The Influence of Soil Salinity Gradients On Soybean Production and Nutrient Cycling

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Abstract

Crop response to salt-affected soils is of increasing interest in North Dakota. Over the past 30 years, Eastern North Dakota has entered a wet-cycle, leading to a higher water table and transport of salts from deep in the soil profile to the surface. As a result, producers are experiencing various levels of yield reductions in both corn and soybeans. In this greenhouse study, the effects of various salt levels on above- and below-ground soybean productivity were evaluated. Above-ground parameters included leaf damage and biomass, while below-ground parameters included root development and nodulation. Soil N pools following a soybean crop were also evaluated in response to the common practice of reducing fertilizer inputs the following year when corn is grown.

Methods

A 50:50 mixture of silica sand and soil (Glyndon, course-silty, mixed, superactive, frigid Aeric Calciaquolls: a non-saline soil series in North Dakota) was prepared in plastic lined, 1 kg pots with a "saline layer" (Na_2SO_4 and $MgSO_4$ hydrate salts) in the bottom of each pot (Fig 1). Four different levels of salts were added to achieve a salinity range from 0 – 4 dS m^{-1} ($EC_{1:1}$; levels shown in Table 1), with 10 replicates at each salinity level and growth stage. Nutrients applied at planting included micronutrients, P, K, and FeEDDHA basal. Soybean were planted into each pot and watered gravimetrically during the experiment.

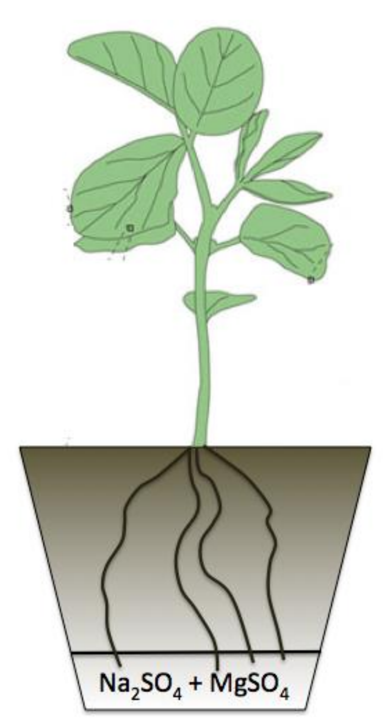

Fig. 1

Two experiments were conducted, harvest occurred at the first and third trifoliate growth stages. Height and leaf measurements were recorded at harvest. Whole plant was cut within 2 cm of the surface, dried at 55°C and ground for total N analysis. Roots were also analyzed by collecting a volumetric core. Roots were gently washed using a 2 mm sieve and scanned using WinRHIZO software (Regent Instruments, Quebec, QC), roots were then dried and weighed. Remaining soil was processed and analyzed for $EC_{1:1}$, total N, NO_3-N, and NH_4-N.

Target EC Level	Level Achieved ($EC_{1:1}$)
0	0.30 (±0.04)
1	1.20 (±0.17)
2	2.10 (±0.28)
3	3.36 (±0.97)

Table 1. Target and achieved $EC_{1:1}$ (dS m^{-1}) levels

Results

Soil Parameters, Nutrient Cycling

Total N and NH_4-N significantly decreased as $EC_{1:1}$ levels increased (r^2 =0.261 and 0.254 respectively; Figs. 3 and 4) . The opposite was observed for NO_3-N, where as $EC_{1:1}$ increased so did concentrations of NO_3-N (r^2 = 0.540; Fig. 2).

