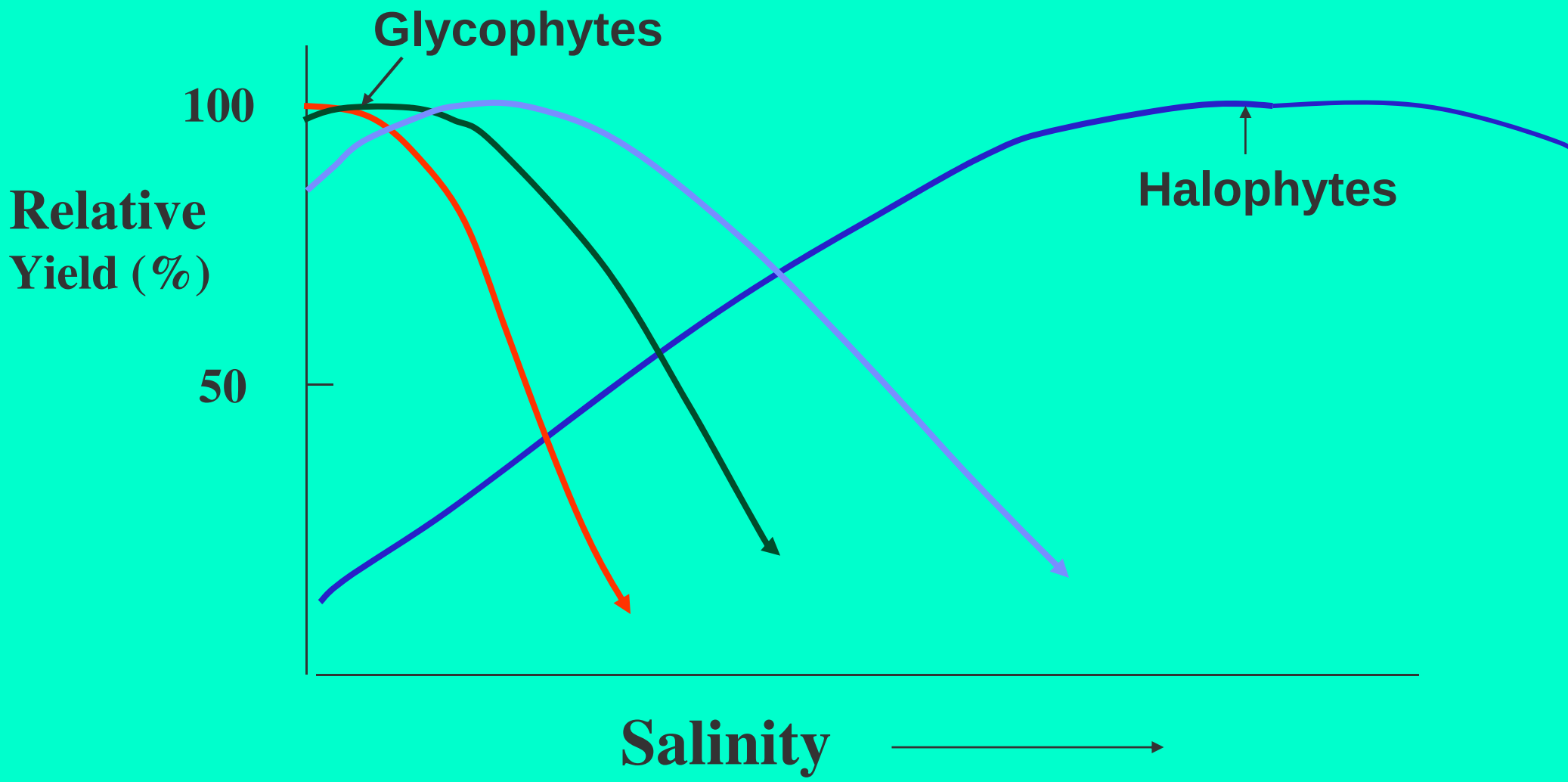
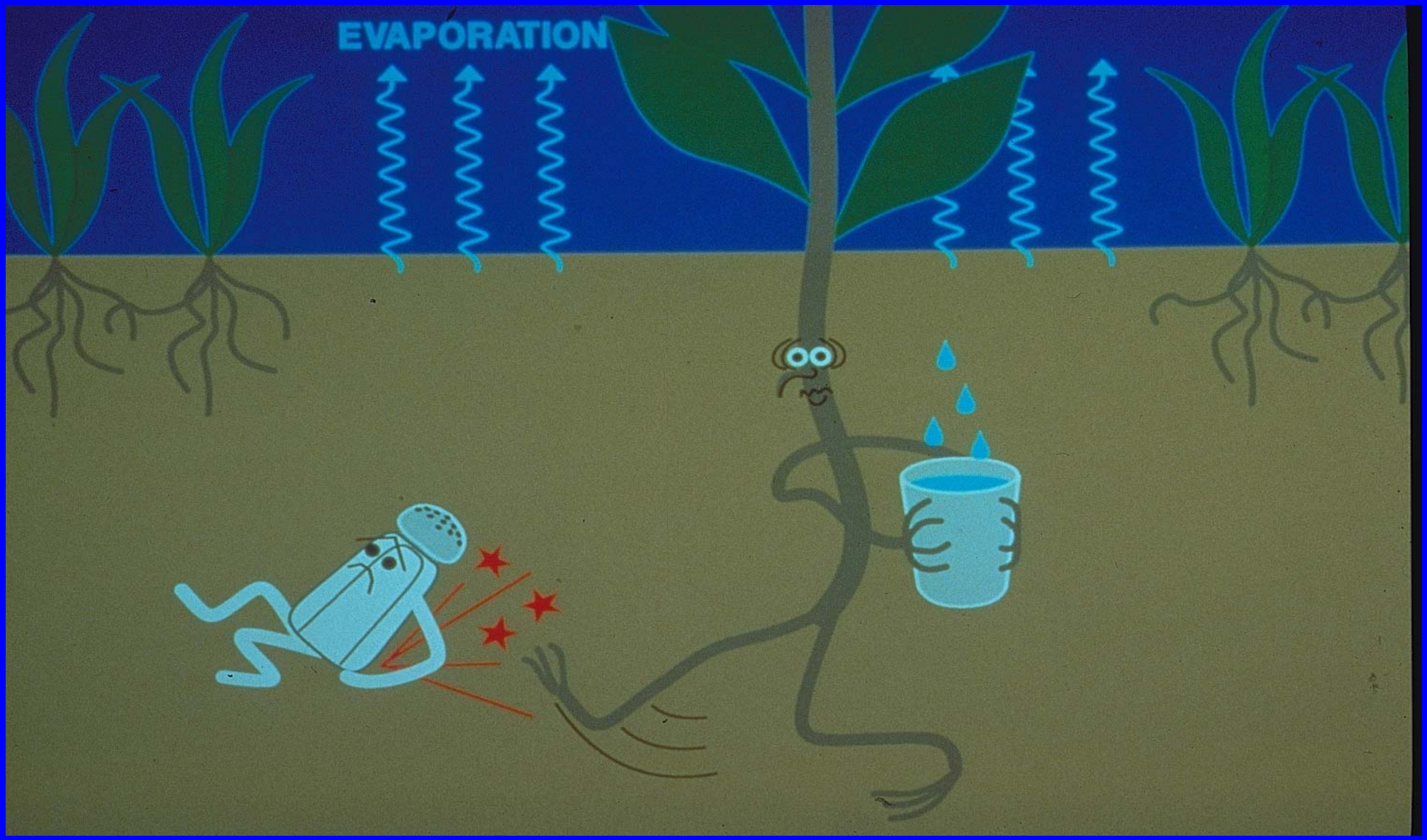
Use of high-salinity well water for irrigation: Long-term consequences affecting crop production

