Food and Agriculture Organization of the United Nations

International Network of Salt-Affected Soils

Adverse effects of Na and Cl on plants and strategies leveraging on saline soil heterogeneity to mitigate them

Nadia Bazihizina

Università degli Studi di Firenze

GSP Webinars

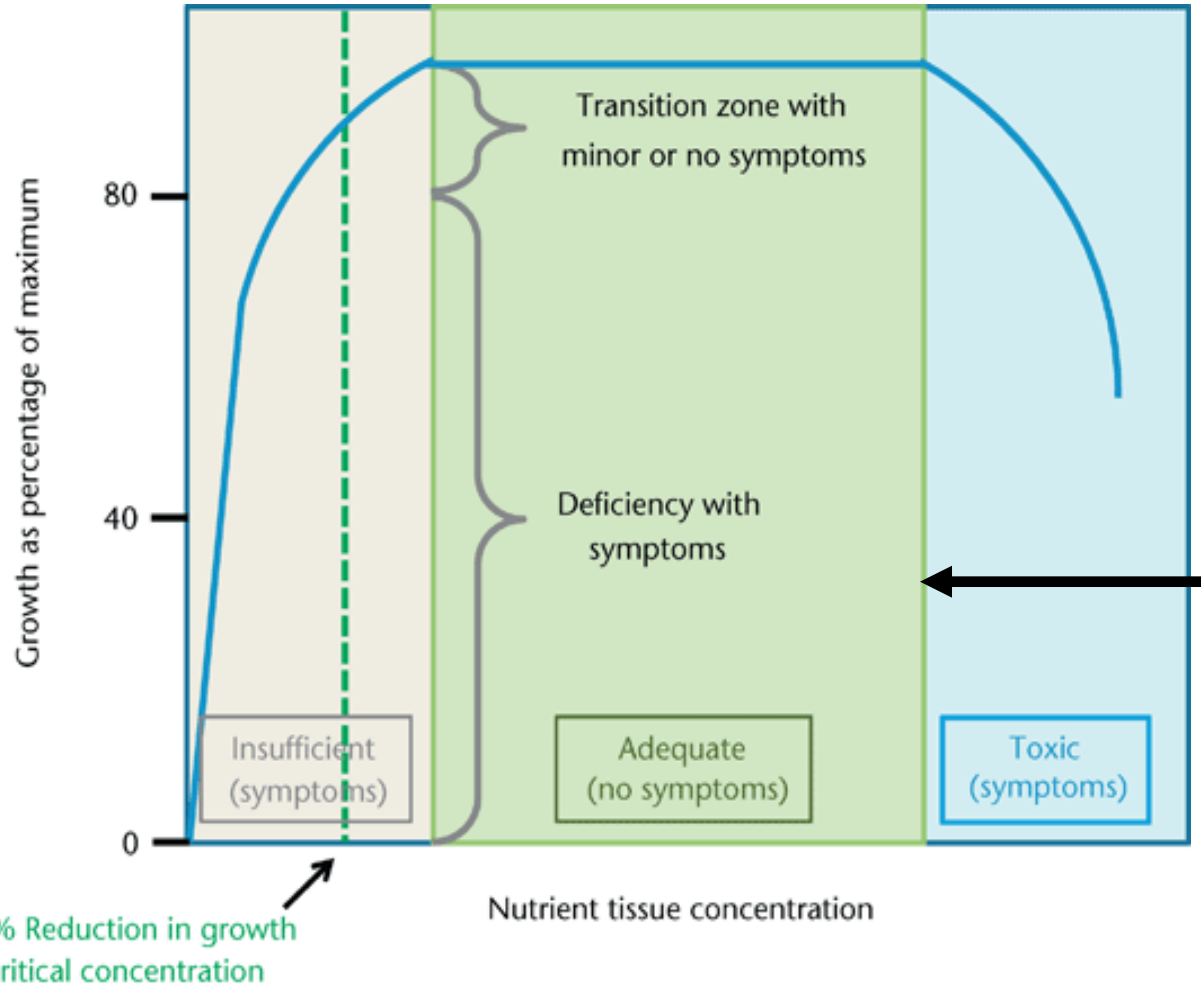
Crop nutrition in salt-affected soils, 24 April, 2024

GLOBAL SOIL PARTNERSHIP

Outline

1. Na and Cl toxicity in salt-affected plants – are all plants equally affected?
2. Na and K interactions – the importance of high K:Na ratio
3. Management options
4. Heterogeneity of saline soils and implications for crop nutrition and management

