

# **Reduction of Plant Diseases Using Nutrients**

**“Fertilizer Labels-A Foreign Language”**

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# Essential Plant Nutrients

17

# Plant Nutrient Uptake

**1. Dissolve in water (form ions)**

**Soil Solution, Foliage**

**2. Gasses**

**Carbon (CO<sub>2</sub>), Nitrogen fixation (N<sub>2</sub>)**

## Nutrients: 3 of 17

**Carbon C (Carbon Fixation,  
Photosynthesis)**

**Oxygen O**

**Hydrogen H**

**Mainly from air and water**

# Essential Nutrients, 14

<u>Nutrient</u>	<u>Fertilizer</u>	<u>Uptake Form</u>
Nitrogen N	Urea, NH <sub>4</sub> , NO <sub>3</sub>	NH <sub>4</sub> <sup>+</sup> , NO <sub>3</sub> <sup>-</sup>
Phosphorus P	Phosphate	HPO <sub>4</sub> <sup>-2</sup> , H <sub>2</sub> PO <sub>4</sub> <sup>-1</sup>
Potassium K	Potash	K <sup>+</sup>
Ca, Mg, Zn, Mn, Cu, Fe, Ni	(all as divalent cations)	<sup>-2</sup>
Sulfur S	Sulfate	SO <sub>4</sub> <sup>-2</sup>
Chlorine Cl	Chloride	Cl <sup>-1</sup>
Boron B	Borate	H <sub>3</sub> BO <sub>3</sub>
Molybdenum Mo	Molybdate	MoO <sub>4</sub> <sup>-2</sup>

# Beneficial Nutrients

Not shown to be essential.

**Many! Maybe 12 or more!**

**Another seminar!**

# 14 Essential Nutrients Uptake

**Must be soluble in water!**

Soil Solution: Equilibrium

**Insoluble  $\longleftrightarrow$  Soluble**

**Hydroponics**

**Foliar Feed Solution**

# Fertilizer Label

## Nitrogen (N)

Percentage listed in pure form

**20-20-20**

**20% Nitrogen**



# Fertilizer Label

## Nitrogen

### 3 Chemical Forms

Urea

Ammonium

Nitrate

# Fertilizer Label

## Phosphorus (P) & Potassium (K)

Listed as % oxides.

Not in the elemental forms.



# Fertilizer Analysis

20-20-20

Nitrogen

P<sub>2</sub>O<sub>5</sub>

K<sub>2</sub>O

20%

43.6% P

83% K

Nitrate

Ammonium

Urea

# Soil & Foliar Tests

**Nutrients are listed in elemental forms.**

**N, P, K etc.**

# Typical/General Concentrations Found in Dried Plant Material as Dry Weight

## Primary Plant/Mobility

<u>Nitrogen (N)</u>	<u>4.0%</u>	High
Phosphorus (P)	0.5%	High
<u>Potassium (K)</u>	<u>4.0%</u>	Very High

## Secondary

Calcium (Ca)	1.0%	Low
Magnesium (Mg)	0.5%	High
Sulfur (S)	0.5%	Low -Medium

# **Typical/General Concentrations Found in Dried Plant Material as Dry Weight**

<b><u>Micronutrients</u></b>	<b><u>Plant/Mobility</u></b>	
<b>Iron (Fe)</b>	<b>200 ppm ?</b>	<b>Low</b>
<b>Manganese (Mn)</b>	<b>200 ppm ?</b>	<b>Low</b>
<b>Zinc (Zn)</b>	<b>30 ppm</b>	<b>Low</b>
<b>Copper (Cu)</b>	<b>10 ppm ?</b>	<b>Low</b>
<b>Boron (B)</b>	<b>60 ppm</b>	<b>High</b>
<b>Molybdenum (Mo)</b>	<b>1</b>	<b>Nitrogen Utilization</b>
<b>Nickel (Ni)</b>	<b>?</b>	<b>Nitrogen Fixation</b>