- Accumulation of salts
- Accumulation of boron
- Reduction in water infiltration rates

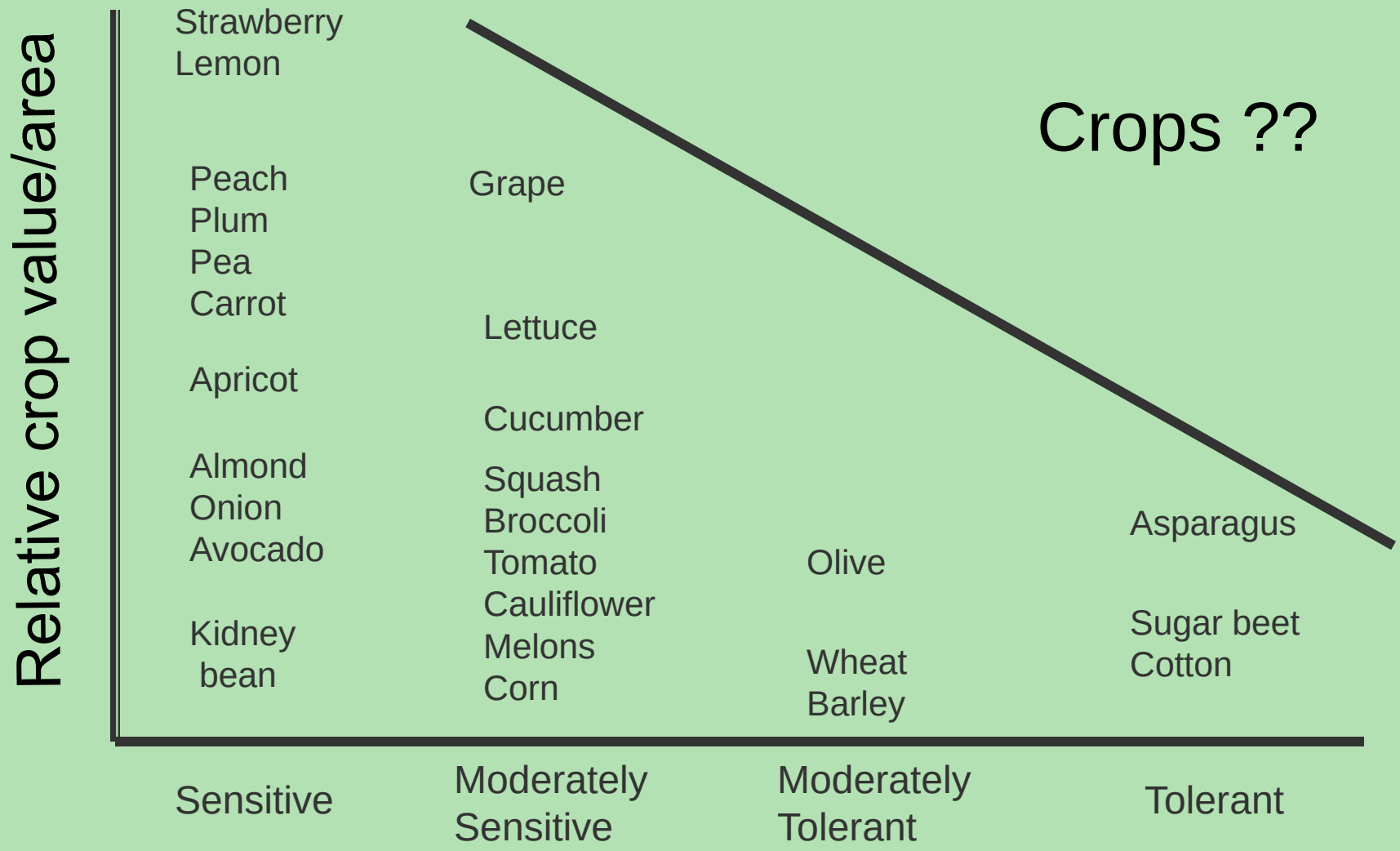
Glycophytes and Halophytes





Glycophytes (most crop plants)

