Preventing, diagnosing and understanding nutrient deficiencies in plants

Dr. Michael J. Mulvaney

Cropping Systems Specialist

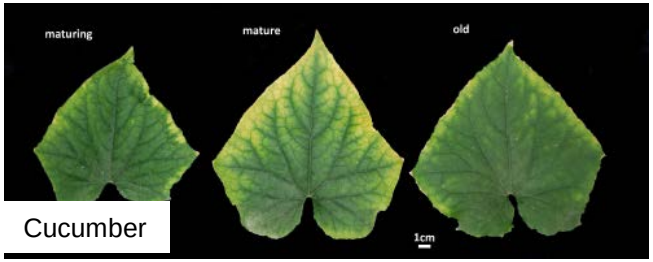
35th Florida Master Gardener Continued Training Conference

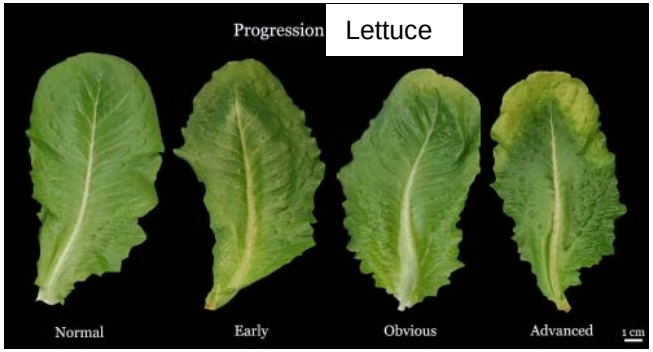
St. Augustine, FL

Oct. 16, 2017

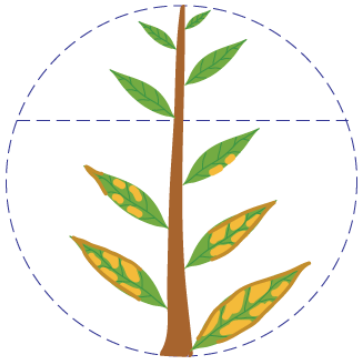
UF | UNIVERSITY of FLORIDA

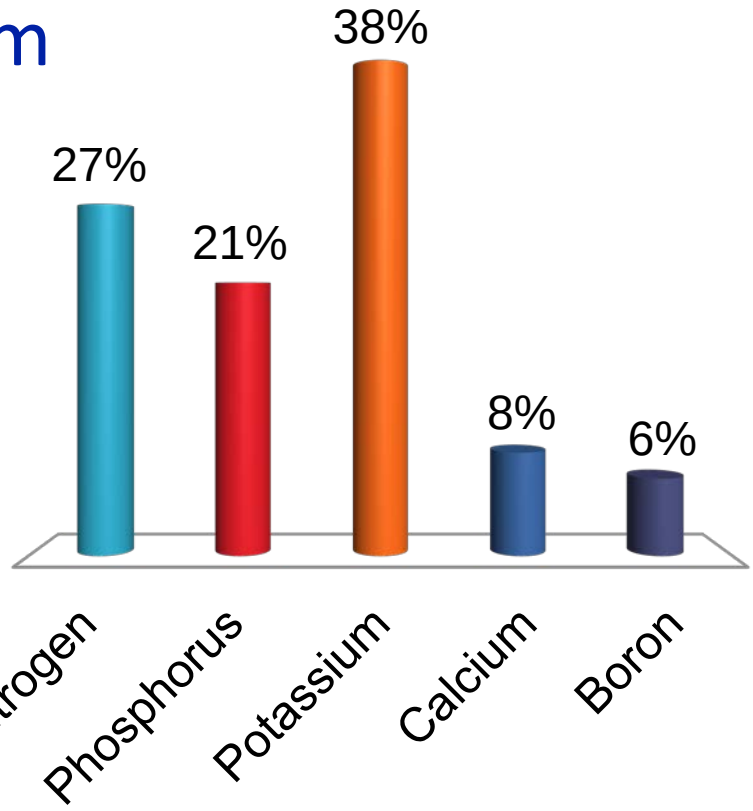
What nutrient deficiency is this?





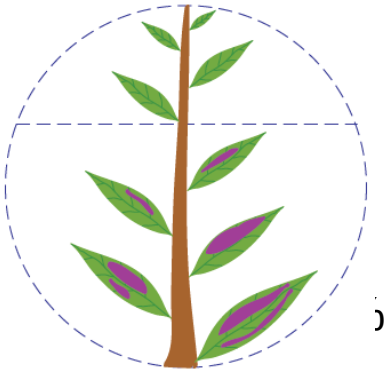
A. Nitrogen
B. Phosphorus
C. Potassium
D. Calcium
E. Boron

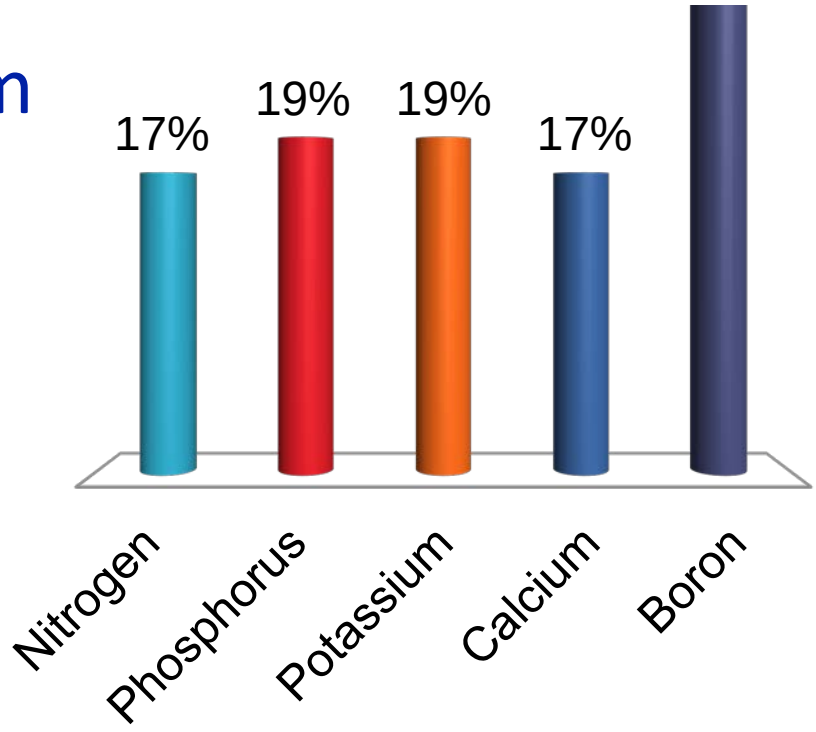




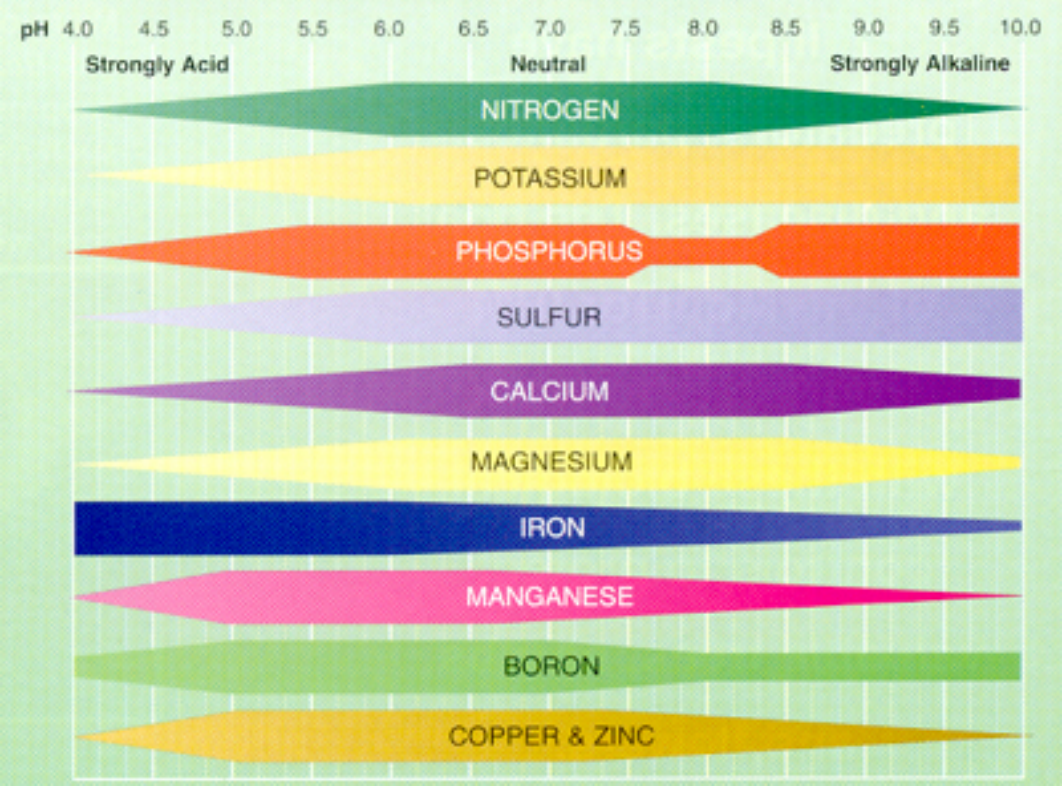
What nutrient deficiency is this?

