Food and Agriculture Organization of the United Nations

Salt-affected soils: threats and potentials

Joint meeting of INSAS and SUSTAIN

International Network of Salt-Affected Soils

Funded by the European Union

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SUSTAIN Sustainable use of salt-affected lands

VNIVERSITAT DE VALÈNCIA

International Union of Soil Sciences

Valencia, Spain
May 27-31, 2024

GLOBAL SOIL PARTNERSHIP

Salinity shapes *Salicornia europaea* L. functional traits

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This research was funded by the Polish National Science Center project No. 2021/43/D/NZ8/01137

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Introduction

- Increasing interest in *Salicornia europaea* is due to its extreme salt tolerance and growth in marginal saline soils.

- It has potential economic value because it can be used as food, forage, or biofuel and has potential in pharmaceuticals and cosmetics (Cárdenas-Pérez et al. 2021).

- The variation in *S. europaea* functional traits in response to environmental conditions still needs to be studied.

- Plant functional traits are all traits related to morphology, physiology, or phenology, which can be measured in a single individual from the cell to the whole organism level (Violle et al. 2007). They reflect plant life strategies and determine how plants respond to environmental conditions.

Aim and hypothesis

- To fill the gap in the knowledge, we focused on addressing how *S. europaea* traits coming from different scales are controlled by salinity level.

- We hypothesised that:

(a) salinity affects plant morphological, anatomical, and physiological responses in different ways,

(b) plant trait responses can indicate optimum growth in the salinity gradient.

Materials and methods

POT EXPERIMENT

- *S. europaea* seeds were collected from the "Ciechocinek" halophyte reserve located in north-central Poland (52,530 N, 18,470 E) based on the permit WOP.640.12.2020.JC

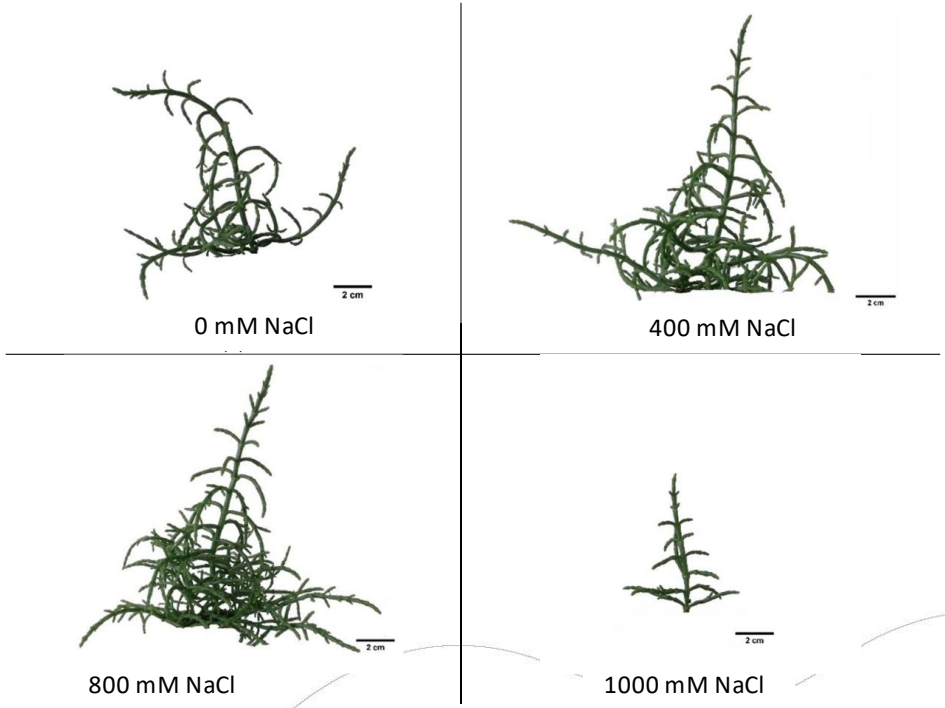
- *S. europaea* germinated seedlings were planted in substrate saturated to the total capacity of 0, 200, 400, 800, and **1000** mM NaCl solution (ca. 0.5 l per treatment, 1:1 sand to vermiculite, pot size: height 5.3 cm, diameter 5.5 cm).

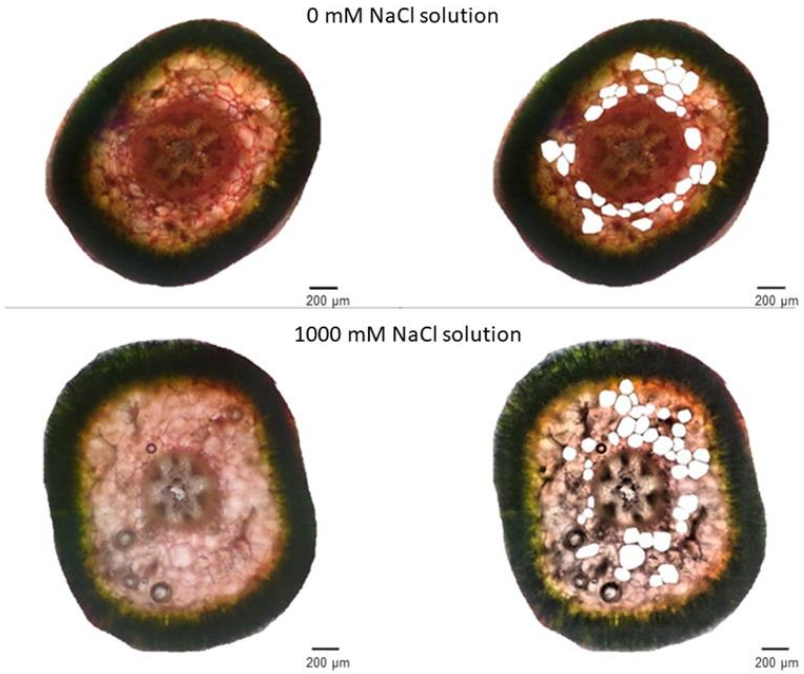
- Plants were grown for 60 days in a growth chamber (22 °C and a 16 h light period) and irrigated by dist. H_2O and Hoagland's solution once a week and once every two weeks respectively.

