The Influence of Chloride on Plant Response to Nitrogen Level

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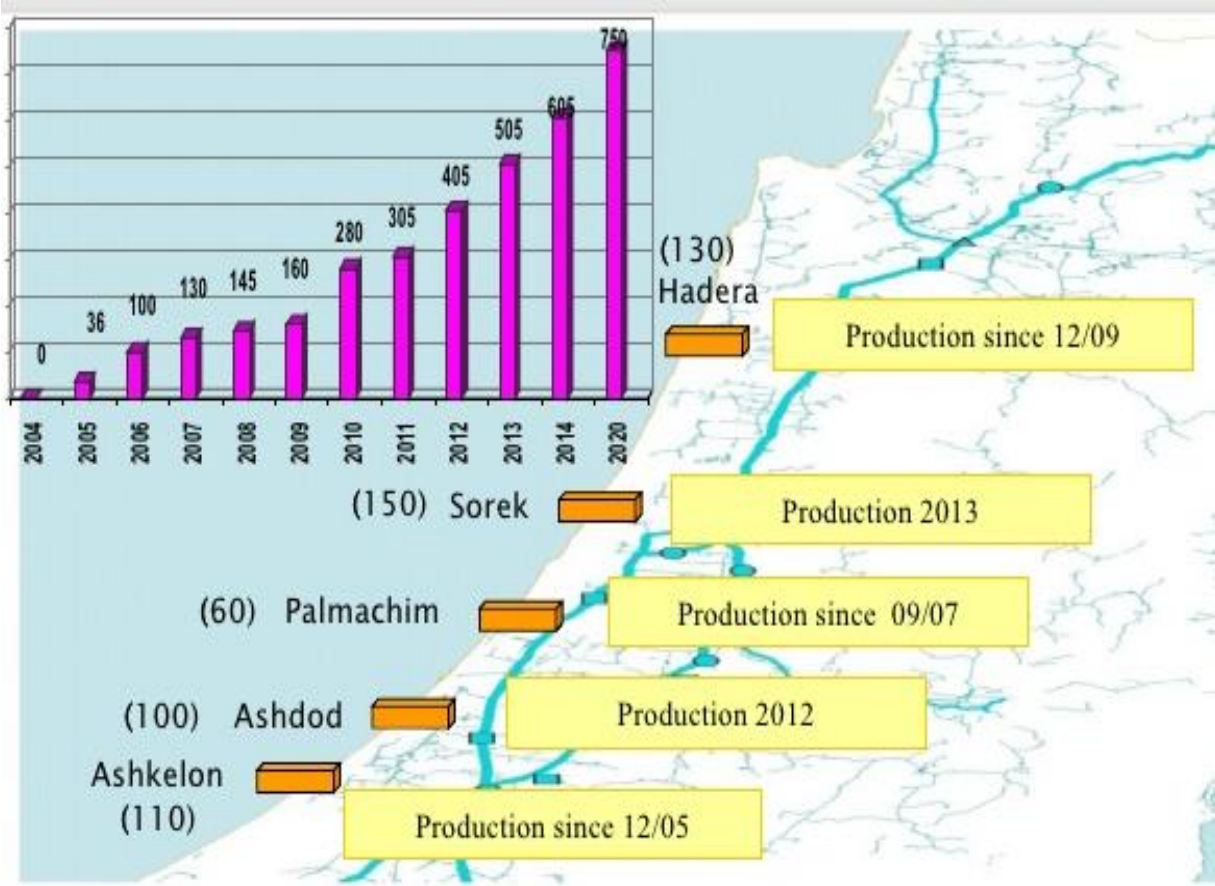
Introduction

Water Desalinization Plants – A revolution in water supply and quality in Israel

- Water demand in agriculture production led to increase in desalinition of saline water and use in irrigation.
- Similar projects are ongoing worldwide
- Six Sorek like desalination plants are coming online every year worldwide.

Desalination production vs Time



Desalination Water Quality

Quality parameter	units	Contractual Demands			Ashkelon Actual	Palmachim Actual	Hadera Actual	Sea of Galilee
		Ashkelon	Palmachim	Hadera				
Chloride	ppm	20	80	20	10-15	30-40	10-15	240-300

Research Question

Should we adjust nitrogen fertilization recommendation to the quality (salinity) of the water? Is the optimal level of nitrate is lower when the concentration of Cl^- is lower?

Hypothesis

Both nitrate and chloride are anions that compete with each other on uptake by plants. Therefore, optimal nitrate concentration increases with the Cl^- concentration in the irrigation water.

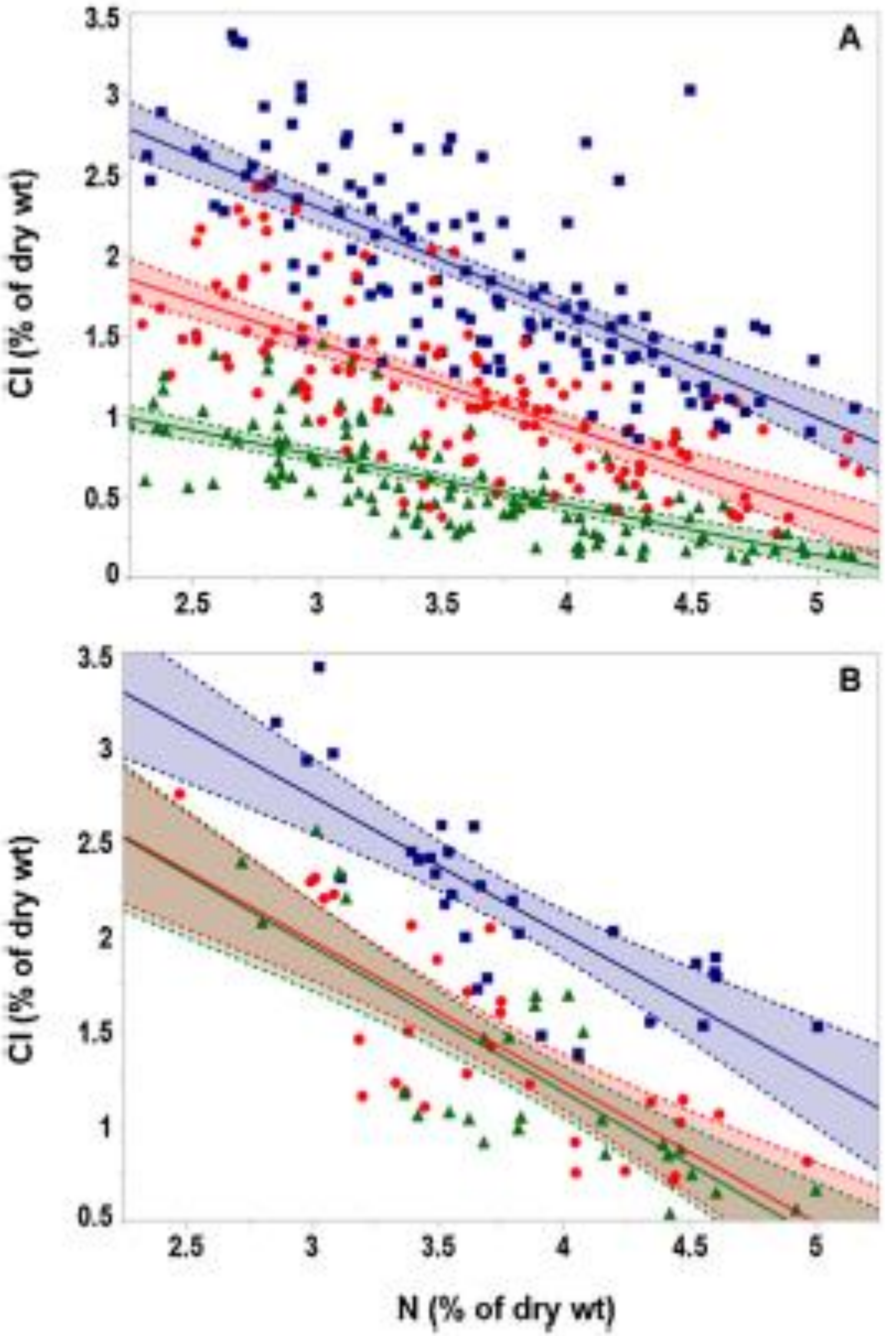
The low Cl^- concentration in the irrigation water will lead to reduction in contamination of groundwater.

Nitrate and Chloride interactions

Confounding information on NO_3^- and Cl^- interactions

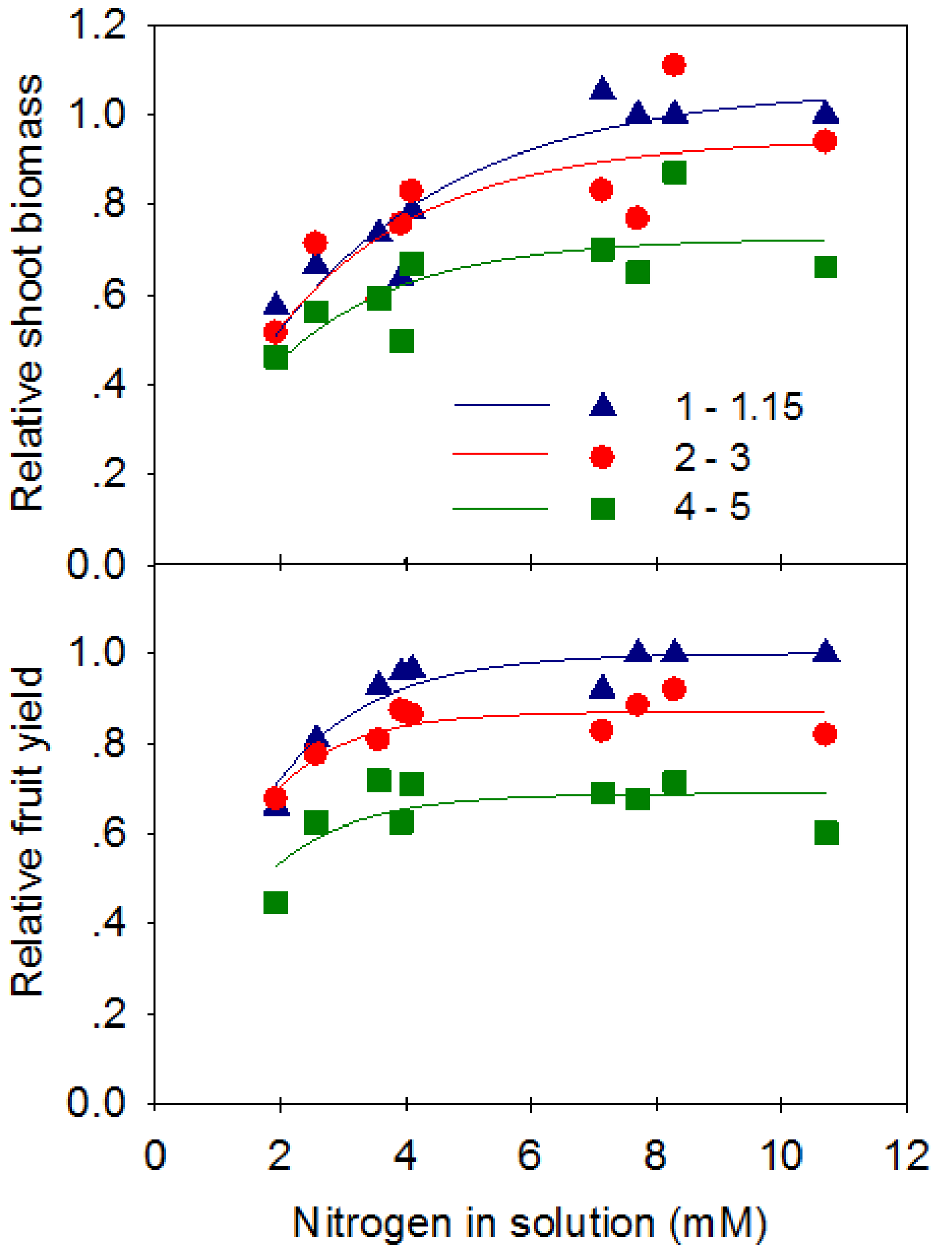
- Supporting - Chloride interaction with nitrate and phosphate nutrition in tomato, Cl- content in plant was depressed by increasing NO_3^- concentration (Kafkafi et al 1982 J Plant Nutrition 5:30).
- Partly supporting - The positive effect of salinity-KNO3 interaction on dry matter was obtained just under moderate salinity and vanished under high salt stress (Imas and Feigin 1995 Acta Horticulturae 401:301-308).
- No interaction - Despite a large number of studies demonstrate that salinity reduces nutrient uptake and accumulation little evidence exists that addingnutrients at levels above those considered optimal in non-saline environments improve crop yield (Grattan and Grieve 1999 Sci. Hort. 78:127-157).