Salt tolerance vs. crop value



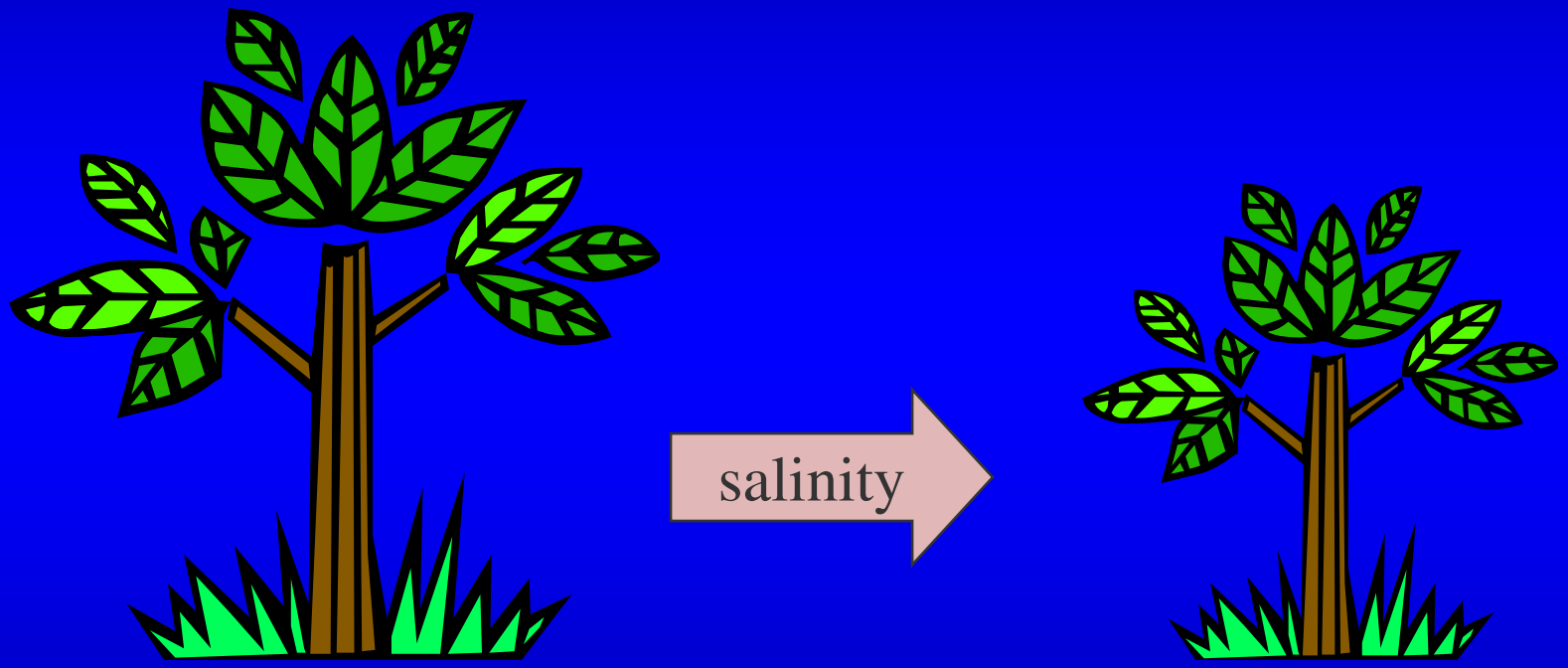
Adapted from Grattan and Rhodes, 1990

Salt affects crop growth and performance several ways

- Osmotic effects
- Ion toxicities
- Nutritional disorders

} Specific ion effects

The overall osmotic effect is stunting of plant growth



Non-stressed crop

Salt-stressed crop

Note: moderately salt-stressed crops may appear healthier

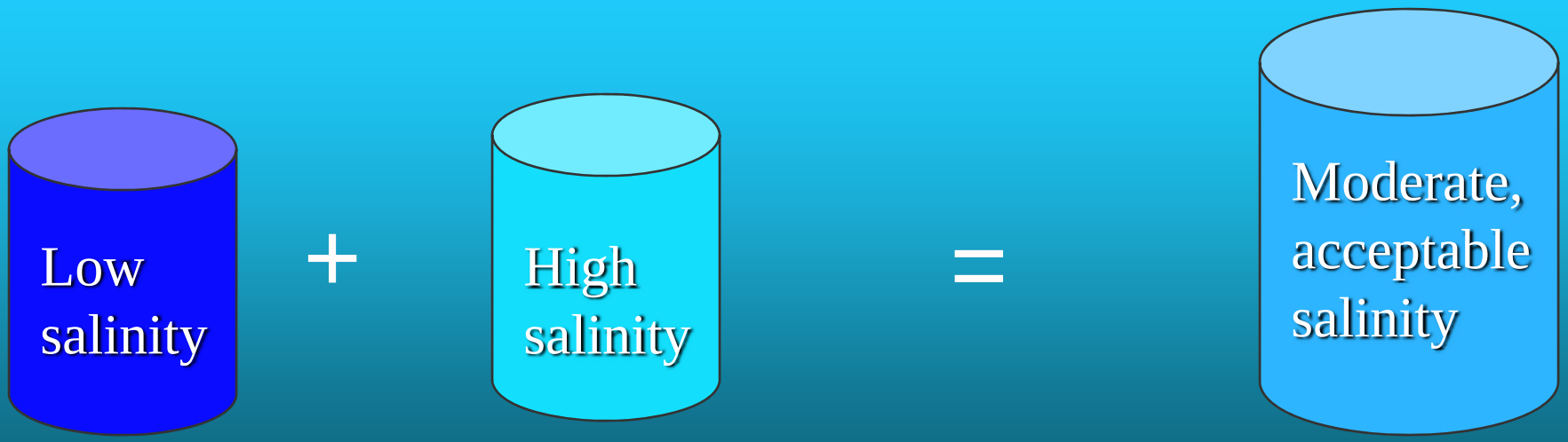
Salinity

Various strategies for using saline water for irrigation

- Blending
- Cyclic
- Sequential

Blending Strategy:

Mix two water supplies together that vary in quality in the correct proportion such that the resulting blended water is suitable for irrigation



Blending:

Do not use water that is too salty…

1 gallon seawater
+ 1 gallon aqueduct water
0 gallons of useable water

It make little sense if the saline fraction of the blend can not contribute at least 25%

Blending Formula (Long-term irrigation)

$$Vc/Vs = (Cs - Cb) / (Cb - Cc)$$

- Where Vc and Vs are the volumes of canal and saline well water; Cs, Cc and Cb are the concentrations (or ECs) of the saline well water, canal water and blended water, respectively
- Don’t blend if Vc/Vs > 3

Blending Example

$$Vc/Vs = (Cs - Cb) / (Cb - Cc)$$

- Assume saline well has and EC of 4.0 dS/m and canal has an EC of 0.3 dS/m and you want to irrigate tomatoes
- Let Cb = irrigation water threshold for tomato (1.7 dS/m)
- Vc/Vs = (4.0 - 1.7) / (1.7 - 0.3)
- Vc/Vs = 1.6
- For every ac-ft of saline water, you need to blend it with 1.6 ac-ft of good quality water

