Over 10% of agricultural land is affected by salinization, particularly in arid and semi-arid regions

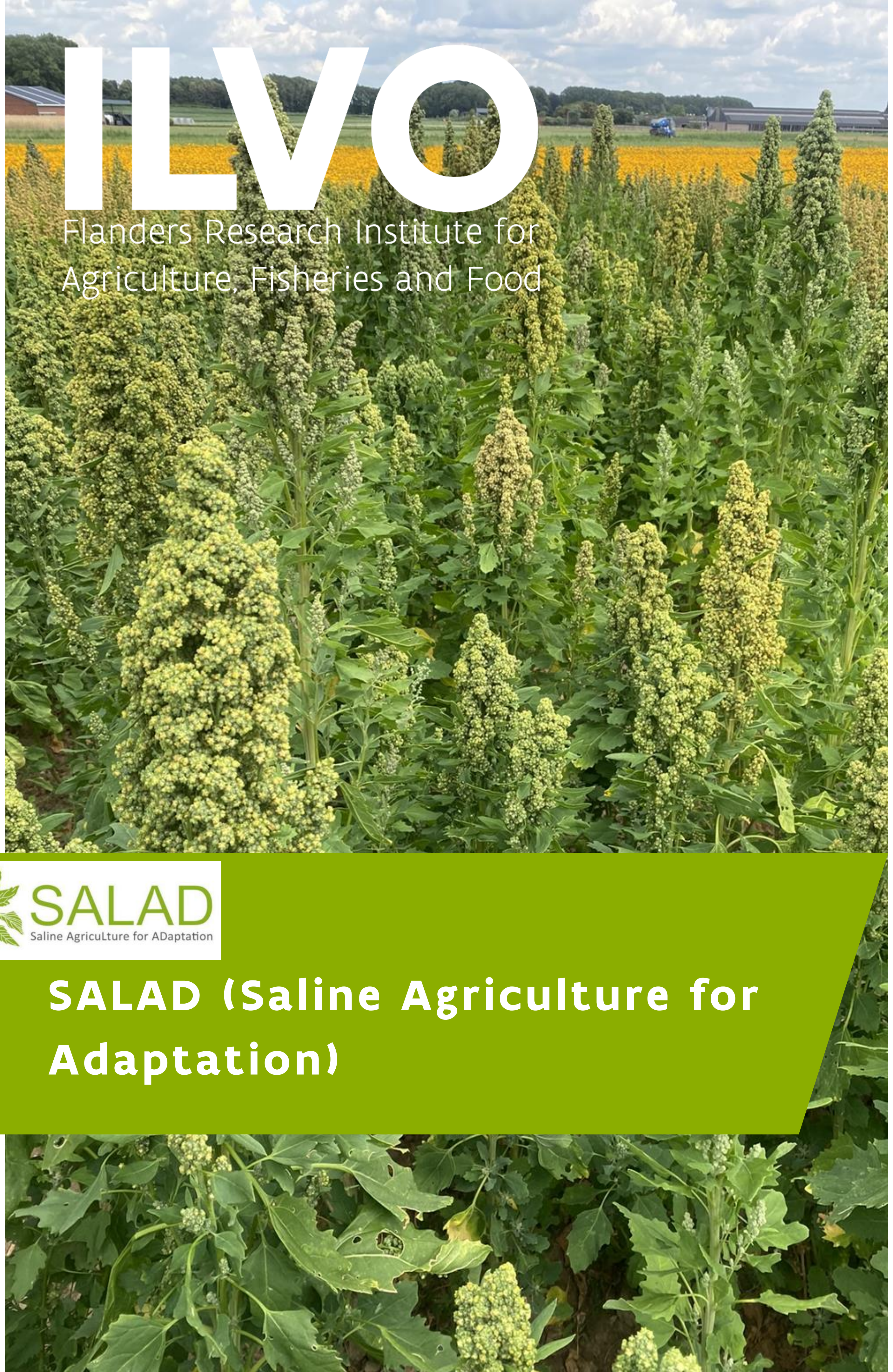
https://www.fao.org/newsroom/detail/world-soil-day-fao-highlights-threat-of-soil-salinization-to-food-security-031221/en

Improved irrigation practices

Cultivation of salt and drought tolerant crops like Quinoa

Soil management

How to tackle soil salinization in agriculture ?



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Saline AgricuLture for ADaptation

SALAD (Saline Agriculture for Adaptation)

