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Nutrition Management and Fertilization for Christmas Tree Production

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Essential Elements for Plant Growth

Macros		Micros	
Carbon	C	Iron	Fe
Hydrogen	H	Boron*	B
Oxygen	O	Manganese	Mn
Phosphorus	P	Copper	Cu
Potassium	K	Zinc	Zn
Nitrogen	N	Molybdenum	Mo
Sulfur	S	Chlorine	Cl
Calcium	Ca	Nickel	Ni
Magnesium	Mg		

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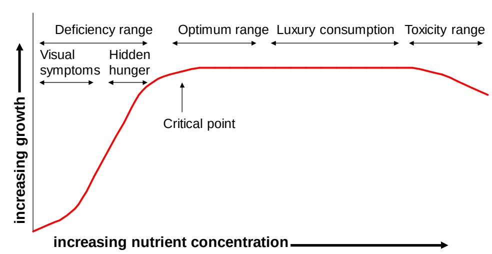
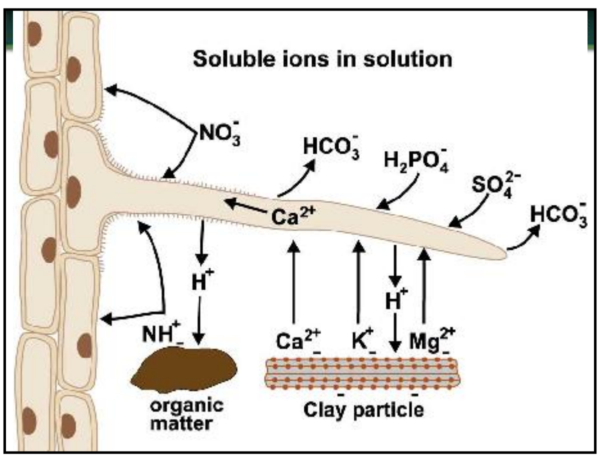
Relationship between plant growth and nutrient concentration



Adapted from Landis et al. (1989)



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Soil physical properties

Soil texture & Organic matter
Soil structure
Density
Water content

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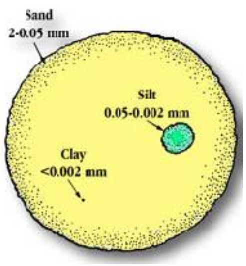
Soil texture

- Sand
- Silt
- Clay



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Soil Texture Triangle

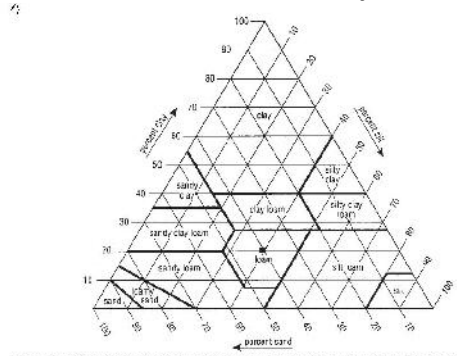

Figure 5. Soil textural triangle showing the percentages of clay, silt, and sand in the textural classes.

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Clay

- Most chemical active fraction in most soils
- Consist of fine (< 0.02 mm), platy-shaped mineral grains
- **Clay particles are not just small grains of silt or sand**

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Soil chemical properties

- Important chemical properties
  - Soil pH
  - Salinity
  - Cation exchange capacity
  - Nutrient content

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Soil pH

- Measure of acidity or basicity of soil
- pH = log $(1/H^+)$

1	7	14
Acidic	Neutral	Basic

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Soil pH

- Favorable pH range for most plants is 5.5 to 7.5

5.5 - 7.5

Acidic Neutral Basic

- Conifers generally grow better under lower pH than hardwoods

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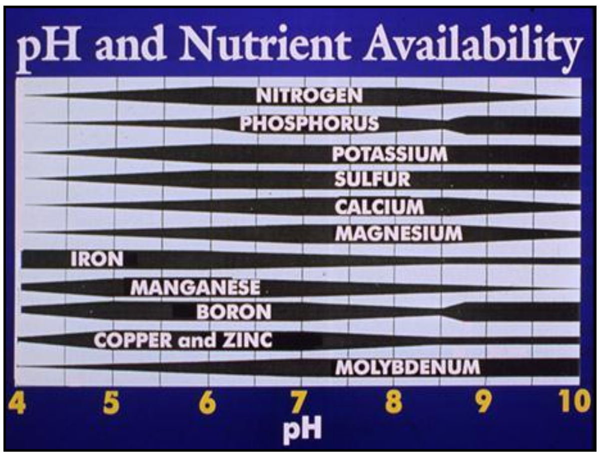
Desired soil pH for selected Christmas tree species

