Phosphorus Basics

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Phosphorus-Basics

- Atomic number 15
- Atomic weight 30.974
- Two isotopes: ^{32}P and ^{33}P
- Density 1.82 g/cm^3
- Four allotropic forms (white, red, black and violet)

Phosphorus-Basics

- Gr. Phosphoros-Light bearing
- Discovered in 1669 by Brand who prepared it from urine (by boiling, filtering, and further processing 60 buckets of human urine-dedicated scientist)
- Never found free in nature
- Must be kept under water in pure form
- Very poisonous 50mg fatal dose (white form)
- Phosphate rock (apatite, $Ca_3(PO_4)_2$) found in
  - Russia, Morroco, Fl, TN, UT, ID

Phosphorus

- Found in every cell
- 85% of P in body is in bones (hydroxyapatite)
- Phospholipids structural components of cell membranes
- Dietary P is absorbed in small intestine, excess is excreted by kidneys

P is essential element for metabolic processes

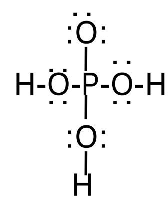
- Component of Adenosine tri and di phosphate ATP and ADP used in energy transformations
- Essential component of deoxyribonucleic acid DNA (genetic inheritance) and ribonucleic acid RNA (protein synthesis)

Soil P Forms

- Inorganic forms
  - Calcium phosphates
  - Fe and Al phosphates
- Organic forms (% of organic P)
  - Inositol $C_6(PO_4)_6$ (10-50%)
  - Nucleic acids (1-5%)
  - Phopholipids (.2-2.5%)

Most of the Earth's P is in the form of very slowly soluble minerals: for example :

- Tricalcium phosphate $Ca_3(PO_4)_2$
- Fluorapatite [3 $Ca_3(PO_4)_2$]CaF_2
- Variscite $AlPO_4 2H_2O$