A. Nitrogen
B. Phosphorus
C. Potassium
D. Calcium
E. Boron





Diagnosing nutrient deficiencies: Soil pH and nutrient availability

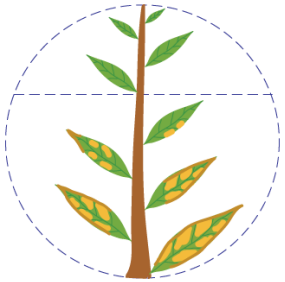


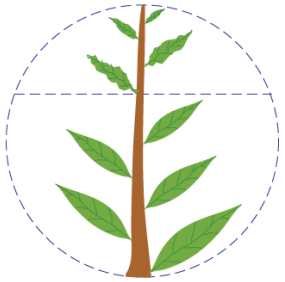
UF UNIVERSITY of FLORIDA

http://articles.extension.org/sites/default/files/w/c/c6/PHandavailability.jpg

Plant mobile vs. immobile

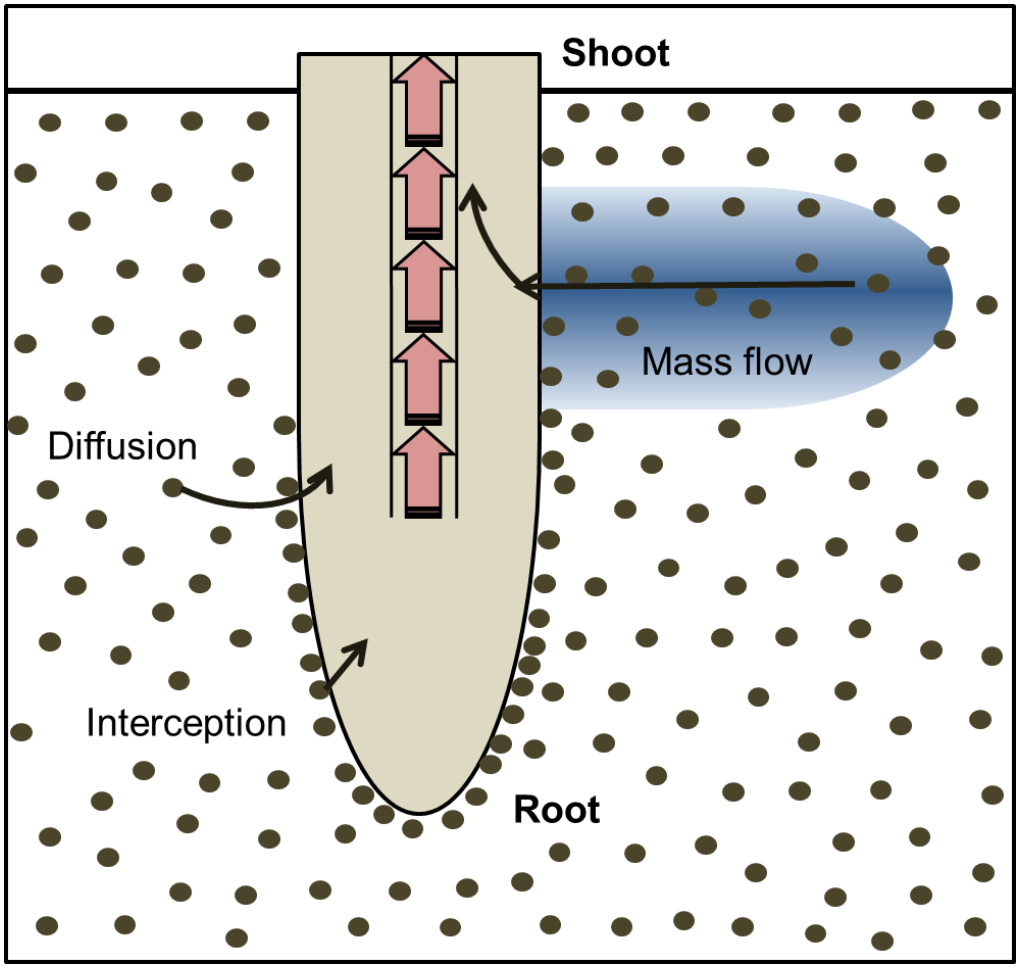
- All nutrients are xylem mobile: They move up the plant.
- “Immobile” nutrients = does not move in phloem.





Mobile nutrients in plants	Immobile nutrients in plants
Remobilized to parts that have higher demand.	Locked in place after assimilation.
Older growth becomes deficient.	Newer growth becomes deficient.

Nutrient movement in soil

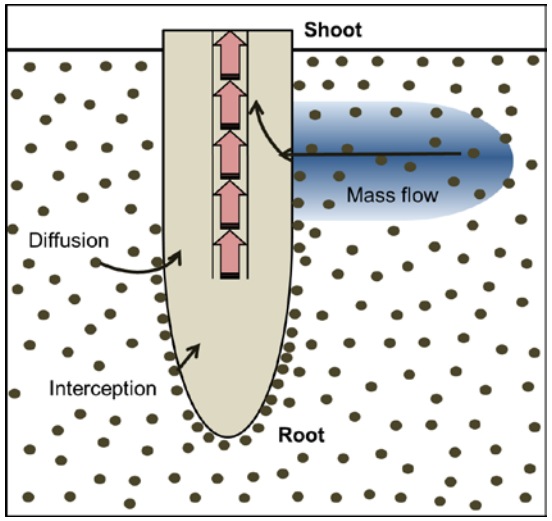


UF UNIVERSITY of FLORIDA

http://plantsinaction.science.uq.edu.au/book/export/html/234

Nutrient movement in soil

- Mass flow
  - Movement of ions in water
  - Can move up (via ET) or down (leaching)
  - Major: NO_3^-, Cl^-, K+, Mg2+
  - Moderate: SO_4^{2-}
  - Others depending on physical & chemical soil characteristics

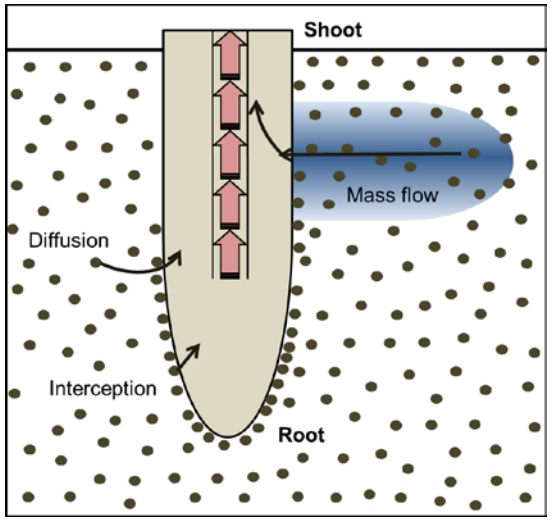


UF UNIVERSITY of FLORIDA

http://plantsinaction.science.uq.edu.au/book/export/html/234

Nutrient movement in soil

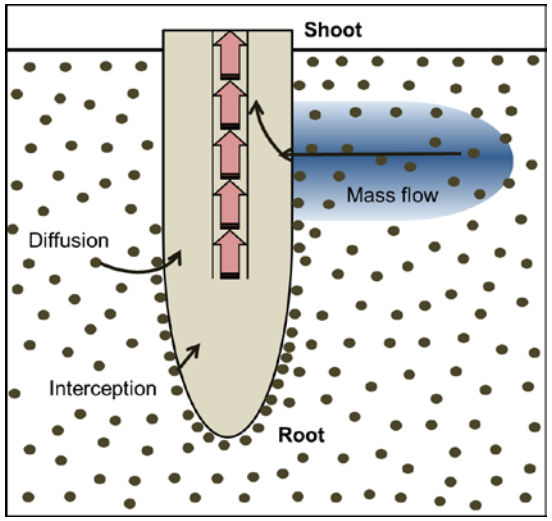
- Diffusion
  - Concentration gradient
  - 1 cm/day for soluble ions
  - If bound to soil, takes longer
    - NO_3^- about 3 mm/day
    - K^+ about 1 mm/day
    - PO_4^{3-} about 0.1 mm/day
  - Important for P, K, S, Fe, Zn



http://plantsinaction.science.uq.edu.au/book/export/html/234

Nutrient movement in soil

- Root interception
  - Root contacts CEC sites
  - Relatively minor absorption
  - Mycorrhizal infection effectively increases root area – P uptake
  - Mainly Ca, Mg, Zn, Mn