Sodium and chloride beneficial nutrients and toxicants

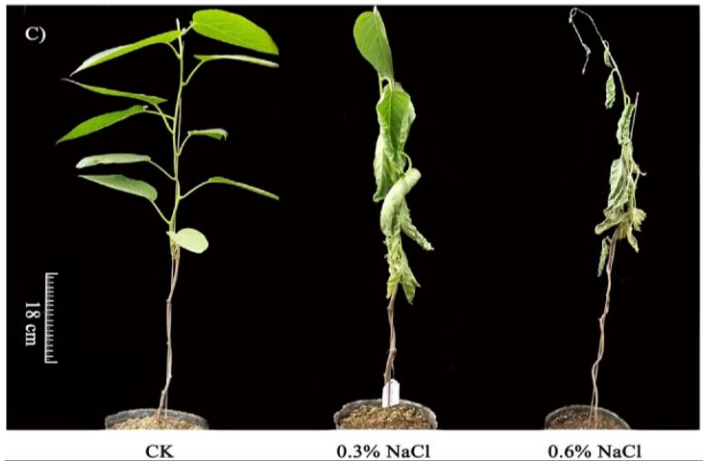


A nutrient is an element which is **essential** or **beneficial** for plant growth and development or for the quality attributes of the plant or harvested product.

This threshold will vary greatly depending on the species and cultivar

Miller 2014. DOI: (10.1002/9780470015902.a0023717)

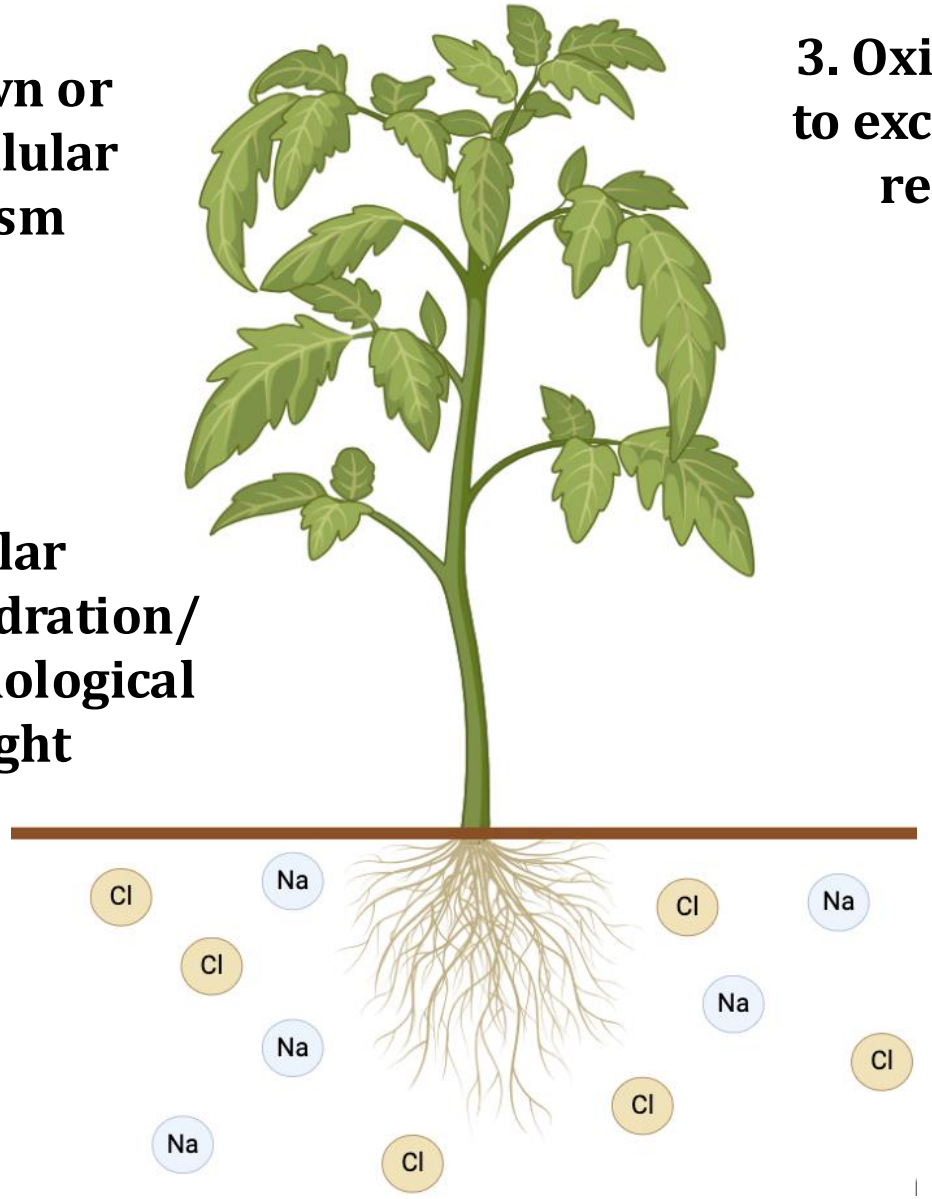
Na and Cl: why are they toxic?