Modeling quinoa growth under salinity and drought stress

Diana Estrella, Tom De Swaef, Jan Vanderborght, Sarah Garré

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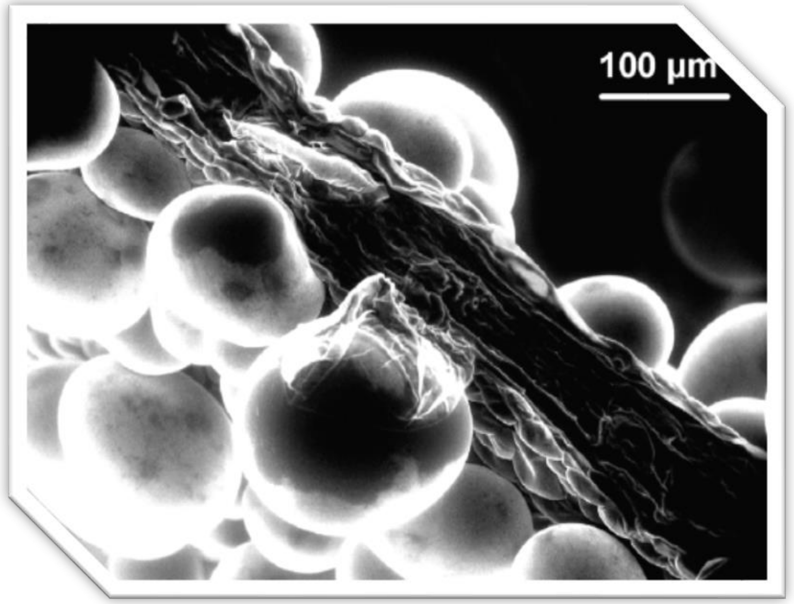
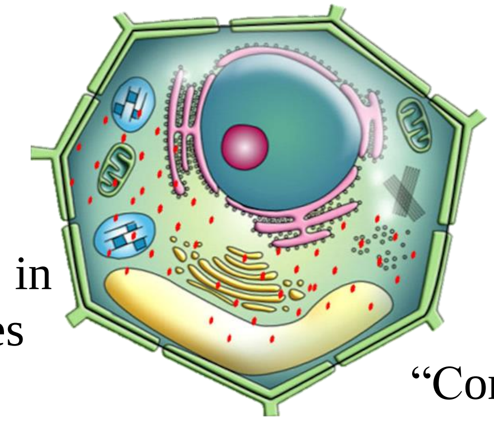
Quinoa is a promising crop to cope with soil salinization

“Salt glands” on leaf surface



https://doi.org/10.1016/j.envexpbot.2012.07.004

Osmotic adjustment



Na^+, K^+ and Cl^-, in leaf cell vacuoles

“Compatible solutes” such as proline and sugars in the cytosol and organelles

Reduction of transpiration by closing the stomata

Activation of antioxidants

Salt inclusion or exclusion

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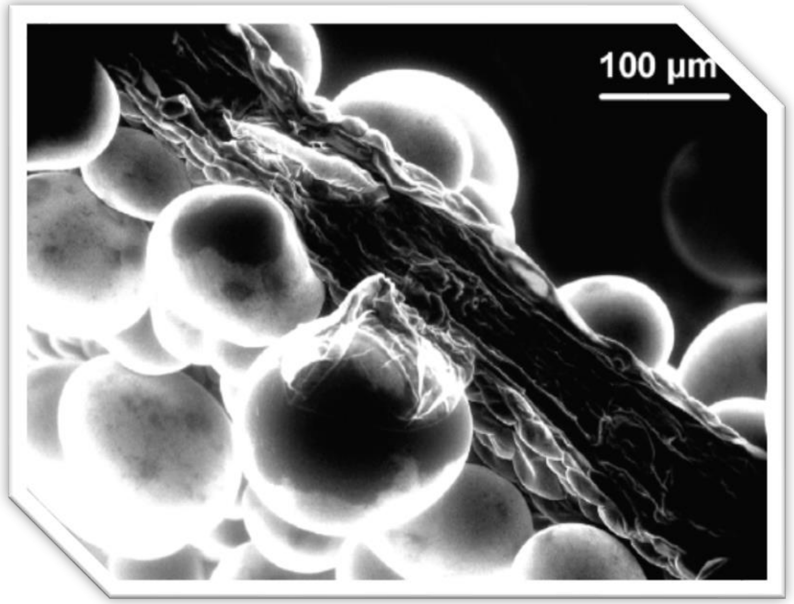
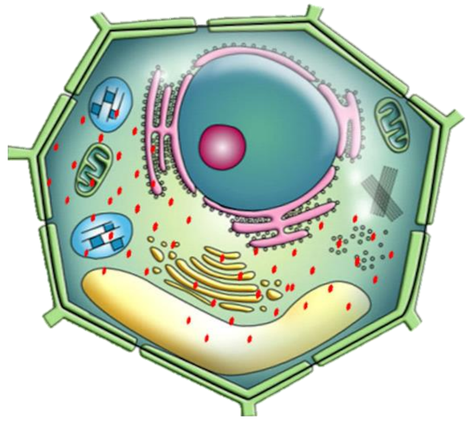
“Salt glands” on leaf surface



How to represent these mechanisms in crop models?

