Plant Nutrients: N, P, K

Plate I.—Nitrogen-deficiency symptoms in apple twig. Note the relatively small, yellowish-green leaves and the reddish leaf stalks, which form narrow angles with the stem.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Martha E. Rosemeyer

Ecological Agriculture
February 17, 2006

Outline

- Introduction
- N review and deficiency symptoms
- P and deficiency symptoms
- K and deficiency symptoms
- Self test on nutrient deficiency recognition
- Study Questions

Carbon, Hydrogen, Oxygen

- "Carbon-containing" is the meaning of "organic" in chemistry
- Provided by photosynthesis
- Used for structure and energy of cell--glucose $C_6H_{12}O_6$ and cellulose
- Backbone of enzymes (proteins), lipids
- 95% of matter of plant is C H O
- 5% are "nutrients" from soil

Macronutrients

	anion		cation
Nitrogen (N)	NO_3^-	or	NH_4^+
Phosphorus (P)	HPO_4^{--} , $H_2PO_4^-$		
Potassium (K)			K^+
Calcium (Ca)			Ca^{++}
Magnesium (Mg)			Mg^{++}
Sulfur (S)	SO_4^{--}		

Do all plants use the same amount of nutrients?

- Variability in amount of nutrient needed
- Variability in ability to take up nutrients under low availability condition
- Choice of plant or breeding can help plant adapt to the site, as opposed to the other way around

How nutrients become available to plants

Mineral Particles Organic matter (OM)

Not Available

\- -

Available

1) Solubilization of minerals (weathering and acid secretion)
2) Mineralization of OM by soil biota

Nitrogen

- Important in **vegetative growth (leaves)**
- Can take up as cation on anion (more leachable)
- Often deficient in temperate zone
- Plants need in rel. large amounts: 1-2%
- Legumes can fix N
- Used in every amino acid and protein
- Deficiency can affect nearly every enzymatic reaction
- Required in chlorophyll, necessary for photosynthesis

Symptoms of N deficiency

- Yellowing of leaves
- Reduced quantity of flowering and fruit set
- Symptoms in corn on oldest leaves because mobile within the plant
- Symptoms in bean oldest leaves before nodulation begins

Nitrogen deficiency in corn

Courtesy of North Carolina Agricultural Experiment Station and U. S. Department of Agriculture

Plate 2.—Nitrogen made the difference! Nitrogen at the rate of 180 pounds per acre was applied to the corn on the left. The corn on the right received no added nitrogen. The yields were 110.3 and 24.4 bushels per acre, respectively.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

N deficiency in corn: 1) new or old leaves? 2) symptoms on leaf? 3) field pattern

Courtesy of North Carolina Agricultural Experiment Station, U. S. Department of Agriculture and American Potash Institute

Plate 1.—Left, severe nitrogen deficiency. Note yellowing begins at tip of lower leaves and proceeds up the midrib, giving a V-shaped pattern. Center, symptoms of extreme drought. As distinguished from nitrogen deficiency, drought affects upper as well as lower leaves. Severe potassium deficiency shows up in the plant on the right as a marginal scorch.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Nitrogen deficiency of bean before nitrogen fixation begins

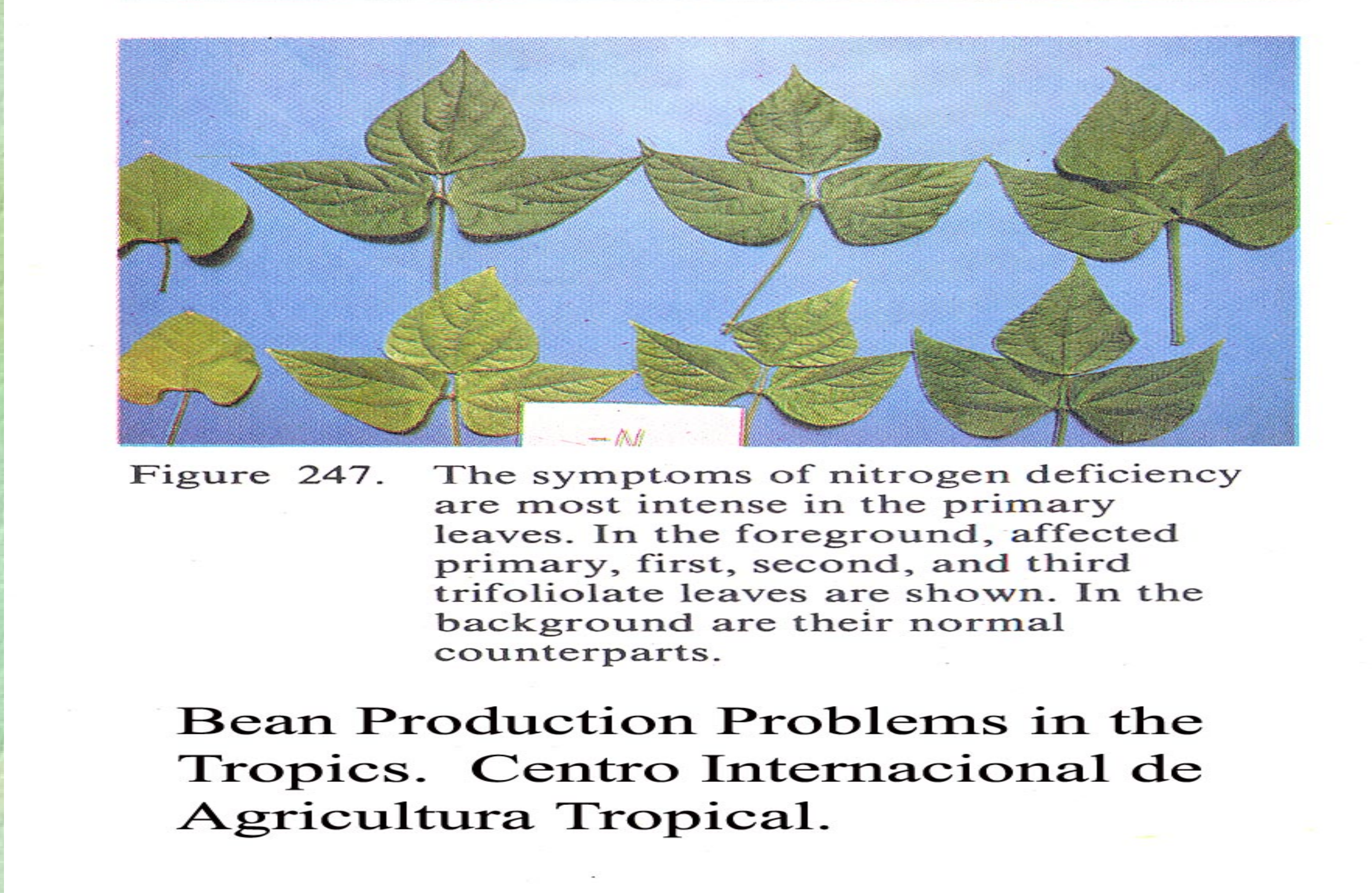


Figure 247. The symptoms of nitrogen deficiency are most intense in the primary leaves. In the foreground, affected primary, first, second, and third trifoliolate leaves are shown. In the background are their normal counterparts.

Bean Production Problems in the Tropics. Centro Internacional de Agricultura Tropical.

Nitrogen fixing nodules of bean
Active about 2 weeks after germination

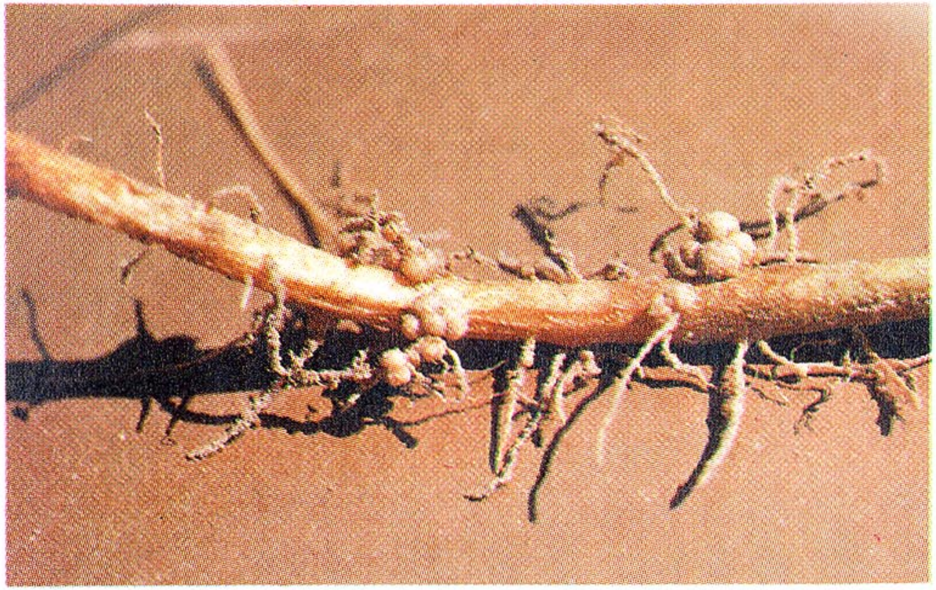


Figure 245. *Rhizobium* nodules on bean root.

Bean Production Problems in the Tropics. Centro Internacional de Agricultura Tropical.

N deficiency in Apples

- Small yellowish leaves
- Reddish twigs

Plate 1.—Nitrogen-deficiency symptoms in apple twig. Note the relatively small, yellowish-green leaves and the reddish leaf stalks, which form narrow angles with the stem.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

N def in pine, corn

- Text Plate 50, 58

PLATE 58 Nitrogen deficiency on a pine tree. The yellowing (chlorosis) occurs mainly on the older needles.

PLATE 50 Nitrogen-deficient corn on Udolls in central Illinois. Ponded water after heavy rains resulted in nitrogen loss by denitrification and leaching.

Phosphorus

- Note spelling– the element is not “ous” (adjective)
- Taken up as an inorganic anions HPO_4^{-2}, $H_2PO_4^-$ and to a lesser extent organic P
- Plants accumulate 0.2-0.4% (ave 0.25%) in dry wt
- Essential nutrient for plants and animals
- Part of nucleic acids which make proteins (enzymes), ATP (energy stored in bonds), cell membranes, uptake of CO_2

- **Root and fruit** are affected by deficiencies
  - affects photosynthesis, respiration, nitrogen fixation
  - flowering and seed production
  - maturation
  - encourages lateral roots
- Symptoms in grasses- purplish leaves and stems; of beans- small, dark green upper leaves plus early defoliation;
- Generally stunted, dark green to purple, if severe symptom is yellowing

P deficiency in corn

Plate 4.—Phosphorus hunger causes purpling of the leaves of many strains of corn.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Phosphorus deficiency of bean

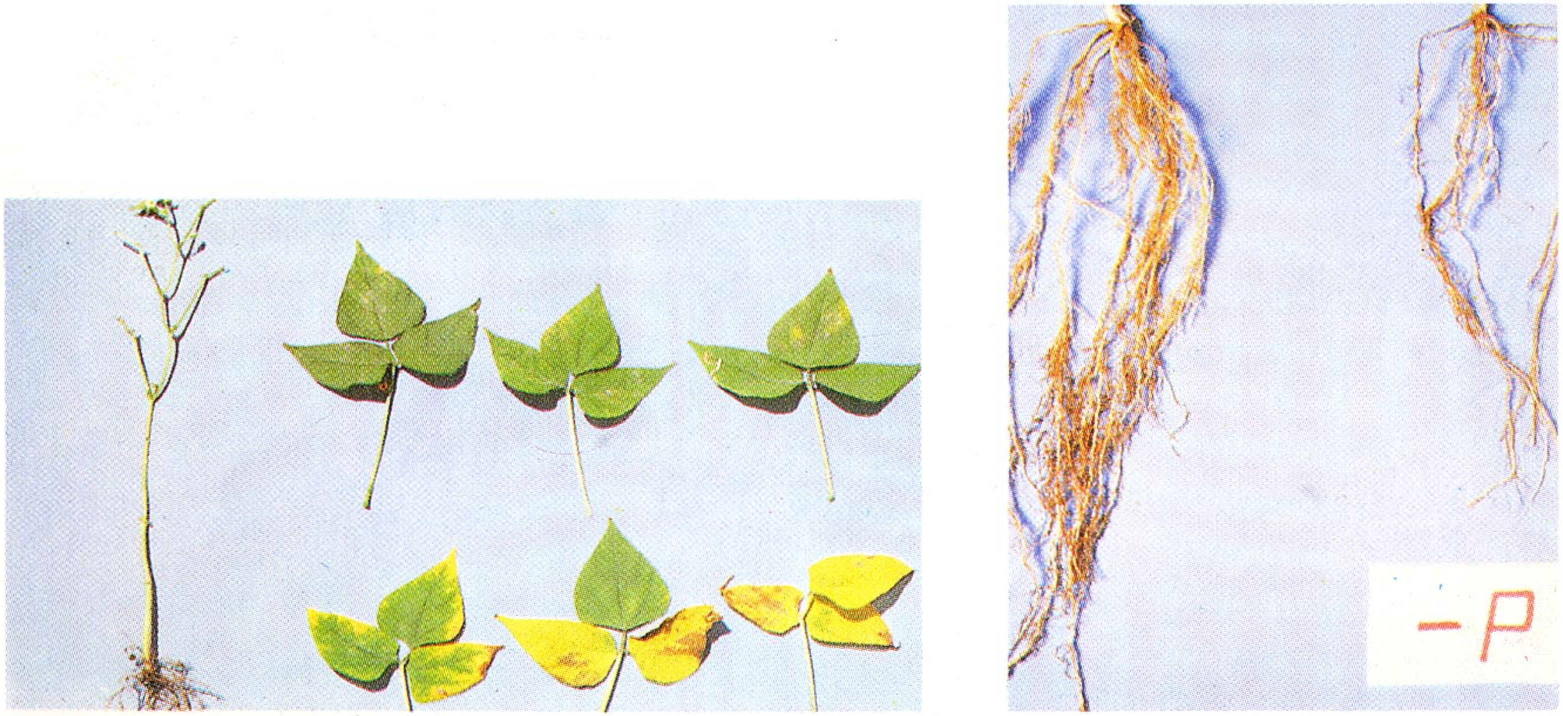


Figure 240. Symptom complex of phosphorus deficiency. In photo at right, roots on left are normal.

Bean Production Problems in the Tropics. Centro Internacional de Agricultura Tropical.

P deficiency symptoms in apples

- Leaves abnormally small and dark green
- Twigs purplish

Plate 2.—Symptoms of phosphorus deficiency in a growing tip of the apple. Leaves are abnormally small and dark green, with conspicuous purple pigmentation. Twig is slender and abnormally purplish.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

P symptoms in tomato and corn

- Brady and Weil Plate 47, 52

PLATE 47 Phosphorus deficiency causes severe stunting and purpling of older leaves of this tomato.

PLATE 52 Normal *(left)* and phosphorus-deficient *(right)* corn plants. Note stunting and purple color.

The P Problem

1) <u>Total</u> P in soil is low -- lower than N and K

2) <u>Available</u> P is very low, because insoluble

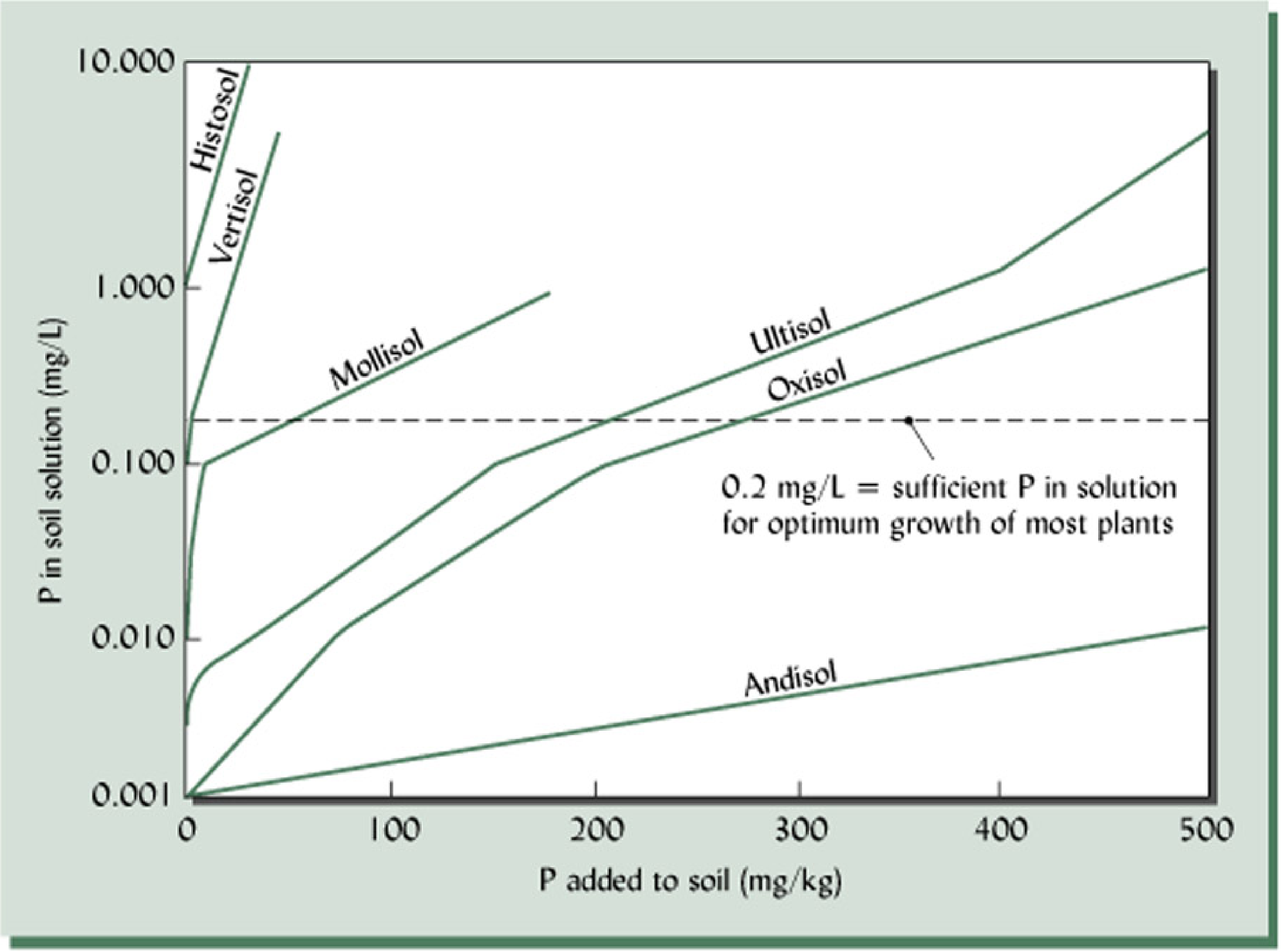
3) When P added most is “fixed” into unavailable forms (10-15% available that yr)

- Too ***low*** in P-fixing soils, especially in developing world, also where soil P has been “mined” where soils were less rich to begin with
- Too ***high*** in industrialized countries where P has been applied

Too little P-- a common problem in the Tropics

- Commonly deficient in native soils of the Tropics (for different reasons):
- volcanic (Andisols), due to high anion exchange capacity and
- highly weathered soils (Ultisols and Oxisols), due to Fe and Al oxide clays

Figure 14.20



When P added to soil little available in Andisol, Ultisol, Oxisol

Low available P soils
(23% of wet Tropics)