Materials and methods

MORPHOLOGICAL AND ANATOMICAL TRAITS ASSESSMENT

- To assess morphological and anatomical traits, we used a novel image analysis method - ImageJ program version 1.47 (National Institutes of Health, Bethesda, MD, USA).





Materials and methods

GROWTH PERFORMANCE

- Morphological traits included plant height, number of branches, surface area and shoot diameter, and biomass expressed by shoot and root fresh and dry mass (drying for 72h, temp. 85 °C).
- Anatomical traits included parenchyma cell area, perimeter, cell diameter, cell roundness, and aspect ratio.

BIOCHEMICAL TRAITS

- Biochemical traits covered photosynthetic pigments, soluble protein content, hydrogen peroxide and proline content, catalase and peroxidase activity.

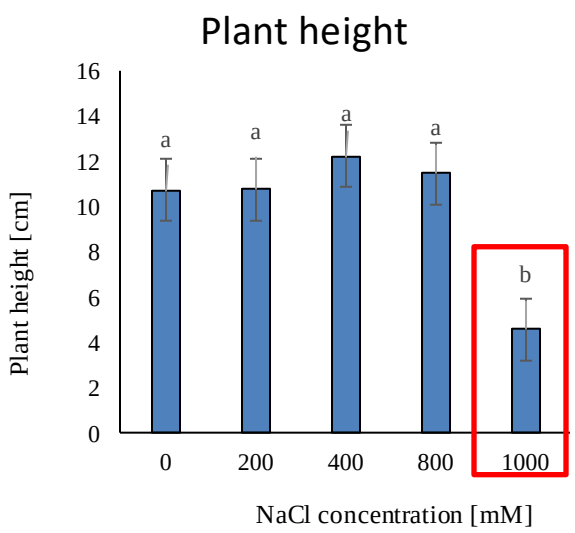
Materials and methods

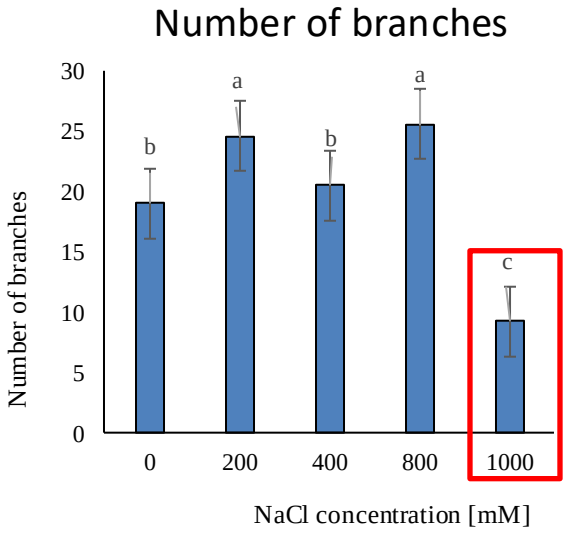
STATISTICAL ANALYSIS

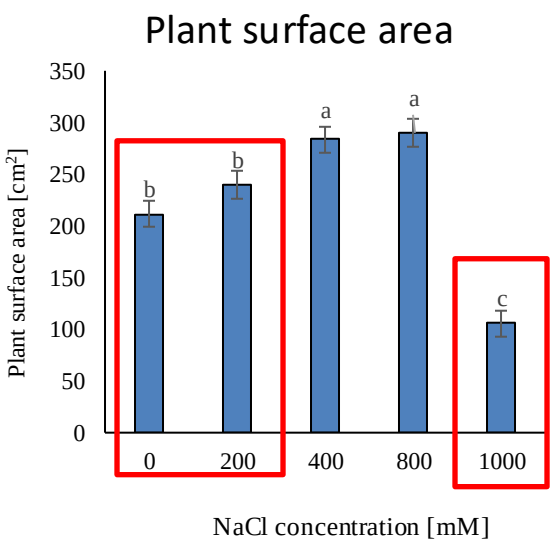
- Results were compared by one-way ANOVA with Tukey post hoc comparisons between treatments (PAST 4.15).
- Differences based on the whole set of traits were generalised by non-metric multidimensional scaling (NMDS) with the Bray-Curtis dissimilarity measure (Canoco 5.0 package).
- The most affected traits by salinity treatments were identified by discriminant analysis (Canonical Variate Analysis, CVA) with a forward-selection procedure and Monte Carlo permutation test (Canoco 5.0 package).