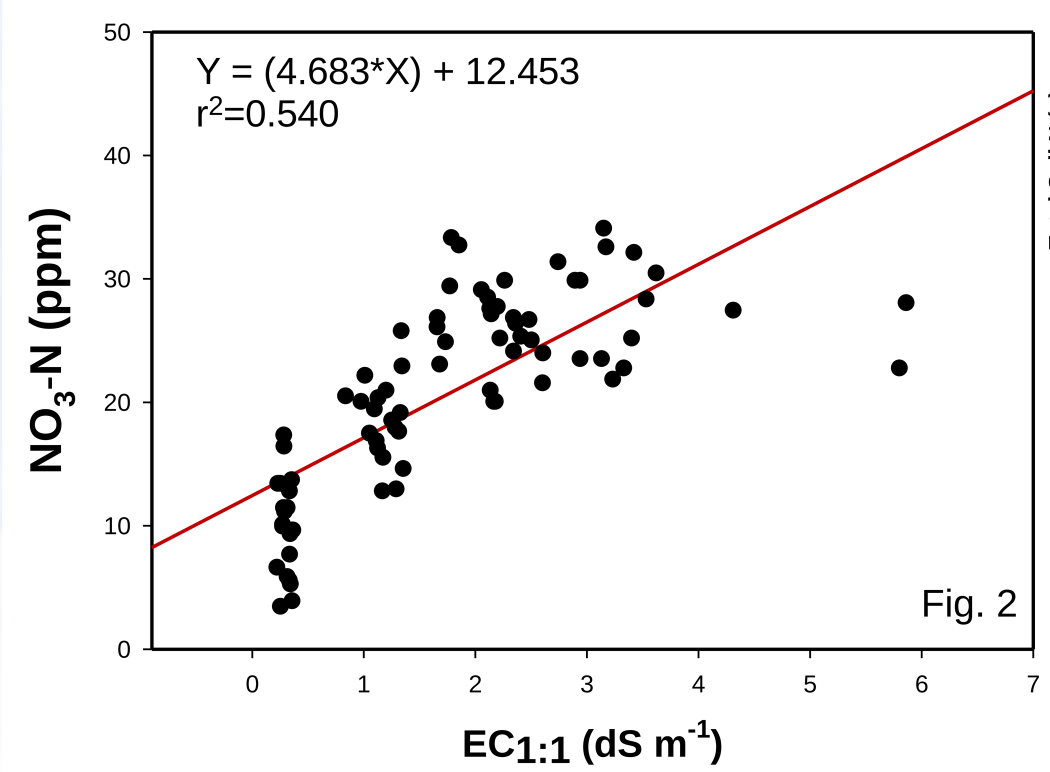

Fig. 2

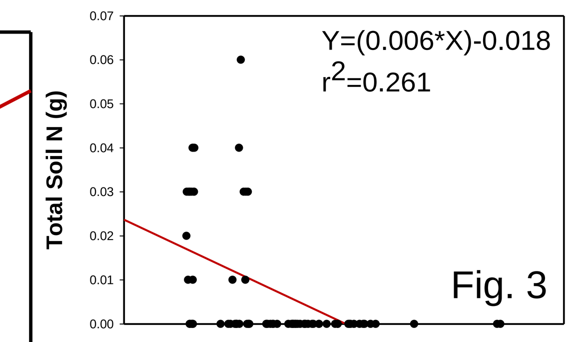

Fig. 3

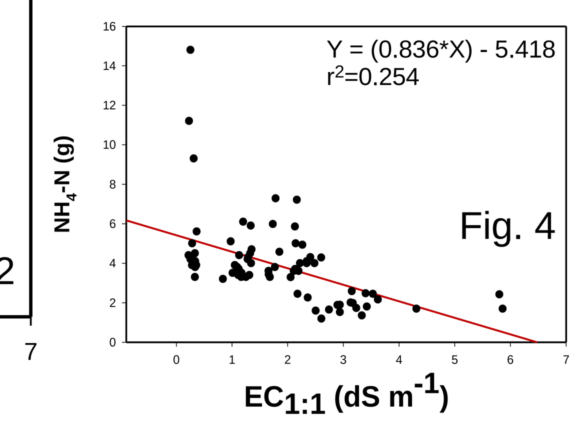

Fig. 4

Plant Parameters

Below-ground parameters (root mass, root length and nodulation) decreased as salinity increased (Figs. 5, 6, 7 and 8). These relationships held true for both 1st and 3rd trifoliate stages. Plant parameters shown below are from the 3rd trifoliate data. Above-ground biomass and leaf area decreased as salinity levels increased (Figs. 9 and 10). Inversely, total plant N in the leaf increased with higher salinity levels (Fig. 11).