Osmotic adjustment



Reduction of transpiration by closing the stomata

Activation of antioxidants

Salt inclusion or exclusion

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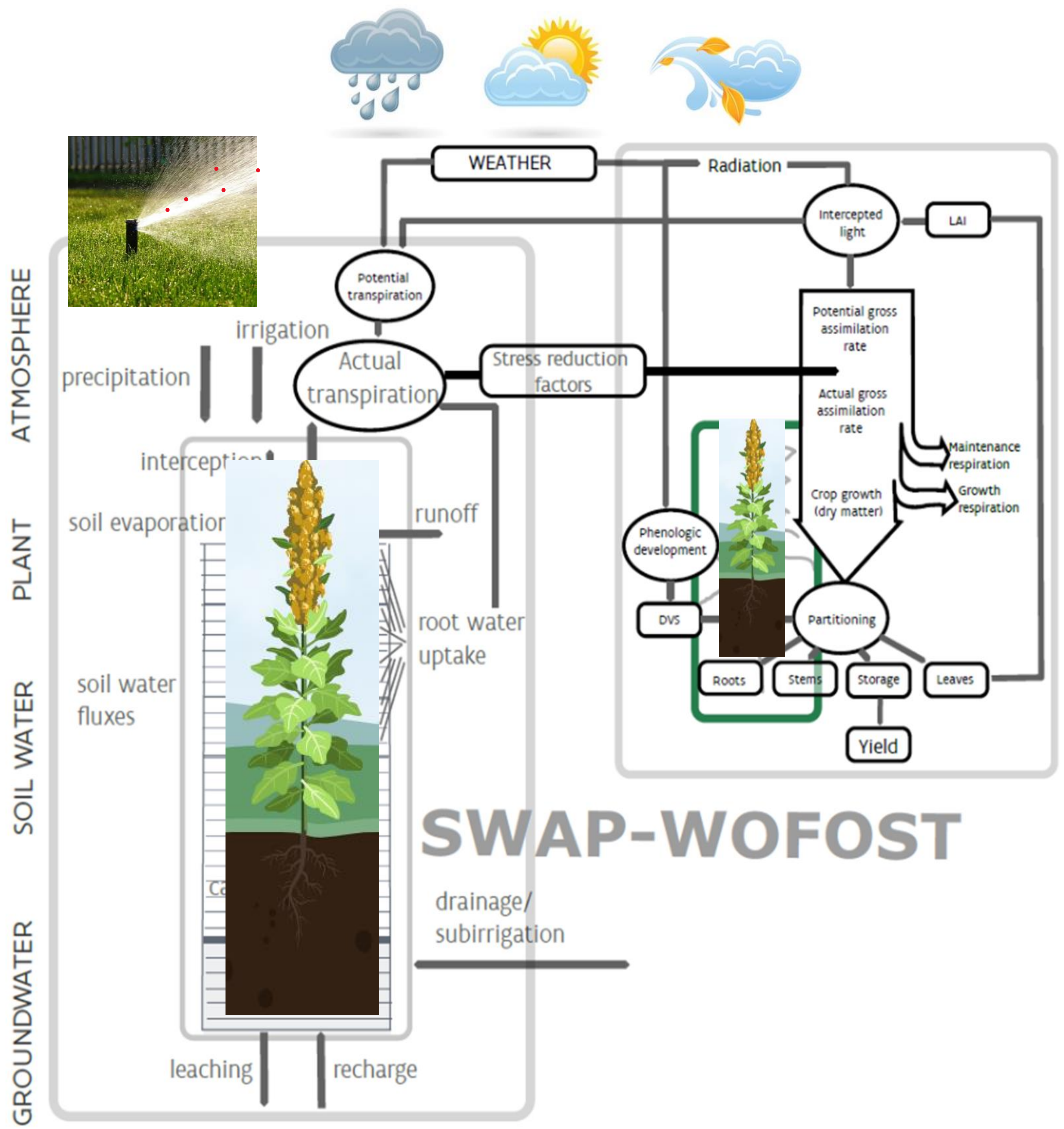
stress -> root water uptake -> transpiration -> yield

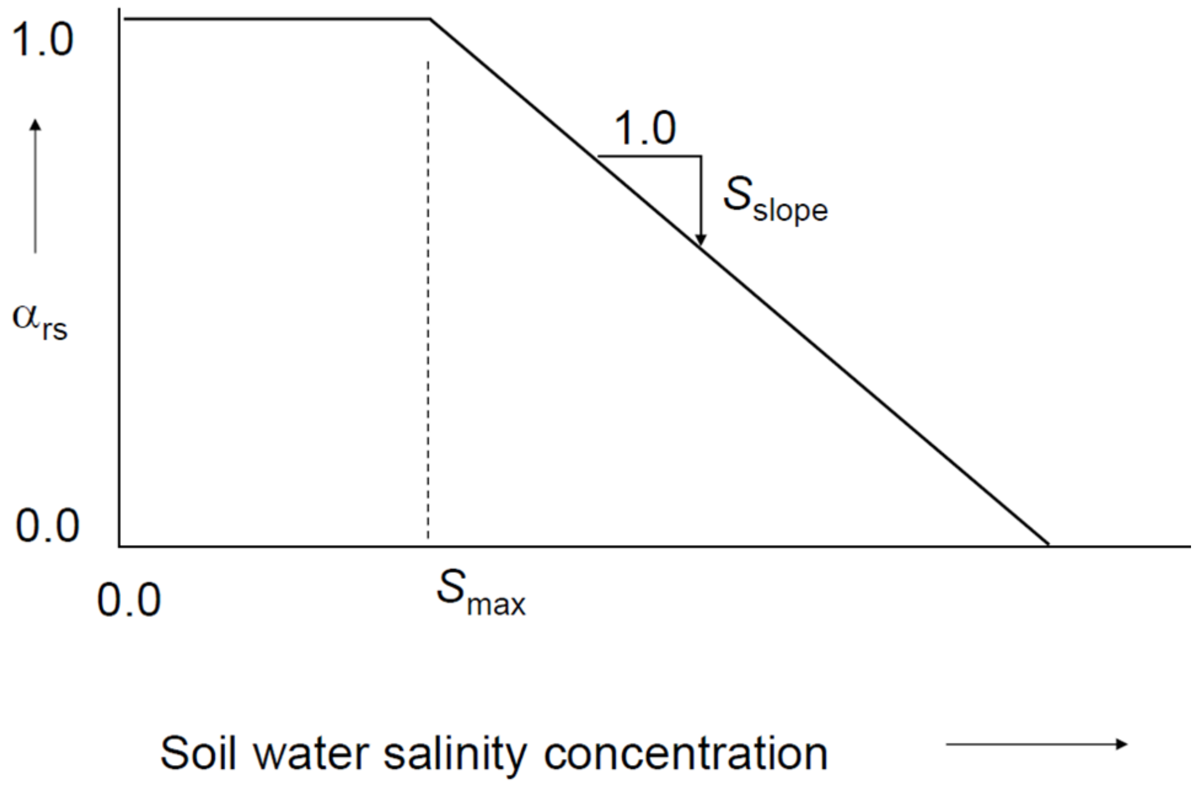
Drought stress

Feddes et al. (1978)



