PORT COLBORNE FIELD TRIAL OF LIMESTONE AND MANGANESE APPLICATION TO AGRICULTURAL LAND TO REDUCE NICKEL TOXICITY IN FIELD CROPS

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Outline

- Introduction
- Materials and Methods
- Results
- Conclusions
- On Going Research

Introduction

- As the number of contaminated sites increases, new in situ remediation techniques need to be developed

Introduction

- Current techniques
  - Phytoremediation
    - Time consuming
    - What do we do with the plants after remediation?
  - Removal of contaminated soil
    - Expense increases as area of contamination rises
    - Contaminated soils need to be disposed
    - Clean fill required to replace contaminated soil

Introduction

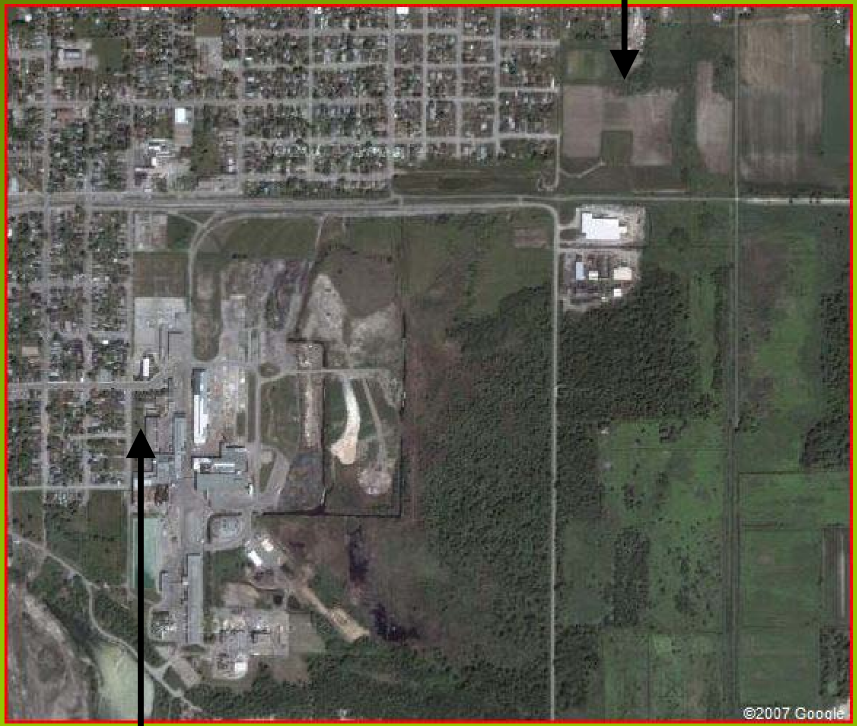
- Are these techniques practical for agricultural lands?
  - Phytoremediation
    - Land is unavailable during remediation
  - Removal of contaminated soil
    - May remove essential nutrients for plant growth as well

Introduction

- What's the alternative?
  - Chemically treat soil to reduce bioavailable amount of soil metals
    - Addition of lime
  - Proved successful in remediation of Sudbury soils
    - Soils were raised from a range of 3.0-4.5 to a range of 5.5 – 6.0
    - Range suitable for plant growth and reduced cationic metal bioavailability

Introduction

Research Fields



INCO Ltd.

- Port Colbrone, ON
- Approx. 1 km NE of INCO Ltd.
- Refinery operation from 1918 to 1984

Introduction

- Field site has soil Ni concentrations ranging from 1300 ppm to 4900 ppm
  - Ontario Guideline – 200 ppm
- The pH of these soils were 5.2 – 6.1 prior to lime application
  - pH increased to 6.2 – 7.6

Introduction

- Effects of elevated pH
  - May reduce bioavailability of cationic metals
    - Reduction in phytotoxcity
  - May also reduce bioavailability nutrient cations
    - Potential for induced Mn and Fe deficiency