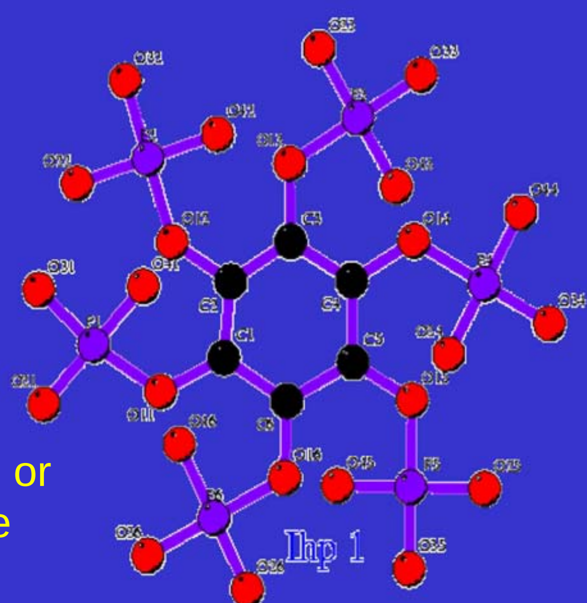


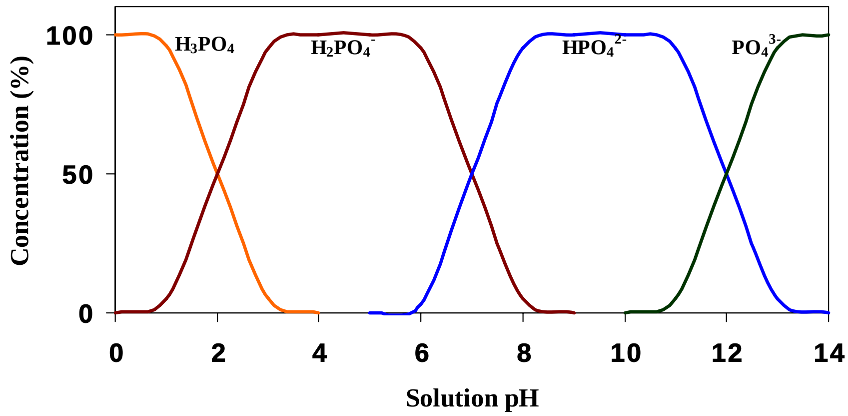
"Phosphate" = PO_4^{3-}

Phosphoric acid = H_3PO_4

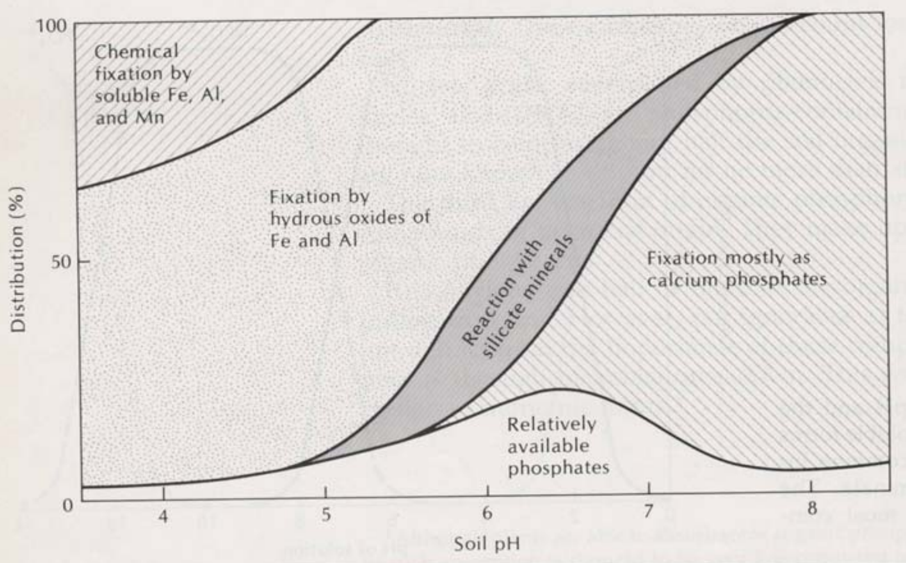
In soil solution HPO_4^{2-} and $H_2PO_4^{-}$

Inositol or Phytate





Soil pH affects mechanism of P fixation



Soil P Forms

TABLE 12.1

Total Phosphorus Content of Soils from Different Areas and the Percentage of Total Phosphorus in the Organic Form

Soils	*Number of samples*	*Total P (mg/kg)*	*Organic fraction (%)*
Western Oregon soils			
Hill soils	4	357	66
Old valley-filling soils	4	1479	30
Recent valley soils	3	848	26
Iowa soils			
Mollisols	2	613	42
Alfisols	2	574	37
Alfisols	2	495	53
Arizona soils			
Surface soils	19	703	36
Subsoils	5	125	34
Australia soils			
Spodosol	1	398	65
Vertisol	1	362	86
Mollisol	1	505	75
Hawaii soils			
Hydrandept	1	4700	37
Haplustoll	1	2250	21
Gibbsiorthox	1	1414	19
Gibbsiorthox (Subsoil)	1	2575	7

Data for Oregon, Iowa, and Arizona from sources quoted by Brady (1974); Australia from Fares et al. (1974); Hawaii from Soltanpour et al. (1988).

TABLE 12.4

Concentration of Phosphorus in Soil Solution That Provided 95% of Maximum Yield of Several Crops in Hawaii

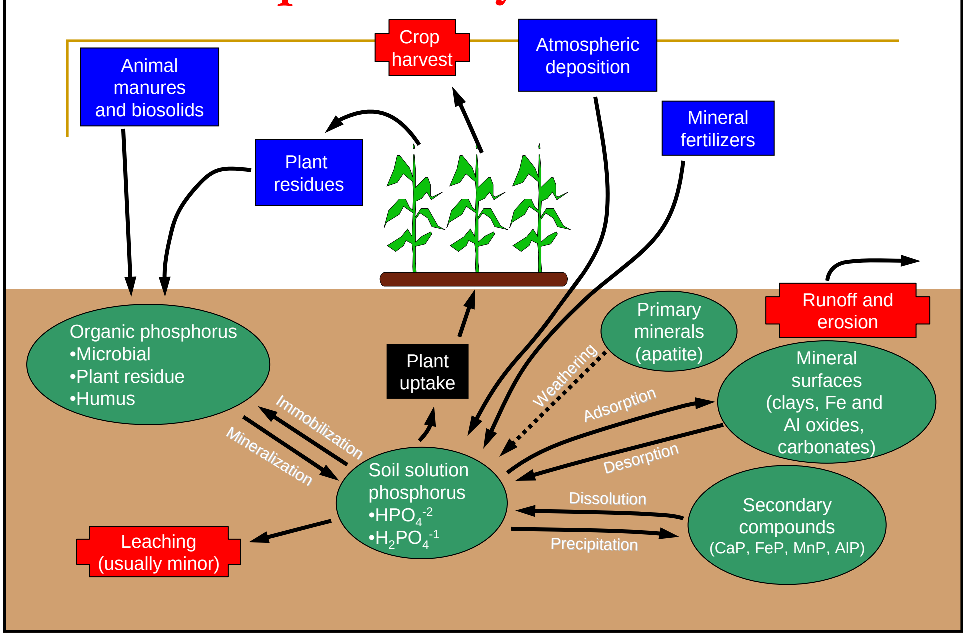
Crop	*Soil*	*Approximate P in soil solution (mg/kg)*
Cassava	Halii	0.005
Peanut	Halii	0.01
Corn	Halii	0.05
Soybean	Halii	0.20
Cabbage	Kula	0.04
Tomato	Kula	0.20
Head lettuce	Kula	0.30

