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Aerating the subsurface by micro-nano-bubble infused irrigation water

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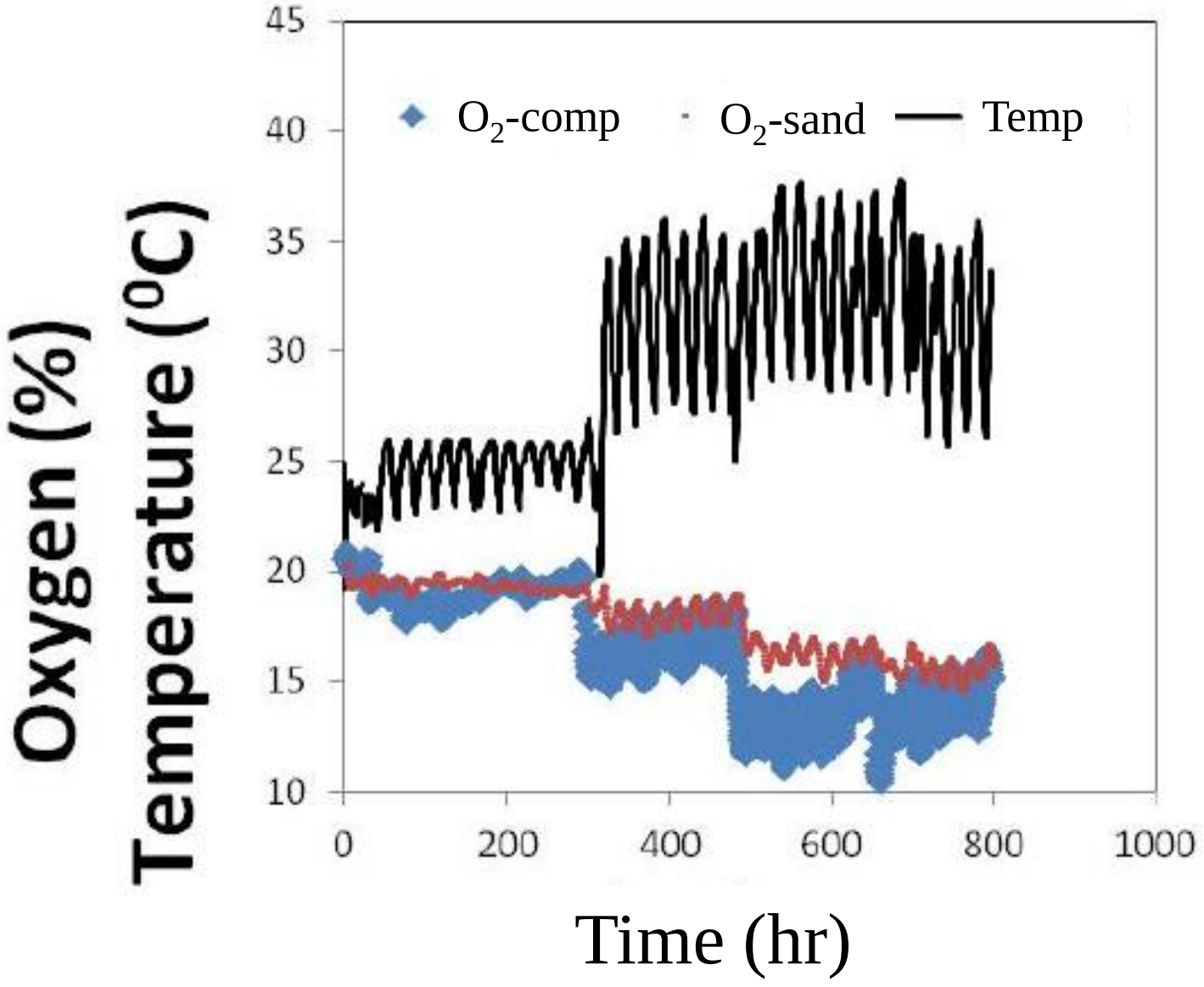
Motivation

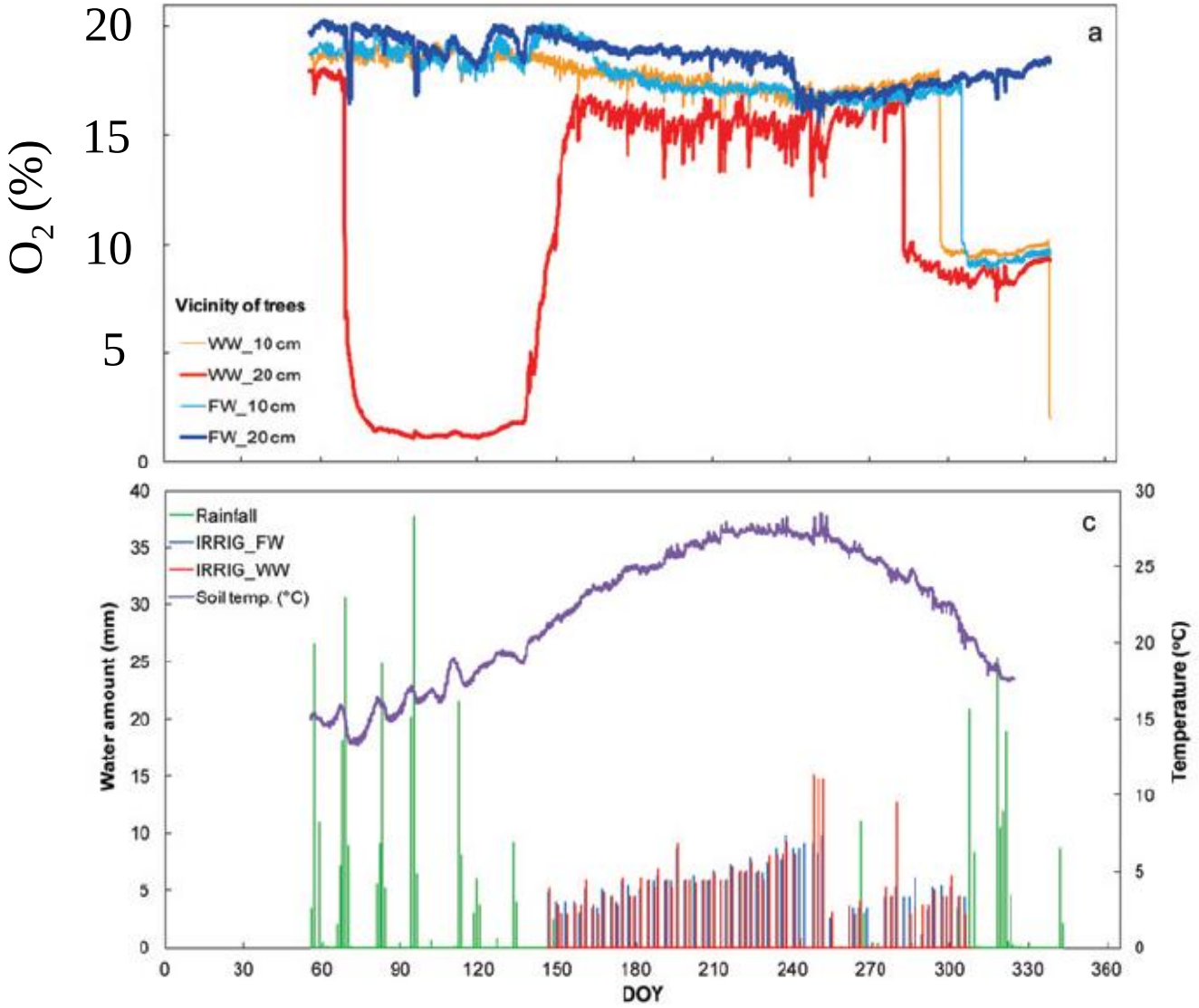


Oxygen deficiencies

Greenhouse planting (sand & compost)

Motivation

Avocado orchards (heavy clay)



Assouline and Narkis. 2013, Vadose zone J.

Oxygen deficiencies

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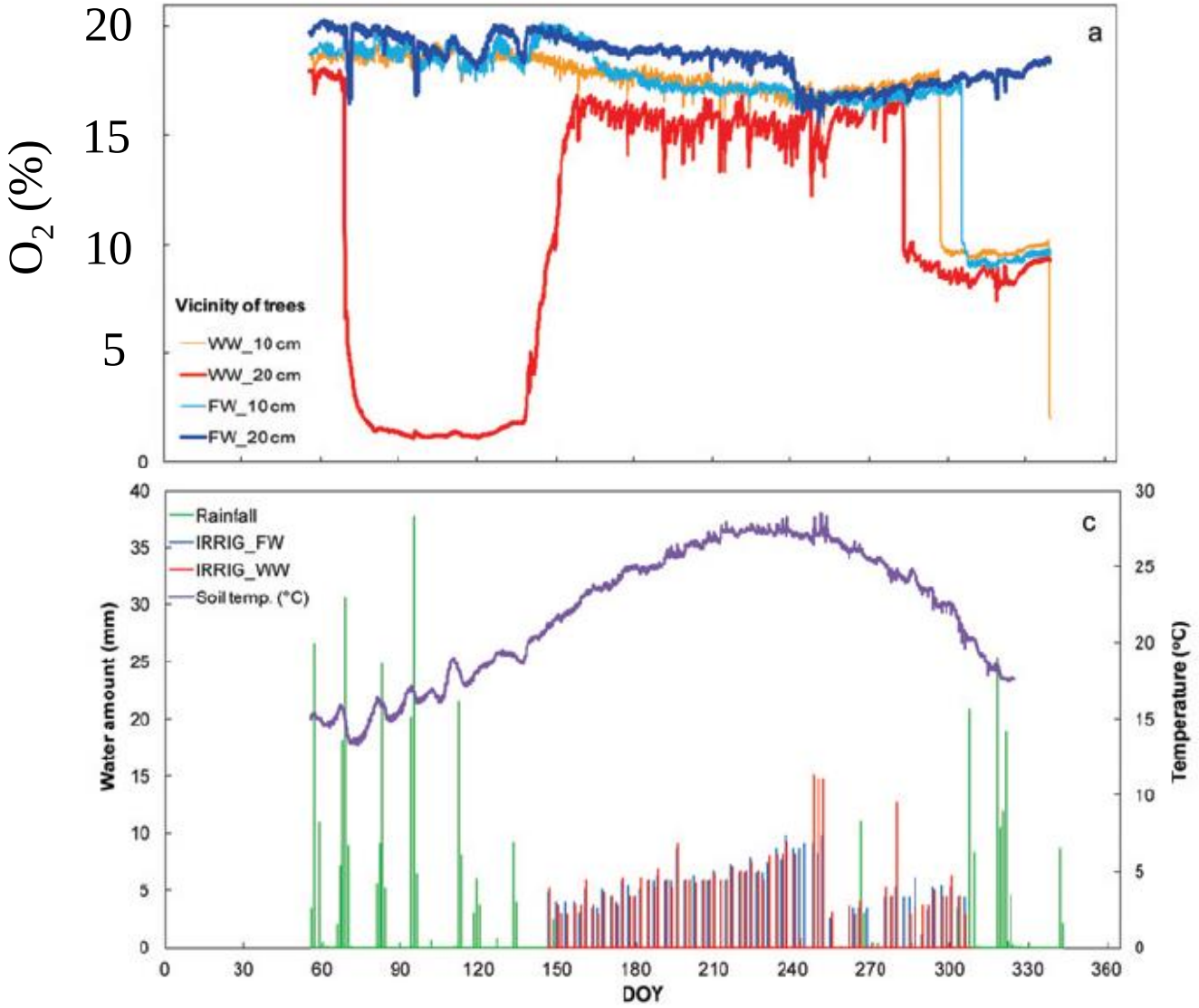

Assouline and Narkis. 2013, Vadose zone J.

