Douglas-fir growth and foliar nutrient status with nitrogen and multi-nutrient fertilization across soil parent materials of the Inland Northwest, USA

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Overview

- **Chapter 1 of my thesis**
- **Douglas-fir growth and foliar nutrient status with nitrogen and multi-nutrient fertilization across soil parent materials of the Inland Northwest, USA**

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- Typical layout: Introduction, Methods, Results and Discussion

Introduction

- DF are nitrogen (N) deficient
- Inconsistent response to fertilizer
- Other nutrients found to limit growth along with N

- IFTNC looks at soil parent materials as a proxy
- Soil parent material classes: underlying geology + tephra and/ or loess

- Use of foliar nutrient diagnostics to predict stem growth improvements have been ineffective
- Different approach: screen trial studies

Introduction

- Hypotheses:

1. Growth improvements to fertilizer depend on soil parent material,
2. Foliar nutrient status depends on fertilizer and soil parent material, and

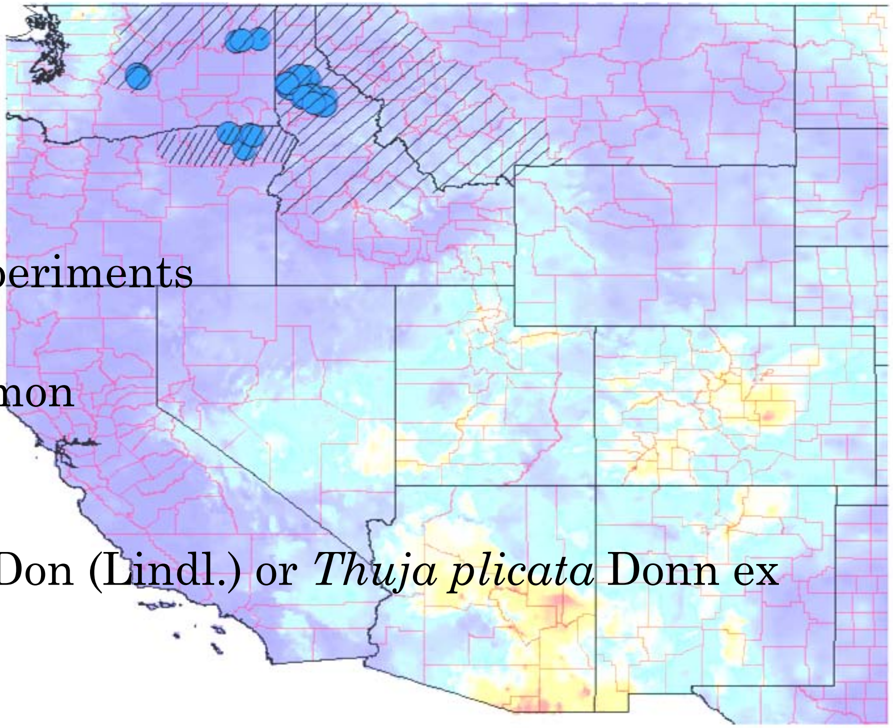
- Softer analyses:

1. Foliar nutrient status can predict growth responses
2. Explore who is limiting growth

METHODS

- Sites and design

1. 33 individual-tree fertilization experiments



- Sites have important things in common

1. No crown closure
2. Trees were 1.2-m to 12-m tall
3. Either *Abies grandis* Dougl ex D. Don (Lindl.) or *Thuja plicata* Donn ex D. Don) vegetation series

- Soil parent materials

1. Classified in the field

Soil Parent Material	Class Codes	# of Sites
Basaltic + Tephra	A	4
Low-Ca Metamorphosed-sediment + Tephra + Loess	B	3
Basaltic without surficial deposits	C	4
Low-Ca Metamorphosed-sediment + Tephra	D	5
Medium-Ca Metamorphosed-sediment + Tephra	E	7
Basaltic + Tephra + Loess	F	2
Granitic + Tephra	G	5
Low-Ca Metamorphosed-sediment + Loess	H	1
Unconsolidated Sediment + Tephra	I	2

