Evapotranspiration as a criterion to estimate Nitrogen requirement of maize under salt stress

Authors:

Claudivan F. Lacerda
Jorge S. F. Ferreira
Xuan Liu
Donald Suarez

Key Words

- Salinity
- Nutrient demand
- Evapotranspiration
- Photosynthesis
- N losses

Interaction salinity x nitrogen

(Explaining the Hypotheses)

Interactions – A way to become our researches more realists

Salinity and water deficit
Salinity and high temperature
Salinity and waterlogging
Salinity and water deficit and high temperature
Salinity and mineral nutrition

Salinity x Plant Nutrition

Very complex interaction

- Several conditions of salinity – "salinities"
- 15 essential elements
- 300 thousand plant species
- Different nutrient demand
- Different salt tolerance

Salinity

Osmotic + toxic effects

↓Stomatal aperture
↓Transpiration

↓Leaf growth

↓Photosynthesis

↓Evapotranspiration

↓Plant Growth

↓Nutrient extraction

Cowpea irrigated at field conditions

EC w (dS m^{-1})	N	P	K
		Kg ha^{-1}	
0.8	**100**	**10**	**96**
5.0	**59** (-41%)	**5** (-50%)	**49** (-49%)

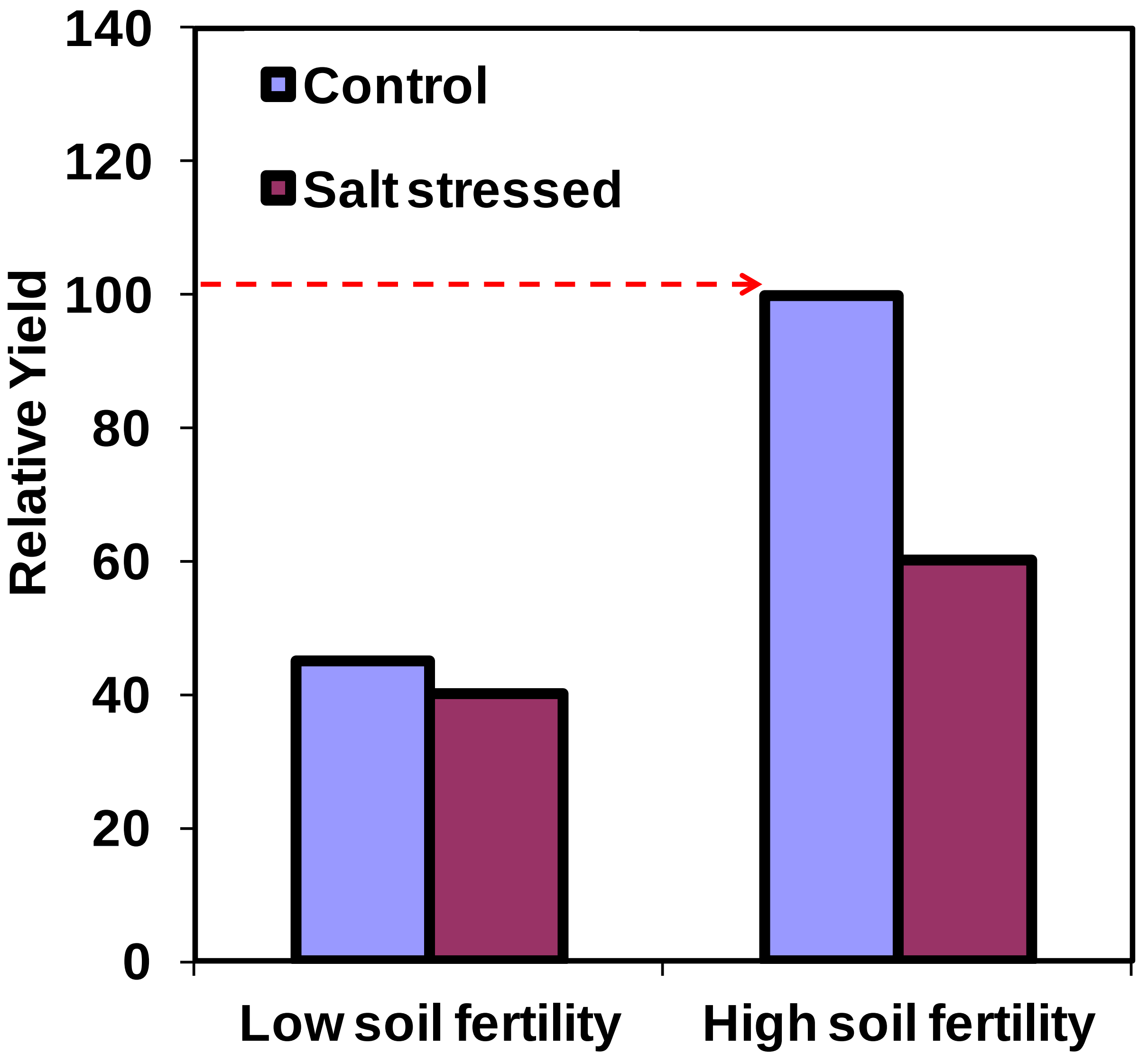
Dry matter – 44% less

(Neves et al., 2009)

In many papers...

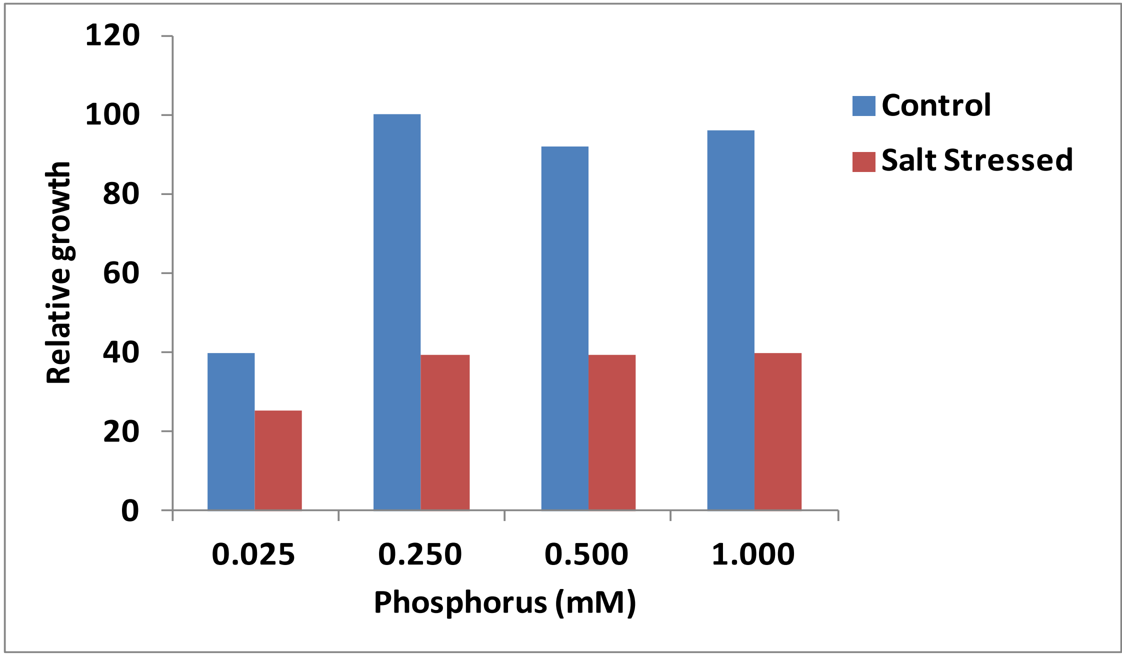
“Application of N (P or K) fertilizers may improve salt tolerance”