Below-ground Analysis

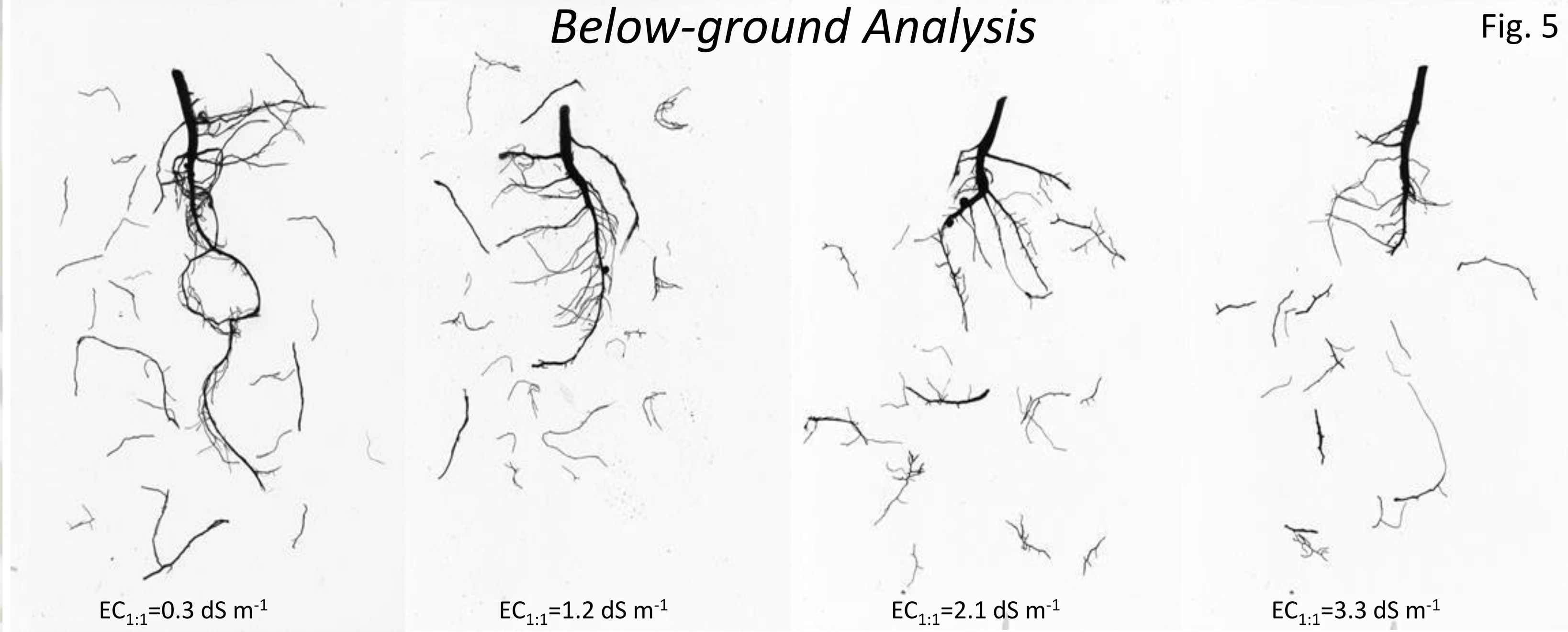

Fig. 5

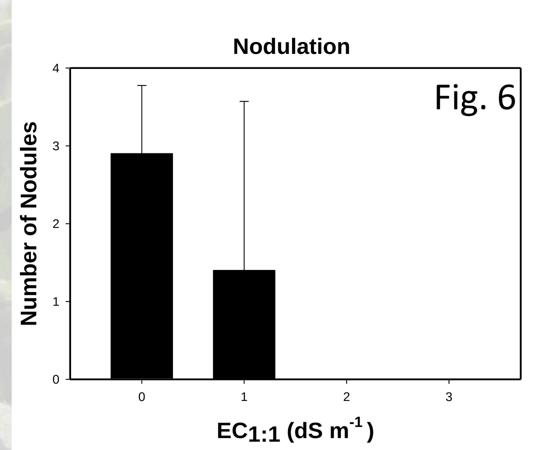

Fig. 6

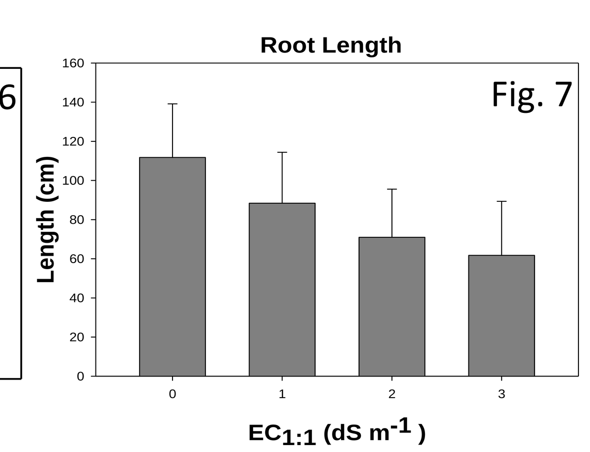

Fig. 7

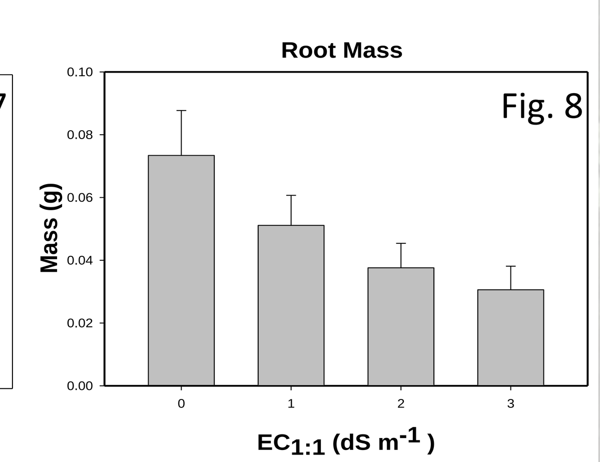

Fig. 8

Above-ground Analysis

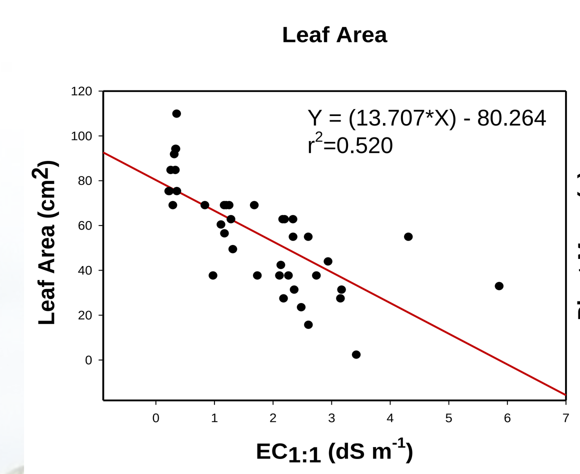

Fig. 9

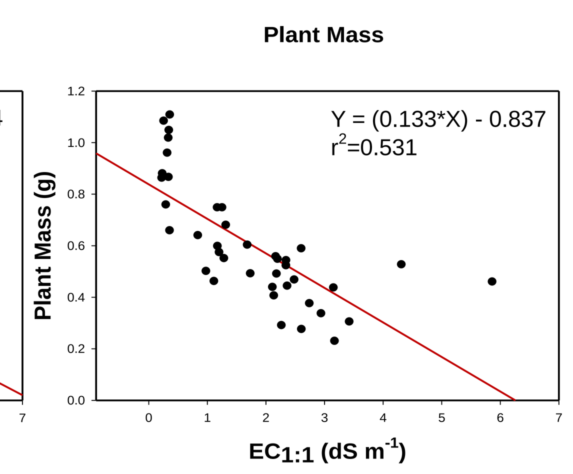

Fig. 10

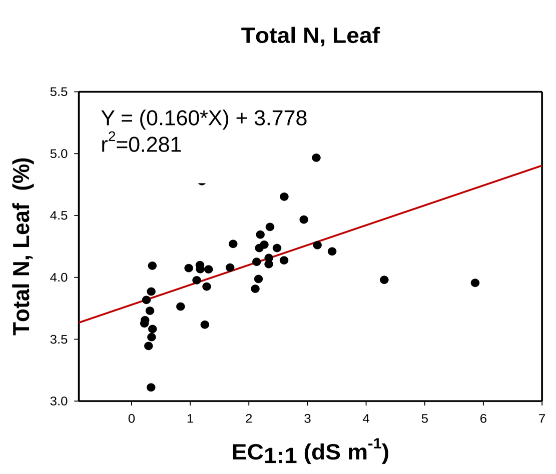

Fig. 11

Discussion

In this experiment, we were interested in soybean response to low levels of salinity. There is clearly a plant response, both above- and below-ground. Above-ground, decreases in leaf area