Introduction

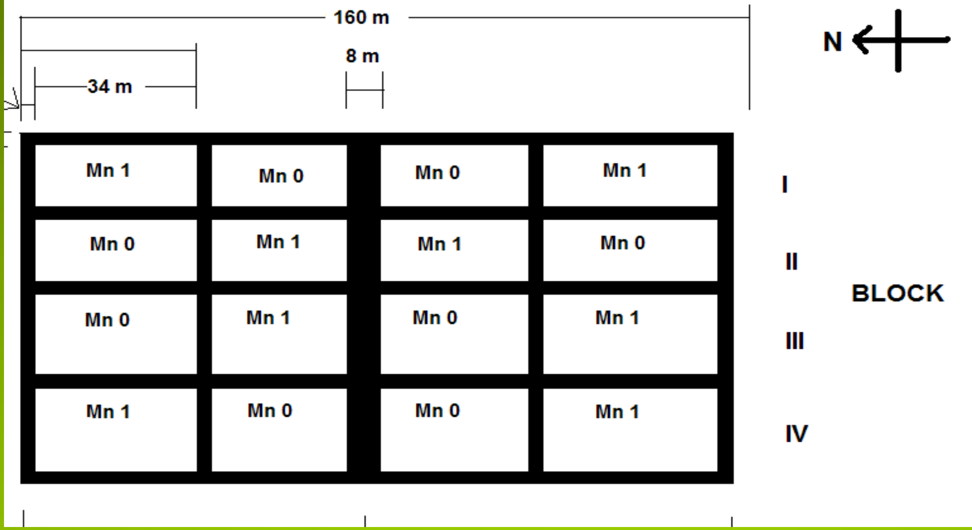
Purpose of our research

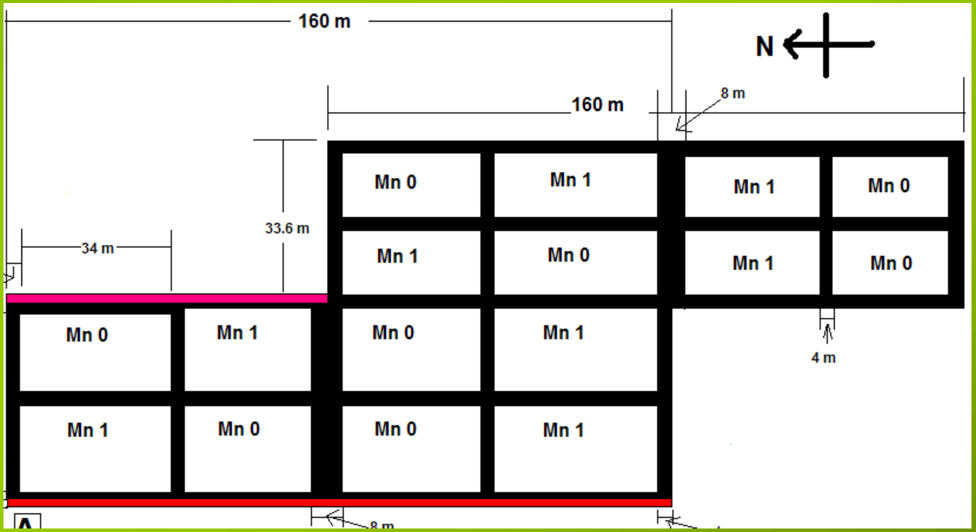
– Test the usefulness of rendering metal-contaminated soils alkaline with addition of dolomitic lime, in the context of extremely high Ni concentration, and induced Mn deficiency

Materials and Methods

- Hruska West – 50 t/ha added lime
- Hruska East – 10 t/ha added lime
- Snider Road – 0 t/ha added lime

Materials and Methods





- 100 kg Mn/ha added to half of the plots

Materials and Methods

2005 Field Preparation

- Oat plots (AC Rigodown, Certified 1–OMAF)
  - Fertilizer (18:18:18) – rate of 224 kg/ha
  - Planted at a depth of 1.25 inches
  - Rows 7.5 inches apart
- Soybean plots (29-FL-2R)
  - Fertilizer (6:24:24) – rate of 168 kg/ha
  - Planted at a depth of 1.25 inches
  - Rows 7.5 inches apart

Materials and Methods

2005 Harvest

- Oat plots
  - Combine harvested
  - Each plot was harvested separately to determine agronomic yields