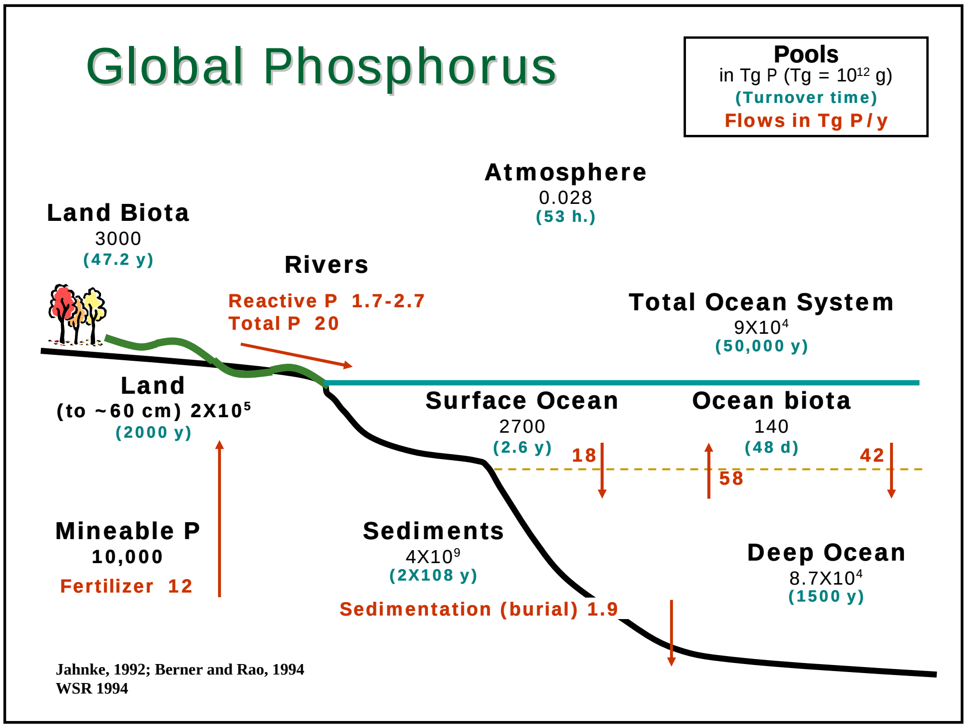
From Fox (1981).

Two Contrasting Soils for P Buffering Capacity

- Soil A
  - Sandy soil (low in P –binding compounds)
  - Little buffering
- Soil B
  - Finer textured soil (high in Fe, Al, Mn, Mg, and Ca)
  - Highly buffered

The Phosphorus Cycle

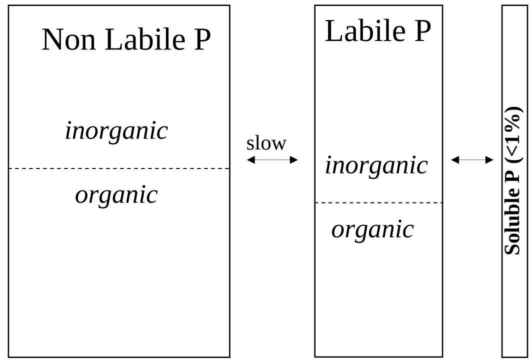




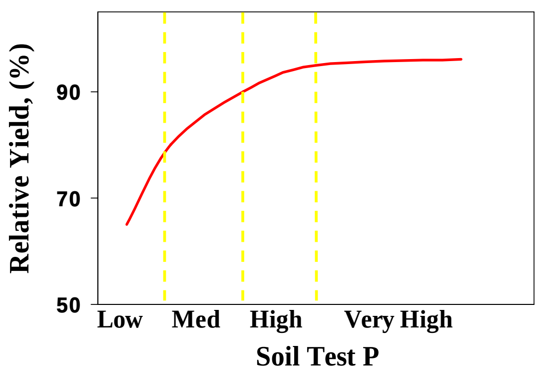
Soil Test P and Crop Response

What is “soil test P” and which forms does it measure?
How does soil test P compare with soil TOTAL P?