Methods

- Fertilization

1. Applied by granular broadcast in October of the application year
2. Reclassification

Nutrient Addition Rates of the Fertilizers (kg ha^{-1})						
N	**K**	**S**	**B**	**Cu**	**# of Sites**	**Reclassification**
0	0	0	0	0	29	Control
224	0	0	0	0	11	N-only
336	0	0	0	0	18	N-only
224	0	90	3.36	11.2	4	Multi-nutrient
224	190	100	3.36	11.2	3	Multi-nutrient
224	190	100	3.36	0	4	Multi-nutrient
336	190	100	3.36	0	18	Multi-nutrient

Methods

- Measurements and variables

- Stem diameters and heights at two time points

1. Calculated tree volumes and stem growth ($dm^3\ yr^{-1}$)

- Foliar nutrient concentrations N, K, S, B

1. Calculated nutrient concentration ratios

$$nutrient\ concentration\ ratio = \frac{M\ foliar\ concentration}{N\ foliar\ concentration} \times 100$$

- Needle mass and foliar nutrient content

$$nutrient\ content = M \times g\ 100\ needles^{-1}$$

Methods

- Analyses:

- ANCOVA / ANOVA

1. Growth

$$G_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \gamma_{ijk} + s_{k(j)} + \varepsilon_{ijk}$$

2. Foliar nutrient contents and concentration ratios

$$F_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + s_{k(j)} + \varepsilon_{ijk}$$

- Graphical vector analysis

Results

Hypothesis 1

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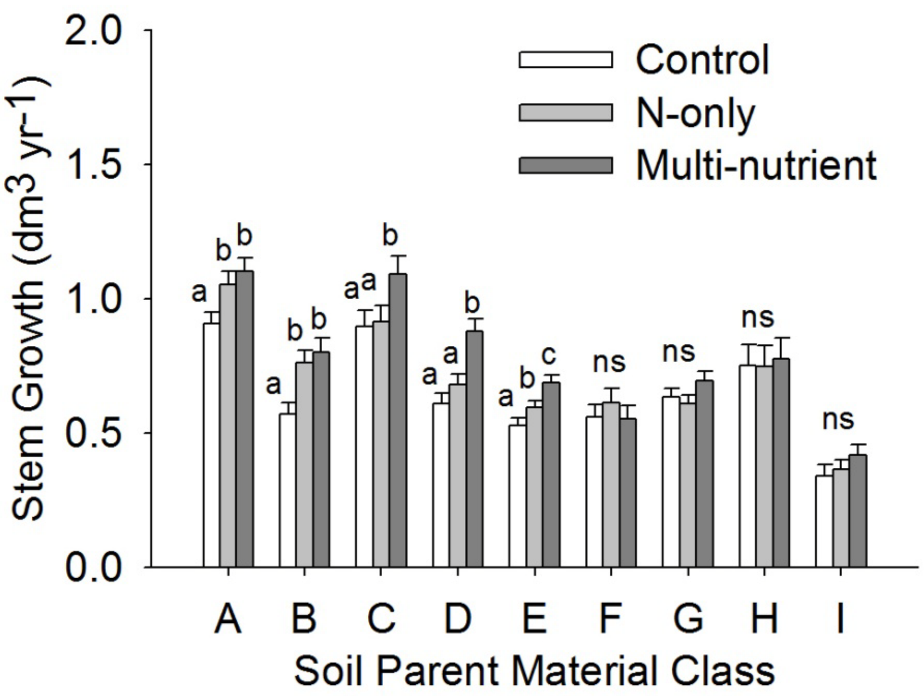


