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_2), Nitrogen fixation (N_2)

Nutrients: 3 of 17

Carbon C (Carbon Fixation, Photosynthesis)

Oxygen O

Hydrogen H

Mainly from air and water

Essential Nutrients, 14

Nutrient	Fertilizer	Uptake Form
Nitrogen N	Urea, NH4, NO3	NH_4^+, NO_3^-
Phosphorus P	Phosphate	HPO_4^{-2}, $H_2PO_4^{-1}$
Potassium K	Potash	K^+
Ca, Mg, Zn, Mn, Cu, Fe, Ni	(all as divalent cations)	$^{-2}$
Sulfur S	Sulfate	SO_4^{-2}
Chlorine Cl	Chloride	Cl^{-1}
Boron B	Borate	H_3BO_3
Molybdenum Mo	Molybdate	MoO_4^{-2}

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 ⟷ 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.

$$P_2O_5$$

$$K_2O$$

Fertilizer Analysis

20-20-20

Nitrogen	P_2O_5	K_2O
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
Nitrogen (N)	4.0%	High
Phosphorus (P)	0.5%	High
Potassium (K)	4.0%	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

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

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

¾ 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%!**

Amendment	Oz/Cu. Ft.	Nutrients
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

Soilless Mixes

Slow-release

14-14-14

N = 100% P = 43.6% K = 83%

14--6.1--11.62

Soilless Mixes

Target soilless 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)