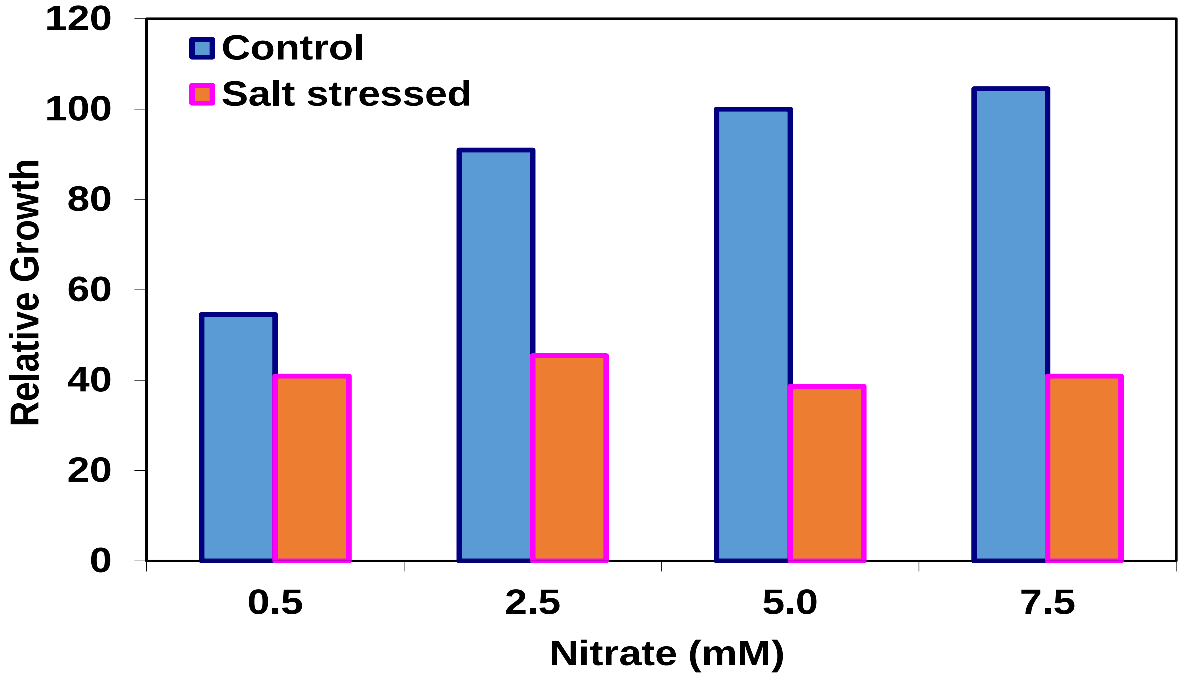
Is it true???



Lacerda et al. (2010)

Cowpea and maize growing at greenhouse





Lacerda et al. (2010)

“Demand of N by plants under salt stress”

Is it higher, same, or lower than that of non-stressed plants???

Three possibilities

- Put additional N fertilizers to increase salt tolerance – **It's not recommended**

- Put the same amount for stressed and non stressed plants – **It's practical**

- **Put less for stressed plants.** **Is it possible?**

If...

1. Salinity reduces growth, water consumption and nutrients demanded by plants

(Shenker et al., 2003; Neves et al., 2009; Lacerda et al., 2010; Segal et al., 2010; Ramos et al., 2012; Zhang et al., 2012; Semiz et al., 2014)

2. There is positive correlation between ET x total N extracted by crops

(Shenker et al., 2003; Feng et al., 2005; Ramos et al., 2012; Wang et al., 2012)

3. Absorption of N is mainly due to mass flow

4. NO_3 uptake is more related to reduced water use than to chloride antagonism

(Lea-Cox and Syvertsen, 1993; Albdelgair et al., 2014)

Then…

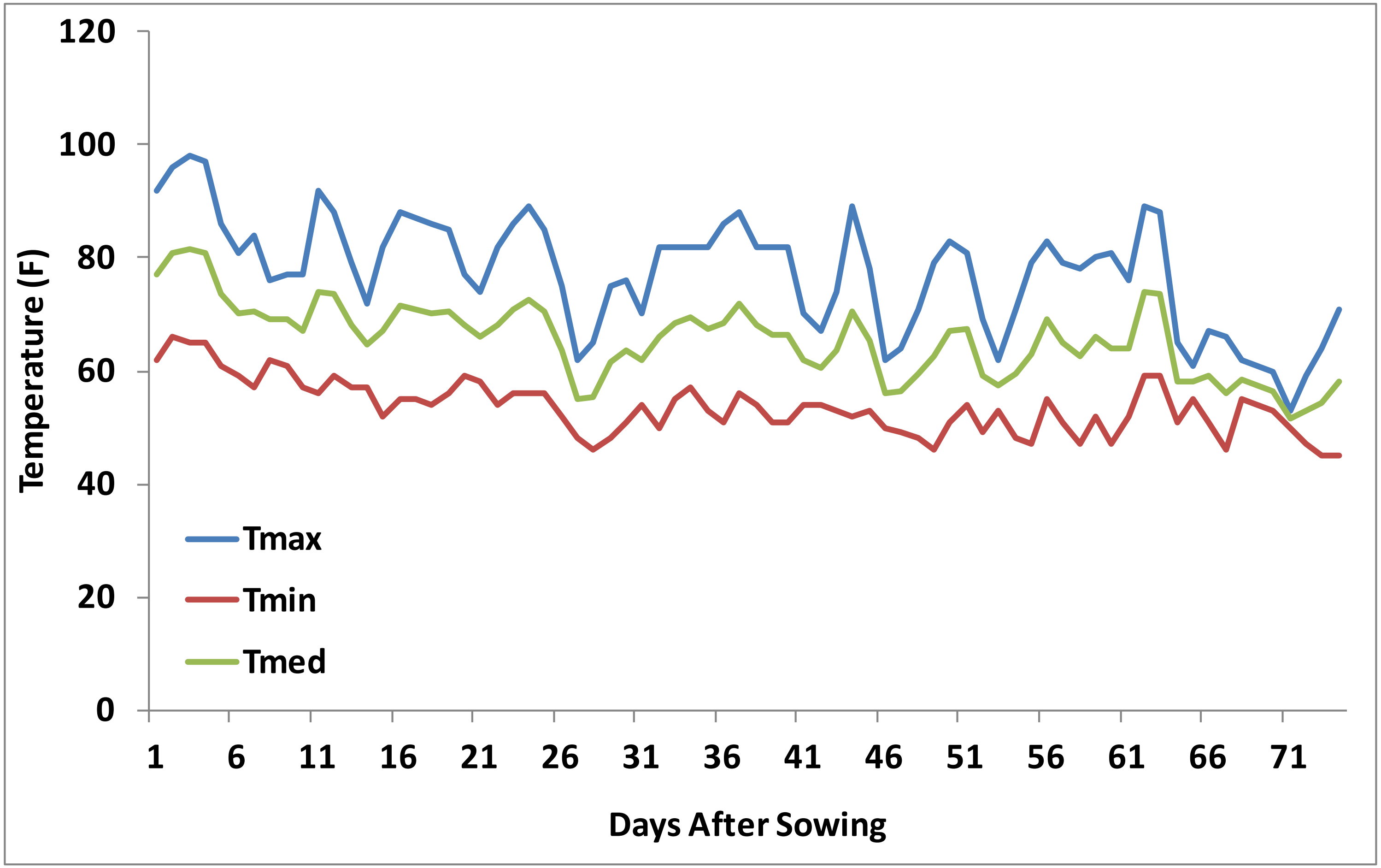
Our hypothesis is that reducing the supply of N, based on the decrease in evapotranspiration expected by increasing salinity, it is possible to reduce N loss and to increase N-use efficiency without cause nitrogen deficiency in salt-stressed maize plants.