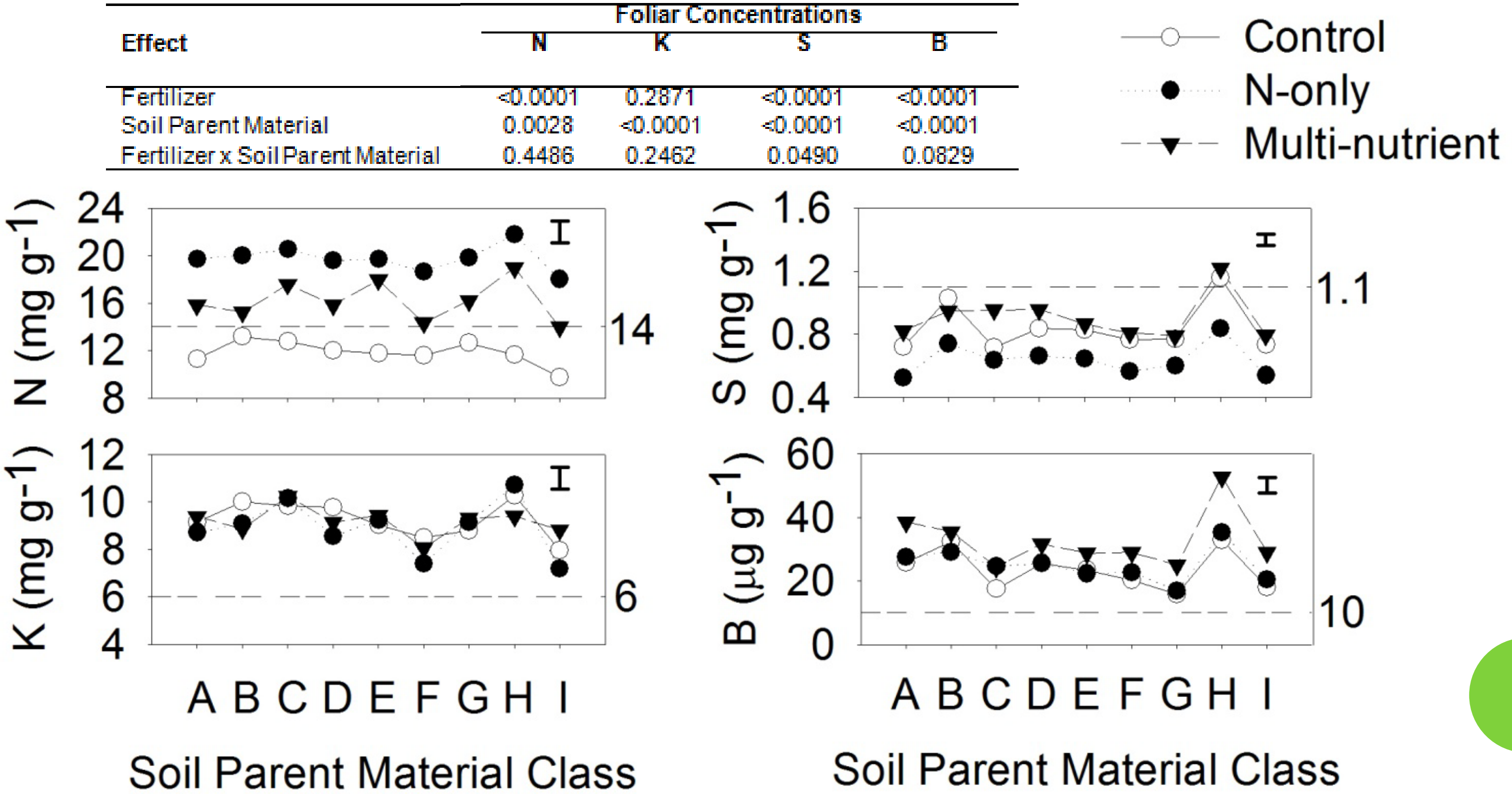
Effect	Stem Growth
Fertilizer	<0.0001
Soil Parent Material	<0.0001
Fertilizer x Soil Parent Material	0.0726

Results

Hypothesis 2

Soil Parent Material	Class Codes	# of Sites
Basaltic + Tephra	A	4
Low-Ca Metamorphosed-sediment + Tephra + Loess	B	3
Basaltic without surficial deposits	C	4
Low-Ca Metamorphosed-sediment + Tephra	D	5
Medium-Ca Metamorphosed-sediment + Tephra	E	7
Basaltic + Tephra + Loess	F	2
Granitic + Tephra	G	5
Low-Ca Metamorphosed-sediment + Loess	H	1
Unconsolidated Sediment + Tephra	I	2

Effect	Foliar Concentrations			
	N	K	S	B
Fertilizer	<0.0001	0.2871	<0.0001	<0.0001
Soil Parent Material	0.0028	<0.0001	<0.0001	<0.0001
Fertilizer x Soil Parent Material	0.4486	0.2462	0.0490	0.0829