Soilless 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

K^+

1992 Dr. Steve Petrie

534 References Reviewed

K^+ Most Important

Insect and Disease Reduction

K^+

Potassium

1. Mobilization of Plant Defense System

2. Increases Cuticle Thickness

K+

Potassium

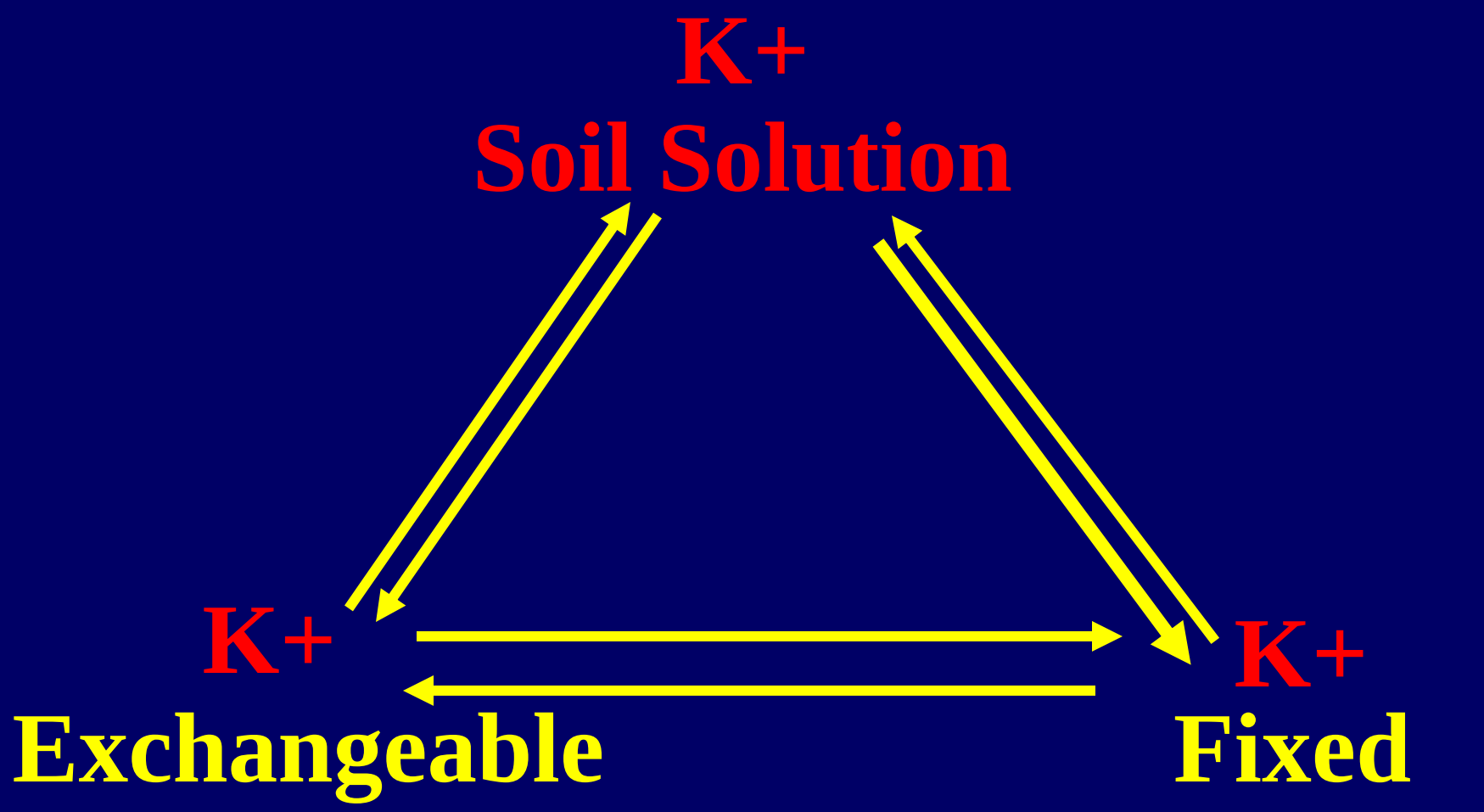
Tolerance to Adverse Conditions

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



Source: Unocal Nitrogen Group

Effect of K, N and Ca on Severity of Phytophthora Diseases

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

Phytophthora, Its Biology, Taxonomy, Ecology and Pathology, 1983 APS Press, St. Paul, MN Page 191

K^+

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 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^{++}

More Calcium in Middle Lamella Reduces Pathogen Enzyme Activity

Pectolytic Enzyme Activity:

Polygalacturonase

Ca^{++}

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: Fusarim Spore Attachment (ferrocacti, bananas)

4.Reduces Rhizoctonia enzyme activity

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

Cation content (mg/g dry wt.)			Infection[1] with
K	**Ca**	**Mg**	***Botrytis***
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

[1] Infection index:

0-5 slight infection
6-10 moderate infection
11-15 severe infection

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

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

	Nitrogen Level	
Pathogen and Disease	**Low**	**High**
Obligate parasites		
Puccinia spp. (rusts)	+	+++
Erysiphe graminis (powdery mildew)	+	+++
Facultative parasites		
Alternaria spp. (leaf spots)	+++	+
Fusarium oxysporum (wilts and rots)	+++	+
Xanthormonas spp. (spots and wilts)	+++	+

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

	Potassium Level	
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Facultative parasites		
***Alternaria spp.* (leaf spots)**	++++	+
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***Xanthormonas spp.* (spots and wilts)**	++++	+

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

Cu^{++} - Copper

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

Cu^{++} - Copper

- **Necessary for polyphenoloxidase activity.**

- **Polyphenoloxidase system produces some phytoalexins and other anti-pathogenic molecules.**