2. Slow down or distrupt cellular metabolism

3. Oxidative stress due to excess generation of reactive oxygen species

1. **Cellular dehydration/ physiological drought**



Ravelombola et al. 2018 *Theor Appl Genet* ; Abid et al. 2020. *Sci Hortic*

Na and Cl are not always equally damaging

Using a combination of different Na salts and Cl salts, Na-dominant and Cl-dominant soils are produced

Table 2. The shoot dry matter, plant height, and leaf chlorophyll of two genotypes of faba bean (line 1487/7 and Nura) grown on soils treated with Na^+, Cl^-, and NaCl salts for 49 d

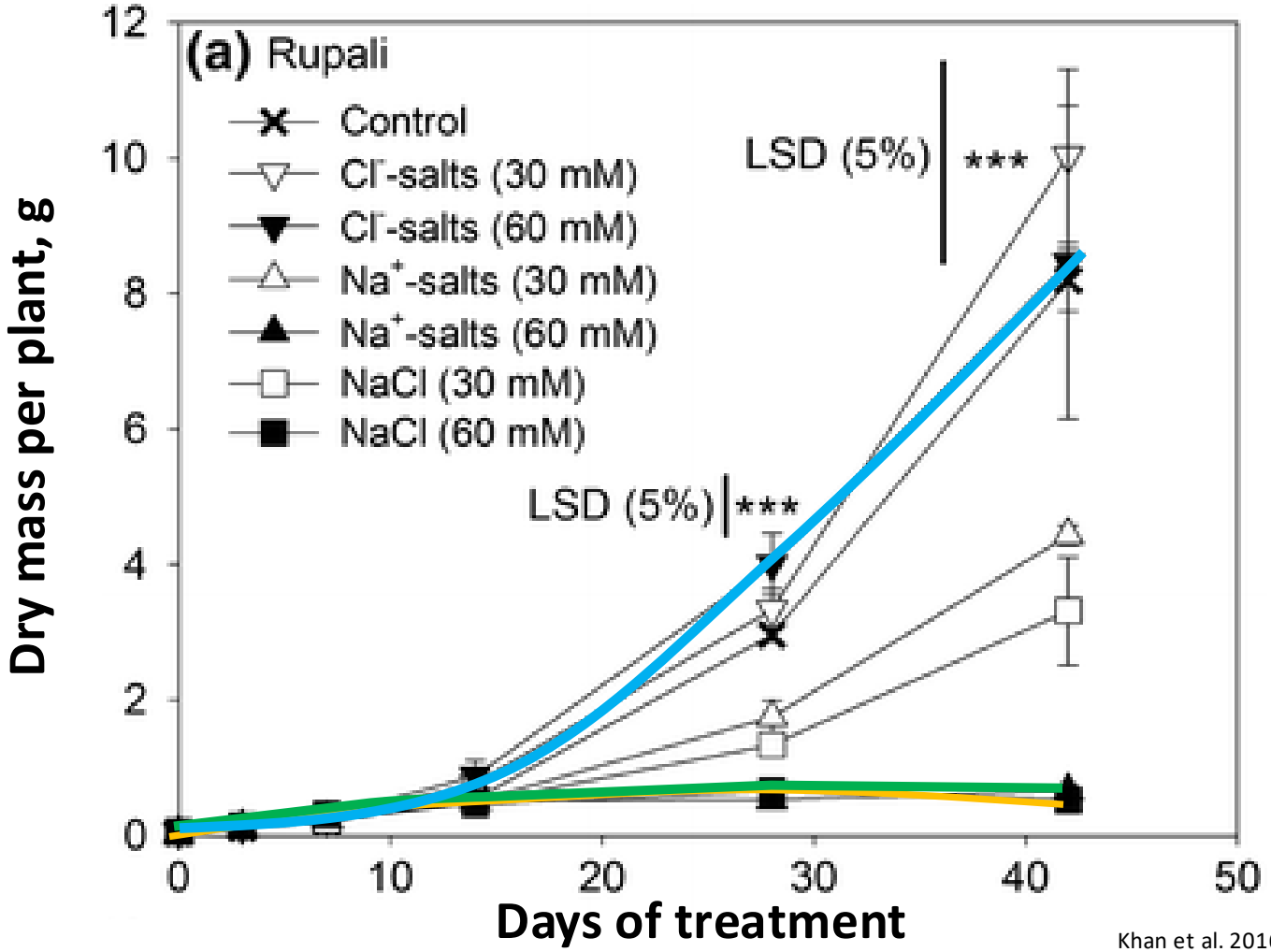
		Control	Na^+-soil	Cl^--soil	NaCl-soil
		Dry weight (g)	EC_{FC}: *approx* 9 dS m^{-1}		
T	1487/7	1.498			
S	Nura	1.608			