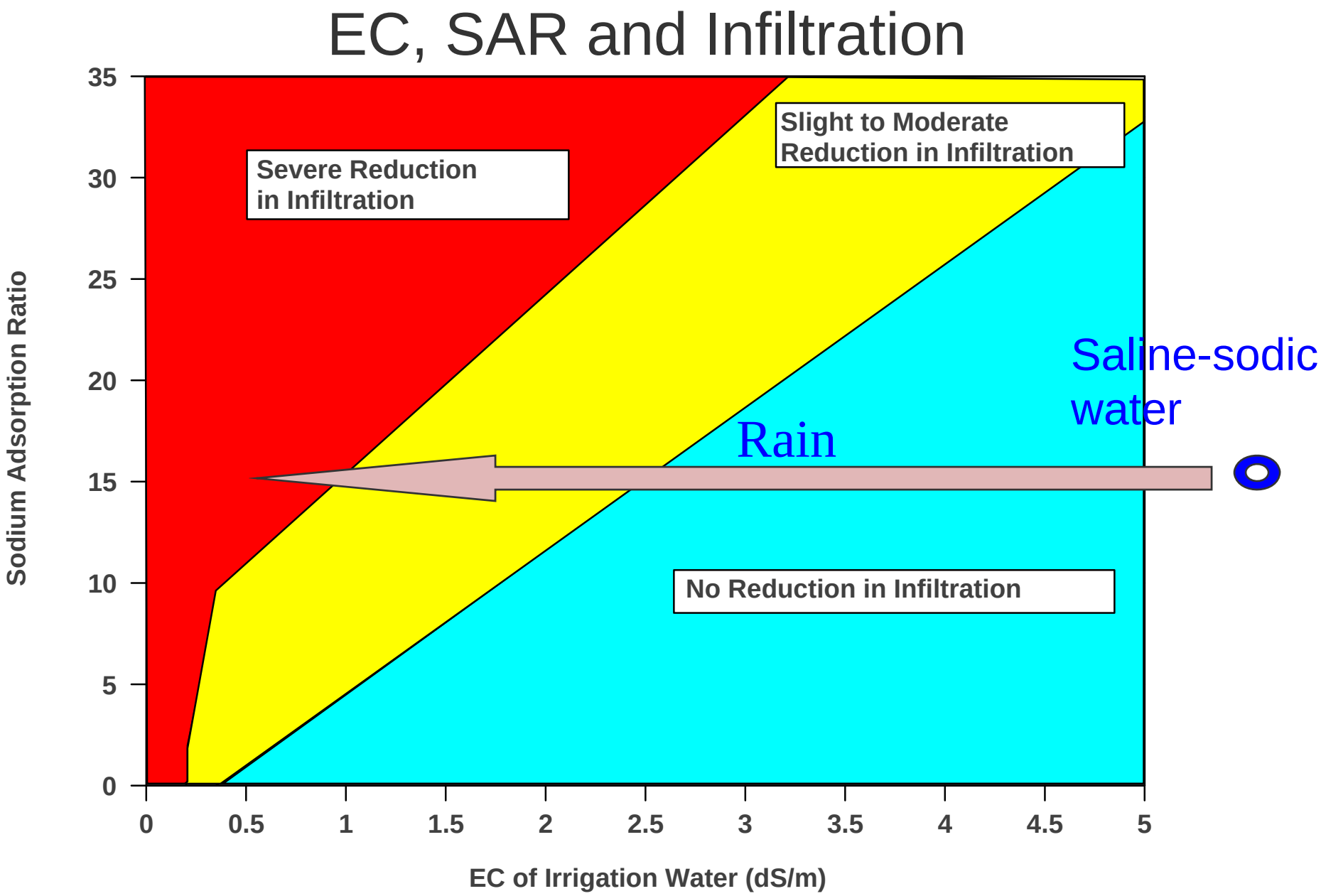
Salinity vs Sodicity

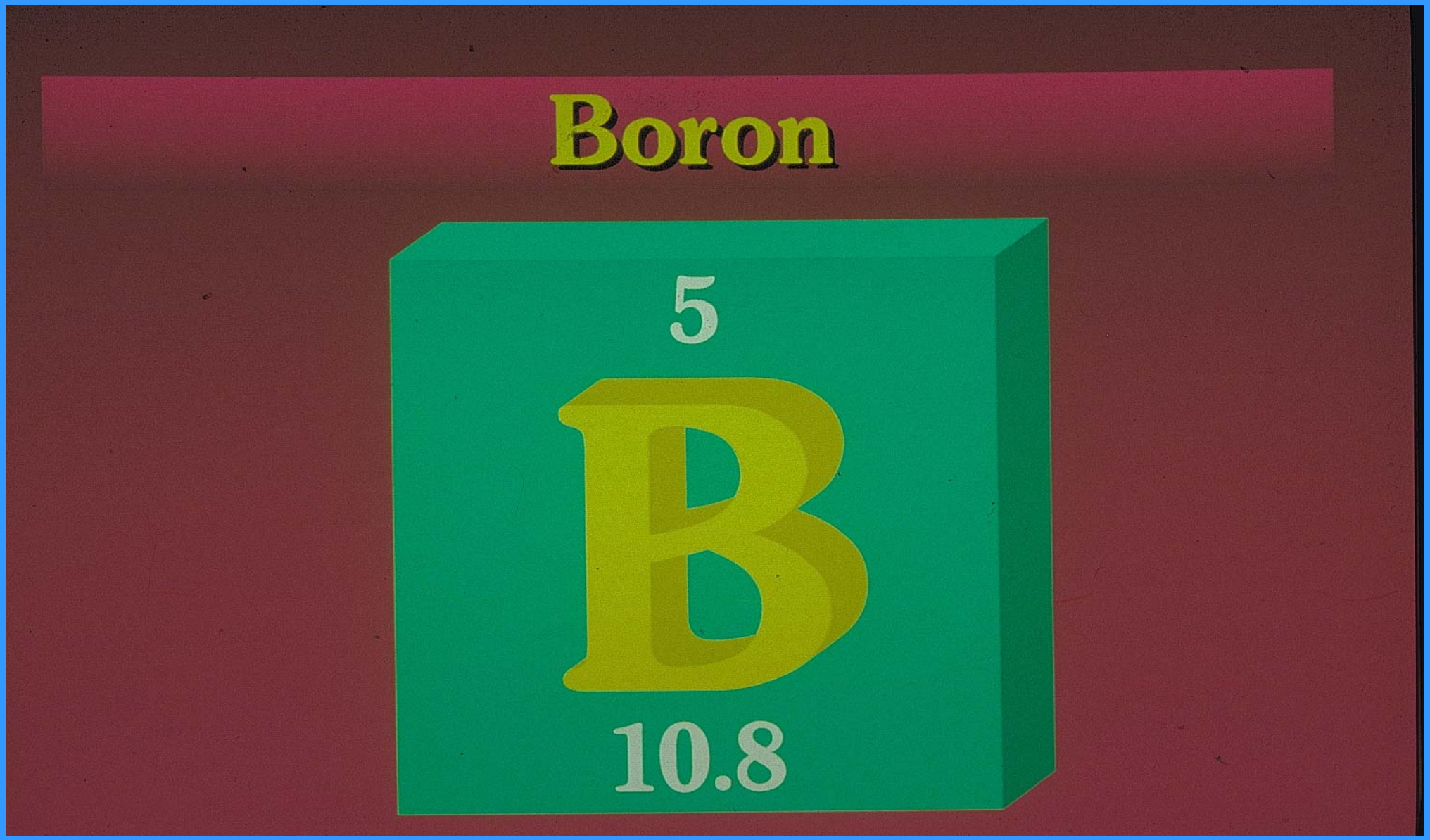
- Salinity (EC) is a condition where the salt concentration reduces yields

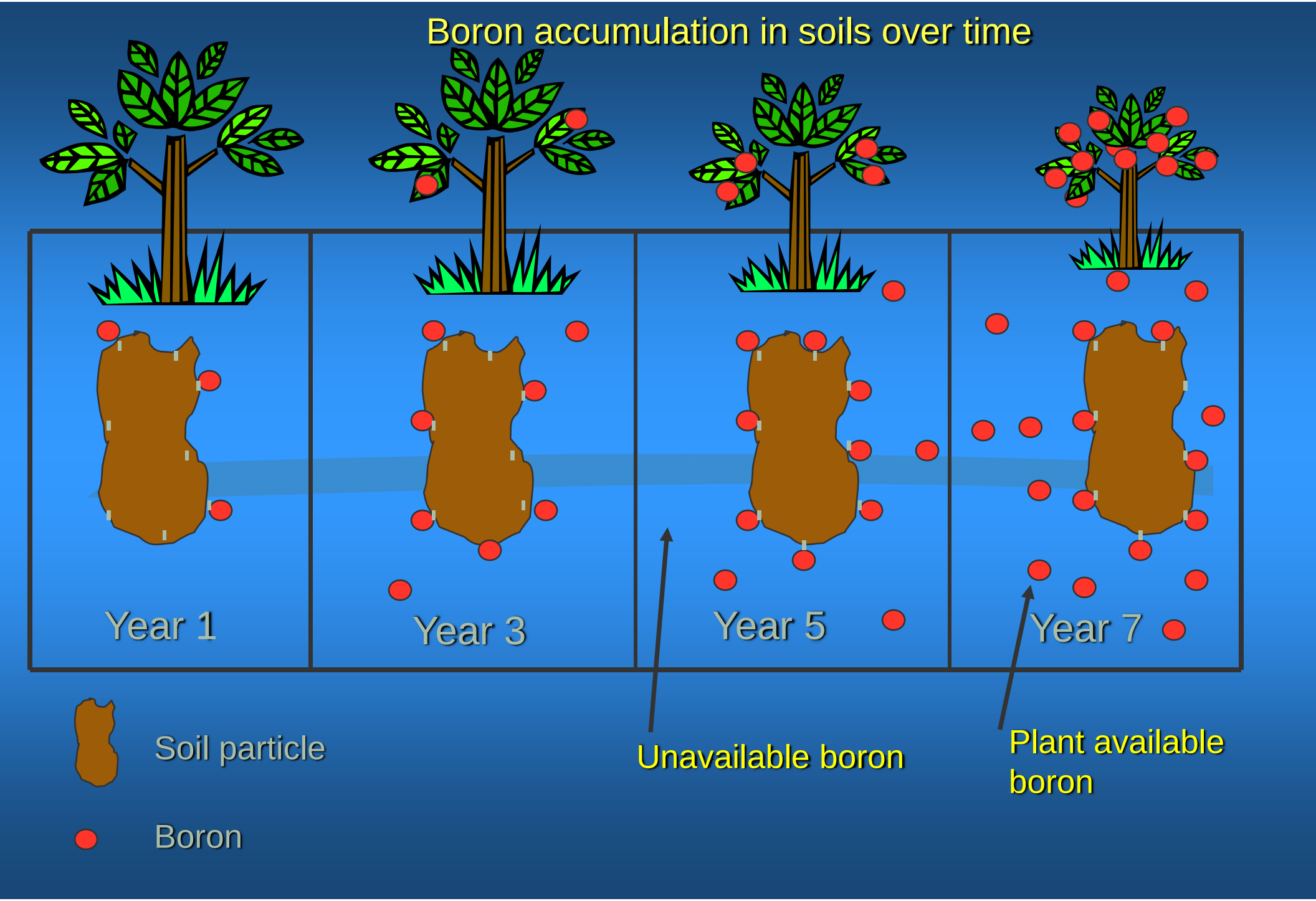
- Sodicity (SAR) is a condition where the cations are dominated by Na; affecting soil structure and water infiltration; secondary effects on plants