Salinity stress

Maas and Hoffman 1977



$$\alpha_{rs} = \begin{cases} 1 & c \leq S_{max} \\ 1 - S_{slope}(c - S_{max}) & c > S_{max} \end{cases}$$

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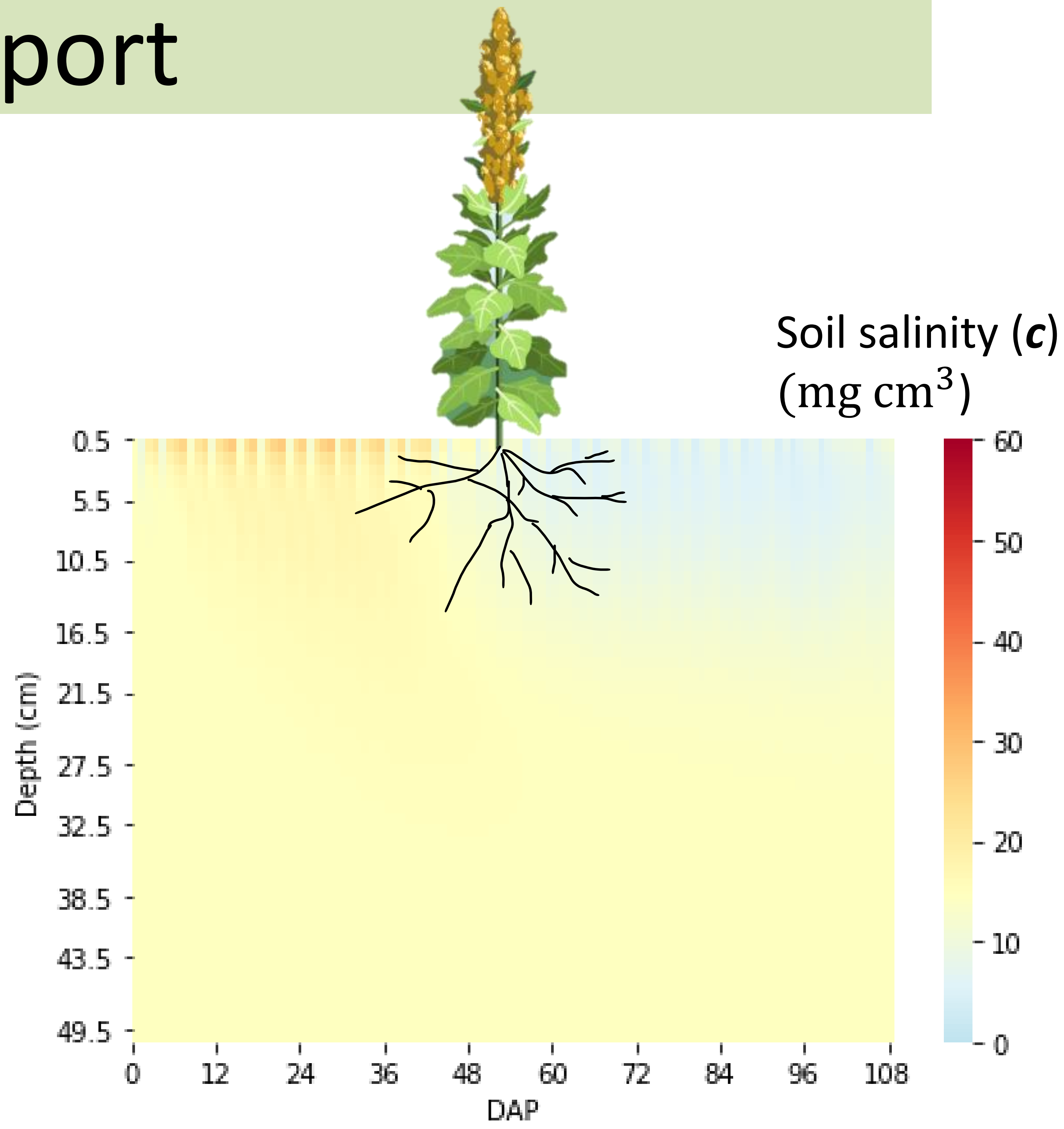
Solute transport

$$\frac{\partial(\theta c)}{\partial t} = -\frac{\partial(qc)}{\partial z} + \frac{\partial\left[\theta(D_{dis})\frac{\partial c}{\partial z}\right]}{\partial z} - K_r S_a c$$

Convection flux   Dispersion flux   Root uptake

$\boldsymbol{K_r}$ represents the preference of the plant for taking up solute ions relative to the amount of water extracted from the soil