Cu^{++} - 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^{++}

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^{++}

- **Involved in the production of lignin.**

- **Lignin is the principal component of wood and very difficult to degrade.**

Manganese Mn^{++}

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

Manganese Mn^{++}

- Mn^{+2} 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

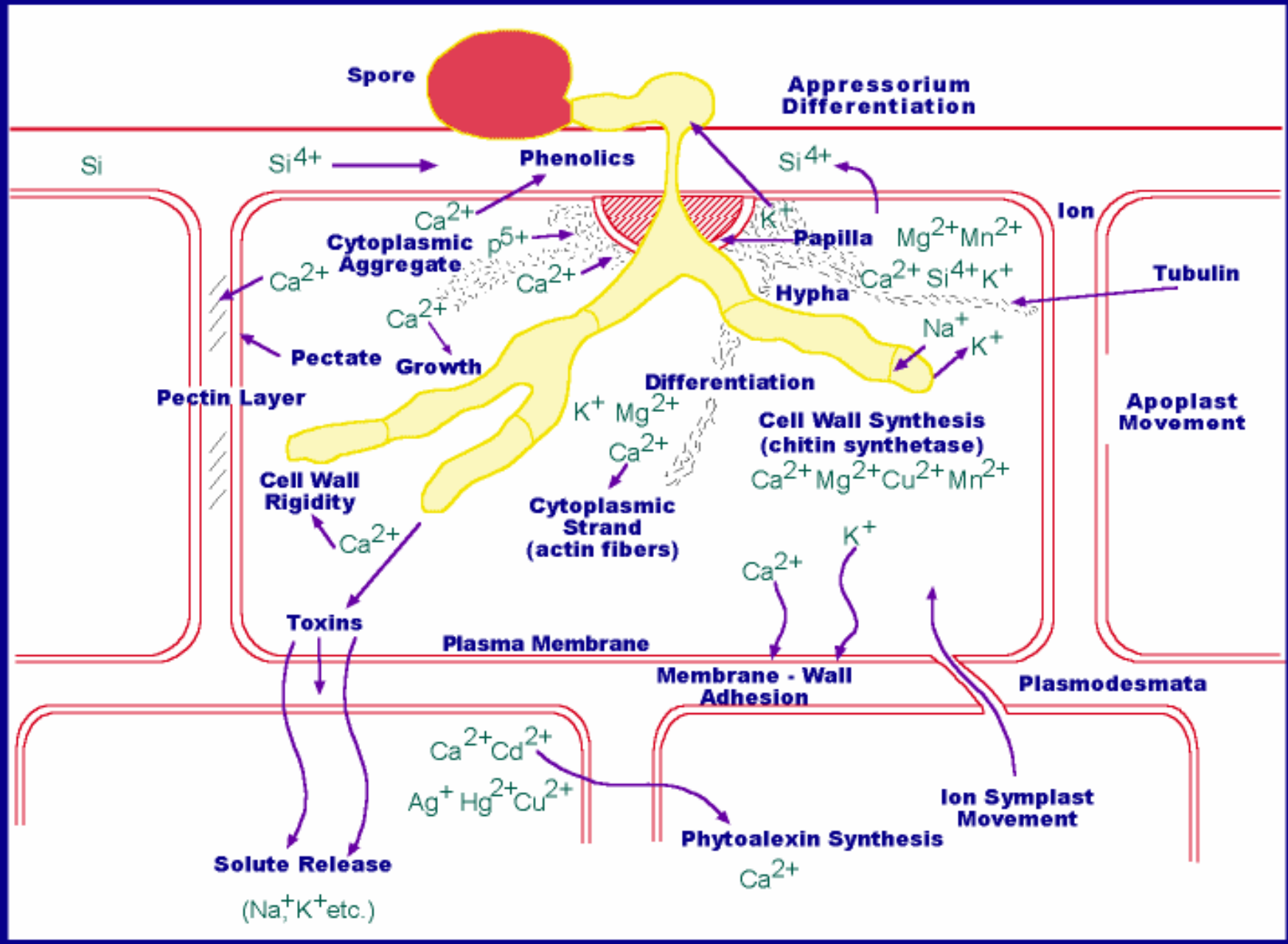
- Take-all and powdery mildew of wheat
- Common scab of potato
- Blast and leaf spot of rice
- Root rot of avocado
- Powdery mildew of canola, sorghum
- Nematodes attacking barley

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 plans.
- Dicots are more reactive than monocots

Thank you!

Questions!



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ANN. REV. PLANT. 1990.
28:93-111.

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

- **Take-all** **Bentgrass**
  Gaeumannomyces graminis var. avenae

- **Bermudagrass Decline** **Bermudagrass**
  G. graminis var. graminis

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^{++} 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 NH_4 or urea

Mineral Elements Affecting Take-all of Cereals

Increase Take-all	Reduce Take-all
Potassium nitrate	Potassium chloride
Phosphorus excess	Phosphorus sufficiency
Calcium carbonate (lime)	Sulfur
Magnesium carbonate	Magnesium chloride
Magnesium sulfate	Calcium chloride
Molybdenum	Manganese
	Iron, Zinc
	Copper chloride

Adapted from D. Huber, Purdue

Forms of Nitrogen
General Effects

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

Rhizosphere pH decrease

Modify Rhizosphere Microbes

Increase available Mn, Fe, Cu, Zn

Acidification decreases nitrification: NH_4 to 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

Factor	Nitrification	Disease
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 = Mn^{++}

Alkaline pH in soil and rhizosphere = Mn^{+4}

Mn^{++} Available

Mn^{+4} Non-available

Manganese Influence on Root Lesions and Lignin in Wheat

Variable	Total Length of Ggt lesions (mm)	Lignin Content (Abs_{280}/root system)
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

