Knowledge grows

Impact of Improved Plant Nutrition on Pest Management

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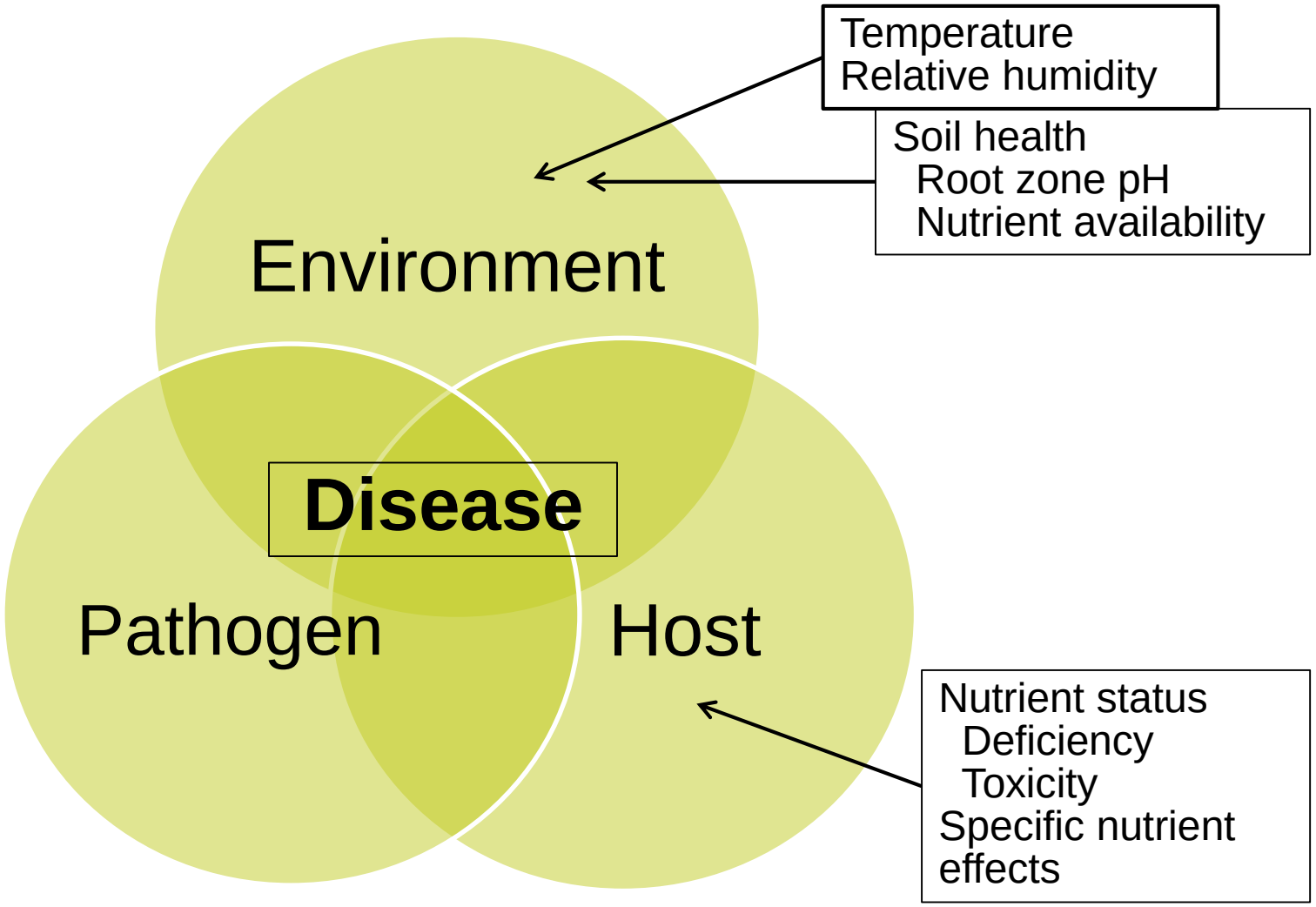
Impact of improved plant nutrition on pest management

- Fertilizers are not pesticides
- Fertilizers are not PGR’s
- Fertilizers do not mitigate pests
- Fertilizers supply plant nutrients to crops

Plant disease triangle



Plant nutrition effects on diseases

Improved mineral nutrition helps plants escape diseases by two mechanisms:

1. Formation of physical barrier that reduces infection by pathogens
2. Stimulation of natural defense compounds
    1. Anti-oxidants
    2. Phytoalexins
    3. Flavenoids

Specific nutrient effects on diseases

- Macronutrients
  - N
  - P
  - K
  - Ca
- Micronutrients
  - B
  - Cl
  - Cu
  - Mn