Tavakkoli et al. 2010. *JXB*

In fava bean, while there are additive effects, plants are more sensitive to Cl

Khan et al. 2016. *Planta*

Na and Cl are not always equally damaging

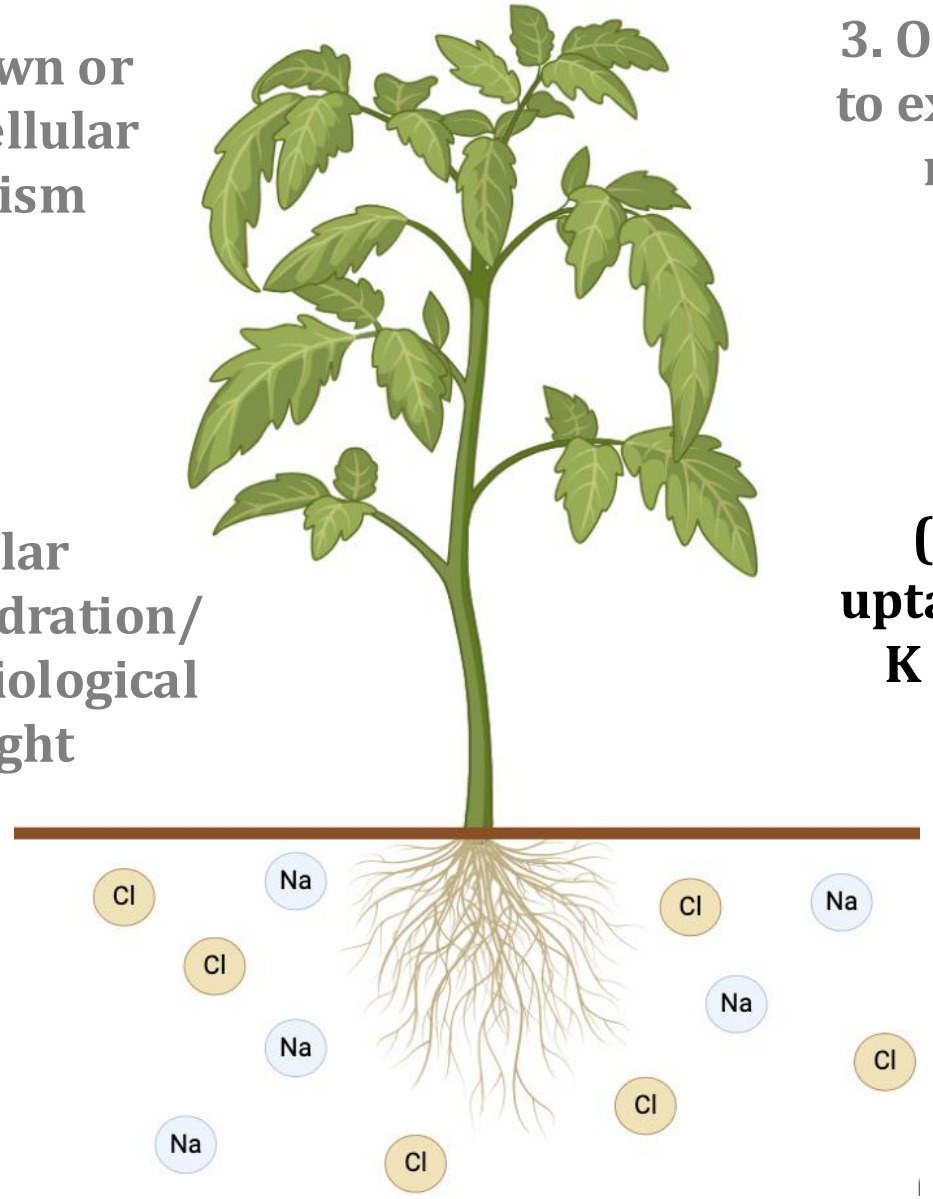


Salt sensitivity due to Na toxicity

Khan et al. 2016. *Planta*

Na and Cl: why are they toxic?

2. Slow down or distrupt cellular metabolism



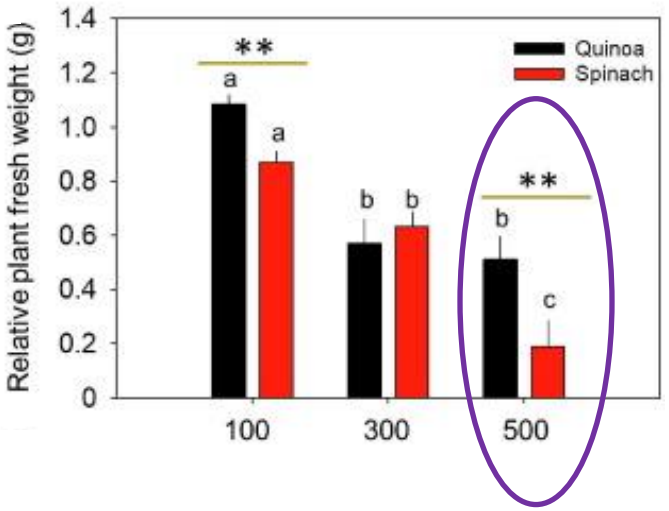
3. Oxidative stress due to excess generation of reactive oxygen species

