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Faba bean (*Vicia faba* L.) salt stress response under different soil organic matter content

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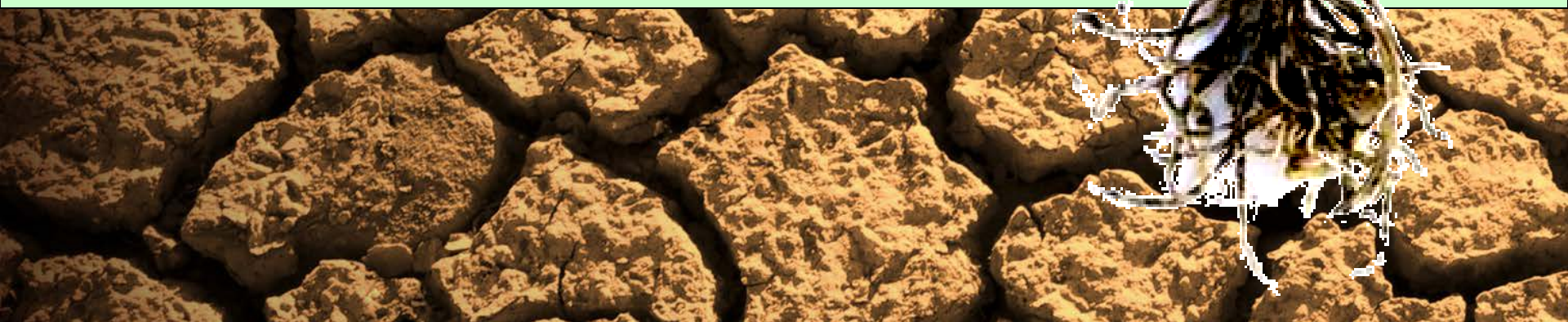

Introduction

- In Mediterranean coastal areas seawater intrudes into rivers and aquifers
- Irrigation water supply: surface and groundwater resources
  - Use water of poor quality for crop irrigation

Introduction

- Horticultural production is dependent on soil and water quality

Although high agricultural productivity is the aim of extensive crop irrigation, use of saline water for irrigation threatens the sustainability of crop production on the irrigated land

Introduction

- **Plant salt stress**

  morphological, physiological, biochemical and molecular changes

- Plant salt stress: osmotic stress

  ionic stress

  often leading to oxidative stress

- Ionic stress

  alteration in nutrients competitive uptake, transport and partitioning within the plant

Introduction

- Low levels of soil organic matter (SOM) can favor the negative effects of salinization
- The saline soils properties can be improved by SOM addition, consequently enhancing plant growth and development

Introduction

- SOM is an important factor in soil biogeochemical processes
- It plays significant role in retaining trace elements (TEs) in soil
- The sorption of TEs in the soil is mostly determined by SOM complexation

Introduction

- Legumes can support biological N fixation
- Screening for legumes that can grow and provide economic yield under saline conditions has a dual ecological benefit:

  (i) less N fertilization needed

  (ii) ability to grow in a saline environment would reduce the effects of the saline irrigation water

Introduction

- Legumes are either sensitive or moderately tolerant to salinity
- *Vicia faba* (L.) is moderately sensitive to salinity, with vegetative growth reduction at irrigation water electrical conductivity of 6 dS m^{-1} and more
- Faba bean is one of the major cool season grain legume crops produced worldwide
  - high yield: attractive to producers
  - high protein content: attractive to consumers

Introduction

- A fact that crop performance may be adversely affected by salinity–induced nutritional disorders fostered research on salinity–mineral nutrient relations in horticultural crops
- Salinity–mineral nutrient relations were studied for faba bean as well

Aim of research

- *The aim of this study was to examine faba bean (Vicia faba* L.*) salt stress response and element plant tissue content, after exposing plants to rising irrigation water salinity under different SOM content*

Experimental: Growing conditions

- The study was carried out in spring 2012 (April, 2 – June, 15) in a greenhouse at the experimental station of the Faculty of Agriculture University of Zagreb
- Three weeks old uniform faba bean (*Vicia faba* L. cv. Aguadulce) seedlings were transplanted into pots containing