# Fertilizer Analysis: 10-30-20

**Nitrogen**

**10 % N**

**(Ammonium, Nitrate, Urea)**

**Phosphate 30 % ( $P_2O_5$ ) X 43.6%) 13.08% P**

**Potash 20% ( $K_2O$  X 83%) 16.6 % K**

**Elemental Analysis: 10--13.08--16.6**

# Soluble Fertilizer Rates/Soilless Mixes

**20-20-20, 10-30-20, 10-26-38**

**(all + micronutrients)**

## Normal Watering of Pots and Flats

**2 lbs. in 100 gal.**

**Applied at 1 quart per sq. foot or as  
normal watering.**



# Soluble Fertilizer Rates/Soilless Mixes

## Normal Watering of Pots and Flats

2 lbs. in 100 gal.

1 oz. in 3 gallons

1 tablespoon in 3 gallons

$\frac{3}{4}$  teaspoon in 1 quart

# Soluble Fertilizer Rates/Soilless Mixes

**20-20-20, 10-30-20, 10-26-38**

**(all + micronutrients)**

## Injections Rates

**200-300 ppm N per 7-21 days**

**Some labels go as high as 470 ppm N.**

## Fertilizer Rates/Soilless Mixes\*

**\*Lower rates of solubles by 25-50%!**

<u>Amendment</u>	<u>Oz/Cu. Ft.</u>	<u>Nutrients</u>
Dolomitic lime	2-10	Ca, Mg
Lime	2-10	Ca
Gypsum	2-10	Ca, S
K-Mag (21/10/21)	4-5	K, Mg, S
Ammonium Phosphate	2-3	N, P
Ferrous sulfate	1/4	Fe, S

# Soiless Mixes

## Slow-release

14-14-14

**N = 100%**

**P = 43.6%**

**K = 83%**

14--6.1--11.62

# Soiless Mixes

**Target soiless mix pH: 6.0-6.8**

**Best solubility of most nutrients best at  
6.8.**

**Phosphorus most soluble at pH 6.5.**

# Soilless Mixes

The pH becomes too low, too acid.

1. Degradation of organic matter
2. Application of soluble fertilizers
3. Organic matter has low pH, e.g. peat moss

## Soilless Mixes

**Adjust up, increase pH using lime.**

**Calcium carbonate**

**Calcium/Magnesium carbonate**

**(Dolomitic lime)**

# Soiless Mixes

“Special Case”

## Fusarium oxysporum-Crown Rot

This fungus kills ferrocacti if soil pH is acid.

Adjust soil pH to greater than 7.0.

Lime!