Experimental Procedures

Experimental conditions

- US Salinity Laboratory/ARS/USDA
- University of California, Riverside – UCR
- September 13th to November 26th

Air temperature during the experiment



Experimental conditions

- 80 soil columns – diameter of 20 cm and length of 100 cm
- Soil – sandy loam soil, pH 6.8, ECe 1.6 dS m^{-1}
- The soil was passed through a 5-mm metal sieve.

Bottom - 10 cm fine sand

Soil – 84 cm

8 cm layer

Bulk density: 1.7

Experimental design and treatments

- complete randomized block design following a 4 x 4 factorial, 5 replications

- 4 ECw - 0.5; 2.5; 5.0; and 7.5 dS m^{-1}

NaCl, $CaCl_2.2H_2O$, and $MgCl_2.6.H_2O$ salts in a 7:2:1 ratio

- 4 N rates

N rates

- **N1: N recommendation for maize (2.6 g per plant);**
- N2: 0.3 times the N recommendation for maize (0.78 g per plant);
- **N3: Reduction in N1 based on the decrease in evapotranspiration caused by salinity in the previous stage;**
- N4: Reduction in N2 based on the decrease in evapotranspiration caused by salinity in the previous stage.

Salinity and N rates

Table 1. Rates of nitrogen **(g per column)** applied for different salt treatments

ECw (dS m^{-1})	Rates of Nitrogen[1]			
	(N1)	**(N2)**	**(N3)**	**(N4)**
0.5	**(2.60)**	**(0.78)**	**(2.60)**	**(0.78)**
2.5	**(2.60)**	**(0.78)**	**(2.42)**	**(0.725)**
5.0	**(2.60)**	**(0.78)**	**(2.21)**	**(0.663)**
7.5	**(2.60)**	**(0.78)**	**(1.82)**	**(0.546)**

[1]The amounts of N for N3 and N4 were reduced (in relation to N1 and N2) in 7, 15, and 30% for 2.5, 5.0 and 7.5 dS m^{-1}, respectively;

Nutrients application

The application of N and K

15% at sowing;

25% at 20 days after sowing (DAS);

30% at 35 DAS

30% at 50 DAS.

The reduction in N application according to evapotranspiration (N3 and N4) started at 20 DAS.

K_2O - 120 kg ha^{-1}

P_2O_5 – 85 kg ha^{-1}

Micronutrient – solid complex Micromax + Hoagland solution

Evapotranspiration (ET) and irrigation (I)

- ET = Water added – water drained
- Irrigation each other day
- I = ET/0.9
- two rainfalls were observed (13 and 25 mm)
- Actual leaching fraction for treatments were respectively, 0.16, 0.17, 0.19, and 0.23

Plant material

- *Zea mays* L. cv Nothstine Dent
- Thinning was done 7 days after sowing (DAS), leaving only one plant per column.
- The treatment with saline waters was initiated eight DAS.
- All evaluations were carried out during the vegetative growth stage and the start of the reproductive stage.

Plant Analysis

Plant growth (74 DAS)

Leaf gas exchange (38, 53 and 68 DAS)

Chlorophyll index (38, 53 and 68 DAS)

Nitrogen compounds

Carbohydrates

Nitrogen use efficiency (NUE)

Water use efficiency (WUE)

Leas gas exchange and Chlorophyll index -

Soil analyses

Soil layers – 0-20; 20-40; 40-60; 60-80 cm

- ECe

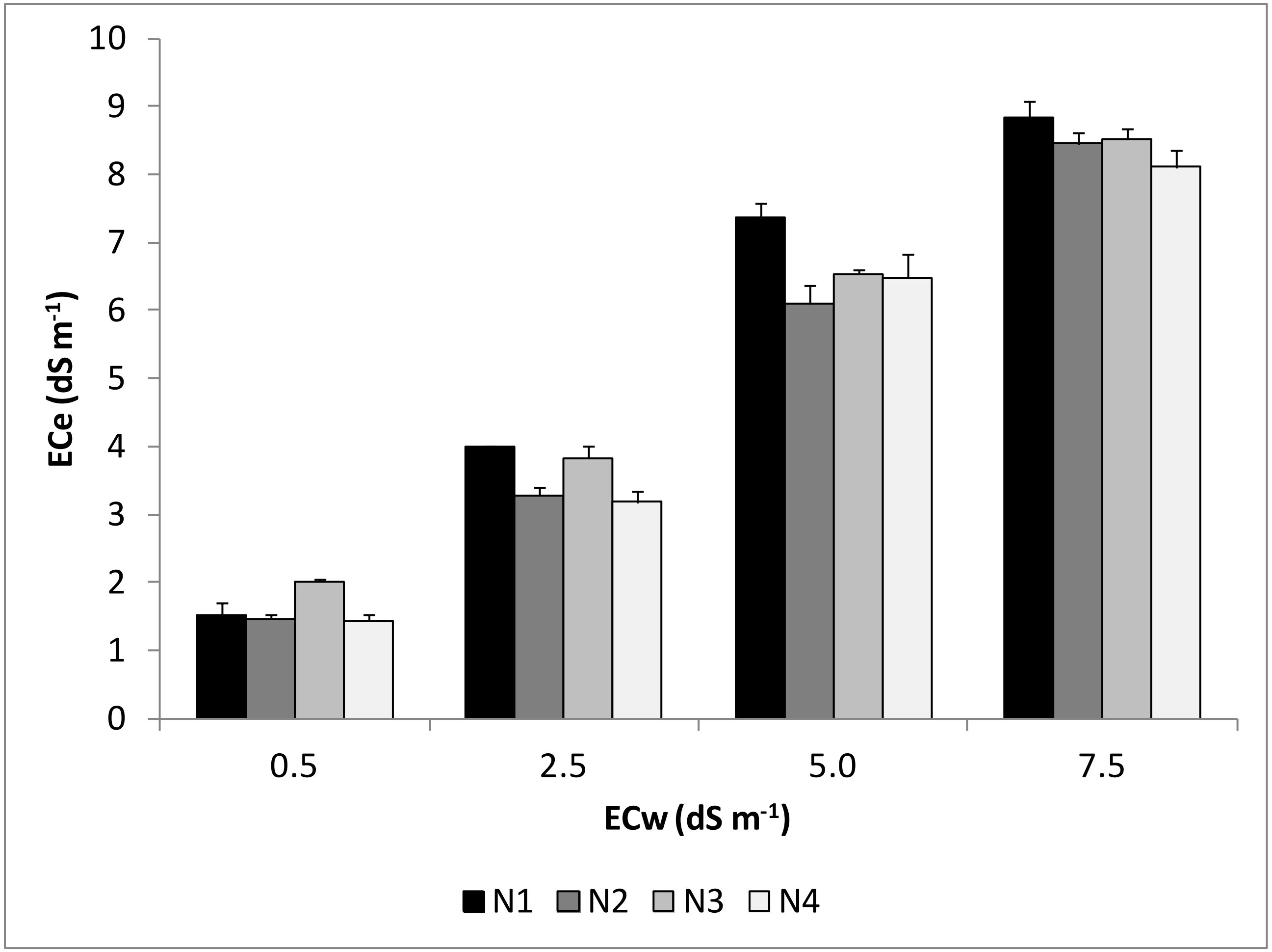
- Nitrate concentration

- ΔN-nitrate in the soil

$\Delta N\text{-}NO_3 = (N\text{-}NO_3 \text{ final}) - (N\text{-}NO_3 \text{ initial})$