Reduced stand establishment in cotton

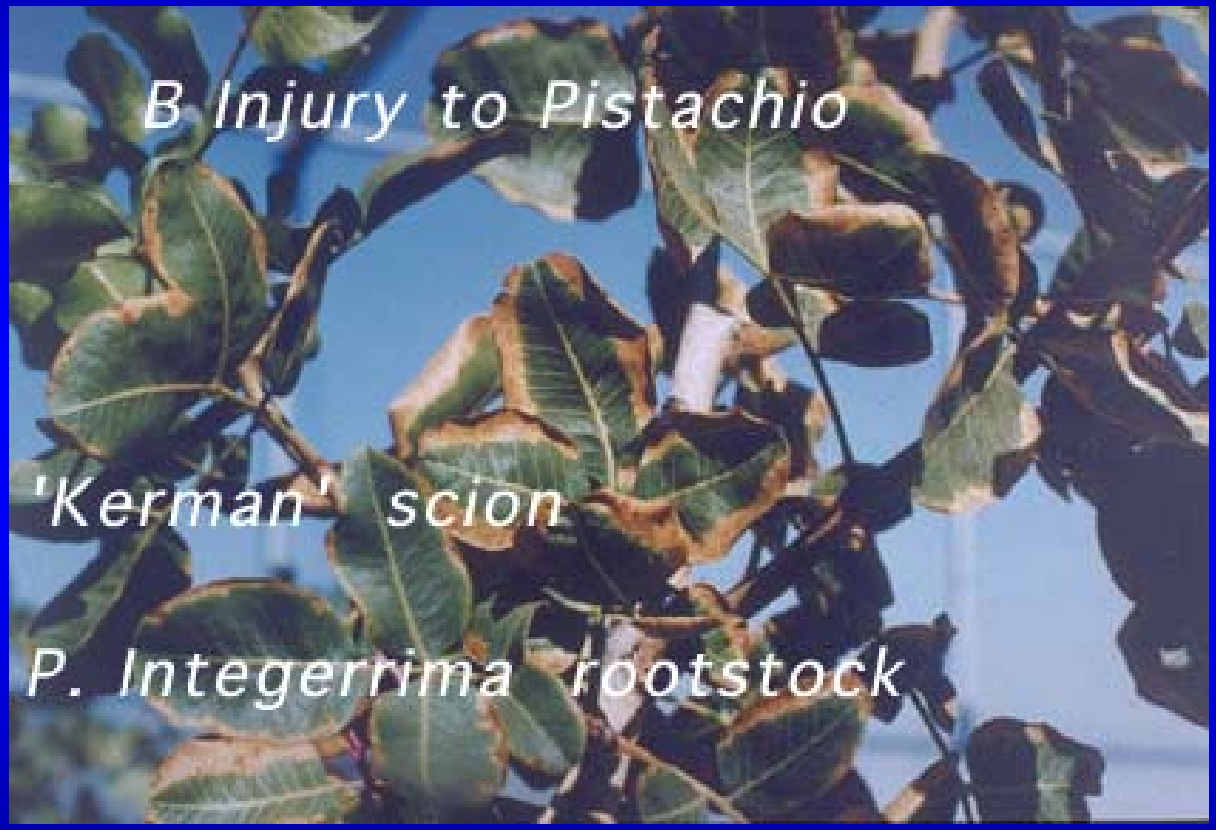
Goyal et al. 1992; Mitchell et al., 1995; Shennan et al., 1995


EC, SAR and Infiltration
Severe Reduction in Infiltration
Slight to Moderate Reduction in Infiltration
No Reduction in Infiltration
Saline-sodic water
Rain
Sodium Adsorption Ratio
EC of Irrigation Water (dS/m)
0
5
10
15
20
25
30
35
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


Boron
5
B
10.8


Boron accumulation in soils over time
Year 1
Year 3
Year 5
Year 7
Soil particle
Boron
Unavailable boron
Plant available boron

Pistachios were found to be more salt-tolerant than most nut trees but were injured by boron



As salinity increased, B injury decreased even though Leaf B was not affected

Ferguson et al., 2002

Salinity-B Interaction Study with Broccoli

Treatments

Salinity
Boron
Salt type (Cl vs SJV)

Sand-tank system
at the US Salinity Lab

Smith et al.,
2005

Low salt (EC 2 dS/m)
High Boron (24 mg/L)

High salt (EC 20 dS/m)
High Boron (24 mg/L)

Search for salt-tolerant crops

- High crop value
- High biomass production
- High salt-tolerance
- Tolerant to high boron
- Accumulate low concentrations of Se and Mo

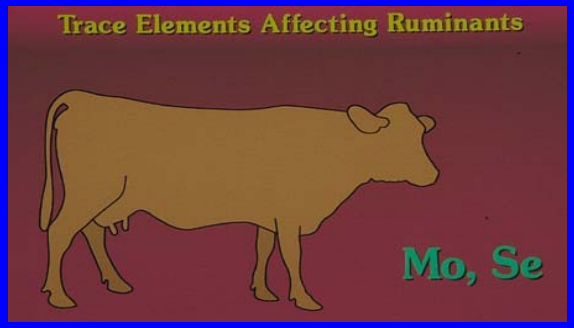
Search for salt tolerant forages

Forages in sand tanks at the US Salinity Lab irrigated with either 15 or 25 dS/m synthetic drainage water 2001-2002