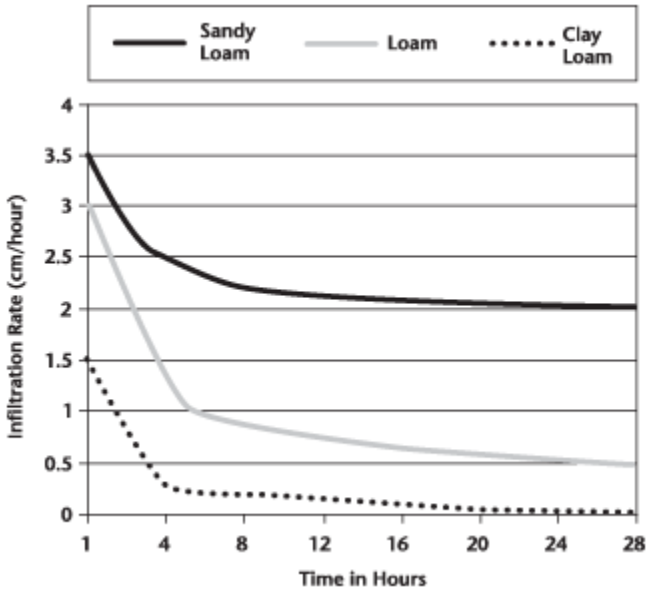


UF UNIVERSITY of FLORIDA

http://plantsinaction.science.uq.edu.au/book/export/html/234

Soil texture effects on nutrient movement

- As % sand increases, NPK & S movement increases.
- Like OM, as % clay increases, NPK & S movement decreases.

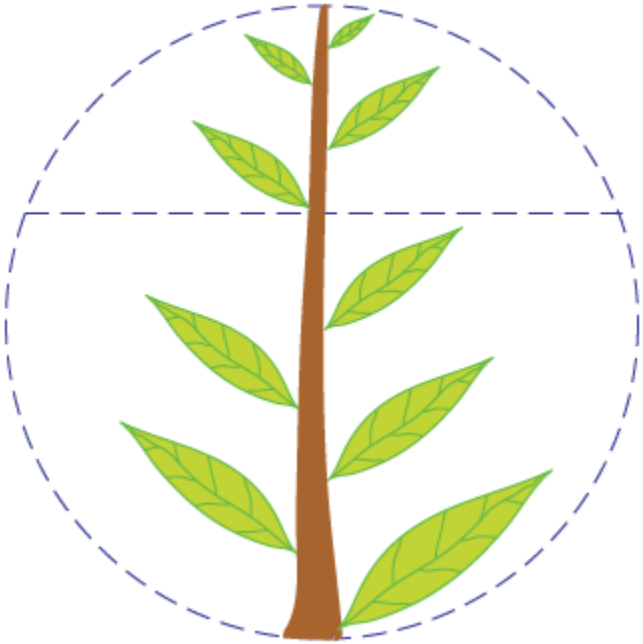


http://www.canolacouncil.org/

UF UNIVERSITY of FLORIDA

Nitrogen

- Mobile in plant
- Forms amino acids, vitamins, proteins, cell division, chlorophyll
- Mobile in soil as NO3-
- Immobile in soil as NH4+
- Chlorosis in older leaves first, then in younger tissue



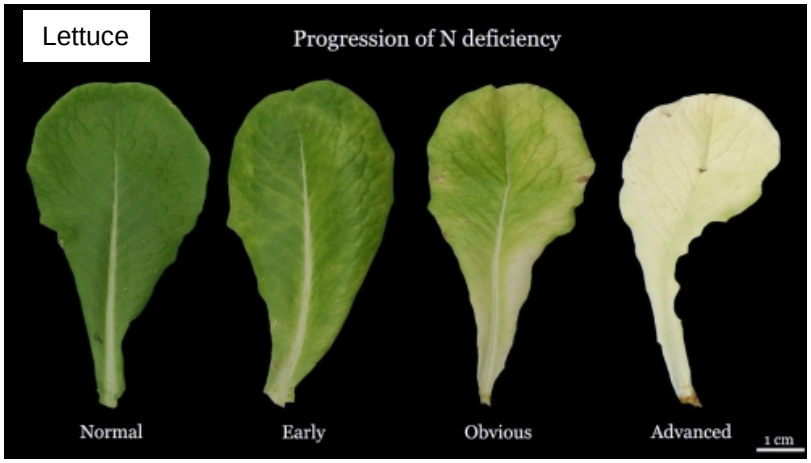
UF UNIVERSITY of FLORIDA

Credit: IPNI Crop Nutrient Deficiency Image Collection

Nitrogen deficiency

Maize

Lettuce



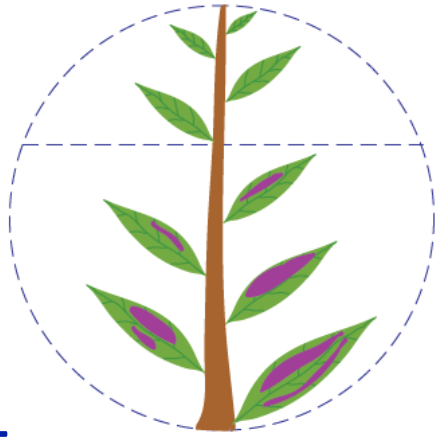
Potato

UF | UNIVERSITY of FLORIDA

Credits: IPNI Crop Nutrient Deficiency Image Collection

Phosphorus

- Somewhat mobile in plant
- Role: Energy storage and transfer, cell growth, root and seed growth, winter hardiness, water use/stomatal regulation
- Immobile in soil – but sand is different
- Moves to plant by diffusion and mycorrhizal fungi assn.
- Increased deficiency when temp is low



UF | UNIVERSITY of FLORIDA

Credit: IPNI Crop Nutrient Deficiency Image Collection

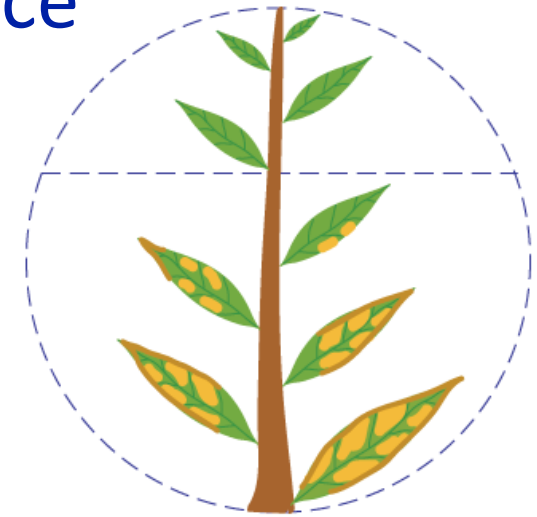
P deficiency

UF | UNIVERSITY of FLORIDA

Credits: IPNI Crop Nutrient Deficiency Image Collection

Potassium

- Highly mobile in plant
- Metabolism, water regulation, fruit formation, winter hardiness, disease resistance
- Somewhat mobile in soil
  - Depends on texture, clay type
  - Finer soils = less mobile
  - Mica clays = more availability

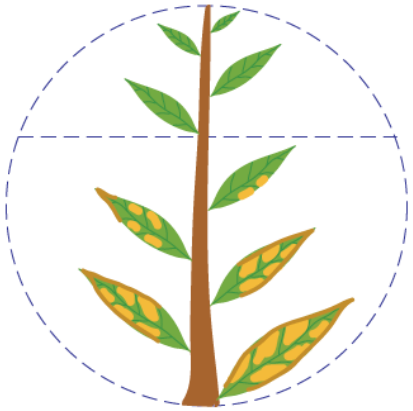


- Deficiencies in dry conditions when there is sufficient soil K – lack of movement to roots

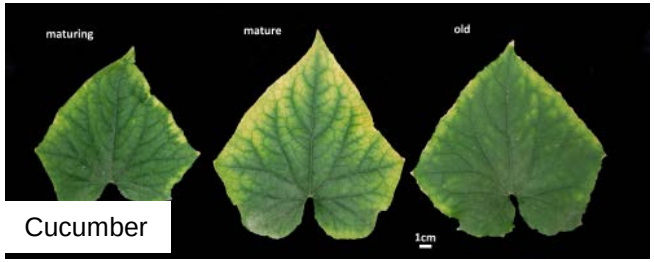
UF UNIVERSITY of FLORIDA

Credit: IPNI Crop Nutrient Deficiency Image Collection

K deficiency



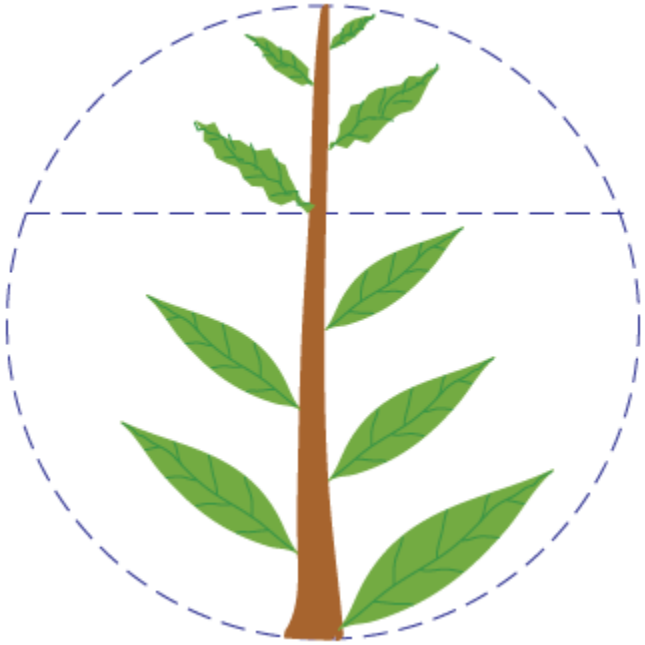
Credit: Bobby Golden, MSU



Credit: IPNI Crop Nutrient Deficiency Image Collection, C.R. Crozier

Calcium

- Immobile in plant
- Cell division & formation, N metabolism, translocation, fruit set
- Somewhat mobile in soil
- Soil deficiency usually occurs:
  - Acid, sandy soils
  - Strongly acid peat and muck