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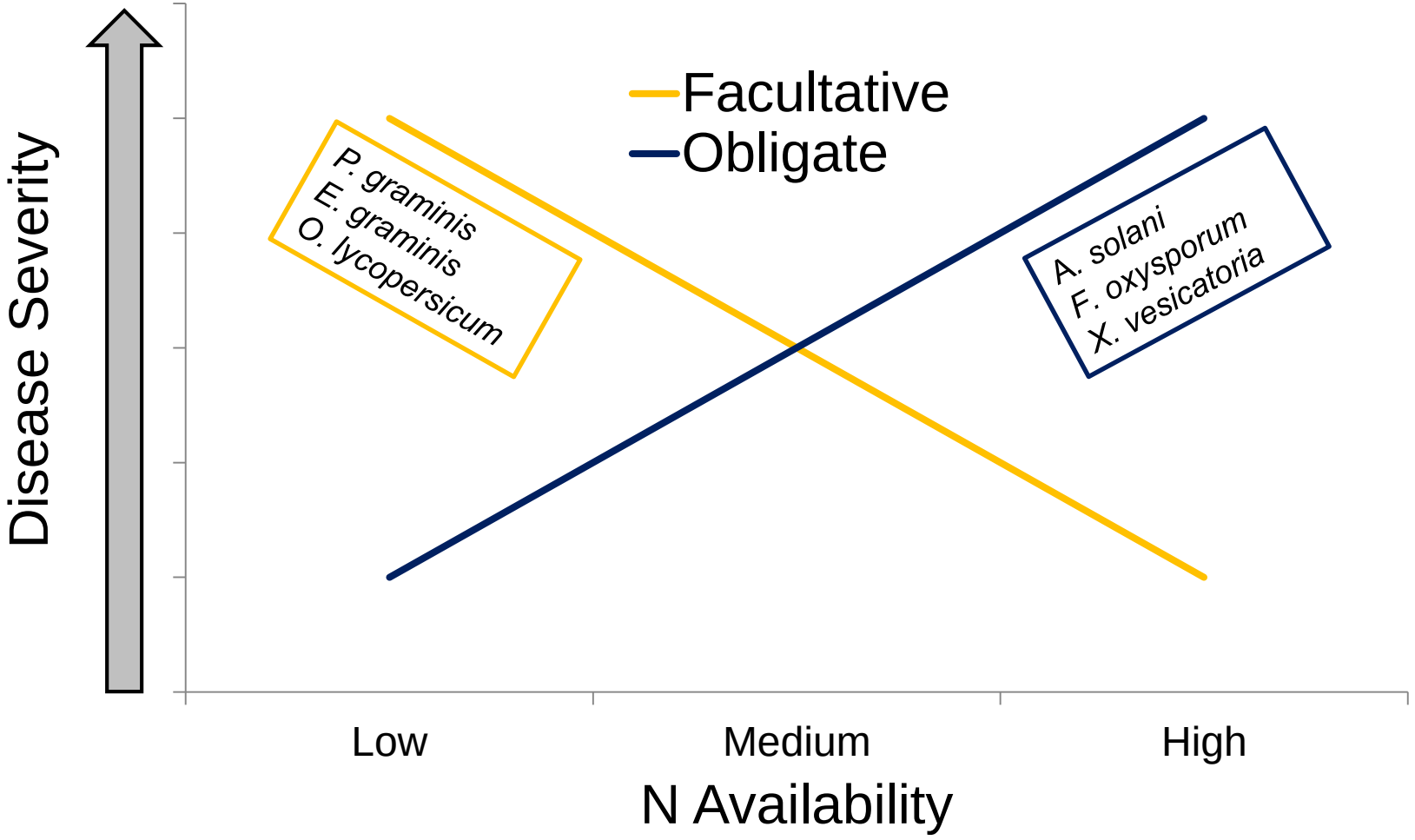
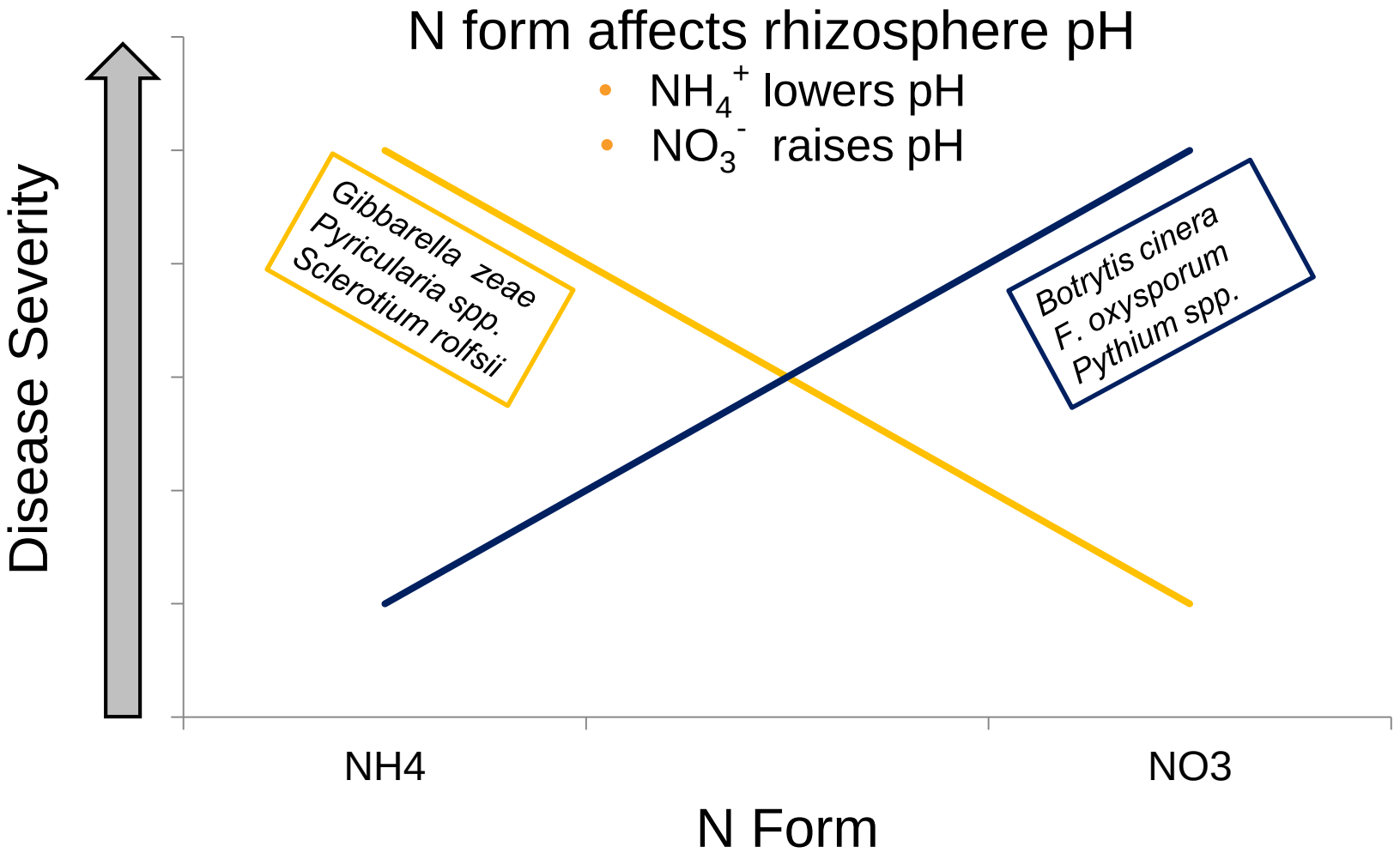
N effects on plant diseases