Oxygen deficiencies

Motivation

- Increasing O_2 availability in the soil (Oxygation) is known to increase yields of many different crops.

- Current solutions are expensive and not readily implemented

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Definitions

Micro-nano bubbles (MNBs) = bubbles with diameters of 50 nm-10 μm (Agarwal, et al., 2011)

Unique properties:

- large specific surface area
- high internal pressure (3-10 atm)
- long storage time
- strong air solubility
- strong adsorption
- Negative zeta potential

Objective:

- Increase oxygen availability in heavy clay soils (Vertisols) through irrigation with nanobubble infused treated wastewater
- Reduce the system leakiness (i.e. improved WUE, NUE, lower N_2O emissions)

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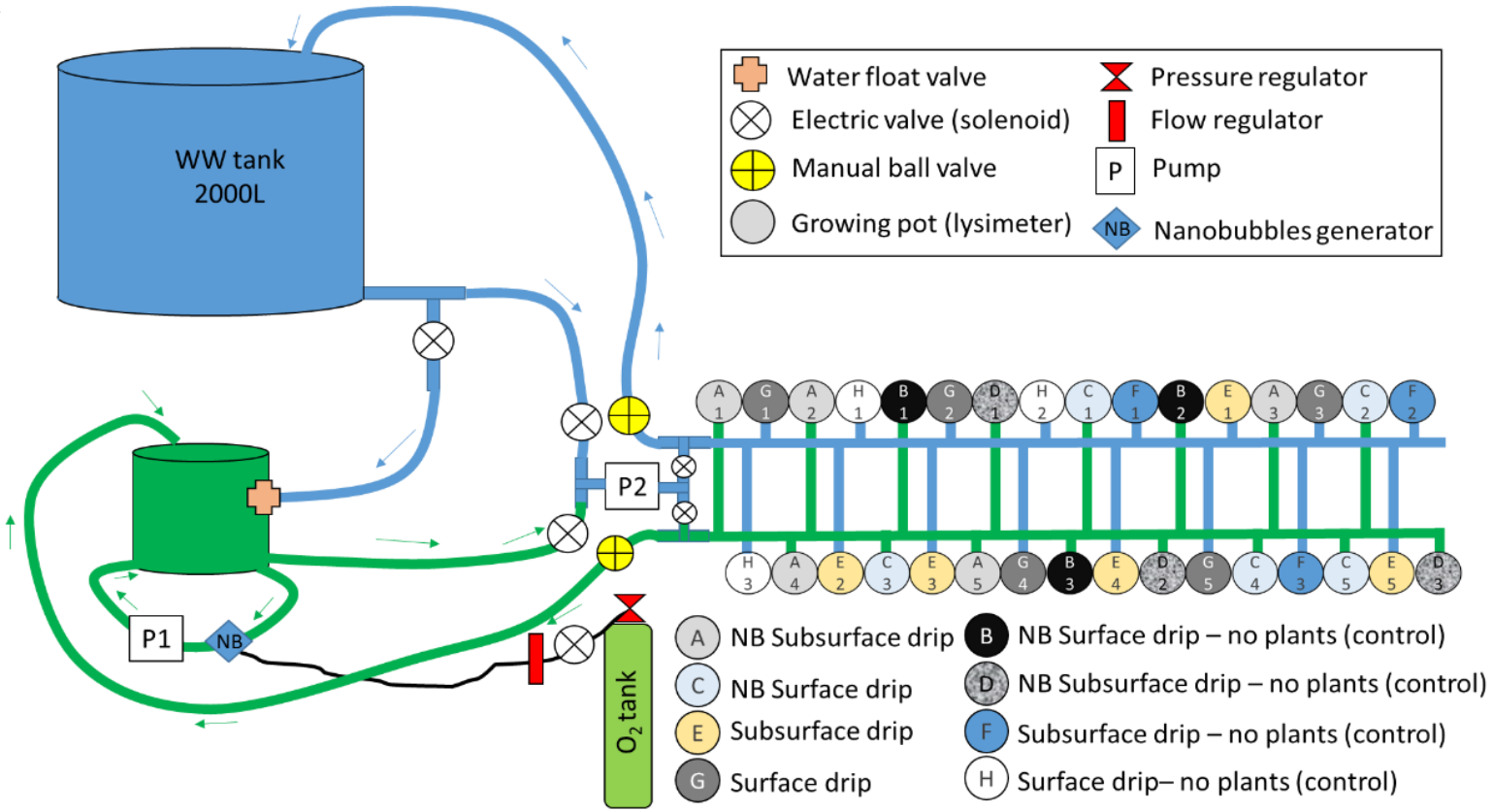
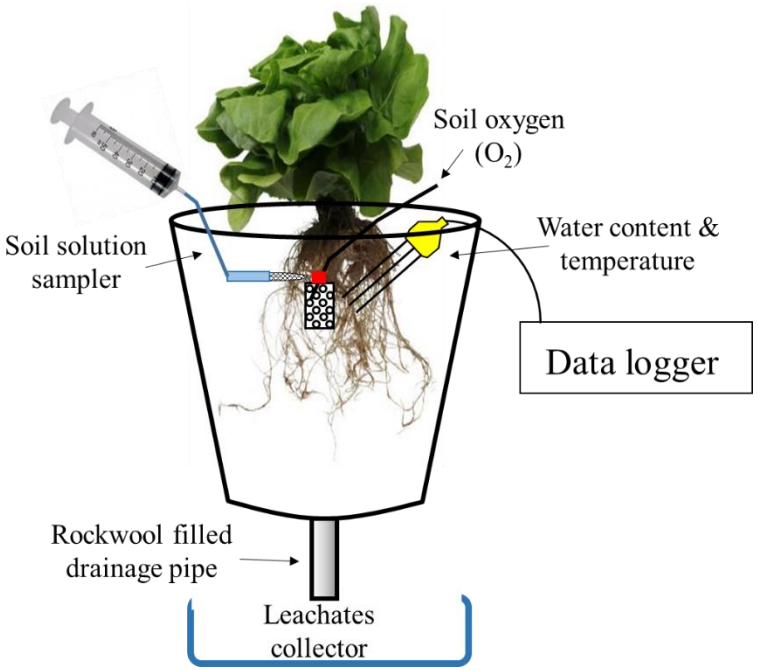
The design of the experiment





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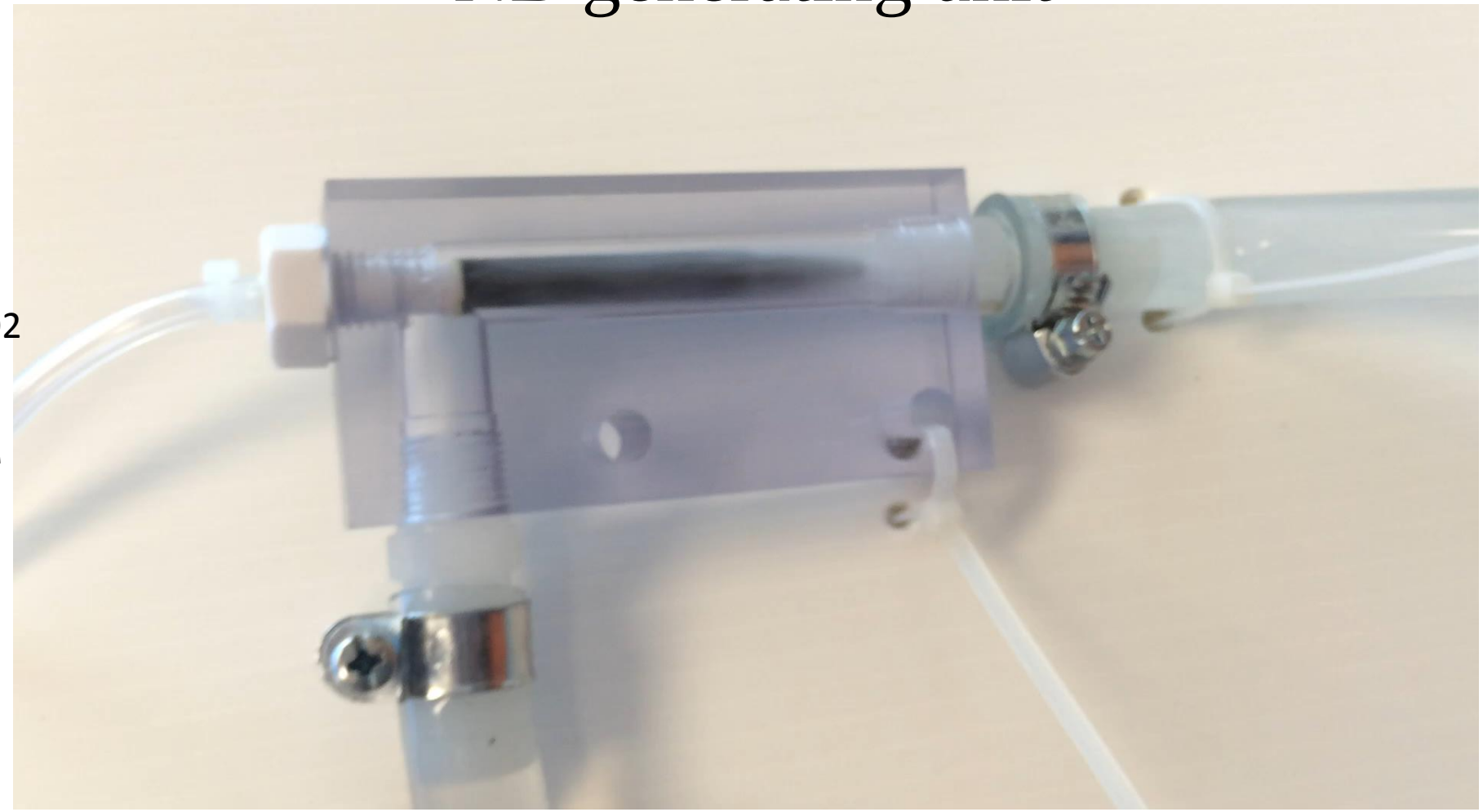
NB generating unit