Spp	Desired pH
Balsam fir	5.0-5.5
Fraser fir	5.0-5.5
White pine	5.0-5.5
Canaan fir	5.5-6.0
Concolor fir	6.0-6.5
Blue spruce	6.0-7.0
Douglas-fir	6.0-7.0



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Recommended Tons of Limestone per Acre,[a] Estimated from Soil pH and Texture, to Raise the pH of a 6 2/3-in. Plow Layer of Different Soils to pH 6.5

Texture of Plow Layer	*pH Range*			
	4.5 - 4.9	5.0 - 5.4	5.5 - 5.9	6.0 - 6.4
Clay and silty clay	6	5	4	2 1/2
Clay loams or loams	5	4	3	2
Sandy loams	4	3	2 1/2	1 1/2[b]
Loamy sands	3	2 1/2	2	1[b]
Sands	2 1/2	2	1 1/2[b]	1/2[b]

[a]Lime recommendations based on a liming material having 25% passing through a 100-mesh sieve and having a neutralizing value of 90%

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Effective Neutralizing Value (ENF)

- Based on chemical effectiveness (calcium carbonate equivalent)
- CaCO3 =100
- Particle size (finer mesh increases effectiveness)
- Moisture content

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Calcium carbonate equivalent (CCE) of a few common liming materials.

Common name	Chemical formula	CCE
Calcitic limestone	$CaCO_3$	100
Dolomitic limestone	$CaMg(CO_3)_2$	109
Burned lime, quick lime	CaO	179
Hydrated or slaked lime	$Ca(OH)_2$	136

Assuming 100% pure material.

Effective Neutralizing Value (ENF)

- Example:
- Soil test lab recommends 2 tons/ac @ ENF = 60
- Your product has ENF = 50
- You need to add 60/50 = 1.2 times recommended amount (2.4 tons/ac)

Amount of elemental S needed to reducing soil pH (#/Ac)

Starting	Soil CEC		
pH	5	15	25
6	218	327	436
6.5	436	654	872
7	654	981	1308
7.5	872	1308	1744

Reducing pH

Table 2. Common acidifying materials

Material (100% basis)	Chemical Formula	Pounds of Material Equivalent to 100 Pounds of Sulfur*
Sulfur, Elemental	S	100
Aluminum Sulfate	$Al_2(SO_4)_3 \cdot 18H_2O$	694
Ammonium Sulfate	$(NH_4)_2SO_4$	260
Ferric Sulfate	$Fe_2(SO_4)_3 \cdot 9H_2O$	585

* Based on 100% materials. Adjust rate accordingly.

Cation Exchange Capacity (CEC)

- Common nutrient elements that occur as cations are K^+, Mg^{+2}, Ca^{+2}, NH_4^+
- The ability of a soil to hold positively charged ions (cations)
- Gives an indication of the ability of soil to hold nutrients

What factors determine CEC?

- Soil texture
- Organic matter
- Type of clay mineral

Soil CEC ranges

Soil texture	CEC (meq/100g soi)
Sands (light-colored)	3-5
Sands (dark-colored)	10-20
Loams	10-15
Silt loams	15-25
Clay and clay loams	20-50
Organic soils	50-100

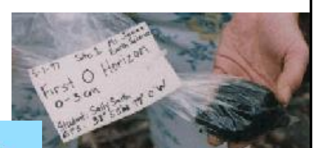
Determining need for fertilization

- In general fertilization in field nursery production is based on at least one of the following:
  - Visible symptoms
  - Soil testing
  - Foliar testing

Assessing nutrient status

- Visual symptoms
  - Problem: Some deficeincies have similar symptoms
  - Symptoms may result from causes other than nutrition

Soil sampling



Stratify soil sampling

- Divide fields into sections based on
  - Slope
  - Drainage
  - Past cropping or use
  - Manageable unit size

Nutrient analysis

- Soil analysis
  - Typical soil analysis will give macronutrients and some micros (Fe, Mn, Zn, Cu) and also elements that can be toxic (Al)
  - Limitation of soil analysis is that it may not indicate amount available to plants (Fe chlorosis)
  - Some elements can interfere with uptake of others (K -induced Mg deficiency)