Results

Electrical conductivity (ECe)



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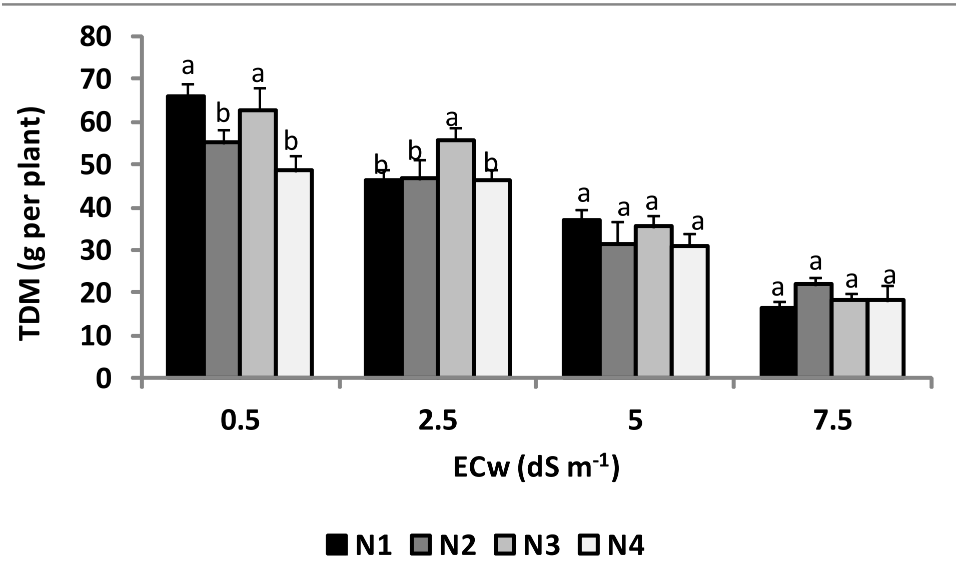
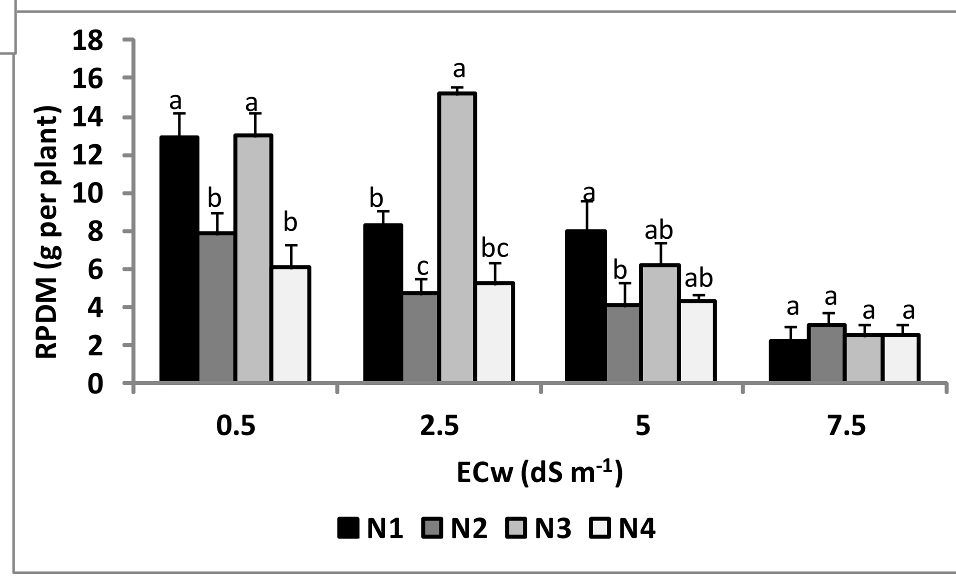
Plant Growth