The relationship between Cl and N concentrations in diagnostic leaves[ab1] . A) Exp. 1 and 2. B) Exp. 3. Low salinity irrigation water (green), medium salinity (red), and high salinity (blue). Concentration values are averages. Data of each treatment was collected from of 5 replicates of each treatment and 4 to 5 dates of sampling. Each data point represents one leaf analysis and the line representing linear regression with 95% confidence curve (broken line). Pepper, Yasuor et al., 2017

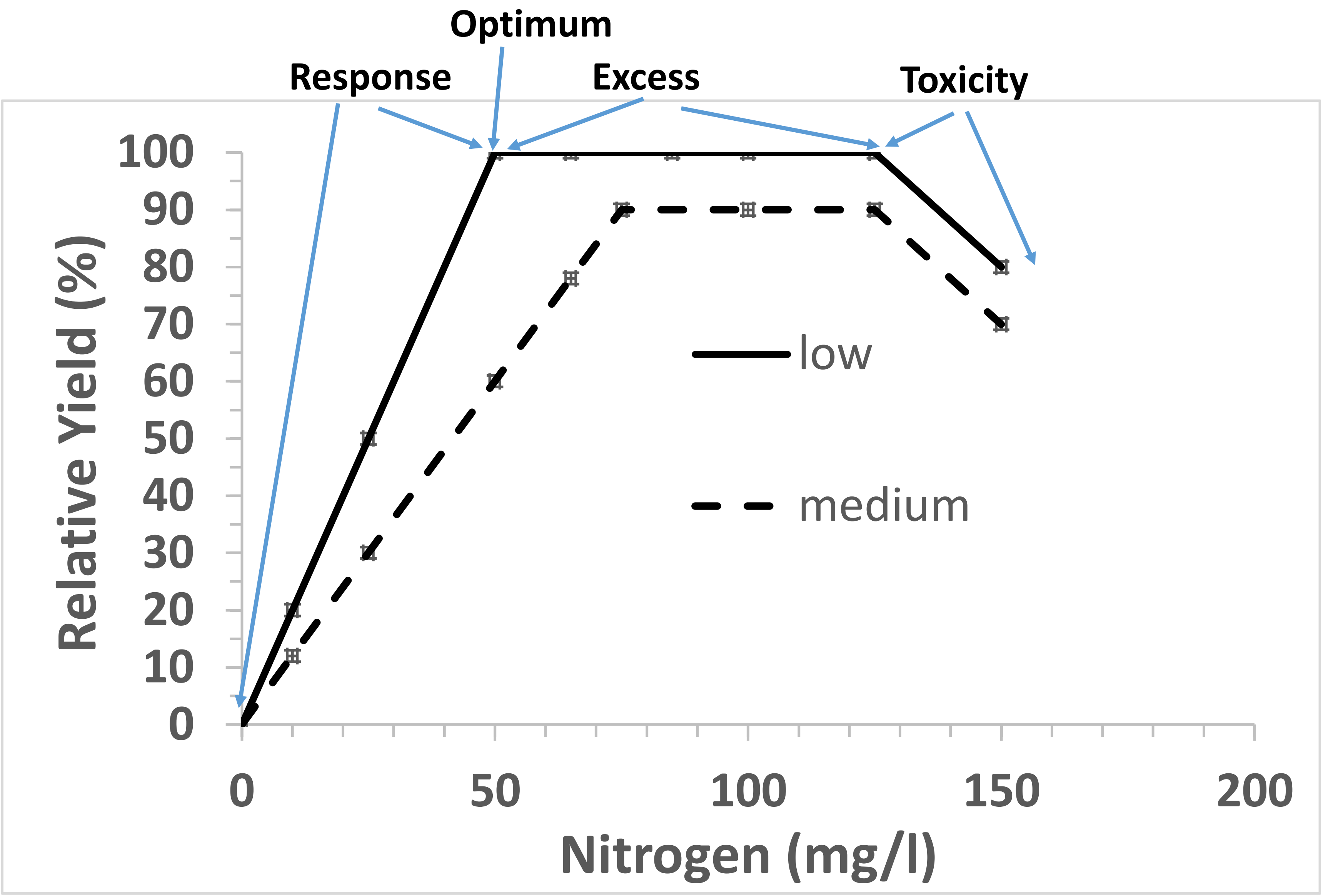


Pepper dry weight biomass as a function of nitrogen as affected by Cl concentration, Yasuor et al., 2017

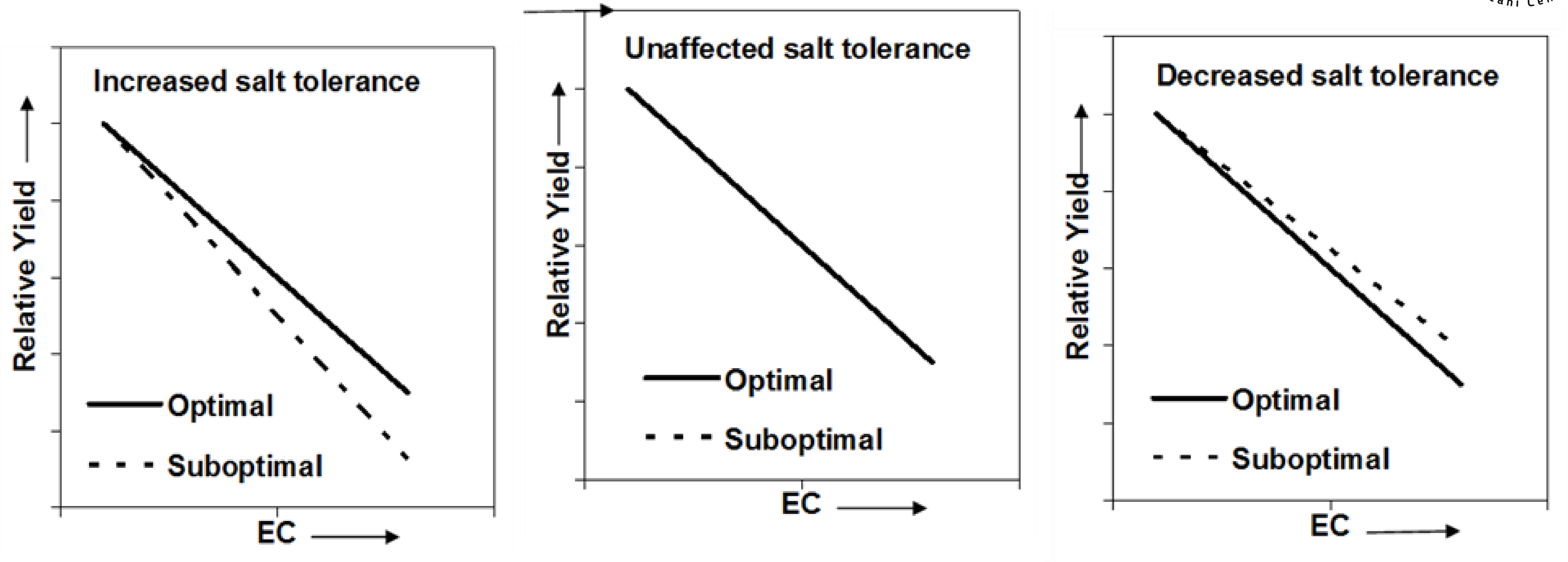
Relative biomass (a) and relative fruit yield (b) as a function of applied N under different salinity levels. Plants were irrigated with low (blue triangle, 1.1-1.15 dS m^{-1}), medium (red circle, 2.0-3 2.9 dS m^{-1}) or high (green square, 43.8-5.2 dS m^{-1}) saline water. The lines are representing best fit correlation to for *Y=a(1-bx)* equation.



Background – Schematic plants response to nutrient



Background – Plants response to salinity as affected by fertilization



Types of idealised interactions between salinity and nutrients level, in their effects on absolute and relative yields. (a) increased salt tolerance under deficient nutritional levels; (b) independent effects of salinity and nutrition at optimal and deficient nutritional levels; and (c) decreased salt tolerance under deficient nutritional levels. Based on Bernstein et al. (1974)

Research Objectives

Overall objective

To optimize nitrogen fertilization of several representing crops under different Cl levels for high yield, while minimizing N and Cl leaching.

Specific objectives:

To study the interaction effects of nitrogen with chloride concentrations in the irrigation water on:

- The performance and yield of maize, potato and lettuce.
- The uptake and concentrations of Cl and N in plants' organs.
- The downward leaching of Cl and N out of the roots zone

Methodology

Lysimeter experiment

Computer controlled Irrigation with final solutions from containers.

The irrigation of each lysimeter is controlled by the control system using separate valve.

Drip irrigation with 8 l/h dripper split to 4.

Drainage of each lysimeter is collected, weighed and the ions composition is analyzed.

The growing substrate is coarse sand.

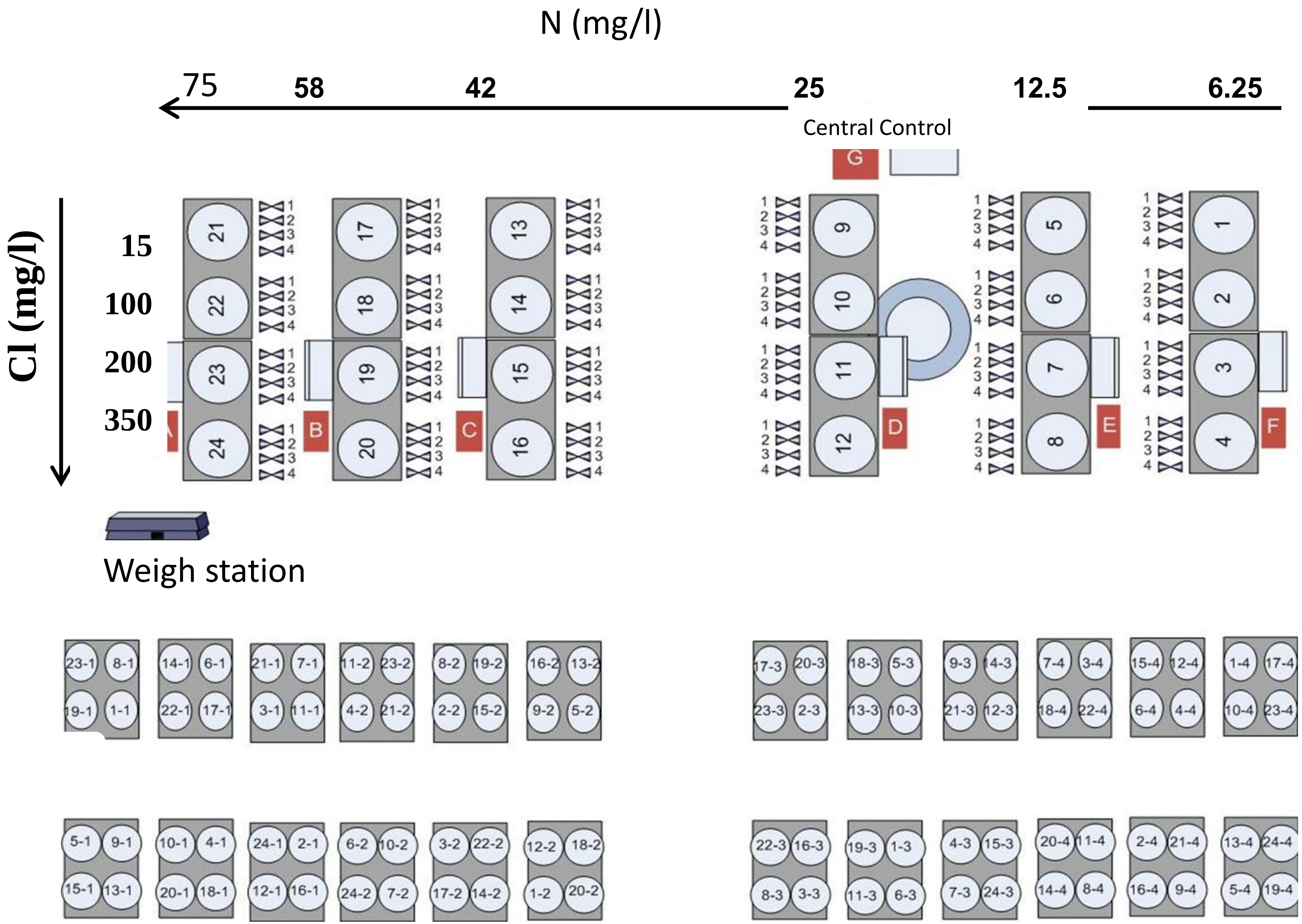
Treatments: 4 Cl concentrations, 6 N concentrations

Experiment design – Full factorial 4 X 6 = 24 treatments, randomized replicates in 4 blocks

Water source – Desalinated water produced by reverse osmosis.