UF UNIVERSITY of FLORIDA

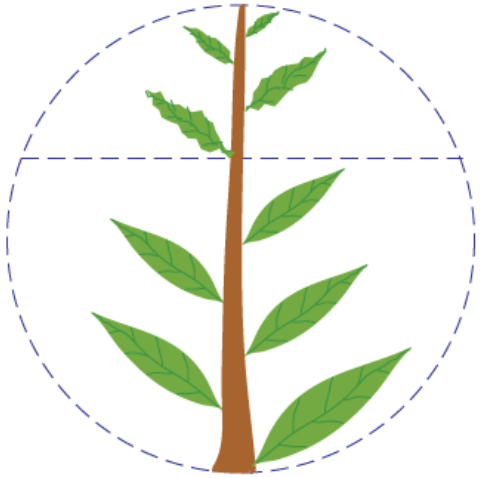
Credit: IPNI Crop Nutrient Deficiency Image Collection

Ca deficiency

Credits: IPNI Crop Nutrient Deficiency Image Collection

UF | UNIVERSITY of FLORIDA

Boron



- Immobile in plant
  - Except peanut
- Pollen grain germination & tube growth, seed & cell wall formation, maturity promotion, sugar translocation
- Mobile in soil
  - In sands, you may need split applications

UF | UNIVERSITY of FLORIDA

Credit: IPNI Crop Nutrient Deficiency Image Collection

B deficiency


Maize


Soybean

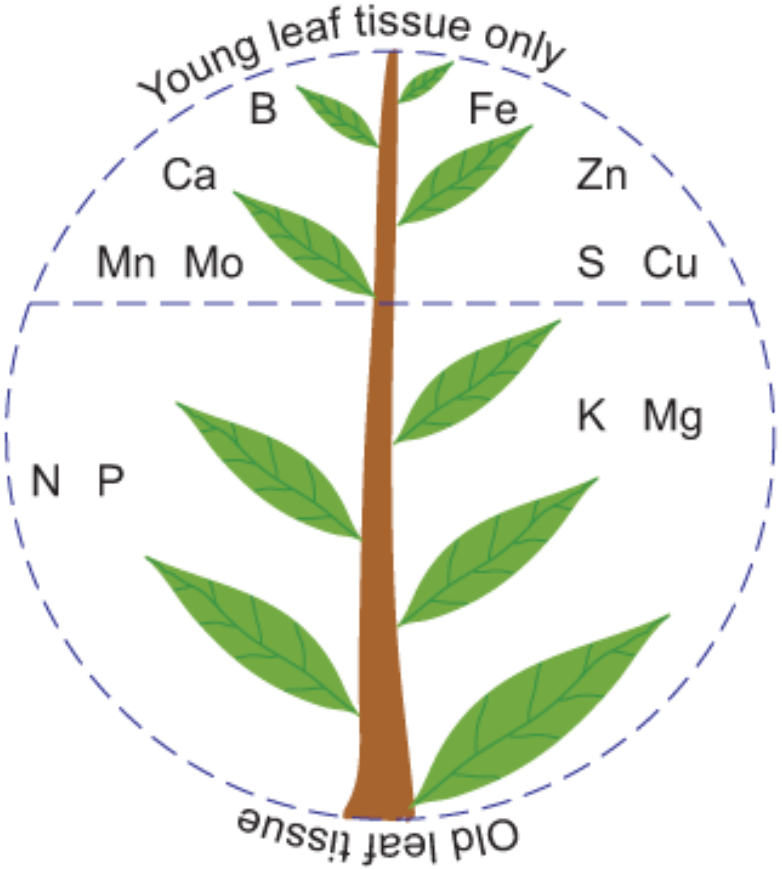

Cauliflower


Peanut

UF | UNIVERSITY of FLORIDA