- Soybean plots
  - Did not grow well
  - Too short to harvest with combine

Materials and Methods

2006 Field Preparation

- Fields sprayed with herbicide Round-Up™
- “Mn plots” sprayed with $MnSO_4$ at 8 kg/ha
- Foliage sampled in triplicate in mid-August for foliar Ni concentration
- Samples were oven dried and stored until analysis

Materials and Methods

2006 Harvest

- Desiccant was applied to dry out the crop for harvest
- Extremely wet fall and a freak snow storm made it impossible to harvest with a combine
- Harvested three 1m^2 sub-samples per plot
- Threshed beans with a portable thresher
- Estimated plot yield by scaling up 3 m^2 yield

Materials and Methods

Materials and Methods

Foliar Ni Analysis

- 1 gram dried tissue sample acid digested in 10 mL concentrated HNO_3
- Digested in Teflon bombs at 110˚C over night
- Filtered, diluted and analysed with a Flame Atomic Absorbance Spectrometer

Results

2005 Oat Crop

Liming (t/ha)	Mn	Soil Ni (mg/kg)	Soil pH	Yield (kg/plot)
50	0	2150	7.4	33
	1	2260	7.3	27
10	0	3010	6.8	41
	1	2910	6.7	46
0	0	2210	5.6	87
	1	1970	5.4	64
0	0	50	5.2	35

Means, n=4

- Edaphic or climatic variables other than those measured may influence yield

Results

$$\frac{[Foliar\ \ Ni]}{[Soil\ \ Ni]} \times 100\%$$

2006 Soybean Crop

Liming (t/ha)	Mn	Soil pH	Soil Ni (ppm)	Foliar [Ni] (µ/g DW)	Bioavailability Index (%)	100 Seed weight (g)	Yield (kg/plot)
50	0	7.4	2150	27	1.27	12.6	46
	1	7.3	2260	22	1.02	13.5	51
10	0	6.8	3010	30	1.08	13.6	63
	1	6.7	2910	33	1.18	14.0	76
0	0	5.6	2210	36	1.5	13.9	29 46
	1	5.4	1980	54	2.93	13.2	20 40
0	0	5.2	50	0.83	1.66	13.3	82

Means, n=8

Results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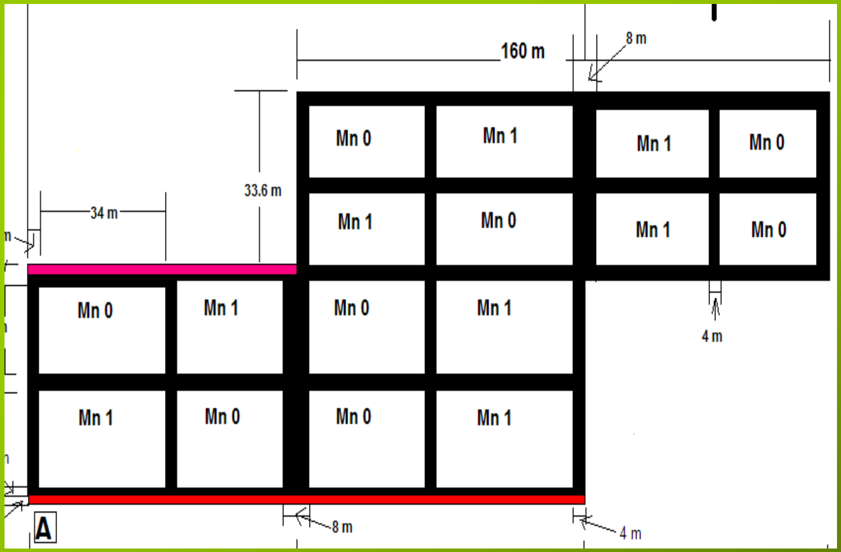
160 m
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Mn 0
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Results