Genotype	Total Length of Ggt Lesions (mm)	Lignin Content (Abs_{280}/root system)
Mn-inefficient		
Bayonet	30	0.14
Millewa	27	0.16
Mn-efficient		
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 lease 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

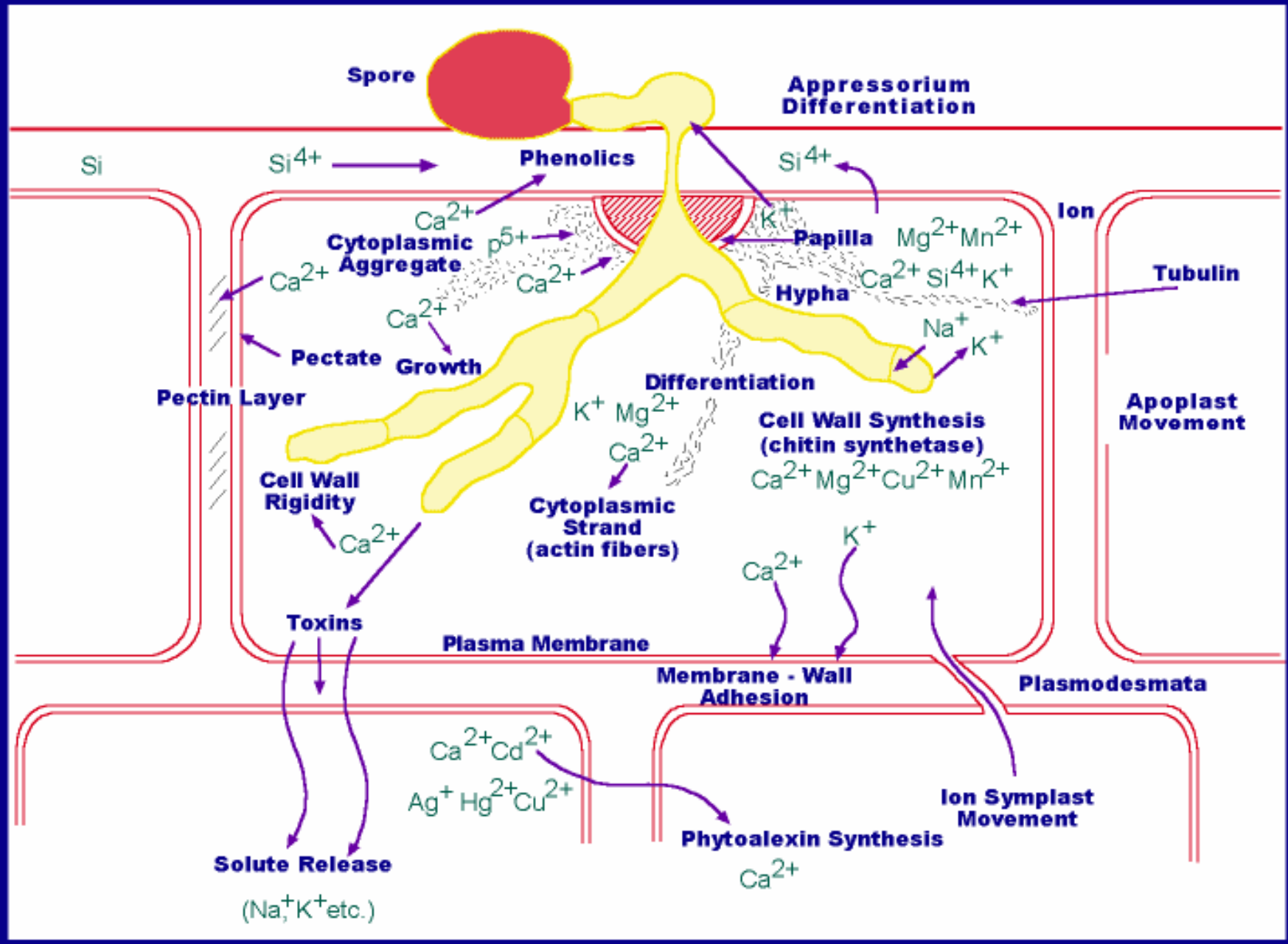
Free Calcium

Increases Plant Membrane Stability

Improves Soil Structure: Water/Oxygen Distribution

Lime Increases Soil pH:

Stops or Reduces Spore Pathogen Attachment



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