# Cacti, Succulents and Native Plants

## Respond to Higher Nutrient Levels

**1. Optimum Yield/Growth**

**2. Disease & Insect Resistance**

# Most Important Nutrients for Disease Resistance

**K, Ca, Cu, B, Mn, S,  
Si\***

**\* Not essential, but beneficial**

**Most Important Nutrients for**  
**Disease Resistance**

**“Context”**

**Sufficient Quantities of all Essential  
Nutrients Must be Delivered to the  
Plant**

# Potassium



1992 Dr. Steve Petrie

534 References Reviewed

$\text{K}^+$  Most Important

Insect and Disease Reduction



Potassium

**1. Mobilization of Plant Defense System**

**2. Increases Cuticle Thickness**

**K<sup>+</sup>**

**Potassium**

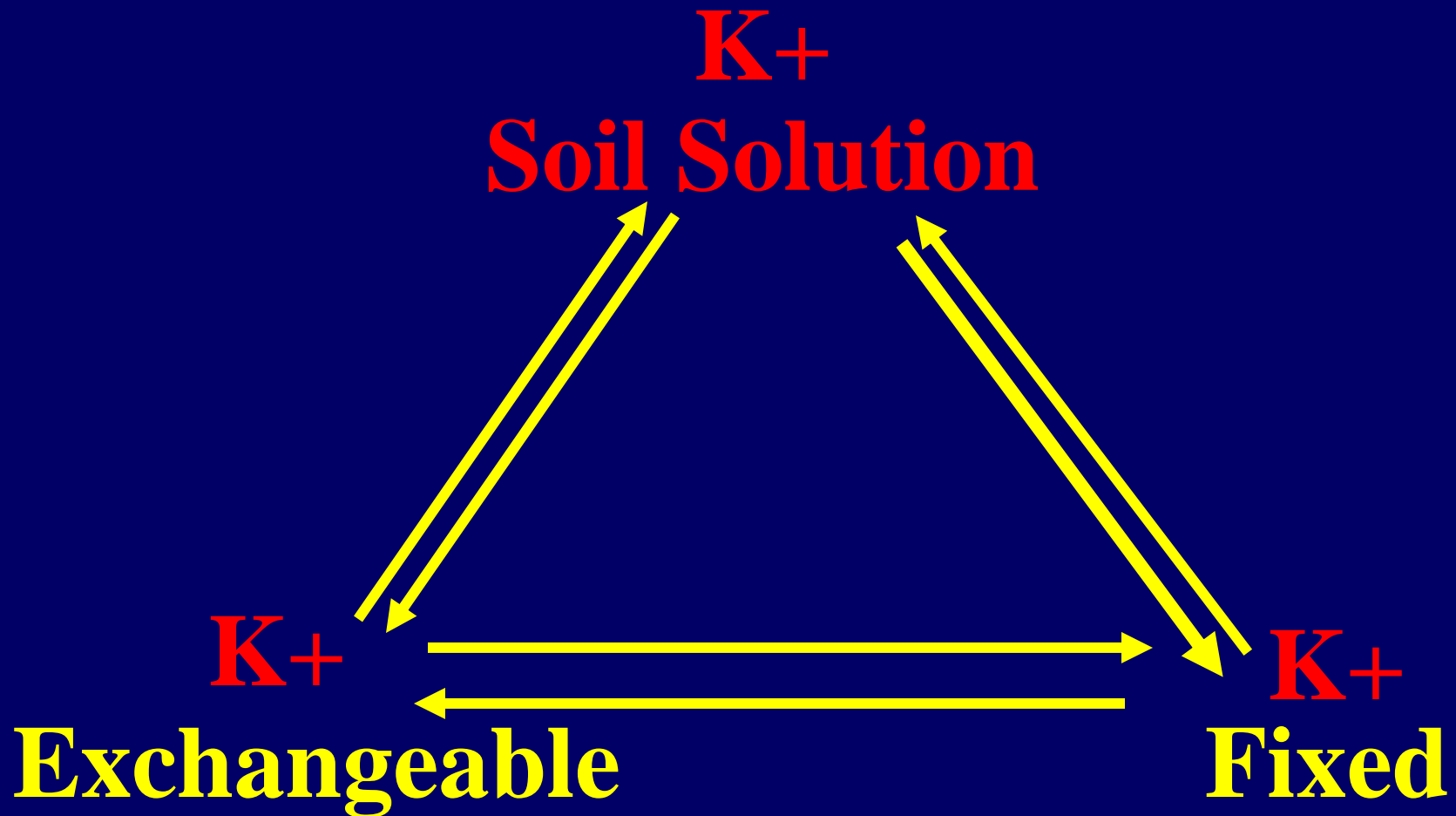
**Tolerance to Adverse Conditions**

**Stress: Heat, Cold, Drought**

# Potassium $K^+$ : 4 Issues

- 1. Tied up in clay soils**
- 2. Slowly available from native soils**
- 3. Leaches out in light soils**
- 4. High nitrogen overcomes K effect**

# Potassium Behavior in Soil





# Effect of **K**, N and Ca on Severity of Phytophythora Diseases

<u>Pathogen</u>	<u>Host/Disease</u>	<u>Factor</u>	<u>Effect</u>
<i>P. infestans</i>	Potato Late Blight	K	Decrease
		K	None
		High K	
		High N	Increase
<i>P. capsici</i>	Pepper Blight	K	Decrease
<i>P. drechsleri</i>	Pigeon Pea Blight		
		High K	
		Low N	Decrease
<i>P. parasitica</i>	Citrus gummosis		
		High K	
		Low Ca	Increase