Top candidates

‘Jose’ tall wheatgrass

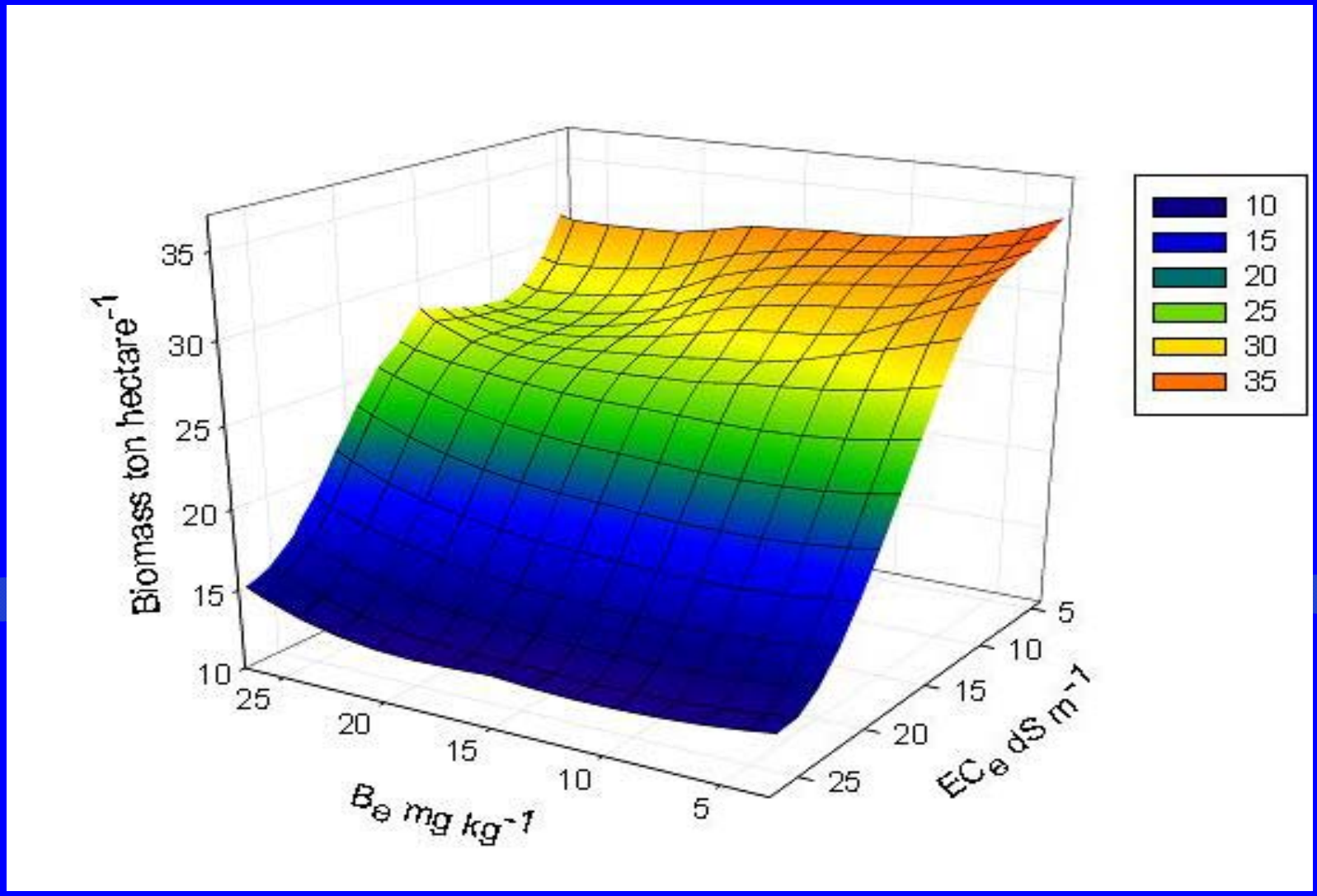
Bermudagrass



Overall Forage Quality

- When salinity influenced forage quality, it did so positively.
- High Mo and high S could cause Cu deficiency in ruminants
- All forages accumulated S to high levels (above the MTC of 0.4%)
- Se accumulated in forage but not to potentially toxic levels

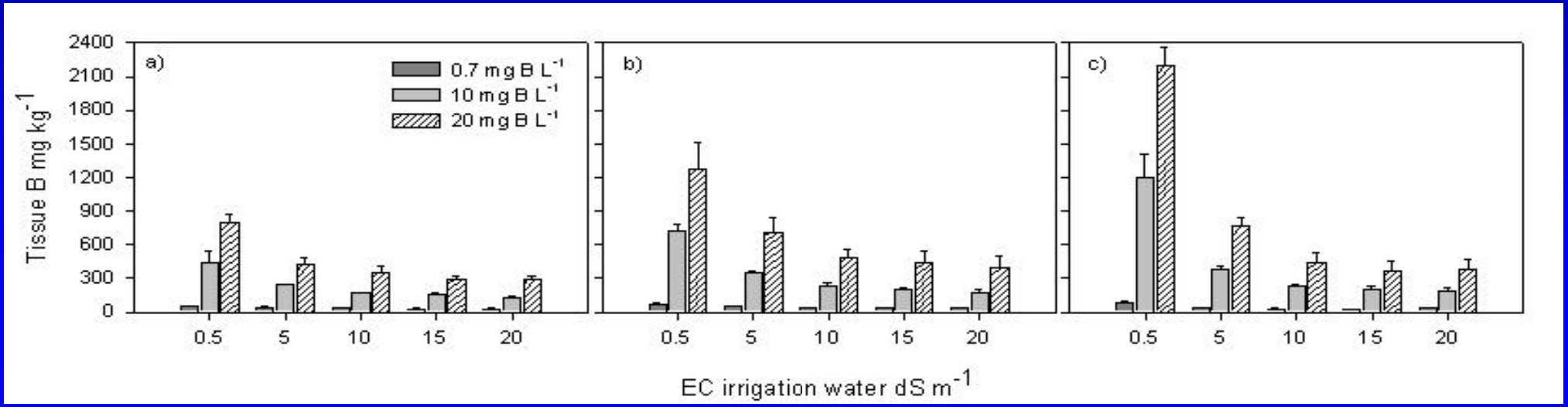
Grattan et al, 2004



Cumulative shoot biomass at the end of the study in relation to the electrical conductivity (ECe) and boron (Be) in the saturated soil extract.

Diaz and Grattan, 2009

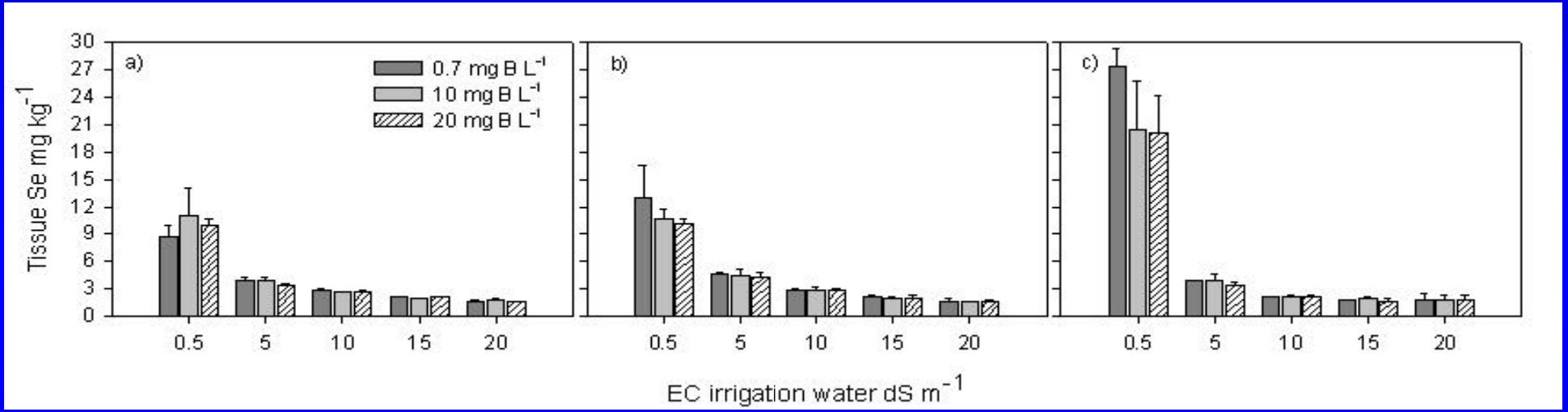
Tissue Boron



Tissue B concentration at different stages of the experiment a) 97 days after sowing, b) 174 days after sowing, c) 254 days after sowing. Bars represent means and standard deviation.

Diaz and Grattan, 2009

Tissue Se Concentration



Tissue Se concentration at different stages of the experiment a) 97 days after sowing, b) 174 days after sowing, c) 254 days after sowing. Bars represent means and standard deviation.