Credits: IPNI Crop Nutrient Deficiency Image Collection

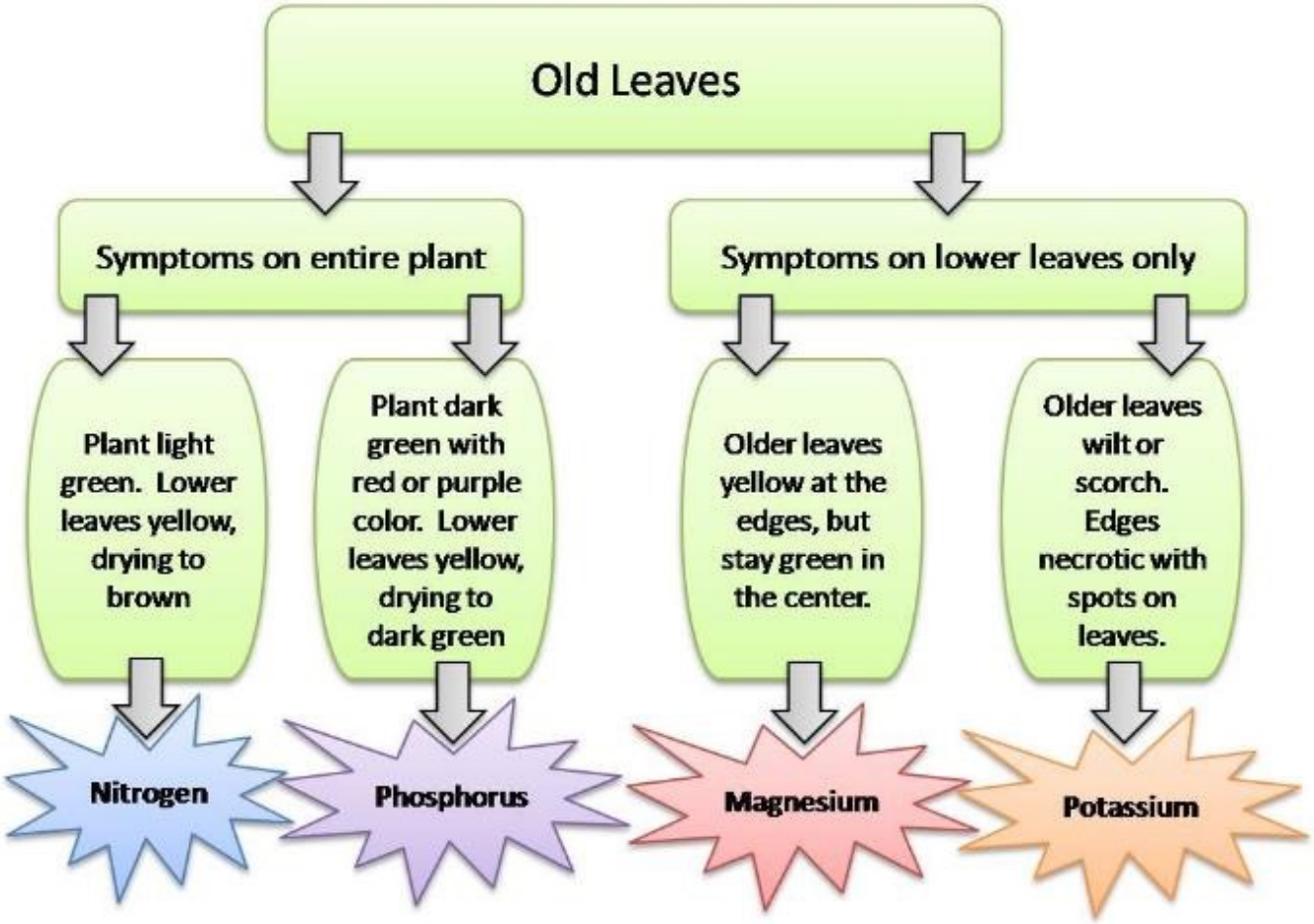
Field diagnosis



UF UNIVERSITY of FLORIDA

Credit: IPNI Crop Nutrient Deficiency Image Collection

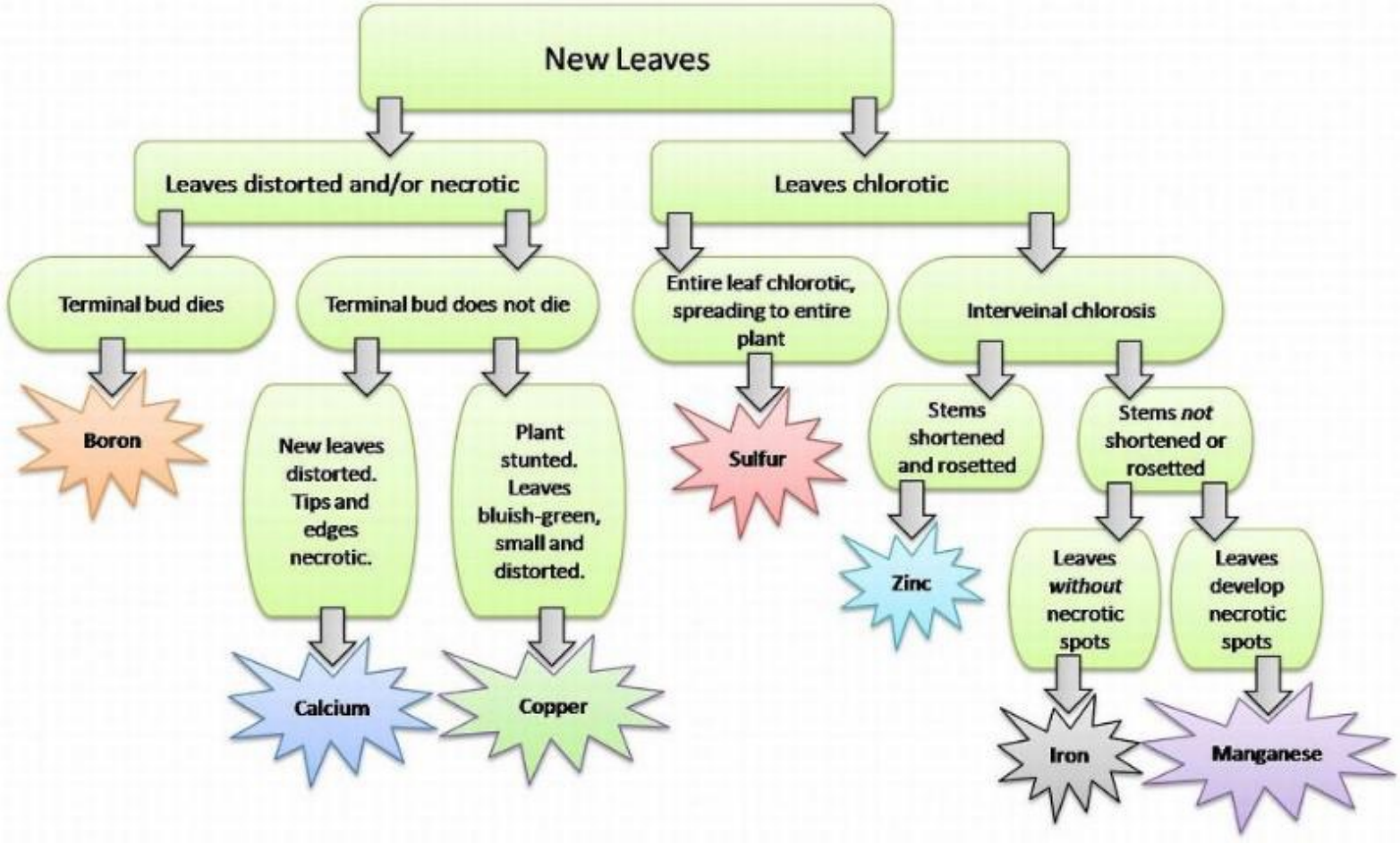
Field diagnosis



UF UNIVERSITY of FLORIDA

Credit: Gene McAvoy

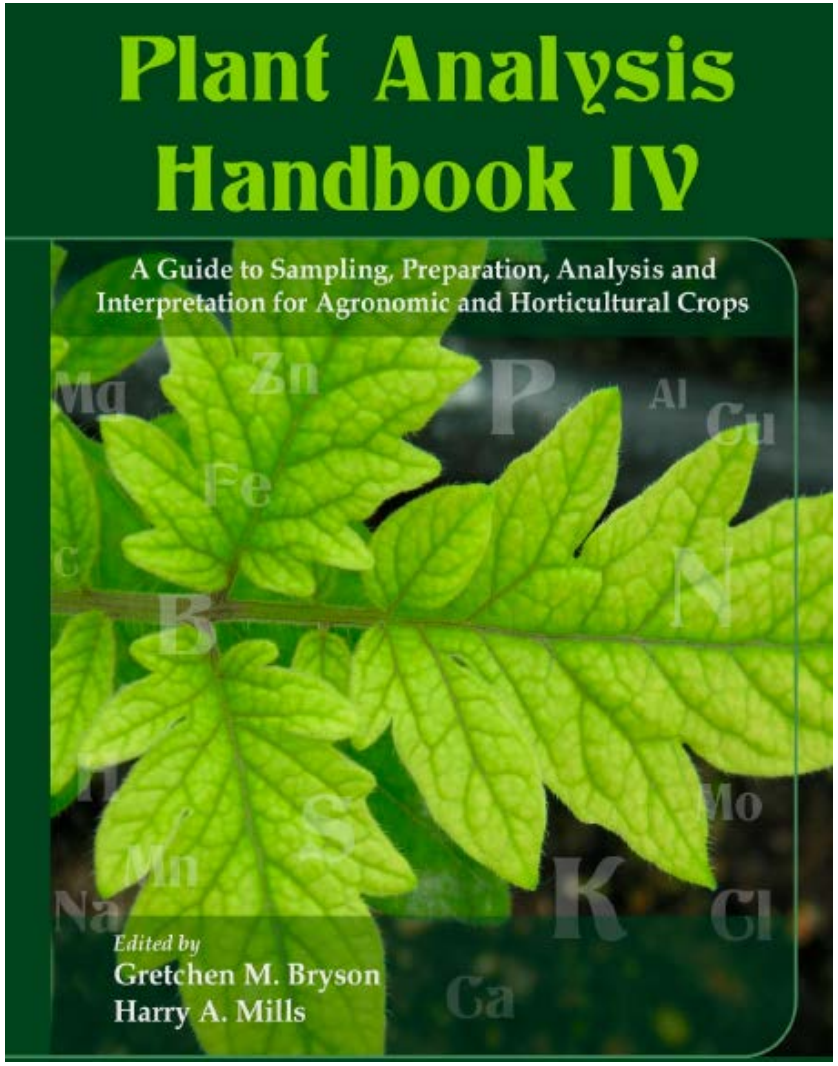
Field diagnosis



UF UNIVERSITY of FLORIDA

Credit: Gene McAvoy

Tissue sampling for nutrient deficiency



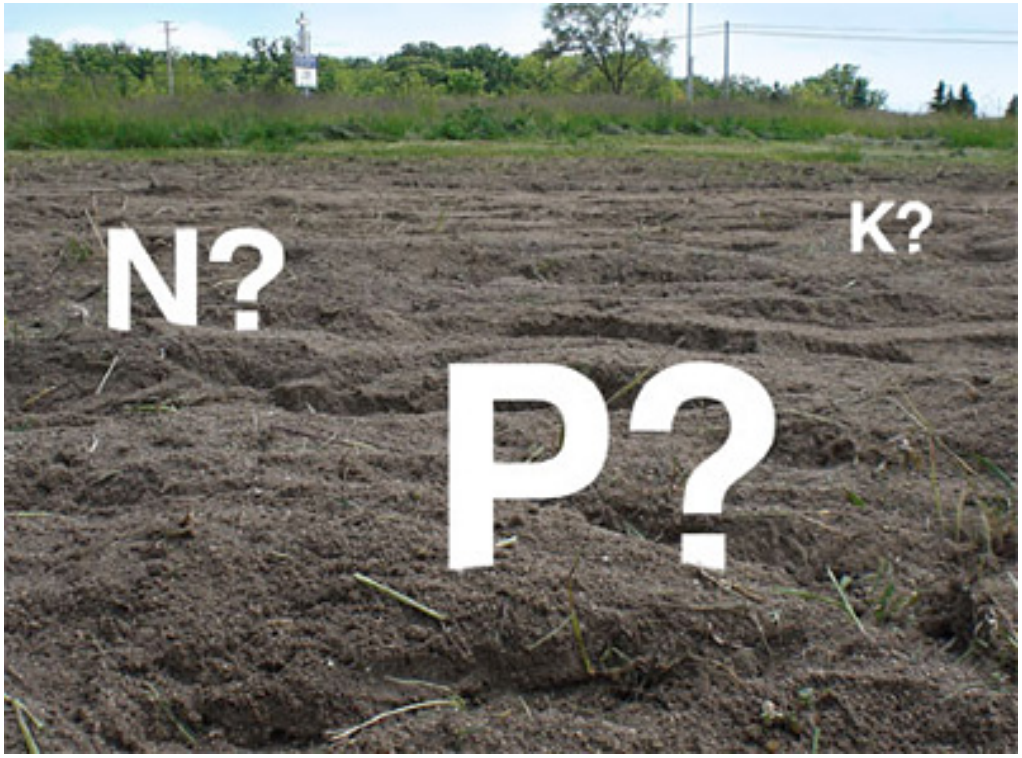
Scientific Name	*Triticum aestivum*
Common Name	**Winter Wheat**
Collected From	Production fields
Plant Part	50 leaves, top two leaves
Season	Just before heading
Data Type	Sufficiency Range
Cultivars Used	