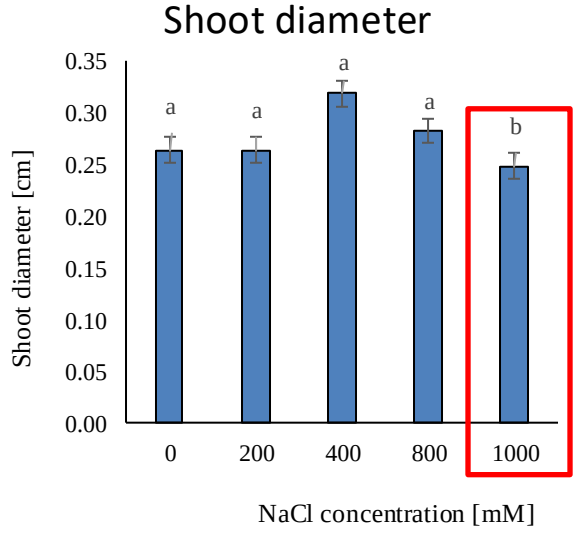
Results

GROWTH RESPONSES TO DIFFERENT SALINITY LEVELS





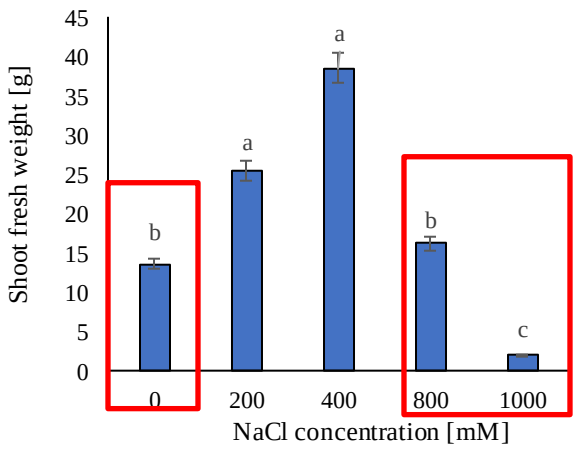




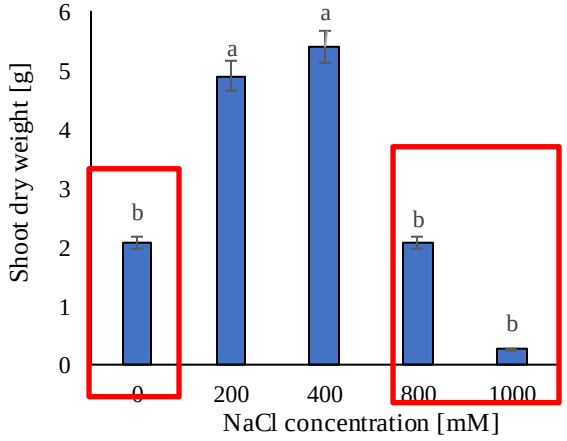
Results

GROWTH RESPONSES TO DIFFERENT SALINITY LEVELS

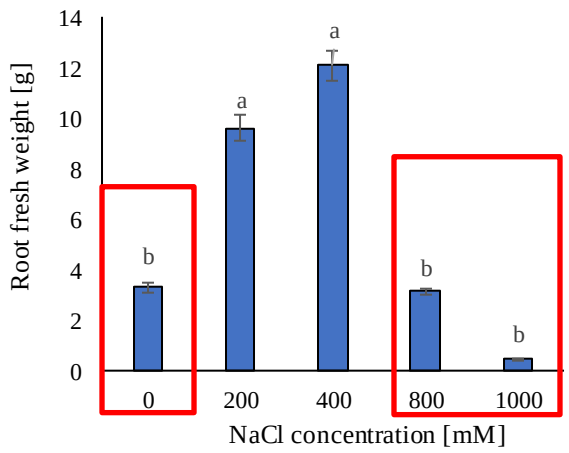
Shoot fresh weight



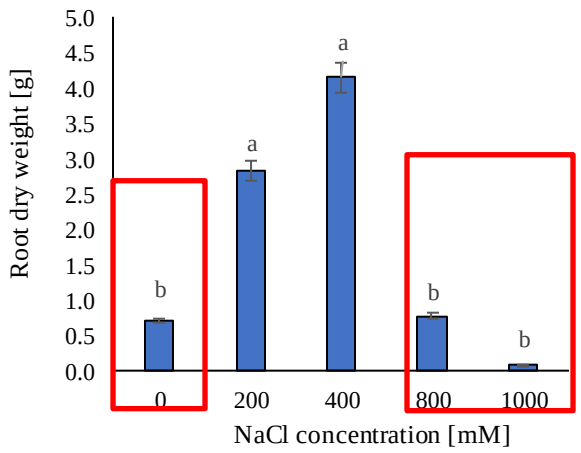
Shoot dry weight



Root fresh weight



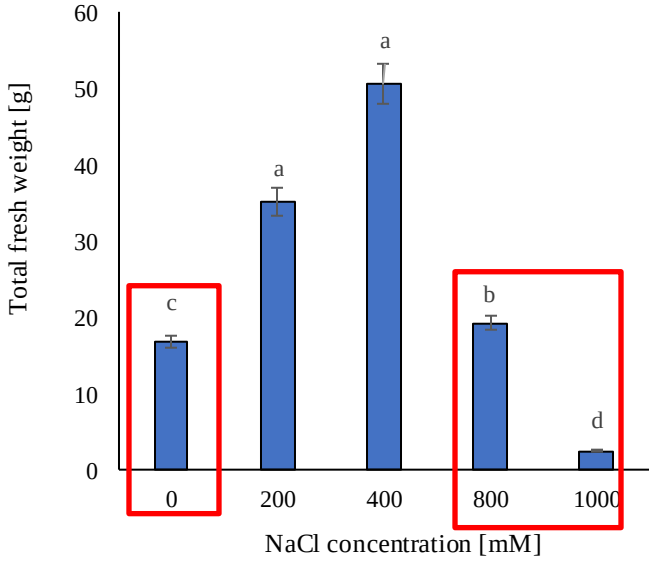
Root dry weight



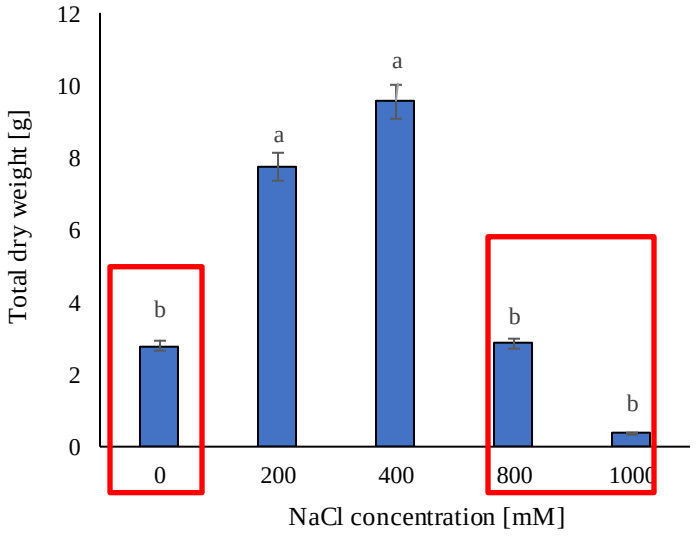