Diaz and Grattan, 2009

Evaluation of forages irrigated with saline drainage water containing high Se on ruminant growth and health

Tall wheatgrass (*Thinopyrum ponticum* var. 'Jose') &
Creeping wildrye (*Leymus triticoides* var. 'Rio')

S. Benes, et al 2007 - present

*Tall wheatgrass (*Thinopyrum ponticum* var. 'Jose') & Creeping wildrye (*Leymus triticoides* var. 'Rio') --

2002-2004 data

Forages	Field	DW irrigation (yrs.)†	ECw (dS/m)	ECe†† (dS/m)	Soil Boron (mg/kg)	SAR	BM Production (MT/ha/yr)†††	Forage Quality†††† ME (MJ/kg DM)	CP (%)	NDF (%)	Ash (%)	S (%)	Se (mg/kg)
Tall Wheatgrass	1	5	7.2	19.1	25.1	38.0	7.1	9.32	15.6	56.5	9.7	0.36	6.12
"	2	5	9.8	17.6	23.0	35.3	6.8	9.22	11.3	62.1	8.0	0.35	7.38
Creeping wildrye	1	2	8.6	13.3	18.7	29.4	10.6	8.24	16.4	60.9	8.7	0.22	2.98
"	2	5	9.8	12.9	18.7	28.1	12.3	7.91	13.9	65.1	8.1	0.41	10.7
Puccinellia	1	5	9.8	15.0	23.2	29.9	5.5	9.56	17.7	60.4	8.8	0.29	4.37
Tall fescue	1	5	9.8	12.1	16.8	27.3	4.5	9.32	19.0	54.4	11.5	0.57	7.41
Alkali sacaton	1	5	9.8	12.4	15.8	26.7	6.7	6.72	12.1	72.2	9.3	0.59	6.88
Alfalfa/DW	1	1	6.7	6.9	7.1	17.5	16.7	9.62	23.7	37.5	9.9	0.37	1.45
Alfalfa/FW	2	0	1.1	4.7	3.6	12.2	19.1	9.85	24.8	34.8	10.3	0.34	0.80

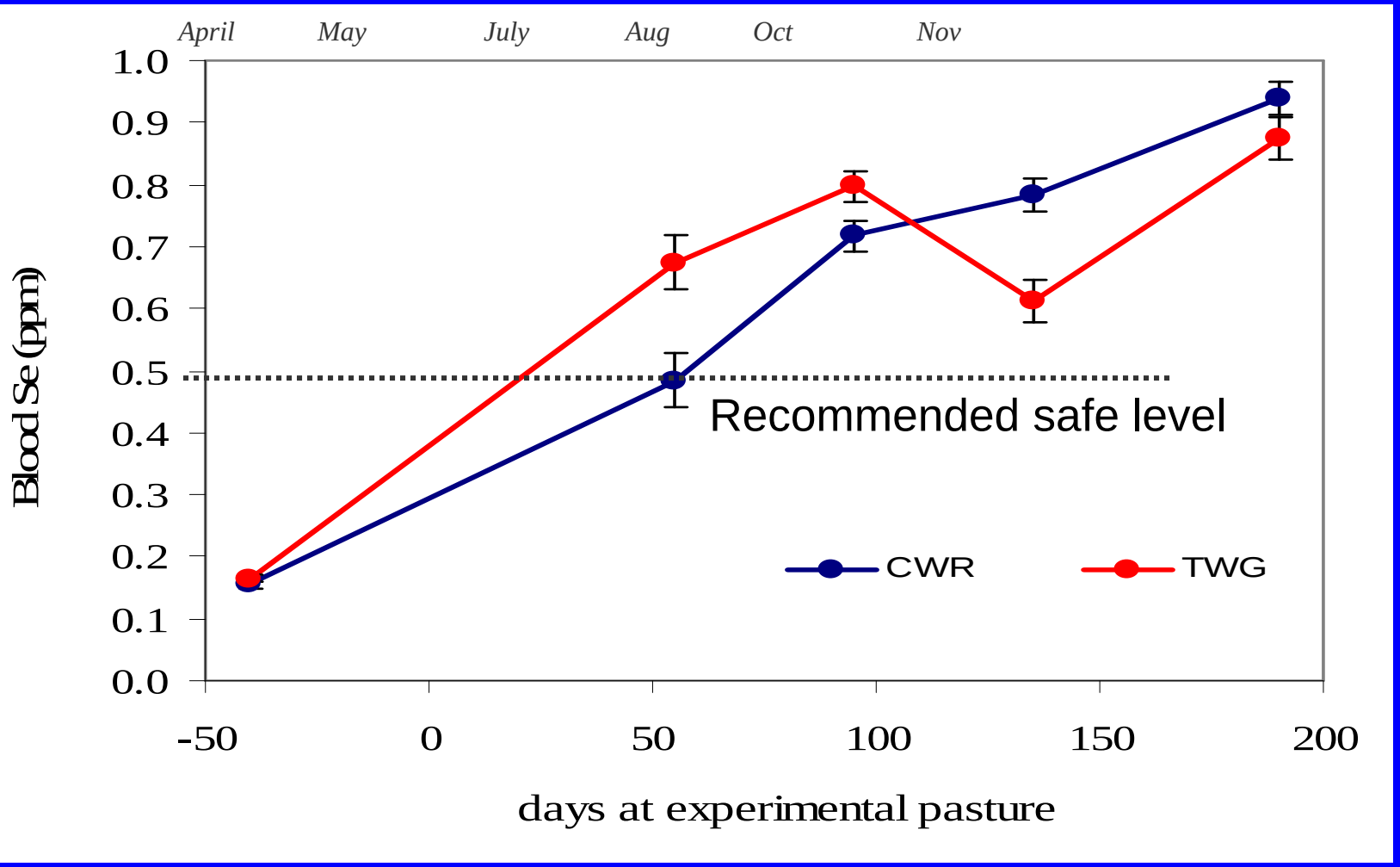
Benes et al 2004

Evaluation of forages irrigated with saline drainage water containing high Se on ruminant growth and health