## Potassium

### **Solutions to K needs:**

**1. Increase soil concentration, apply more K more often (3% CEC)**

**2. Foliar applications of high K and low N fertilizers**

# Calcium $\text{Ca}^{++}$

## **1. Fortifies the Middle Lamella**

**Middle Lamella = Calcium Pectate**

## **2. Slows degradation by pathogens**

**(Especially soft rot bacteria that attack cacti and succulents.)**

Ca<sup>++</sup>

**More Calcium in Middle Lamella  
Reduces Pathogen Enzyme Activity**

**Pectolytic Enzyme Activity:**

**Polygalacturonase**

Ca<sup>++</sup>

**Stops Motile Spores=Zoospores**

**Encyst or Stop Swimming**

**Phytophthora and Pythium**

# Pathogens of Cacti and Succulents

Phytophthora species

Hosts

Boogum-trees

# Pathogens of Cacti and Succulents

Pythium species

Hosts

Agaves, Cacti & Euphorbiaceae  
seedlings

# Calcium

- 1. Increases Plant Membrane Stability**
- 2. Improves Soil Structure:  
Water/Oxygen Distribution**
- 3. Lime Increases Soil pH: Fusarium  
Spore Attachment (ferrocacti,  
bananas)**
- 4. Reduces Rhizoctonia enzyme activity**



# Relationship Between Cation Content and Severity of Infection with *Botrytis cinerea* Pars. In Lettuce

<u>Cation content (mg/g dry wt.)</u>			<u>Infection<sup>1</sup></u>
<u>K</u>	<u>Ca</u>	<u>Mg</u>	<u><i>Botrytis</i></u>
14.4	10.6	3.2	4
23.8	5.4	4.1	7
34.2	2.2	4.7	13
48.9	1.8	4.2	15

<sup>1</sup> Infection index:

0-5 slight infection

6-10 moderate infection

11-15 severe infection

Based on Krauss (1971). 1998. "Mineral Nutrition of Higher Plants." 2<sup>nd</sup> ed. Horst Marschner. P.447

## Tentative Summary of the Effect of Nitrogen and Potassium Levels on the Severity of Diseases Caused by Parasites

<u>Pathogen and Disease</u>	<u>Nitrogen Level</u>	
	<u>Low</u>	<u>High</u>
<u>Obligate parasites</u>		
<i>Puccinia spp.</i> (rusts)	+	+++
<i>Erysiphe graminis</i> (powdery mildew)	+	+++
<u>Facultative parasites</u>		
<i>Alternaria spp.</i> (leaf spots)	+++	+
<i>Fusarium oxysporum</i> (wilts and rots)	+++	+
<i>Xanthomonas spp.</i> (spots and wilts)	+++	+

## Tentative Summary of the Effect of Nitrogen and Potassium Levels on the Severity of Diseases Caused by Parasites (continued)

<u>Pathogen and Disease</u>	<u>Potassium Level</u>	
	<u>Low</u>	<u>High</u>
<b><u>Obligate parasites</u></b>		
<i>Puccinia spp.</i> (rusts)	++++	+
<i>Erysiphe graminis</i> (powdery mildew)	++++	+
<b><u>Facultative parasites</u></b>		
<i>Alternaria spp.</i> (leaf spots)	++++	+
<i>Fusarium oxysporum</i> (wilts and rots)	++++	+
<i>Xanthomonas spp.</i> (spots and wilts)	++++	+

Based on Kiraly (1976) and Perrenoud (1977). 1998. "Mineral Nutrition of Higher Plants. 2<sup>nd</sup> ed. Horst Marschner." p. 443.

## Cu<sup>++</sup> - Copper

- **Increases cuticle thickness**
- **Cuticle: a barrier to infections**
- **Careful!**

## Cu<sup>++</sup> - Copper

- **Necessary for polyphenoloxidase activity.**
- **Polyphenoloxidase system produces some phytoalexins and other anti-pathogenic molecules.**

## Cu<sup>++</sup> - Copper

**Phytoalexins-antimicrobial compounds produced by plants in response to a host-parasite interaction.**

**Some phytoalexins are phenolics.**

**Others such as sulfur are not organic molecules.**

# Boron

## B

- 1. Increases the uptake of cations (Blevins, Schon, U. of Missouri)**
- 2. K, Ca and Cu are cations that are vital for plant resistance to disease.**
- 3. Involved in the metabolism of phenolics.**

# Boron

## B

Phenolics include phytoalexins and other molecules that are toxic to plant pathogens.