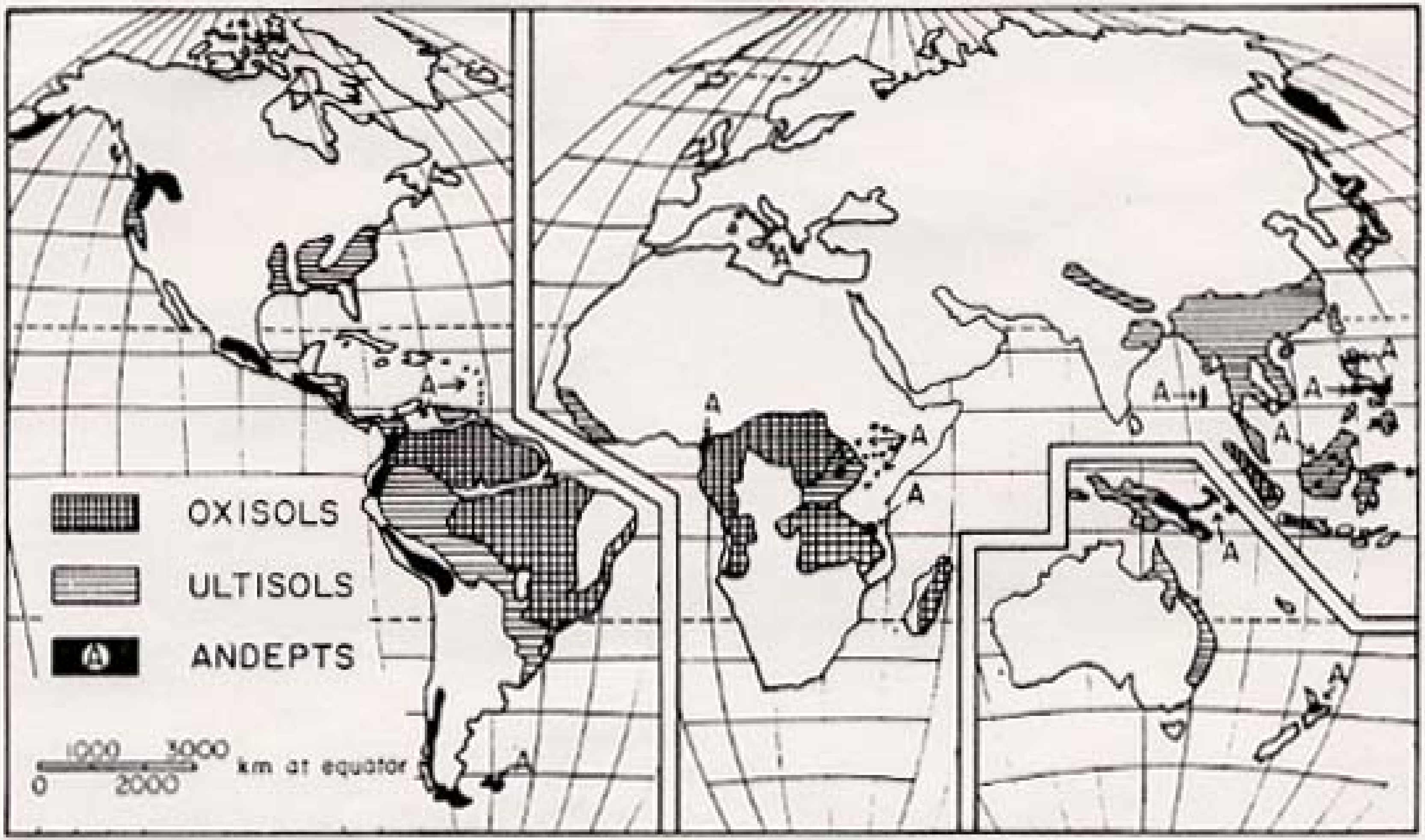
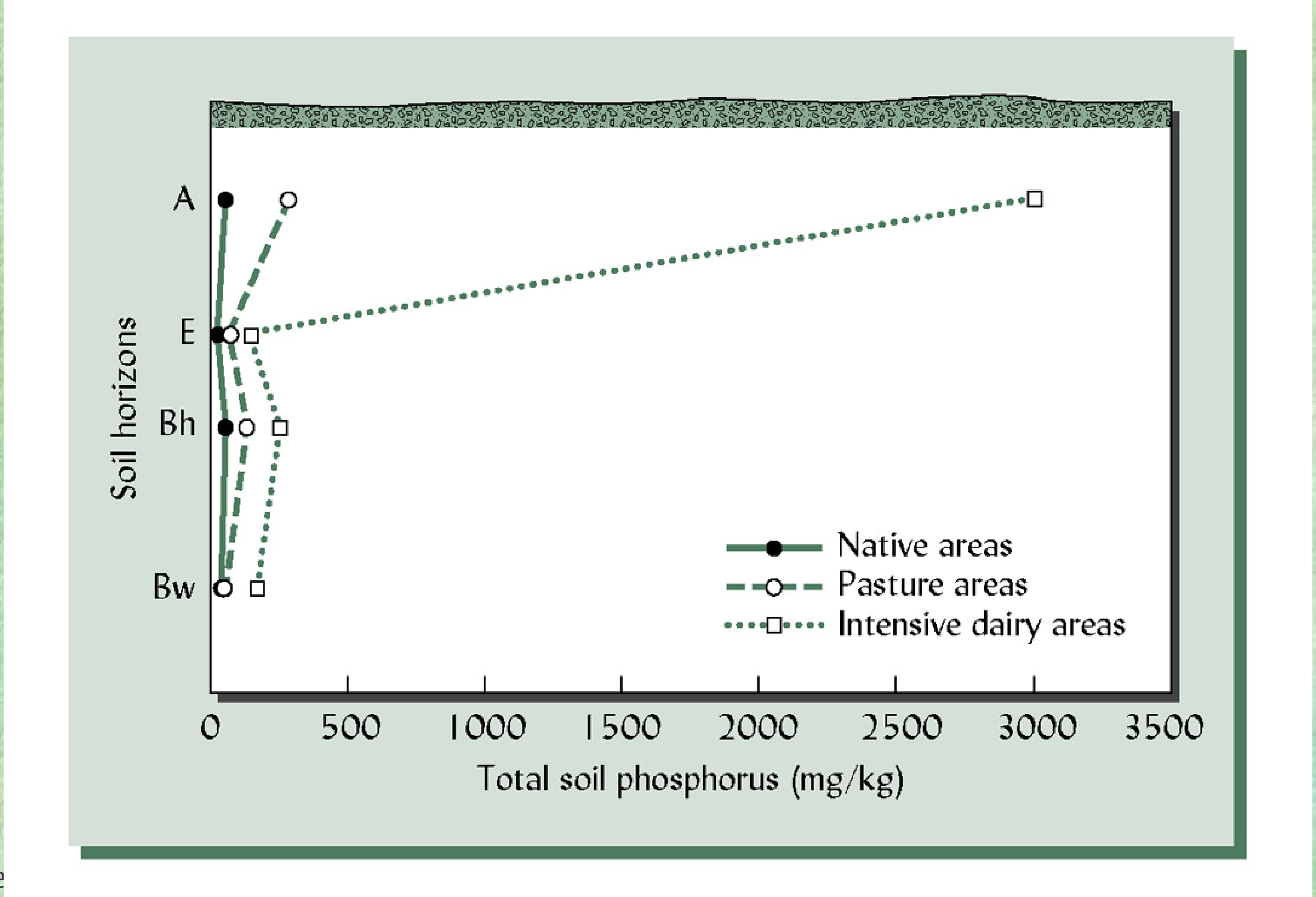


Fig. 1—Geographical distribution of Oxisols, Ultisols and Andepts in the world.

Too much:Industrialized countries increase in soil P

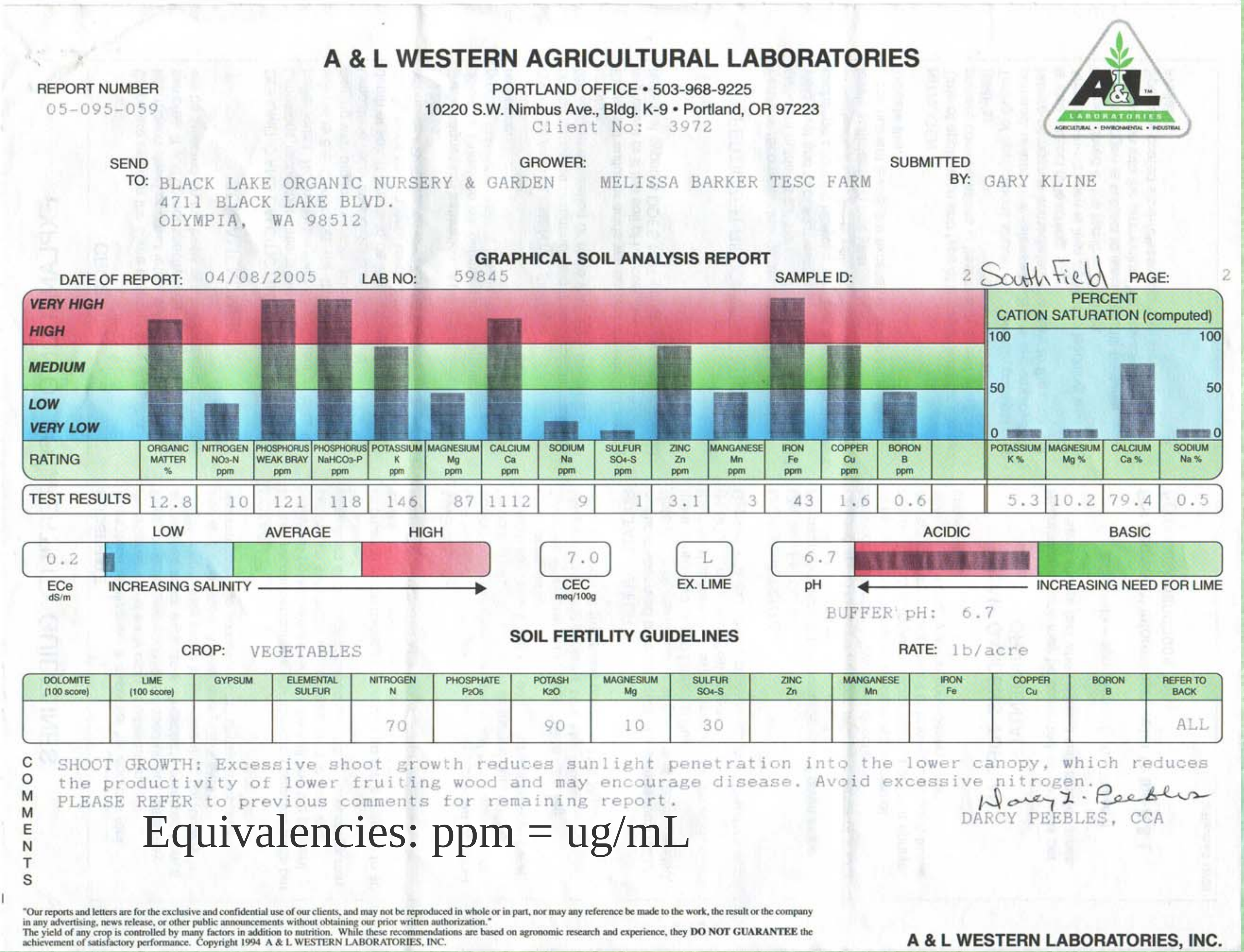
- Apply two to three times amount of element taken up by plant is applied because of natural fixation, even in soils that fix lower levels of P
- Add manure to level to correct N and have 2-4x more P than need
- Confined animal feeding operations (CAFOs)
  - wastes from 10,000 beef cattle = 100,000 people
- Buildup of P in soil

High P in intensive animal operations



Figure

Where is the organic farm with respect to available P (2005 data)?



A & L WESTERN AGRICULTURAL LABORATORIES

PORTLAND OFFICE • 503-968-9225
10220 S.W. Nimbus Ave., Bldg. K-9 • Portland, OR 97223
Client No: 3972

REPORT NUMBER
05-095-059

SEND TO: BLACK LAKE ORGANIC NURSERY & GARDEN
4711 BLACK LAKE BLVD.
OLYMPIA, WA 98512

GROWER: MELISSA BARKER TESC FARM

SUBMITTED BY: GARY KLINE

GRAPHICAL SOIL ANALYSIS REPORT

DATE OF REPORT: 04/08/2005
LAB NO: 59845
SAMPLE ID: 2 South Field
PAGE: 2

RATING	ORGANIC MATTER %	NITROGEN NO3-N ppm	PHOSPHORUS WEAK BRAY ppm	PHOSPHORUS NaHCO3-P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SULFUR SO4-S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		POTASSIUM K %	MAGNESIUM Mg %	CALCIUM Ca %	SODIUM Na %
TEST RESULTS	12.8	10	121	118	146	87	1112	9	1	3.1	3	43	1.6	0.6		5.3	10.2	79.4	0.5

LOW AVERAGE HIGH
ECe dS/m: 0.2
INCREASING SALINITY →

CEC meq/100g: 7.0

EX. LIME: L

ACIDIC BASIC
pH: 6.7
← INCREASING NEED FOR LIME

BUFFER pH: 6.7

SOIL FERTILITY GUIDELINES

CROP: VEGETABLES
RATE: lb/acre

DOLOMITE (100 score)	LIME (100 score)	GYPSUM	ELEMENTAL SULFUR	NITROGEN N	PHOSPHATE P_2O_5	POTASH K_2O	MAGNESIUM Mg	SULFUR SO_4-S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B	REFER TO BACK
				70		90	10	30						ALL

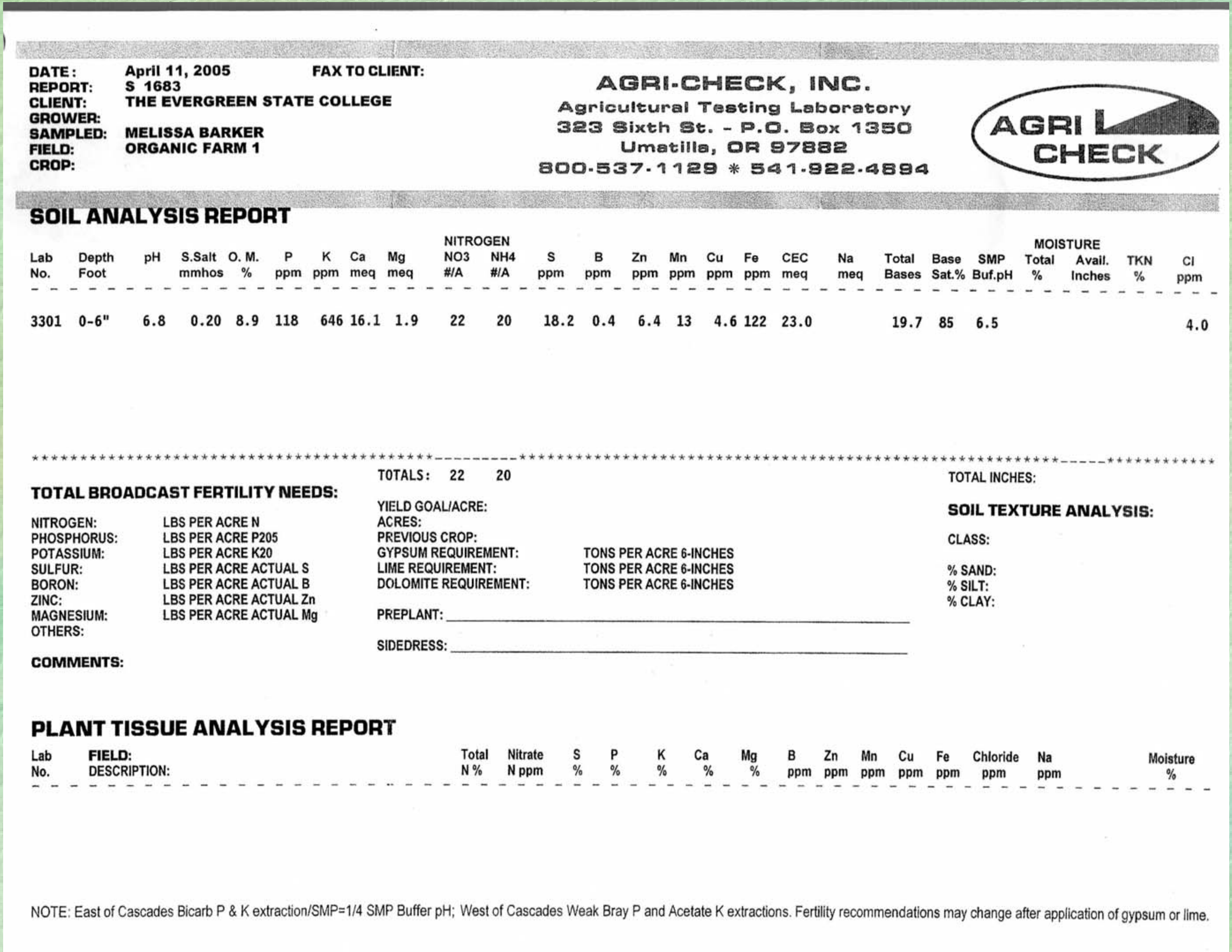
COMMENTS

SHOOT GROWTH: Excessive shoot growth reduces sunlight penetration into the lower canopy, which reduces the productivity of lower fruiting wood and may encourage disease. Avoid excessive nitrogen.
PLEASE REFER to previous comments for remaining report.

Darcy L. Peebles
DARCY PEEBLES, CCA

Equivalencies: ppm = ug/mL

A & L WESTERN LABORATORIES, INC.



DATE: April 11, 2005
REPORT: S 1683
CLIENT: THE EVERGREEN STATE COLLEGE
GROWER:
SAMPLED: MELISSA BARKER
FIELD: ORGANIC FARM 1
CROP:

FAX TO CLIENT:

AGRI-CHECK, INC.
Agricultural Testing Laboratory
323 Sixth St. - P.O. Box 1350
Umatilla, OR 97882
800-537-1129 * 541-922-4894

SOIL ANALYSIS REPORT

Lab No.	Depth Foot	pH	S.Salt mmhos	O. M. %	P ppm	K ppm	Ca meq	Mg meq	NITROGEN NO3 #/A	NH4 #/A	S ppm	B ppm	Zn ppm	Mn ppm	Cu ppm	Fe ppm	CEC meq	Na meq	Total Bases	Base Sat.%	SMP Buf.pH	MOISTURE Total %	Avail. Inches	TKN %	Cl ppm
3301	0-6"	6.8	0.20	8.9	118	646	16.1	1.9	22	20	18.2	0.4	6.4	13	4.6	122	23.0		19.7	85	6.5				4.0

* * *

TOTALS: 22 20

TOTAL INCHES:

TOTAL BROADCAST FERTILITY NEEDS:

NITROGEN: LBS PER ACRE N
PHOSPHORUS: LBS PER ACRE P205
POTASSIUM: LBS PER ACRE K20
SULFUR: LBS PER ACRE ACTUAL S
BORON: LBS PER ACRE ACTUAL B
ZINC: LBS PER ACRE ACTUAL Zn
MAGNESIUM: LBS PER ACRE ACTUAL Mg
OTHERS:

YIELD GOAL/ACRE:
ACRES:
PREVIOUS CROP:
GYPSUM REQUIREMENT: TONS PER ACRE 6-INCHES
LIME REQUIREMENT: TONS PER ACRE 6-INCHES
DOLOMITE REQUIREMENT: TONS PER ACRE 6-INCHES

PREPLANT: ____________________

SIDEDRESS: ____________________

SOIL TEXTURE ANALYSIS:

CLASS:

% SAND:
% SILT:
% CLAY:

COMMENTS:

PLANT TISSUE ANALYSIS REPORT

Lab No.	FIELD: DESCRIPTION:	Total N %	Nitrate N ppm	S %	P %	K %	Ca %	Mg %	B ppm	Zn ppm	Mn ppm	Cu ppm	Fe ppm	Chloride ppm	Na ppm	Moisture %

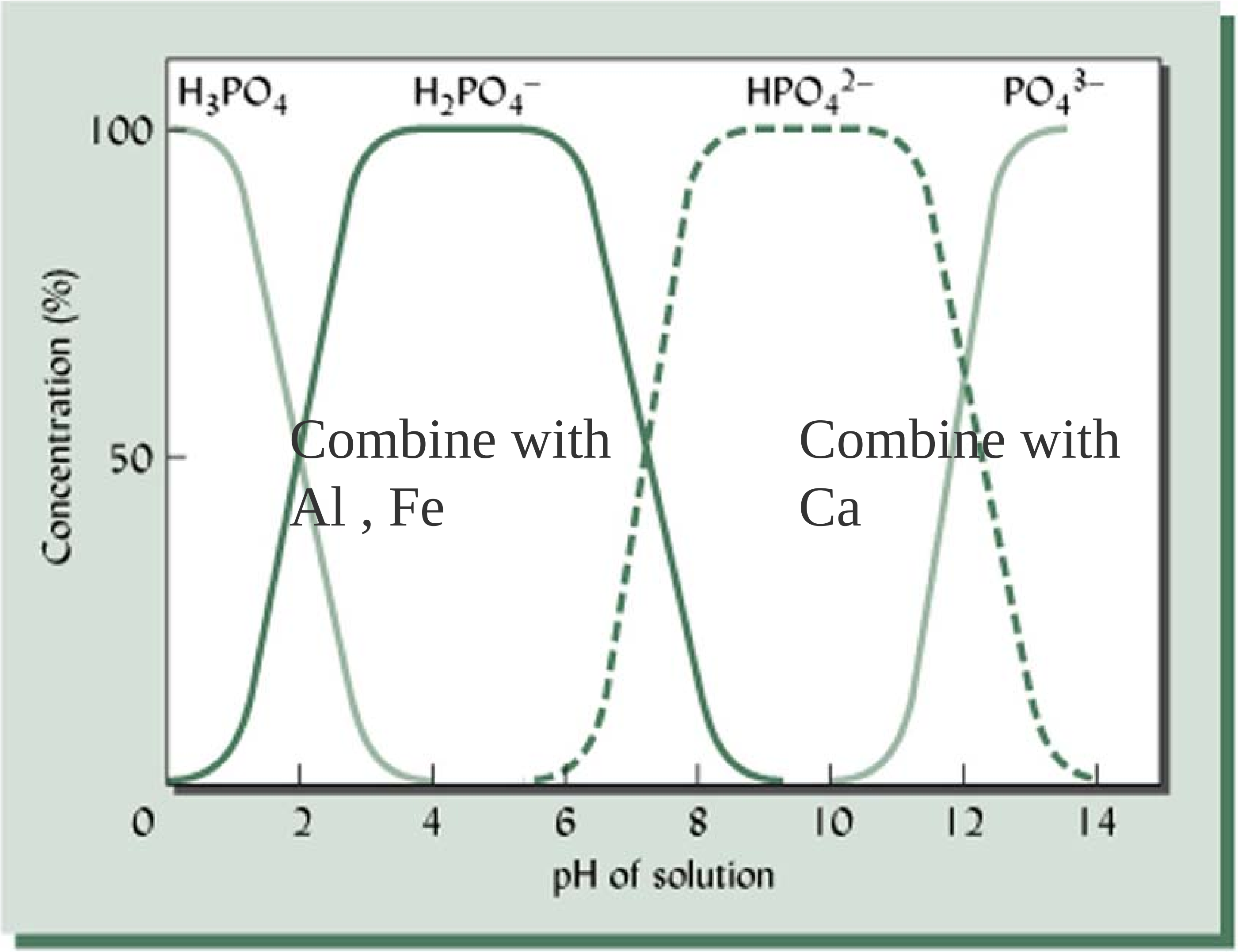
NOTE: East of Cascades Bicarb P & K extraction/SMP=1/4 SMP Buffer pH; West of Cascades Weak Bray P and Acetate K extractions. Fertility recommendations may change after application of gypsum or lime.