Irrigating solutions
containers
Lysimeters


Irrigating solutions
containers
Lysimeters



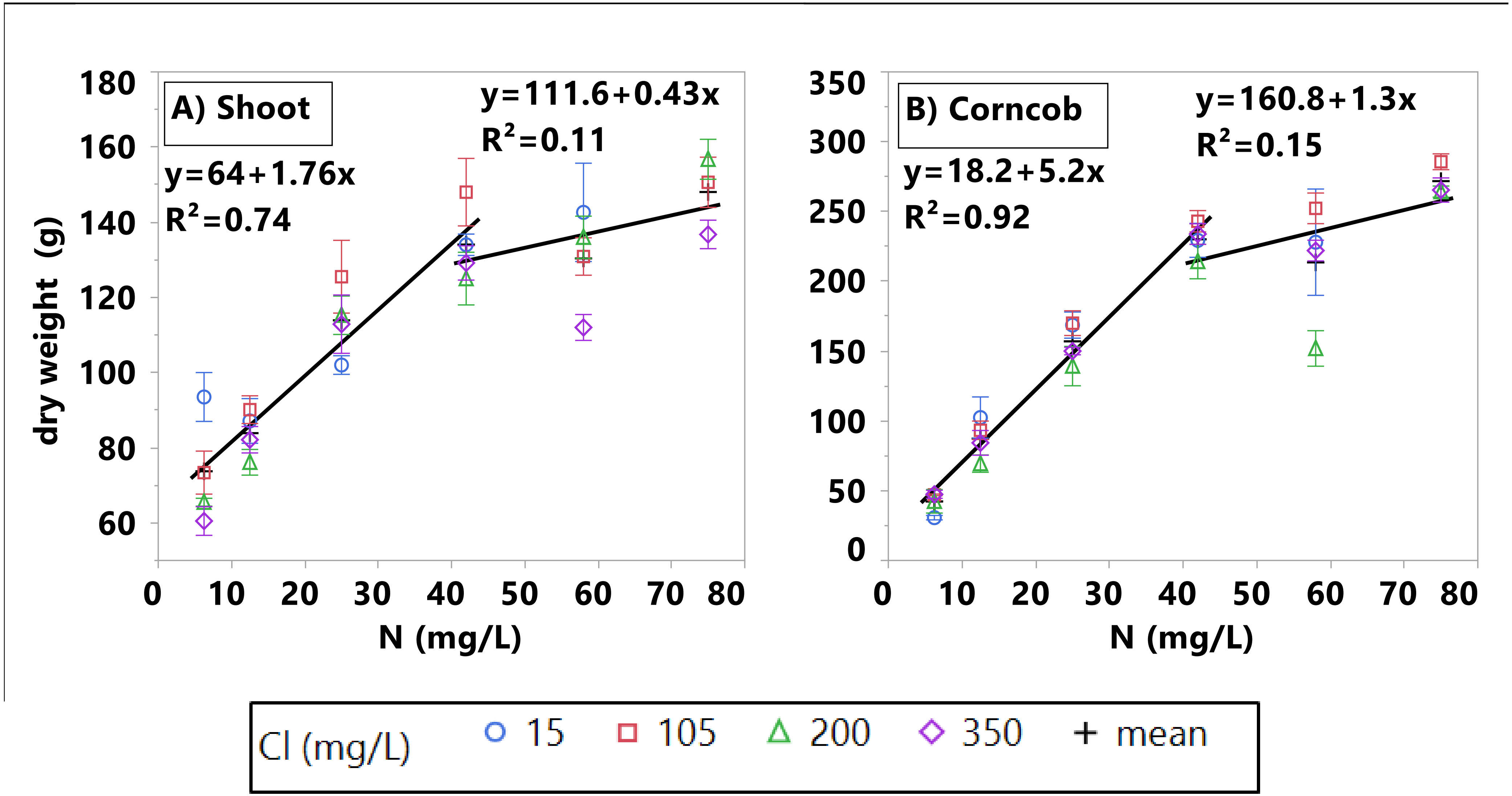
N (mg/l)
75
58
42
25
12.5
6.25
Central Control
Cl (mg/l)
15
100
200
350
A
B
C
D
E
F
G
Weigh station

Treatments in the 4 crops experiments

Crop	Corn	Potato	Lettuce	Potato	Lettuce	Potato
Planting	5.8.2015	15.1.2016	17.8.2016	15.1.2017	14.9.2017	1.3.2018
Harvest	14.10.2015	31.5.2016	27.9.2016	17.5.2017	22.10.2017	27.6.2018
Cl (mg/l)	15, 105, 200, 350	15, 150, 350, 700	15, 150, 350, 700	15, 150, 350, 700	15, 150, 350, 700	15, 200, 600, 1100, 1500
N (mg/l)	6.25, 12.5, 25, 42, 58, 75	10, 20, 30, 40, 60, 80	25, 50, 75, 100, 125, 140	10, 50, 100, 150	25, 45, 65, 85, 100, 125	10, 50, 100, 150

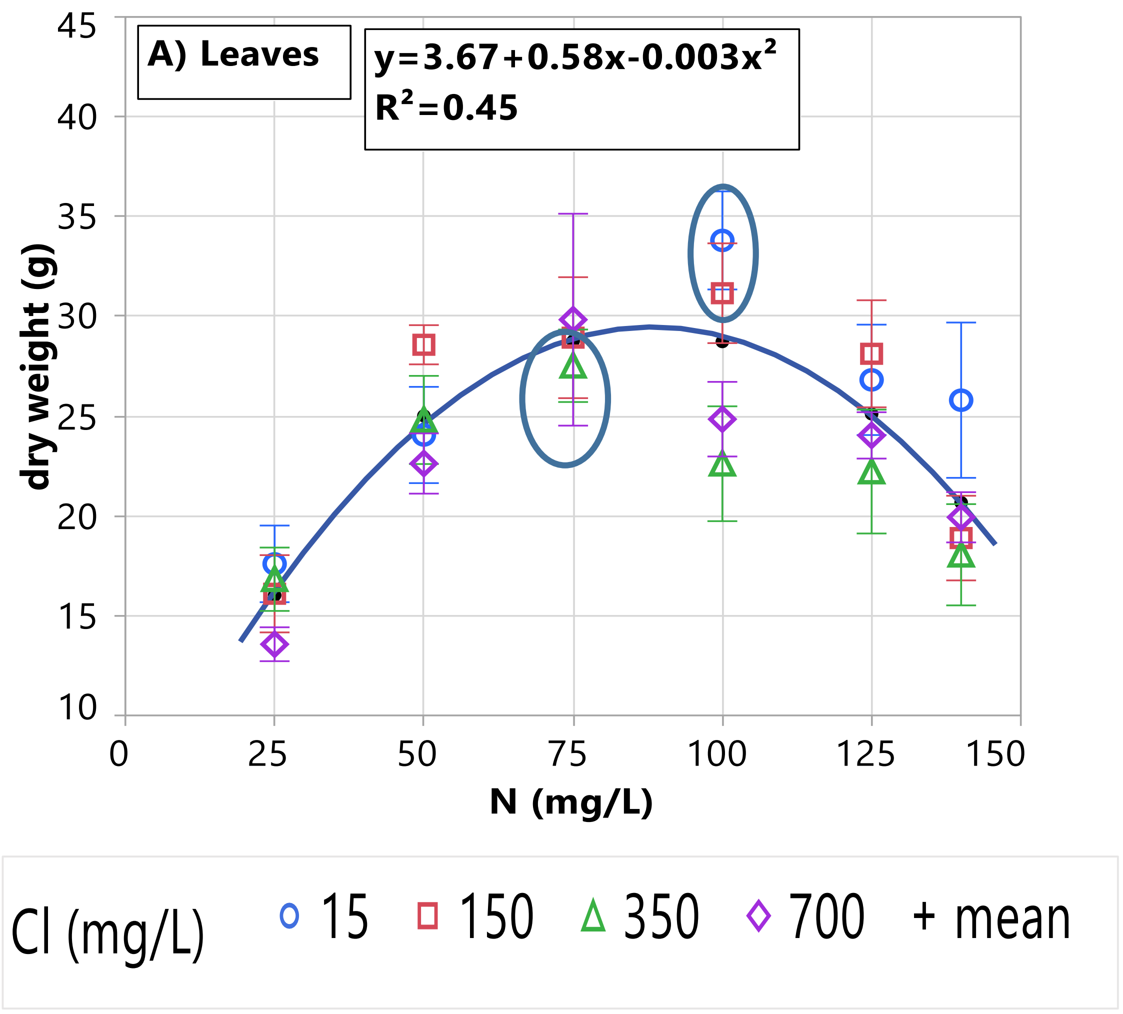
Dry weight biomass as a function of nitrogen as affected by Cl concentration