Macronutrients %		Micronutrients ppm	
N	1.75 - 3.00	Fe	10 - 300
P	**0.20 - 0.50**	**Mn**	**16 - 200**
K	1.50 - 3.00	B	1.5 - 4
Ca	**0.20 - 1.00**	**Cu**	**5 - 50**
Mg	0.15 - 1.00	Zn	20 - 70
S	**0.15 - 0.65**	**Mo**	**0.1 - 0.5**

UF | UNIVERSITY of FLORIDA

Bryson, G.M., and H.A. Mills. 2014. Plant Analysis Handbook IV. Micro-Macro Publishing, Athens, GA.

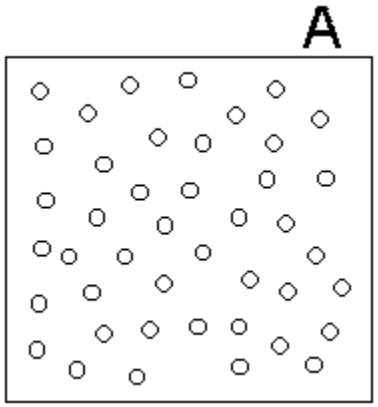
Preventing nutrient deficiency: It's all about the soil!

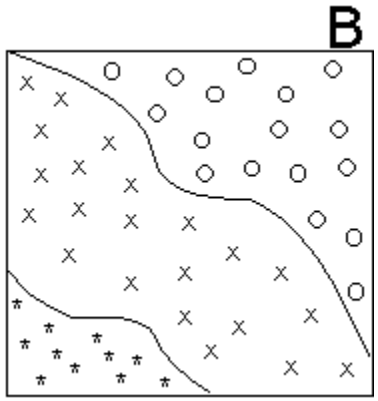


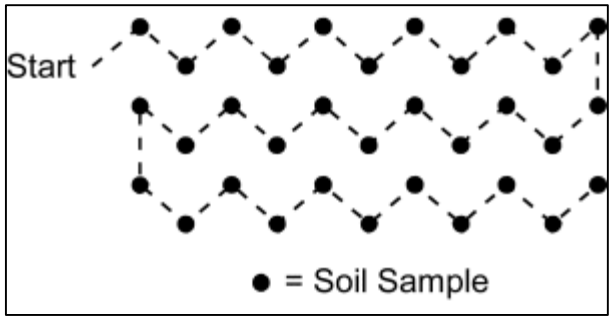
UF | UNIVERSITY of FLORIDA

First line of defense: Soil sampling

- Soil sample within management zones
- Sample in a W pattern
- Sample to rooting depth
- Variable fields need more samples
- Sample in early spring





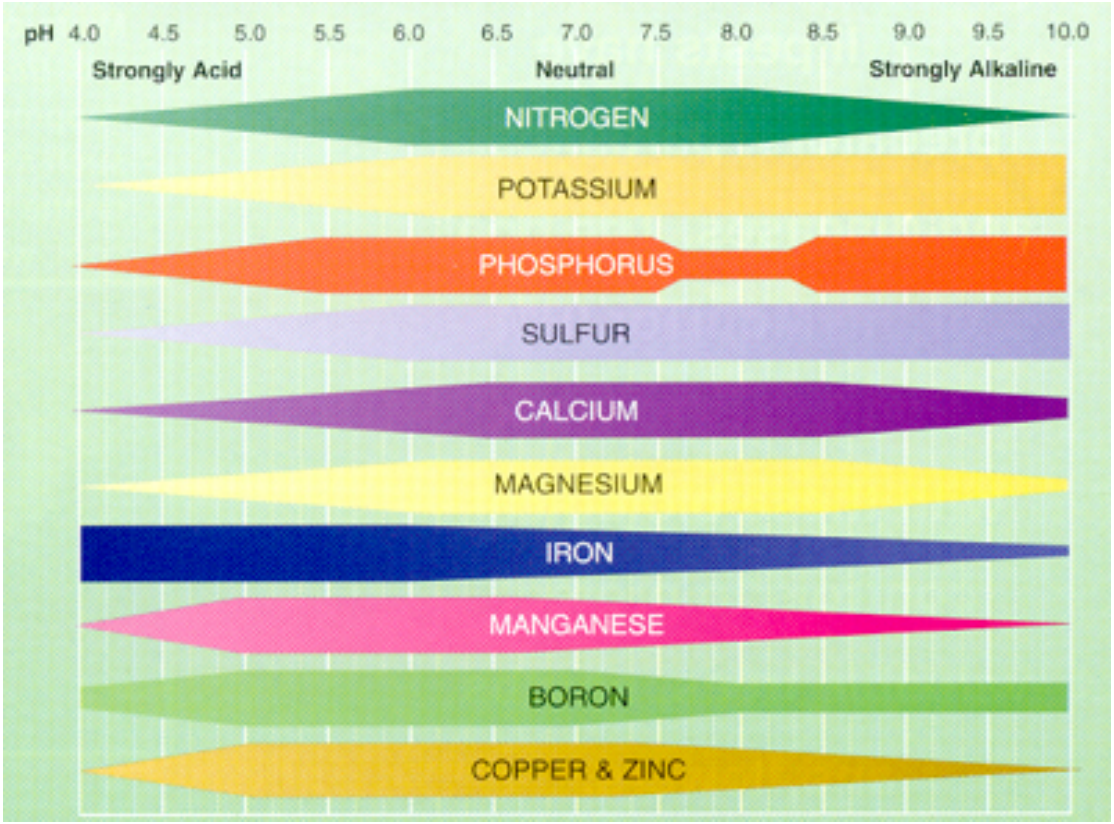


UF | UNIVERSITY of FLORIDA

Soil sampling equipment

UF FLORIDA

The Master Variable: soil pH



UF | UNIVERSITY of FLORIDA

UF | IFAS Extension
UNIVERSITY of FLORIDA

Revised November 2013 SL135

Mailing Address (please print)

Name _____ Date _____

Address _____

_____ FL, Zip _____ Phone _____

Email* _____
*Please provide an email address to receive your results faster.

Signature _____
(signature only required for UF personnel for approval of chartfield charges)

UF/IFAS Analytical Services Laboratories
Extension Soil Testing Laboratory
2390 Mowry Road/PO Box 110740/Wallace Building 631
Gainesville, FL 32611-0740
Email: soilslab@ifas.ufl.edu Website: http://soilslab.ifas.ufl.edu

PRODUCER SOIL TEST FORM

Note: This lab only tests samples from Florida.

Direct any questions about this test or the interpretation of the results to your county UF/IFAS Extension agent.

Fill in all requested information, using one line per sample. Use additional forms for more than 11 samples.

Lab Use Only	Sample ID	County	Estimated Acreage*	Crop Code(s) (see page 2)	Test Code (see page 2)	Cost (see page 2)

*This information is used to compute the total acreage served by the UF/IFAS Soil Testing Program.

Check ○ Money Order ○ Cash ○ Total _____

Please enclose payment and this sheet in the same package as sample(s).
Please make checks and money orders payable to **UNIVERSITY OF FLORIDA.**
Samples will not be processed without payment. Do not send cash through the mail.

Important Information for Soil Sample Collection and Submission

Before Sampling

1. Develop a soil sampling plan of your field. Samples should represent the area being tested, so collect samples from areas of the same soil type, appearance, or cropping history. Sample problem areas separately, if needed. From this plan, count the number of samples you will collect.
2. Soil sample bags, addressed shipping boxes, and test forms are available for free from your county UF/IFAS Extension office. Obtain the materials you need before completing your sampling plan.

Collecting Samples

1. Collect soil from 20 or more spots in each area, mixing these samples in a clean plastic bucket.
2. Sample from soil surface to depth of tillage, usually 0–6 inches. For pastures, sample from 0 to 4 inches depth.
3. Spread the composited material on clean paper or other suitable material to air-dry. Do not send wet samples.
4. Mix the dry soil, and place about 1 pint of soil in a labeled sample bag.