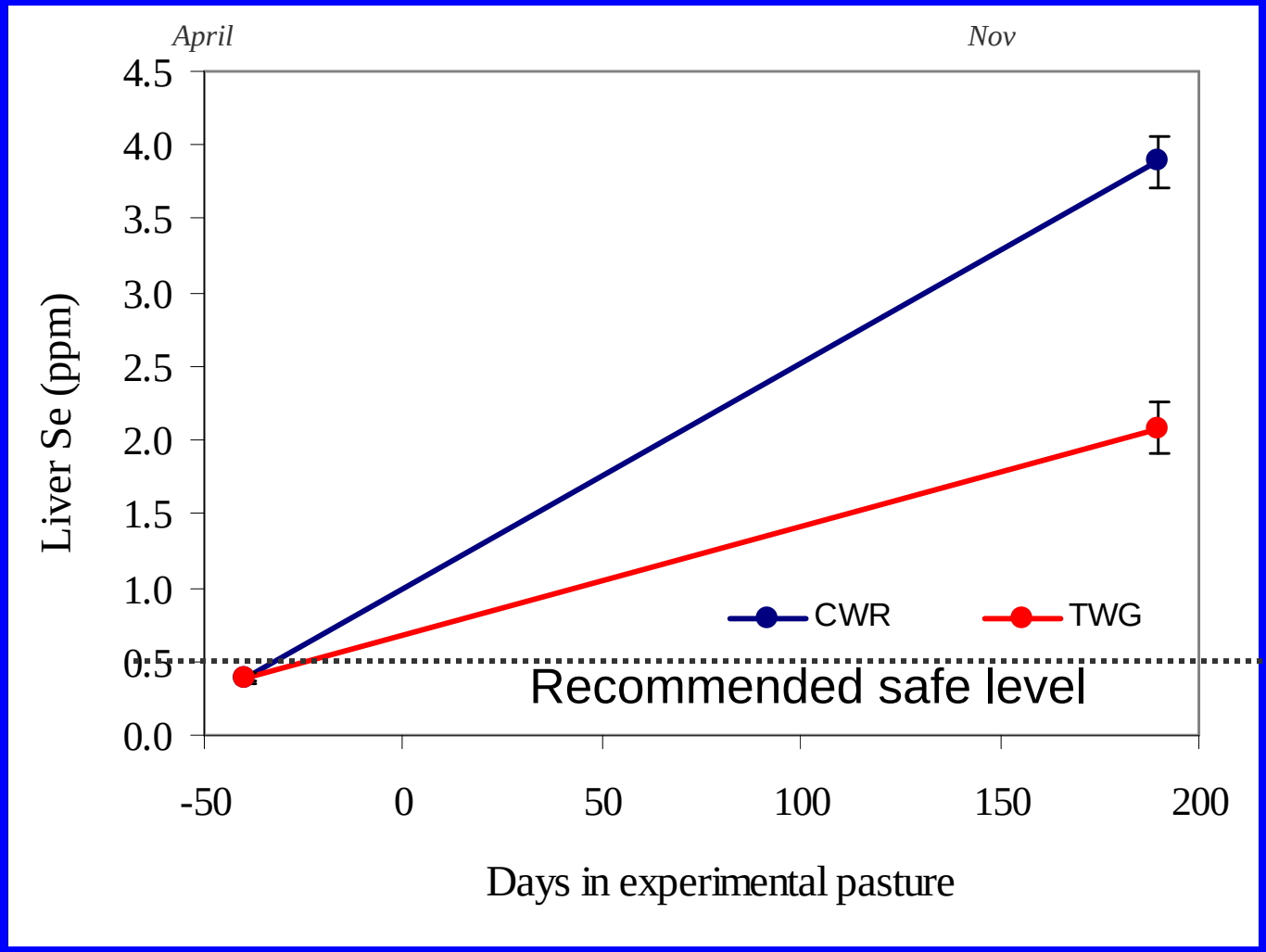
S. Benes, S. Juchem. P. Robinson, P. Chillbroste,

P. Vasquez, M. Brito, S. Grattan

Blood Selenium (mg/L)



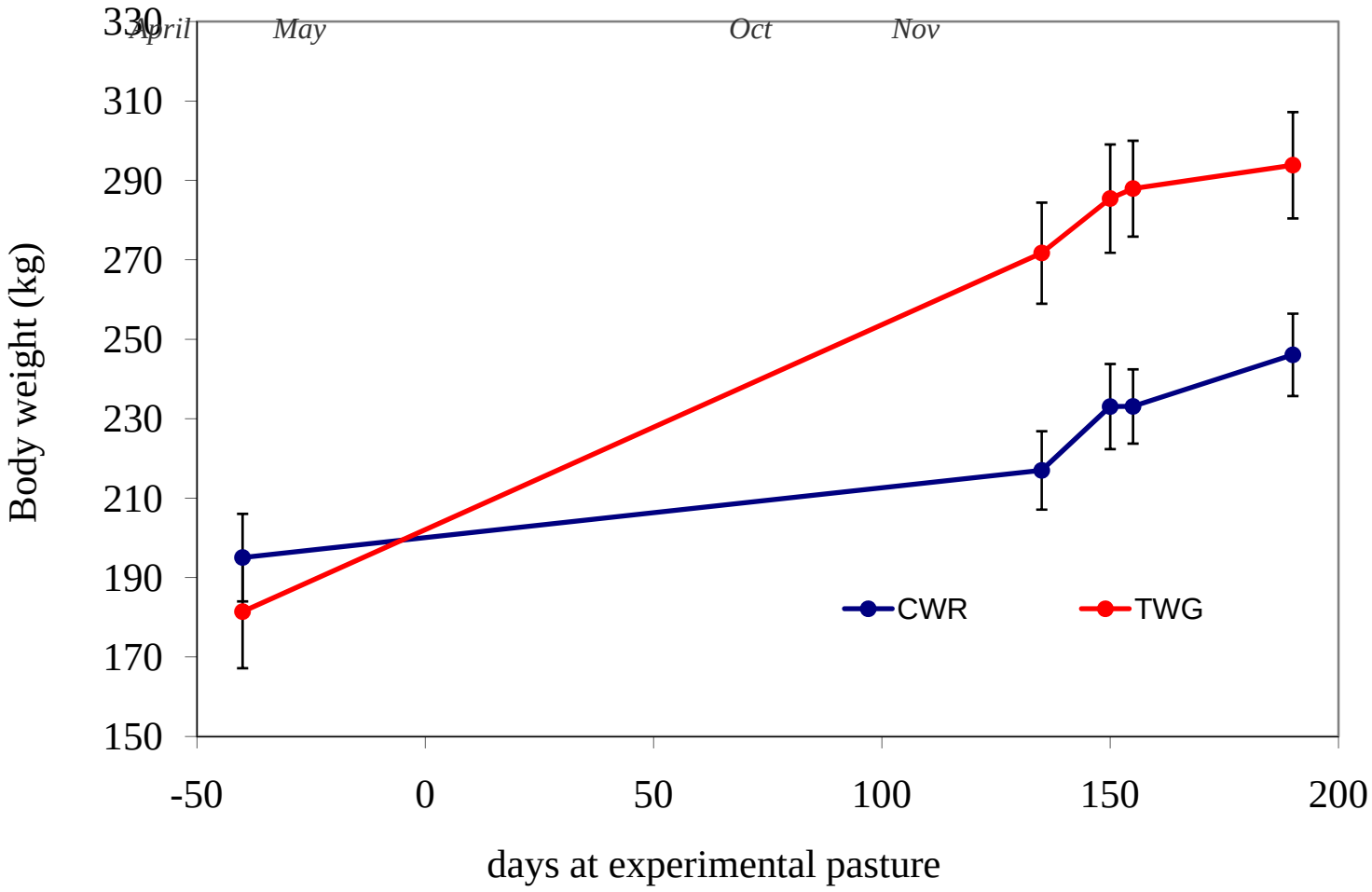
Liver Selenium (mg/kg)



Forage: P < 0.001

Forage*Time: P < 0.001

Body weight change



Assessing the Selenium Hazard for Grazing Beef Cattle

- Se in Blood, liver and muscle samples increased in heifers over the irrigation season (both 2007 ad 2008)
- Concentrations in animal tissue were above the recommended 'safe' level
- No clinical signs of Se toxicity were observed in the beef heifers in either year of grazing
- Heifers gained weight and were otherwise healthy at the end of 2007 and 2008 grazing seasons
- Uncertainties regarding reproductive effects

Benes et al., 2009

What is the potential feasibility of irrigating with high salinity well water containing high B, Se and Mo?

- Long-term use of saline water (up to 10 years) has been feasible
- Soil salinity can be readily reduced by leaching but concerns over long-term B accumulation in the soil
- Stand establishment can be reduced without proper management
- Se accumulation in crops and forages has not shown to be problematic
- High S and Mo in forages can reduce Cu availability in ruminants but high S in itself may be problematic over the long term

What is the potential feasibility of irrigating with high salinity well water containing high B, Se and Mo? (continued)

- Heifers grazing on high S and Se containing forages gained weight and showed no clinical signs of toxicity
- Some evidence that crops are more tolerant to B when irrigated with SJV drainage water