Corn

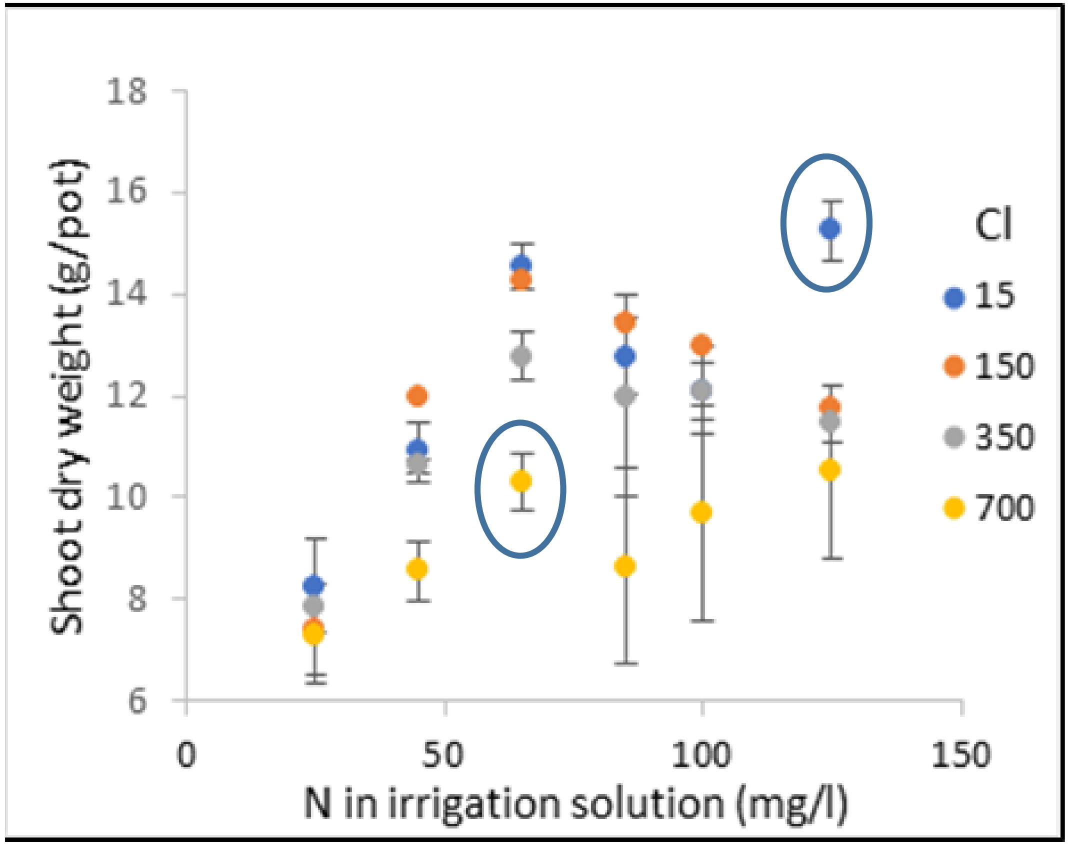


Lettuce biomass as a function of nitrogen as affected by Cl concentration

2016

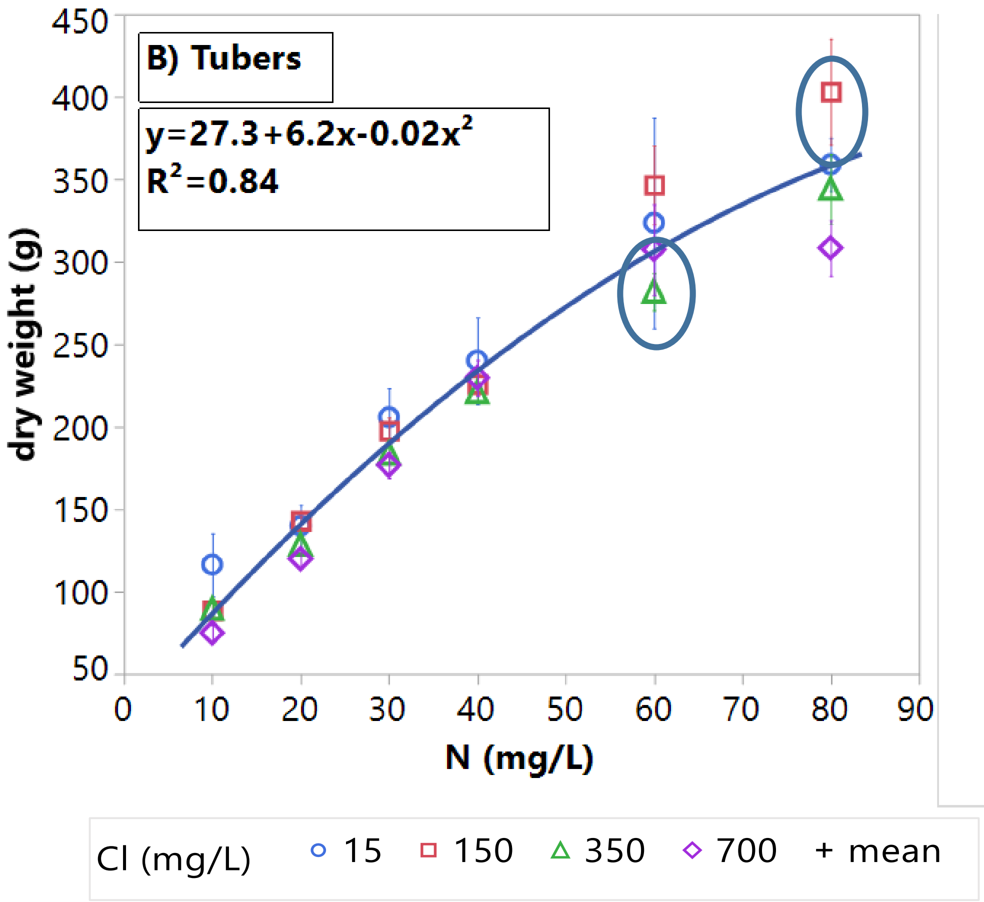


2017

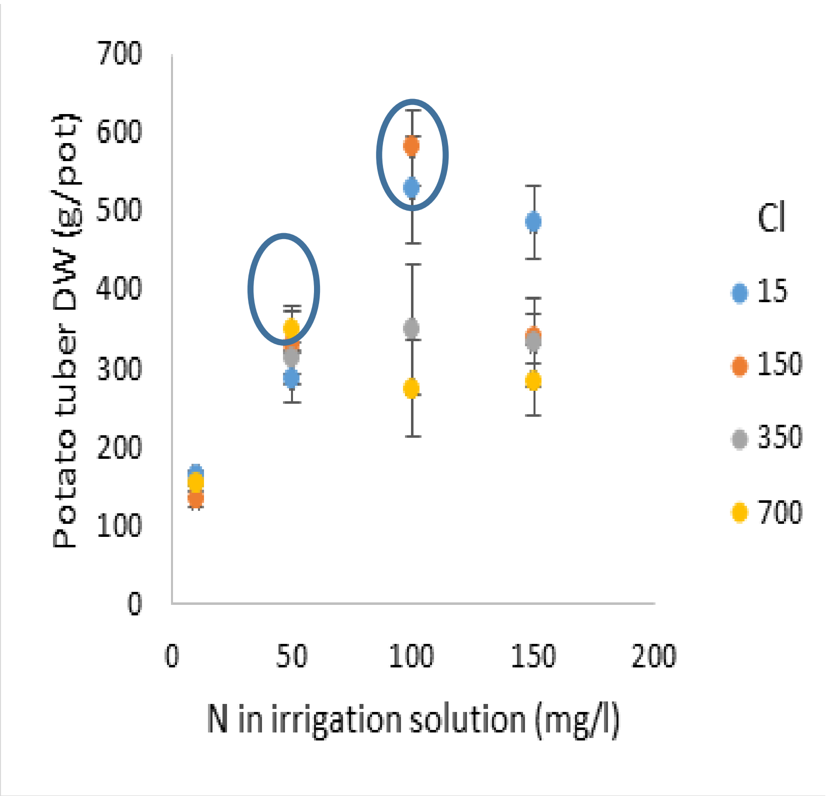


Tubers biomass (dry weight) as a function of nitrogen and as affected by Cl concentration

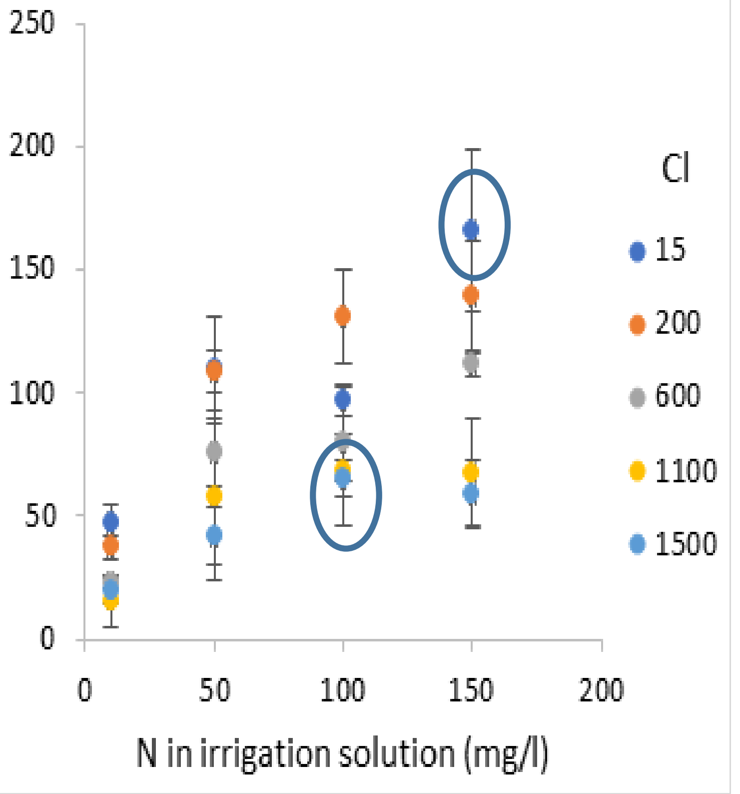
Potato 2016



Potato 2017



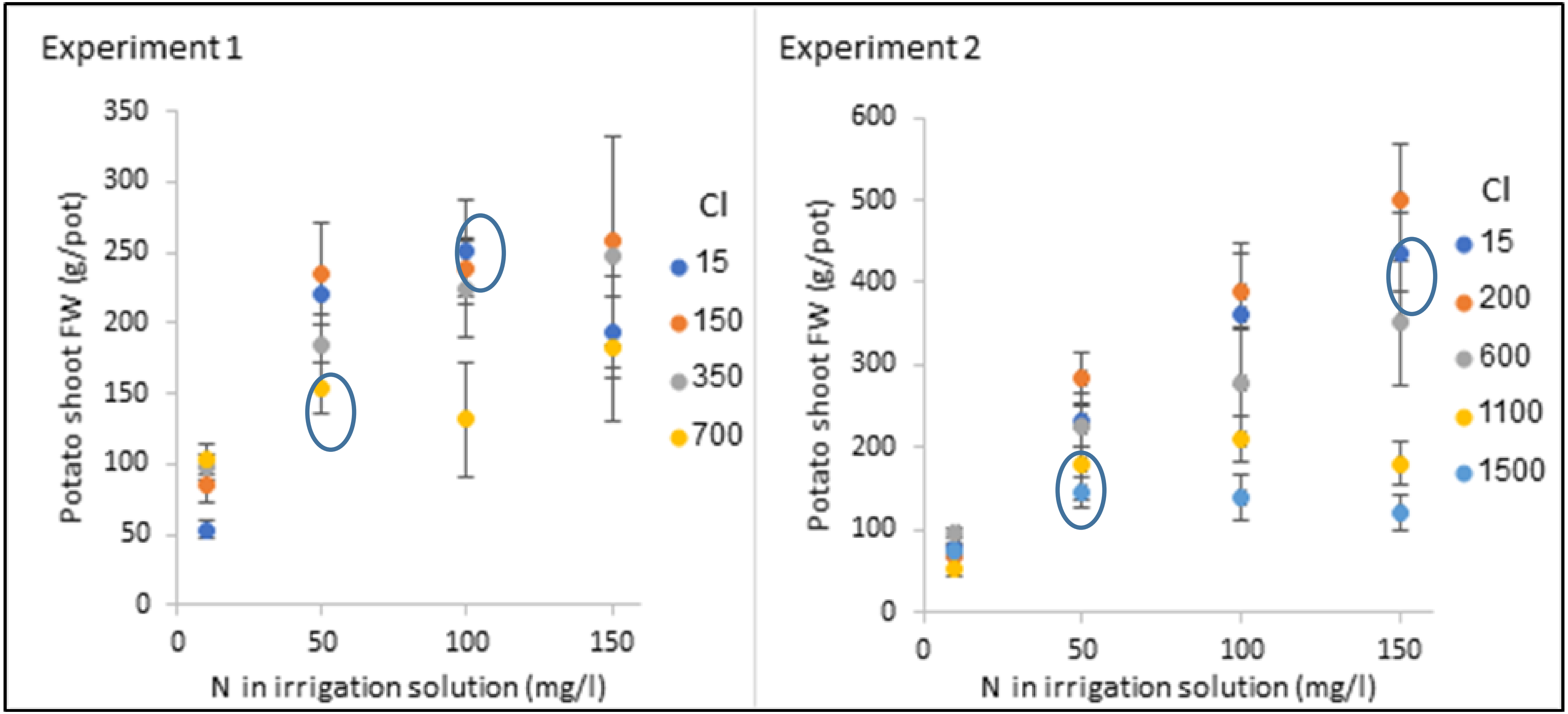
Potato 2018



Tubers biomass (dry weight) as a function of nitrogen and as affected by Cl concentration

Potato 2017

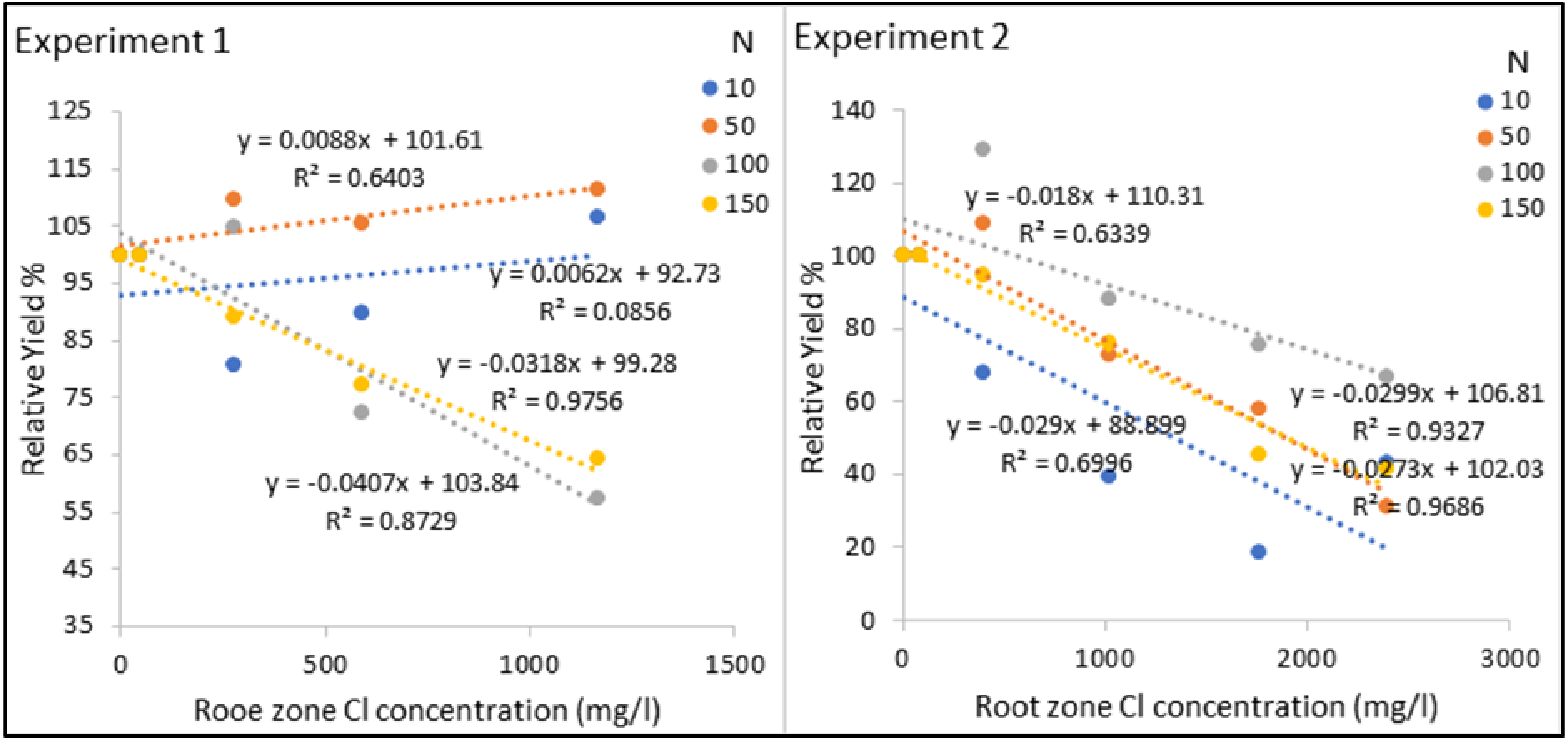
Potato 2018



Relative yield of tubers biomass (dry weight) as a function of root zone Cl concentration and as affected by the nitrogen treatment