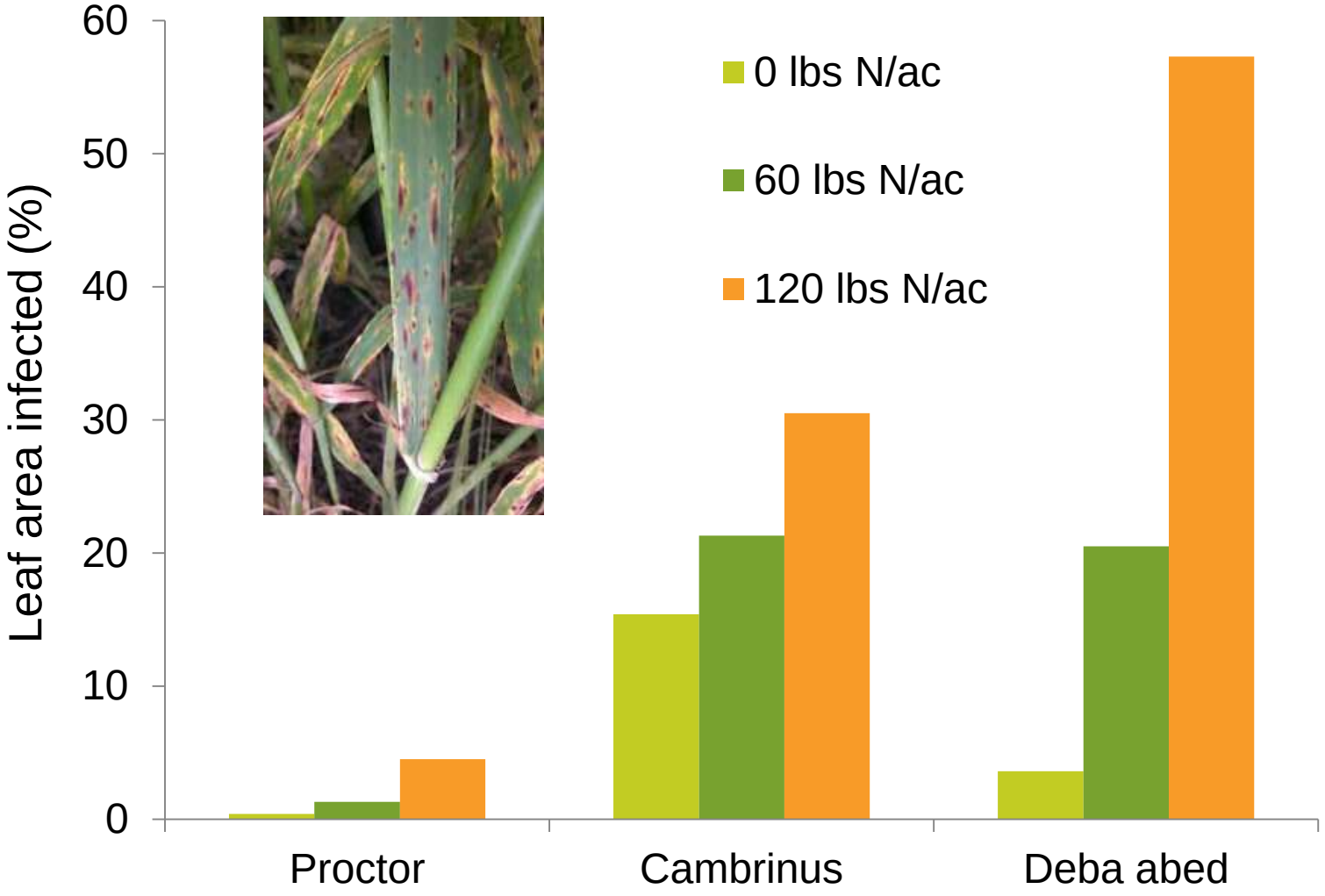
N rate effects



N form effects



N effect on leaf blotch of spring barley



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P effects on plant diseases

P effects on plant diseases

- P has inconsistent effects on plant diseases
- Beneficial when applied to seedlings to help plants escape disease
- P banded at planting to help wheat escape pythium

P effects on Hessian fly

Variety	P_2O_5	Infested plants	Infested tillers	Pupae	Yield
	Lbs/ac	---------- # /3 ft of row ----------			Bu/ac
Alpowa	0	24.2	42.8	67.5	31.7
Alpowa	20	7.3	22.4	14.4	40.5
Zak	0	3.0	3.9	3.9	37.1
Zak	20	0.5	0	0.7	38.8
LSD $_{(0.05)}$		12.7	11.9	29.3	5.4