Water out

Air/O2

Water in

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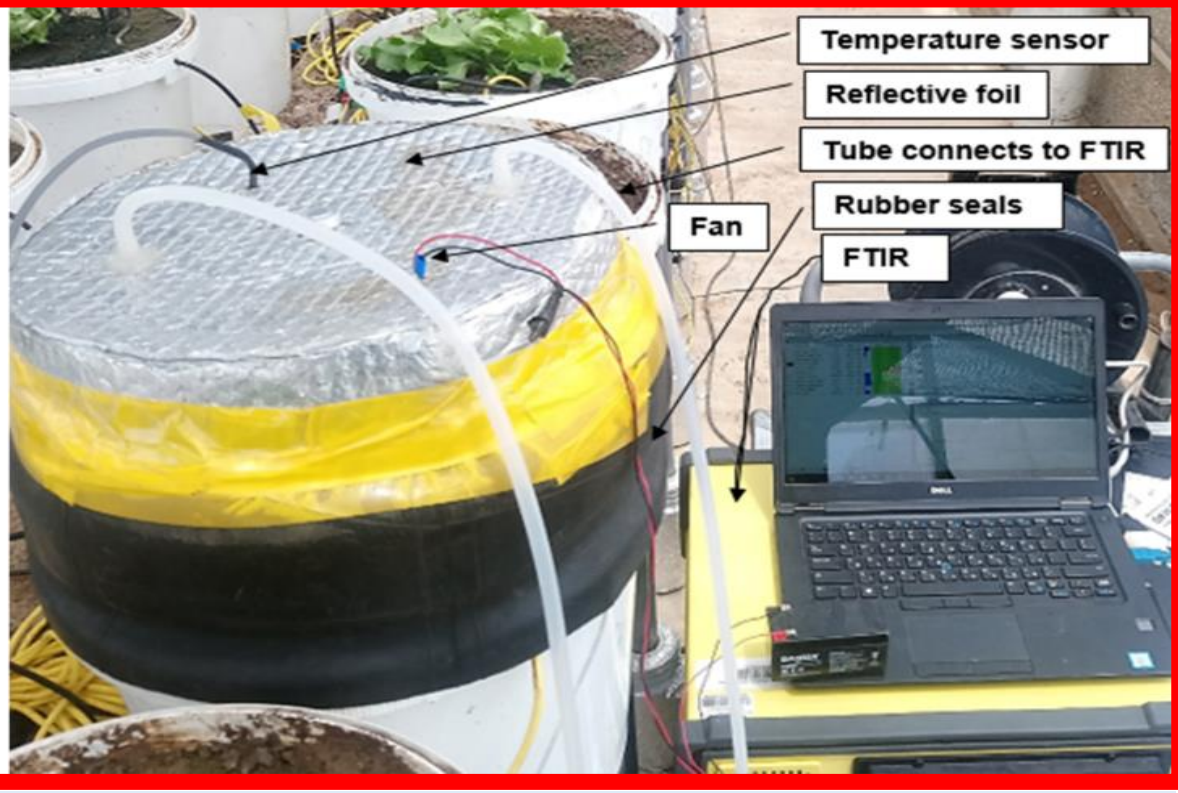
The static Chamber



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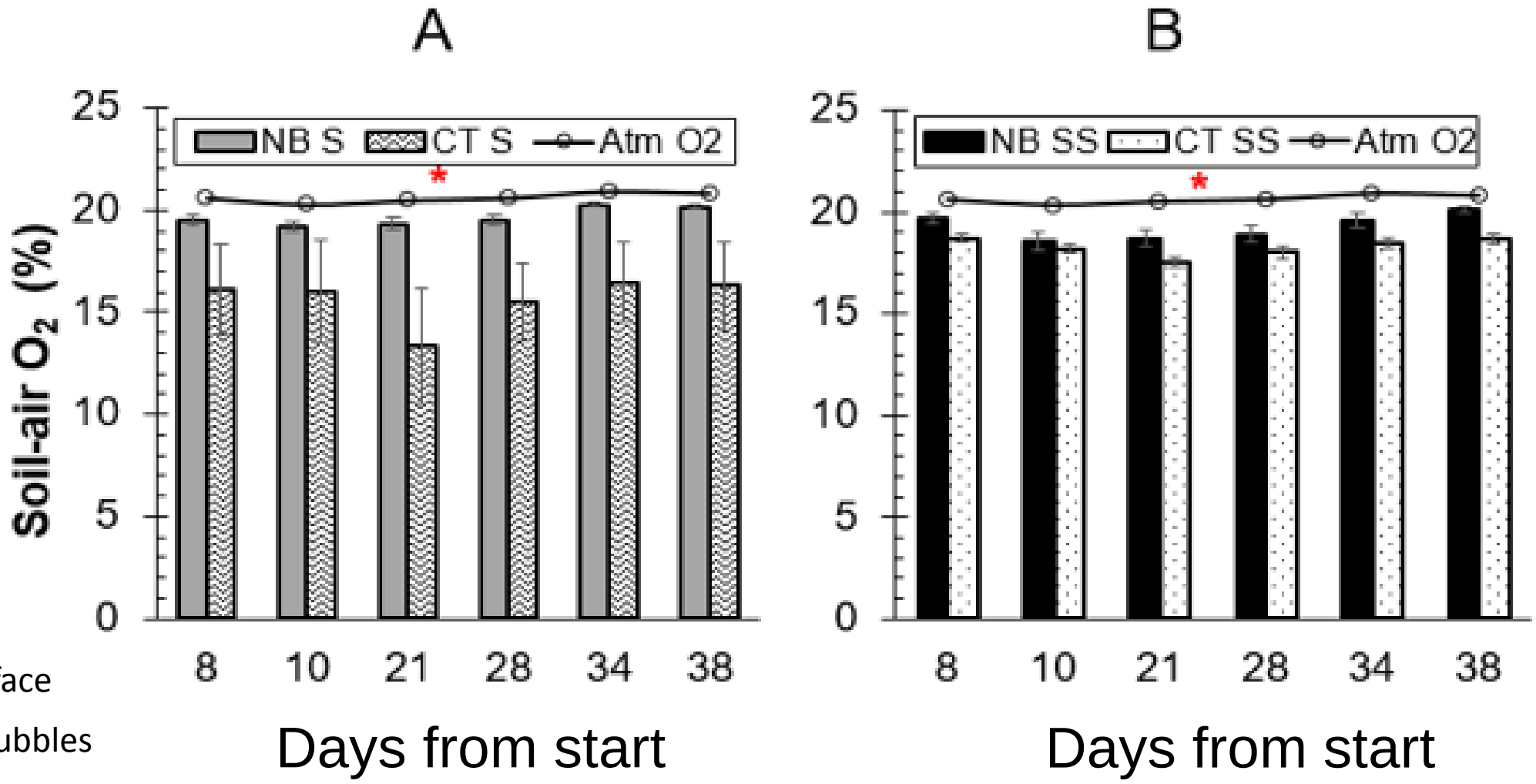
Results:



S - surface
SS - Subsurface

NB - nanobubbles
CT - control

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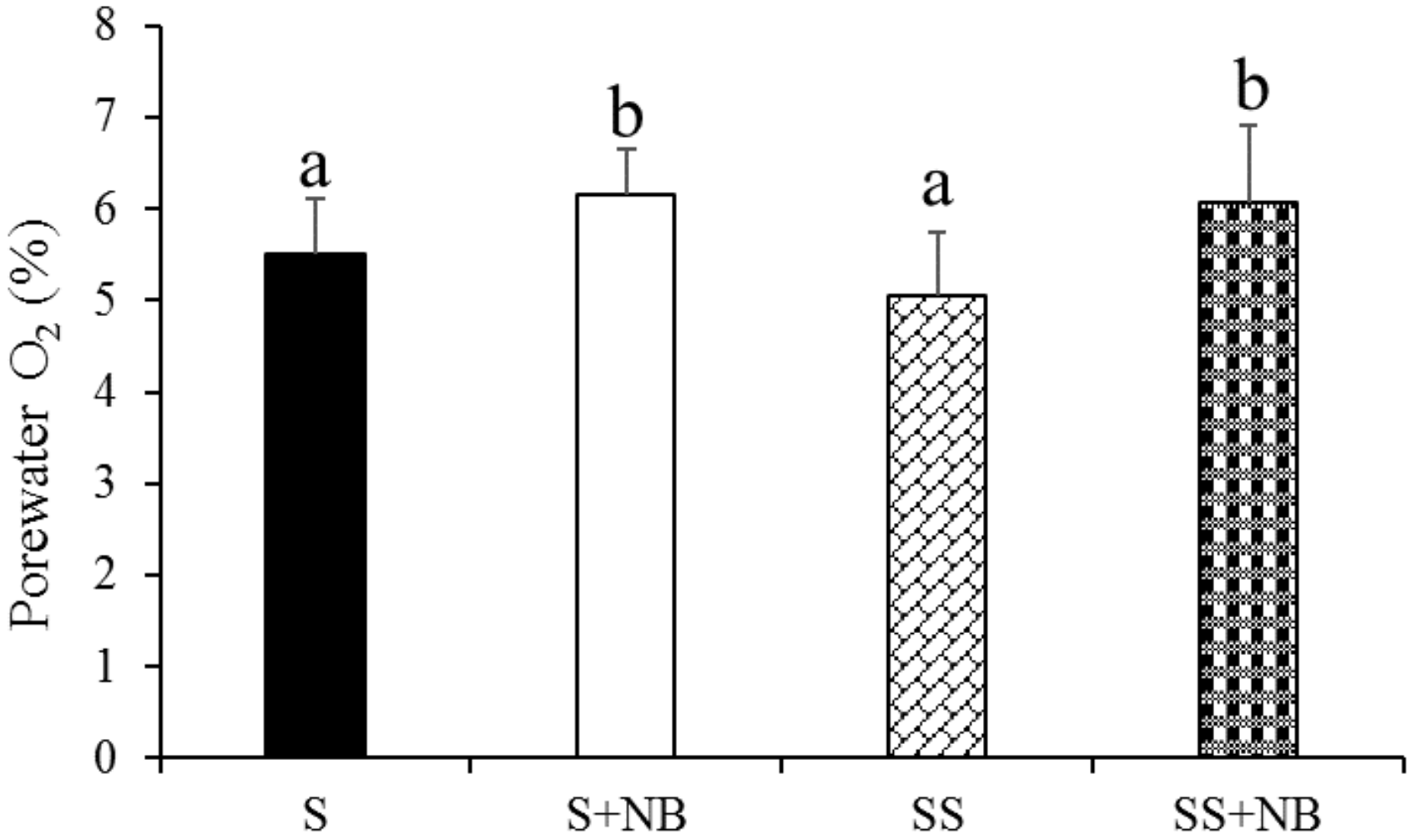
Results:



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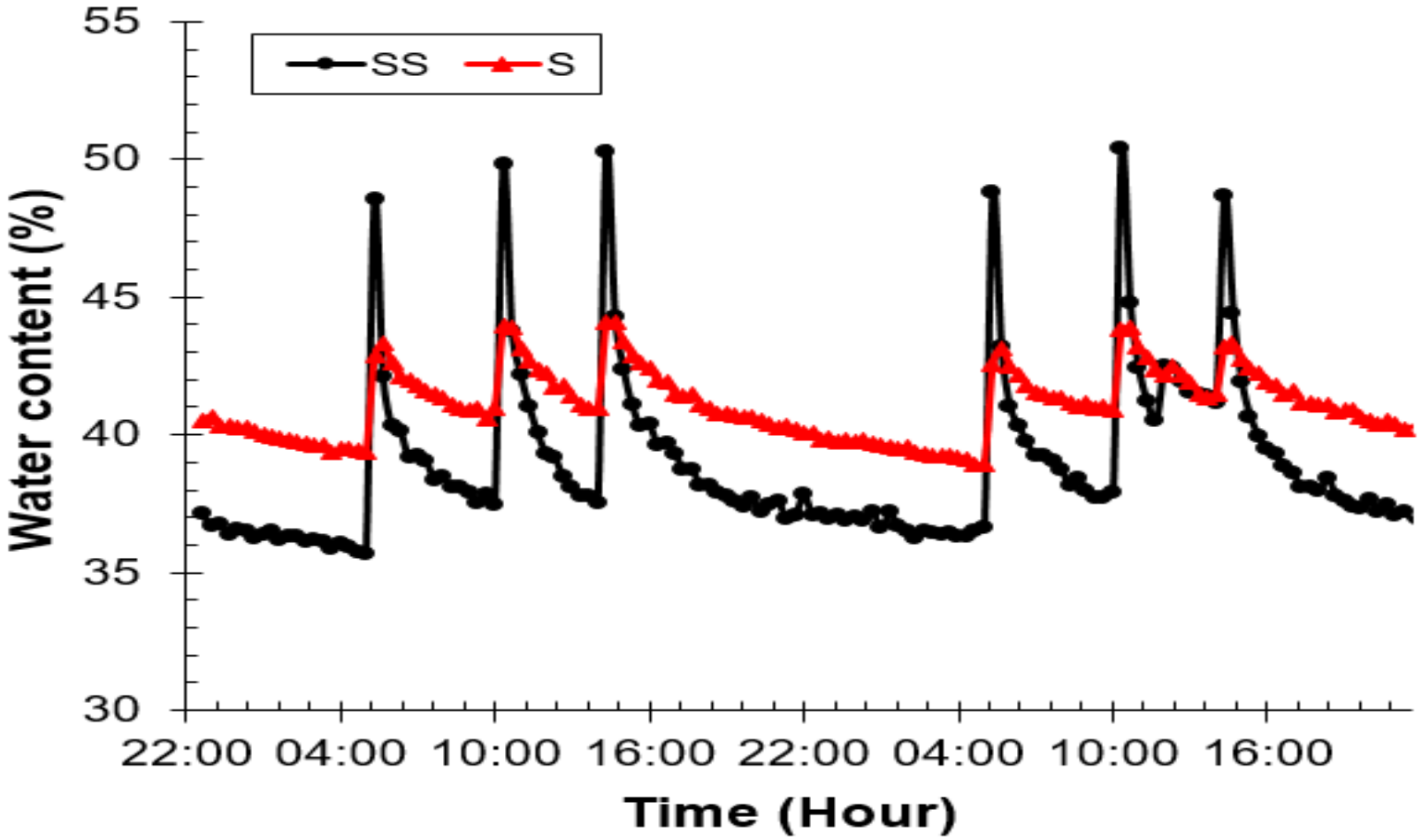

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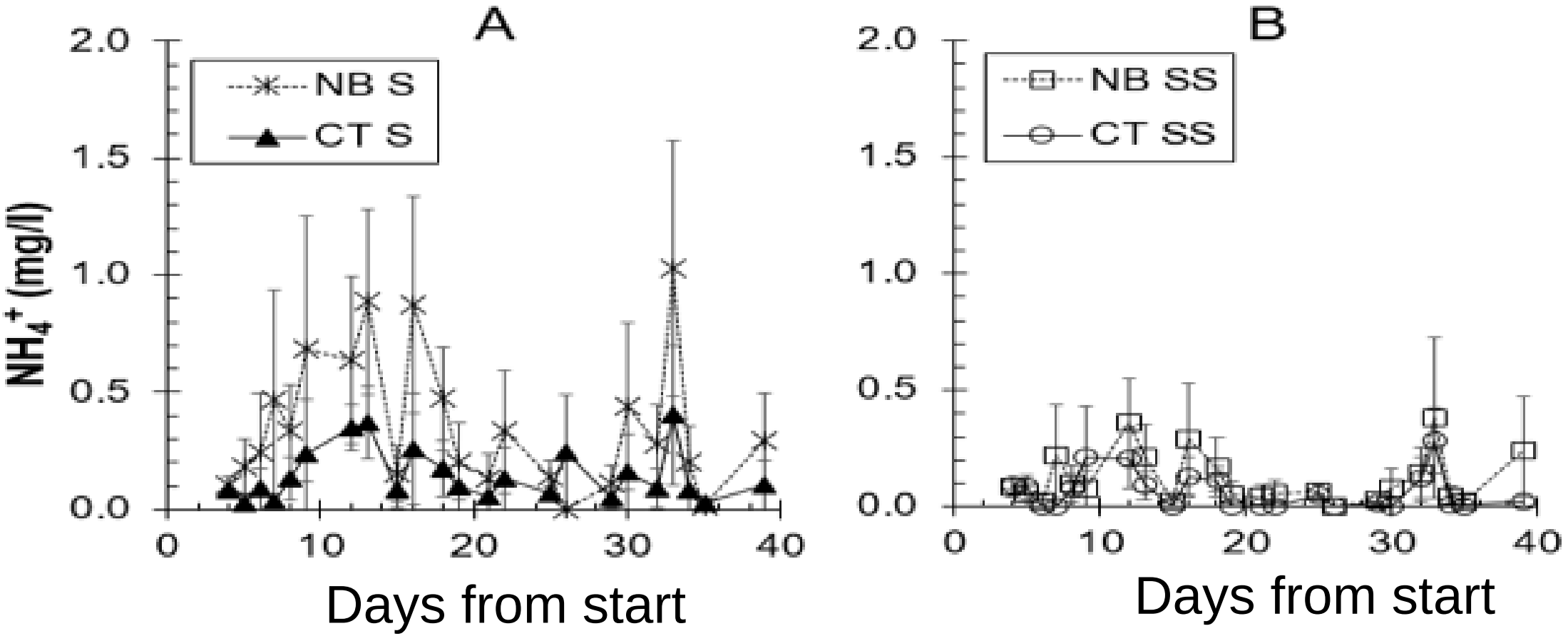
Daily mean pore-water concentrations of NH_4^+



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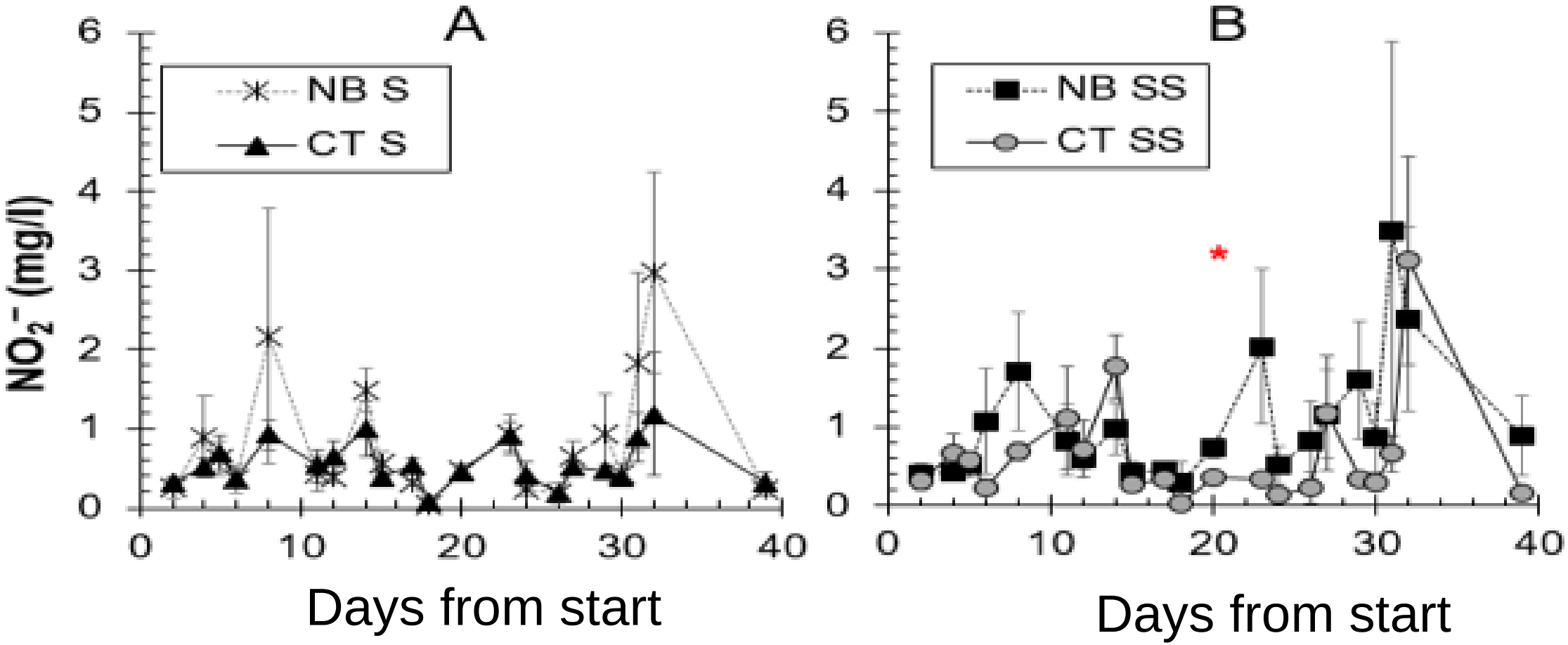
Daily mean pore-water concentrations of NO_2^-