Total dry matter



N3 ≥ N1

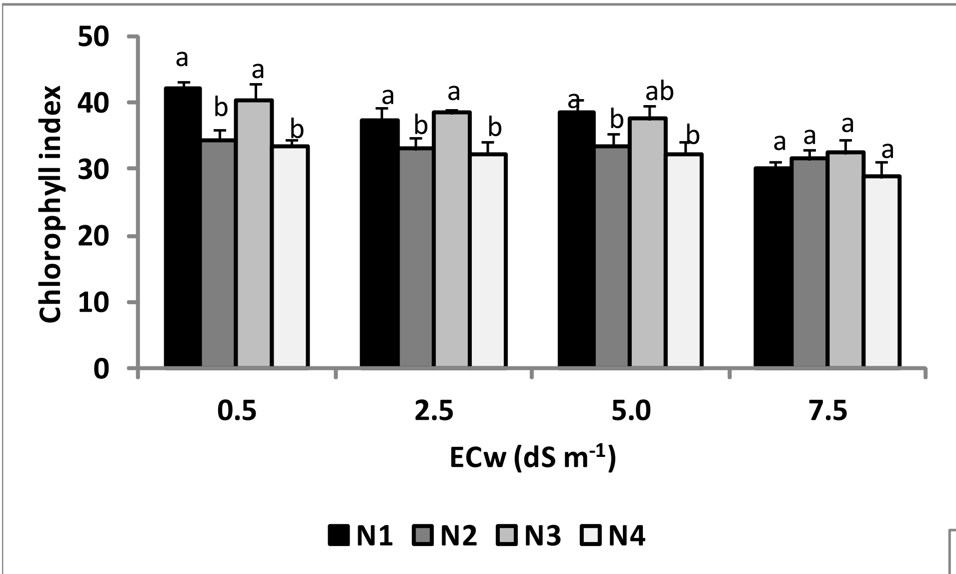
Reproductive dry matter



N3 means less N added for salt stressed plants

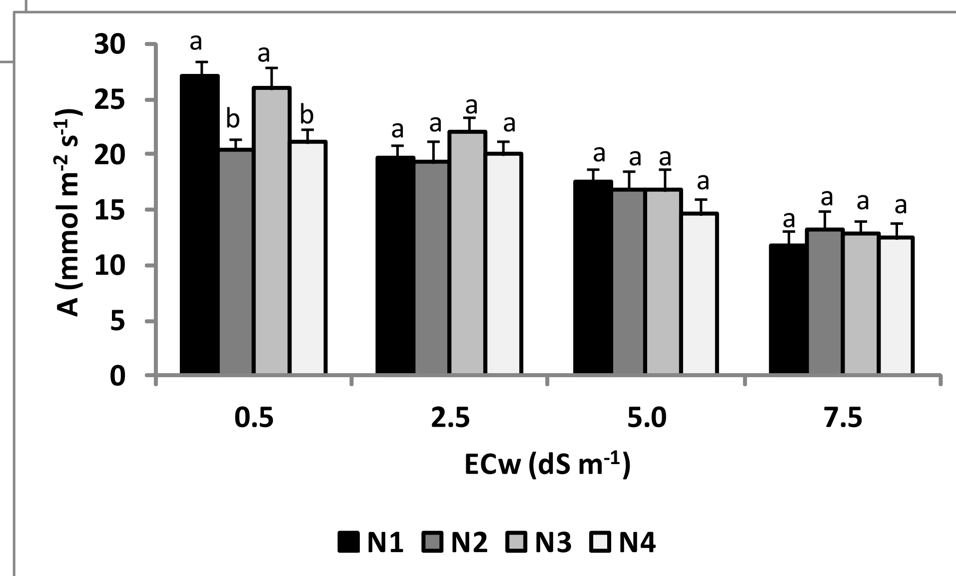
Chlorophyll and Leaf gas exchange

Chlorophyll index



N3 = N1

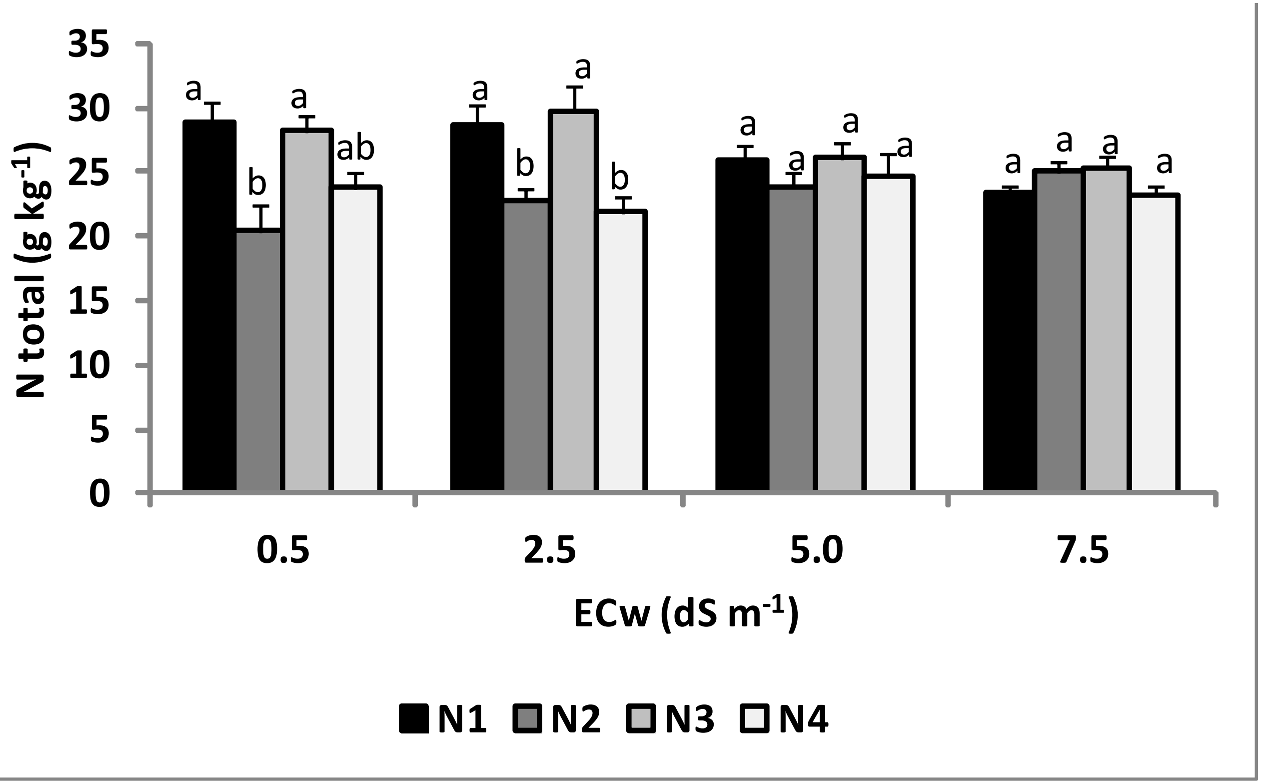
Photosynthesis rate



Similar response for stomatal conductance and transpiration rate

N compounds in the leaves

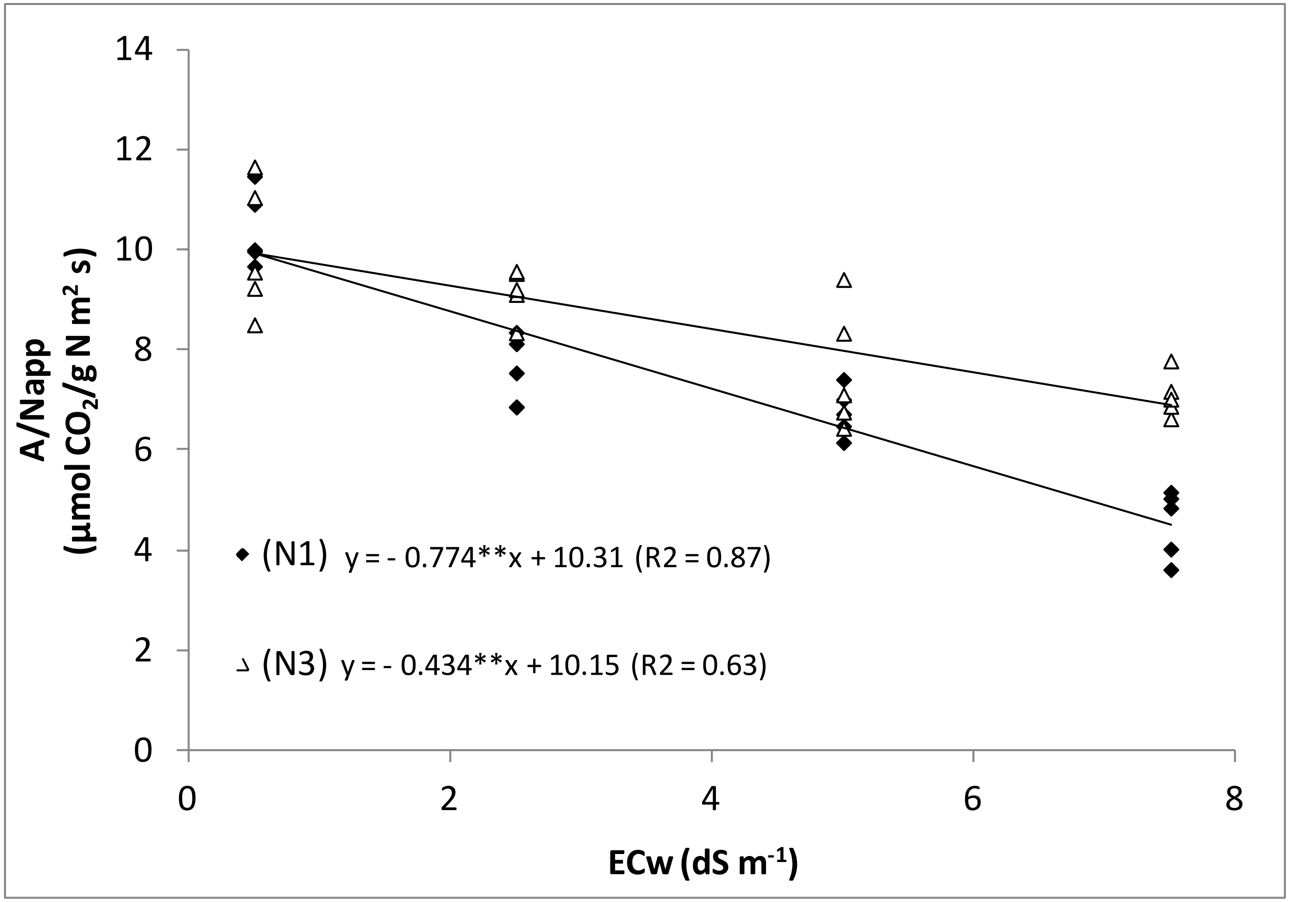
Total N concentration



N3 = N1

Same results for N-protein and N-amino

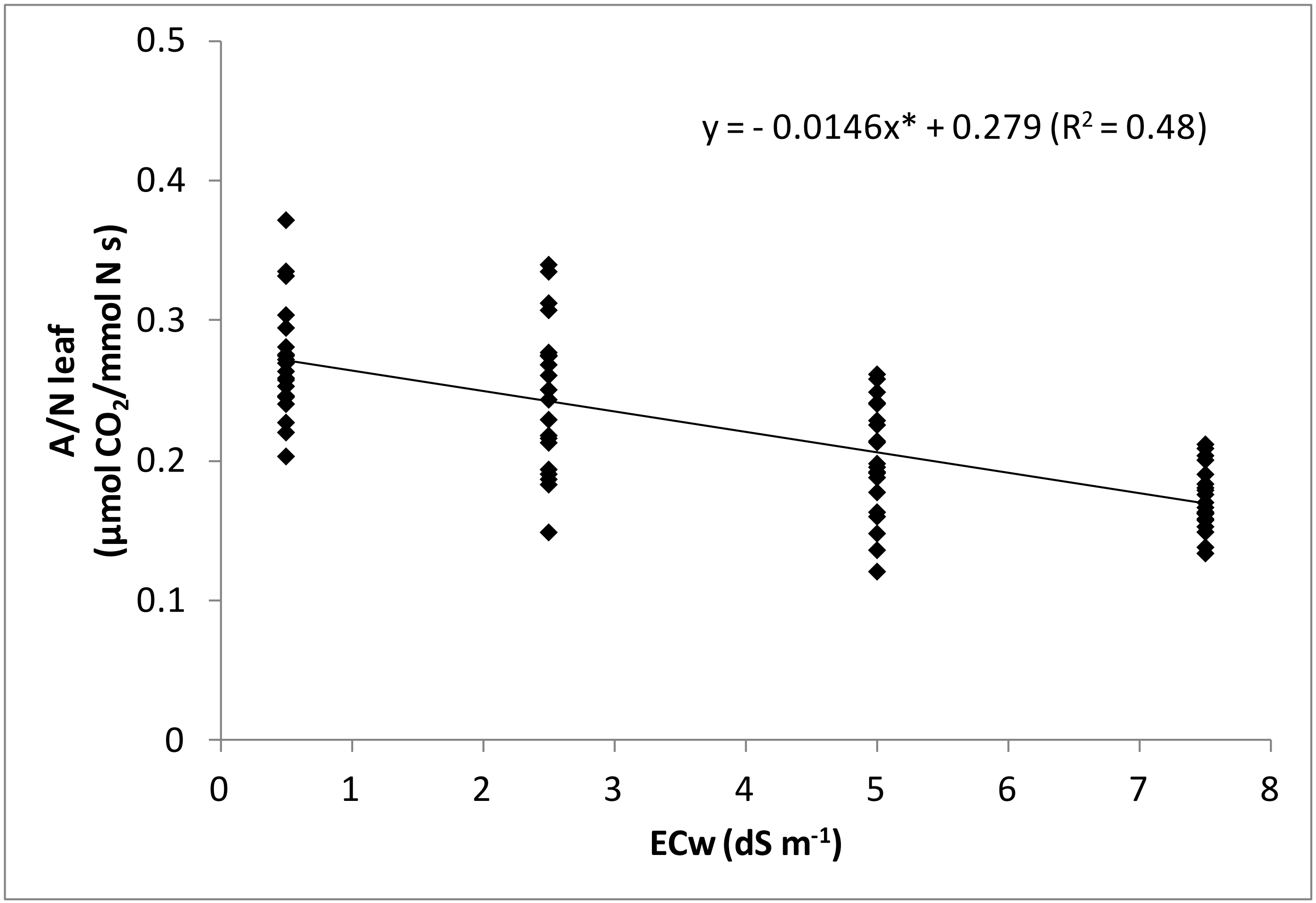
Nitrogen Use efficiency



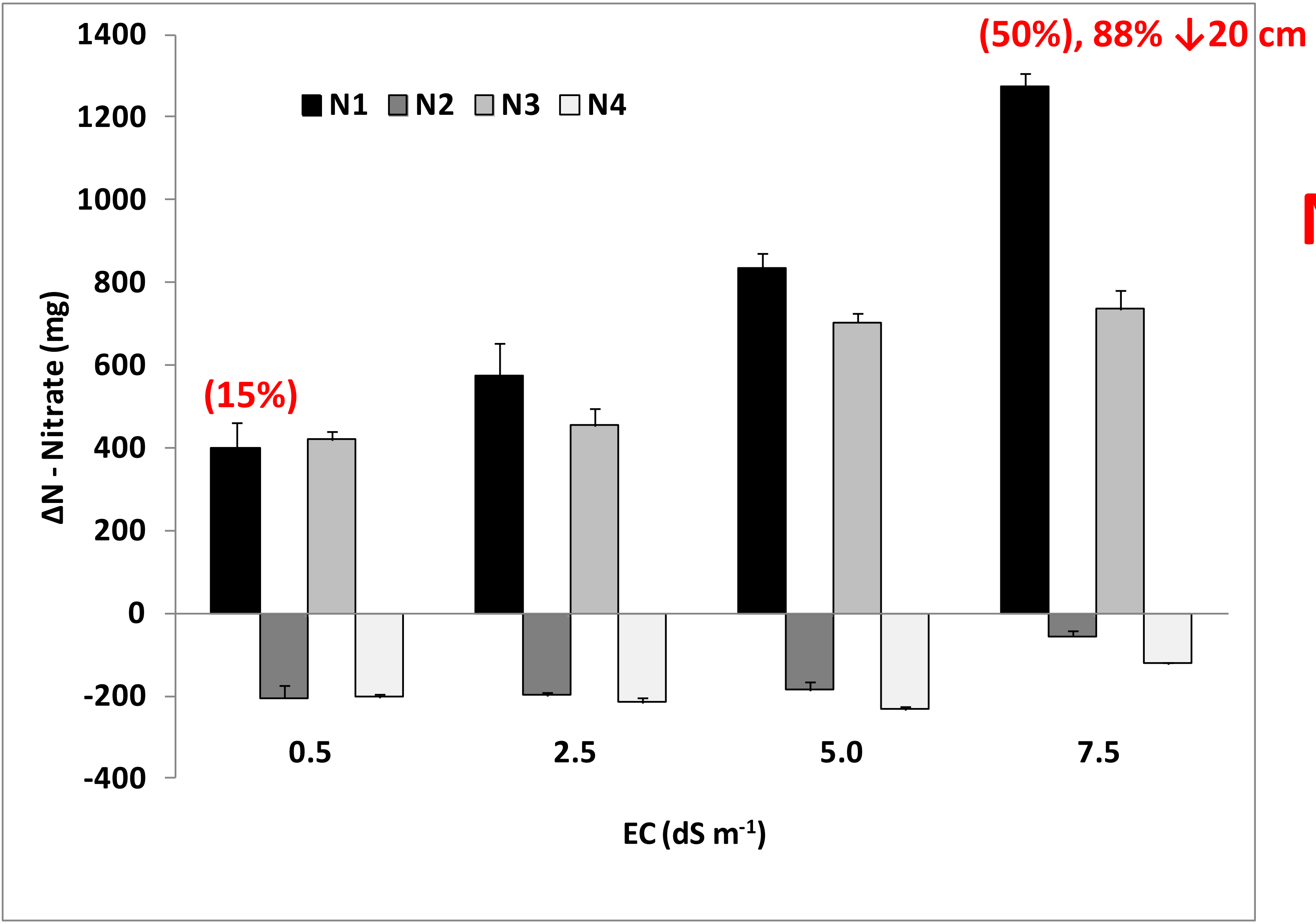
N3 > N1

N3 means less N added for salt stressed plants

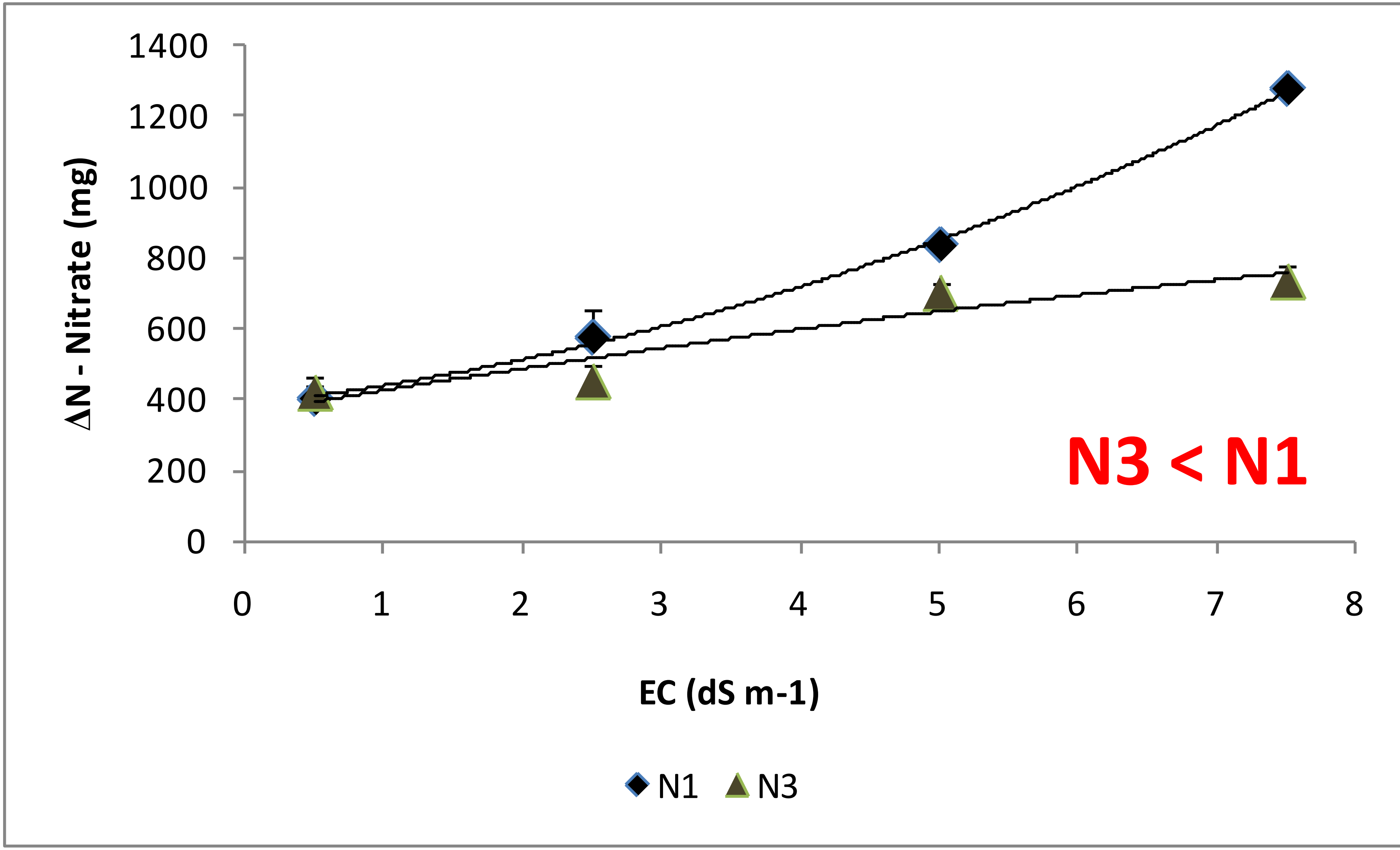
Nitrogen use efficiency