  (i) agricultural soil and

  (ii) agricultural soil added with commercial peat (4:1) to increase SOM content

Experimental: Growing conditions

- During the first two weeks after transplanting, the seedlings were irrigated daily with a basic nutrient solution (Poly–Feed Drip 20–20–20 with micronutrients)
- Good drainage was ensured in order to provide aeration of soil and soil/peat mixture and prevent waterlogging
- The fertigation rate and frequency was adjusted to the plant phenology and to the climatic conditions in the greenhouse

Experimental

Treatments applied and experimental design

- Alluvial soil from horticultural land in a Croatian coastal region was used for the experiment
- Soil was initially purged from roots and other plant parts, manually fragmented and passed through a 1 cm mesh
- Commercial peat was added to the half of the provided soil (1:4) to increase SOM content
- In next three weeks period, soil was manually mixed with peat and homogenized
- Two SOM trial variants,

unmodified (SOM_0) and **increased (SOM_1)** were investigated

Experimental

Treatments applied and experimental design

- Three weeks after transplanting faba bean plants, treatment with raising NaCl concentrations in nutrient solution was applied as follows:

NaCl0 control
(basic nutrient solution without added NaCl)

NaCl50 control + 50 mM NaCl

NaCl100 control + 100 mM NaCl

Experimental

Treatments applied and experimental design

- Split–plot experimental design with three blocks was applied
- In each block, the main plots were assigned to two SOM variants and the sub-plots were randomly assigned to three NaCl salinity treatments

Experimental: Data collecting and sampling

- Leaf, pod and seed samples were collected five weeks after salinity treatment started

- One leaf sample consisted of fully developed leaves, located next to the pods
- One pod sample consisted of all pods from three plants
- One seed sample consisted of all seeds extracted from the pods

from three plants under the same SOM variant and subjected to the same NaCl treatment

(two samples per treatment)

Experimental: Plant tissue analysis

- Dried (24 h at 60 °C) and ground plant material was dissolved by multiwave–assisted digestion in concentrated HNO_3:H_2O_2 (10:1, v/v) mixture

- P, Ca, Mg, S, Fe, Mo, Mn, Cu and Zn concentrations were determined (ICP–OES Vista MPX, Varian)
- Na and K (Atomic Absorption Spectrometer 3110, Perkin–Elmer)
- Cl in a plant water extract (San++ Continuous Flow Analyzer, Skalar)

- *Plant reference material (**WEPAL IPE**) and blanks were included in digestion and mineral detection*

Experimental: Statistical analysis

- Statistical analysis was done using the

  SAS statistical software package

  (SAS Institute, 2007)

- Plant tissue analysis data were subjected to the analysis of variance by using MIXED procedure

- The significance of differences between the means was determined using a Tukey–Kramer's test at $P<0.05$

Results: Leaf tissue element content

Effect of saline irrigation water (50 and 100 mM NaCl) and soil organic matter (unmodified – SOM0 and increased – SOM1) on dry matter (DM) percentage and mineral accumulation in faba bean (*Vicia faba* L.) leaves

Treatment	DM	Na	Cl	K	Ca	Mg	P	S	Mo	Cu	Fe	Zn	Mn
	%	g/kg							mg/kg				
Leaf tissue element content													
SOM_0	12.7a	34.7a	54.3a	19.1a	34.9a	3.3b	2.4a	2.7a	0.6b	8.5a	662.2a	14.3a	88a
SOM_1	12.7a	31.4a	46.4b	17.7a	37.6a	4.2a	2.5a	2.6a	5.1a	8a	674.9a	14.1a	84.8a
$NaCl_0$	15.2a	2.3c	9.4c	33.7a	42.7a	4.8a	2.7a	2.8a	2.6a	6.5a	297.7a	14.5a	92.6a
$NaCl_{50}$	12b	38.8b	56.1b	13.3b	32.9b	3.1b	2.5a	2.6a	2.7a	9.1a	803.2a	14.3a	86.9a
$NaCl_{100}$	10.9c	57.9a	85.6a	8.1c	33b	3.4b	2.2a	2.6a	3.3a	9.2a	904.8a	13.7a	79.7a
SOM*NaCl	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Means with the same letter are not significantly different at $P<0.05$; n.s.: non–significant interaction.

