SOIL TESTING

1

17 ESSENTIAL ELEMENTS

- CARBON C
- HYDROGEN H
- OXYGEN O
- PHOSPHORUS P
- POTASSIUM K
- NITROGEN N
- SULFUR S
- CALCIUM Ca
- IRON Fe
- MAGNESIUM Mg
- BORON B
- MANGANESE Mn
- COPPER Cu
- ZINC Zn
- MOLYBDENUM Mo
- CHLORINE Cl
- NICKEL Ni

2

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MACRONUTRIENTS

- 1000 mg/kg or more
- C, H, O, N, P, K, S, Mg, AND Ca

MICRONUTRIENTS

- Less than 100 mg/kg
- Mo, Cu, Zn, Mn, B, Fe, Cl, and Ni

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C. HOPKNS
CaFe Mn B Mg CuZn Mo Cl Ni

C. Hopkns café managed by my cousin Mo the Clown for a nickel

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TAKE A REPRESENTATIVE SAMPLE

- **Collect from several locations**
- **Depth depends on lab**
- **Combine and mix samples**
- **Take a sub-sample, approximately 1 cup**
- **How often?**

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SOIL TESTING

- SLAN--sufficiency level of available nutrients
- BCSR--basic cation saturation ratio
- MLSN minimum level for sustainable nutrition

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SLAN

- Oldest method
- 80 Years + Research
- Interpretation varies with crop, soil type, climate etc.
- Public labs

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YIELD CURVE

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BCSR

Basic Cation Saturation Ratio

- Based on an ideal ratio of cations on exchange sites
- Newer method
- Less research
- Private labs
- Tends to overestimate
- Do not use for turfgrass

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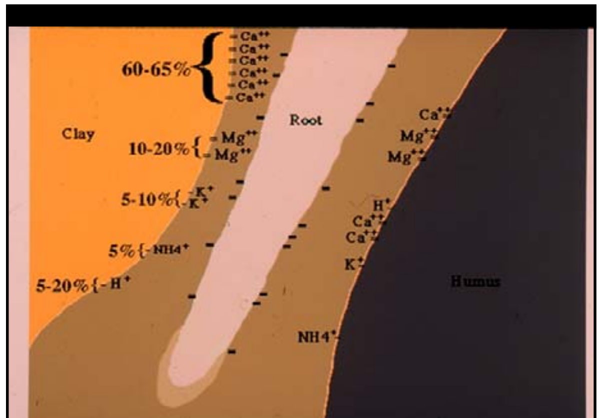

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Minimum Level for Sustainable Nutrition

- **Developed recently by PACE Turf and Asian Turfgrass Center**
  - Dr. Larry Stowell and Dr. Micah Woods
- **Replacement for SLAN**
- **Set minimum required for optimal turf growth**
  - Baseline soil nutrient concentrations
    - Keep soil levels above this value
  - Gives minimum values instead of a range
  - Tells how much to apply
  - Incorporates turf "growth potential"

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Why Use MLSN?

- **Focus on sustainability**
- **Reduce inputs**
- **Reduce maintenance costs**
  - (or redirect costs, more on this later)
- **Maintain expected turf performance**
- **Show reception to environmental concerns**
- **Plant health and soil health**

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Minimum Level for Sustainable Nutrition

- **Apply all nutrients at ratio determined by MLSN**
- **Why a ratio? Nutrient uptake driven by nitrogen**
- **Only apply what the plant can use**
  - Amount determined by clipping nutrient content

Nutrient	Tissue ppm	Ratio:N
N	40,000	1
P	5,000	0.125
K	20,000	0.5
Ca	4,000	0.1
Mg	2,000	0.05

This gives us a nutrient use ratio:

N:P:K → 8:1:4

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Minimum Level for Sustainable Nutrition

- **We need three quantities:**
- **A. What nutrient amount does the turf use?**
  - Site-specific estimate from growth potential
- **B. What amount is required in the soil?**
  - Soil reserve, the MLSN guideline level
- **C. What amount is *IN* the soil?**
  - Soil test result numbers

MLSN Soil Survey Guideline Level Results

	MLSN Soil Guideline
pH	>5.5
Potassium (K ppm)	37
Phosphorus (P ppm)	21
Calcium (Ca ppm)	331
Magnesium (Mg ppm)	47