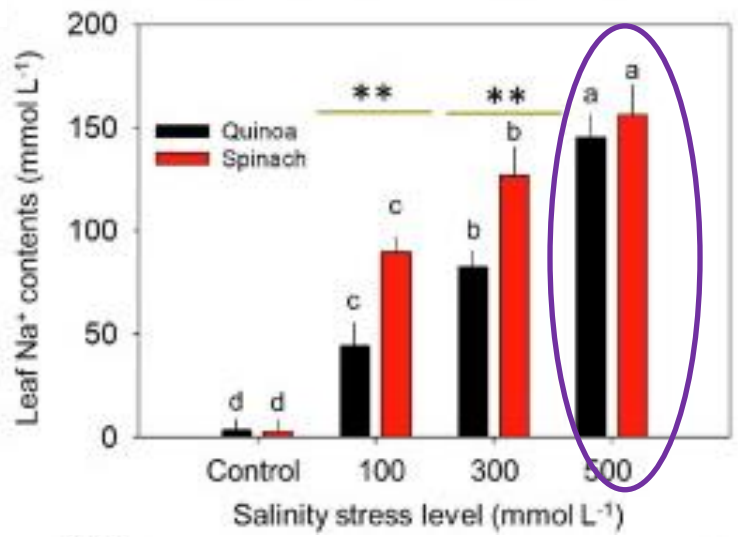
1. Cellular dehydration/ physiological drought

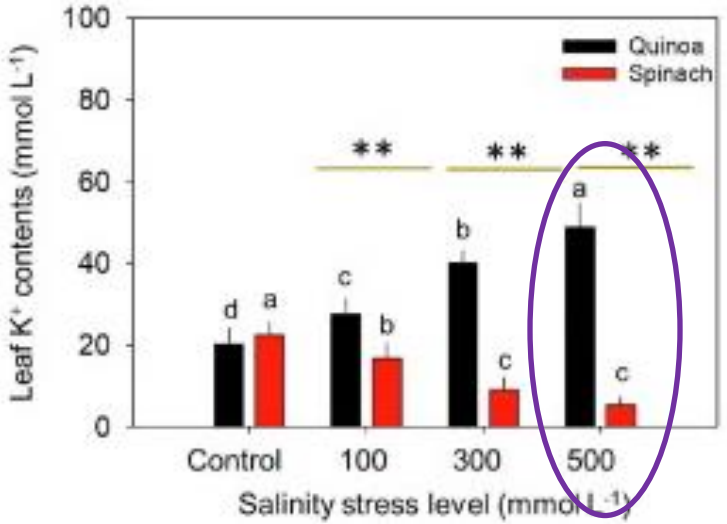
4. Nutrient deficiencies (competition for uptake and promoting K efflux from roots and leaf cells)

Ravelombola et al. 2018 *Theor Appl Genet* ; Abid et al. 2020. *Sci Hortic*

Not only Na and Cl:
the ability to mantain K homeostasis is often key for salt tolerance