$\boldsymbol{S_a}$ is the actual root water uptake, under stressed conditions



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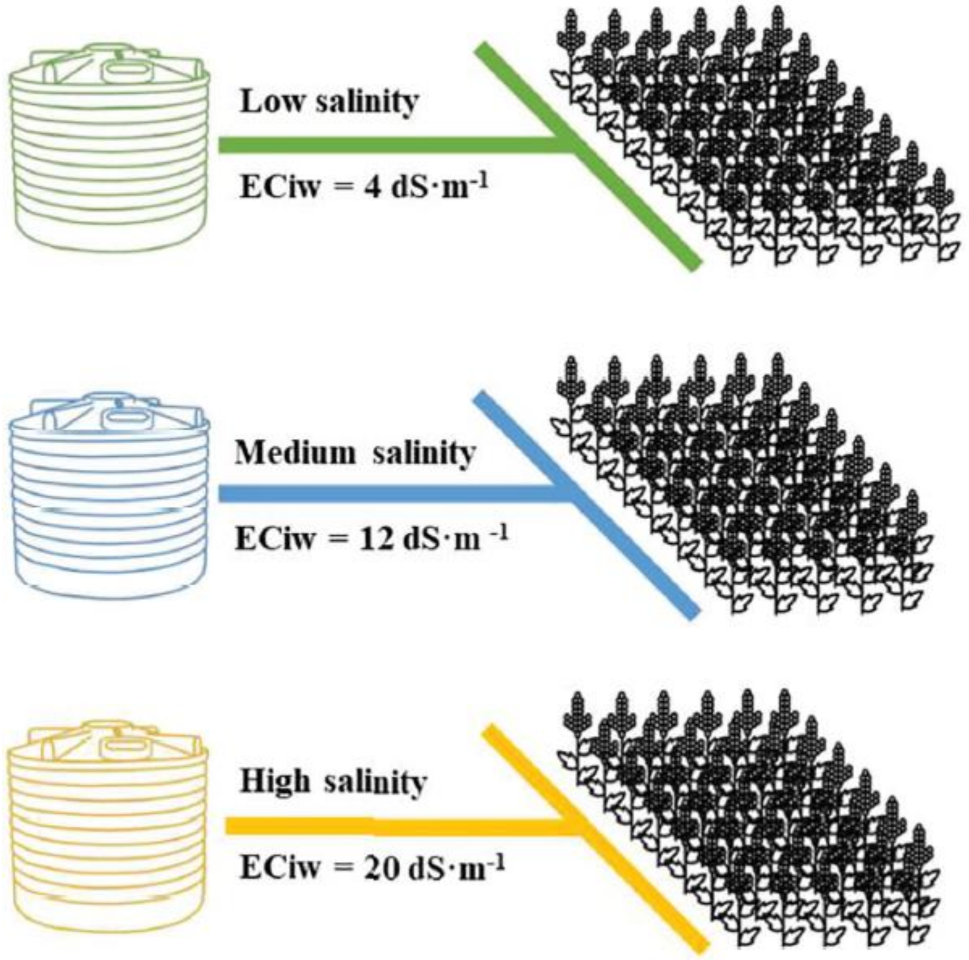
Field experimental data: Laayoune, 2021

- Irrigation with three salinity levels: 4, 12 and 20 dS/m, 240 mm in total



- Variety ICBA-Q5
- Sandy loam soil

https://doi.org/10.3389/fpls.2023.1143170

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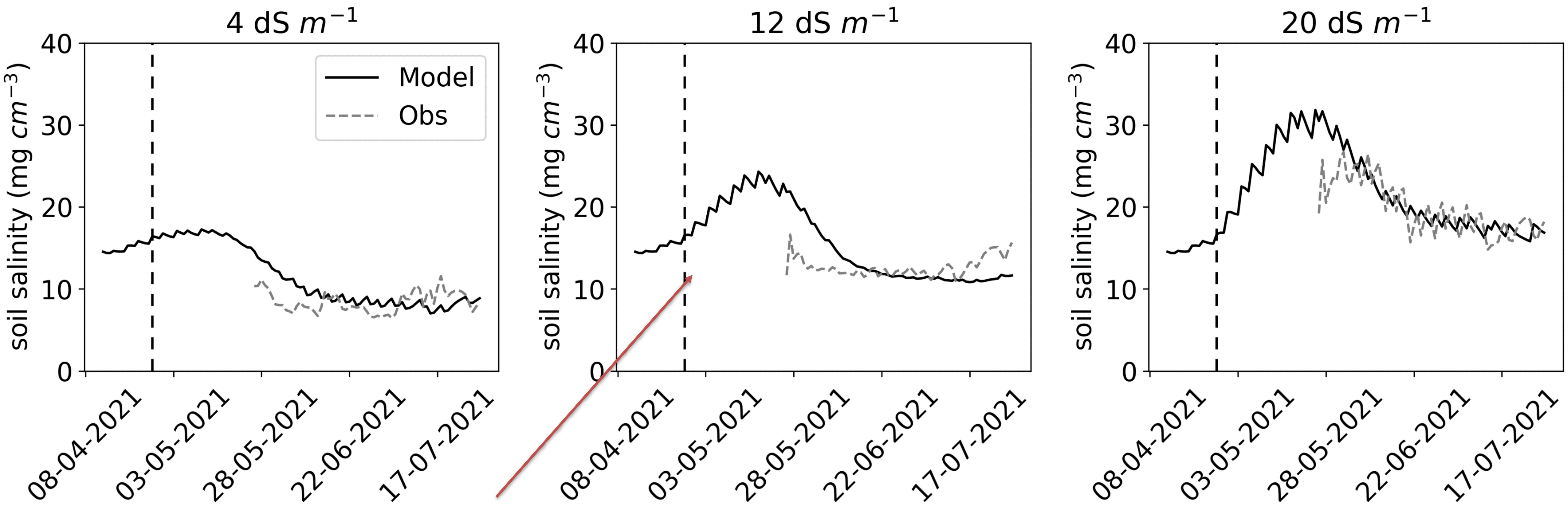
Quinoa actively takes up solutes