Phytoalexins are phenolics that are toxic to plant pathogens.

Qinones from phenolics may form: also toxic to plant pathogens.



# Manganese Mn<sup>++</sup>

**1988 Study by Huber and Wilhelm**

**82 scientific papers were review**

**Papers addressed disease and Mn content.**

**All but 4 papers indicated that added  
Mn decreased disease.**

**Two of the 4 papers showed Mn in the toxic  
range.**

## Manganese Mn<sup>++</sup>

- **Involved in the production of lignin.**
- **Lignin is the principal component of wood and very difficult to degrade.**

## Manganese Mn<sup>++</sup>

- **Wheat with higher uptake of manganese has a higher content of lignin and is more resistant to take-all disease.**

## Manganese Mn<sup>++</sup>

- **Mn<sup>+2</sup> inhibits the enzyme pectin methyl-esterase.**
- **Pectin methylesterase is a fungal pathogen exoenzyme for degrading host cell walls.**

# **Diseases Reduced or Controlled by the Addition of Manganese**

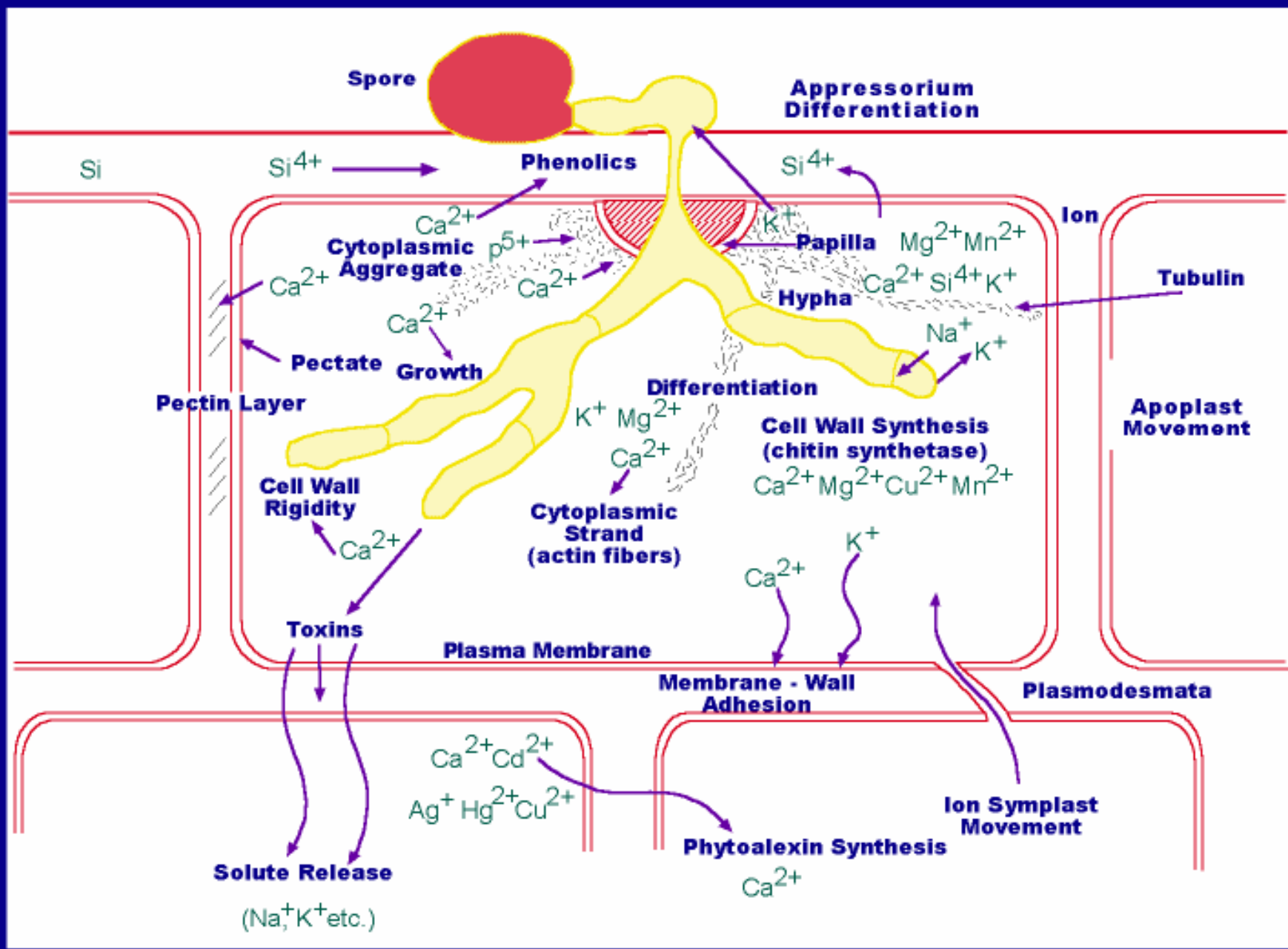
- **Take-all and powdery mildew of wheat**
- **Common scab of potato**
- **Blast and leaf spot of rice**
- **Root rot of avocado**
- **Powdery mildew of canola, sorghum**
- **Nematodes attacking barley**