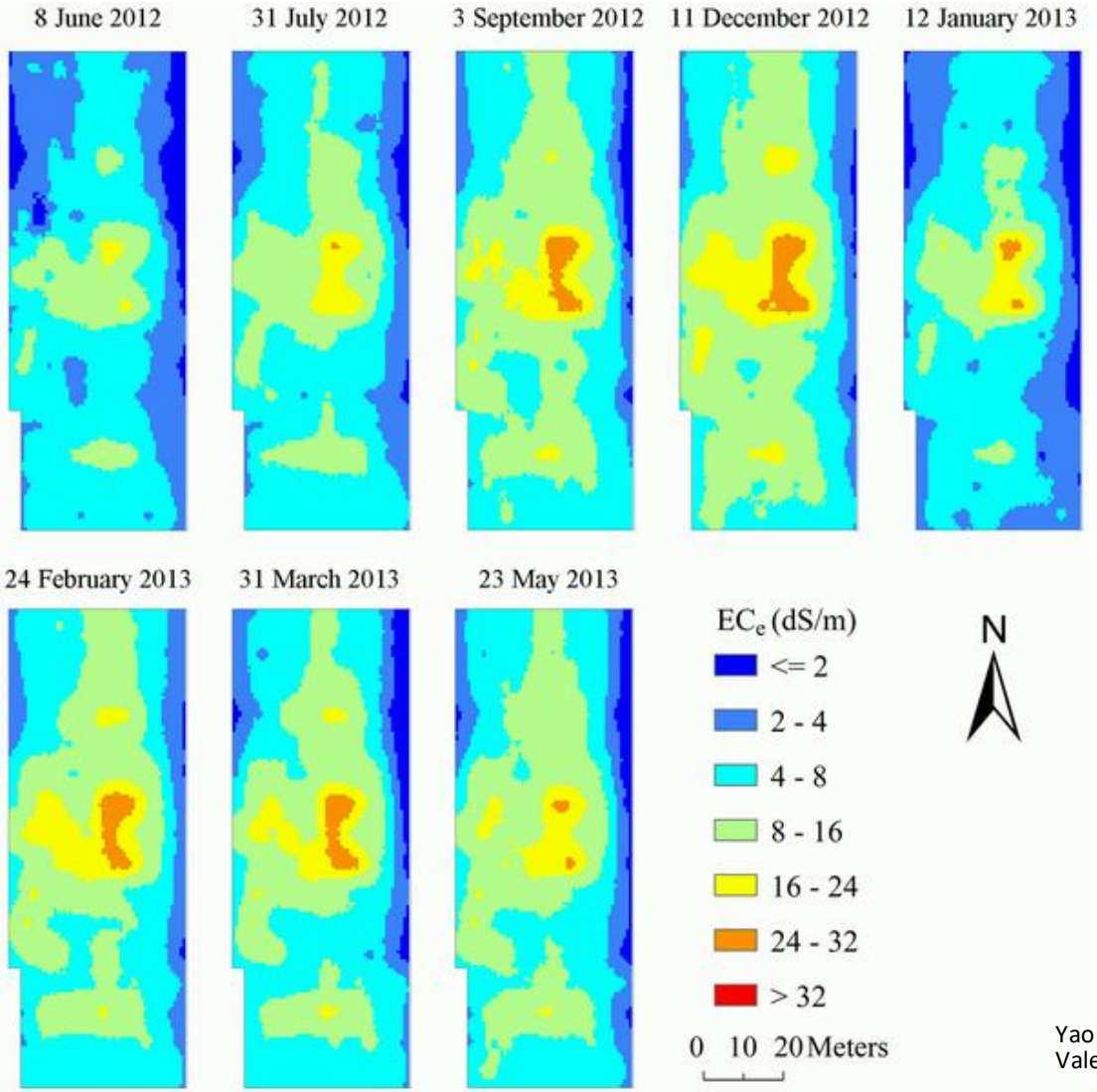


<u>Take home message:</u>
Ion homestasis is crucial for long-term salt tolerance

Tanveer et al. 2024. *The Crop Journal*

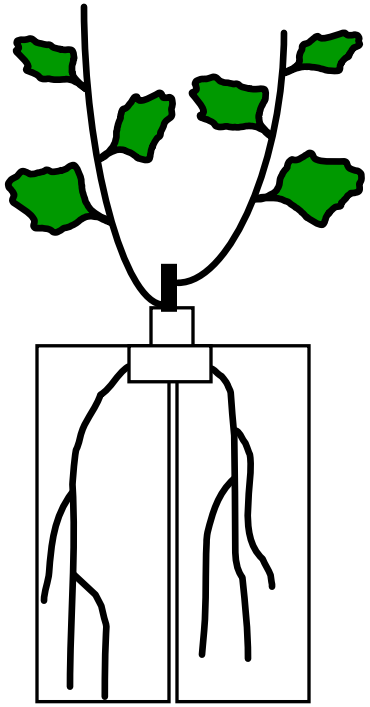
Heterogeneity is the norm in saline soil


Courtesy of Patrick Brown



Yao et al. 2016
Valenzuela et al. 2022

How do plant respond to heterogeneous salinitiies?