Source: www.paceturf.org

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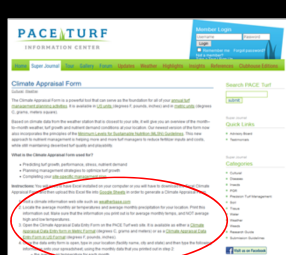
Turf Use / Growth Potential

- **Growing degree day model for turf growth**
- **Site specific estimates of what the plant needs**
- **www.paceturf.org**



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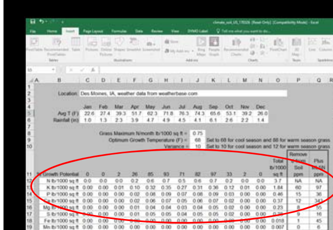
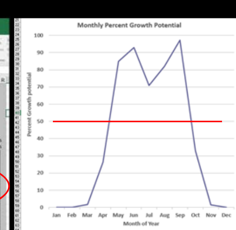
Turf Use / Growth Potential

- **Get local weather data**





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MLSN Calculation Example 1

- **Des Moines, IA**
- **Turf Use + Soil Minimum - Soil Test = Amount Required**

Nutrient	Removed/Used by Plant	MLSN Minimums	Test Results	Amount Required
N	NA	NA	3.7*	3.7*
P	15	21	95	15+21-95= **-59**
K	60	37	125	60+37-150= **-28**
Ca	12	331	1,890	12+331-1890= **-1547**
Mg	8	47	275	8+47-275= **-220**

- * Soil tests do not measure available Nitrogen

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MLSN Calculation Example 2

Turf Use + Soil Minimum - Soil Test = Amount Required

Nutrient	Removed/Used by Plant	MLSN Minimums	Test Results	Amount Required (ppm)
N	NA	NA	4.7*	4.7*
P	25	21	30	25+21-30= **16**
K	105	37	40	105+37-40= **102**
Ca	20	331	205	20+331-205= **146**
Mg	10	47	75	10+47-75= **-18**

Application of 1 lb nutrient per 1000 ft² = 33 ppm in top 4 inches

Divide ppm required by 33 to get lbs per 1000 ft²

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MLSN Calculation Example 2

- **Application of 1 lb nutrient per 1000 ft² = 33 ppm in top 4 inches**
- **Divide ppm required by 33 to get lbs per 1000 ft²**

Nutrient	Amount Required (ppm)
N	4.7*
P	25+21-30= **16**
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Ca	20+331-205= **146**
Mg	10+47-75= **-18**

Phosphorus MLSN:

$$\frac{\text{Lbs Phosphorus}}{1000\ \text{ft}^2} = \frac{\text{16 ppm from soil test}}{\text{33 ppm Conv. Factor}} = \frac{\textbf{0.48 lb P}}{1000\ \text{ft}^2}$$

$$\frac{0.48\ \text{lb P}}{1000\ \text{ft}^2} \times \frac{2.29\ \text{lb}\ P_2O_5}{1.0\ \text{lb P}} = \frac{\textbf{1.10 lb}\ P_2O_5}{1000\ \text{ft}^2}$$

$$\text{Using 0-55-0:}\ \frac{1.10\ \text{lb}\ P_2O_5}{0.55} = \frac{\textbf{2.0 lb}\ \text{0-55-0}}{1000\ \text{ft}^2}$$

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MLSN Calculation Example 2

- **Application of 1 lb nutrient per 1000 ft² = 33 ppm in top 4 inches**
- **Divide ppm required by 33 to get lbs per 1000 ft²**

Nutrient	Amount Required (ppm)
N	4.7*
P	25+21-30= **16**
K	105+37-40= **102**
Ca	20+331-205= **146**
Mg	10+47-75= **-18**

Phosphorus SLAN:

$$\frac{\text{Lbs Phosphorus}}{1000\ \text{ft}^2} = \frac{\text{50-30 ppm from test}}{\text{33 ppm Conv. Factor}} = \frac{\textbf{0.6 lb P}}{1000\ \text{ft}^2}$$

$$\frac{0.6\ \text{lb P}}{1000\ \text{ft}^2} \times \frac{2.29\ \text{lb}\ P_2O_5}{1.0\ \text{lb P}} = \frac{\textbf{1.39 lb}\ P_2O_5}{1000\ \text{ft}^2}$$

$$\text{Using 0-55-0:}\ \frac{1.39\ \text{lb}\ P_2O_5}{0.55} = \frac{\textbf{2.52 lb}\ \text{0-55-0}}{1000\ \text{ft}^2}$$