Methods of measuring soil P

- Extractants used to predict P availability through a season
  - Bray (acid extractants)- used with soil of pH<7.2
  - Melich (acid extractants)- pH < 7.2
  - Olsen (or bicarbonate) - pH >6.0
- Anion exchange membranes
  - Similar to absorption by root

Plant Root Simulator®

Soil solution P forms: effect of pH



Combine with Al , Fe

Combine with Ca

Figure 14.8

Microbes can solubilize soil P through secretion of organic acids

1) Fungus, *Aspergillus niger* solubilizes rock phosphate (B&W Fig 14.17)
2) Phosphorus-solubilizing bacteria used in Cuba
   - 50-100% of the P fertilizer on vegetables, cassava, sweet potato, citrus fruits, coffee nurseries

     Source: Martínez Viera and Hernández, 1995; Treto et al., 2002.
3) Mycorrhizae

Plant **available** P = 0.01% of **total** P

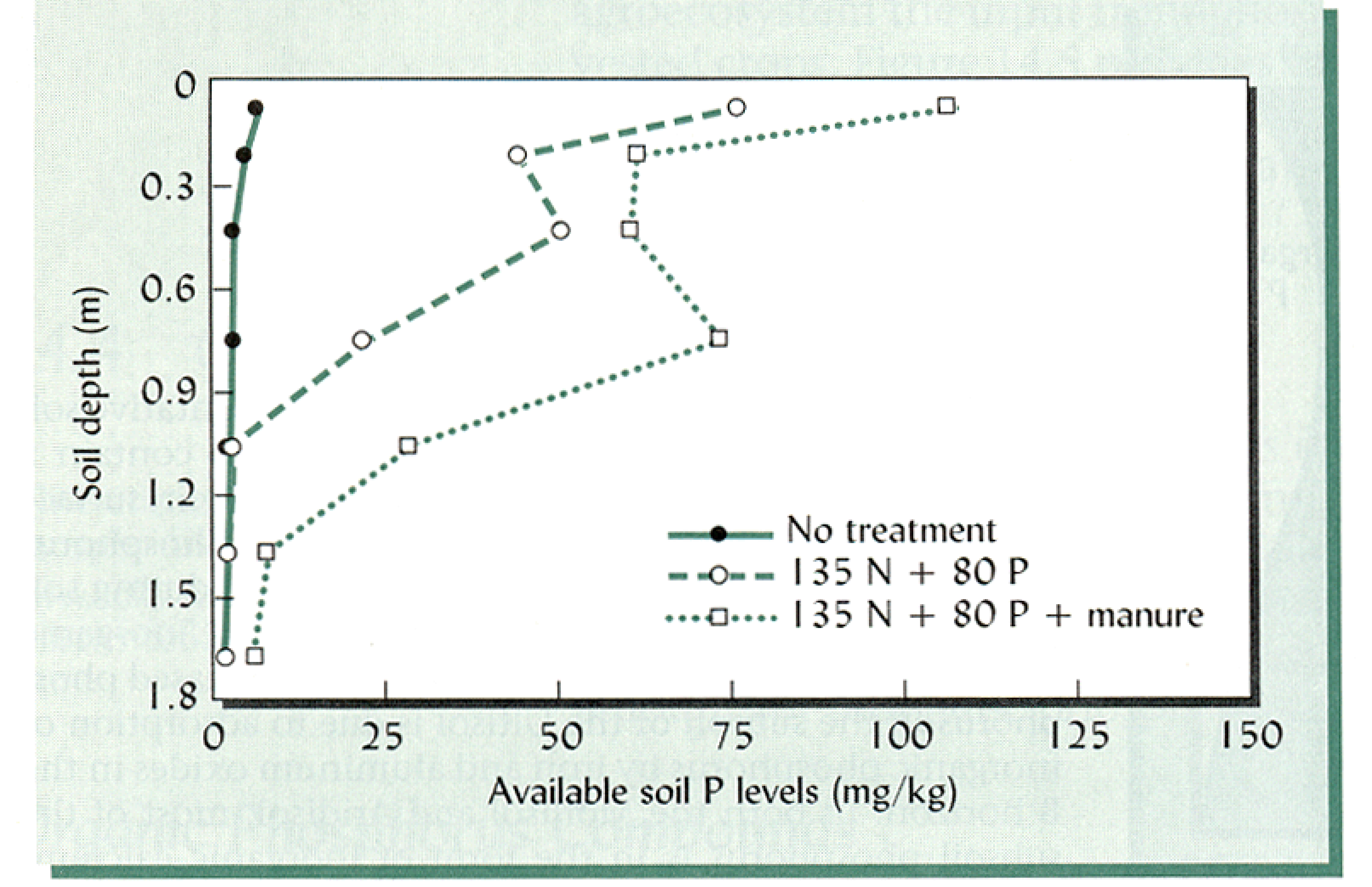
- Concentration of P in soil solution is very low compared to other macronutrients
  - 0.001mg/L to 1 mg/L
- Most important plant available species in uptake is HPO_4^{-2}, $H_2PO_4^-$ and to a lesser extent organic P (less known)

Organic P in soil

- Can be 20 to 80% of **total P** in soil surface layers
- May be dissolved organic P (DOP)
- Organic P $\rightleftarrows$ $H_2PO_4^-$ $\rightleftarrows$ Fe, Al, Ca phosphates
- Immobilized if >300 C : 1 P
- Mineralized if < 200 C : 1 P

Temperate region mineralization= 5-20 kg P/yr, which if equal to amount a natural system takes up

Manure w/DOP allows further P penetration in soil



Organic P is converted to inorganic P as SOM decreases

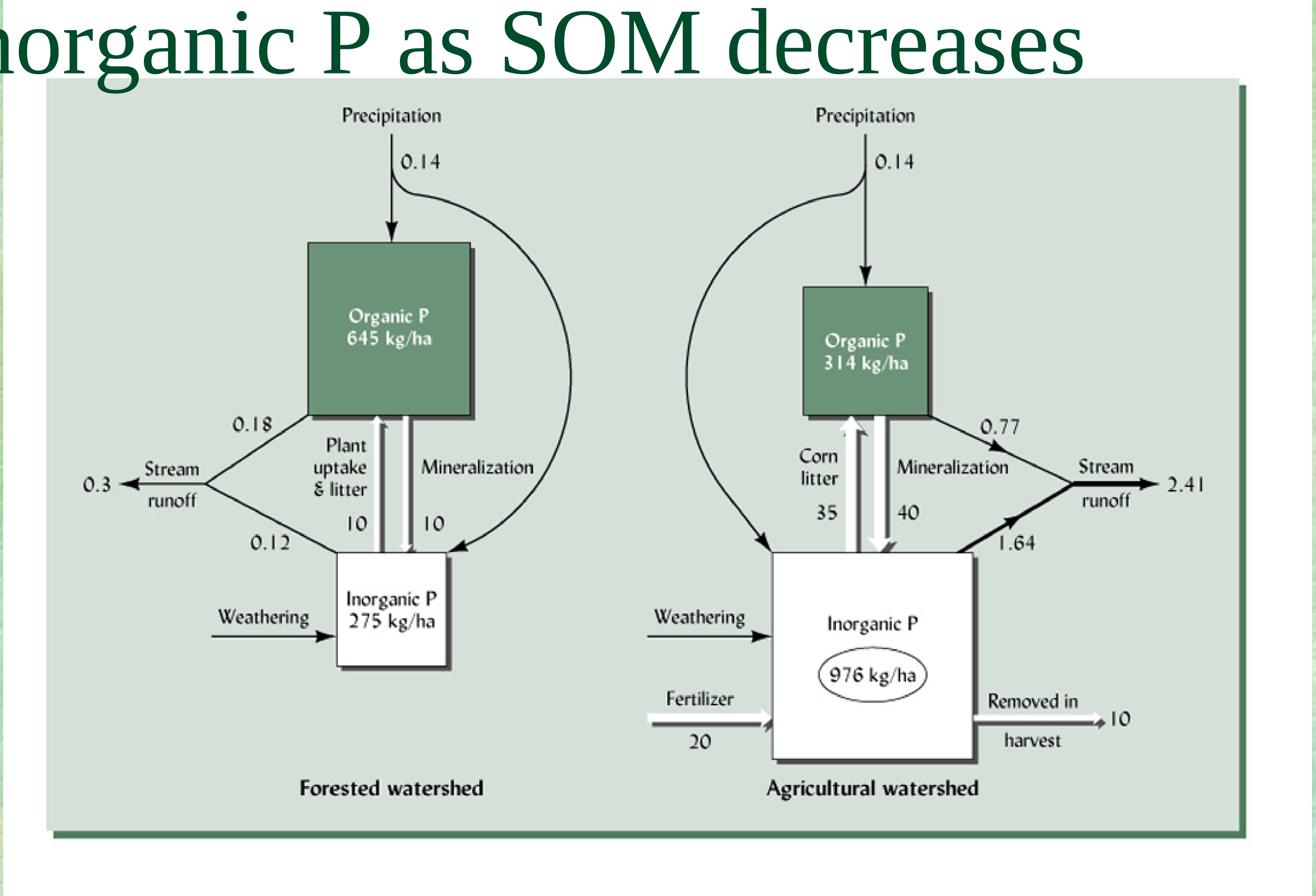


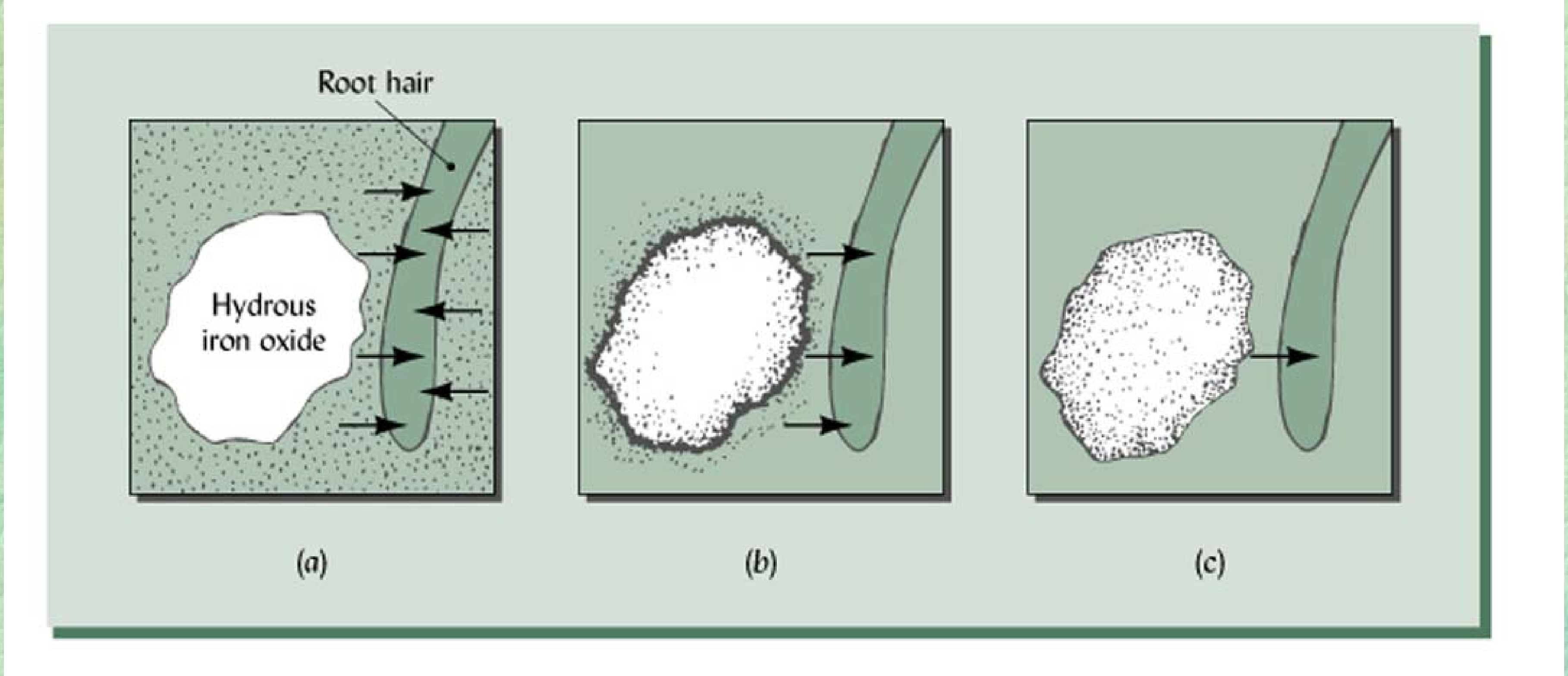
Figure 14.5

Inorganic P in soil

- Relatively immobile-- controlled by 1) the solubility of compound and 2) fixation on soil particles
- P fixation - reactions that remove dissolved phosphate ions from solution to produce compounds of low solubility
  - Low pH- Fe or Al phosphates
  - High pH- Ca phosphates

Figure 14.13

P fixation over time and loss of availability



Considered high P fixing soil is >350 mg P/kg or 700 kg P/ha

As clay content increases the P fixation of soil increases

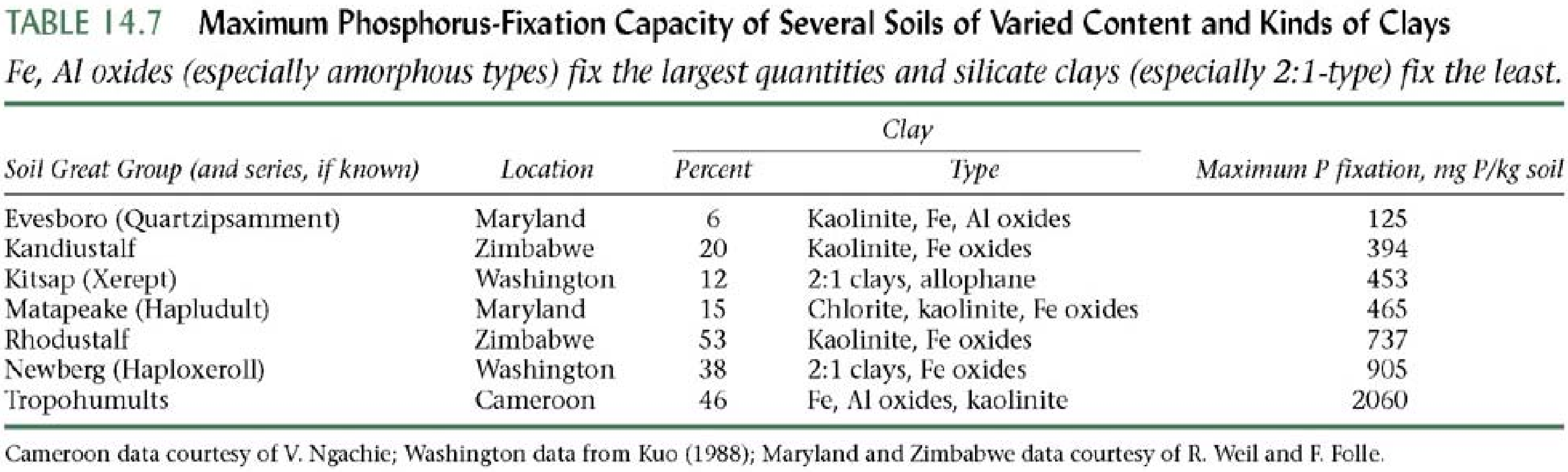


TABLE 14.7 Maximum Phosphorus-Fixation Capacity of Several Soils of Varied Content and Kinds of Clays

Fe, Al oxides (especially amorphous types) fix the largest quantities and silicate clays (especially 2:1-type) fix the least.

		Clay		
Soil Great Group (and series, if known)	*Location*	*Percent*	*Type*	*Maximum P fixation, mg P/kg soil*
Evesboro (Quartzipsamment)	Maryland	6	Kaolinite, Fe, Al oxides	125
Kandiustalf	Zimbabwe	20	Kaolinite, Fe oxides	394
Kitsap (Xerept)	Washington	12	2:1 clays, allophane	453
Matapeake (Hapludult)	Maryland	15	Chlorite, kaolinite, Fe oxides	465
Rhodustalf	Zimbabwe	53	Kaolinite, Fe oxides	737
Newberg (Haploxeroll)	Washington	38	2:1 clays, Fe oxides	905
Tropohumults	Cameroon	46	Fe, Al oxides, kaolinite	2060

Cameroon data courtesy of V. Ngachie; Washington data from Kuo (1988); Maryland and Zimbabwe data courtesy of R. Weil and F. Folle.