Results

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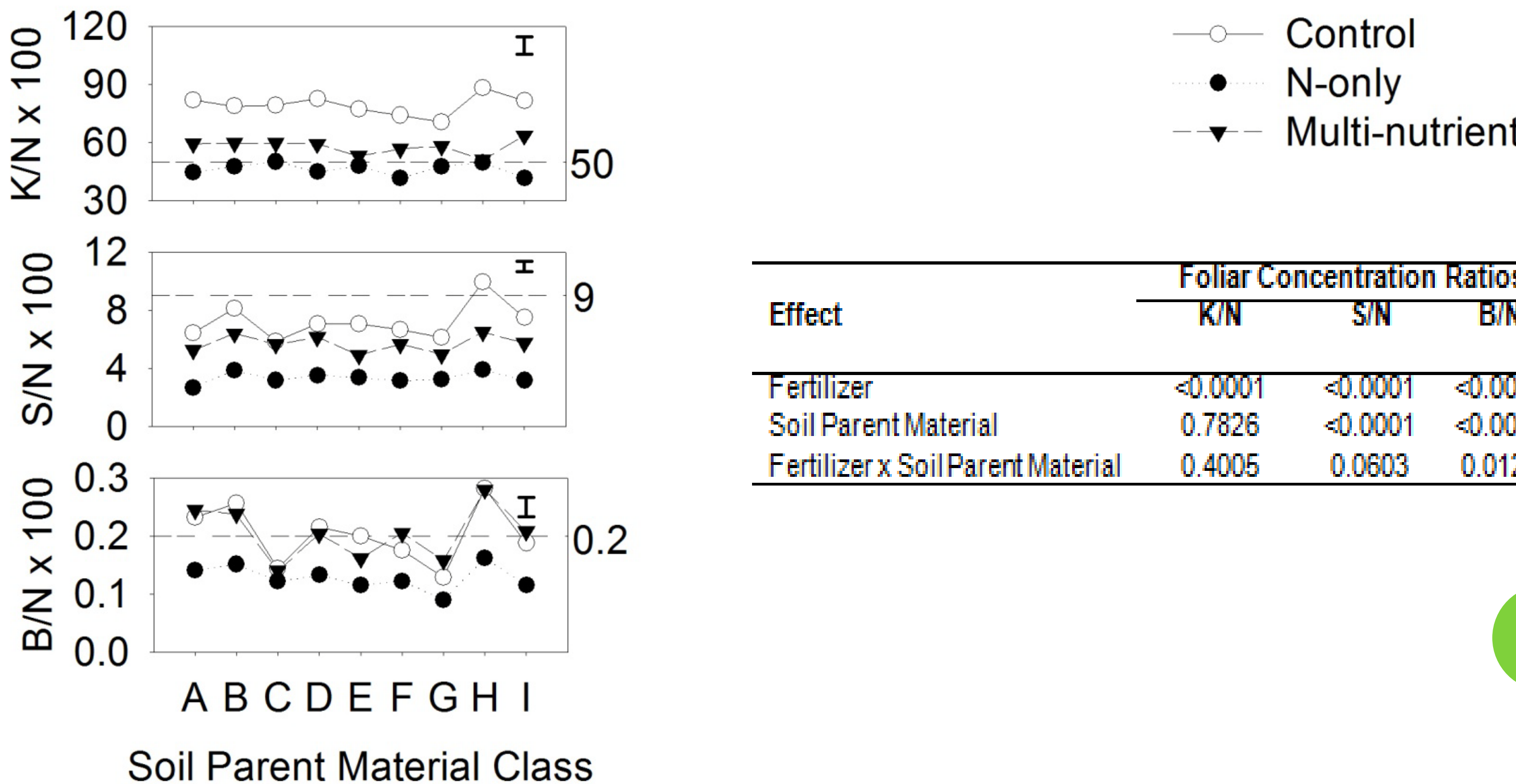
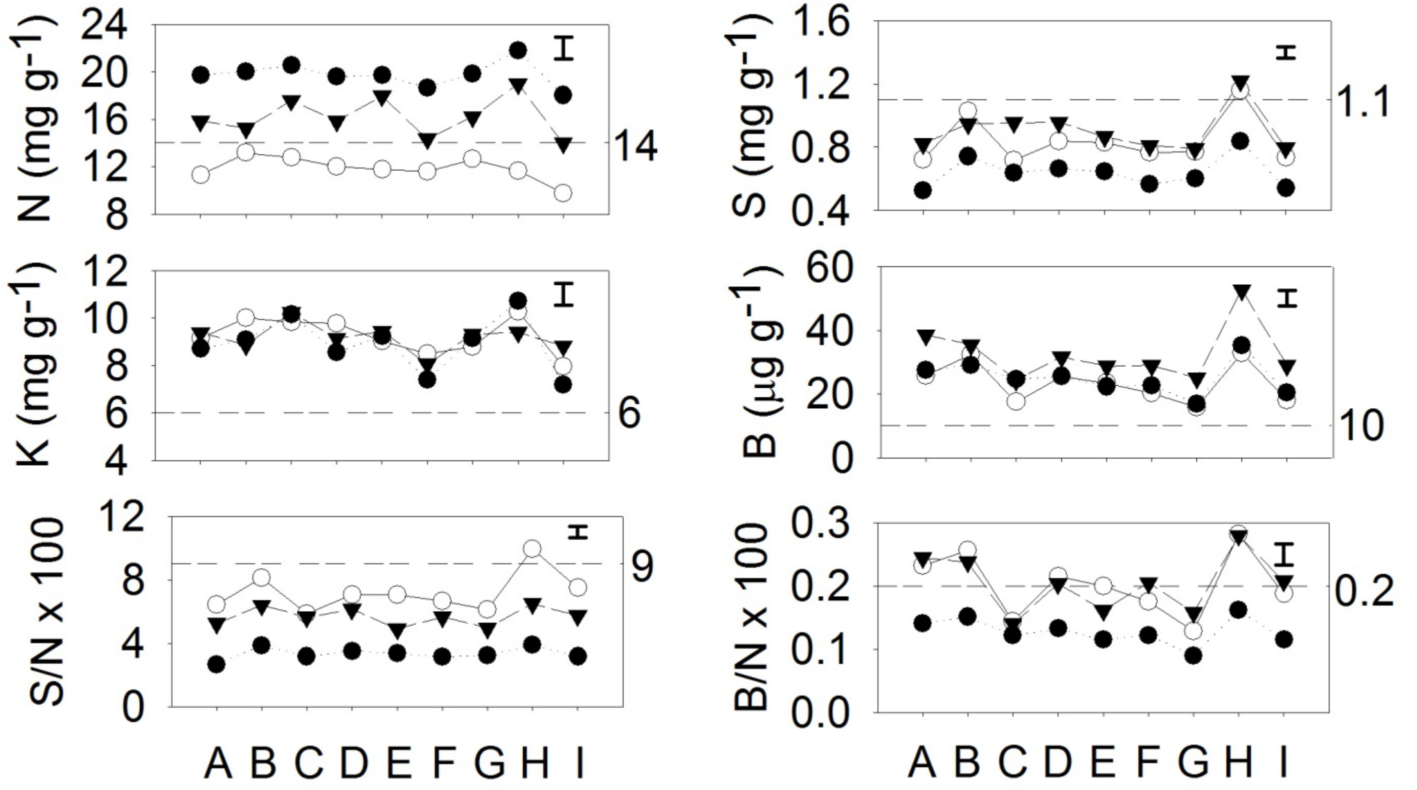