Soil Phosphorus Forms

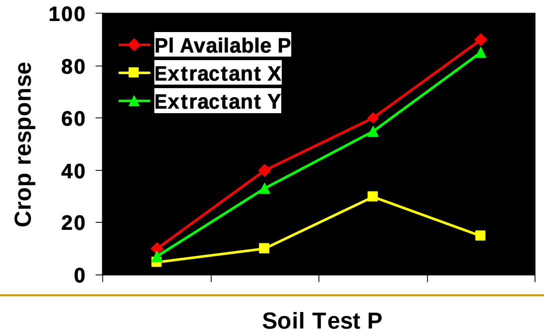


P in Crop Production



Soil Test Phosphorus

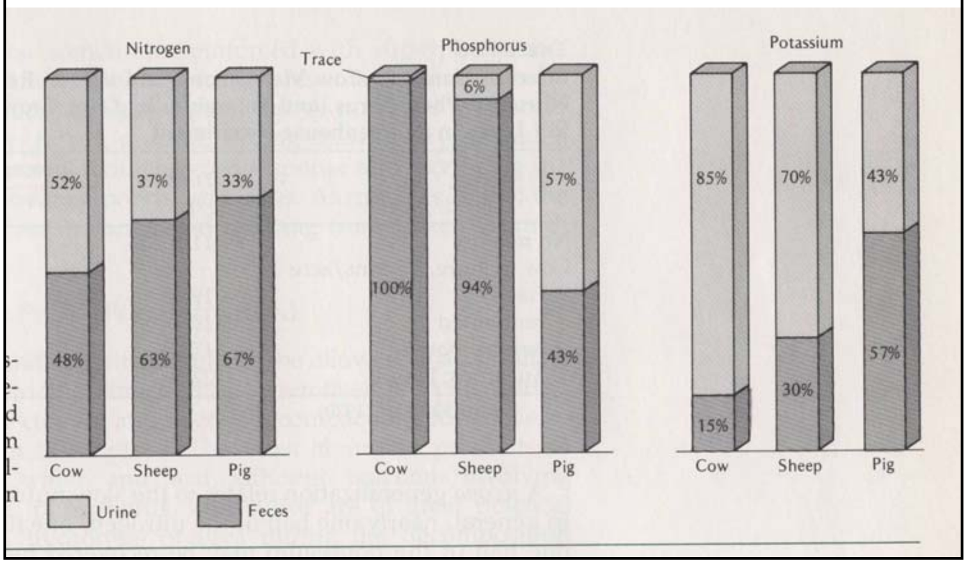
Determined by chemical procedures that extract a portion of the soil P and are used to estimate plant availability.



Soil pH determines the appropriate phosphorus extracting solution.

Soil pH	Soil P Compounds	Extractant
Acidic <6.0	Al, Fe, and Mn	Bray, Mehlich
Near Neutral 6.0-7.4	Al, Fe, Mn, Mg, and Ca	Bray, Mehlich, Olsen
Calcareous >7.4	Ca and Mg	Olsen

Distribution of N, P, and K between urine and feces for Cow, Sheep, and Pigs



Phosphorus and Eutrophication

- P is most often the limiting nutrient in freshwater systems
- Lake water concentrations >0.02 ppm generally accelerate eutrophication
- Soil solution concentrations - 0.2 to 0.3 ppm

Phosphorus and Eutrophication

Concentration of P in Cropping System Components

P source	ppm P	Comments
fertilizer	200,000	concentrated, metered precisely
manure	20,000	slow release, ideal mix of nutrients
plant tissue	2,000	cost effective way to control particulate losses, snow melt losses?
soil solution	.2	plants need energy to take up soil P
lakes	.02	critical level is relatively low for algae

P Basics - Summary

- P is an essential nutrient for plants and animals
- P is primarily found in insoluble mineral and organic forms
- P management is critical for agricultural production and for environmental quality