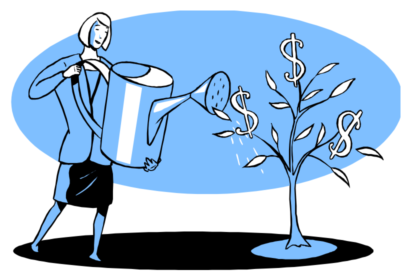
Nutrient analysis

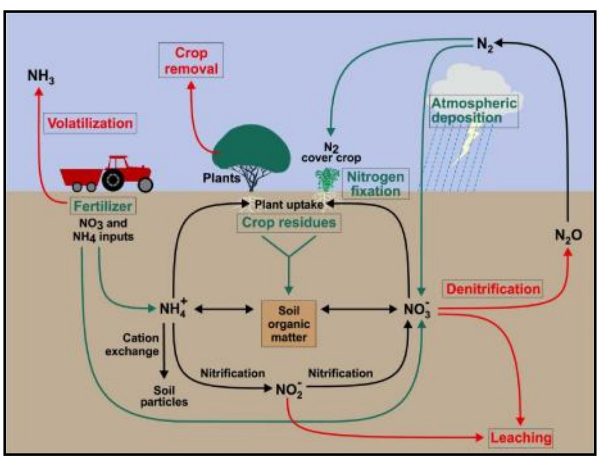
- Foliar analysis
  - Foliar analysis provides measure of actual nutrient concentration of plant tissue
  - Problem: Often only very general guidelines are available for “optimal” nutrients concentrations
  - Concentrations can vary by: age of plant, leaf position, time of year

Foliar nutrient analyses

- Sample recently expanded foliage
- Keep track of time of year when sampled
  - Deciduous -> Mid-late summer
  - Conifers -> Early fall
- If possible, sample ‘good’ and ‘bad’ plants

Fertilization





Gains and losses of N

- Increase N availability
  - Fertilization
  - Mineralization
  - N fixation
- Decrease N availability
  - Leaching
  - Denitrification
  - Crop harvest

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How much nitrogen should I apply?

- Historically, recommendations for N have ranged as high as 250-300 lbs N/ac
- Trees don't need that much N
- Excessive fertilization can lead to nitrate leaching

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Nitrogen recommendation for firs & spruces

Tree age	Oz. N/tree	1bs N/Ac
1	0.5	40
2	0.625	50
3	1	75
>4	1.25	100

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Late season fertilization

- Two schools of thought
  - Fertilizing late in the year will 'push' growth and delay hardening
  - Fertilizing late in the year will result in luxury consumption = ***Nutrient Loading***

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In order to optimize plant uptake and minimize environmental contamination:

- Fertilize more frequently in smaller amounts
- Band fertilizer along the crop root-zone to ensure that nutrients are intercepted
- Minimize ammonia volatilization by incorporating fertilizer
- Avoiding the use of urea during warm, dry periods

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Fertilizer application methods

- Granular
  - Choice of material
  - Timing
  - Broadcast vs. banding

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Broadcast vs Banding

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Salt Index
Nitrogen sources

Material	Salt index
Ammonium nitrate	104.7
Ammonium sulfate	69.0
Calcium nitrate	52.5
DAP	34.2
Potassium nitrate	73.6
Urea	75.4
Sodium nitrate	100.0

Adapted from Rader et al. 1943

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Summary

- Proper nutrition is essential to maintaining plant quality and growth
- Nutrient management differs between field-grown and container-grown plants
- Symptoms can be diagnostic for some deficiencies but foliar and/or soil testing is usually needed.

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MSU Nitrogen source Study

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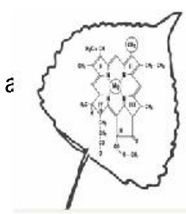
Why is nitrogen so important?

Usually the most limiting element for tree growth and quality

- Component of chlorophyll
- Component of essential amino a
  - ‘Building blocks’ of proteins
  - Enzymatic reactions



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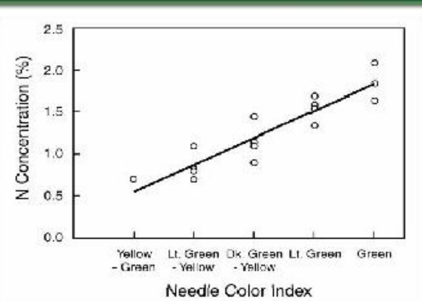

Figure 6. Nitrogen concentration in relation to color of Norway spruce needles (modified from 5).

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Nutrient budget for a Nordmann fir crop

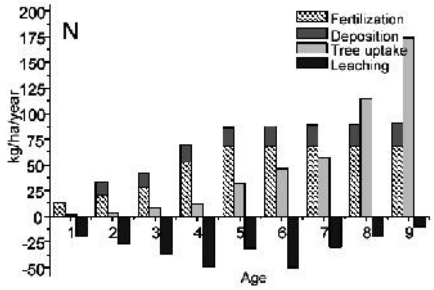

Figure 1 Nitrogen cycling model for a typically Danish Christmas tree stand

HRT 210-2007

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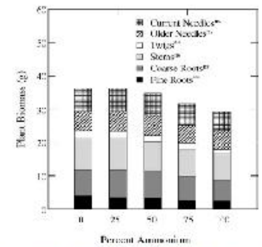