Results

GROWTH RESPONSES TO DIFFERENT SALINITY LEVELS

Total fresh weight

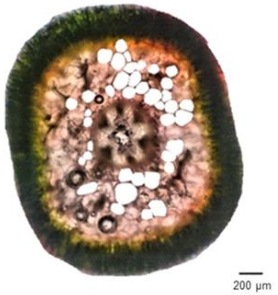


Total dry weight

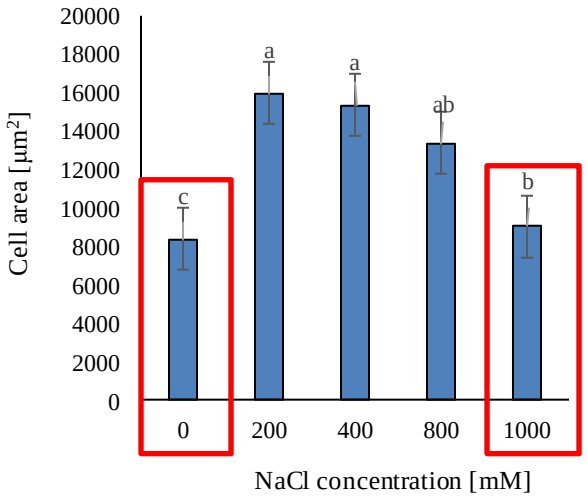


Results

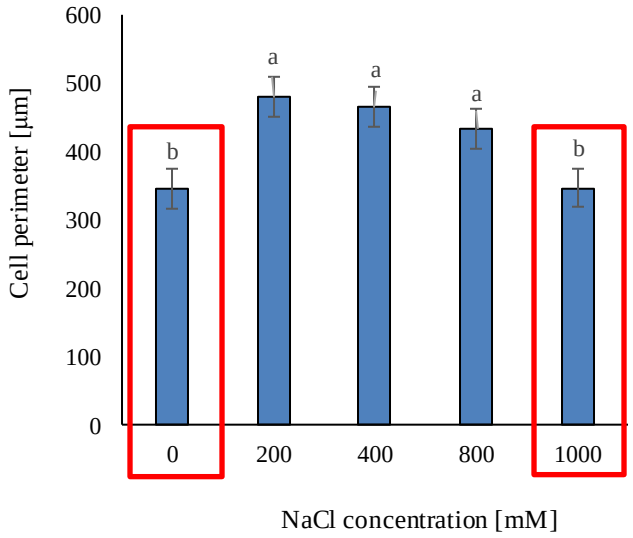
ANATOMICAL RESPONSES TO DIFFERENT SALINITY LEVELS



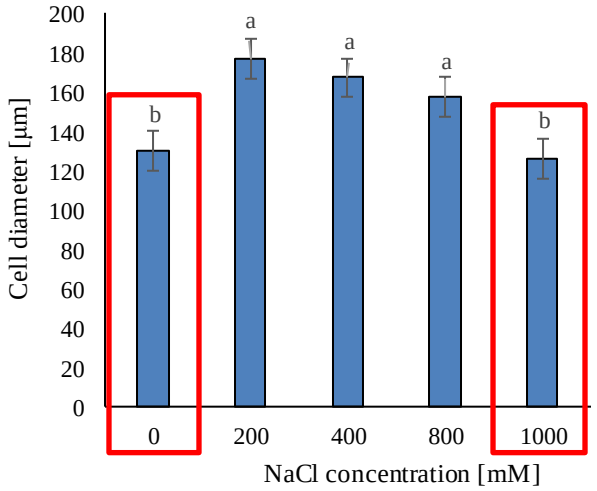
Cell area



Cell perimeter

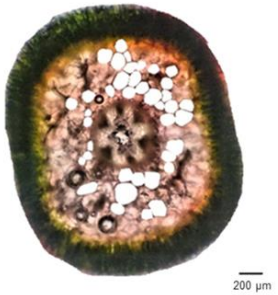


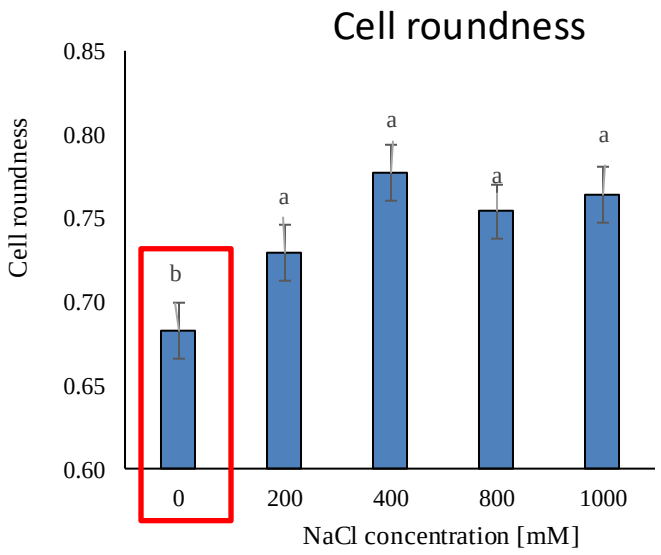
Cell diameter

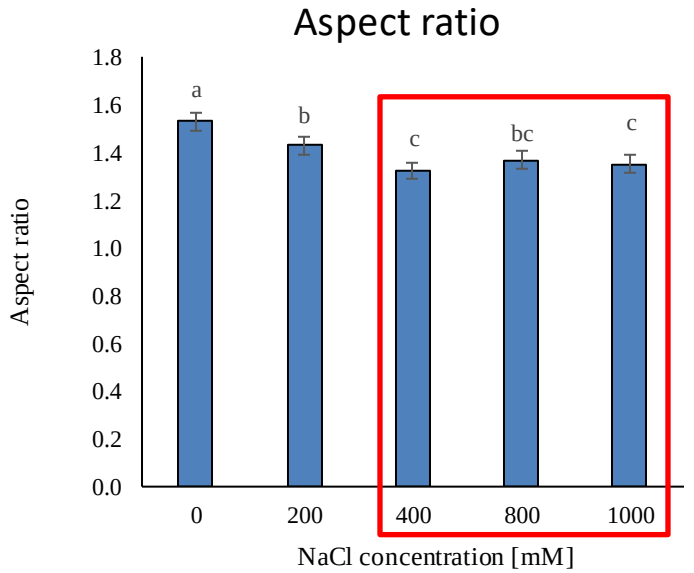