## Zinc $Zn^{++}$

- **Not directly involved in disease resistance**
- **Most important micronutrient in plants**
- **A cofactor for more than 100 plant enzymes**
- **Applications to foliar almost always produce a response in plants.**
- **Dicots are more reactive than monocots**

**Thank you!**

**Questions!**





# Major Turf Disease Problems

- Turfgrass patch diseases
- Pythium blight
- Dollar spot
- Fusarium blight

## Patch Diseases

- **More prevalent during the past 3 year.**
- **More positive IDs during last year.**
- **Several fungal pathogens involved.**
- **Identification/taxonomy is unclear.**
- **All ascomycetes: Indicates the active fungicides.**

# Pathogenic Patch Fungi

## Genera

• Leptosphaeria Magnaporthe Gaeumannomyces

- Sexual stages: Ascomycetes (powdery mildews)
- All form black or olivaceous ectotrophic hyphae
- Ectotrophic hyphae: mycelium over root surfaces



# Turfgrass Patch Diseases

•Necrotic Ring Spot    Bentgrass Poa annua, P. trivialis

Festuca rubra

Leptosphaeria korrae

•Spring Dead Spot    Bermudagrass

Leptosphaeria narmari

# Turfgrass Patch Diseases

• Summer Patch      Fescues, Poa, Bentgrass

• Magnaporthe poae

# Reducing Take-All and Other Patch Diseases

- **Soil pH in the acid range (?)**
- **Potassium 200- 250 PPM USGA Greens**
- **Sulfur (sulfate as nutrient and to lower pH)**
- **Mn <sup>++</sup> 35 or more parts per million**

# Reducing Take-All and Other Patch Diseases

- **Ca as gypsum (calcium sulfate)**
- **Cu, Fe, and Zn**
- **Control nitrogen, use  $\text{NH}_4$  or urea**



# Mineral Elements Affecting Take-all of Cereals

## Increase Take-all

Potassium nitrate

Phosphorus excess

Calcium carbonate (lime)

Magnesium carbonate

Magnesium sulfate

Molybdenum

## Reduce Take-all

Potassium chloride

Phosphorus sufficiency

Sulfur

Magnesium chloride

Calcium chloride

Manganese

Iron, Zinc

Copper chloride

**Forms of Nitrogen**  
**General Effects**

**Ammonium, Urea-----Acid Forming**

**Rhizosphere pH decrease**

**Modify Rhizosphere Microbes**

**Increase available Mn, Fe, Cu, Zn**

**Acidification decreases nitrification:  $\text{NH}_4$  to  $\text{NO}_3$**

**Disease Suppression is Simple**  
**Interactions are Complicated**

**Root Exudates**

**Rhizosphere Microbes**

**Plant Nutritional Status**

**Soil Type**

# Correlation of factors influencing the form on N in soil and severity of disease-Take all. Adapted from Huber , Purdue

<u>Factor</u>	<u>Nitrification</u>	<u>Disease</u>
Nitrate nitrogen	--	Increase
Ammoniacal nitrogen	--	Decrease
Liming	Increase	Increase
Acid Soils	Decrease	Decrease
Chloride	Decrease	Decrease

## Take-all Patch, Gaeumannomyces

- No resistance
- Manganese is most important nutrient. Why?