Fig. 1. Component and total biomass of Fraser fir seedlings grown under varying $NH_4^+:NO_3^-$ and Mg:Ca ratios. There was no effect of Mg:Ca, nor any interaction between $NH_4^+:NO_3^-$ and Mg:Ca, therefore data are pooled across Mg:Ca treatments. Significance levels for main effects are noted as follows: ns, $P > 0.1$; $^{\dagger}P < 0.1$; $^{*}P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

Effect of NH4/NO3 ratio on Fraser fir

D.E. Rothstein, B.M. Cregg / Forest Ecology and Management 219 (2005) 69–80

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N assimilation (*Highly simplified*)

NO_3 → Energy → NH_4 → Energy → Amino acids → Proteins (enzymes, co-enzymes)

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MSU Nitrogen Source Study

- Objective:
  - Determine the impact of N source (NH_4^+ or NO_3^-) of growth and nutrition of Christmas trees

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MSU Nitrogen Source Study

- Treatments
  - Annual application of 75# N per acre
  - Applied as either NH_4^+ or NO_3^- only
  - Lime or sulfur added to off-set pH effects
  - Treatments applied for 4 years (2009-2012)

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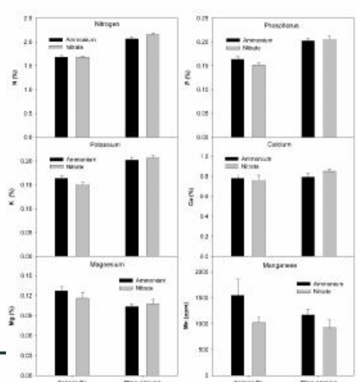
MSU N-source study: Treatment design

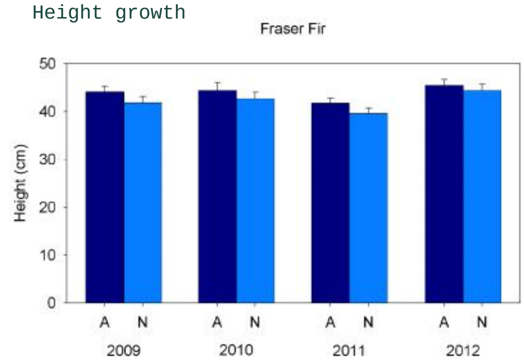
N source: Ammonium only					
		lbs/ac			$CaCO_3$
Fertilizer	product	N	Ca	S	equivalents
$(NH_4)_2SO_4$	357	75		86	-393
CaOH	180		90		245
Total or net		**75**	**90**	**86**	**-148**
N source: Nitrate only					
		lbs/ac			$CaCO_3$
Fertilizer	product	N	Ca	S	equivalents
Elemental sulfur	86			86	-268
$Ca(NO_3)_2$	500	75	95		100
Total or net		**75**	**95**	**86**	**-168**

Results

Little change in foliar nutrtion



N source had little impact on growth: Height growth



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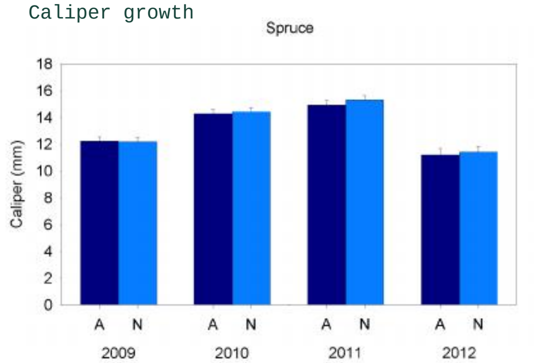
N source had little impact on growth: Caliper growth



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N source cost comparison

Fertilizer	$ per ton*	$ per #N
Urea	$573	$0.62
Ammonium sulfate	$502	$1.19
MAP	$675	$2.81

*Average of co-ops in Montcalm and Missaukee counties Feb. 28, 2013

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Nutrient concentration and soil reaction of common fertilizers

Fertilizer source	%N	P2O5	K2O	Acid/Base Equiv. (#CaCO3/ton fert.)
Anhydrous ammonia	82			-2960
Ammonium nitrate	34			-1260
Ammonium sulfate	21			-2240
Urea	46			-1680
Diammonium phosphate	16-21	48-53		-1480
Monoammonium phosphate	11-12	48-61		-1300
Calcium nitrate	15			400
Potassium nitrate	13		46	520

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Summary

- N source (ammonium vs. nitrate) had little or no impact on tree growth, foliar nutrition or color
- N fertilizer choice should be made based on:
  - Need for other nutrients
  - Cost
  - Soil reaction
  - Other factors