Alpowa is susceptible to Hessian fly, Zak is resistant

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K effects on plant diseases

K effects on pathogenic diseases

- Potassium is widely recognized for its role in minimizing pathogenic diseases
- Potassium uniformly reduced infection of both obligate and facultative pests
- Three extensive literature reviews have documented the benefits of applying K

K effects on bacterial diseases

Crop	Disease	Pathogen	K effect
Apple	Fire blight	*Erwinia amylovora*	Increase
Cabbage	Bacterial blight	*Pseudomonas syringae*	Decrease
Cotton	Leaf spot	*Xanthomonas malvacearum*	Decrease
Cucumber	Leaf spot	*Pseudomonas lachrymans*	Decrease
	Bacterial wilt	*Erwinia tracheiphila*	Increase
Corn	Stewart's wilt	*Erwinia stewartii*	Decrease
Peach	Bacterial spot	*Xanthomonas pruni*	Decrease
Pear	Fire blight	*Erwinia amylovora*	Decrease
Rice	Bacterial blight	*Xanthomonas oryzae*	Decrease
Tomato	Blotchy ripening	*Erwinia herbicola*	Decrease
	Soft rot	*Erwinia carotovora*	Decrease
	Wilt	*Pseudomonas solanacearum*	Decrease

Huber and Arny, 1985

K effects on fungal diseases - 1

Crop	Disease	Pathogen	K effect
Apricot	Gleosporium	*Pezicula malicorticis*	Increase
Avocado	Root rot	*Phytophthora cinnamomi*	Decrease
Cabbage	Club root	*Plasmodiophora brassicae*	Increase
	Gray mold	*Botrytis cinerea*	Decrease
	Yellows	*Fusarium oxysporum*	Decrease
Celery	Yellows	*Fusarium oxysporum*	Decrease
Cereals	Rust	*Puccinia spp.*	Decrease
	Powdery mildew	*Erysiphe graminis*	Decrease
Cotton	Wilt	*Fusarium oxysporium*	Decrease
	Root rot	*Phymatorotrichum omnivorum*	Decrease
	Seedling blight	*Rhizoctonia solani*	Decrease
	Leaf blight	*Cercospora gossypina*	Decrease

Huber and Arny, 1985

K effects on fungal diseases - 2

Crop	Disease	Pathogen	K effect
Corn	Stalk rot	*Gibberella zeae*	Decrease
	Stalk rot	*Diplodia zeae*	Decrease
	Stem rot	*Fusarium culmorum*	Decrease
Grape	Fruit rot	*Botrytis cinera*	Decrease
Melon	Stem blight	*Mycospharella melona*	Increase
Onion	Purple blotch	*Alternaria porri*	Increase
Prune	Canker	*Cytospora leucostoma*	Decrease
Rice	Leaf spot	*Cercospora oryzae*	Decrease
	Leaf spot	*Helminthosporium spp.*	Decrease
	Sheath blight	*Corticium sasakii*	Decrease
	Stem rot	*Helminshosporium signoideum*	Decrease
	Blast	*Pyricularia oryzae*	Decrease

Huber and Arny, 1985

K effects on fungal diseases - 3

Crop	Disease	Pathogen	K effect
Tomato	Wilt	*Fusarium oxysporium*	Dec/Inc
	Leaf blight	*Alternaria solani*	Decrease
Turf	Fusarium patch	*Fusarium oxysorium*	Decrease
	Ophiobolus patch	*Ophiobolus graminis*	Decrease
	Leaf spot	*Helminthisporium spp.*	Decrease
Wheat	Glume blotch	*Septoria nodorum*	Decrease
	Take-all	*Gaeumannomyces graminis*	Decrease
	Stem rust	*Puccinia graminis*	Decrease
	Stripe rust	*Puccinia striiformis*	Decrease
	Powdery mildew	*Erysiphe graminis*	Decrease

Huber and Arny, 1985

K effects on viruses and nematodes

Crop	Disease	Pathogen	K effect
Barley	BYD	BYD virus	Decrease
Potato	Mosaic	Potato mosaic virus	Decrease
	Leaf roll	Potato leaf-roll virus	Decrease
Tomato	Blotchy ripening	Tobacco mosaic virus	Decrease

Crop	Disease	Nematode	K effect
Cotton		*Rotylenchulus reniformis*	Decrease
Cucurbits	Root knot	*Meloidogyne incognita*	Increase
Rice	White tip	*Aphelenchoides oryzae*	Increase
Tomato		*Rotylenchulus reniformis*	Increase
	Root knot	*Meloidogyne incognita*	Increase