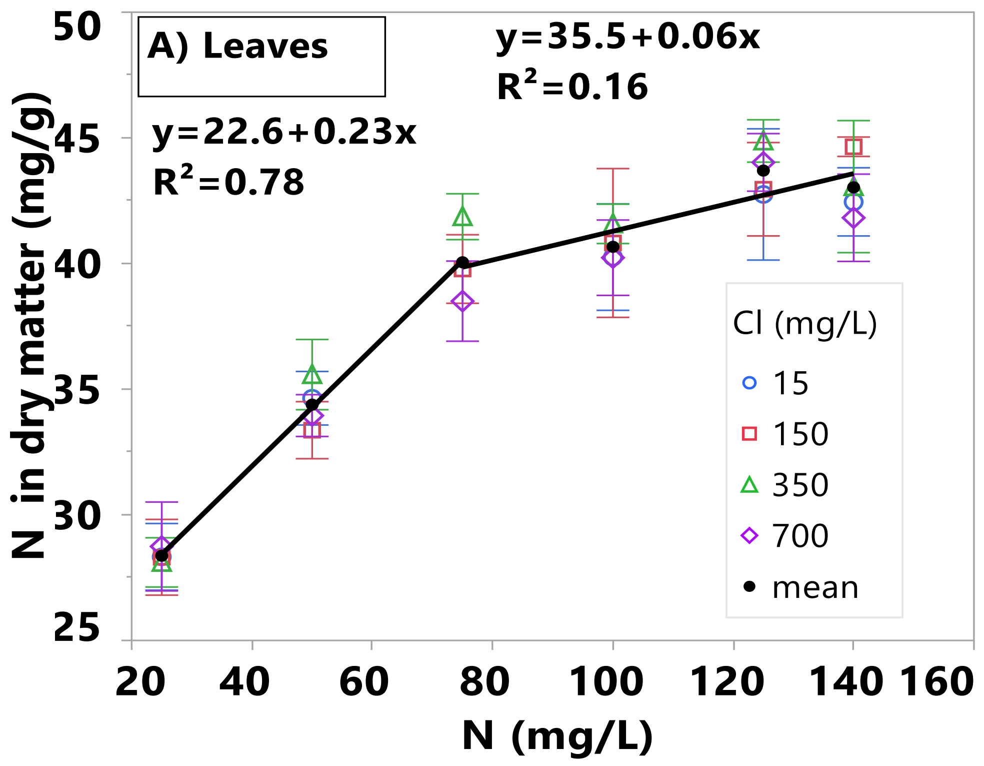
Potato 2017

Potato 2018

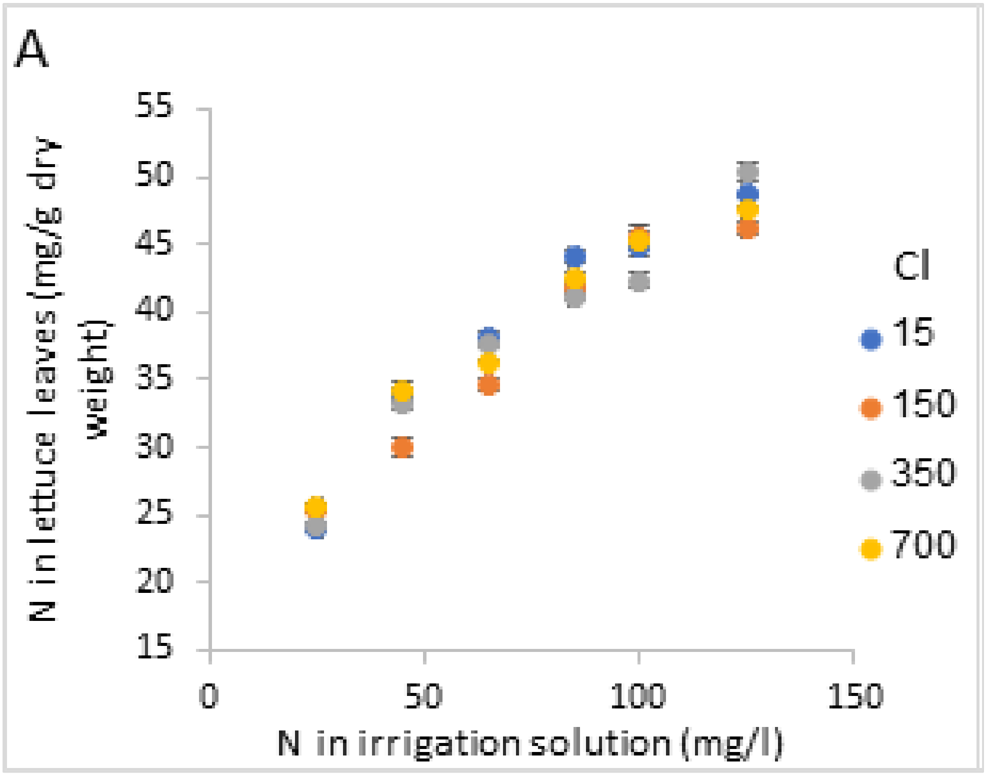


N concentration in lettuce Shoot as a function of nitrogen as affected by Cl concentration

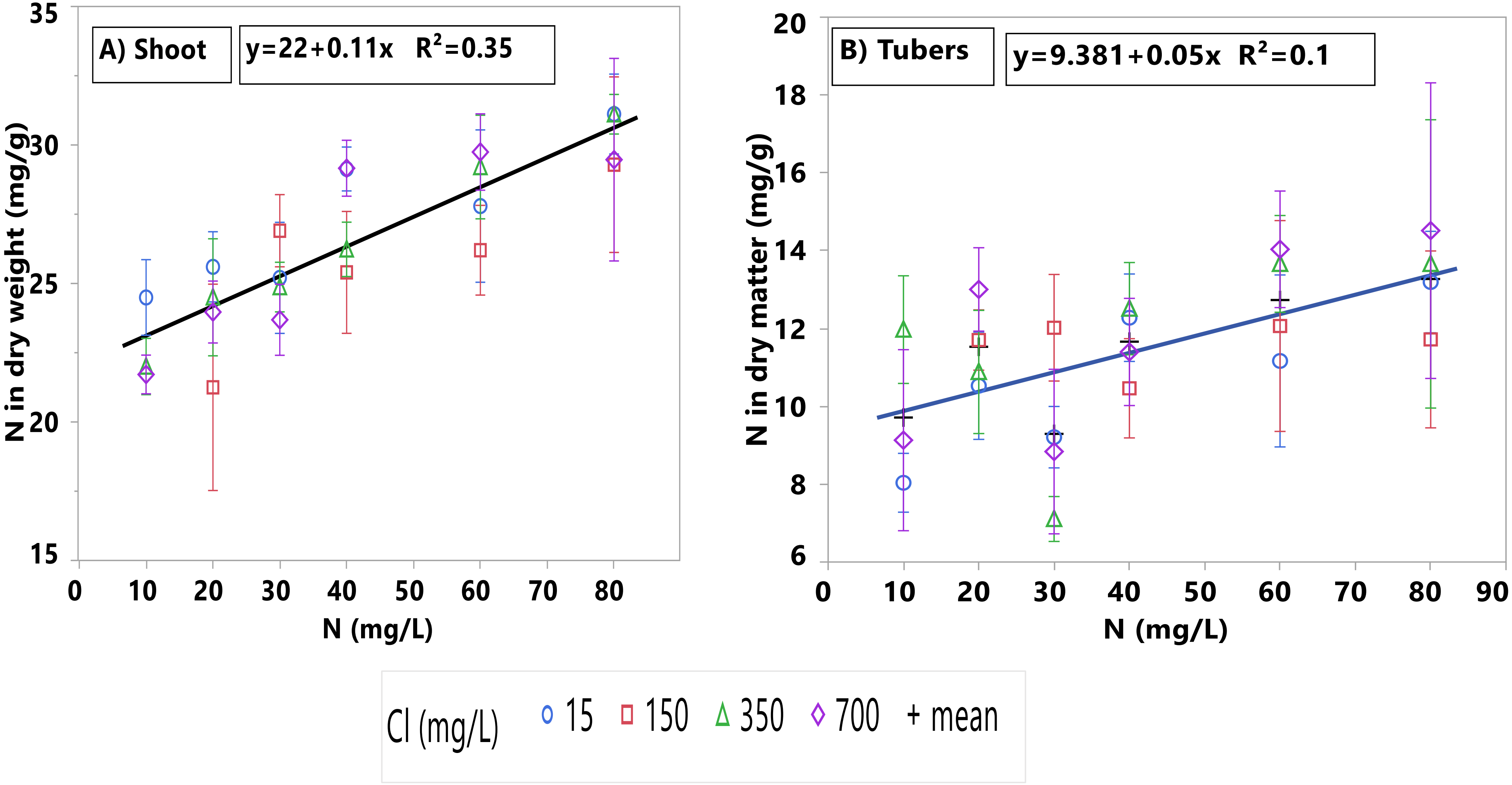
2016



2017

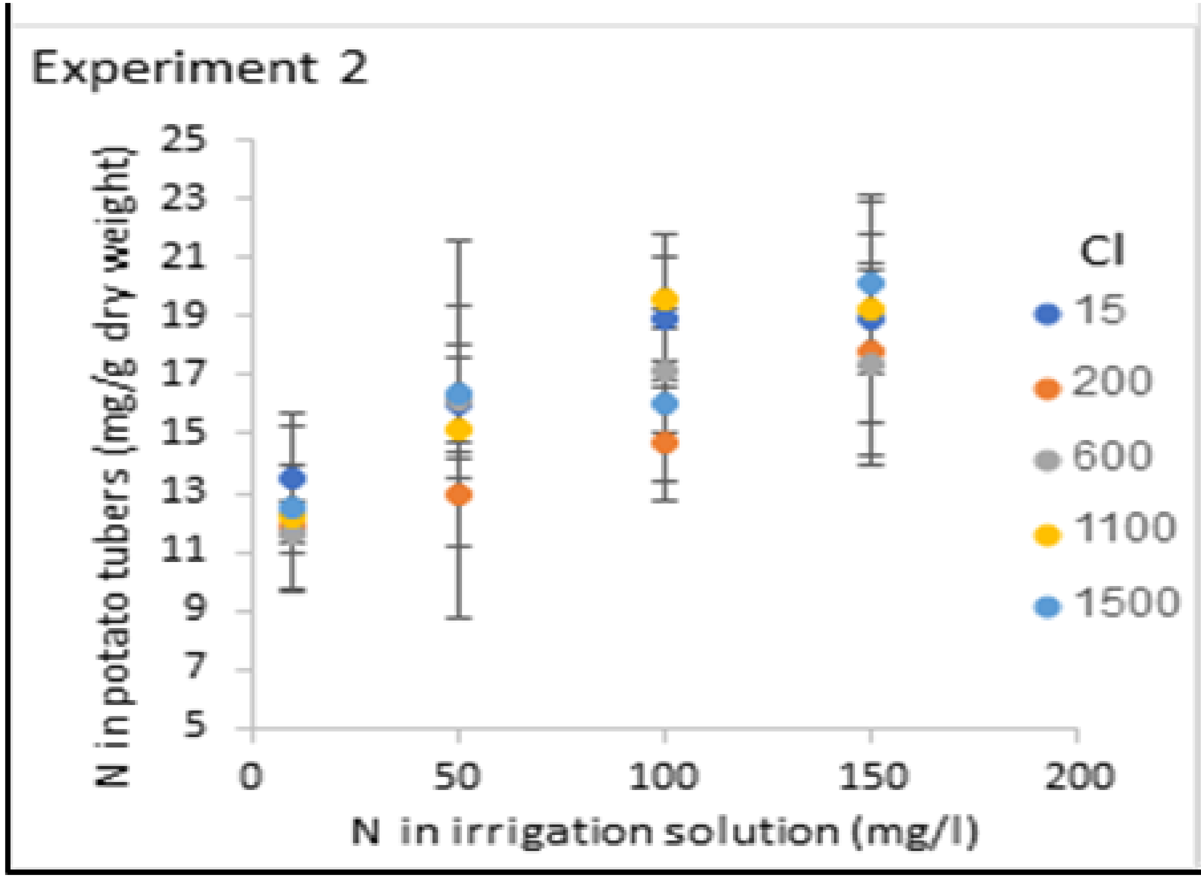


N concentration in potato plants as a function of nitrogen as affected by Cl concentration, 2016