Low salt

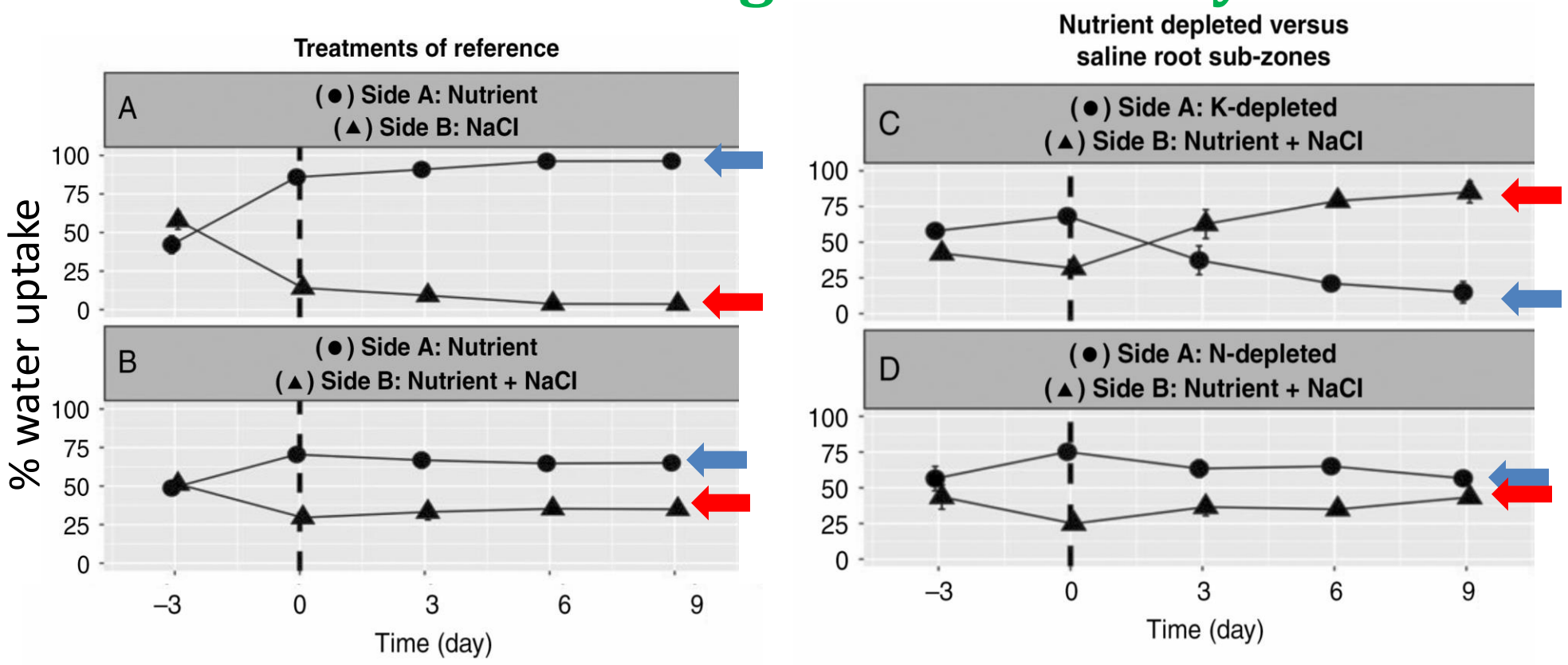
High salt

Leaf Na (mM) **500** **870** **2000**

Plants integrate the salinities in the roots

While tissue ion concentrations in roots reflect those on the external solutions, in shoots they reflect the **root or water uptake weighted-mean** salinity in roots

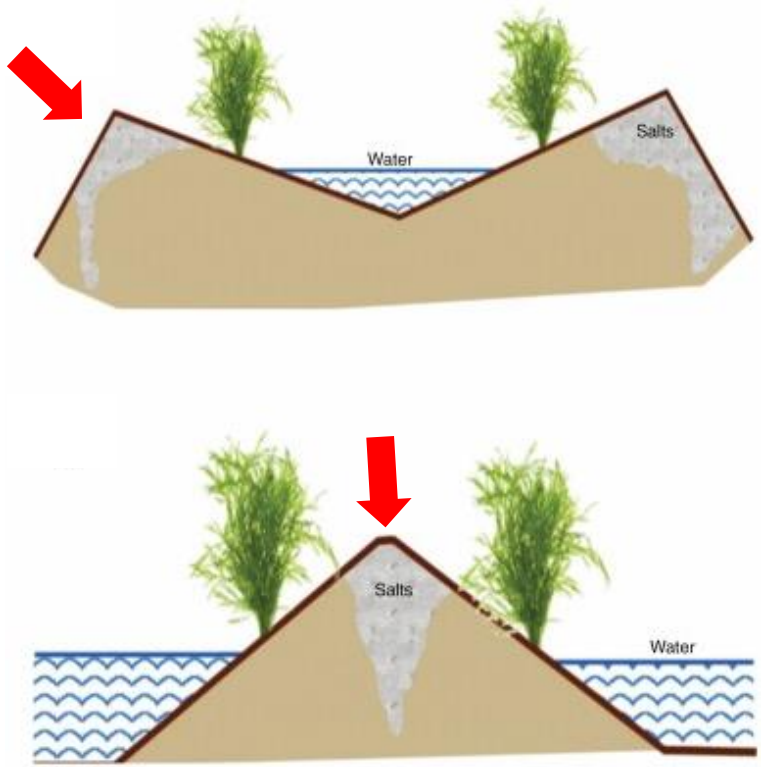
Nutrient ‘patches’ can influence response to heterogeneous salinity