Huber and Arny, 1985

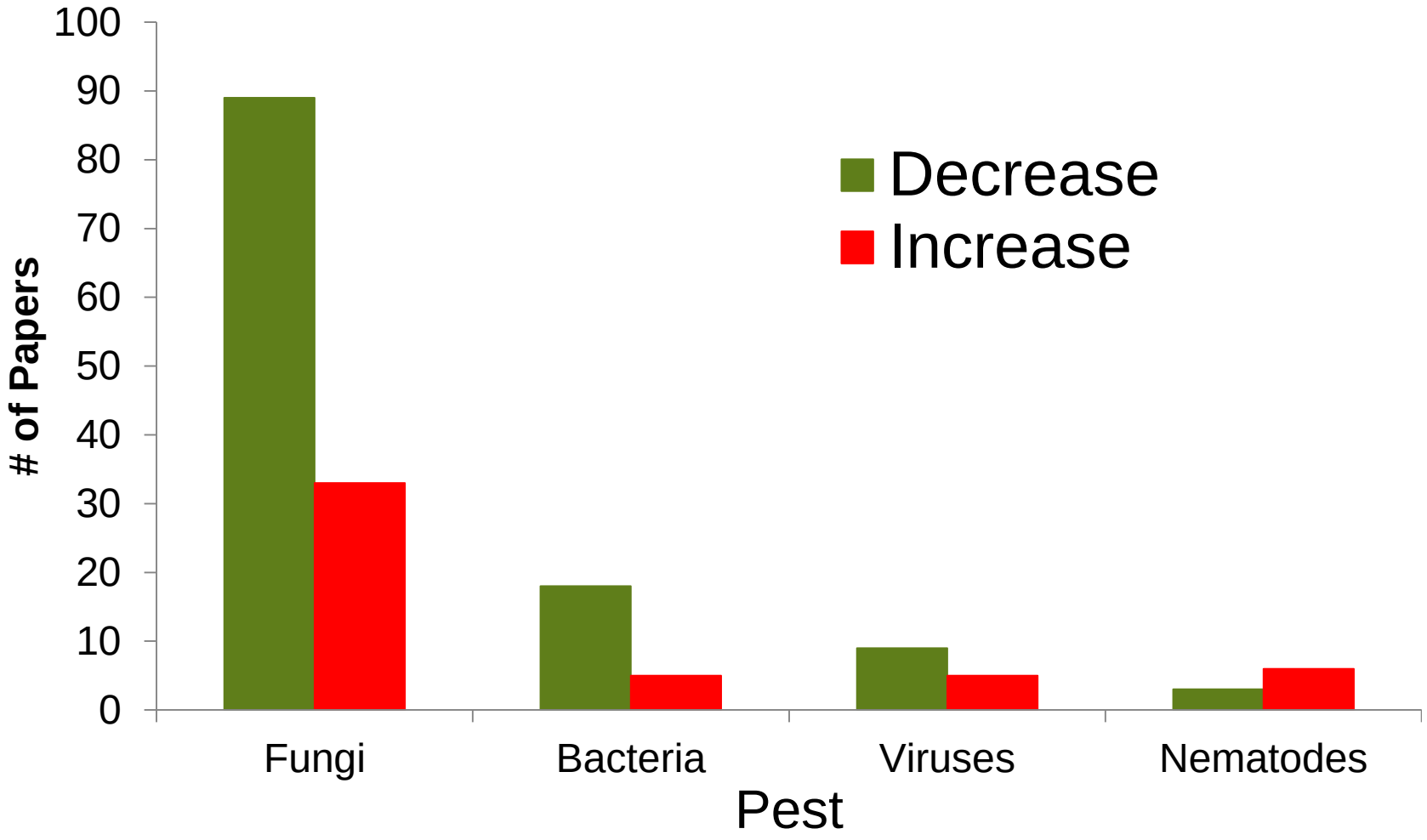
K effects on pests and yield

Summary of more than 2,400 research reports demonstrating the benefits of adequate K nutrition on pests and crop yield

Pest	Reduction	Crop yield increase
	---------- % ----------	
Bacteria	70	42
Fungi	69	57
Insects	63	36
Viruses	41	78

Perrenoud, 1990.

Summary of K effects on pests



Prabhu, et al., 2007.

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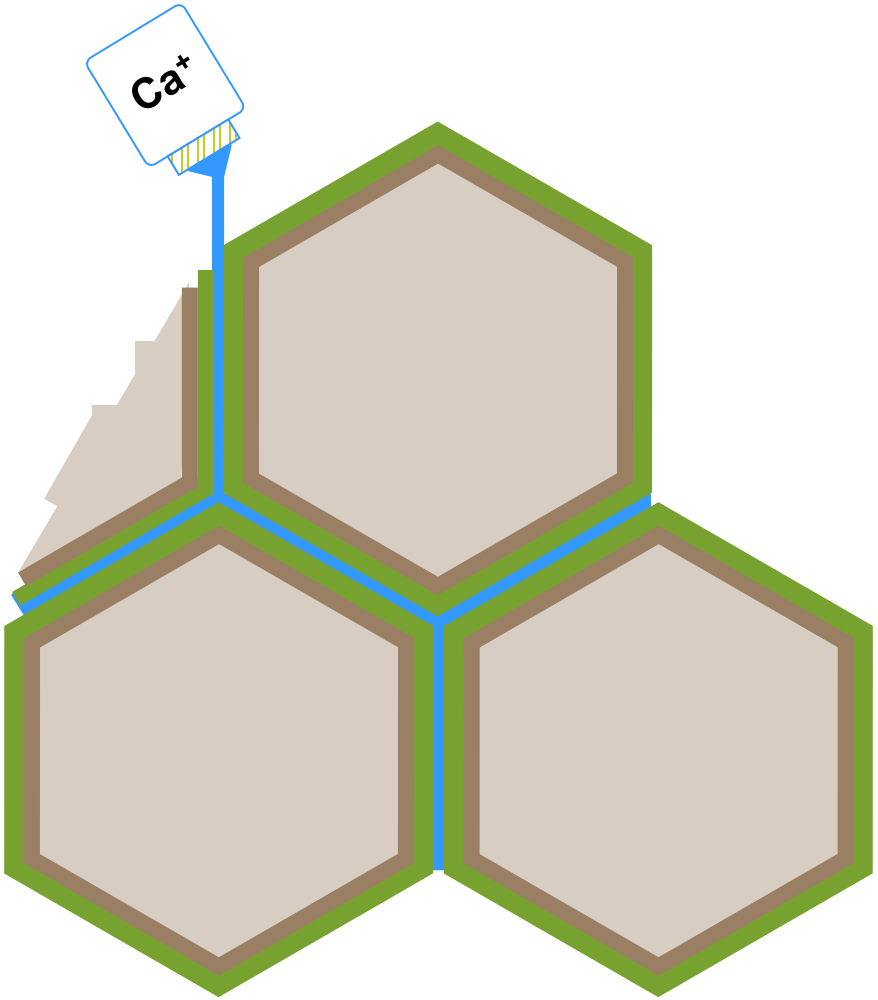
Ca effects on plant diseases