1.Direct toxicity to fungus?

2.Increase in photosynthesis corresponding to greater carbon supply and more organic compounds in soil.? **Rhizosphere microflora**

**Research has ruled out #1 and #2.**

## Take-all Patch, Gaeumannomyces

**3. Increase synthesis of ligneous defense products in roots.**

# Manganese in Equilibrium in Soil and Availability

**Acid pH in soil and rhizosphere =  $\text{Mn}^{++}$**

**Alkaline pH in soil and rhizosphere =  $\text{Mn}^{+4}$**

**$\text{Mn}^{++}$  Available**

**$\text{Mn}^{+4}$  Non-available**

## Manganese Influence on Root Lesions and Lignin in Wheat

<u>Variable</u>	<u>Total Length of Ggt lesions (mm)</u>	<u>Lignin Content (Abs<sub>280</sub>/root system)</u>
Mn, mg/kg soil		
0	38	0.14
3	28	0.12
30	23	0.25
300	22	0.28

From "Biochemistry of Metal Micronutrients in the Rhizosphere" Chapter 10, Regel, Pedler, & Graham.



# Root Lesions and Lignin Content in Root Tissues of Four Wheat Genotypes

<u>Genotype</u>	<u>Total Length of Ggt Lesions (mm)</u>	<u>Lignin Content (Abs<sub>280</sub>/root system)</u>
<b>Mn-inefficient</b>		
Bayonet	30	0.14
Millewa	27	0.16
<b>Mn-efficient</b>		
Aroona	26	0.22
C8MM	23	0.27

Significance Turkey's 0.05; Adapted from "Biochemistry of Metal Micronutrients in the Rhizosphere" Chapt. 10,

Rengel, Pedler, and Graham

# Fungicides for Control of Take- all and Patch Diseases

**Conditions: Soil Temperature at 2'' 65 F for 6 days.**

**Fungicides: Heritage    Banner MAXX    Bayleton  
Compass    Eagle    Rubigan  
Sentinel**

**Benzimidazoles: Fungo, Cleary 3336**

**Application: 4-5 gallons per 1000 sq. ft.**

# Pythium Blight

- Pythium aphanidermatum (water mold)

## Often Seen During:

- High humidity
- Hot weather
- Summer rainy season

# Reducing Pythium Blight

- **High potassium:**

250 PPM USGA Greens

At least 3% of cation saturation

- **Higher potassium for greens with higher clay content and organic matter content**

# Reducing Pythium Blight

- **Calcium-drainage and nutrition**
- **Copper 1-3 PPM in soil**
- **Control nitrogen**

# Dollar Spot

- Sclerotinia homoeocarpa (fungus)

## Reducing Dollar Spot

- **Maintain sufficient nitrogen**
- **Balance nitrogen with high potassium**
- **Collect clippings and reduce thatch**
- **Maintain calcium**
- **Gypsum and sulfur-water penetration, stress**

# Fusarium Blight

- Fusarium species (fungus)

## Reducing Fusarium Blight

- Reduce stress (potassium, calcium)
- Maintain soil pH close to neutral (lime)
- Control nitrogen

# Reducing Pythium and Phytophthora

- **High potassium**
- **High calcium**
- **Good drainage-gypsum, sulfur**
- **Acivator 90 20 PPM kills zoospores**



# Free Calcium

**Increases Plant Membrane Stability**

**Improves Soil Structure:  
Water/Oxygen Distribution**

**Lime Increases Soil pH:**

**Stops or Reduces Spore Pathogen  
Attachment**