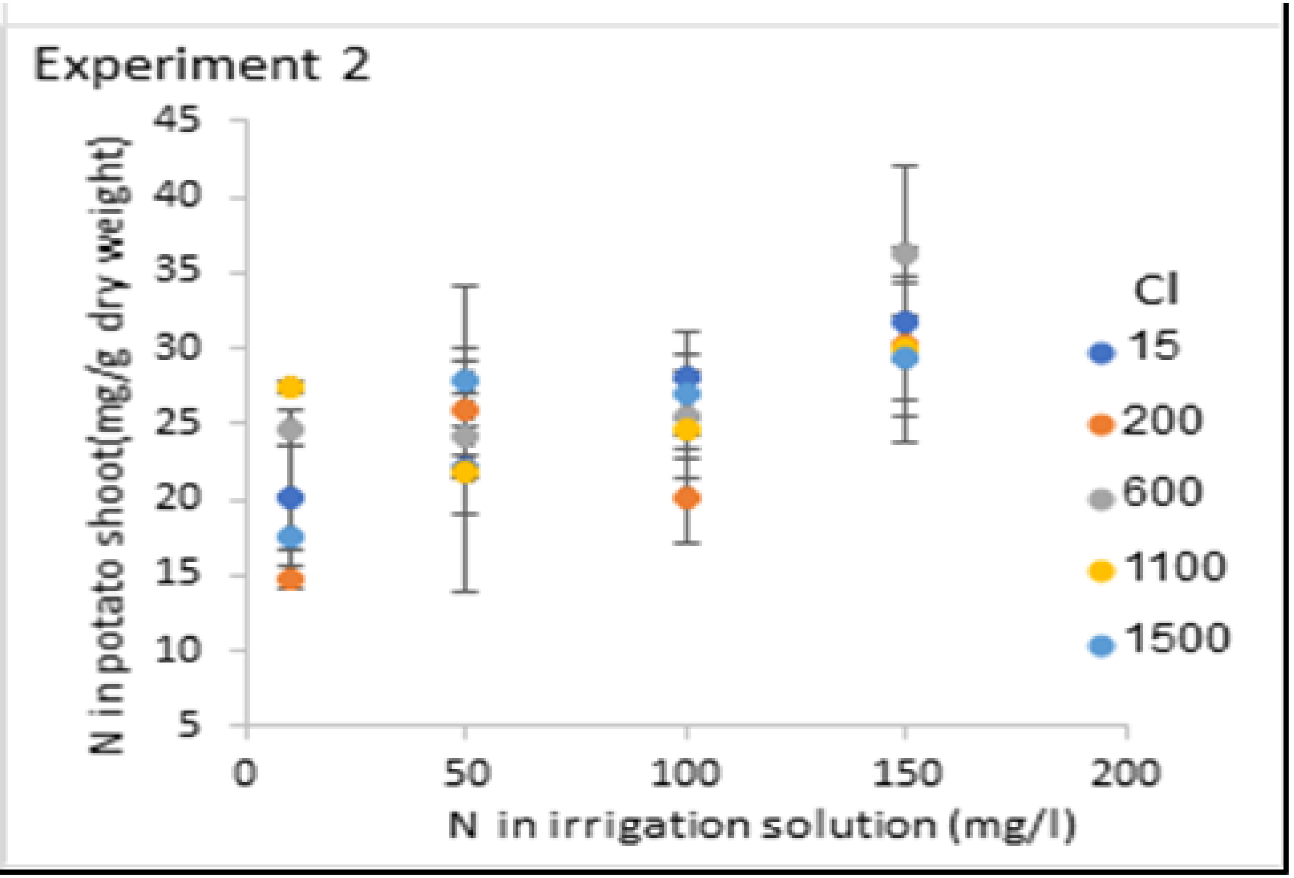


N concentration in potato plants as a function of nitrogen as affected by Cl concentration, 2018

Tubers



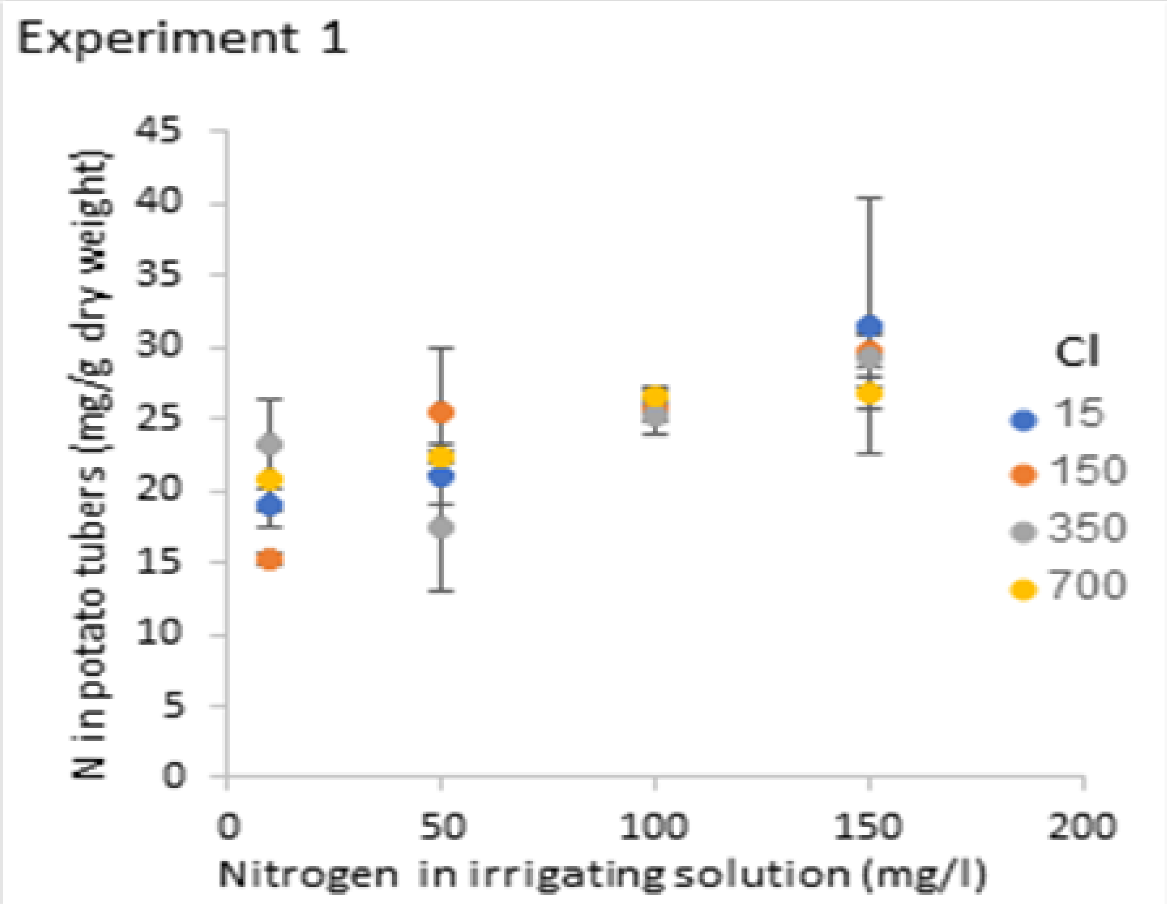
Shoot

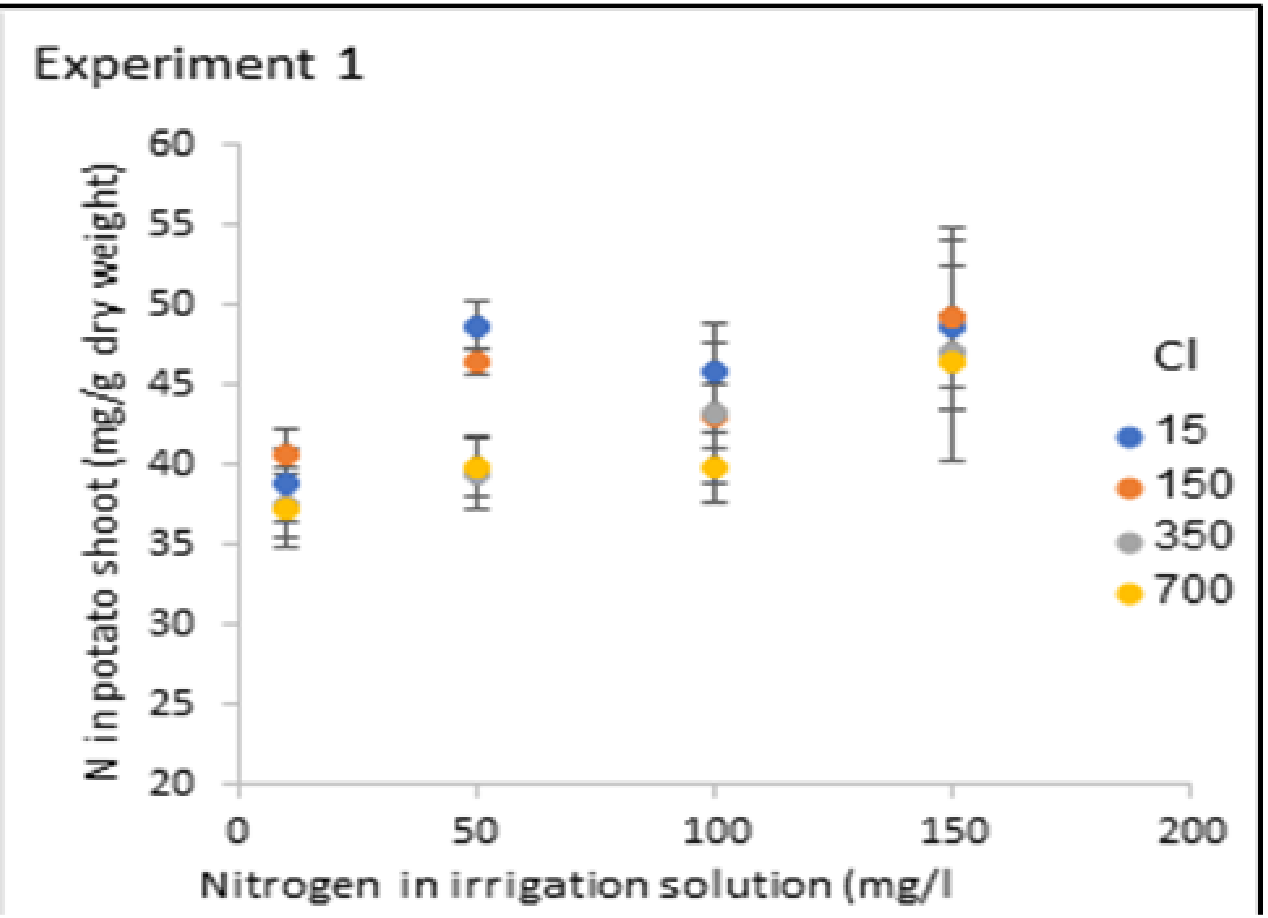


N concentration in potato plants as a function of nitrogen as affected by Cl concentration, 2017