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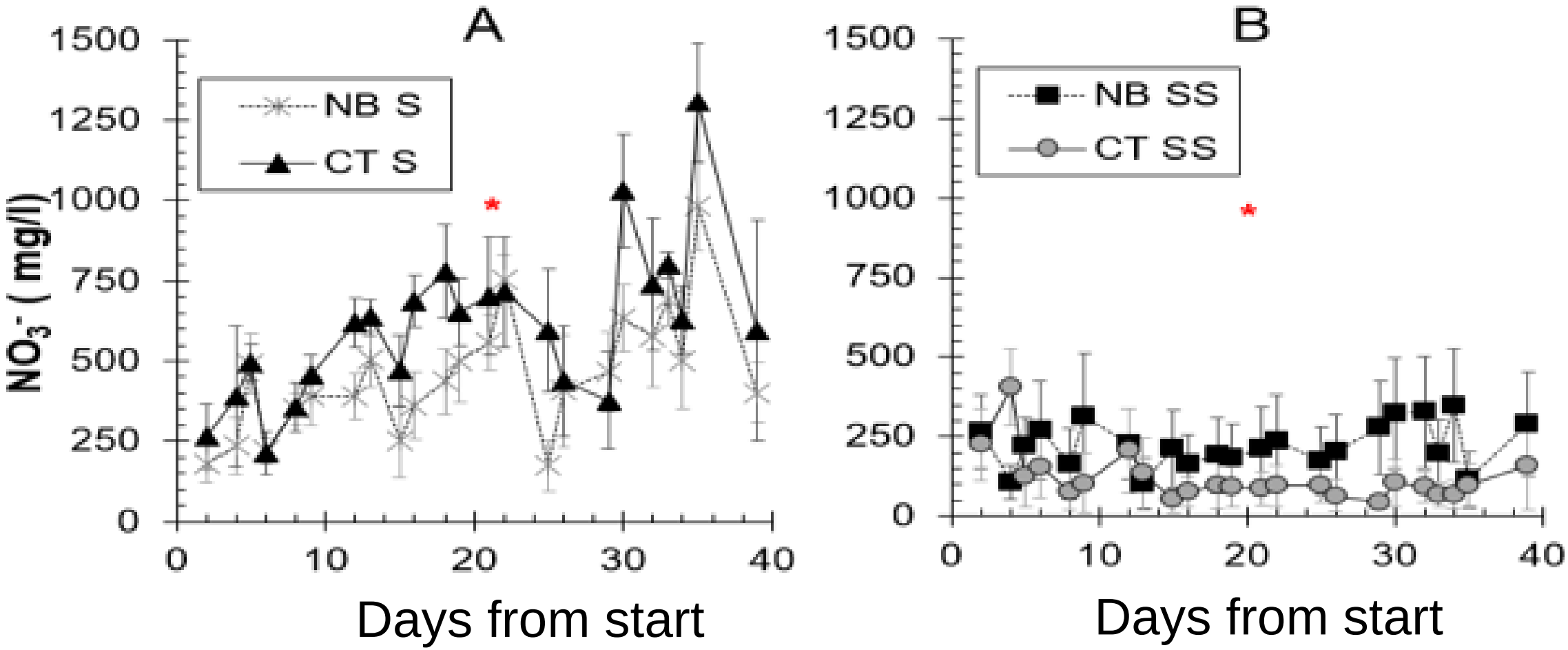
Daily mean pore-water concentrations of NO_3^-



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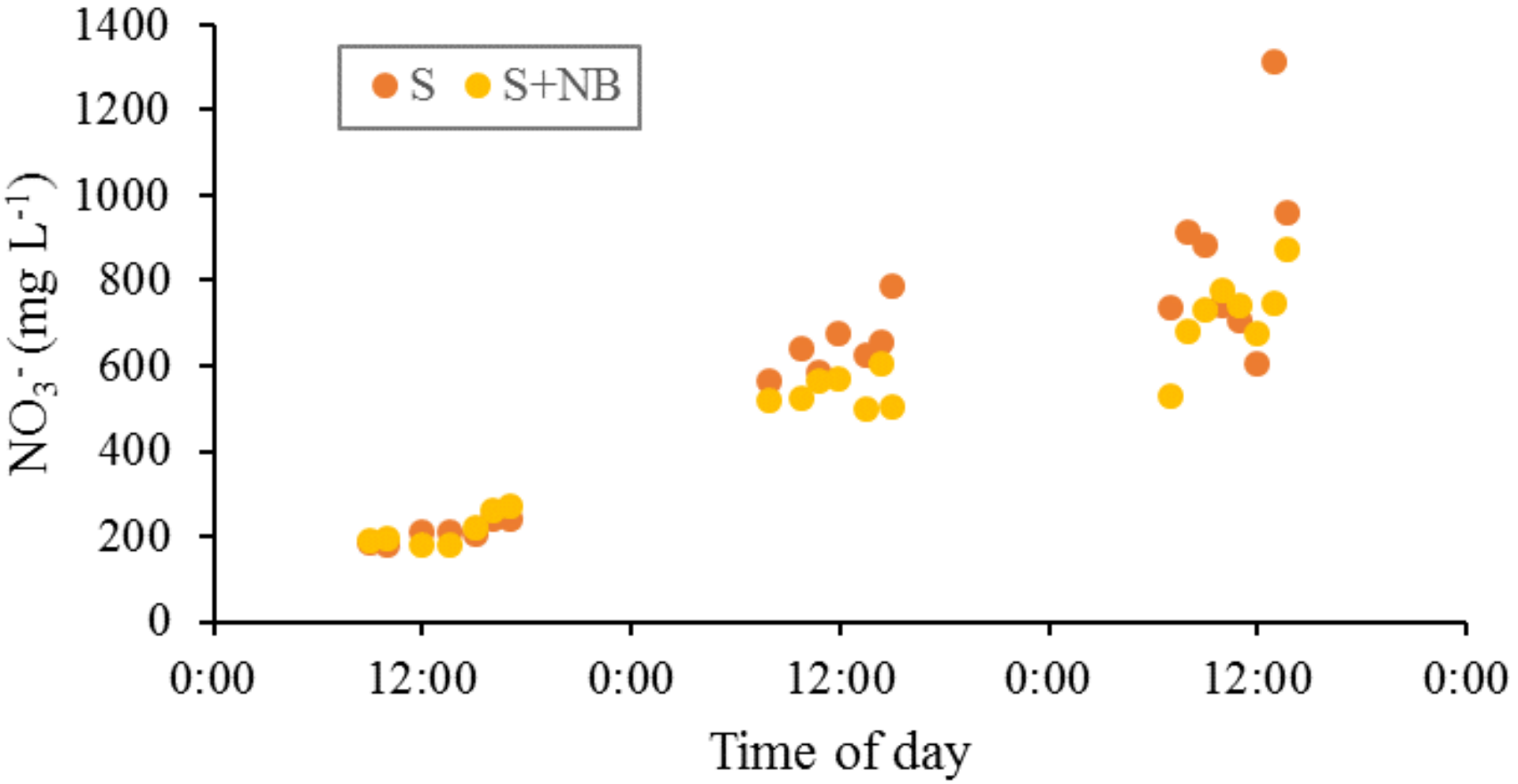
Daily trend in pore-water concentrations of NO_3^-