Results: Pod tissue element content

Effect of saline irrigation water (50 and 100 mM NaCl) and soil organic matter (unmodified – SOM0 and increased – SOM1) on dry matter (DM) percentage and mineral accumulation in faba bean (*Vicia faba* L.) pods

Treatment	DM	Na	Cl	K	Ca	Mg	P	S	Mo	Cu	Fe	Zn	Mn
	%	g/kg							mg/kg				
Pod tissue element content													
SOM_0	14.3a	4.7a	6.2a	18.5a	2a	1.2a	3.1b	1a	3.6b	5.5a	41.9a	14.6a	12.5a
SOM_1	13.9a	4.4a	6.2a	18.6a	2.1a	1.3a	3.4a	1a	12a	4.3b	40.3a	16.6a	12.9a
$NaCl_0$	13b	0.3c	1.4c	18.3a	2.5a	1.5a	3.2a	1a	6.4c	4.4b	50.9a	14.6a	12.3a
$NaCl_{50}$	14.7a	5.1b	6.2b	18.6a	1.9b	1.2b	3.3a	1a	7.8b	5.7a	31.8a	16.3a	13a
$NaCl_{100}$	14.6a	8.3a	10.9a	18.8a	1.8b	1.2b	3.2a	0.9a	9.2a	4.7ba	40.7a	16a	12.7a
SOM*NaCl	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Means with the same letter are not significantly different at P<0.05; n.s.: non–significant interaction.

Results: Seed tissue element content

Effect of saline irrigation water (50 and 100 mM NaCl) and soil organic matter (unmodified – SOM0 and increased – SOM1) on dry matter (DM) percentage and mineral accumulation in faba bean (*Vicia faba* L.) seeds

Treatment	DM	Na	Cl	K	Ca	Mg	P	S	Mo	Cu	Fe	Zn	Mn
	%	g/kg							mg/kg				
Seed tissue element content													
SOM_0	20.4a	0.36a	1.2a	17.8a	0.9a	1.2a	6b	1.6a	8b	10.9a	47.7a	27.2b	9.3a
SOM_1	21a	0.34a	1.1a	17.8a	0.9a	1.3a	6.5a	1.6a	21.6a	11.4a	55a	29.9a	8.7a
$NaCl_0$	20.5a	0.05c	0.8b	17.8a	1a	1.2a	6.5a	1.8a	13.5b	13.4a	63.1a	29.8a	8.9a
$NaCl_{50}$	19.8a	0.42b	1.3a	18a	0.8b	1.2a	6.2a	1.5b	14.7ba	10.3a	47.3a	28.8a	9.3a
$NaCl_{100}$	21.8a	0.57a	1.4a	17.7a	0.8b	1.2a	6a	1.5b	16.2a	9.8a	43.7a	27.1a	8.8a
SOM*NaCl	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Means with the same letter are not significantly different at P<0.05; n.s.: non–significant interaction.

Conclusions

- Saline irrigation water, as well as SOM application, affected certain element accumulation and distribution in faba bean (*Vicia faba* L.) plants

- SOM application could induce a short–termed plant nutritional status improvement: hardly associated to saline soils improvement by increasing SOM *per se*

- All plants used in trial were able to complete their life cycle under salt stress conditions:

  faba bean – rather salt tolerant horticultural crop

Conclusions

- The possibility of faba bean tissue specific (e.g. seed, pod) salt stress protection mechanism was revealed:

  Na and Cl accumulation in the leaves next to the pods, instead in pods or seeds, respectively

- A possibility for using faba bean as primer and/or companion plant in a cropping system is suggested – further research on the issue is needed

Thank you for your attention!