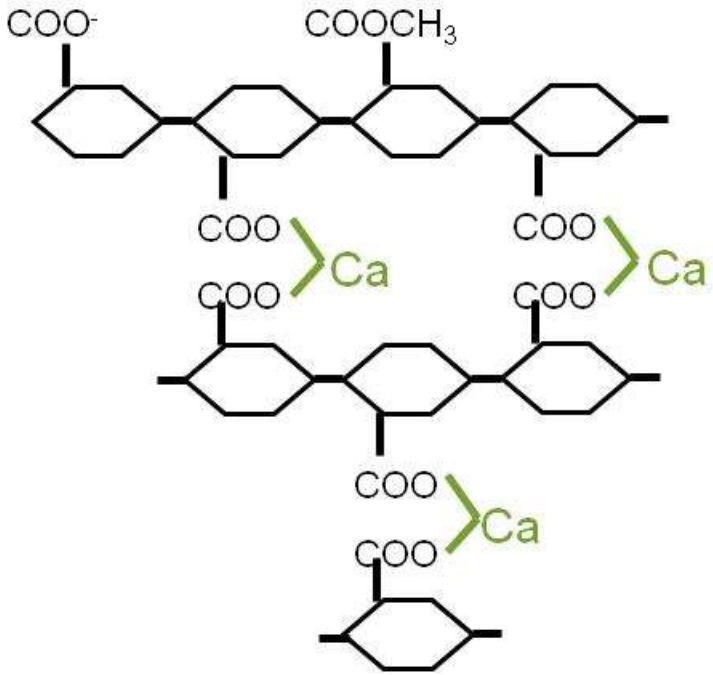
Calcium’s role in defense mechanisms

- Calcium for stronger cell walls and better integrity of cell membranes - mechanical resistance
- Speed up leaf hardening (young leaves become firm in a shorter term, and are therefore less attractive to insects/vectors).
- Reduce the activity of enzymes produced by the fungi or bacteria to penetrate the plant tissue