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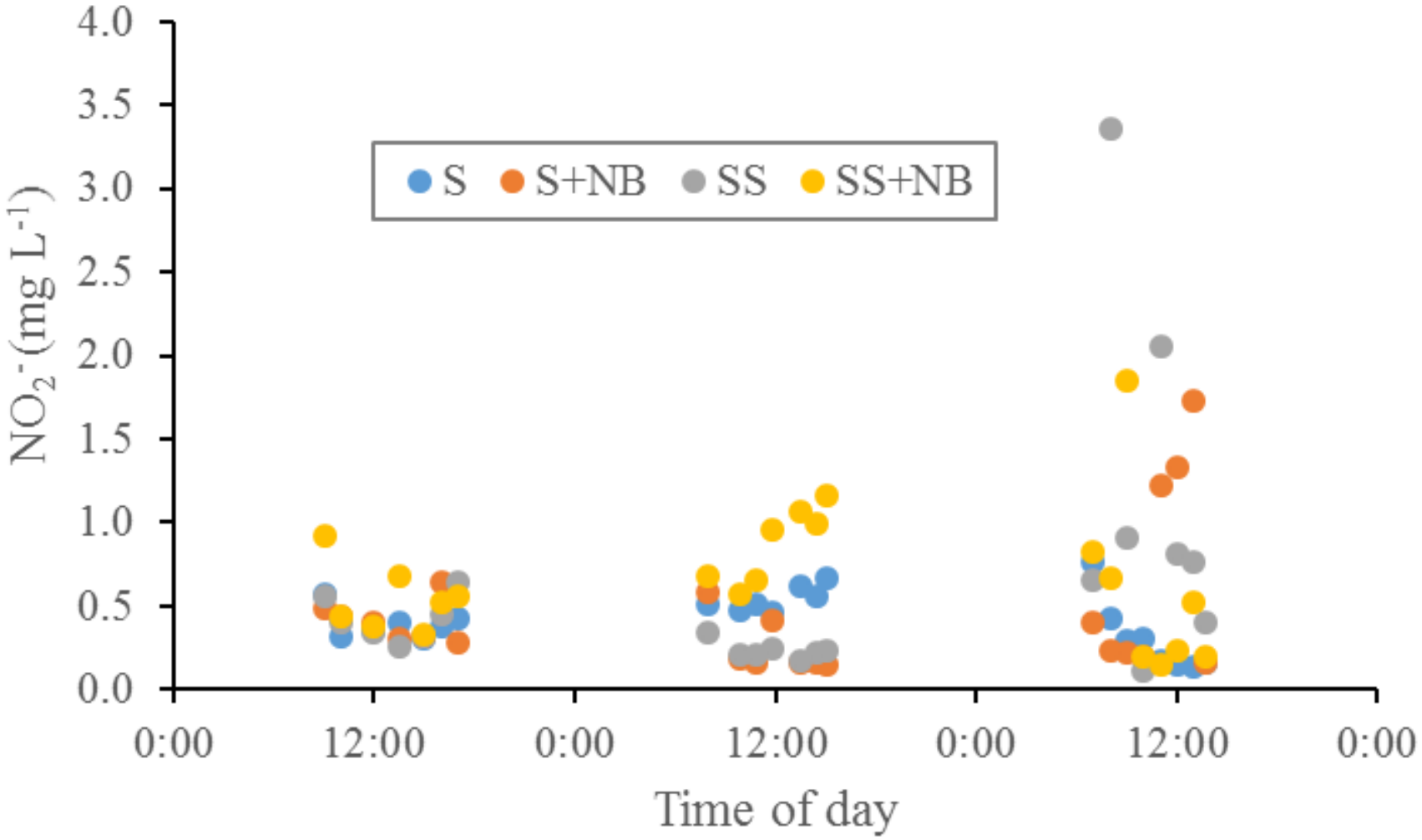
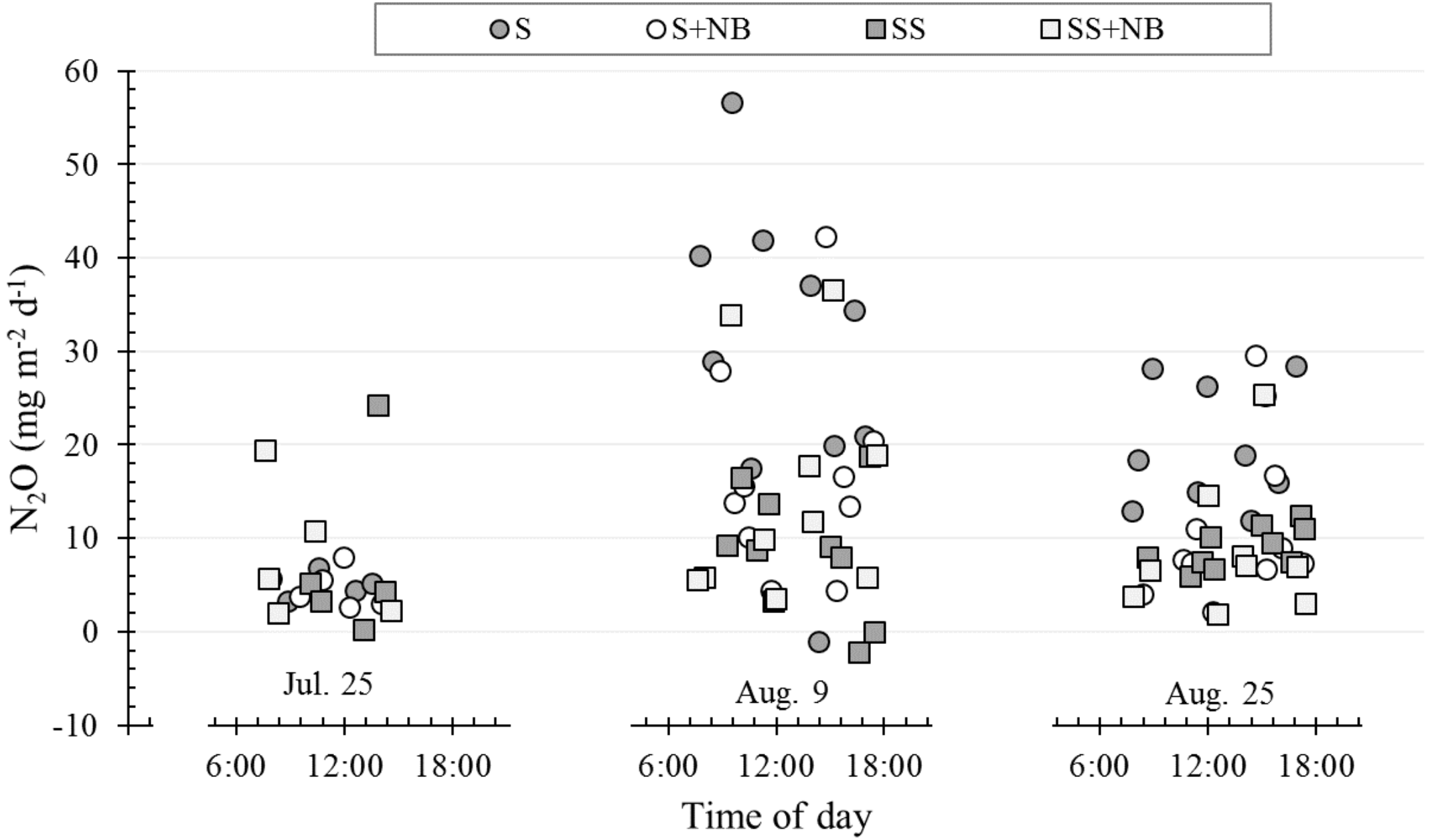
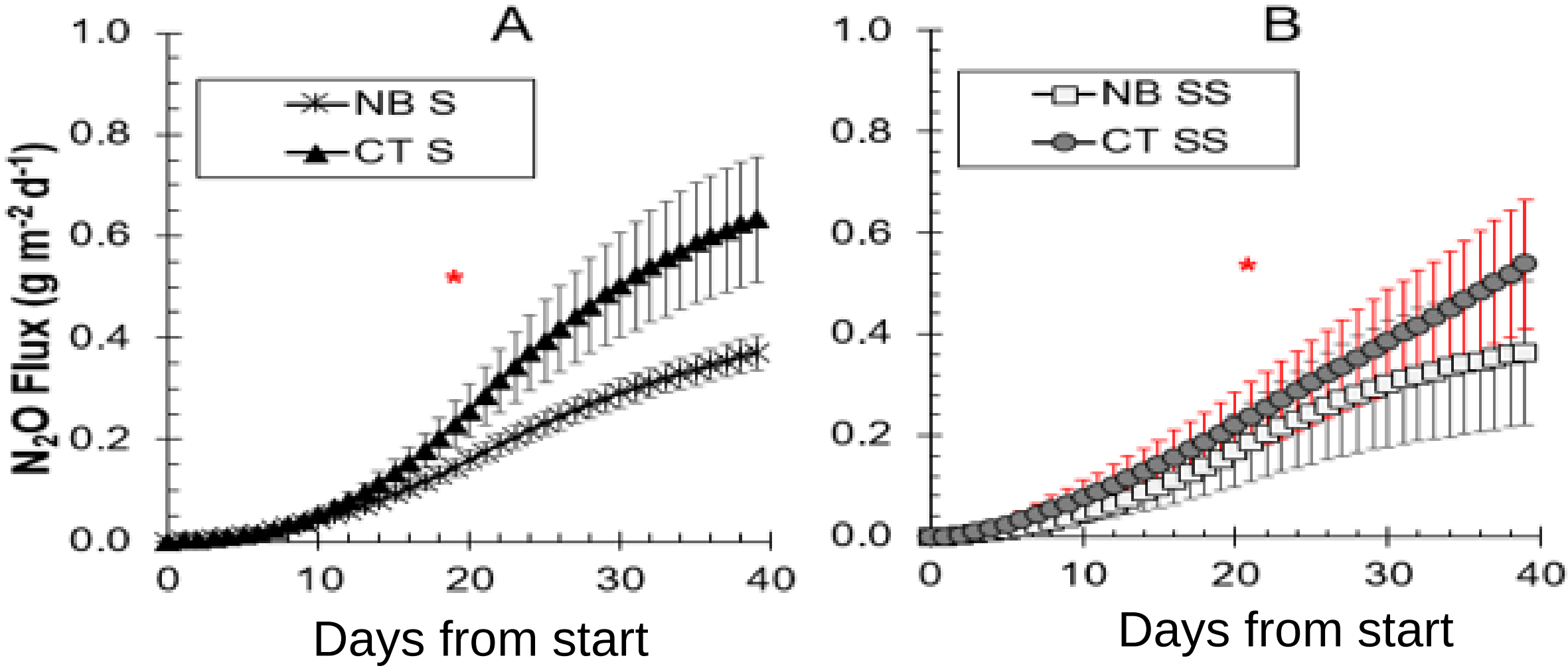
Daily trend in pore-water concentrations of NO_2^-




S
S+NB
SS
SS+NB
60
50
40
30
20
10
0
-10
N_2O (mg m^{-2} d^{-1})
Jul. 25
Aug. 9
Aug. 25
6:00
12:00
18:00
Time of day


A
B
NB S
CT S
NB SS
CT SS
N_2O Flux (g m^{-2} d^{-1})
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
Days from start
Days from start

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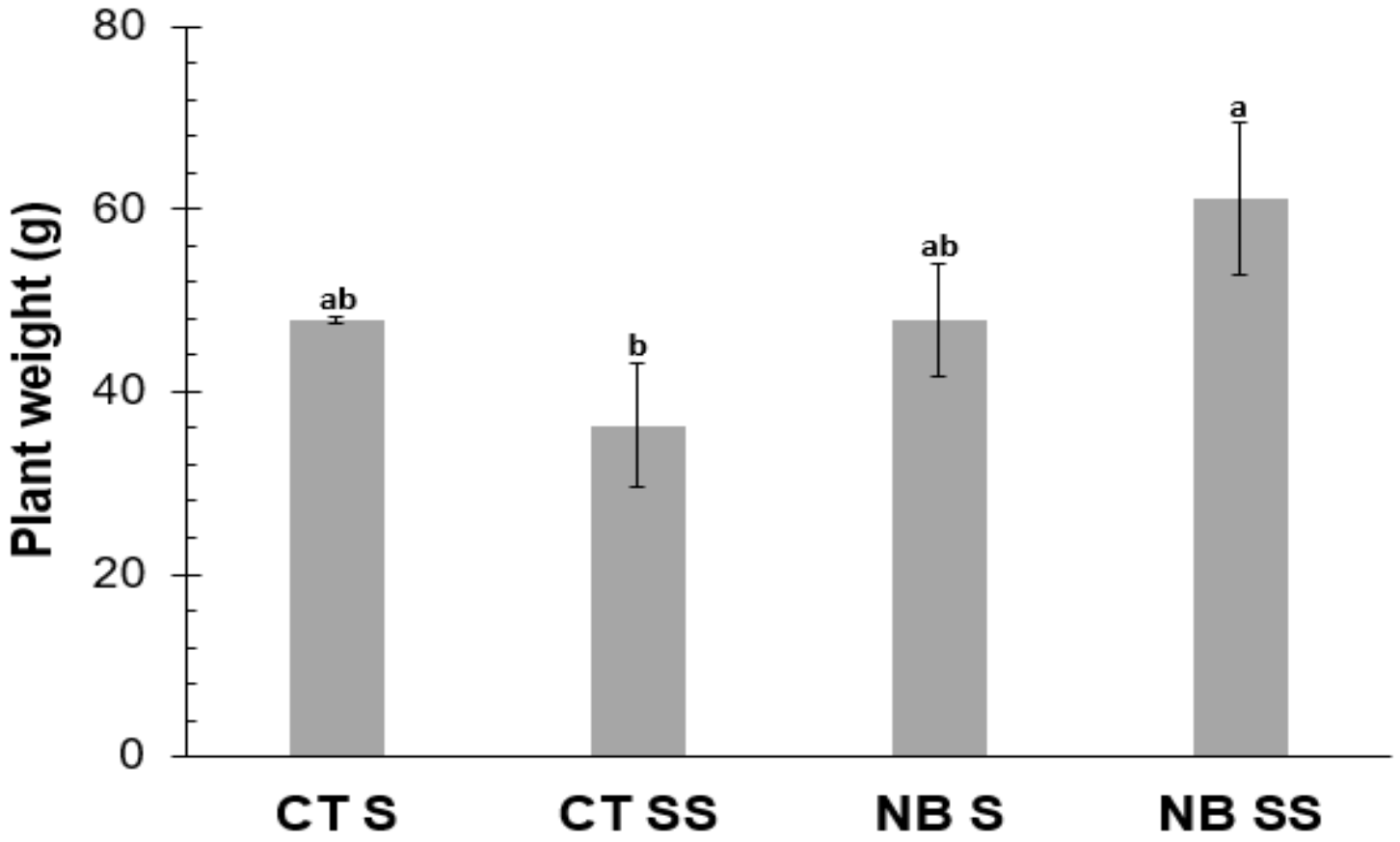
Yield