Tubers

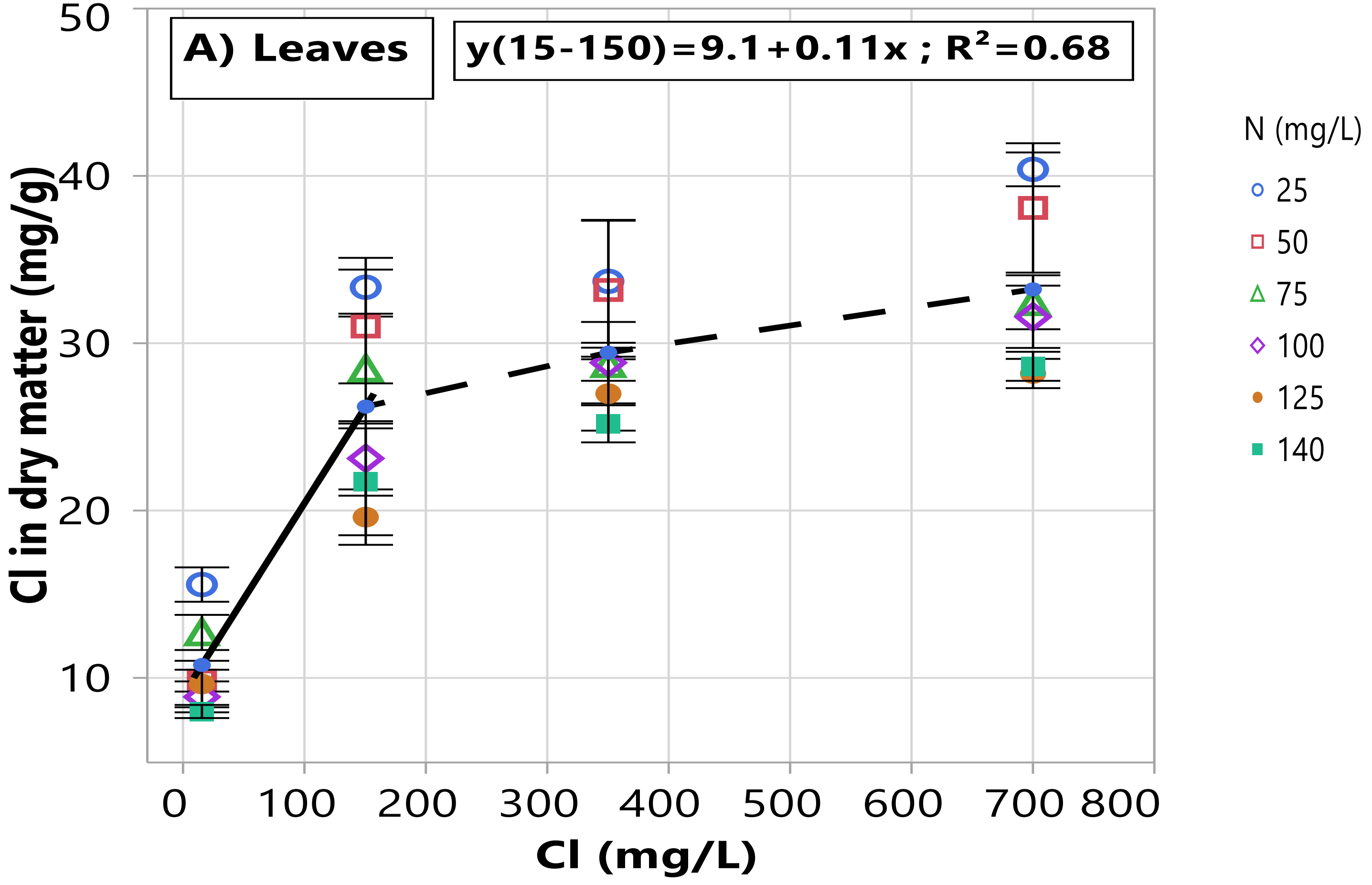
Shoot





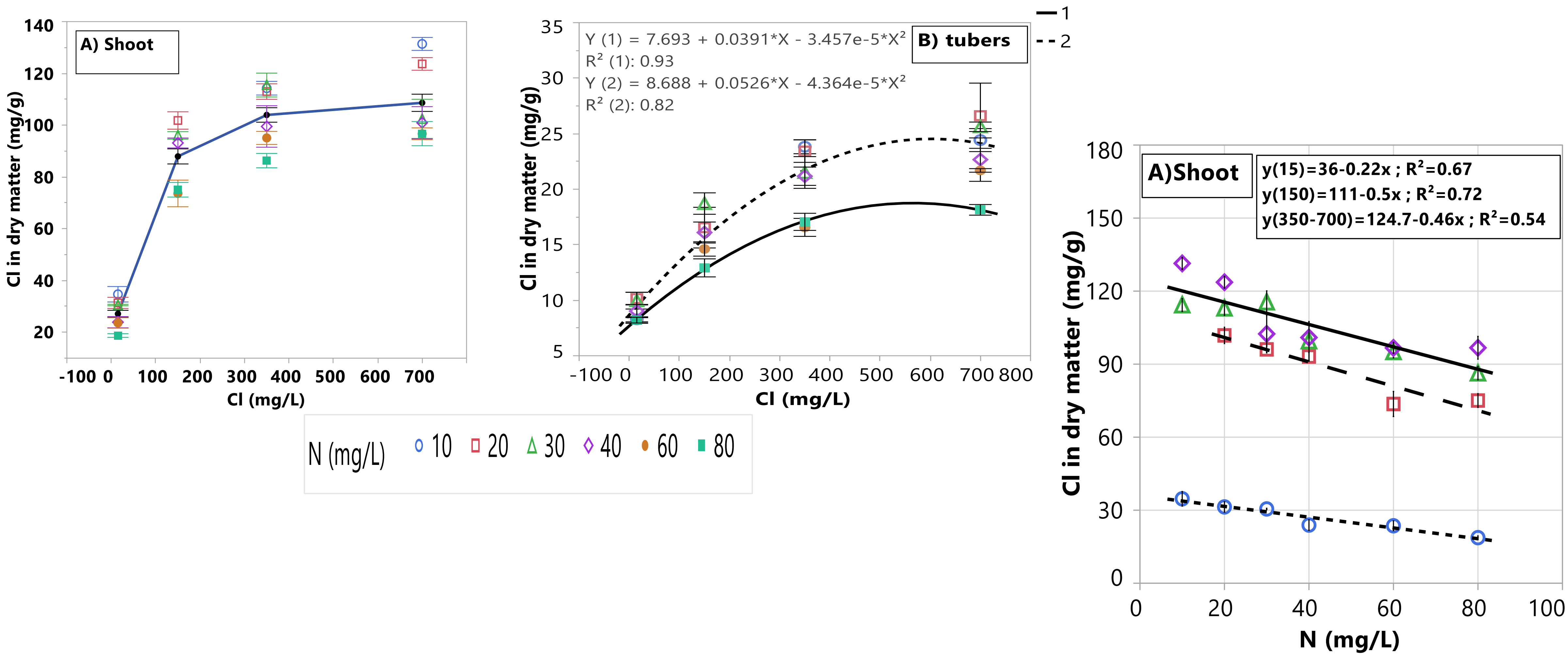
Cl concentration in Lettuce plants as a function of Cl as affected by N concentration

2016



Cl concentration in Potato tubers as a function of Cl and as affected by N concentration

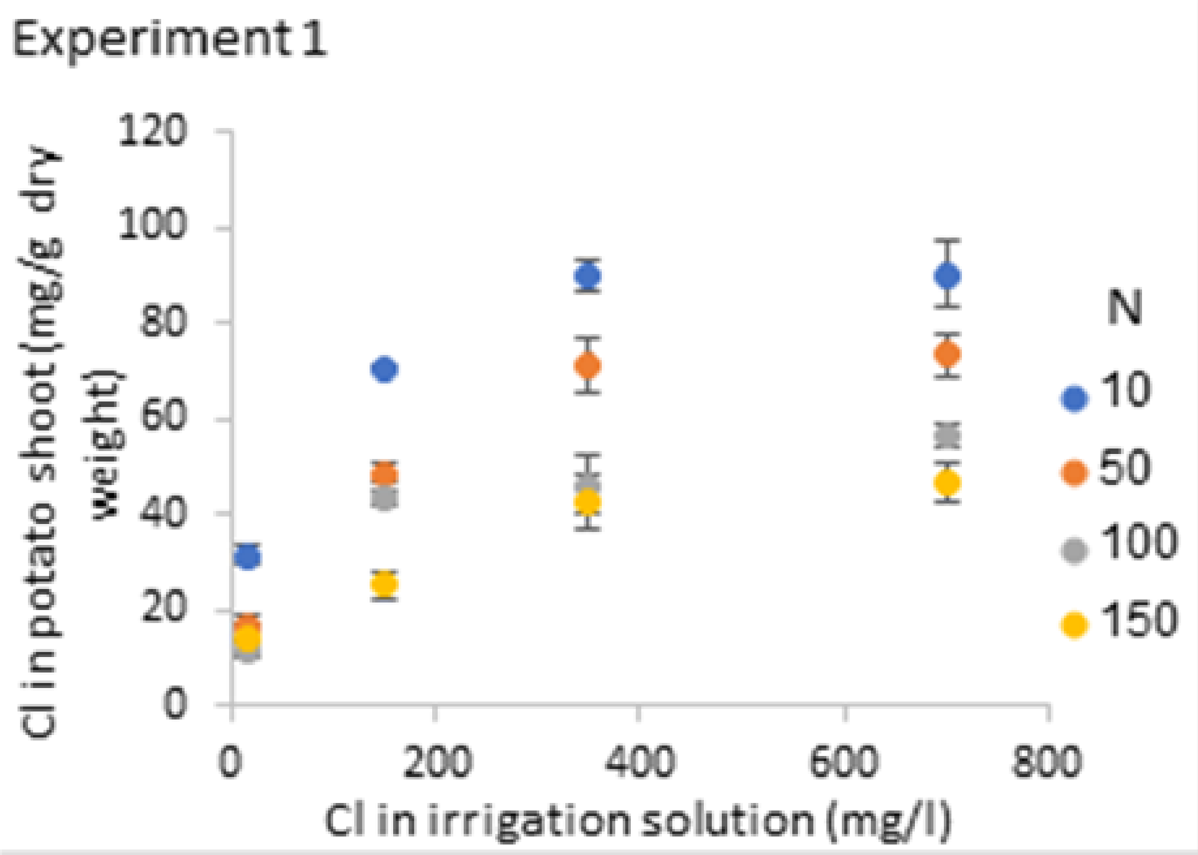
2016

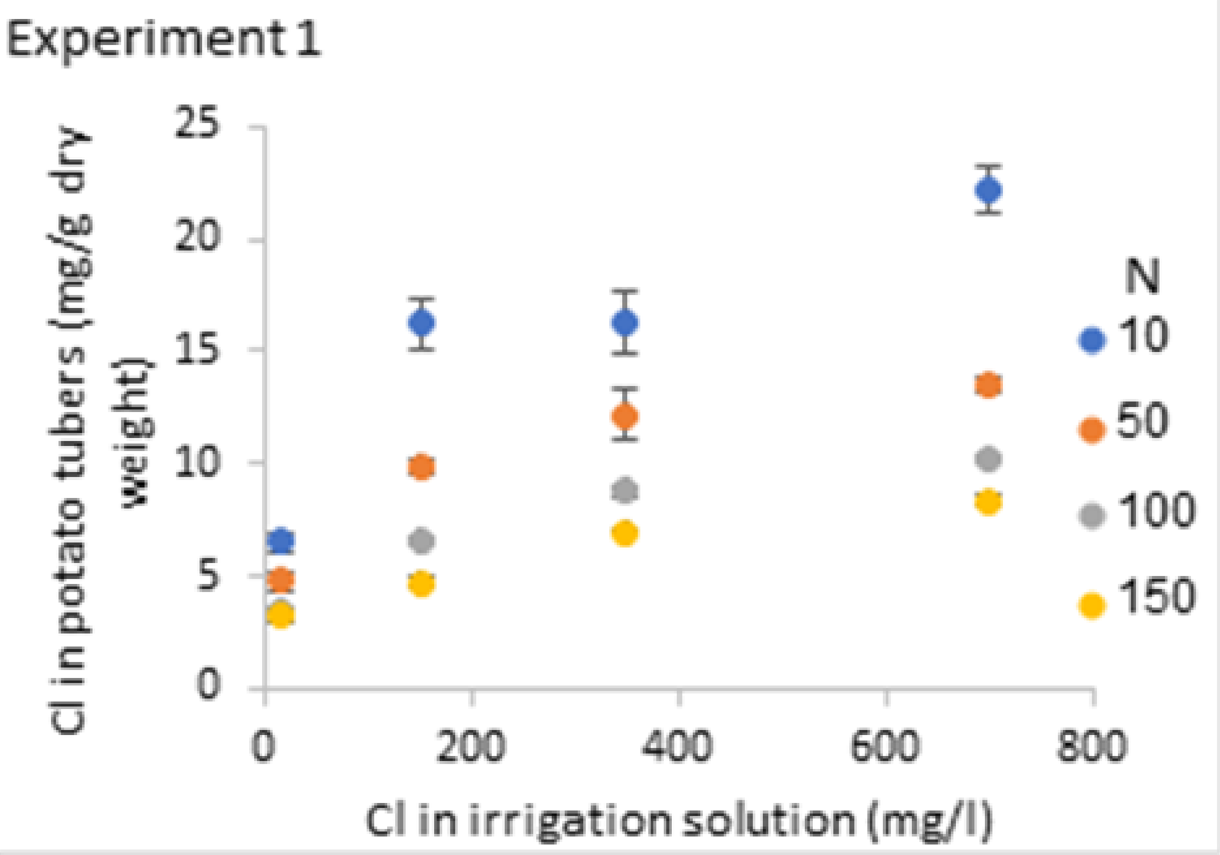


Cl concentration in Potato tubers as a function of Cl as affected by N concentration, 2017