2:1 clays< 1:1 clays< crystalline Al,Fe, Mn oxides
< amorphous Al,Fe, Mn and allophane
Also high and low pH

P saturation as P is loaded onto soils

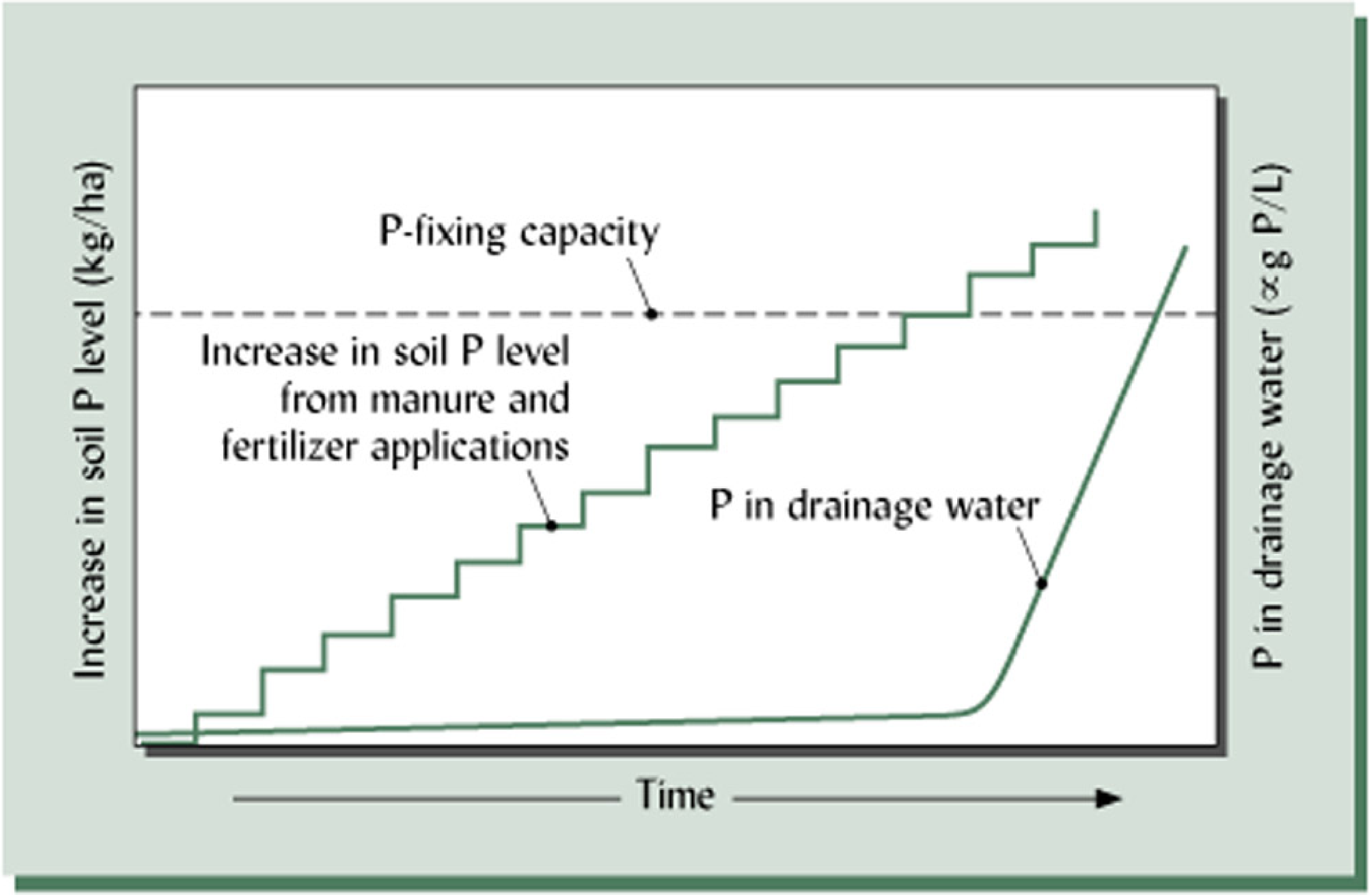


Figure 14.22

The P Cycle: Non-volatile nutrient

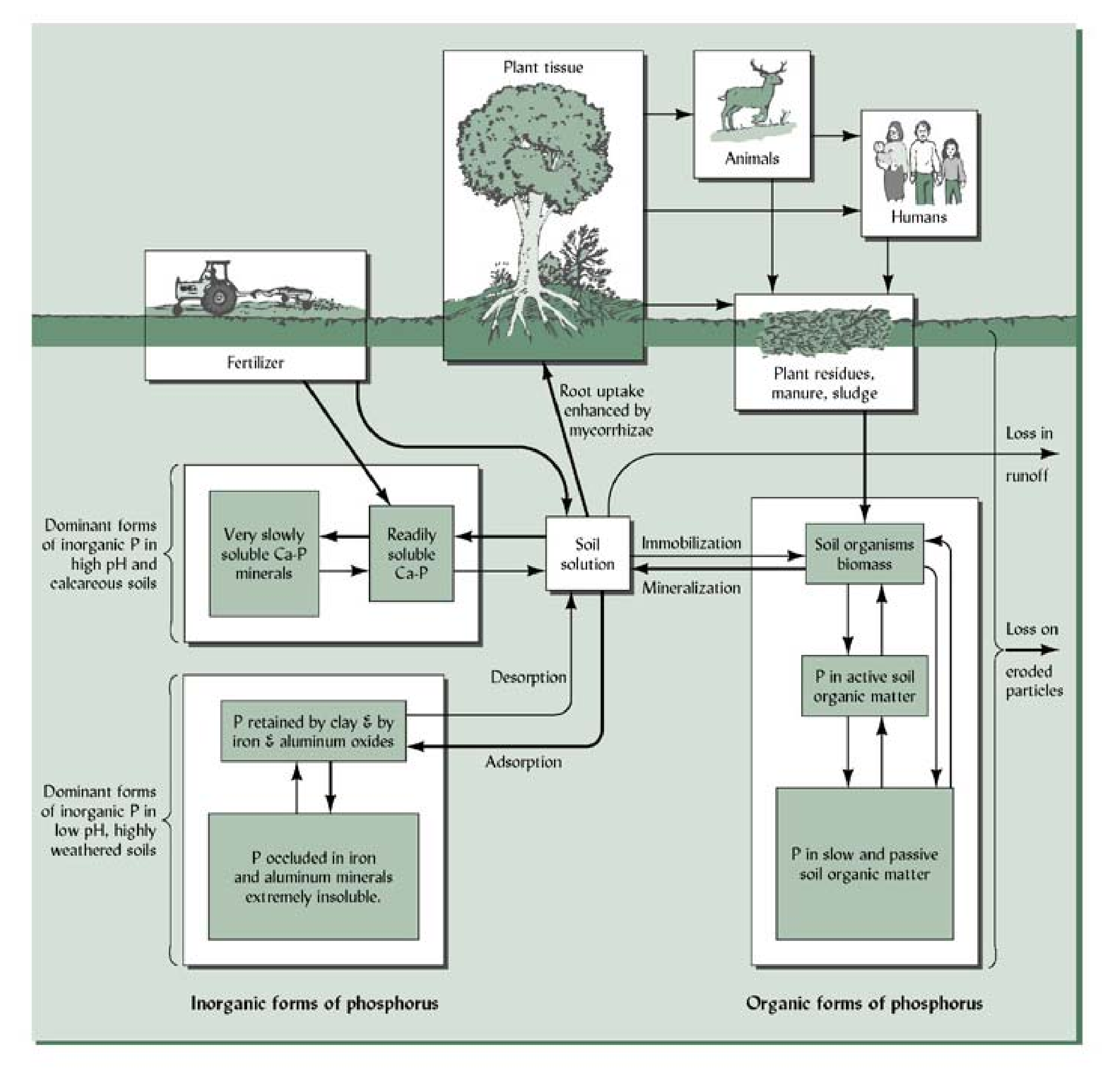


Figure 14.7

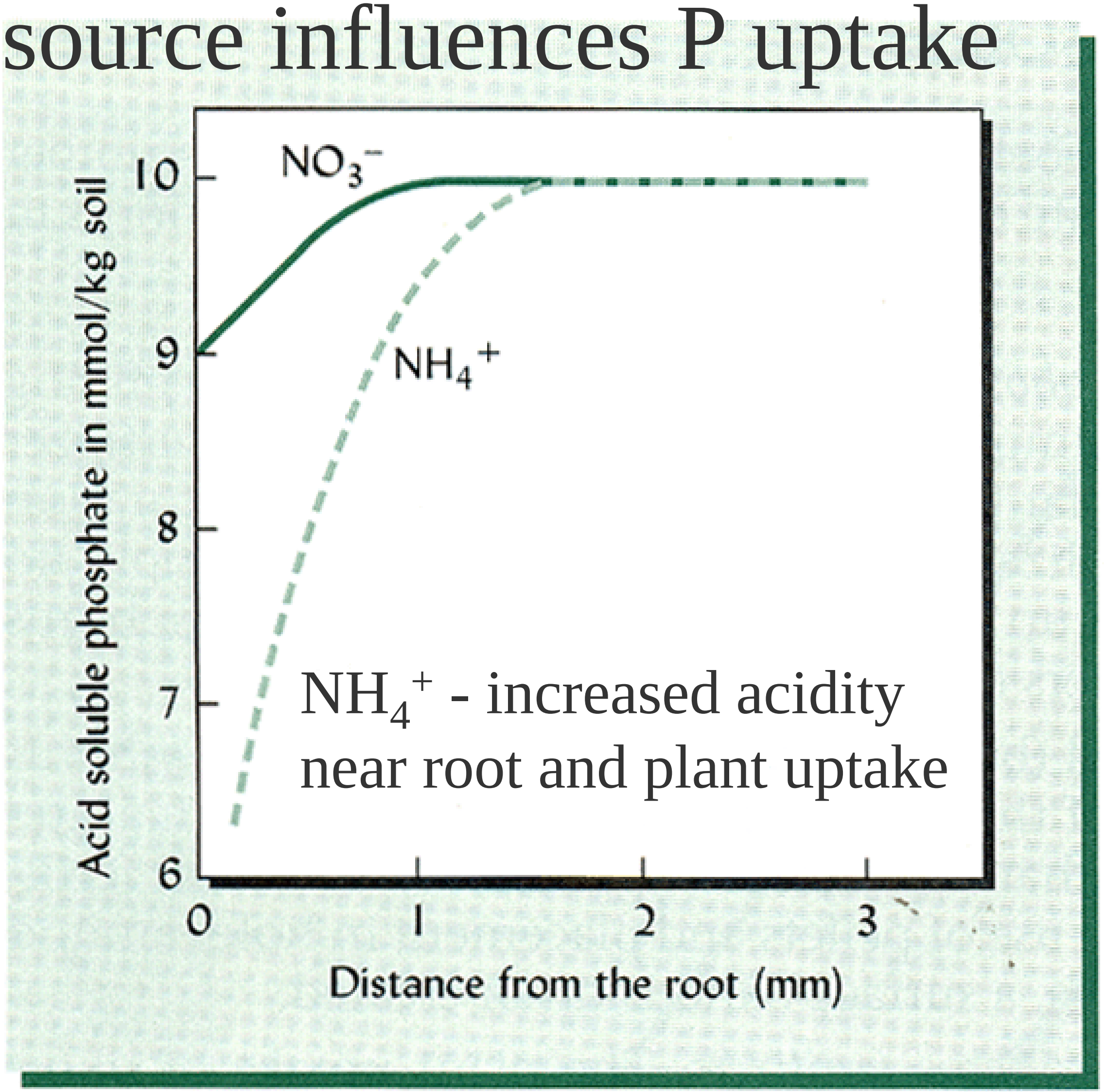
Losses from soil (higher level in cultivated)

- Plants: 5-50 kg/ha annually
- Erosion: 0.1-10 kg/ha
- Runoff: 0.01-0.03 kg/ha
  - Values from Brady and Weil

P losses from system

- Runoff water from fields- dissolved inorganic (dissolved P) and particulate P on organic matter or clay particles
- Runoff from CAFOs
  - *Pfisteria* algal blooms kill fish
- Erosion (soil)- from tilled or burned fields

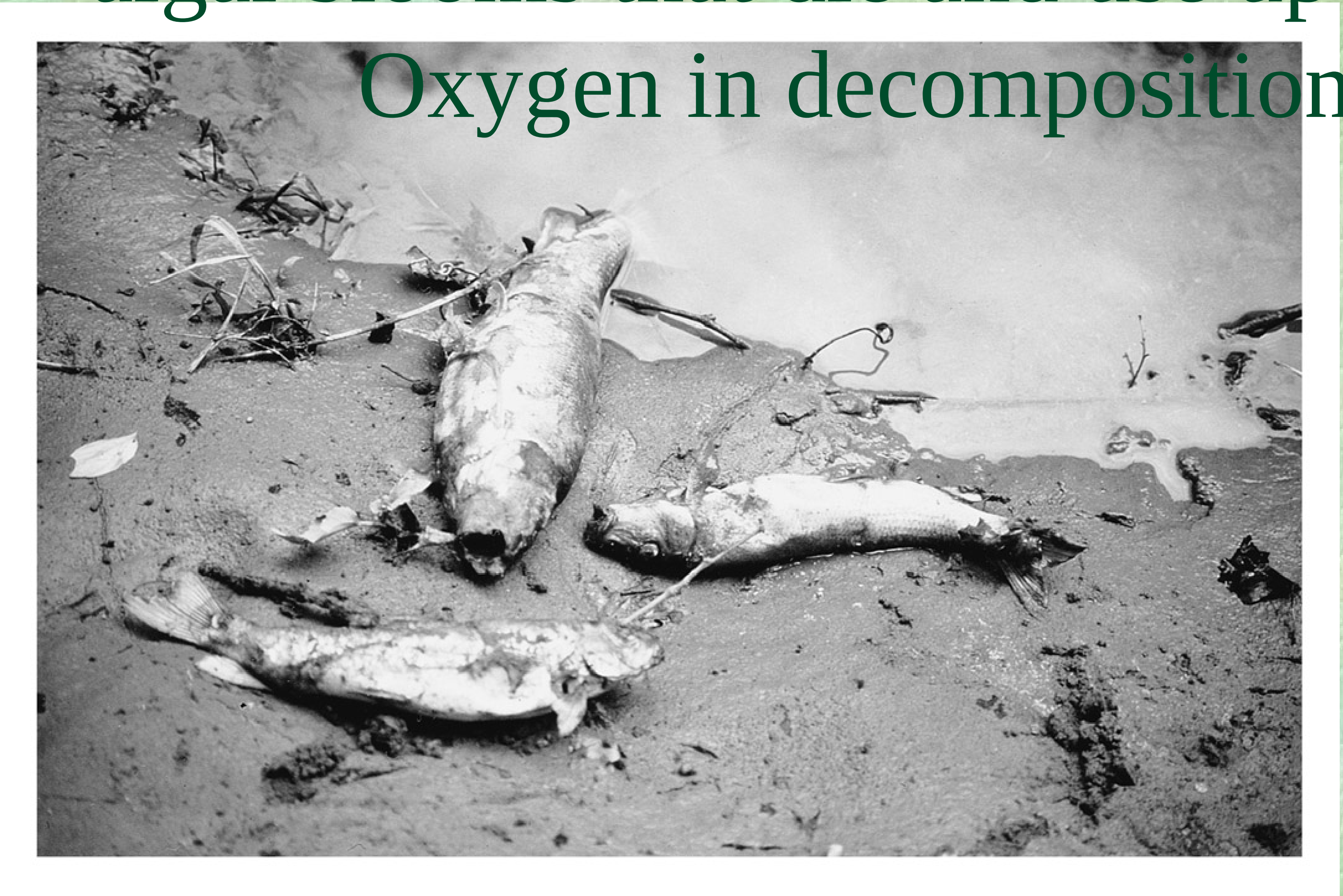
N source influences P uptake



NH_4^+ - increased acidity near root and plant uptake

Fig. 14.23, Brady & Weil, 2002.

Both cause eutrophication: algal blooms that die and use up Oxygen in decomposition



Practical control of P

1) Pattern fertilizer rates to fit soil P level
2) Placement of phosphorus- banded vs. broadcast
3) If use inorganic fertilizers, combine ammonium and P fertilizers (nitric acid in oxidation of ammonium slows formation of more insoluble Ca - P compounds)

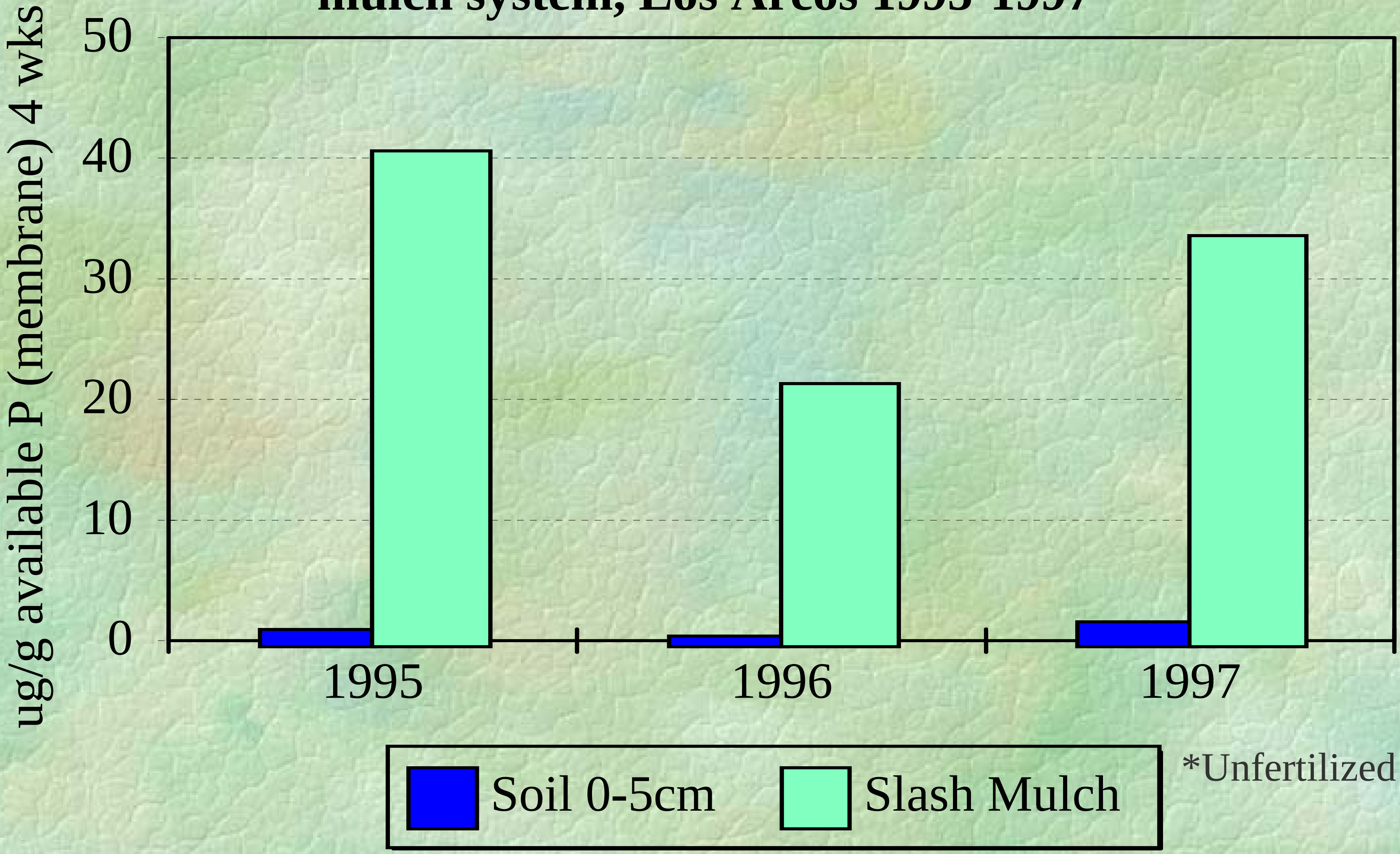
4) Organic matter increases P availability

avoids P fixation of soil, occludes soil particles, forms Al, Mn, Fe chelates

5) Control of soil pH between 6 to 7 to increase plant uptake of P

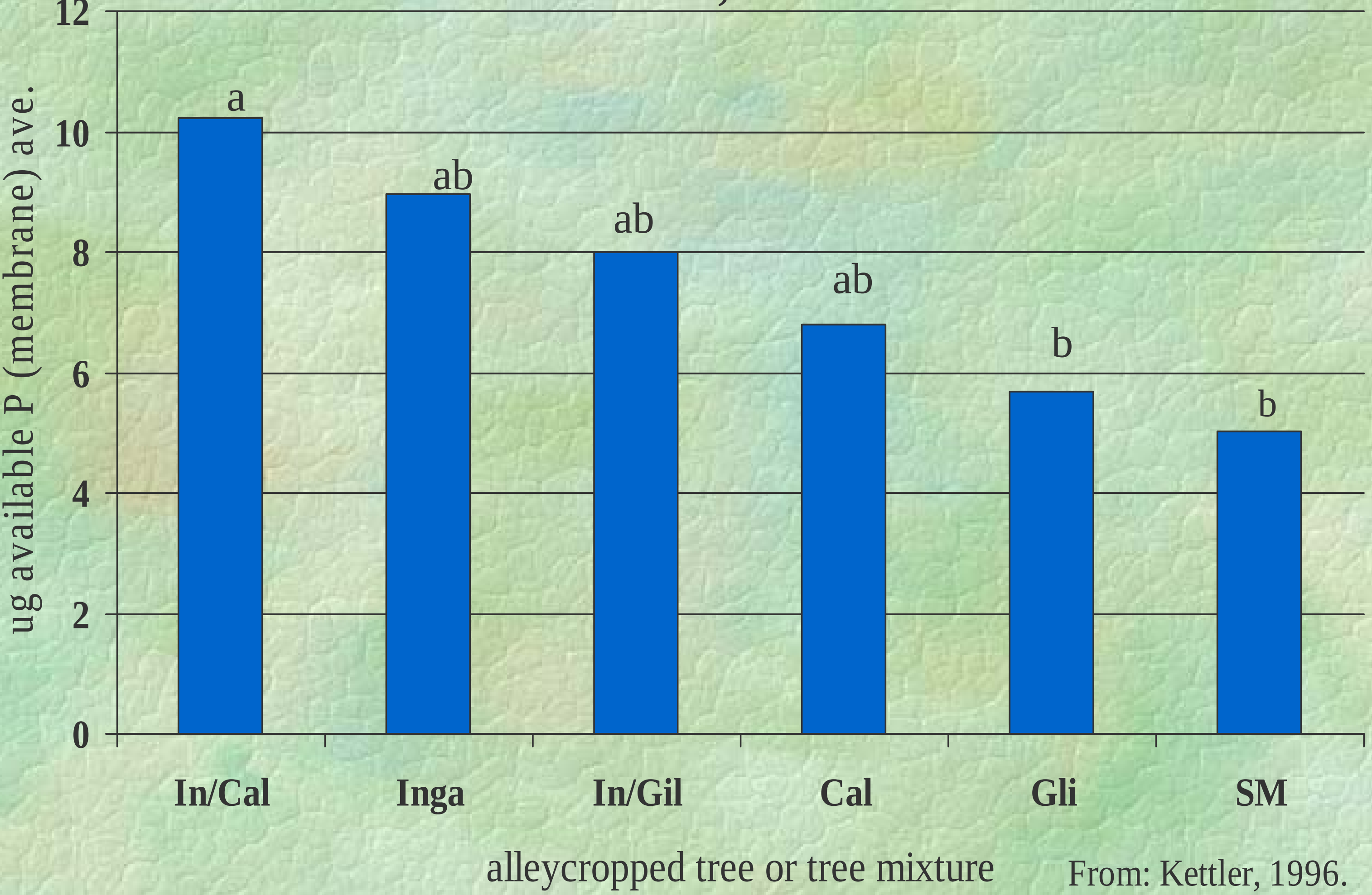
6) Enhancement of mycorrhizal symbiosis

Available P in soil and mulch of slash mulch system*, Los Arcos 1995-1997



*Unfertilized

Available P in soil under tree mulch, Los Arcos, 1994-95



From: Kettler, 1996.