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MLSN Calculation Example 2

- **Application of 1 lb nutrient per 1000 ft² = 33 ppm in top 4 inches**
- **Divide ppm required by 33 to get lbs per 1000 ft²**

Nutrient	Amount Required (ppm)
N	4.7*
P	25+21-30= **16**
K	105+37-40= **102**
Ca	20+331-205= **146**
Mg	10+47-75= **-18**

Potassium MLSN:

$$\frac{\text{Lbs Potassium}}{1000\ \text{ft}^2} = \frac{\text{102 ppm from soil test}}{\text{33 ppm Conv. Factor}} = \frac{\textbf{3.1 lb K}}{1000\ \text{ft}^2}$$

$$\frac{3.1\ \text{lb K}}{1000\ \text{ft}^2} \times \frac{1.2\ \text{lb}\ K_2O}{1.0\ \text{lb K}} = \frac{\textbf{3.7 lb}\ K_2O}{1000\ \text{ft}^2}$$

$$\text{Using 0-0-50:}\ \frac{3.7\ \text{lb}\ K_2O}{0.50} = \frac{\textbf{7.4 lb}\ \text{0-0-50}}{1000\ \text{ft}^2}$$

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MLSN Calculation Example 2

- **Application of 1 lb nutrient per 1000 ft² = 33 ppm in top 4 inches**
- **Divide ppm required by 33 to get lbs per 1000 ft²**

Nutrient	Amount Required (ppm)
N	4.7*
P	25+21-30= **16**
K	105+37-40= **102**
Ca	20+331-205= **146**
Mg	10+47-75= **-18**

Potassium SLAN:

$$\frac{\text{Lbs Potassium}}{1000\ \text{ft}^2} = \frac{\text{110-40 ppm from test}}{\text{33 ppm Conv. Factor}} = \frac{\textbf{2.1 lb K}}{1000\ \text{ft}^2}$$

$$\frac{2.1\ \text{lb K}}{1000\ \text{ft}^2} \times \frac{1.2\ \text{lb}\ K_2O}{1.0\ \text{lb K}} = \frac{\textbf{2.5 lb}\ K_2O}{1000\ \text{ft}^2}$$

$$\text{Using 0-0-50:}\ \frac{2.5\ \text{lb}\ K_2O}{0.50} = \frac{\textbf{5.0 lb}\ \text{0-0-50}}{1000\ \text{ft}^2}$$

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Calculation Results: MLSN vs SLAN

Nutrient	Amount Required (MLSN, ppm)	MLSN	SLAN
N	4.7*	**3.8 – 6.2**† lb N/M	**4.2 – 4.8**‡ lb N/M
P	25+21-30= **16**	**1.10 lb** P_2O_5/M	**1.39 lb** P_2O_5/M
K	105+37-40= **102**	**3.7 lb** K_2O/M	**2.5 lb** K_2O/M

† **Calculated in relation to MLSN P and K**
‡ **Calculated in relation to SLAN P and K**

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MLSN Positives

- **Adaptive to future research**
  - Turf nutrient understanding will evolve
- **Adaptive to site and climate**
- **Reduce/redirect costs**
- **Maintain high quality**
- **Environmentally responsible**

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MLSN

- Good start, Going in the right direction
- Basically SLAN for turf based on turf quality
- Turf quality not always the best guide
- MSLN 6 YEARS, SLAN >86 YRS

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MLSN Limitations

- **Disease control**
  - Diseases reduced by N
    - dollar spot, rust, red thread
- **Site application history**
  - **If you know you need X, apply X!**
- **Budget consequences**
- **Supply company opposition**

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HOW ABOUT PASTE EXTRACT?