Results

ANATOMICAL RESPONSES TO DIFFERENT SALINITY LEVELS

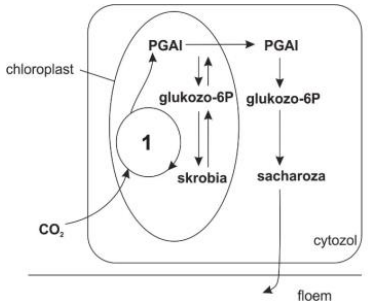


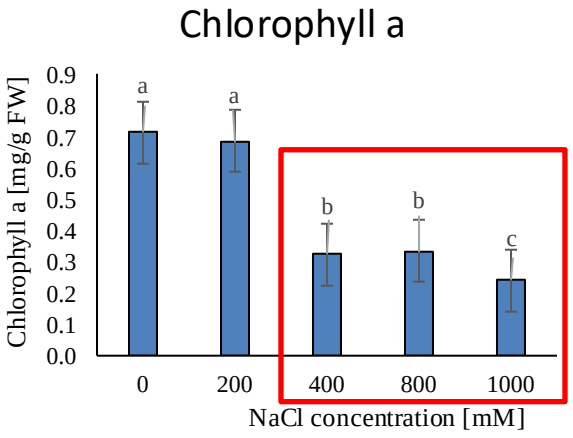


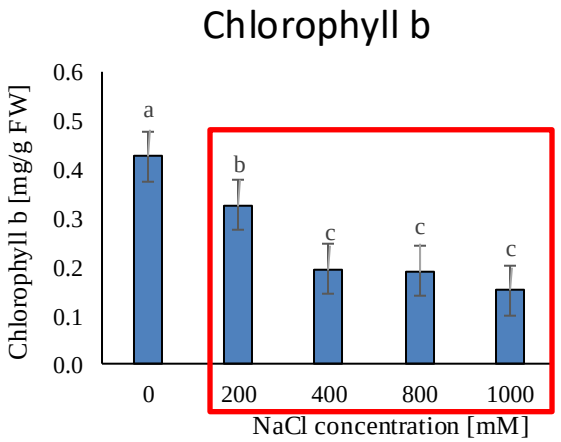


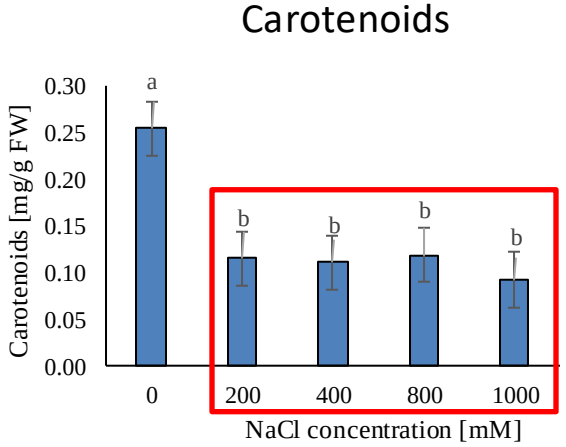
Results

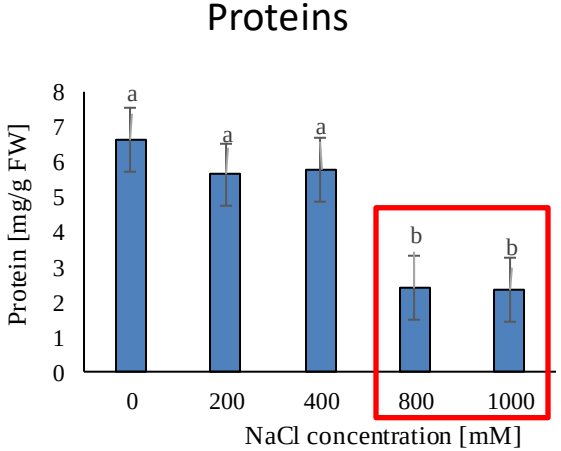
BIOCHEMICAL RESPONSE TO DIFFERENT SALINITY LEVELS





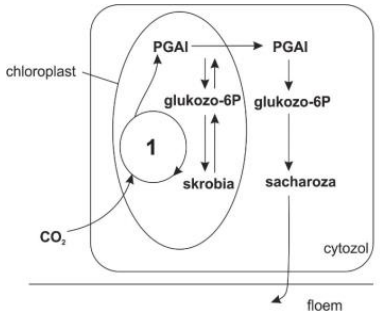




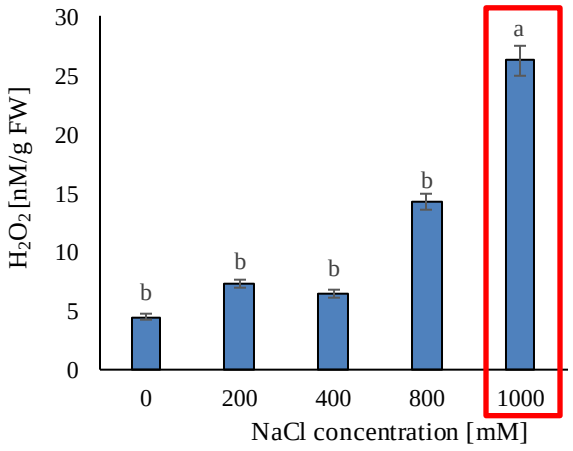


Results

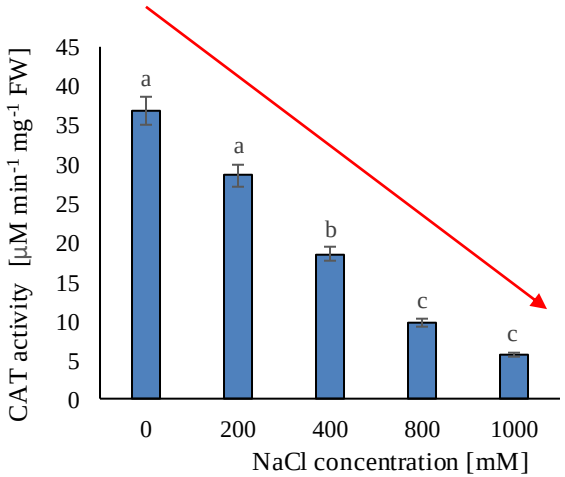