Tithonia facilitated rock phosphate

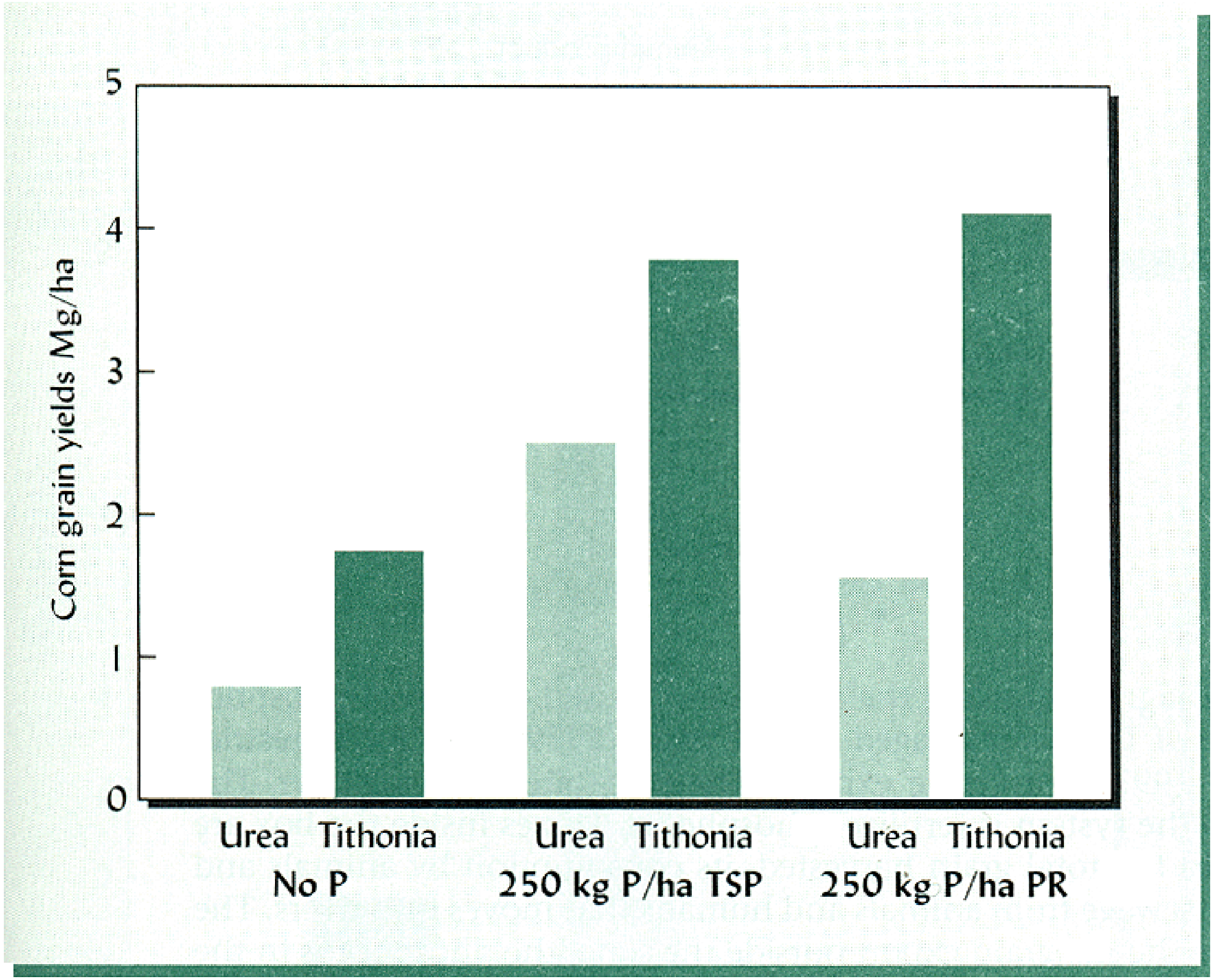


Fig. 14.24, Brady & Weil. 2002.

7) Choose plants or varieties that are adapted to tolerate low P

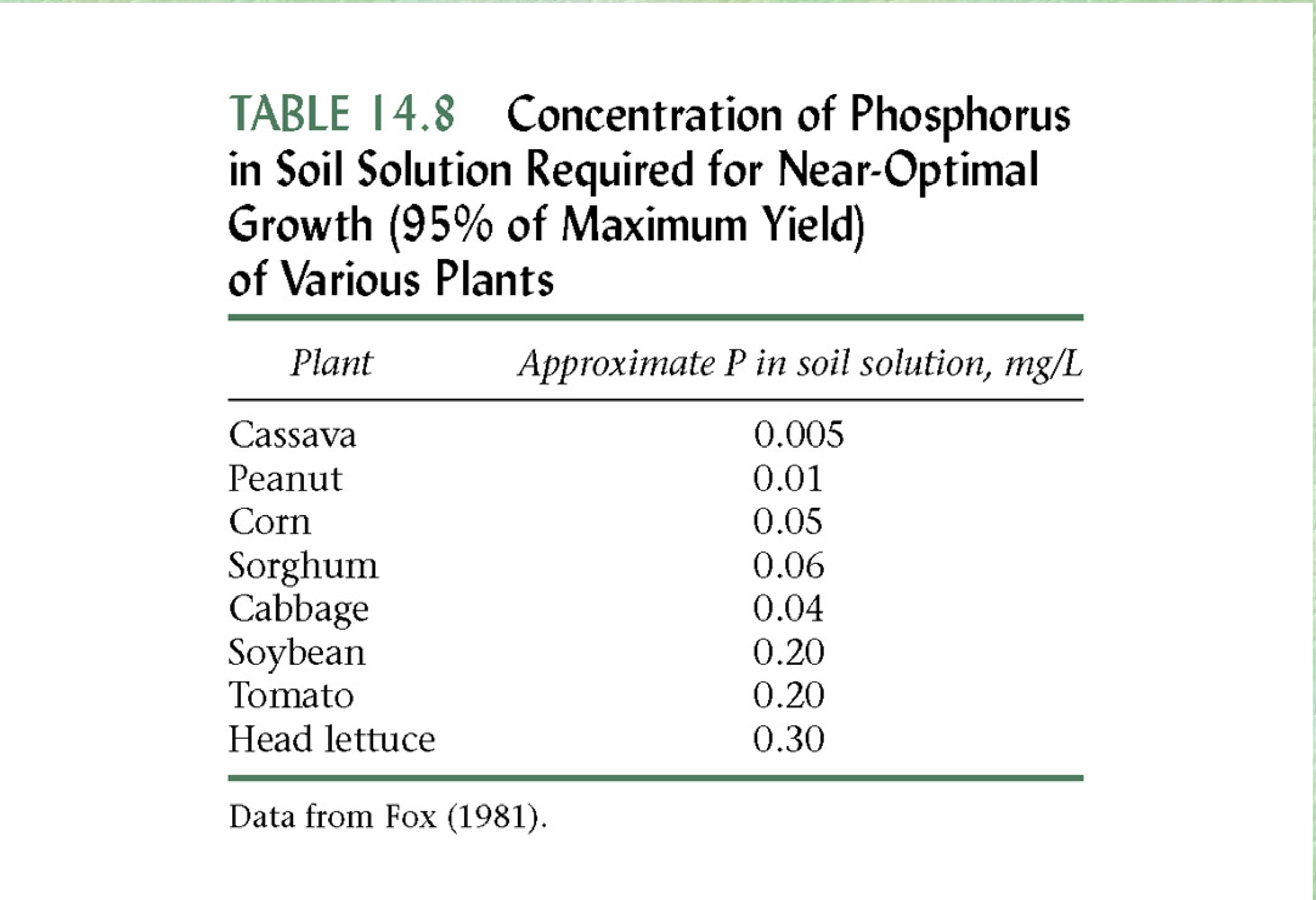
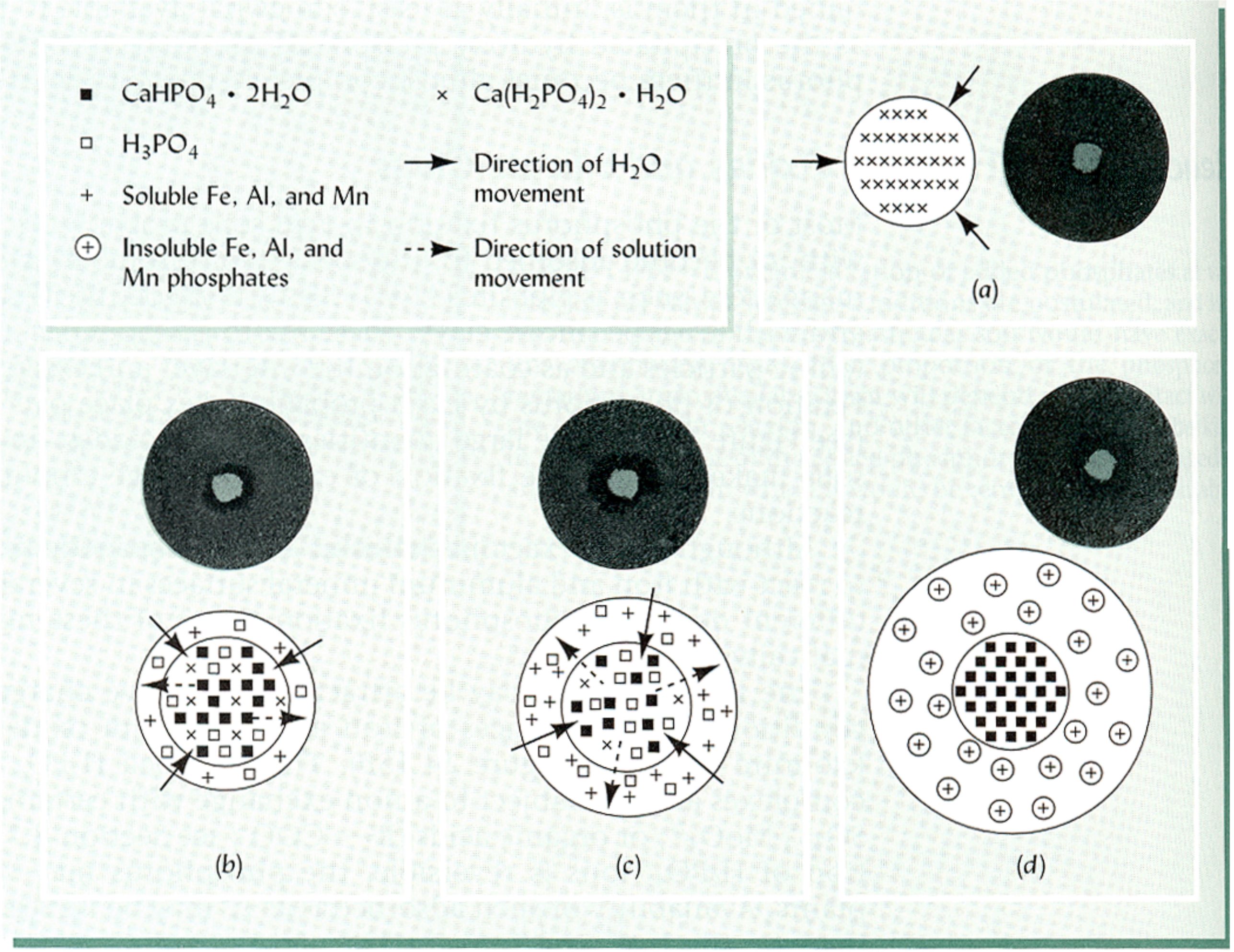


TABLE 14.8 Concentration of Phosphorus in Soil Solution Required for Near-Optimal Growth (95% of Maximum Yield) of Various Plants

Plant	*Approximate P in soil solution, mg/L*
Cassava	0.005
Peanut	0.01
Corn	0.05
Sorghum	0.06
Cabbage	0.04
Soybean	0.20
Tomato	0.20
Head lettuce	0.30

Data from Fox (1981).


■ $CaHPO_4 \cdot 2H_2O$
× $Ca(H_2PO_4)_2 \cdot H_2O$
□ H_3PO_4
→ Direction of H_2O movement
+ Soluble Fe, Al, and Mn
⊕ Insoluble Fe, Al, and Mn phosphates
- - → Direction of solution movement
(a)
(b)
(c)
(d)

Removing P from water with Fe, Al

Does this make sense?

Figure 14.12

Use of aluminum sulfate in poultry operations

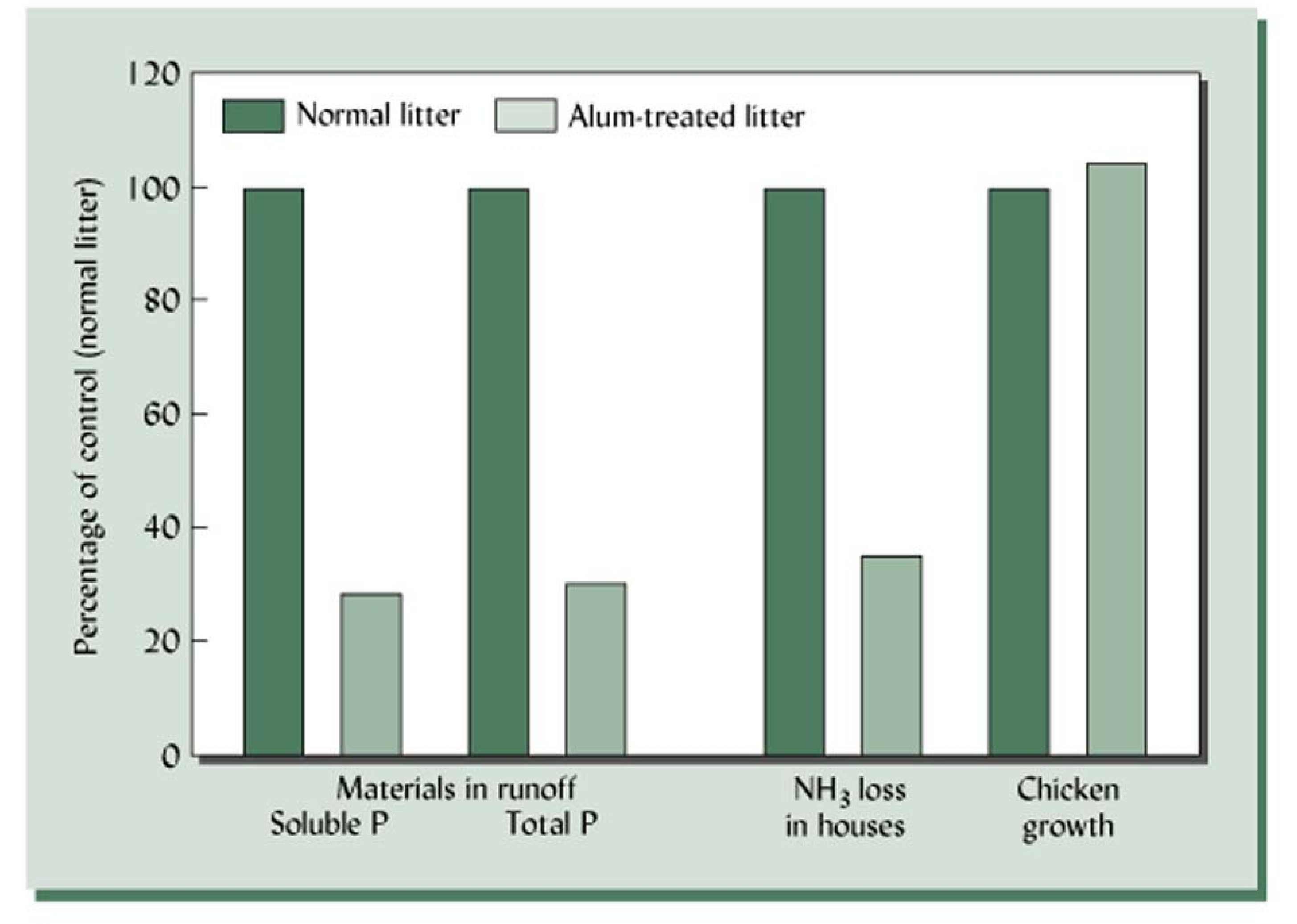
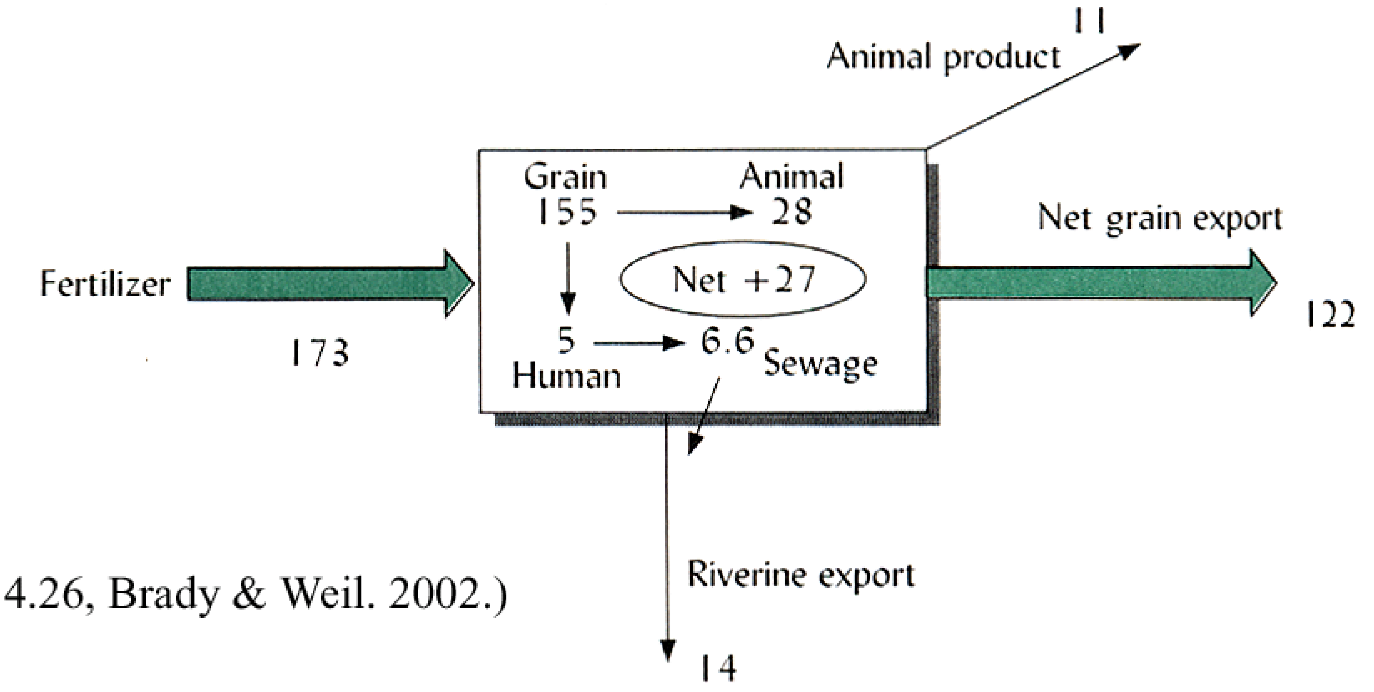


Figure 14.25

P Input/output analysis in IL (similar to your nutrient output: input analysis on your farms!)



(Fig. 14.26, Brady & Weil. 2002.)

