IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

Phosphorus (P)

Soil Tests?
Application rate?

P is essential for plant and animal nutrition

- In plants:
  - involved in photosynthesis, energy transfer, cell division & enlargement
  - root formation and growth
  - improves fruit & vegetable quality
  - vital to seed formation
  - improves water use
  - helps hasten maturity
- In animals:
  - major component of bones and teeth
  - important for lactating animals
  - P and calcium are closely associated in animal nutrition
  - essential for energy transfer and utilization

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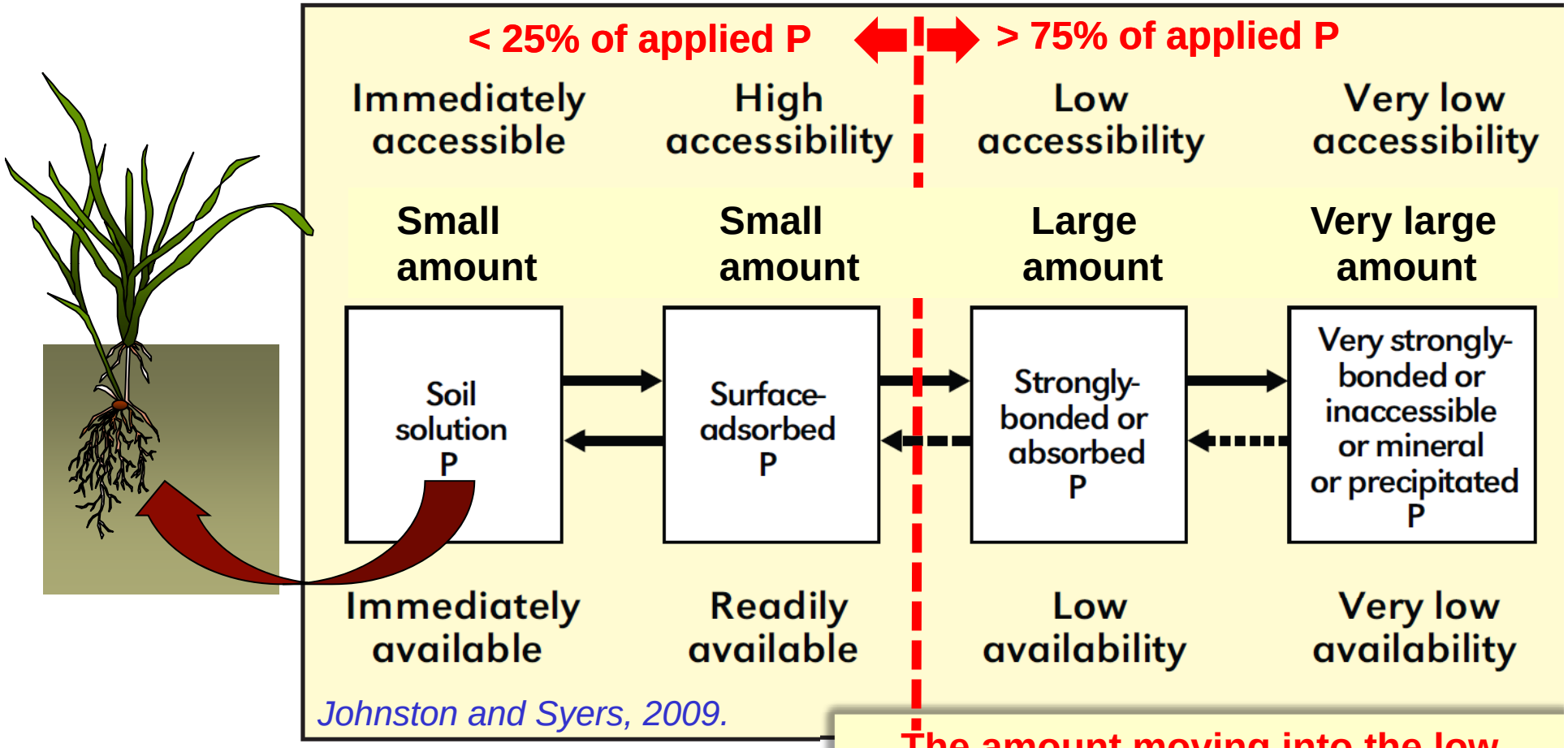
Availability and extractability of soil P pools



The amount moving into the low availability pool is estimated from the soil Phosphorus Buffering Index (PBI).