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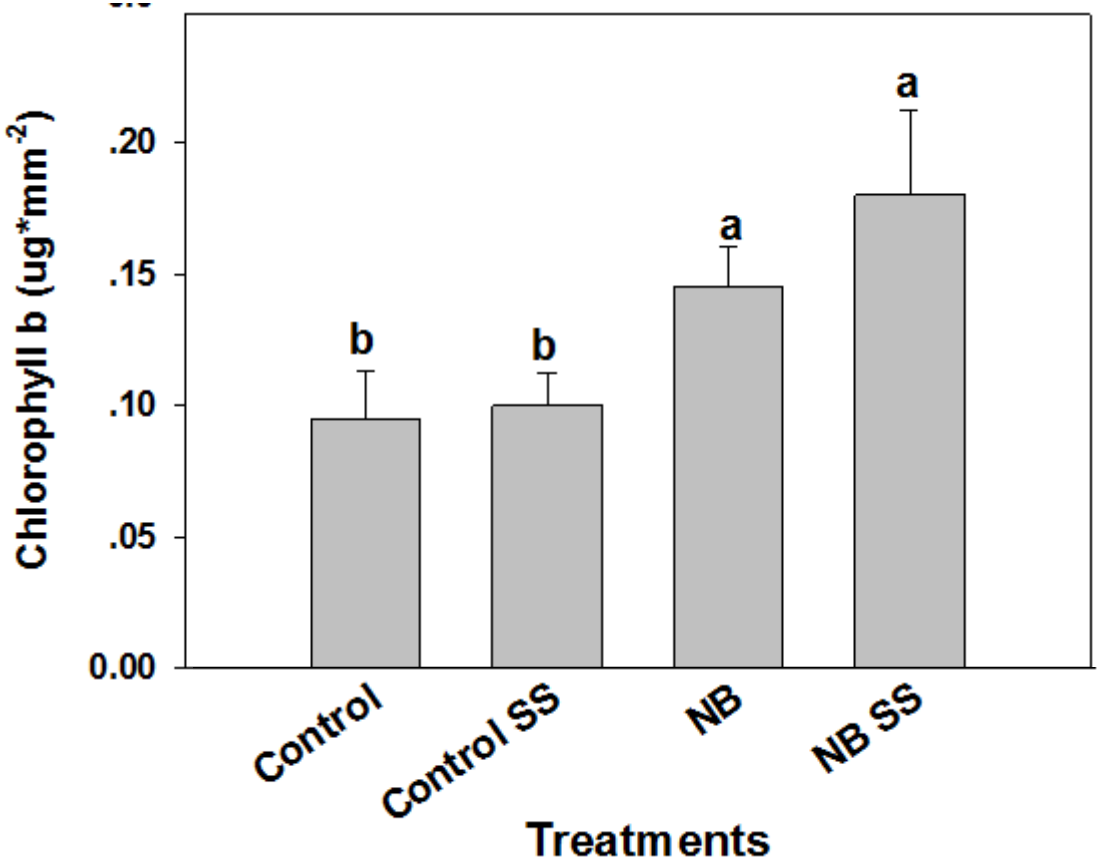
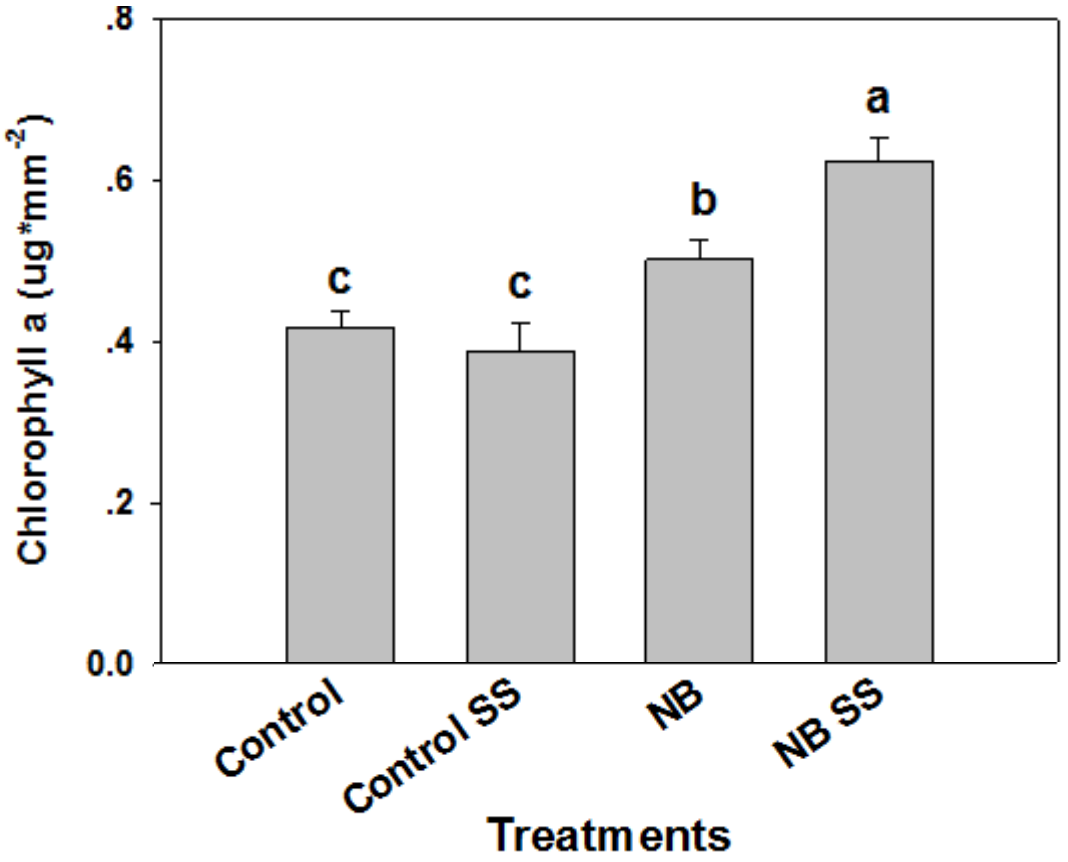
Plant response





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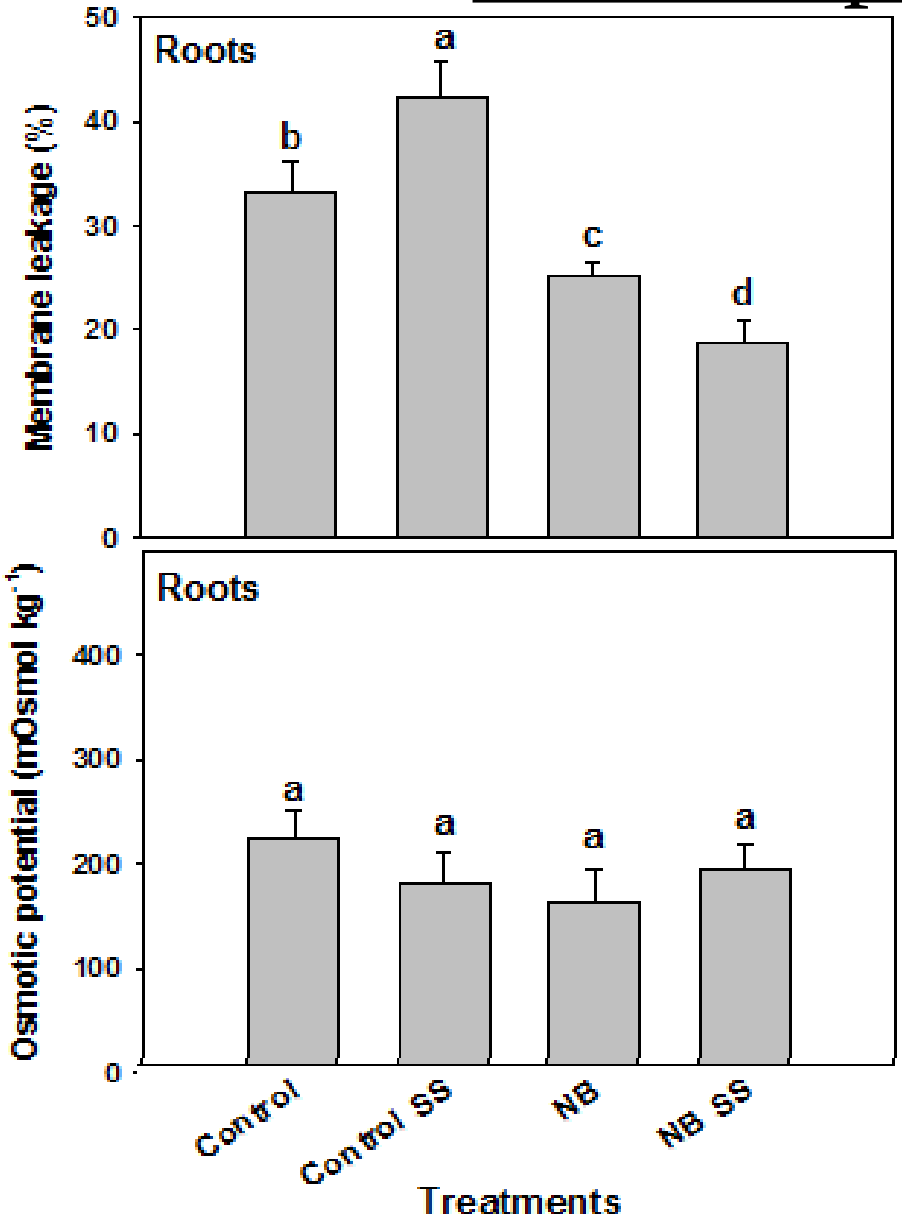
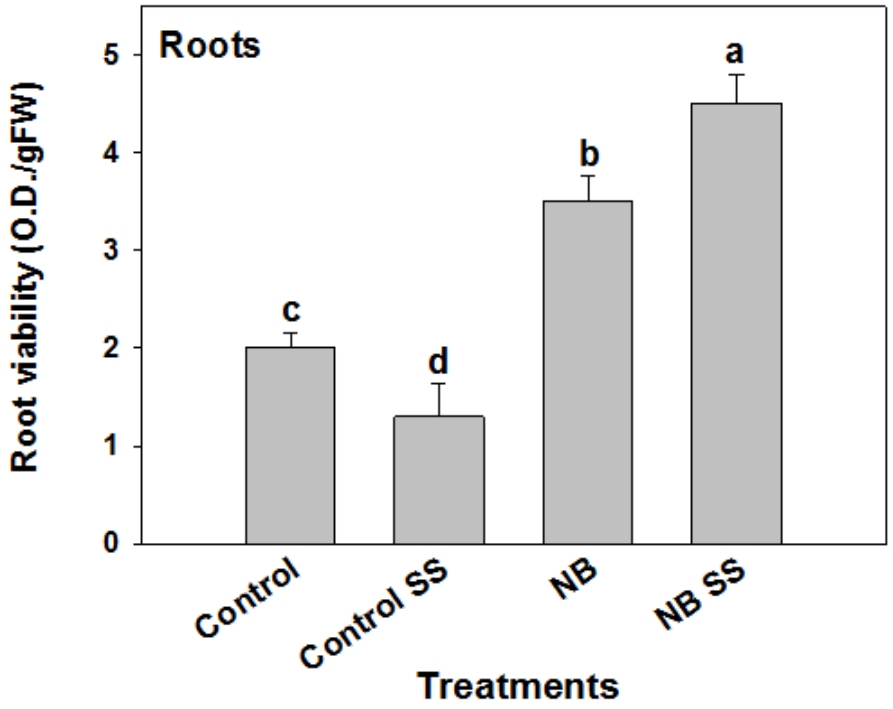
Plant response