ΔN-NO_3 in the soil

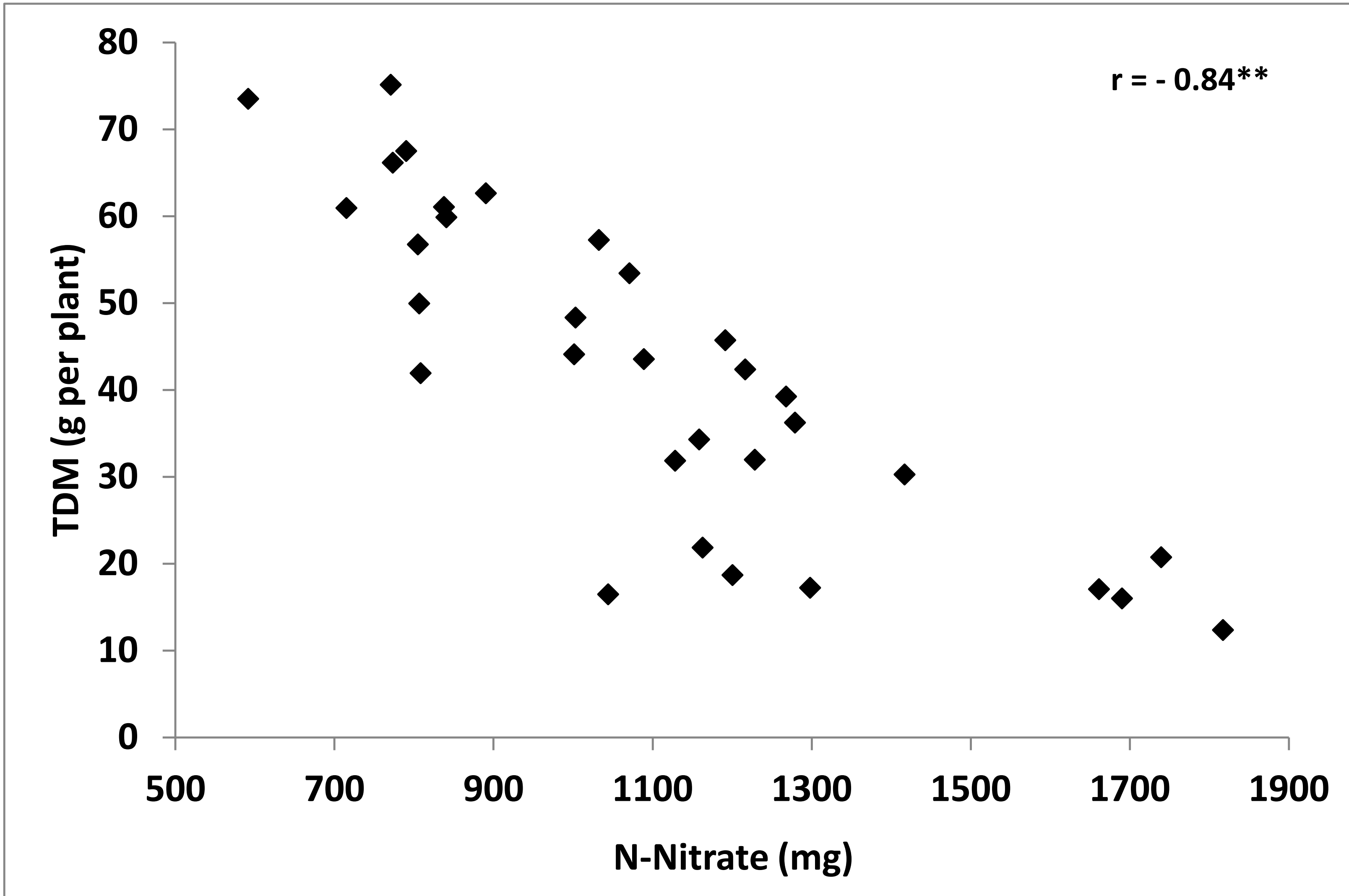


N3 < N1



1400
1200
1000
800
600
400
200
0
ΔN - Nitrate (mg)
0
1
2
3
4
5
6
7
8
EC (dS m-1)
N3 < N1
N1
N3

Soil N-Nitrate x Plant growth



Control, Low N

Control, high N

Control, high N

high salinity, high N

Summary of Results

N3		N1
Plant growth	≥	Plant growth
Photosynthesis and Chlorophyll	=	Photosynthesis and Chlorophyll
N compounds	=	N compounds
Carbohydrates	=	Carbohydrates
WUE	=	WUE
NUE	≥	NUE
N losses	<	N losses
Potential for final yield	=	**Potential for final yield**

N3 means less N (15, 31, and 62 kg ha^{-1}) added for salt stressed plants

Conclusion