2006 Soybean Crop

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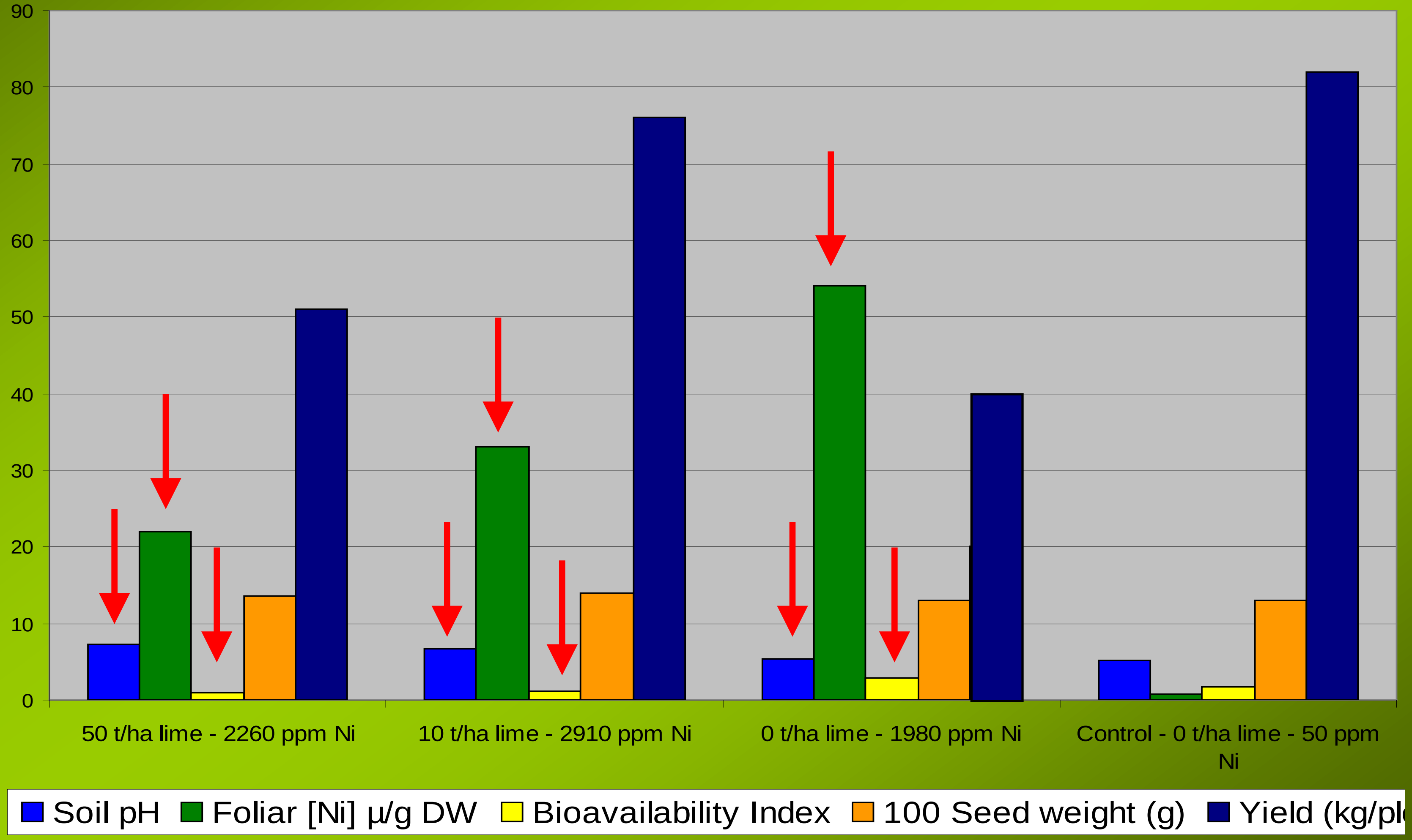
Means, n=8