Calcium ‘glues’ the cells together

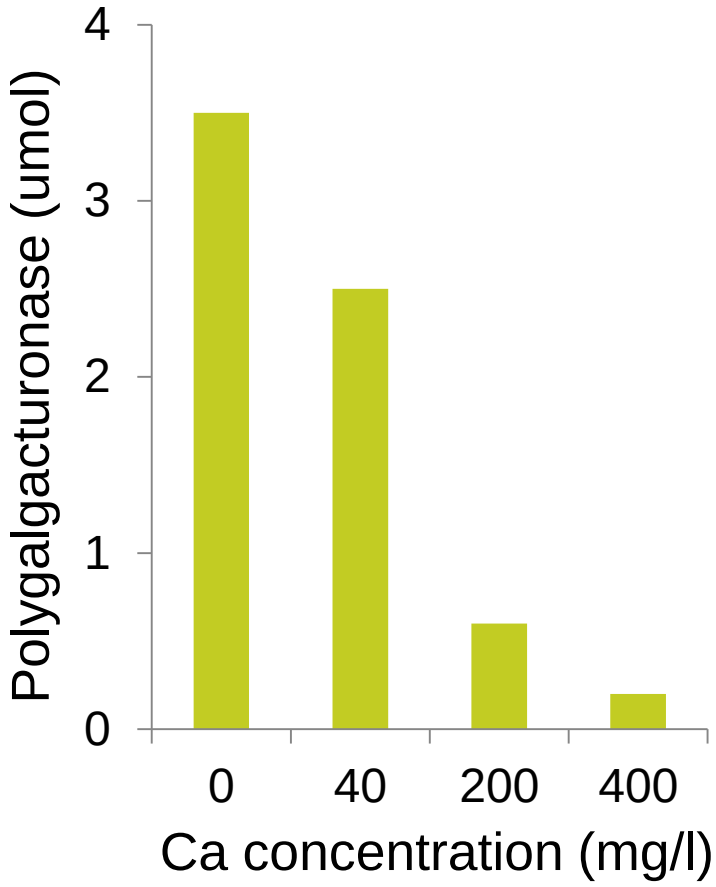


Ca saturates the free COO^- groups of the pectines in the middle lamella

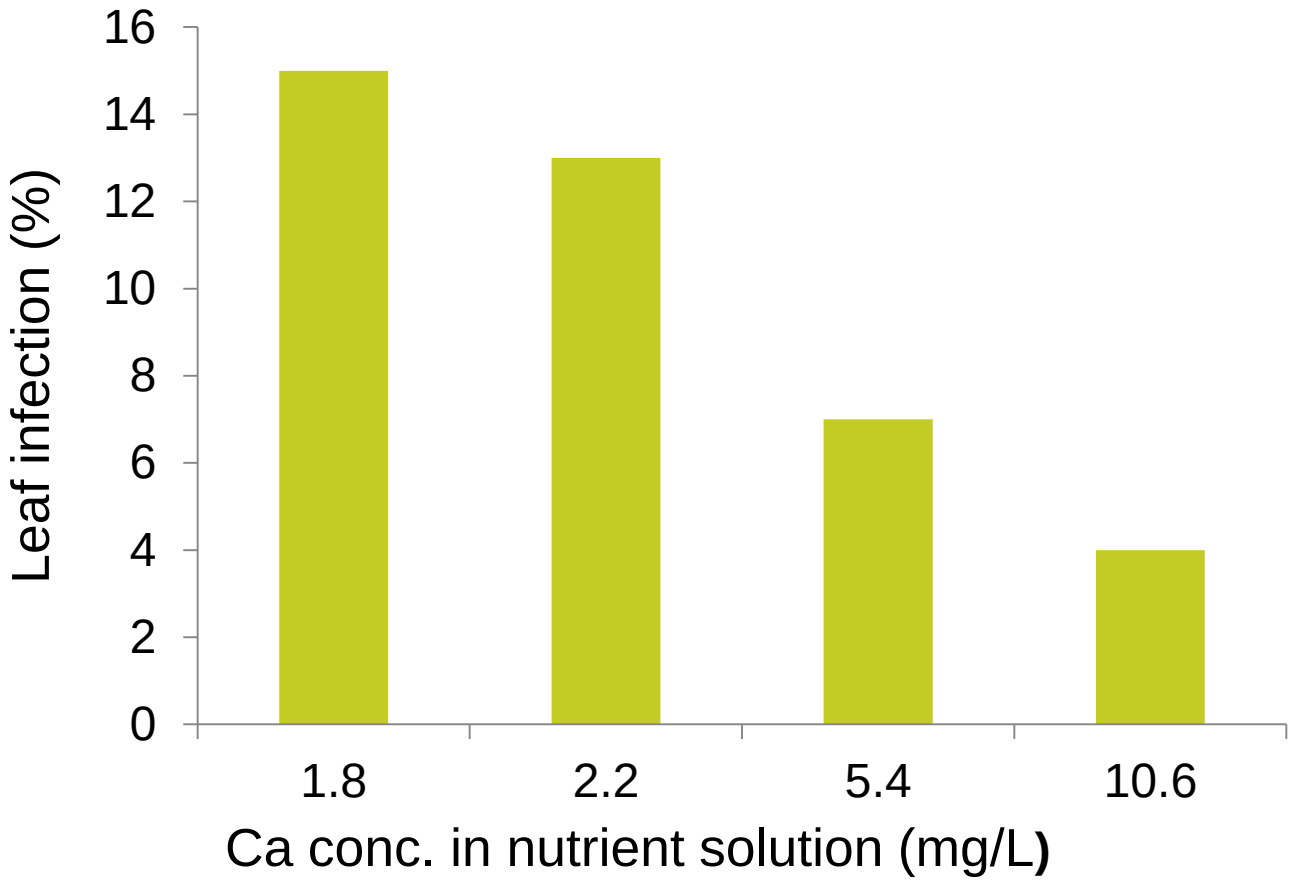


Ca Inhibits polygalacturonase

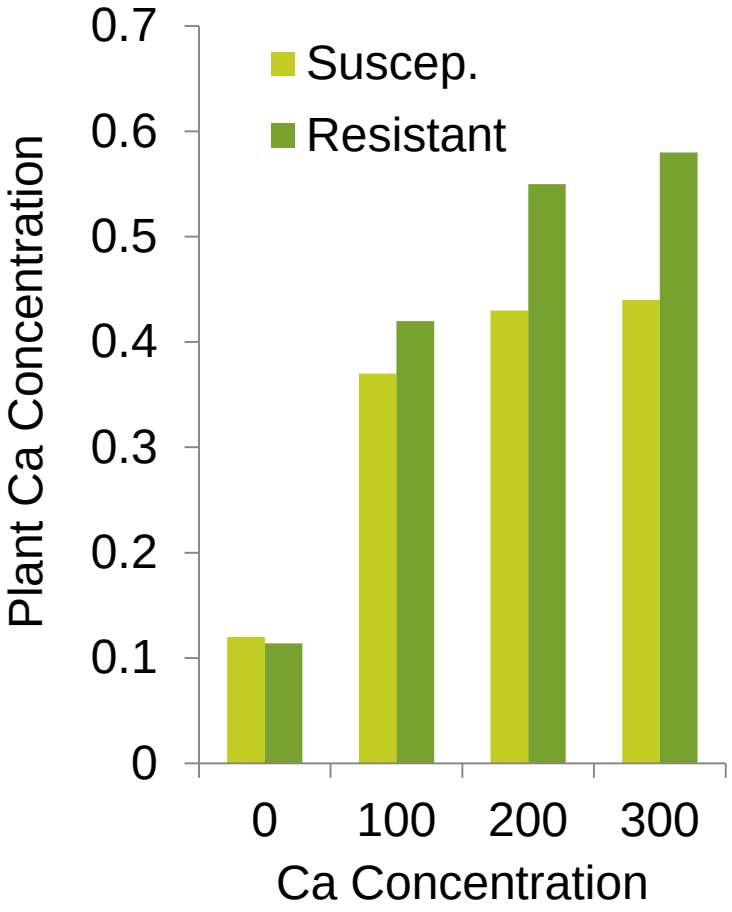
- Ca-polygalacturonates are required in the middle lamella for cell wall stability
- Many parasitic fungi and bacterial produce enzymes such as polygalacturonase that degrade the middle lamella
- Ca dramatically reduces the activity of this enzyme