Potassium

- Important in regulation and **prevention of disease and pest damage**
- Absorbed as cation K^+, not form organic compounds
- Plant tissues 1-2% by dry wt
- Variable in temperate and tropical soils, can be deficient where heavily cropped or leached
- No off-site negative environmental effects

K Function:

- Regulatory particularly water balance, (reducing water loss from leaf stomata)
- cofactor in enzymes (80 different enzymes)
- drought tolerance
- quality and taste
- important in disease and insect resistance
  - Important part of IPM program
- counteracts effects of excess N

Ponderosa pine mortality due to beetle damage with N and K

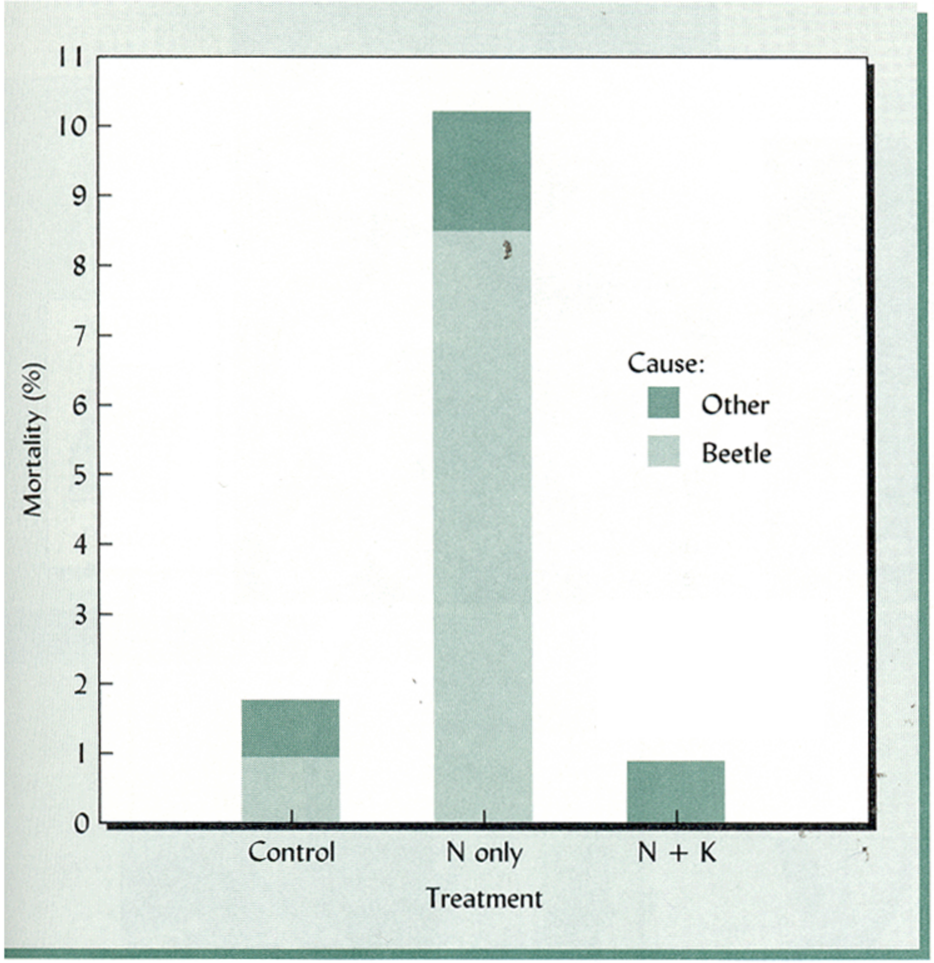
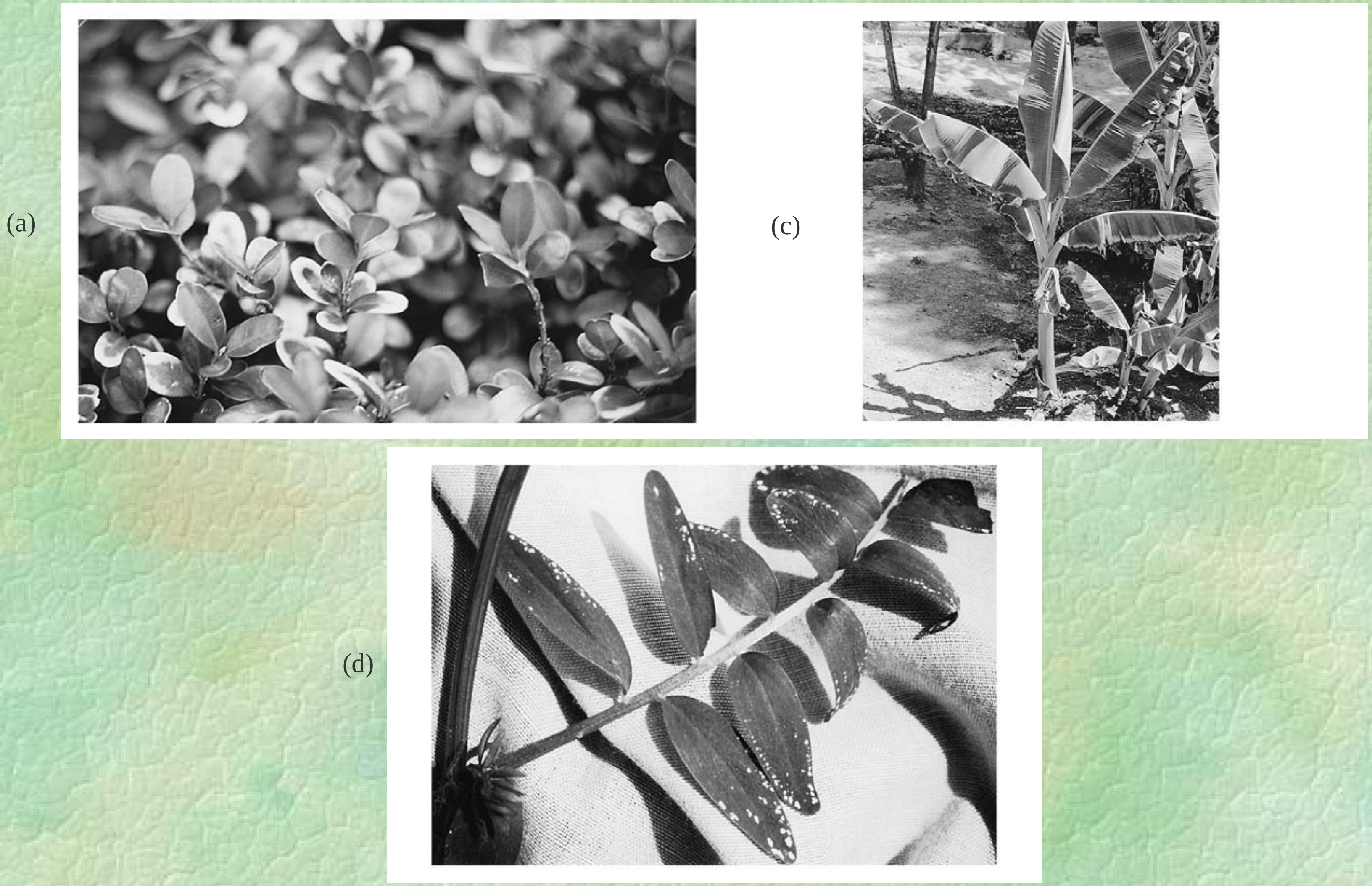


Fig. 14.27, Brady & Weil. 2002.

Symptoms of K deficiency

- Yellowing older leaves (mobile in plant), where tips and edges curl
  - not to be confused with salinity which affects younger leaves
- In some legumes white necrotic (dead) spots
- Ragged leaf edges
- Disruption in water balance, disease, insect damage

Figure 14.28



Potassium deficiency in corn

Courtesy of North Carolina Agricultural Experiment Station and U. S. Department of Agriculture

Plate 7.—Potassium-starved young corn plant. The lower leaves show the typical marginal scorch. At this stage of growth in the field it is possible to apply remedial side dressings of potash salts profitably.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Plate 10.—Potassium starvation results in weak corn stalks with the leaves badly damaged. The marginal "firing" affects all the leaves.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Potassium deficiency of bean

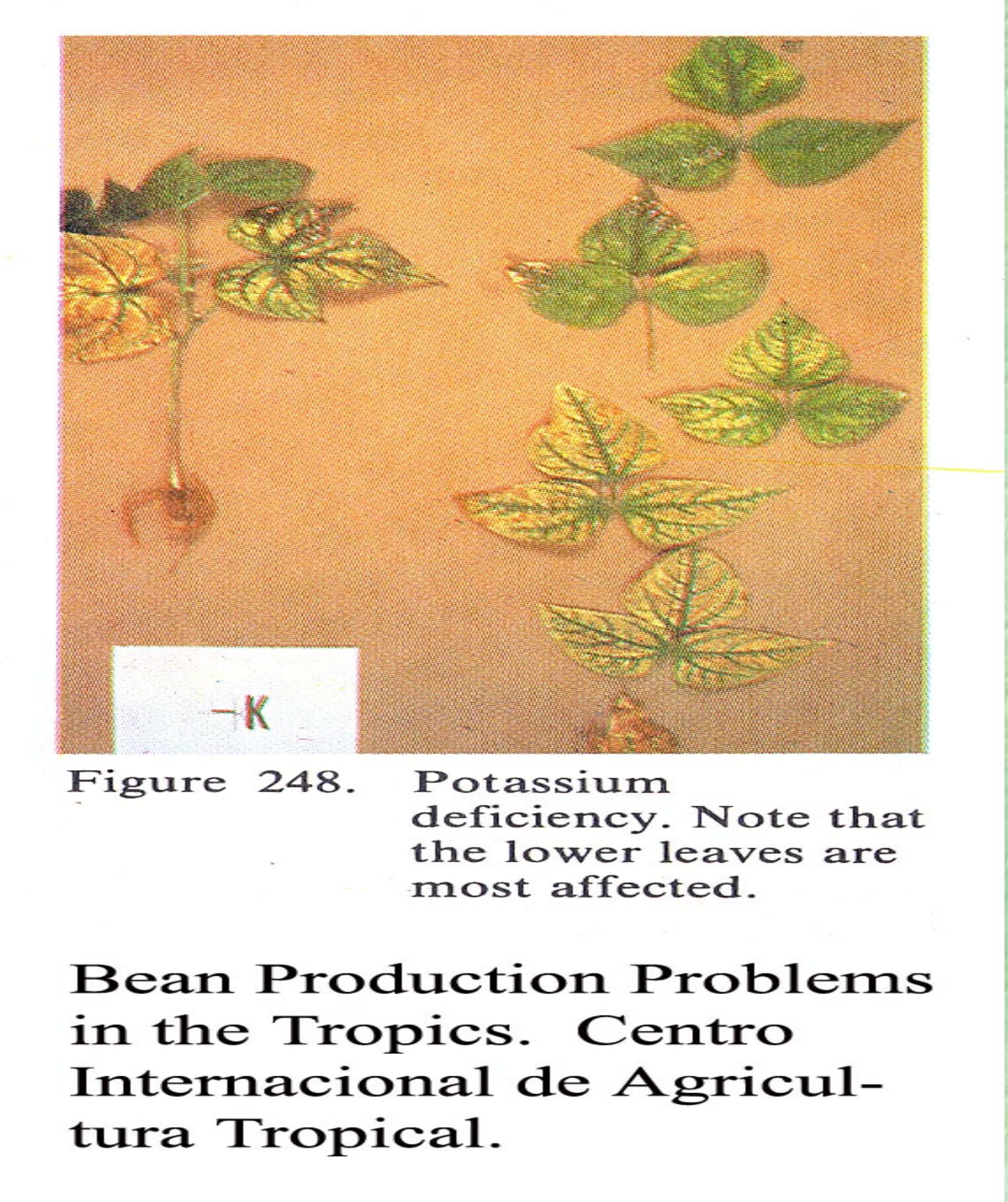


Figure 248. Potassium deficiency. Note that the lower leaves are most affected.

Bean Production Problems in the Tropics. Centro Internacional de Agricultura Tropical.

Potassium deficiency in apple

- Leaf margins dark purplish
- Ultimately dried

Plate 4.—Symptoms of prolonged and severe potassium deficiency in the apple. In this stage, scorched leaves may be found near the tips of twigs. Dark areas in upper leaf are due to plasmolysis preceding scorching.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

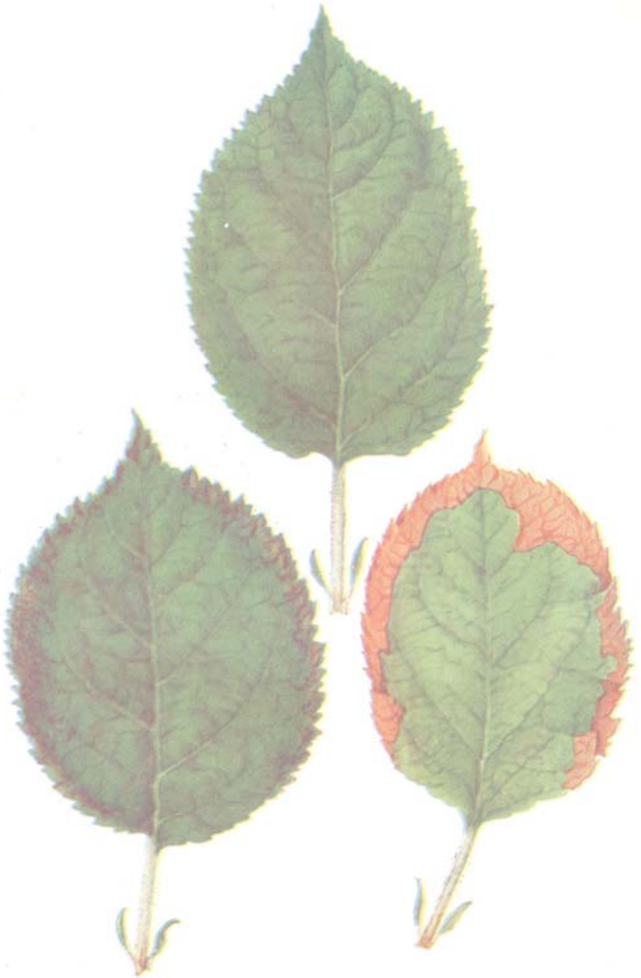


Plate 3.—Successive stages of marginal scorching due to potassium deficiency in apple foliage. Upper leaf is normal. An early stage is shown by the dark-purplish discoloration of leaf on lower left. Well developed scorch is shown in leaf on lower right. Leaves are typical of those found along mid-portions of current-season twigs. After exposure to rain the scorched areas turn dull brown.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

K symptoms

- Plate 44

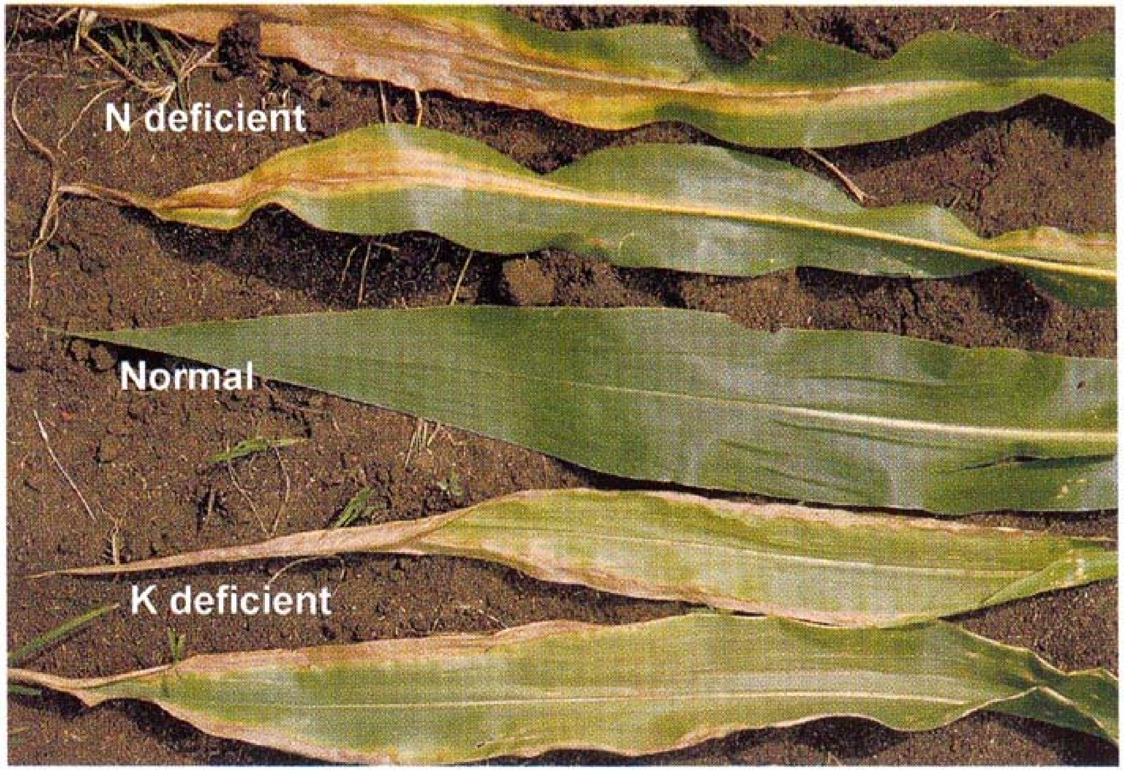
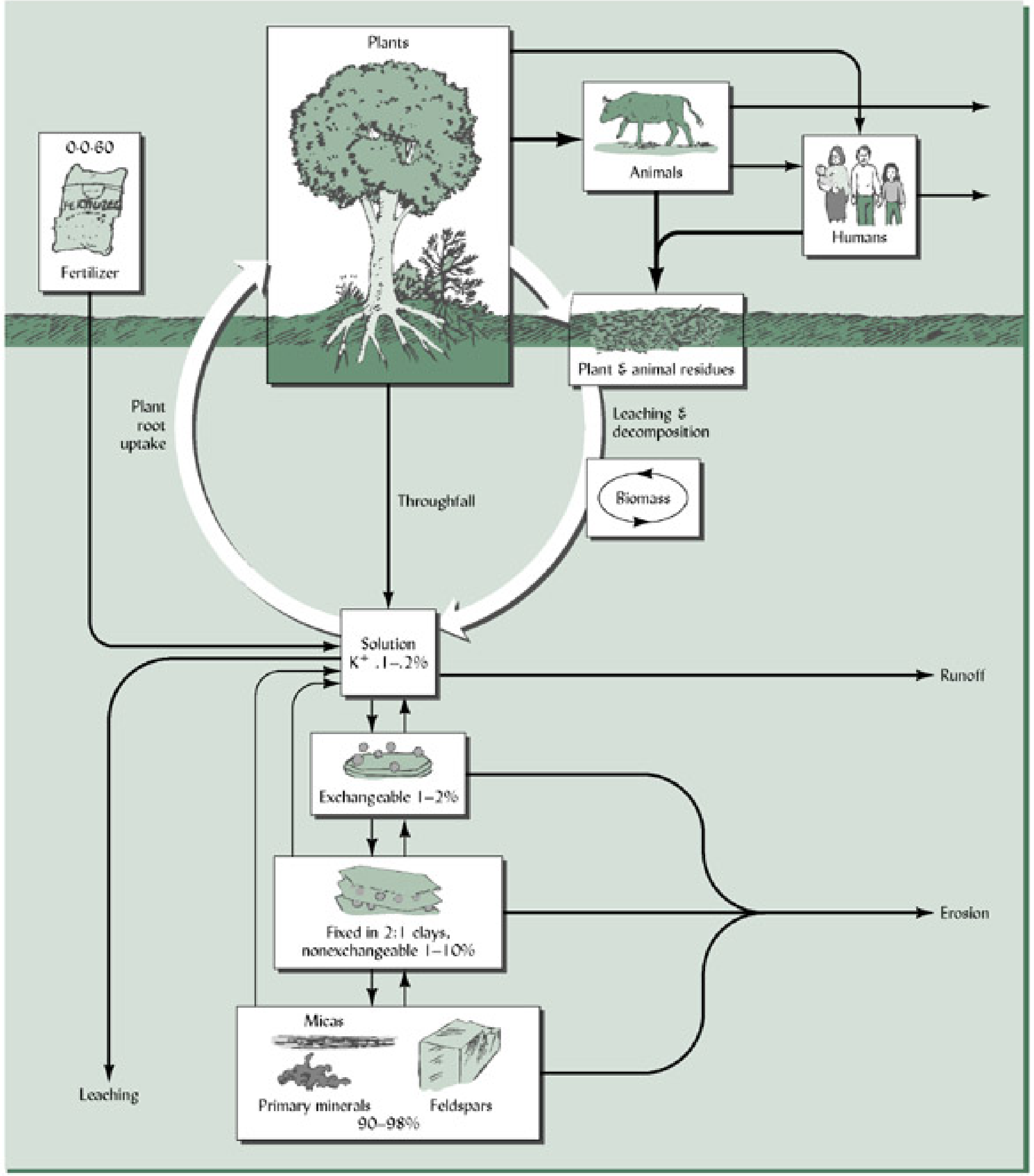


PLATE 44 Leaves from near the bottom of nitrogen-deficient (yellow tip and midrib), potassium-deficient (necrotic leaf edges), and normal corn plants. All the leaves came from the same field.