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Paste Extract Tests

- Water-soluble test for short term results
- Tells what nutrients are soluble in soil
- Factors influencing paste tests
  - Weather (amount of rain), irrigation, poor water quality, high bicarbonate levels, recent fertilizer applications, topdressing etc.
- Great tool for accessing soil salinity

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Paste Extract Tests

- Should be used with standard soil tests every time
- Expect low extraction values for fertility
- Bicarbonates will show up (they dissolve easily in water)- they don't cause structure problems or sealing in the soil
- Data is lacking between turf quality and soluble nutrients

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THE USEFULNESS OF A SOIL TEST DEPENDS ON PROPER INTERPRETATION

32

LABS TEND TO OVERESTIMATE HOW MUCH P IS NEEDED AND UNDERESTIMATE HOW MUCH K IS NEEDED

33

PHOSPHORUS P

FUNCTION

- ENERGY TRANSFER
- STARCH DECOMPOSITION
- GENETIC MATERIAL
  - GRASSES ARE VERY EFFICIENT USERS OF P

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PHOSPHORUS (BRAY P1)

PPM		LB/A	KG/HA
• 0 - 5	VERY LOW	0 - 10	0 - 11
• 6 - 10	LOW	12 - 20	13 - 22
• 10 - 20	ADEQUATE	20 - 40	22 - 45
• 20 - +	HIGH	40 - +	45 - +

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PHOSPHORUS

P SUFFICIENCY LEVEL BY EXTRACTANT(CARROW)					
	ppm P				
	Very low	Low	Medium	High	
BRAY P1	0-4	5-15	16-30	>31	
MEHLICH III	0-12	13-26	27-54	>55	
OLSEN	0-6	7-12	13-28	>29	
NUMBERS VARY SOMEWHAT FROM LAB TO LAB.					

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POTASSIUM K

- MYSTERY ELEMENT
- NOT A PART OF BIOCHEMICALS
- ACTS AS COFACTER
- STOMATAL CONTROL

STRESS

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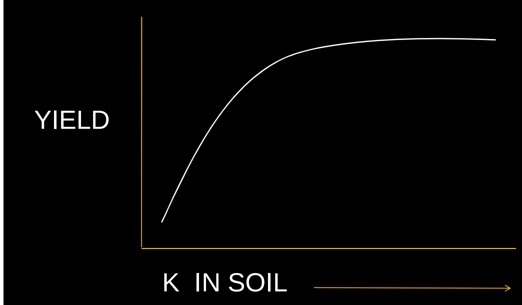
POTASSIUM RESPONSE



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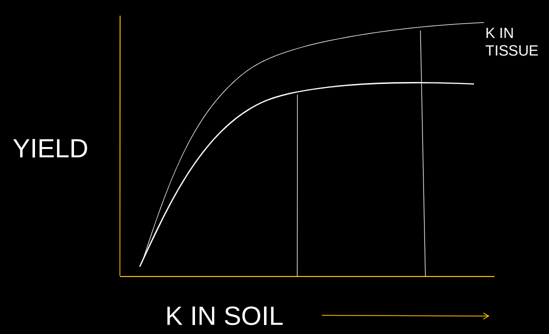
LUXURY CONSUMPTION



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TURF RESPONSE TO K

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POTASSIUM

PPM		LB/A	KG/HA
0 - 40	VERY LOW	0-80	0-90
41 - 175	LOW	81-350	91-392
175 -250	ADEQUATE	350-500	392-560
250- +	HIGH	500-+	560-+

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RECOMMENDATIONS

- Maintain potassium within sufficiency range:
  - Soil K = 100 to 250 lb/acre or 50 to 125 ppm (Mehlich-III)
  - Tissue K = 2 to 3%
- If a deficiency in soil K exists, potassium can be applied biweekly at 0.2 to 0.3 lbs K_2O/ 1000-sq ft to build up soil K
- To maintain soil K level, potassium can be applied biweekly at 0.1 lbs K_2O/ 1000-sq ft

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HOW ABOUT Ca, Mg, S and the MICRONUTRIENTS?

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CALCIUM (Ca)

- Cell wall formation
- Cell division
- Osmotic balance
- Membrane stabilization

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CALCIUM (Ca)

- 0.30 TO 1.25 % IN TISSUE
- YOUNGER LEAVES TURN REDDISH-BROWN
- FADES TO RED
- LOW pH CONDITIONS
- Liming solves problem

45

SOIL TESTING ISSUES

- New emphasis on Ca in 90's
  - Ca applied to Calcareous ($CaCO_3$) sands
- Ca/Mg ratios
  - Gypsum ($CaSO_4$)
  - Other expensive amendments
- Calcareous sands for greens and sports fields
  - Soil test methods?