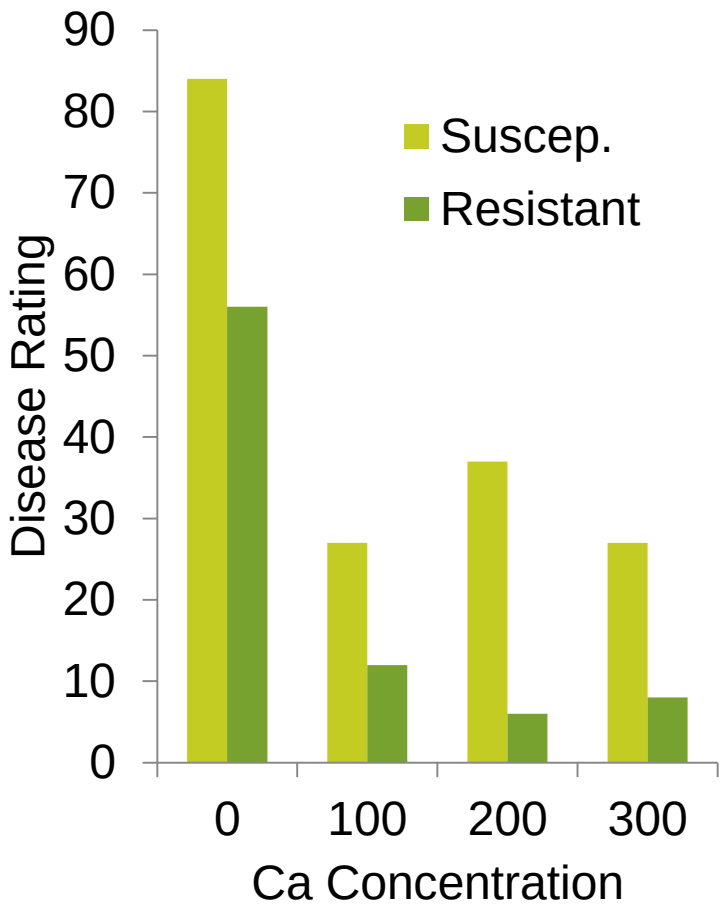


Ca and *Botrytis cinerea* in lettuce



Ca effect on bacterial canker of tomato





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Micronutrient effects on plant diseases

B, Cl, Cu, and Mn

B effects on plant diseases

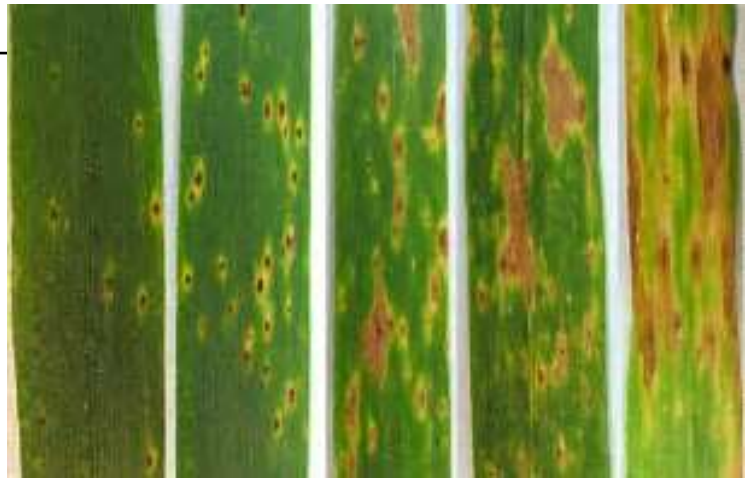
- Most widespread micronutrient deficiency
- Least understood micronutrient
- Role in cell wall structure and cell membrane integrity
- Plant immune responses to diseases
- Diseases reduced by B include:
  - *Plasmodiophoro brassicae* in crucifers
  - *Verticillium spp* tomatoes
  - Tomato yellow leaf curl virus
  - Take-all in wheat

Cl effects on plant diseases

- Cl has been found to suppress diseases independent of the K
- Mechanism is unknown but may involve water relations/hypersensitive response
- NOT a chlorine disinfection
- Examples of pathogenic diseases reduced by Cl include:
  - Stalk rot in corn
  - Stripe rust in wheat
  - Take-all in wheat
  - Septoria in wheat
- Cl also reduces physiological disorders

Cl effect on physiological leaf spot (PLS) and yield of ‘Madsen’ winter wheat

Cl Rate	PLS	Yield	Test Wt.
Lbs/A		Bu/A	Lbs/bu
0	3.5	70	55.6
50	1.0	83	56.9
150	1.0	84	57.4



Cu effects on plant diseases

- Cu is used as a fungicide
- But rates are 10 to 100 times greater than for plant nutrition
- Cu plays a role in phenol synthesis and lignin biosynthesis

Cu reduced stem melanosis of wheat

Treatment			Disease	Yield
Cu source	Placement	Rate Lbs/ac	%	Lbs/acre
Check			92	260
$CuSO_4$	Banded	10	76	460
$CuSO_4$	Incorp.	10	34	1800
$CuSO_4$	Foliar	10	6	1890
Cu chelate	Foliar	2	7	2240

Trial was conducted on a Cu-deficient soil

Mn effects on plant diseases

- Most studied micronutrient with respect to plant diseases
- Mn mediates enzymes that control lignin and suberin biosynthesis which provide a physical barrier to attack
- Plants require higher concentrations of Mn in soil solution than do fungi and bacteria
- Pathogens exploit this differential requirement
- Mild Mn deficiency situation can lead to attack by pathogens in absence of stark Mn deficiency

Mn reduces incidence/severity of many pathogens

- Powdery mildew
- Downy mildew
- Take-all of wheat
- Tan spot of cereals
- Common scab of potatoes
- Fusarium spp. of cotton
- Sclerotinia sclerotium of squash

Summary

- Nutrients are not pesticides
- Proper nutrient management helps plants escape/avoid diseases
- Key nutrients are: N, K, Ca, B, Cl, Cu and Mn
- The rate, form, and timing of nutrient application affect different diseases in different ways