Figure 14.29


Plants
0-0-60
Fertilizer
Animals
Humans
Plant & animal residues
Plant
root
uptake
Leaching &
decomposition
Biomass
Throughfall
Solution
K⁺ .1–.2%
Runoff
Exchangeable 1–2%
Fixed in 2:1 clays,
nonexchangeable 1–10%
Erosion
Micas
Primary minerals
Feldspars
90–98%
Leaching

Key points

- Non-volatile cycle
- K+ in soil solution from weathered rock
  - High total K in rock, less exchangeable or available
- Large quantities taken up by plants (= N or 5-10x that of P) or leached from leaves
- Animals return K through urine
- K+ can be easily leached
- Agroecosystems can remove 1/5 to nearly all (hay) exported – why Amish never sell their hay!

Soil K restored over time through weathering and vegetative pumping

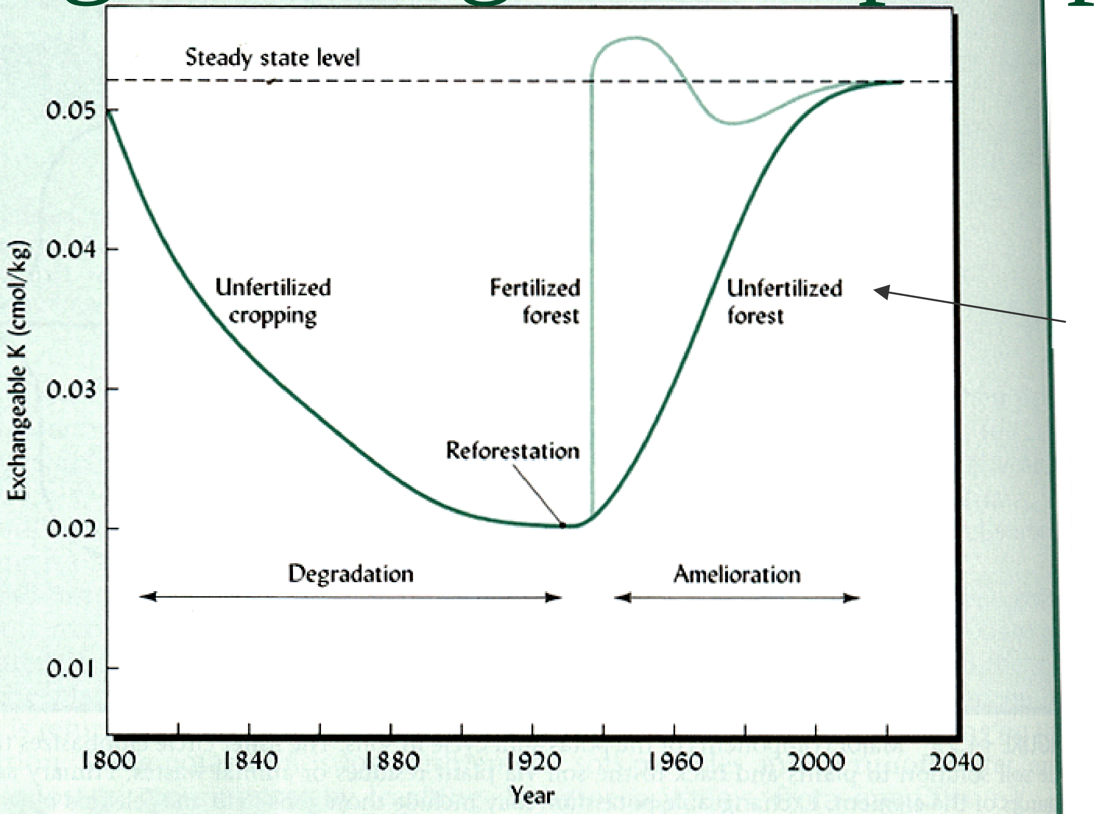


FIGURE 14.30 The general pattern of depletion of A-horizon exchangeable potassium by decades of exploitative farming, followed by its restoration under forest vegetation. The forest consisted of red pine trees planted on a Plainfield loamy sand (Udipsamment) in New York. This soil has a very low cation exchange capacity and low levels of exchangeable K^+. [From Nowak, et al. (1991)]

Fig. 14.30, Brady & Weil. 2002.

K problems

1) very large proportion is unavailable
2) Subject to leaching losses
3) Plants take up much, some of which is “luxury” consumption (over what the plant needs)

Magnitude of non-exchangeable removed can be high (75-80%)

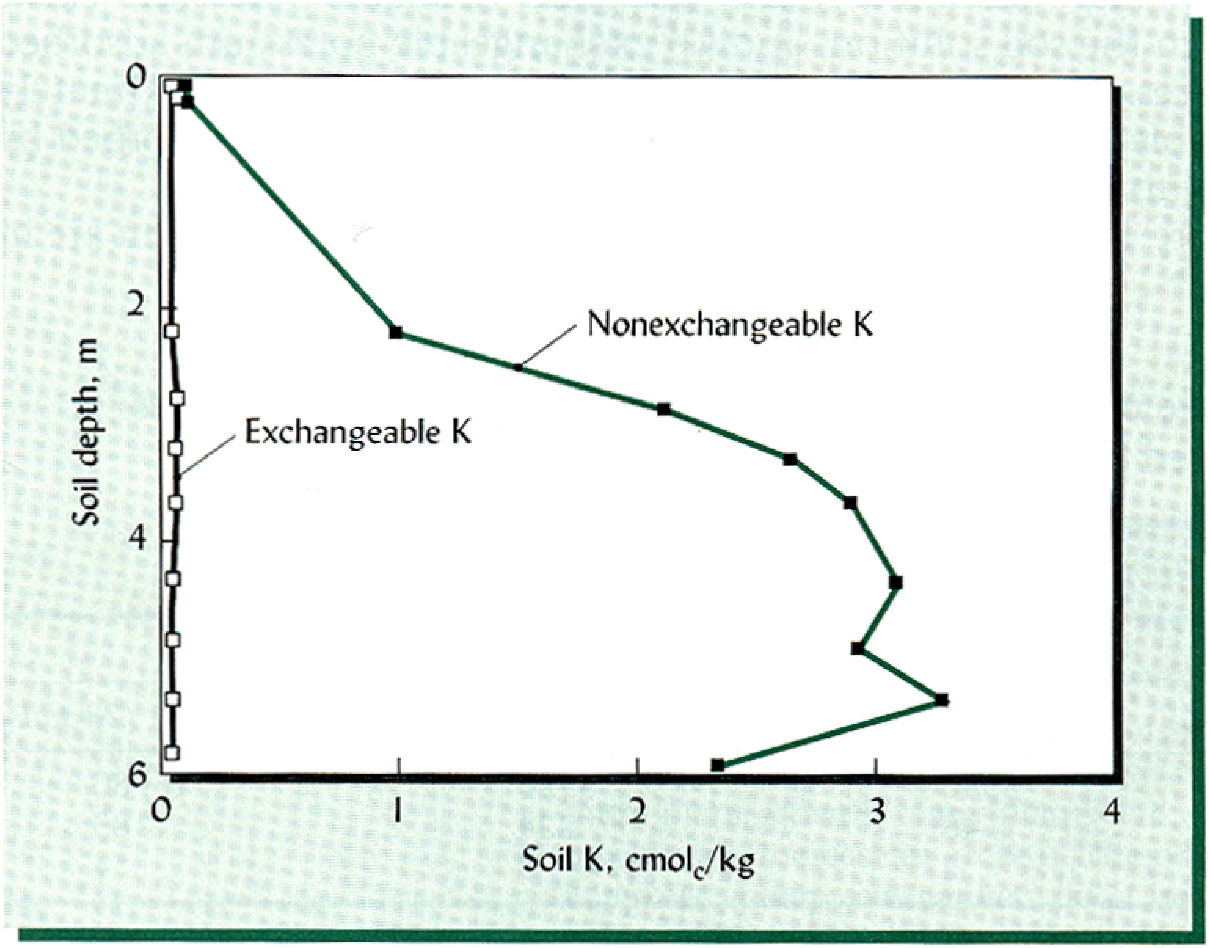


Fig. 14.34, Brady & Weil, 2002.

Luxury consumption

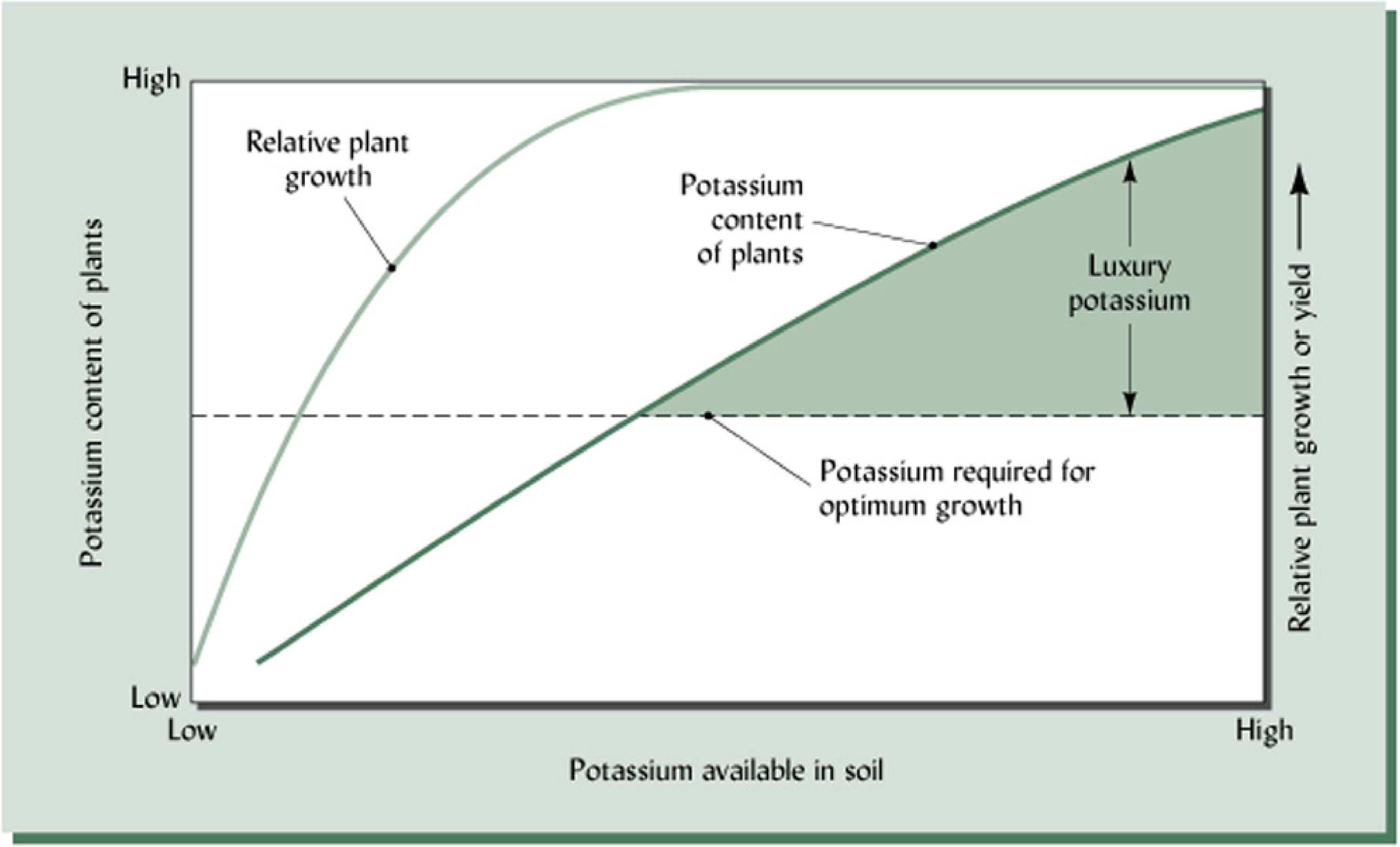


Figure 14.32

Factors that affect K fixation

- Nature of soil colloids
  - 2:1 clays much more fixed, than 1:1
- Wetting and drying/freezing and thawing
  - enhances both fixation and release
- Presence of excess lime
  - At higher pH can move closer to colloid of 2:1 clay and get fixed
  - Ca and Mg compete with uptake of K at high pH

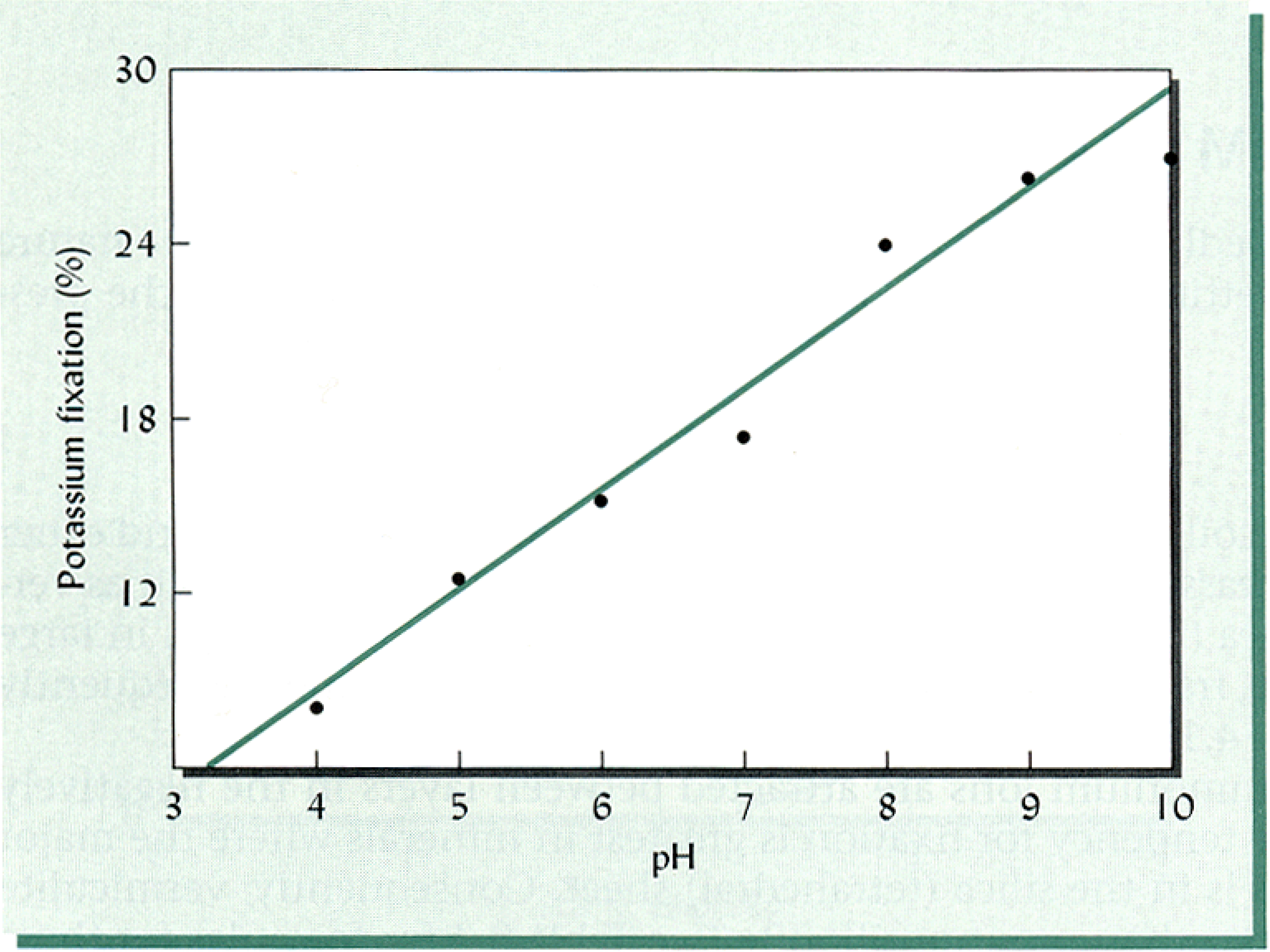


Fig. 14.35, Brady & Weil, 2002.

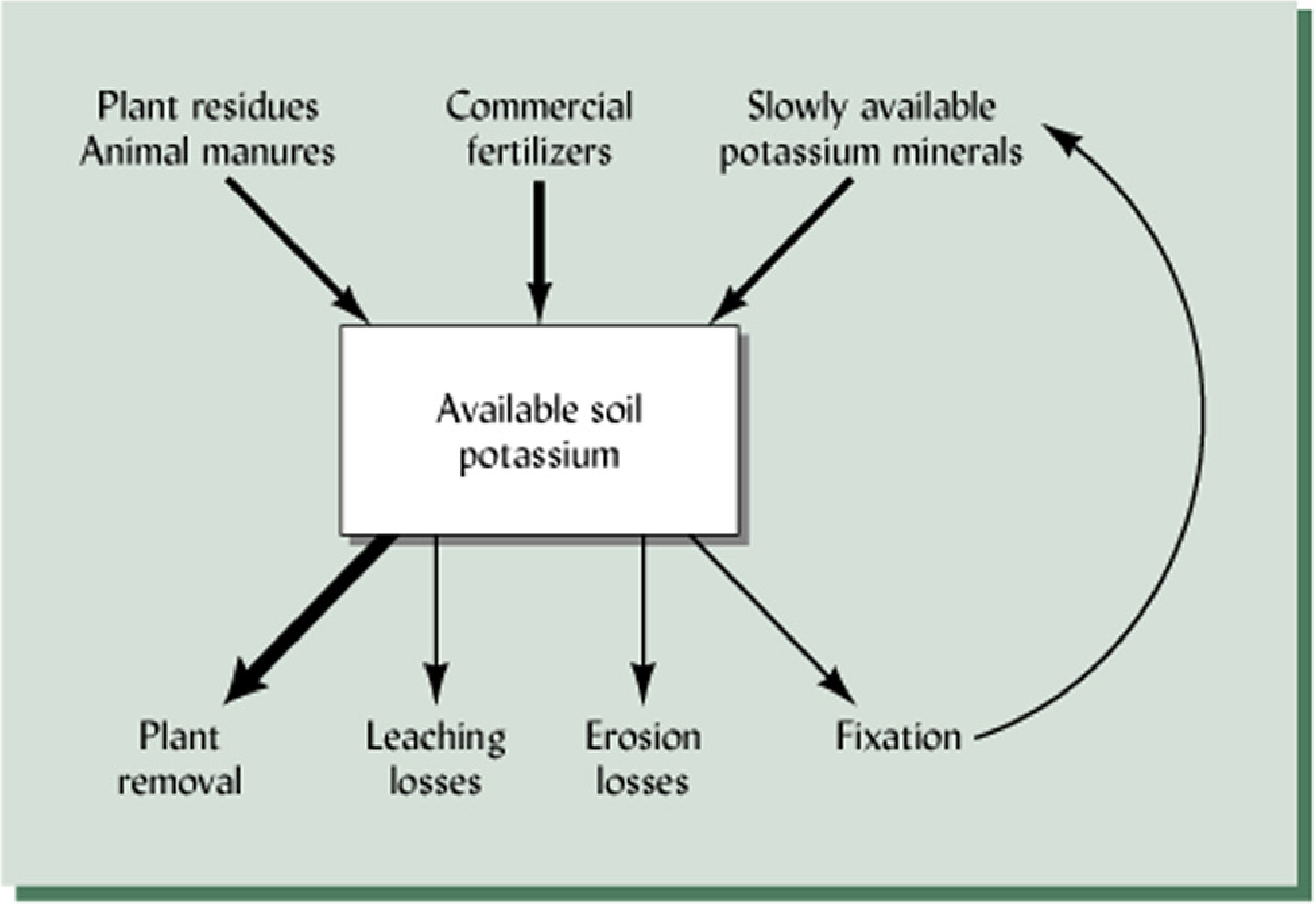
Practical K management

Not total K that is important but rate of transformation from non-avail to available

High plant need and removal (to 400kg/ha) but easily leached

- Lower dose repeated applications
  - prevents luxury consumption and leaching
- Manures and plant residue return very important
- Lime can help reduce leaching losses through increased fixation, but can impede uptake