Effect	Foliar Concentration Ratios K/N	Foliar Concentration Ratios S/N	Foliar Concentration Ratios B/N
Fertilizer	<0.0001	<0.0001	<0.0001
Soil Parent Material	0.7826	<0.0001	<0.0001
Fertilizer x Soil Parent Material	0.4005	0.0603	0.0123

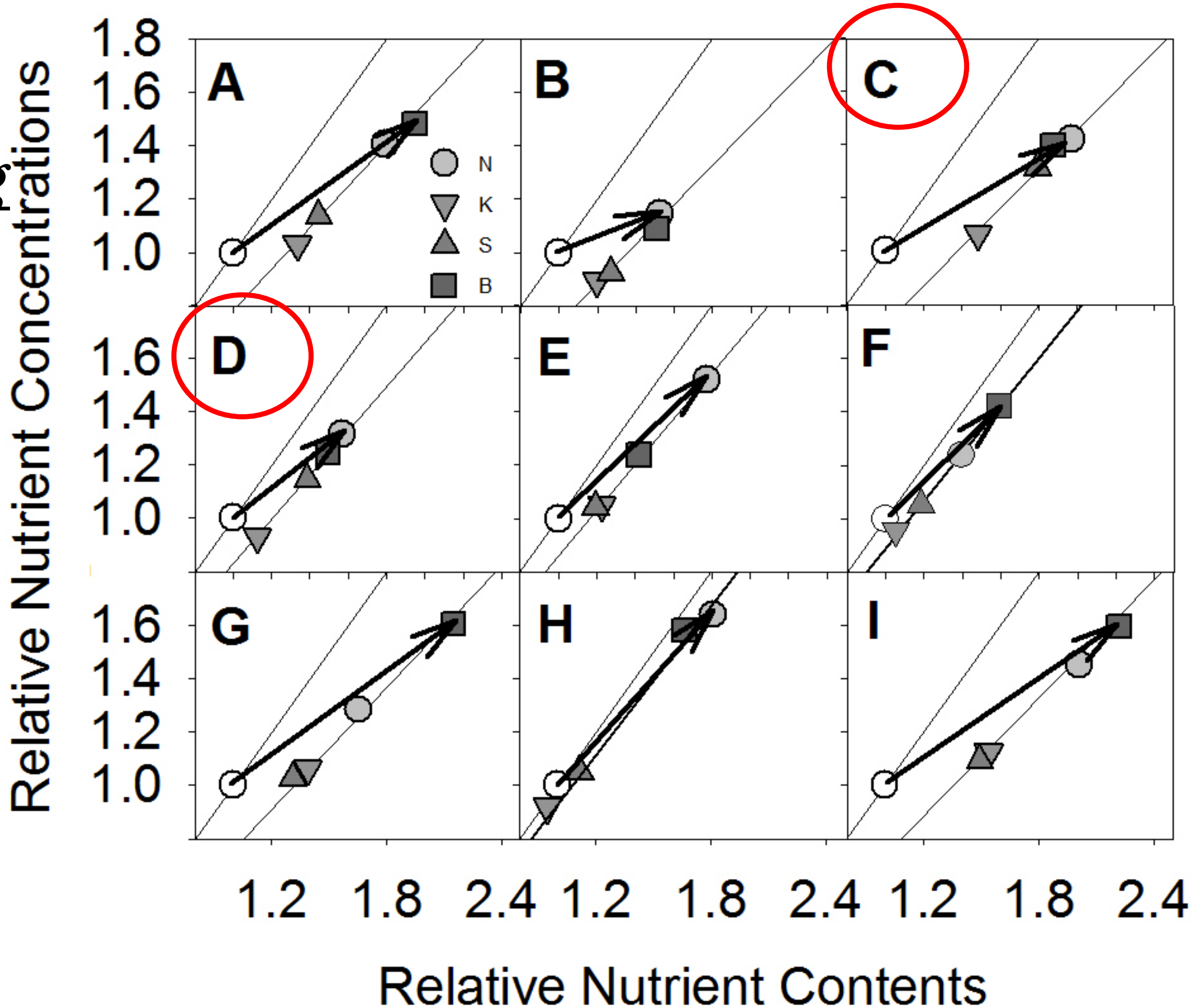
Results

Can we predict growth with foliar analysis?



Results

Who is limiting growth?



Summary

- Growth response to fertilization depended on soil parent T
- Loess deposits consistently alleviated multi-nutrient limitations
- Foliar N, S and B concentrations depended on both factors,
- Foliar K concentration only depended on soil parent material
- S/N and B/N concentration ratios depended on both factors
- K/N was driven mostly by N fertilization
- We corroborated that foliar nutrient status cannot predict
- Graphical vector analysis suggested that S is the limiting nutrient in some cases
- B limitation may be induced by N-only fertilization
- Screening trial studies were effective

Acknowledgements

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