Start of irrigation with saline water

$$\frac{\partial(\theta c)}{\partial t} = -\frac{\partial(qc)}{\partial z} + \frac{\partial\left[\theta(D_{dis})\frac{\partial c}{\partial z}\right]}{\partial z} - K_r S_a c$$

K_r= 1.64

S_{slope}= 0.0103

S_{max}=5.1 mg cm^3

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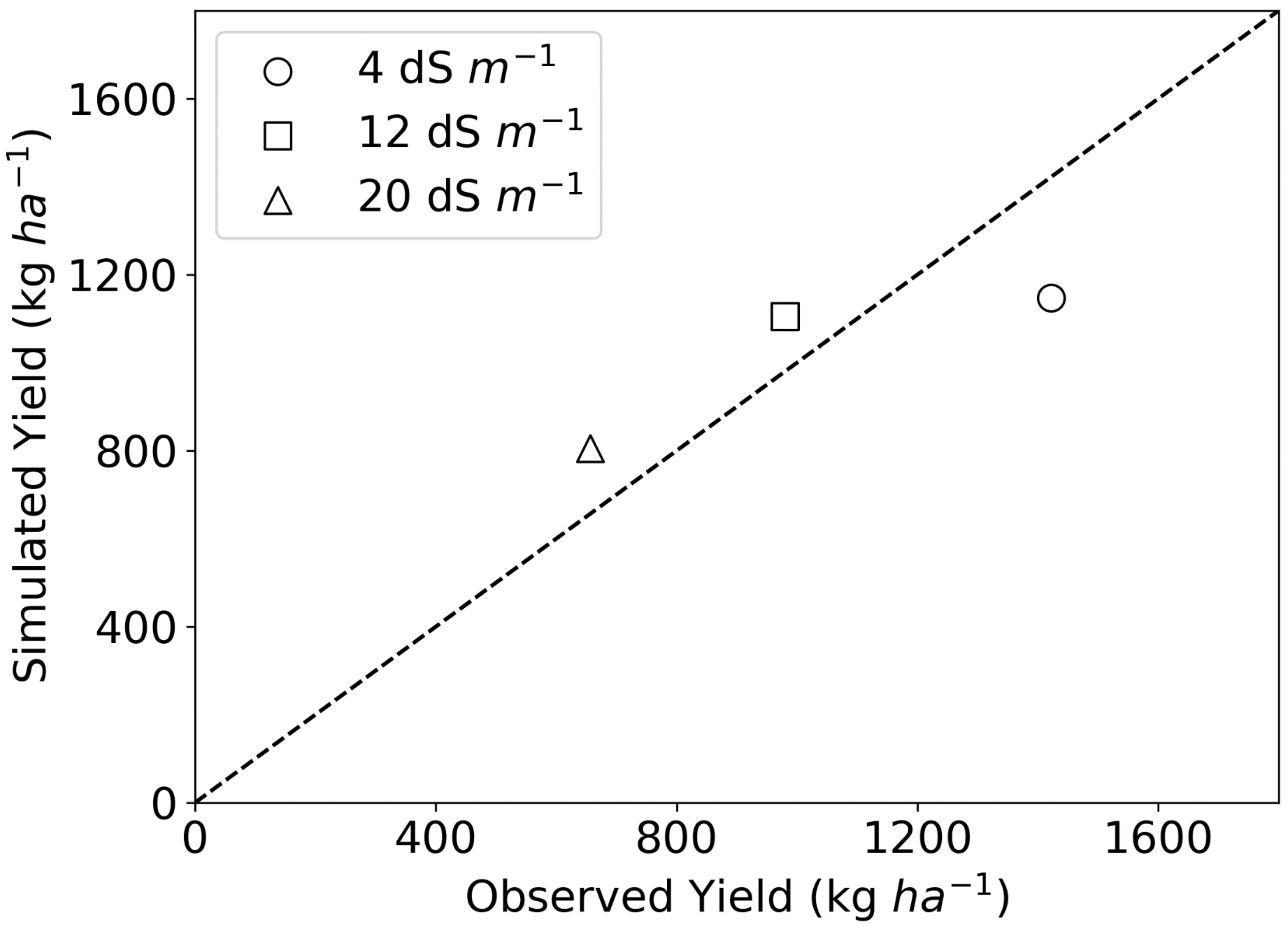
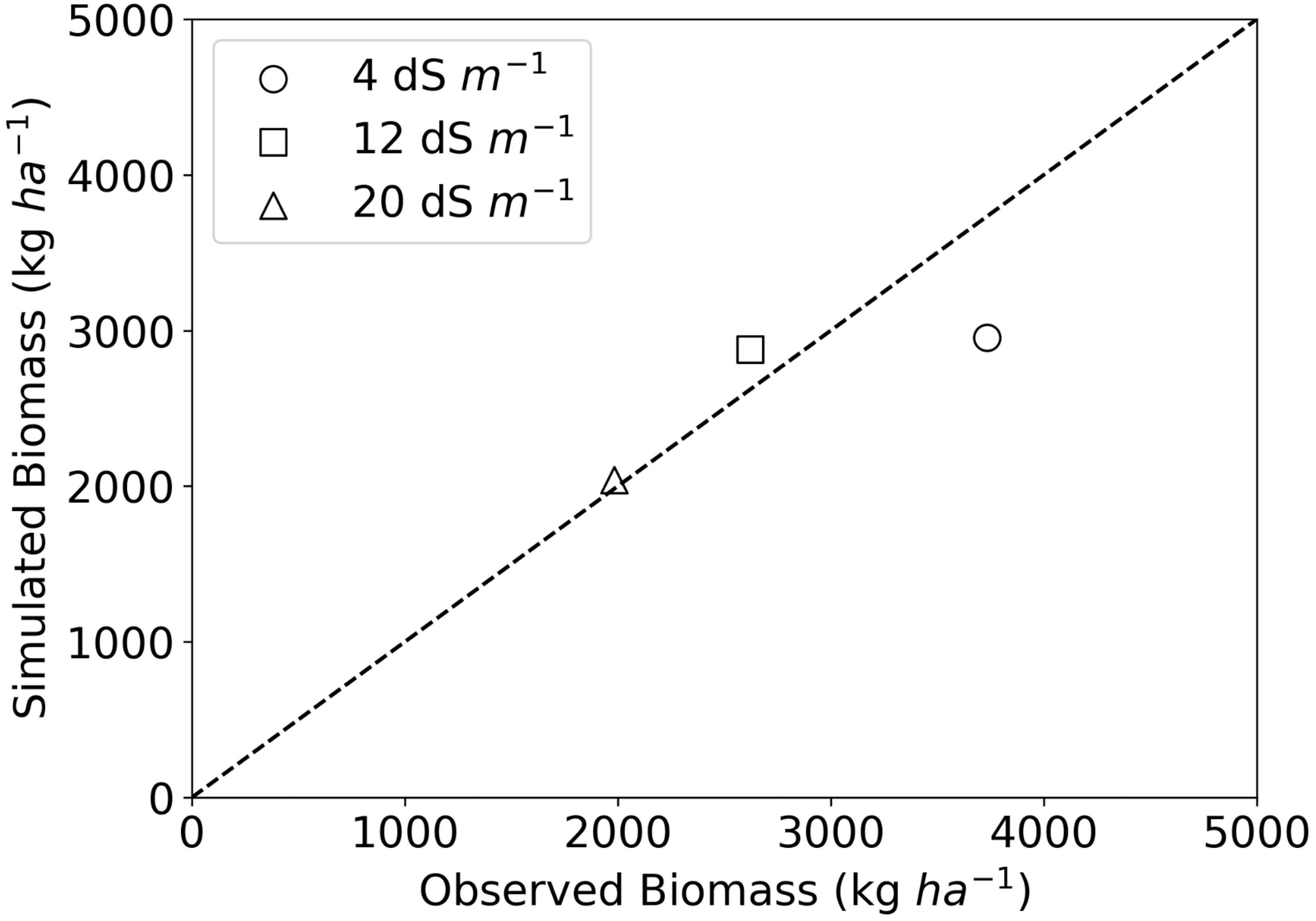
Effect of salinity on yield and biomass