BIOCHEMICAL RESPONSE TO DIFFERENT SALINITY LEVELS



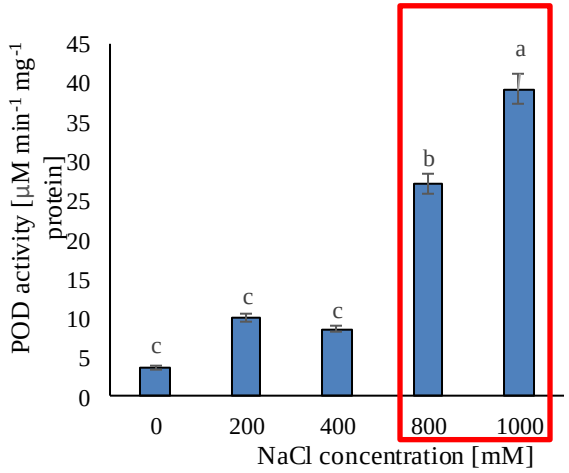
Hydrogen dioxide



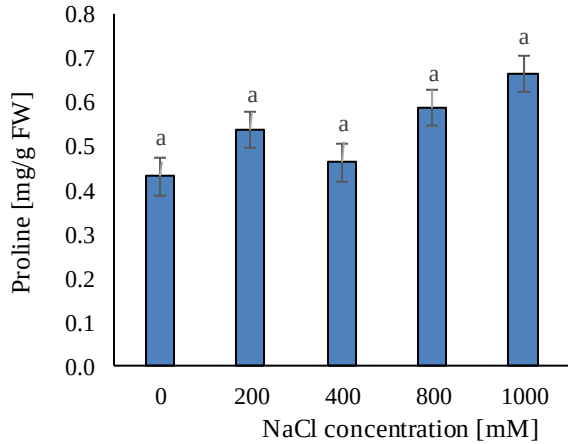
CAT activity



POD activity

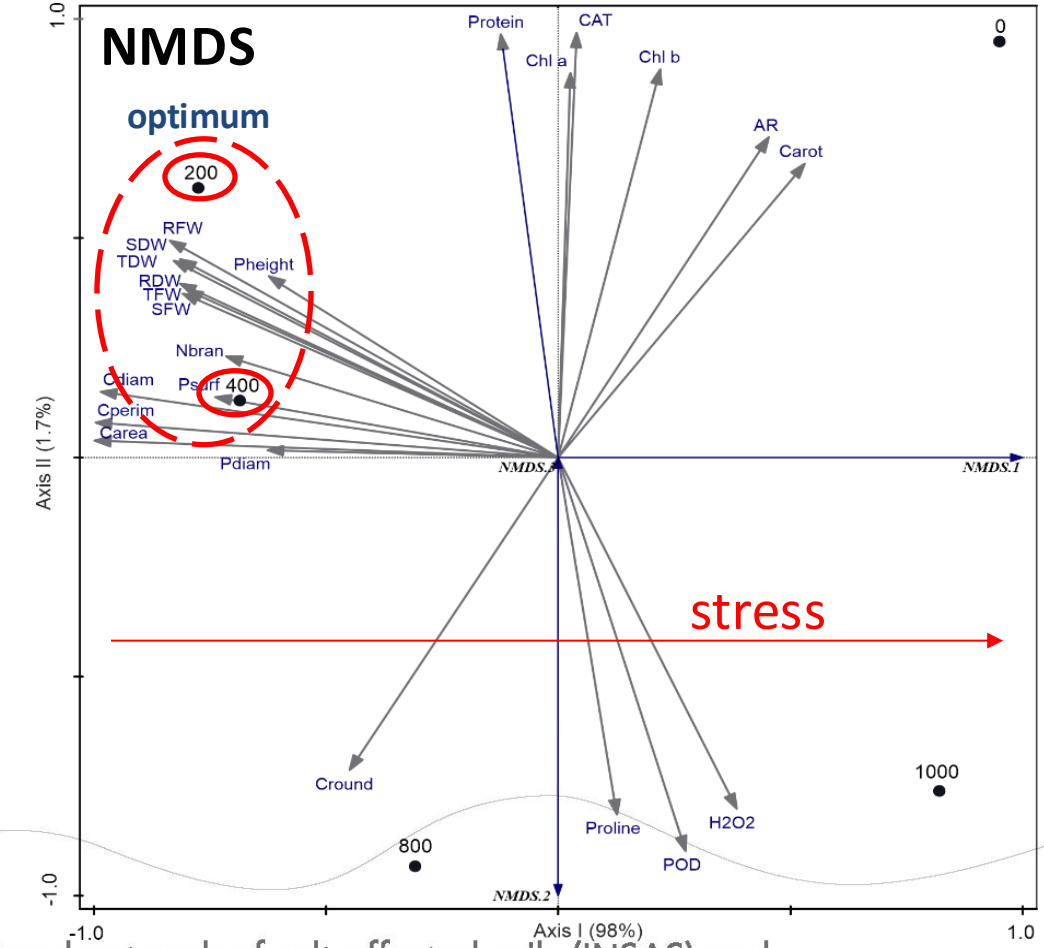


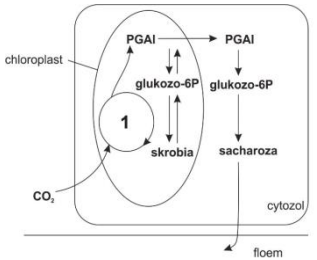
Proline



Discussion

GENERAL GROWTH PERFORMANCE



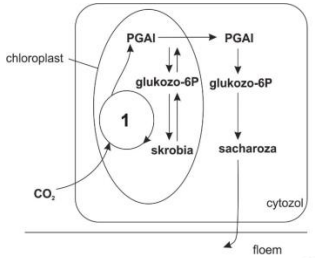


Discussion

RANKING OF FUNCTIONAL TRAITS RESPONSES

Discriminant analysis - CVA with forward selection of variables and Monte Carlo test

Conditional effects			
Variable	**V [%]**	**pseudo-F**	**p**
Chl a	24.8	7.2	0.002
Carot	24.7	10.3	0.002
Psurf	24.5	18.8	0.002
Protein	23.1	147	0.002
POD	0.8	6.5	0.014
Nbran	0.6	6.4	0.012
AR	0.7	11.3	0.004
Cperim	0.2	3.9	0.03
Proline	<0.1	1	0.372
CAT	<0.1	1.4	0.286
H_2O_2	<0.1	0.8	0.516
Cdiam	<0.1	1.3	0.304
Sdiam	<0.1	0.6	0.598
Carea	<0.1	1	0.396
SFW	<0.1	0.9	0.452
TDW	<0.1	1.2	0.334
Pheight	<0.1	0.6	0.624
Chl b	<0.1	2.2	0.144
RFW	<0.1	0.7	0.5
SDW	<0.1	0.8	0.466