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MAGNESIUM (Mg)

- Center of chlorophyll
- Symptom – Chlorosis
- Low pH & Low CEC

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MAGNESIUM (Mg)

- 0.15 to 0.50 % in tissue
- > 0.15 % in tissue deficient
- Soil test levels varies with CEC
  - Less than 4 meq
    - Mehlich 1 (30 to 60 ppm)
    - Mehlich 2 (70 to 140 ppm)
    - Ammonium acetate (80-140 ppm)
  - Higher CEC
    - Double the numbers (Carrow 2001)

48

SULFUR (S)

- 0.10 TO 0.50 % IN TISSUE
- YELLOWING OF YOUNGER LEAVES
- SLOW GROWTH
- RARE IN MOST OF U.S. BECAUSE OF HIGH SULFUR COAL
  - 12 to 15 lb/ac in Midwest
- MAY SEE IT IN RARE SITUATIONS

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IRON (Fe)

- COFACTOR FOR CHLOROPHYLL FORMATION
- SYMPTOM - CHLOROSIS
- HIGH pH
- MOST COMMON OF ALL MICRONUTRIENT DEFICIENCIES

50

IRON (Fe)

- 100 to 500 ppm in tissue
- Soil tests inaccurate
- Very small amounts applied to tissue (0.3 to 0.5 lb Fe/ac)

51

SUMMER INDUCED CHLOROSIS

- David Devetter, MS Student
- Develops during high temperature periods
- Not observed in spring and fall
- Usually on sand, also can be on soil
- It is an iron problem

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OUR OBSERVATIONS

- Summer-induced iron chlorosis
  - Appears from late July to early September
  - Goes away if left untreated
  - Bentgrass and bluegrass
  - Widespread
    - Multiple countries
    - Golf courses
    - Sports fields
    - Home lawns

  * While common on sand soils it is present in finer textured soils as well

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Chlorosis

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Conclusions

- Summer-induced chlorosis was caused by an iron deficiency
- Soil temperature may play a role in summer-induced iron chlorosis
- Summer-induced iron chlorosis can be treated with iron fertilization
- Higher rates of iron lead to more color recovery
- Treating before symptoms occur does not work
- Control of chlorosis depends on timing of iron fertilization

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MANGANESE

- Activator of at least 35 plant enzymes
- Formation of chlorophyll
- Root growth
- Cofactor for lignin formation
- 20 to 500 ppm in tissue
- Soil tests misleading

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MANGANESE

- YELLOWING SIMILAR TO IRON DEFICIENCY
- VEINS REMAIN GREEN - TIPS MAY REMAIN GREEN
- LEAVES DROP (lignin)
- Take All Patch--Rutgers work

58

Zinc (Zn)

- Catalyst of enzymes
- Regulates gene expression
- Membrane function
- Stress management
  - Saturation
  - High temperature
- 20 to 55 ppm in tissue sufficient
- 15 to 20 ppm deficient

59

Zinc (Zn)

- Deficiency rare
- Toxicity?
- Grant Spear graduate project
  - Soil test labs-18 to 20 ppm in soil toxic

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SUMMARY

- CREEPING BENTGRASS CAN TOLERATE MUCH HIGHER LEVELS OF ZN THAN ONCE THOUGHT
- LEVELS TERMED EXCESSIVE BY SOIL TESTING LABS ARE WELL WITHIN THE TOLERANCE LEVELS OF CREEPING BENTGRASS

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COPPER (Cu)

- Catalyst in photosynthesis and resp.
- Carbohydrate formation
- Lignin formation
- 5 to 38 ppm in tissue
- Deficiencies in high pH soils (rare)

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COPPER (Cu)

MIKE FAUST MS PROJECT ‘98 TO ‘99

- 0 to 600 ppm Cu
- Cu reduced Bentgrass rooting at 200 ppm and above. Approximately 50% reduction at 600 ppm

63

BORON (B)

- Membrane and cell wall formation
- Sugar transport, carbohydrate metabolism
- Respiration
- Little needed (5 to 10 ppm in tissue)
- Deficiencies rare
- Very narrow range between deficiency and toxicity
- Sewage effluent (1 to 2 ppm can be toxic)

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MOLYBDENUM (Mo)

- Enzyme reactions
- Sulfur metabolism
- Function of P in plant
- 0.1 to 1 ppm in tissue
- Deficiency
  - older leaves pale green
- Toxicity by mines in mountains

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Chlorine (Cl)
Nickel (Ni)

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SUMMARY

USING SOIL TESTS TO DEVELOP A FERTILITY PROGRAM

THINGS TO BE AWARE OF

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Questions?

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