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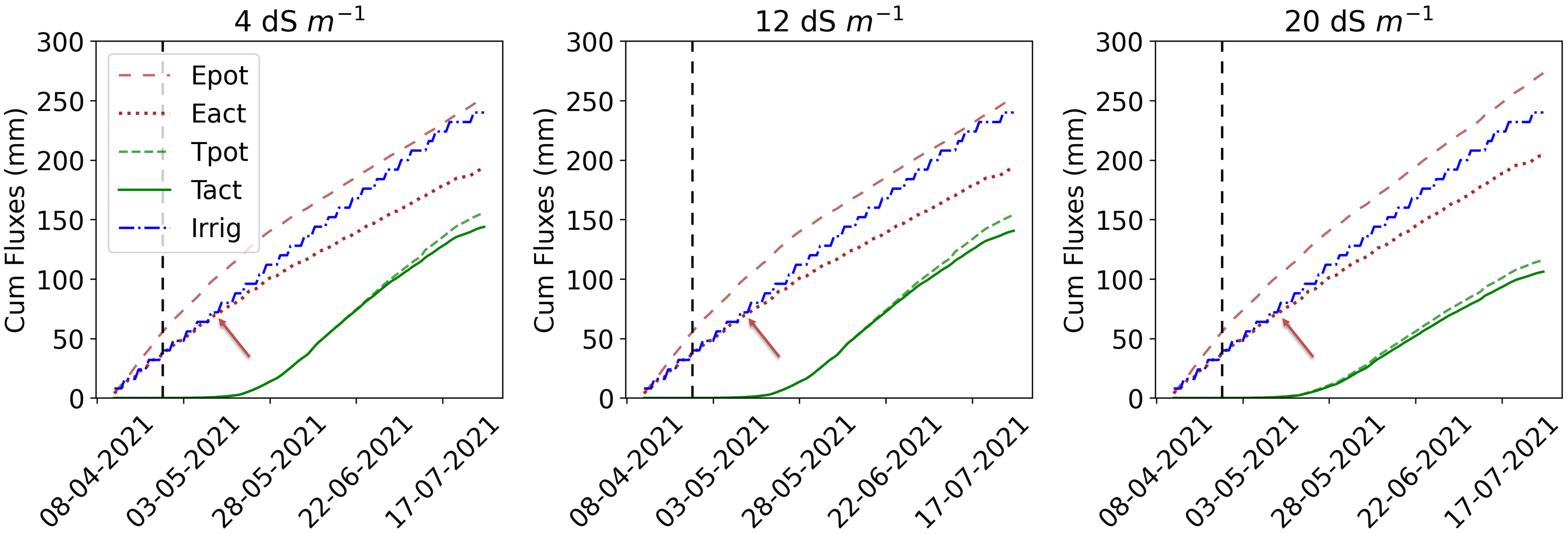
High evaporation at early stages increase salt accumulation