and biomass could result decreased productivity and lower overall yields due to salinity (Franzen, 2012). Below-ground, roots are less developed with lower nodulation. There is a clear N response due to salinity, this response could alter fertilizer recommendations and the success of the following years corn crop.

Continuing Research

Greenhouse evaluation allowed control to isolate salinity as a stressor; this initial experiment will be the backbone for a follow-up field study. All parameters analyzed in the greenhouse will be investigated in the field, focusing on the same salinity gradient 0-4dS m^{-1} ($EC_{1:1}$). An EM-38 will be utilized to locate relative EC levels, as depicted in Fig. 12. The field component will be concentrated in the Red River Valley of the North, an area with increasing salinity due to a long-term wet cycle. Corn-soybean rotations are predominant in this area, making salinity a major concern for producers.

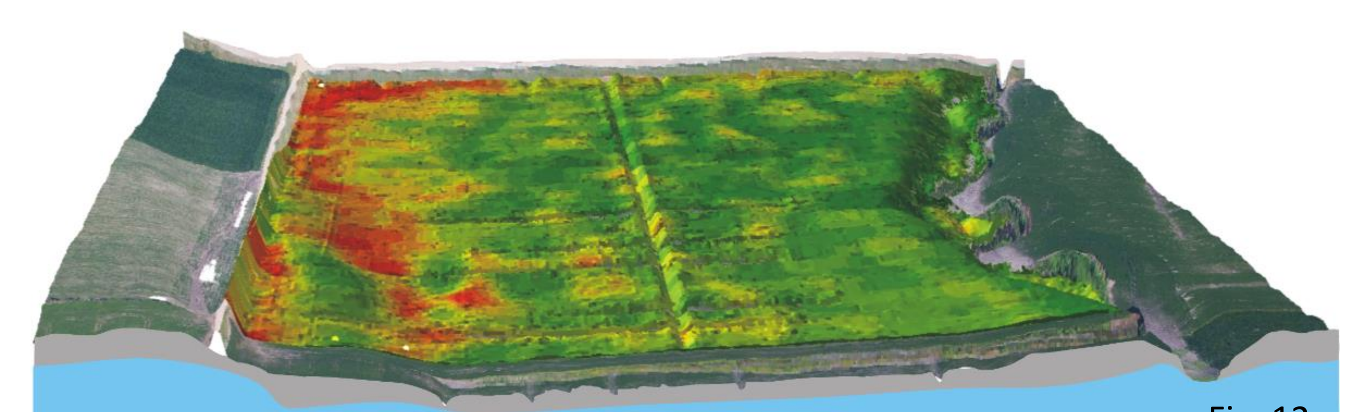
Fig. 12

Literature Cited

Franzen, D. 2012. Managing Saline Soils in North Dakota. North Dakota State Univ Extension Service. SF-1087

*Acknowledgements: Casey, F.X.M., N.E. Derby, A. F. Wick. Fig.12. 2013