Figure 14.36


Plant residues
Animal manures
Commercial fertilizers
Slowly available potassium minerals
Available soil potassium
Plant removal
Leaching losses
Erosion losses
Fixation

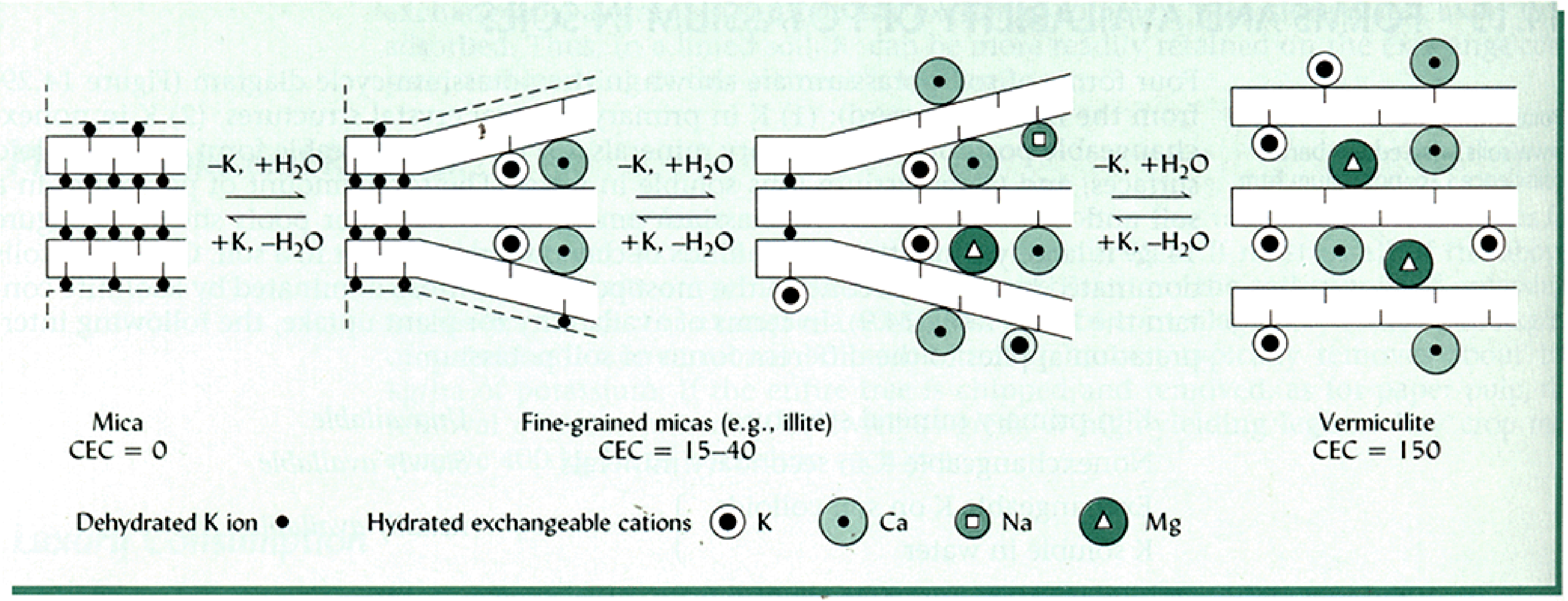


FIGURE 14.33 Diagrammatic illustration of the release and fixation of potassium between primary micas, fine-grained mica (illite clay), and vermiculite. In the diagram, the release of potassium proceeds to the right, while the fixation process proceeds to the left. Note that the dehydrated potassium ion is much smaller than the hydrated ions of Na^+, Ca^{2+}, Mg^{2+}, etc. Thus, when potassium is added to a soil containing 2:1-type minerals such as vermiculite, the reaction may go to the left and potassium ions will be tightly held (fixed) in between layers within the crystal, producing a fine-grained mica structure. Ammonium ions (NH_4^+) are of a similar size and charge to potassium ions and may be fixed by similar reactions. [Modified from McLean (1978)]

Brady & Weil. 2002.

Other Macronutrients: Ca, Mg, S

- Ca- root growth, important in disease prevention (structural in that it is part of middle lamella between cells)
- Mg- chlorophyll, enzyme reactions
- S- chlorophyll, proteins

Plate 5.—Symptoms of calcium deficiency in young and nearly mature apple leaves. Top row, upper and lower surfaces of young leaf showing early stages of discoloration and death of tissues. Bottom row, upper and lower surfaces of nearly mature leaf showing extensive areas of dead tissue.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Ca deficiency- Progressive discoloration and necrosis

Magnesium deficiency in corn, bean and apple

Courtesy of Massachusetts Agricultural Experiment Station

Plate 8.—Magnesium-starved corn. The regular yellowish-white stripes on the leaves indicate the deficiency.

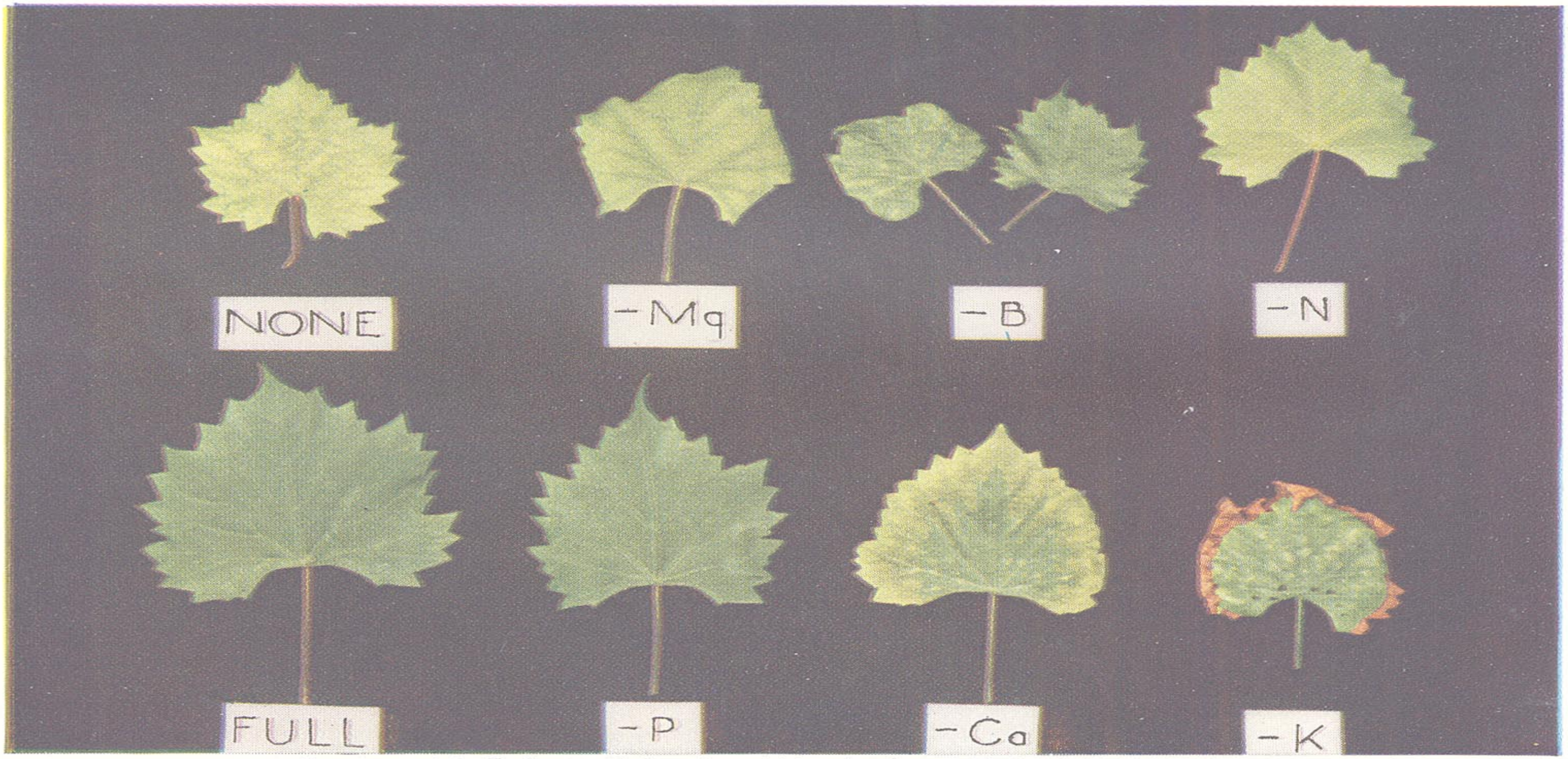
Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Figure 243. Magnesium deficiency. Note that symptoms appear initially in the lower leaves.

Plate 7.—Symptoms of magnesium deficiency in the apple. Three leaves showing successive stages of blotching. This type of necrosis starts near the base of current-season growth and progresses toward the tip. All stages of blotching may occur in leaves on the same twig.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Nutrient deficiencies in grape



Courtesy of L. E. Scott, University of Maryland, and T. B. Hagler, Alabama Polytechnic Institute

Plate 16.—Leaves of the Hunt muscadine grape when grown in sand culture supplied with nutrient solutions lacking the elements as indicated in the picture.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

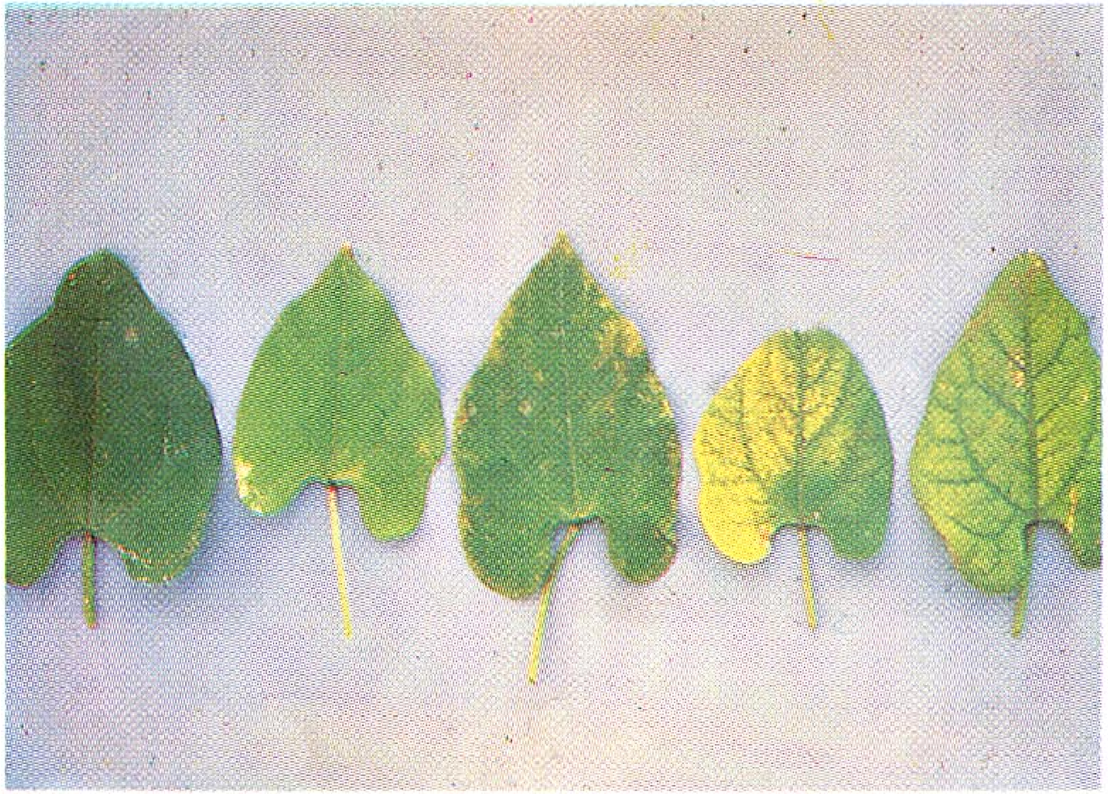


Figure 235. Characteristic symptoms of N, P, K, and Mg deficiencies in the primary leaves. The leaf on the far left is normal.

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Not a nutrient: Aluminum toxicity of bean causes yellowing and root stunting

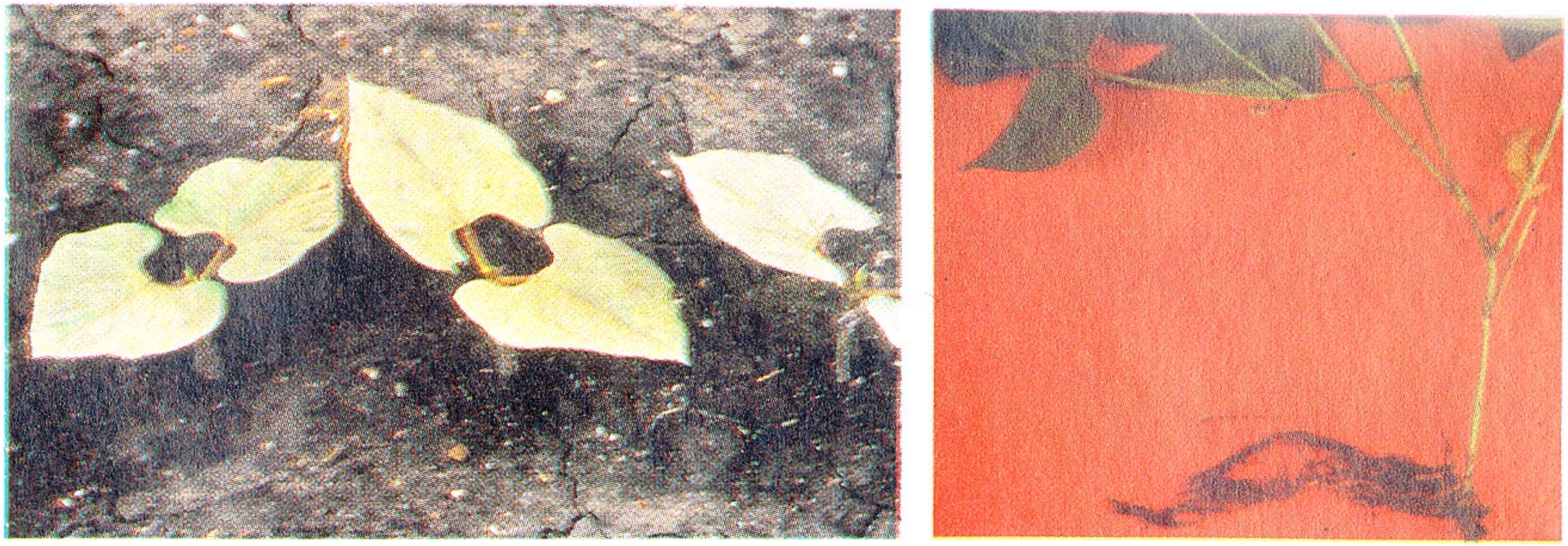


Figure 241. Symptoms caused by aluminum toxicity. Note the horizontal growth of roots.

Bean Production Problems in the Tropics. Centro Internacional de Agricultura Tropical.

How to provide nutrients

- Organic: On-farm recycling of plant residues or manures
  - Compost often provides micronutrients, but depends on feedstock
  - Manures- challenges with organic standards
- Inorganic: Off-farm inputs
  - read labels, analysis
  - form of nutrient is important in terms of availability to plant and leachability
  - More on this later...

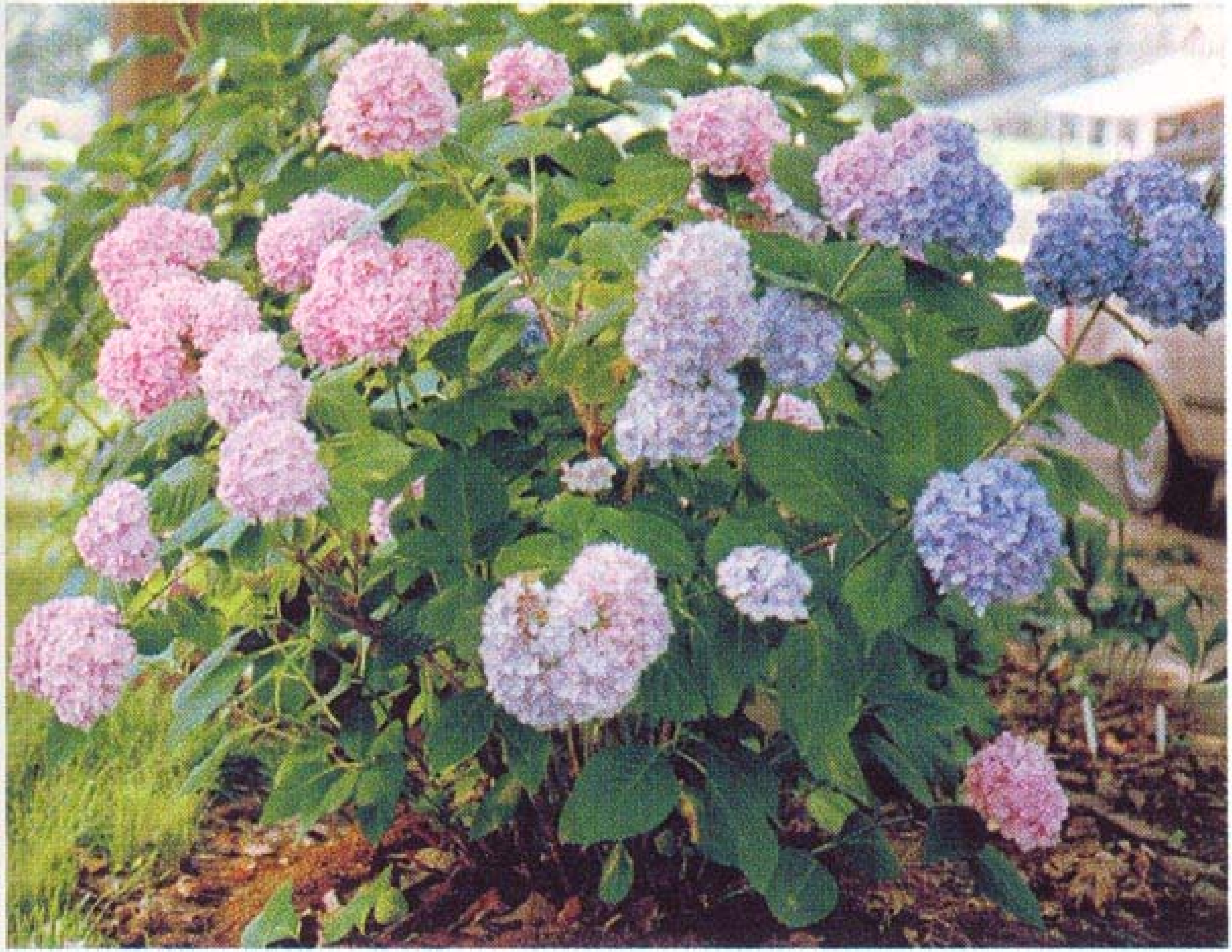


PLATE 43 The soil on the left of this hydrangea was limed, that on the right was acidified (with $FeSO_4$). After a year, blue flowers formed on the low-pH side, pink on the high-pH side.

Test yourself!

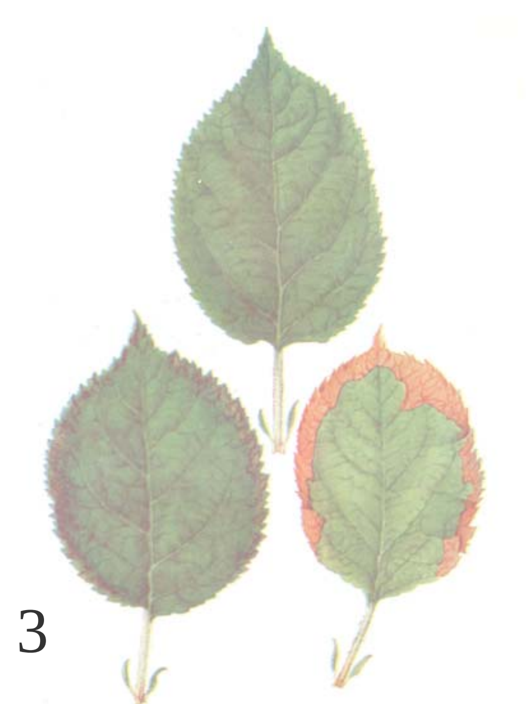
1

2

Plate I.—Nitrogen-deficiency symptoms in apple twig. Note the relatively small, yellowish-green leaves and the reddish leaf stalks, which form narrow angles with the stem.

Hunger Signs in Crops, A Symposium. 1949. 2nd ed. The American Society of Agronomy, Washington, D.C.

Test yourself!



How can you know positively?

- Plant tissue analysis

Study Questions

- B&W 1-11