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Conclusion

Infusion of NB into TWW irrigation:

- Increase oxygen availability in the soil without the need for changes in the system infrastructure
- Increases yield and plant health
- Reduces N_2O emissions
- Potential for increased WUE and NUE

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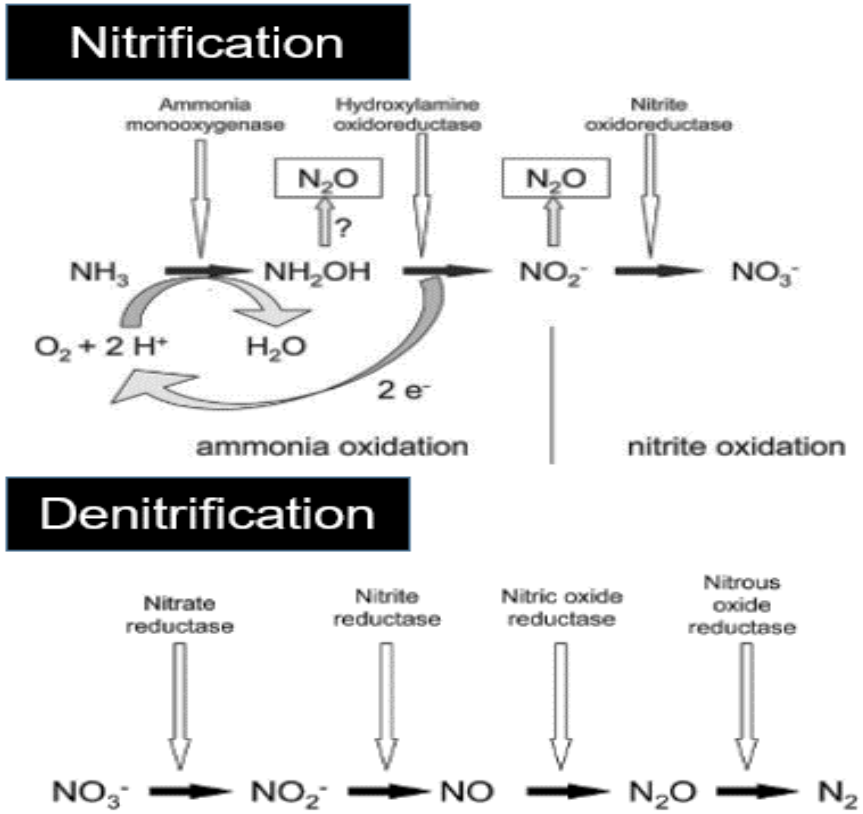
Thank you for your attention


Nitrification
Ammonia monooxygenase
Hydroxylamine oxidoreductase
Nitrite oxidoreductase
N_2O
?
N_2O
NH_3
NH_2OH
NO_2^-
NO_3^-
$O_2 + 2\ H^+$
H_2O
$2\ e^-$
ammonia oxidation
nitrite oxidation
Denitrification
Nitrate reductase
Nitrite reductase
Nitric oxide reductase
Nitrous oxide reductase
NO_3^-
NO_2^-
NO
N_2O
N_2

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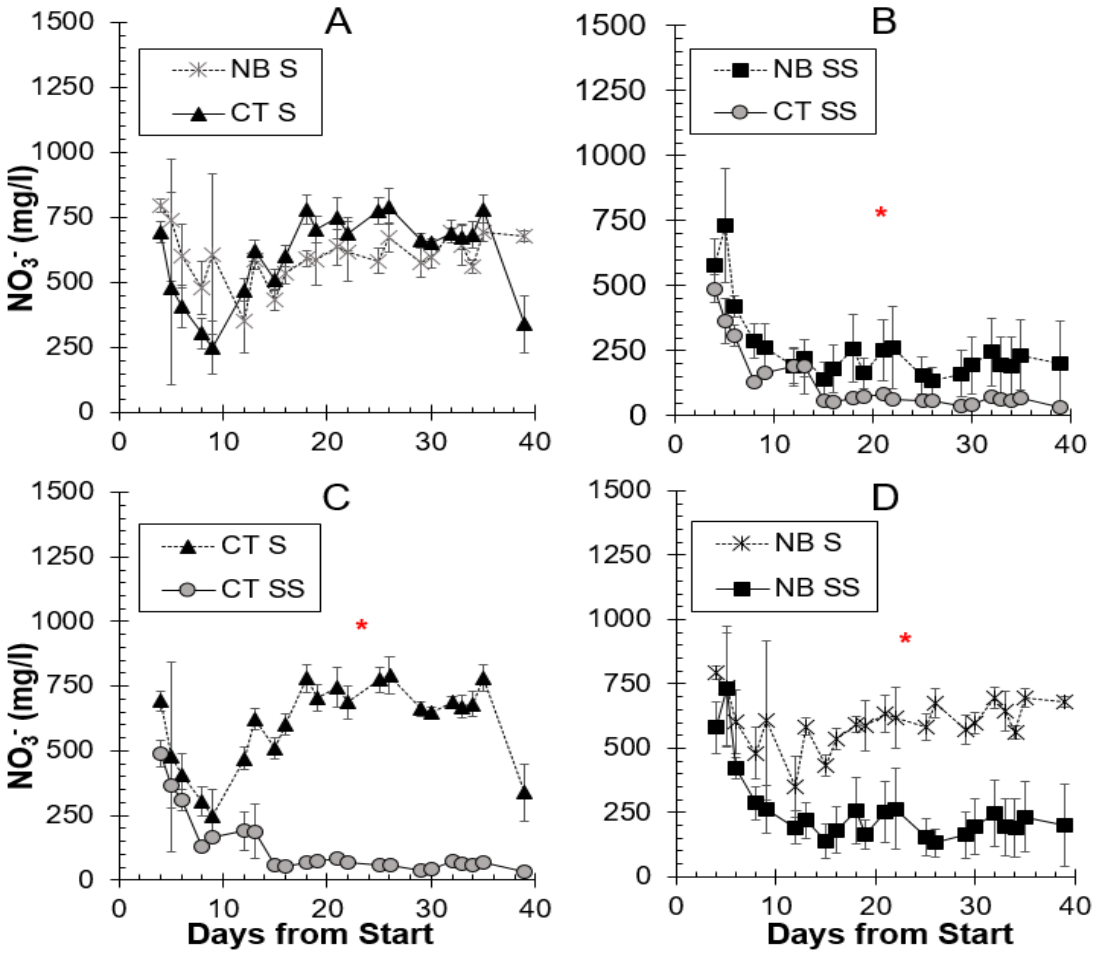
Drainage water



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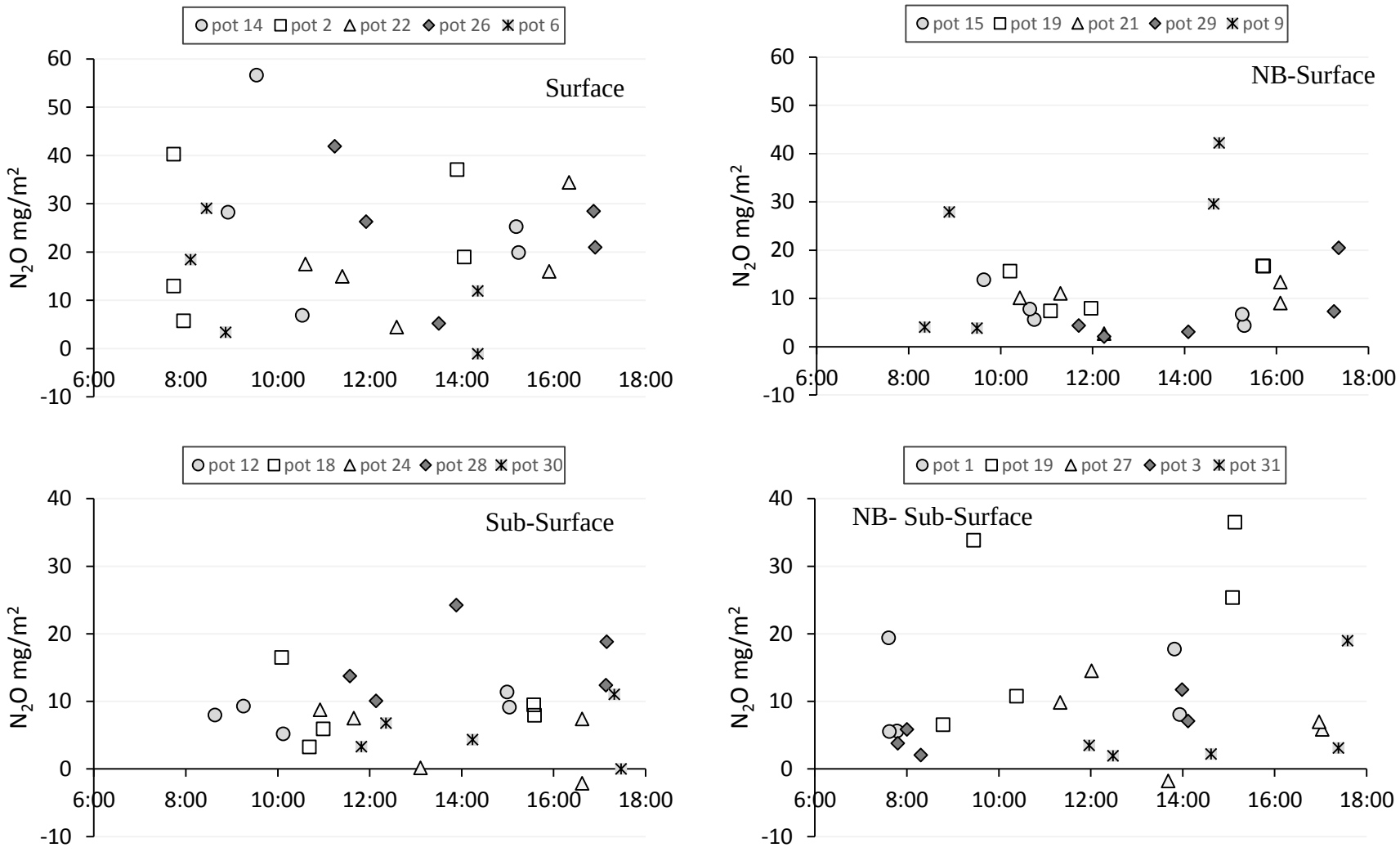

Results: Plant response

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