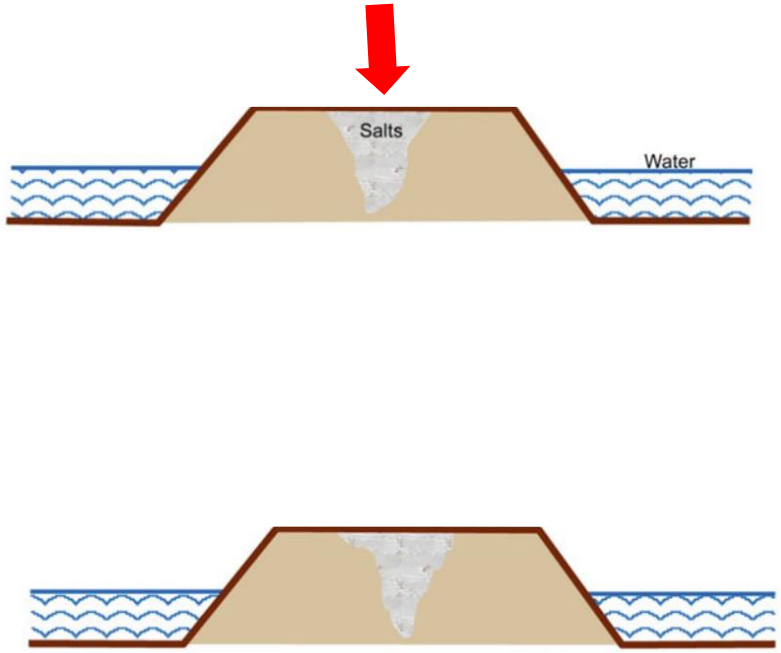
In these experiments, tomato (*Lycopersicon esculentum*) seedlings were grown in a hydroponic split-root method for 9 d under heterogeneous saline and nutritional conditions applied separately and in combination.

Valenzuela et al. 2022

Managing heterogeneity to improve plant performance

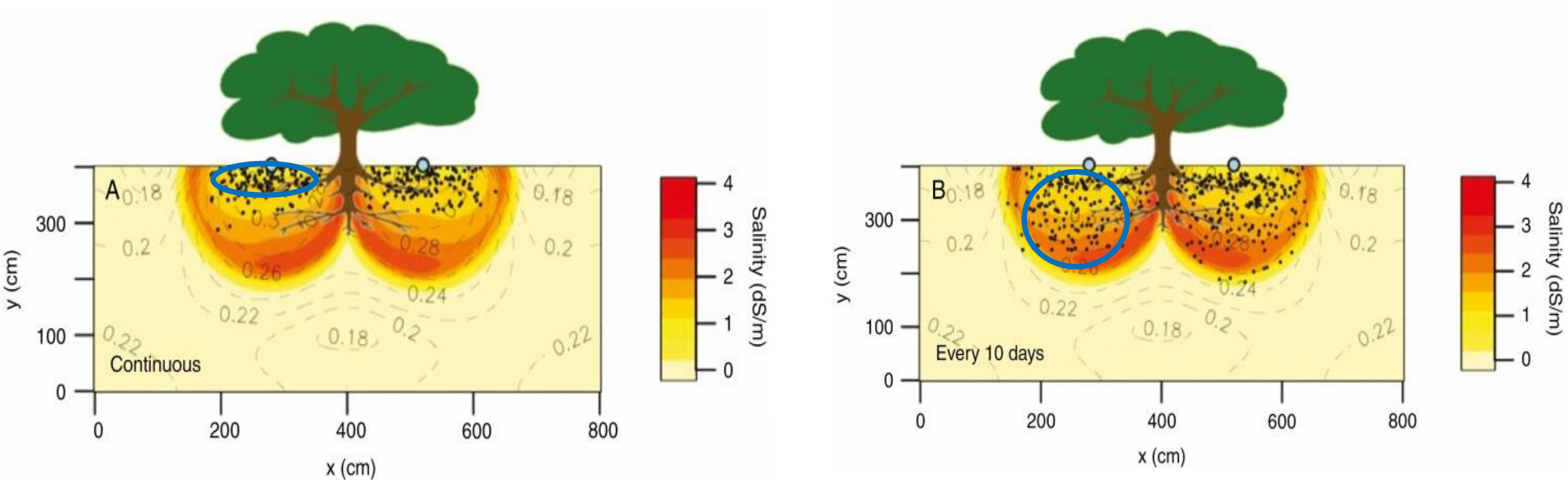


- Agronomical practices (e.g. mulching) and different irrigation systems affect this heterogeneity
- Crop placement in the right place is crucial
- Management of heterogeneity may allow sustainable crop production in saline soils



Valenzuela et al. 2022. *AOB*;
Shahid 2013 Clim Chang Outlook Adapt: Int J
Zaman et al. 2018 doi:10.1007/978-3-319-96190-3_4

Managing heterogeneity to improve plant performance



Simulated spatial distributions of salinity and nitrate following a growing season with an equal amount of nitrate applied continuously (left) and once every 10 d for 8 h (right). The density of black dots represents the concentration of nitrate in the soil

Valenzuela et al. 2022. *AOB*

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24 April, 2024

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