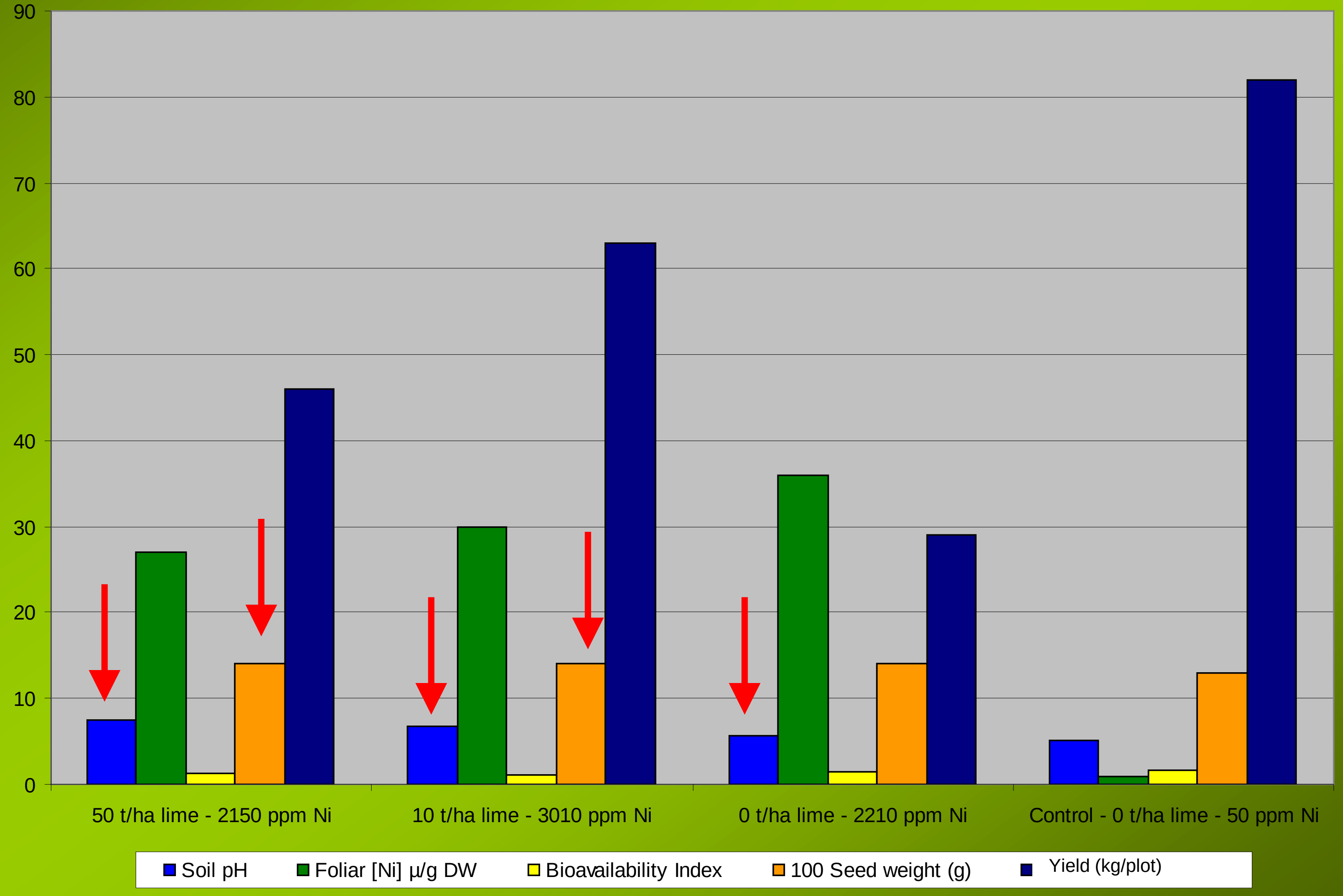
Results

2006 Results of plots receiving Mn supplements



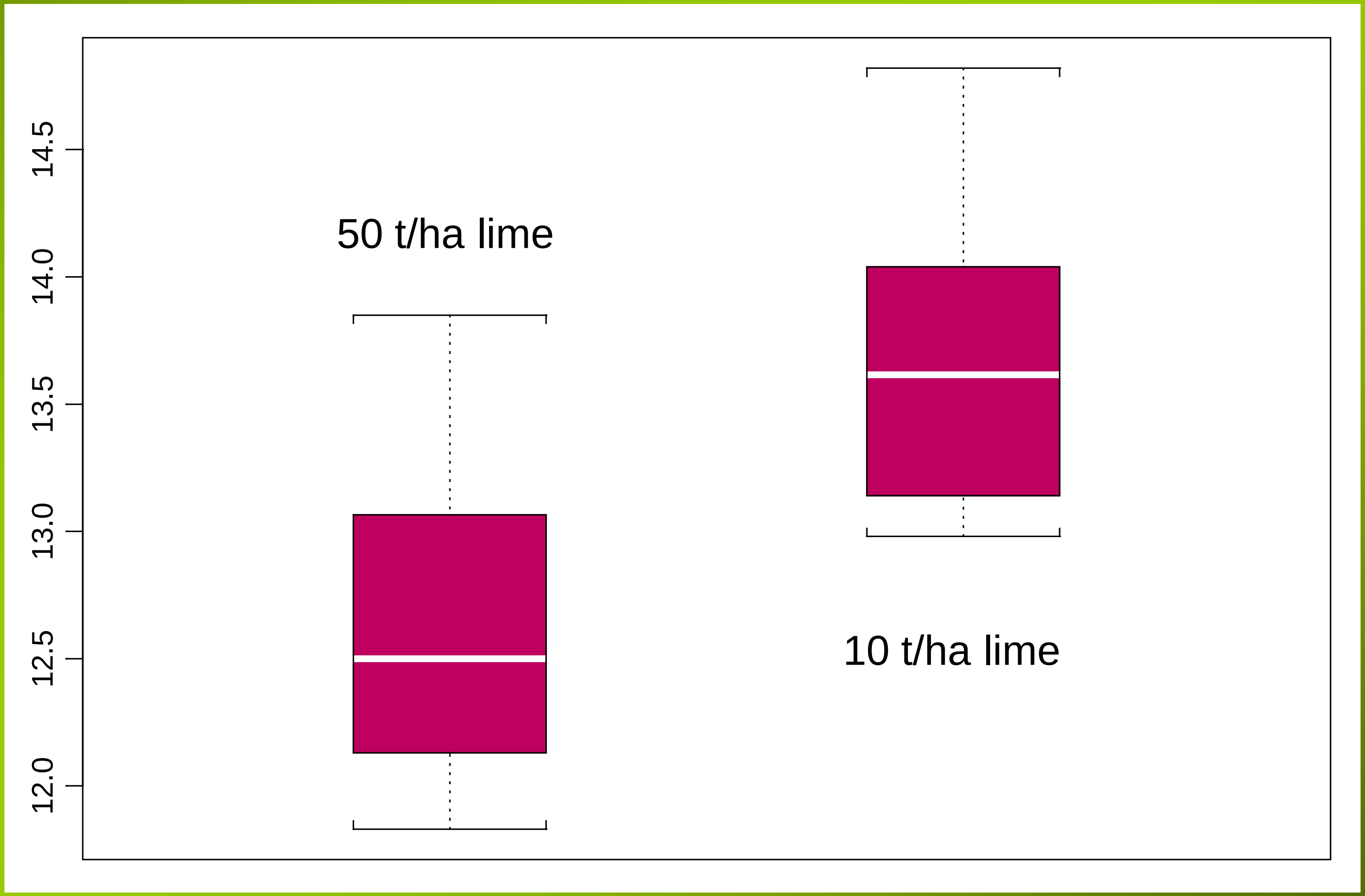
Results

2006 Results of plots receiving no Mn supplements



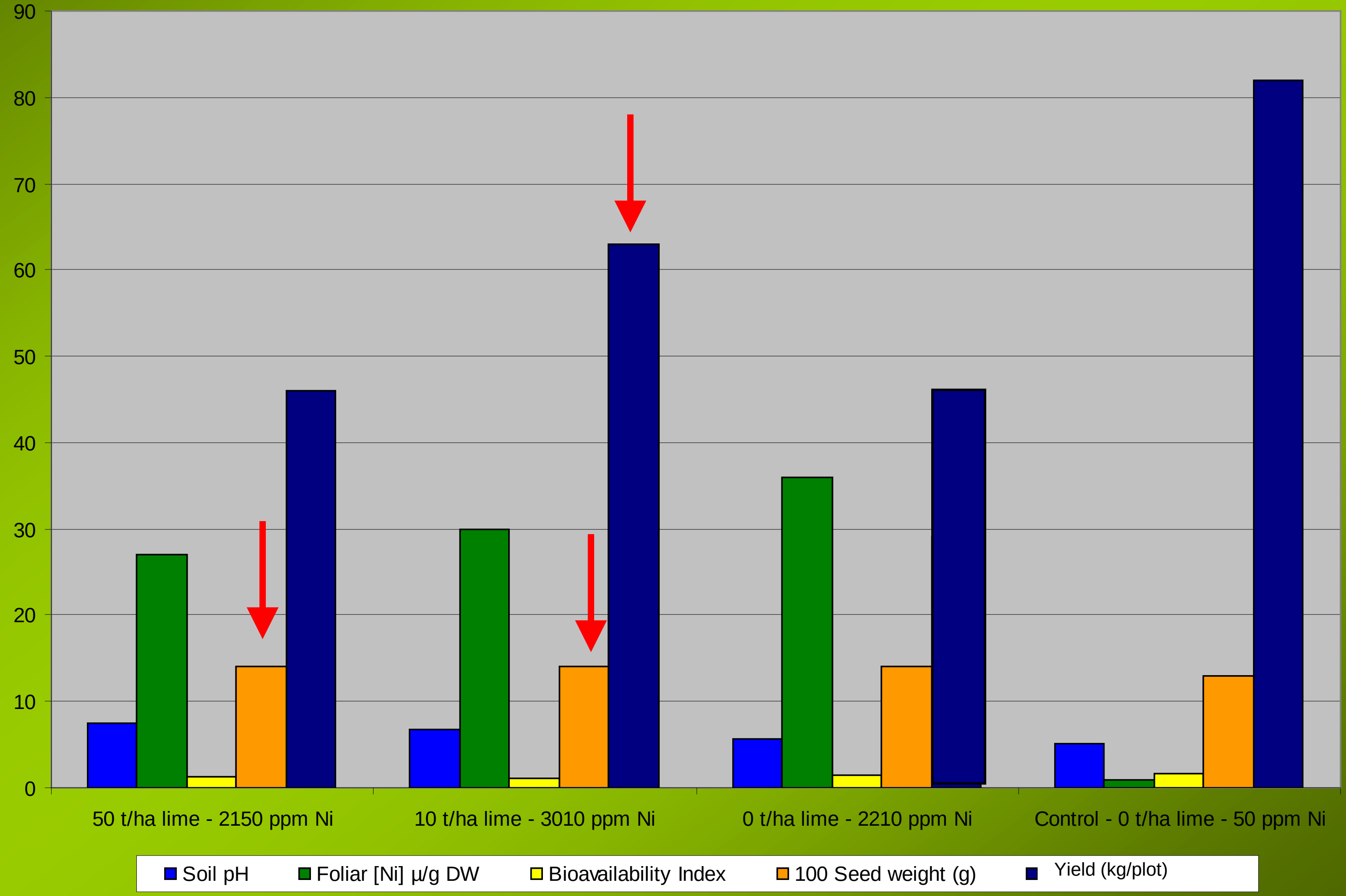
Results

Distribution of 100 seed weight from 50 t/ha and
10 t/ha field plots with no added Mn



Results

2006 Results of plots receiving no Mn supplements



Conclusions

- Little difference between 50 and 10 t/ha treatment
- Both decreased Ni bioavailability and increased plant growth when compared to no lime treatment

Conclusions

- The distribution of foliar Ni differed in plots with added Mn
- Difference in distribution of 100 bean weights with no Mn supplement
  - Unclear if Mn is affecting distributions, or is coincidental with soil Ni concentration

Conclusions

- Liming fields that are contaminated with extremely high concentrations of Ni is an effective way to promote plant growth

On Going Research

- Analysis of 2007 Field Results
  - Had success with both soybean and oat
  - Greater spectrum of analysis on soils and plants

On Going Research

- Further investigation of Snider Road Field
  - $CaCl_2$ extractions of soil
  - Perhaps change the treatment

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