Sending Samples to the Extension Soil Testing Laboratory

1. Enter each sample's ID on its sample bag and in the Sample ID column. List each sample separately.
2. Lime and fertilizer recommendations are provided only if the Crop Code(s) is listed.
3. Include the Test Code for each desired test.
4. Enter costs from the Test Cost list found on page 2 of this form.
5. Add the costs of all samples and tests. Make check or money order payable to **University of Florida**. Checks written to other names will NOT be honored and will be returned, causing a delay in processing the samples.
6. Include the completed Producer Soil Test Form and the check or money order in the shipping box with the sample(s).

Test Results

A soil test report will be emailed/mailed to you in 3–6 days after your sample arrives at the Extension Soil Testing Laboratory. Contact your county UF/IFAS Extension office if you have questions about the soil test report.

UF | UNIVERSITY FLORIDA

Crop and Test Codes for Producer Soil Test Form

Standard fertilizer and lime recommendations based on the soil test results will be supplied with the test results if you indicate a Crop Code. Please write the appropriate Crop Codes on page 1 of this form. If your cropping situation is not in the list of codes below, routine soil tests may not be appropriate. In such instances, consult your local county UF/IFAS Extension agent before sending soil samples for testing.

Use special forms for requesting other tests, including the Landscape and Vegetable Garden Soil Test (SL136), the Container Media Test (SL134), or the Pine Nursery Soil Test (SL132).

AGRONOMIC CROPS

Please use the Landscape and Vegetable Garden Test Form (SL136) for home gardens. Codes for particular vegetables will result in fertilizer recommendations for commercial vegetable production that are not appropriate for home vegetable gardens.

Crop Code	Field Crops
2	Corn, non-irrigated
5	Corn, irrigated
9	Cotton
7	Grain sorghum
8	Oats for grain
10	Peanuts
8	Rye for grain
11	Soybeans
13	Sugarcane for syrup
12	Tobacco (flue cured)
27	Wheat for grain

Crop Code	Pasture and Forage Crops
23	Alfalfa
26	Cool-season annual grasses (small grains and ryegrass)
22	Cool-season legumes or legume-grass mixtures (lupines, sweetclover, vetches, and all true clovers, white, red, arrowleaf, crimson, subterranean)
32	Hay or silage (perennial grass)
25	Improved perennial grasses other than bahiagrass (bermuda, digit, star)
33	Limpograss (Hemarthria)
28	Perennial peanuts
14	Summer forages (e.g., millet or sorghum)
21	Warm-season legumes or legume-grass mixtures (aeschynomene, alyceclover, desmodium, hairy indigo, and other tropical legumes)

FRUIT CROPS

Except for pH and lime requirement, and in some cases P, soil tests are not used as a basis for fertilization of perennial fruit and nut crops in Florida. Program fertilization is practiced, and plant tissue testing is helpful in certain crops. Tissue testing is available from commercial labs. Consult with your county UF/IFAS Extension agent about interpretation before taking samples.

Crop Code	Crop Description
67	Blueberry (bearing)

VEGETABLE CROPS

Please use the Landscape and Vegetable Garden Test Form (SL136) for home gardens. Codes for particular vegetables will result in fertilizer recommendations for commercial vegetable production that are not appropriate for home vegetable gardens.

Crop Code	Crop Description	Crop Code	Crop Description
217	Bean, lima, pole, or snap	227	Okra
228	Beet	223	Onion, bulb
212	Broccoli	229	Onion, bunching
212	Brussels sprouts	204	Parsley
207	Cabbage, head or Chinese	216	Pea, English, snow or southern
226	Carrot	201	Pepper, bell or specialty
212	Cauliflower	215	Potato, Irish
214	Celery	218	Potato, sweet
207	Collard	230	Pumpkin squash
220	Corn, sweet	219	Radish
211	Cucumber	210	Spinach
203	Eggplant	230	Squash, summer or winter
225	Kale	224	Strawberry
229	Leek	200	Tomato, cherry or slicing
209	Lettuce, crisphead endive, escarole, or romaine	225	Turnip
205	Muskmelon	221	Watermelon
225	Mustard		

ORNAMENTAL HORTICULTURE

Do not use this form for potting media used in containers. Use the Container Media Test Form (SL134). For fertilization of plants in the landscape, use the Landscape and Vegetable Garden Test Form (SL136).

Crop Code	Crop Description
601	Commercial nursery growing azaleas, camellias, gardenias, hibiscus, or ixora in the ground
600	Commercial woody ornamental nursery growing plants other than azaleas, camellias, gardenias, hibiscus, or ixora in the ground
71	Athletic field, golf green, tee, or fairway

Test Code	Test Name	Determinations Made	Test Cost
1	Standard Soil Fertility Test	pH, lime requirement, P, K, Ca, and Mg	$7
2*	Soil pH and Lime Requirement	pH and lime requirement	$3
3	Soil Micronutrients	Cu, Mn, Zn, and pH	$5
4	Organic Matter	percent organic matter	$10
5	Electrical Conductivity (soluble salts)	conductivity in 1:2 soil:water	$2
	Other	Additional Tests	Inquire

* Included in standard soil fertility test. Do not request both codes 1 and 2 for the same soil sample.

UF | UNIVERSITY FLORIDA

Waters Agricultural Labs, Inc.
257 Newton Highway
P.O. Box 382
Camilla, GA 31730-0382
(229) 336-7216
Fax (229) 336-7967

Feed Sample Information Sheet

Charge To: MICHAEL MULVANEY UNIV. OF FLORIDA - WFREC 5988 HWY 90, BLDG 4900 MILTON, FL 32583	Grower: MICHAEL MULVANEY UFL - WFREC 4253 EXPERIMENT RD, HWY 182 JAY, FL 32565

Date Submitted:	Total No. of Samples:	Phone #: 850-382-5221	Fax #:

LAB NUMBER	SAMPLE NUMBER	SAMPLE DESCRIPTION	FEED TEST REQUESTED								INDIVIDUAL				OTHER
			1	2	3	4	5	6	7	8	NITRATE NO_3	CALCIUM	PHOSPHORUS	AFLATOXIN	

Explanation of Test:

FEED TEST 1: Moisture And Crude Protein
FEED TEST 2: Feed Test 1 **Plus** Calcium and Phosphorus
FEED TEST 3: Moisture, Crude Protein, Crude Fat, and Crude Fiber
FEED TEST 4: Feed Test 3 **Plus** Calcium and Phosphorus
FEED TEST 5: Moisture, Crude Protein, Crude Fiber, and Total Digestible Nutrients
FEED TEST 6: Feed Test 5 **Plus** Calcium and Phosphorus
FEED TEST 7: Moisture, Crude Protein, Digestible Protein, Crude Fat, Crude Fiber, Nitrogen Free Extract, Total Digestible Nutrients, and Ash
FEED TEST 8: Same as Feed Test 7 **Plus** Calcium and Phosphorus

REMARKS:

UF UNIVERSITY of FLORIDA

Soil test reports

UF UNIVERSITY of FLORIDA IFAS

UF/IFAS Analytical Services Laboratories
Extension Soil Testing Laboratory
Wallace Building 631 PO Box 110740 Gainesville, FL 32611-0740
Email: arl@mail.ifas.ufl.edu Web: soilslab.ifas.ufl.edu Phone #:352-392-1950

Producer Soil Test Report

For further information contact:

Atkins, John (Michael Donahoe-cotton)
Santa Rosa County Coop Extn Service
6263 Dogwood Dr
Milton FL, 32570-3500
Tel: 850-623-3868
Email: srcextag@ufl.edu

To:
WFREC-Jay/Mulvaney, Michael
4253 Experiment Rd Hwy 182
Jay FL, 32565

Client Identification: 1 Set Number: E40558 Lab Number: E102222
Report Date: 20-Jan-17

Crop: Corn, irrigated

SOIL TEST RESULTS AND THEIR INTERPRETATIONS

Target pH: 6.5	*This is the pH at which the above crop will grow at its optimum*
pH (1:2 Sample:Water) 5.9	*This is the pH of your sample in the water medium*
A-E Buffer Value: 7.63	*Buffer pH is the pH of your soil in Adams-Evans Buffer(A-E Buffer). This is done to determine the lime requirement, which will help increase the soil pH to the target pH level desired by the crop.*

Mehlich-3 Extractable		LOW	MED	HIGH
Phosphorus (mg/Kg or ppm P)	94			
Potassium (mg/Kg or ppm K)	50			
Magnesium (mg/Kg or ppm Mg)	30			
Calcium (mg/Kg or ppm Ca)	195			

UF UNIVERSI FLORI

Soil test reports: Extractants, commercial vs. public labs

	P	K	Mg	Ca	soil pH	buffer pH	S	B	Zn	Mn	Fe	Cu	OM	ENR	CEC	Base saturation (%)			
Lab & Extr.	lbs/ac	lbs/ac	lbs/ac	lbs/ac			lbs/ac	lbs/ac	lbs/ac	lbs/ac	lbs/ac	lbs/ac	%	lbs/ac	meq/100g	K	Mg	Ca	H
Waters (M1)	117	91	68	453	5.7	7.7	22	0.3	5.9	15	25	2.3	0.82	16	3.9	3	7.2	28.8	61
UGA (M1)	117	96	58	359	5.5	-	-	-	6	14	-	-	-	-	-	-	-	-	-
Waypoint (M3)	424	94	72	444	6.2	7.91	18	0.4	10	80	2016	4.4	1.6	76	1.8	6.7	16.7	61.7	11.1
UFL (M3)	188	100	60	390	5.9	7.63	-	-	-	-	-	-	1.09	-	-	-	-	-	-