Shoot

Tubers

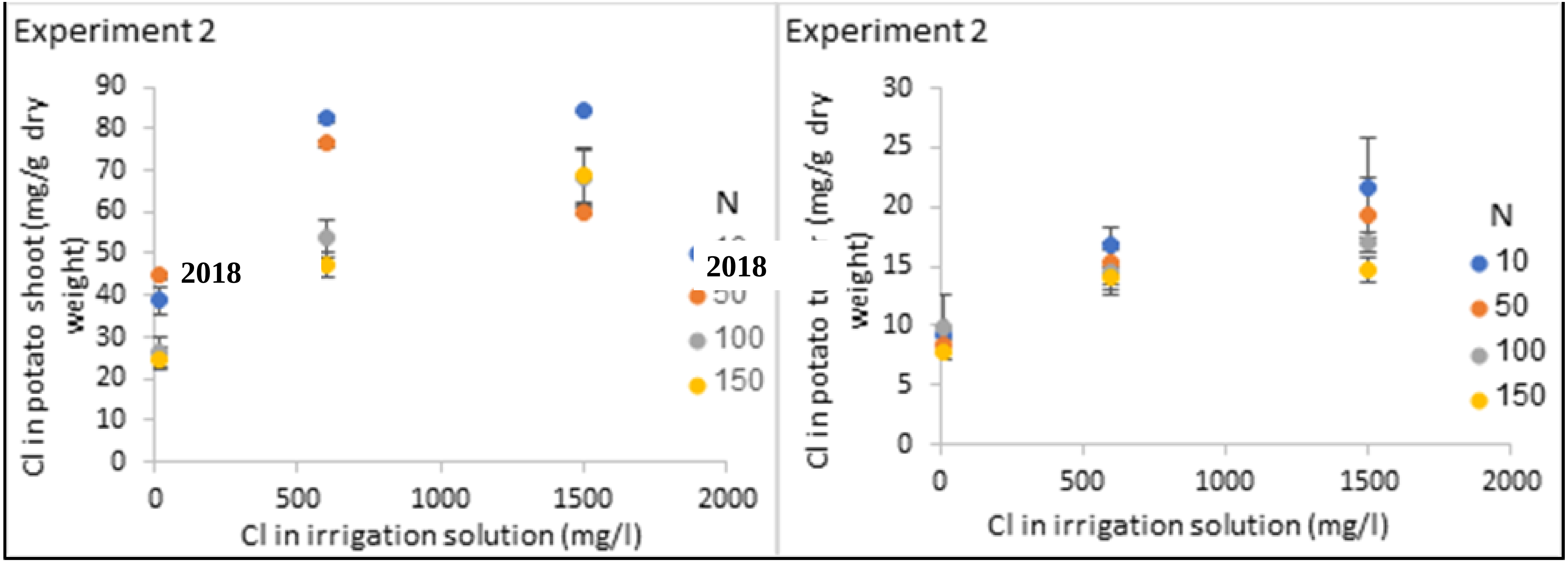




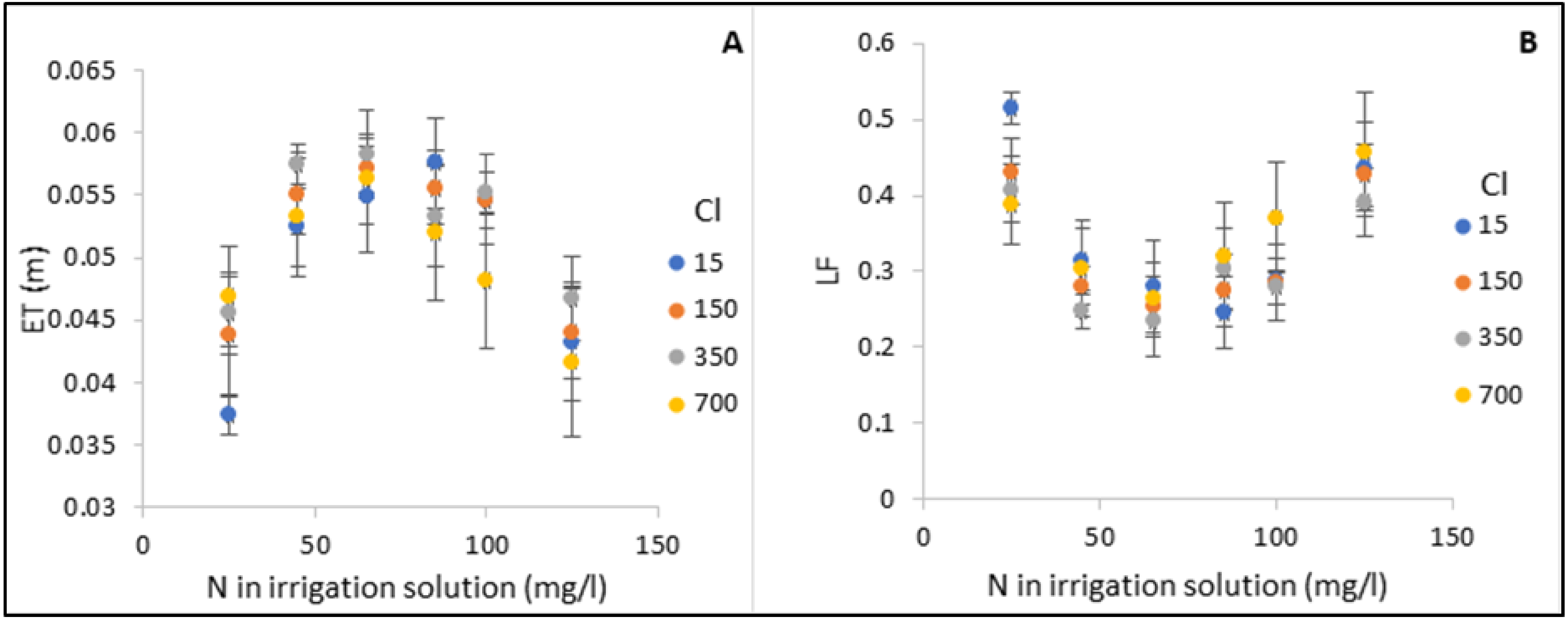
Cl concentration in Potato tubers as a function of Cl as affected by N concentration, 2018

Shoot

Tubers

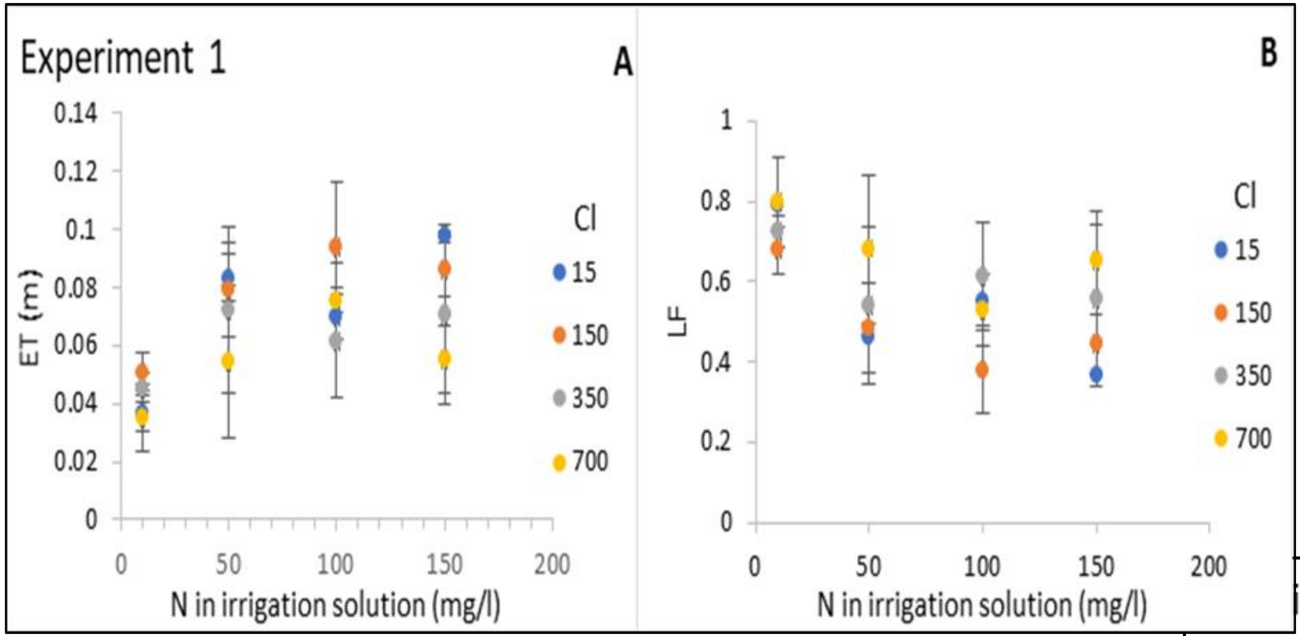


Evapotranspiration and leaching fraction as function of N in irrigation solution and as affected by Cl concentration, Lettuce experiments, 2017

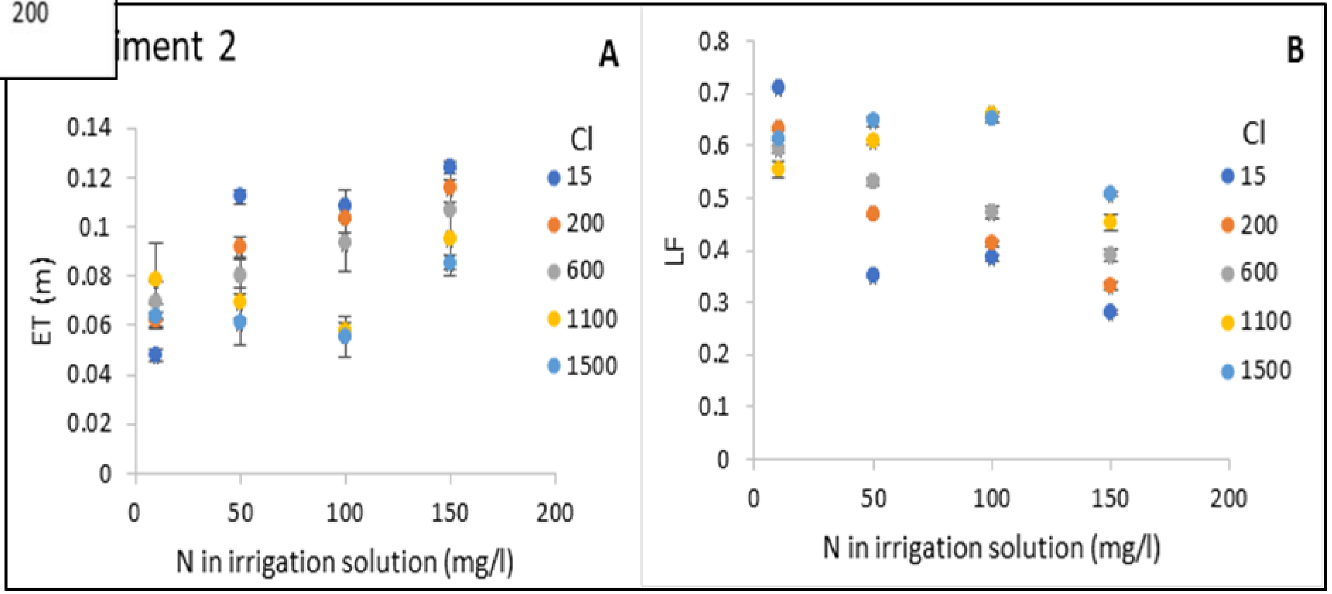


Evapotranspiration and leaching fraction as function of N in irrigation solution and as affected by Cl concentration, Potato experiments

2017



2018



Take Home Message

- Cl concentration in plants increased with Cl concentration in the irrigating solution. Increasing nitrogen concentration in the irrigating water depressed Cl concentration in plants.
- N concentration in plants increased with N concentration in the irrigating solution; No clear effect of Cl concentration in the irrigating water on N concentration in plants was obtained.
- The main negative effect of high Cl on plants biomass is not related to N deficiency.
- There is no evident that N fertilization under the improved water quality (lower Cl concentration) should be reduced.
- The overall conclusion is that as water quality is improved through desalination higher N supply is required for optimal outcome of high yields with less groundwater pollution by downward leaching of N and Cl.

Acknowledgement

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Thanks for your attention