We conclude that reduction of N application, based on reductions in evapotranspiration, is a good strategy to reduce the risk of ground water contamination by NO_3^- leaching and to decrease fertilization cost, without causing any additional damage to plant development under salt stress.

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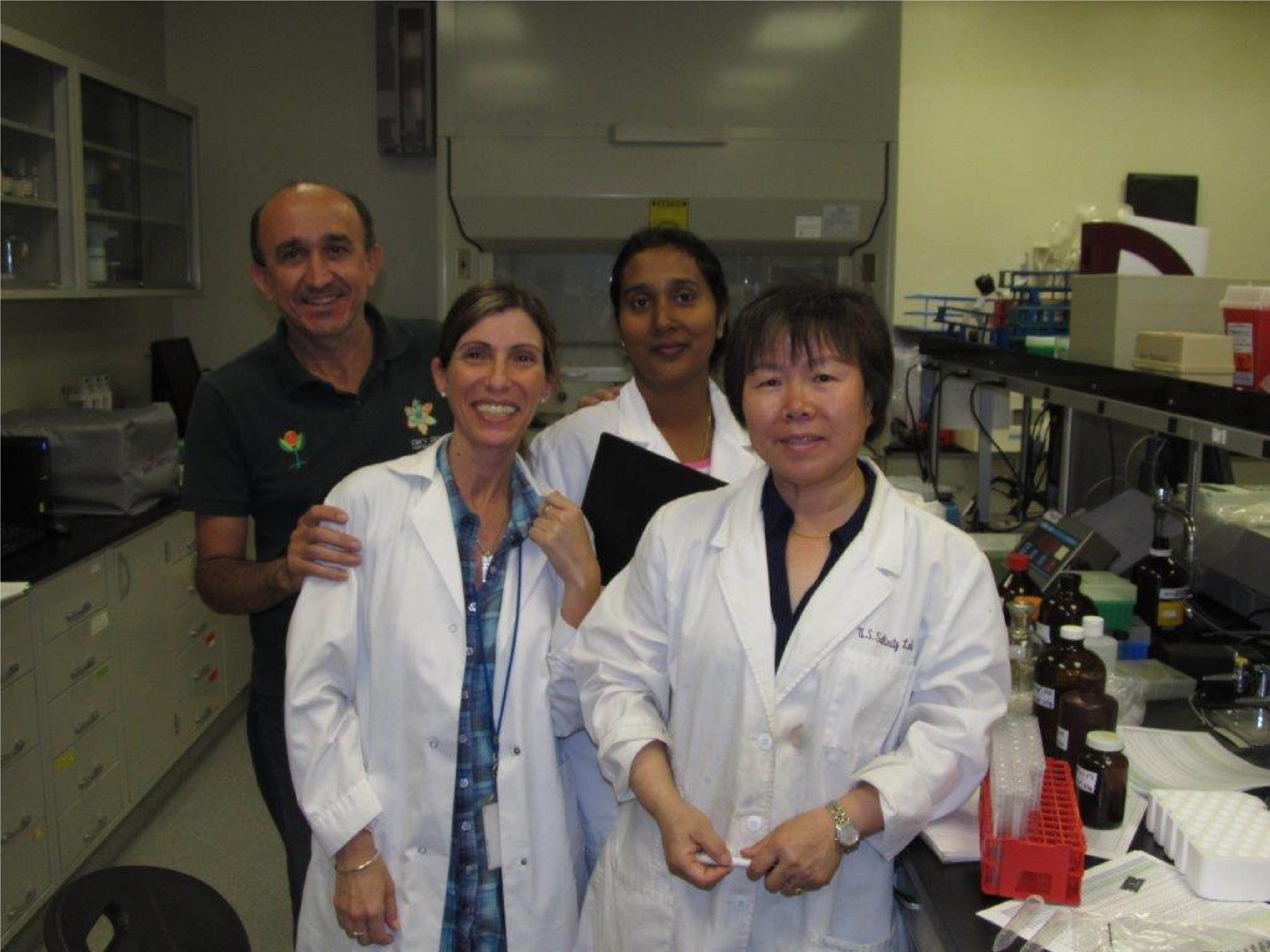
- Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq
- University of California, Riverside – UCR
- US Salinity Laboratory/United States Department of Agriculture - ARS/USDA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SALINITY STRESS

Evapotranspiration as a Criterion to Estimate Nitrogen Requirement of Maize Under Salt Stress

C. F. Lacerda[1], J. F. S. Ferreira[2], X. Liu[2] & D. L. Suarez[2]

1 Department of Agricultural Engineering/Universidade Federal do Ceará and INCTSal/CNPq, Fortaleza, Ceará, Brazil

2 USDA-ARS U.S. Salinity Laboratory, Riverside, CA, USA

Keywords

evapotranspiration; N loss; nutrient demand; photosynthesis; salinity; *Zea mays* L.

Correspondence

C. F. Lacerda

Department of Agricultural Engineering/

Universidade Federal do Ceará and

Abstract

We tested the hypothesis that by reducing the application of N, based on the decrease in evapotranspiration (ET) expected due to increase in soil salinity, it is possible to reduce N loss without causing N deficiency or further yield loss in salt-stressed maize plants. We tested four levels of salinity of irrigation water (S1 = 0.5; S2 = 2.5; S3 = 5.0; and S4 = 7.5 dS m^{-1}) and four N rates using