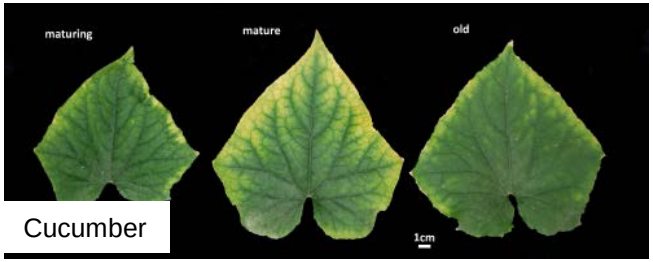
UF | UNIVERSITY of FLORIDA

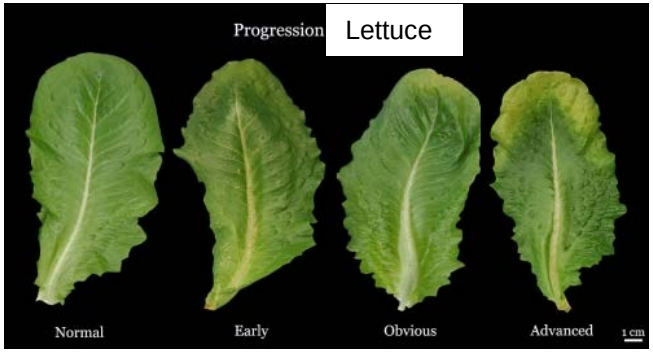
Soil test ecommendations: commercial vs. public labs

Lab & Extr.	Crop rec.	Lime tons/ac	Gyspum tons/ac	N lbs/ac	P lbs/ac	K lbs/ac	Mg lbs/ac	S lbs/ac	B lbs/ac	Zn lbs/ac	Mn lbs/ac	Cu lbs/ac
Waters (M1)	Corn (200 bu/ac)	1.0	-	280	60	230	35	23	1	5	10	-
Waypoint (M3)	Corn (200 bu/ac)	0.5	-	183	0	125	17	11	1.5	0	2	0
UGA (M1)	Corn (200 bu/ac)	1.25	-	240	0	140	-	10	0	0	0	-
UFL (M3)	Corn (200 bu/ac)	0.8	-	210	0	70	20	15-20	-	-	-	-
Waters (M1)	Cotton (2 bales/ac)	1	-	90	40	120	25	18	0.7	-	10	-
Waypoint (M3)	Cotton (2 bales/ac)	0.5	-	100	0	104	17	11	1.5	0	2	0
UGA (M1)	Cotton (2 bales/ac)	0.5	-	60	0	60	-	10	0.5	0	0	-
UFL (M3)	Cotton (2 bales/ac)	0.5	-	60	0	70	20	-	-	-	-	-
Waters (M1)	Peanut (2 tons/ac)	1	0.5	20	40	80	15	8	0.7	-	5	-
Waypoint (M3)	Peanut (2 tons/ac)	0.5	0.5	0	0	97	17	16	1	0	0	0
UGA (M1)	Peanut (2 tons/ac)	0.5-1.25	-	0	0	0	-	0	0.5	-	0	-
UFL (M3)	Peanut (2 tons/ac)	0	0.4	0	0	40	20	-	0.5	-	-	-

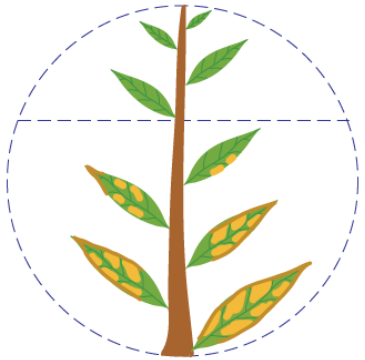
Commercial labs tend to have higher recommendations than public labs

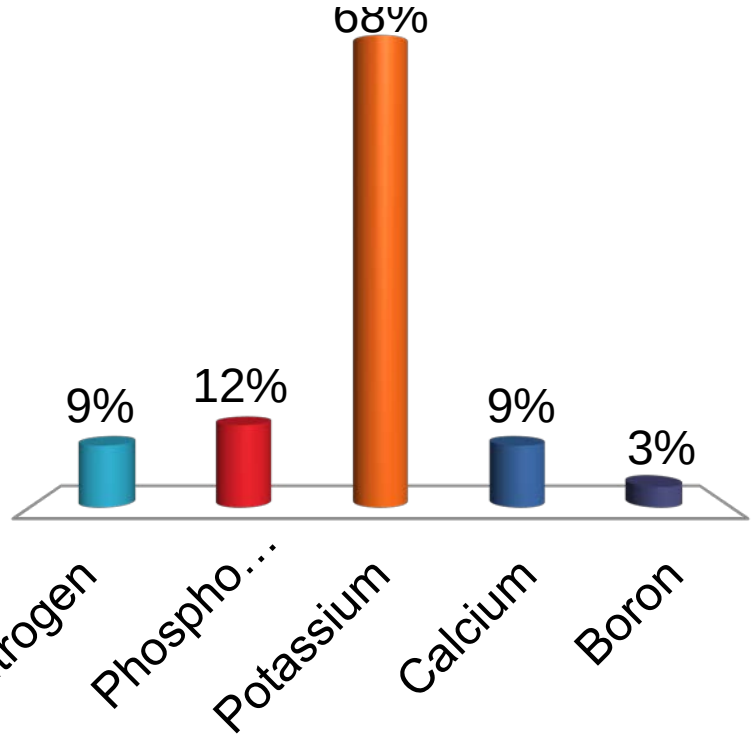
What nutrient deficiency is this?





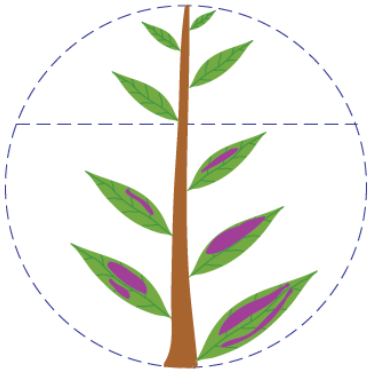
A. Nitrogen
B. Phosphorus
C. Potassium
D. Calcium
E. Boron

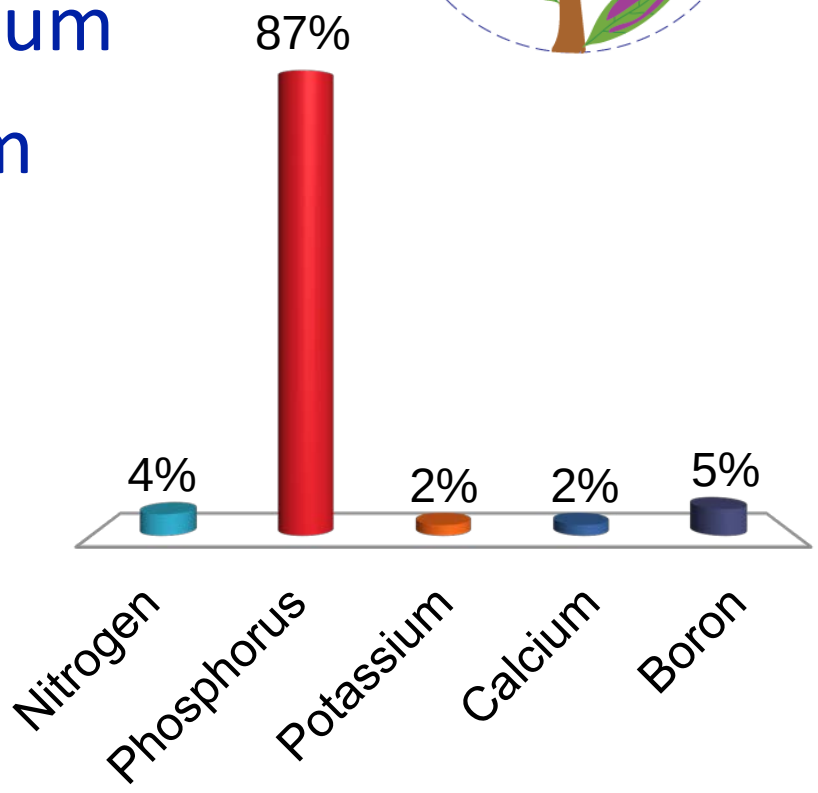




What nutrient deficiency is this?

A. Nitrogen
B. Phosphorus
C. Potassium
D. Calcium
E. Boron





Questions?

@TheDirtDude

www.GatorDirt.com

UF | UNIVERSITY of FLORIDA