Discussion

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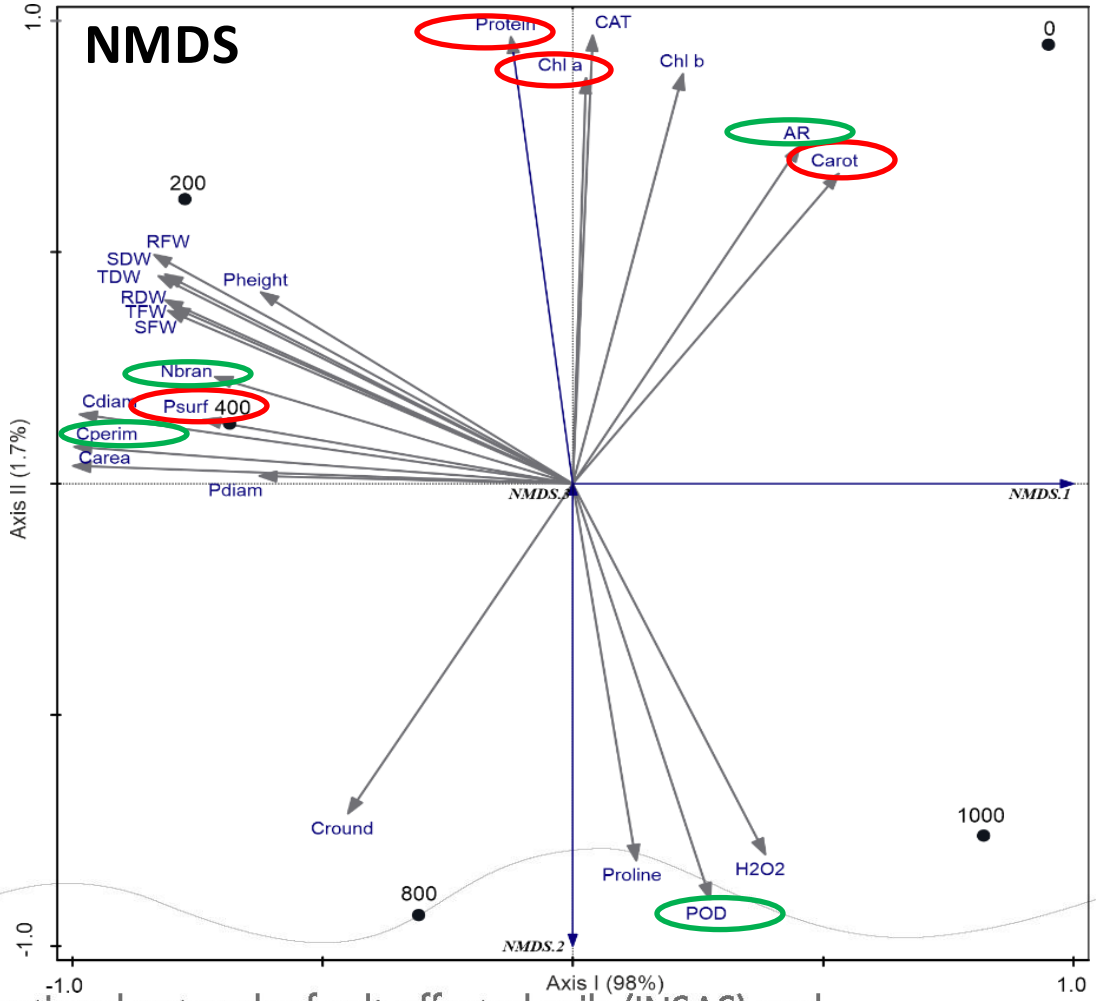

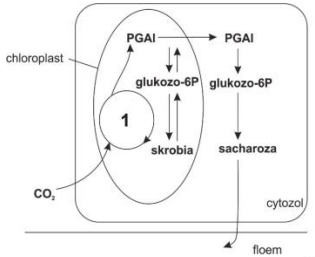

Conclusions

- Almost all functional traits were salinity-dependent, but they were influenced by salinity in different ways.
- The most affected traits include photosynthetic pigments and protein content, plant surface area, peroxidase activity, and anatomic characteristics related to cell shape.
- Morphological, biomass and anatomical properties indicated optimum growth between 200 and 400 mM NaCl and growth limitations at 0, 800, and 1000 mM NaCl (Piernik 2012)
- We did not find a statistically significant relationship between proline levels and increasing salinity, which was not expected based on reported findings regarding glycophyte species (e.g., Rajabi Dehnavi et al. 2022).
- Our results significantly expand the knowledge about *S. europaea* functional traits variation in response to salinity, which can be important for discovering regulating processes and for possible future agricultural applications.

Salinity shapes *Salicornia europaea* L. functional traits

More details

Cárdenas-Pérez *et al. BMC Plant Biology* (2020) 20:467
https://doi.org/10.1186/s12870-020-02633-8

BMC Plant Biology

RESEARCH ARTICLE Open Access

Image and fractal analysis as a tool for evaluating salinity growth response between two *Salicornia europaea* populations

S. Cárdenas-Pérez[1*], A. Piernik[1], A. Ludwiczak[1], M. Duszyn[2], A. Szmidt-Jaworska[2] and J. J. Chanona-Pérez[3]

plants Plants 2022, 11, 1051. https://doi.org/10.3390/plants11081051 MDPI

Article

Salicornia europaea L. Functional Traits Indicate Its Optimum Growth

Stefany Cárdenas-Pérez [1], Ahmad Rajabi Dehnavi [1,2], Karol Leszczyński [1], Sandra Lubińska-Mielińska [1], Agnieszka Ludwiczak [1] and Agnieszka Piernik [1,*]

scientific reports
Scientific Reports (2022) 12: 2968 https://doi.org/10.1038/s41598-022-06385-3

OPEN

Maternal salinity influences anatomical parameters, pectin content, biochemical and genetic modifications of two *Salicornia europaea* populations under salt stress

S. Cárdenas-Pérez[1&2], K. Niedojadło[2], A. Mierek-Adamska[3,4], G. B. Dąbrowska[3] & A. Piernik[1]

Environmental and Experimental Botany 218 (2024) 105606

Contents lists available at ScienceDirect

Environmental and Experimental Botany

journal homepage: www.elsevier.com/locate/envexpbot

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Salinity-driven changes in *Salicornia* cell wall nanomechanics and lignin composition

Stefany Cárdenas Pérez [a,*], Janusz Strzelecki [b], Agnieszka Piernik [a], Ahmad Rajabi Dehnavi [a], Paulina Trzeciak [c], Radosław Puchałka [c], Agnieszka Mierek-Adamska [d,e], Jorge Chanona Pérez [f], František Kačík [g], Vladimír Račko [g], Ján Kováč [h], Samarthya Bhagia [i], Jaroslav Ďurkovič [h]

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Thank you

With the financial support of

Australian Government
Department of Agriculture, Water and the Environment

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SUSTAIN
Sustainable use of salt-affected lands

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