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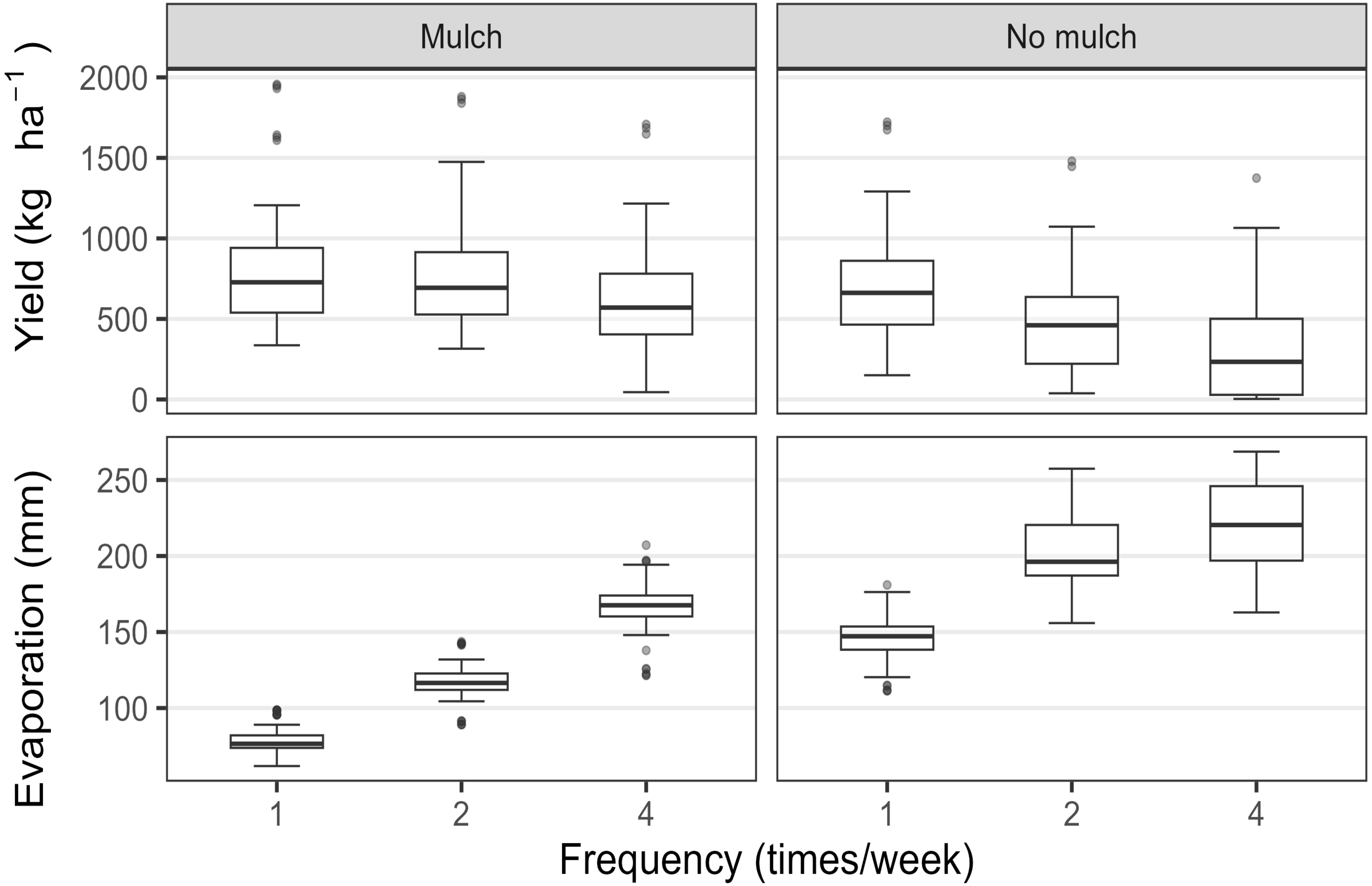
Management scenarios to improve quinoa productivity in Laayoune

12 dS/m and 240 mm of irrigation



Lower **irrigation frequency** and **mulch** significantly decrease soil evaporation and improve yield.

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Conclusions

- Salinity stress function can partly represent quinoa's stress tolerance mechanisms.
- Saline water overirrigation and high evaporation in early stages increase salinity stress
- Reducing irrigation and/or mulching can potentially decrease excessive soil evaporation and improve yield.

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Scientific publications:

Modeling quinoa growth under salinity and drought stress across different climatic conditions using SWAP-WOFOST (under review) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4937117

Crop modelling as a tool to explore management scenarios for alleviation of salt stress during quinoa growth in Laayoune, Morocco (in progress)