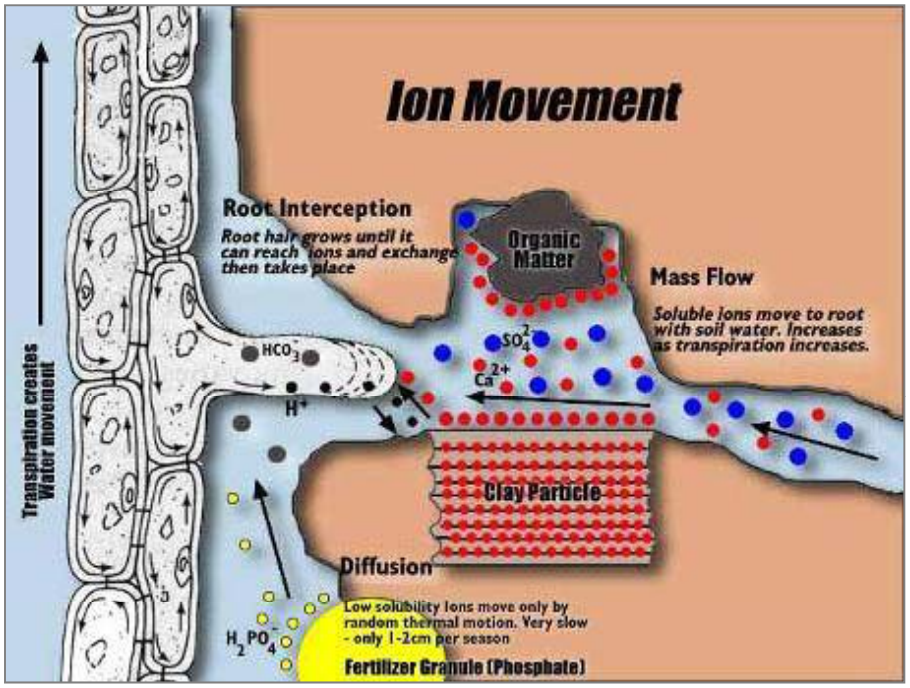
Recovery by balance method accounts for fertilizer P that enters the less available pools

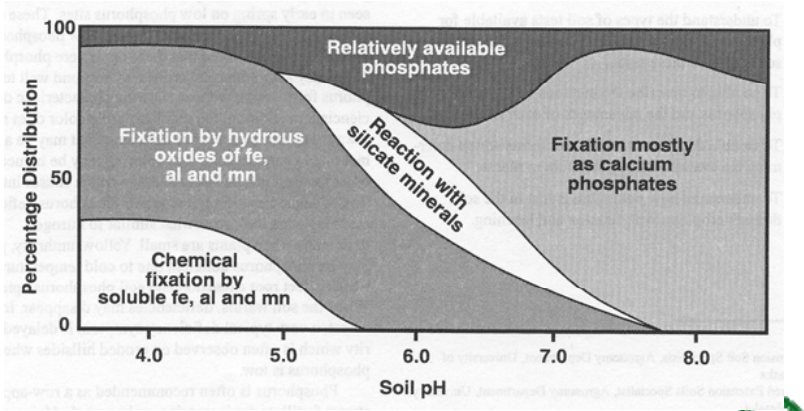
Fate of P fertilizers in the soil

- Roots and soil *compete* for P
- Fate of P is to go:
  - Into soil solution (available)
  - Precipitation (v low availability)
    - Ca phosphate (alkaline)
    - Al & Fe phosphates (acidic)
  - Adsorbtion (available)
  - Active process (energy)
  - Incorporated into organic materials
- Physical inaccessibility (position)

Losses

- Erosion & leaching
- Crop uptake





P off-take rates

- Annual removal of P
  - Vegetables = NSW 143 t, Vic 272 t, Qld 218 t, Tas 205 t (55%)
  - Fruit = NSW 227 t, Vic 201 t, 248 t Qld, 5 t Tas (45%)

- Crops (1500 t of P)
  - Potato (19%). Grapes (17%), Bananas (10%), Tomato (9%)

- Nutrient off-takes
  - Potato (0.42 kg P/t), Citrus (0.18 kg P/t), Carrot (0.40 kg P/t), Broccoli (0.86 kg P/t).
  - Potato (16 kg P/ha), Citrus (7 kg P/ha), carrot (16 kg P/t),

Quite modest off-takes on both an area basis and in absolute terms compared to other nutrients (eg 5 t/ha wheat = 15 kg P)

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Problem of P in horticulture?

- Compared the soil 34 peri-urban vegetable farms with adjacent "reference" sites (*ie* not farmed).

Land Use	$CaCl_2$ P	Colwell P	Total P	Soil C	Soil N	pH
Vegetable	4.26	224	1205	1.47	0.10	5.80
Reference	0.03	9	476	1.51	0.15	5.32
Depth (cm)	30	30	30	30	10	30

- Obviously an impact of farming but of more concern was the fact that growers were still applying P on these soils.

Chan et al. Australian Journal of Soil Research, 2007, ***45, 139–146***

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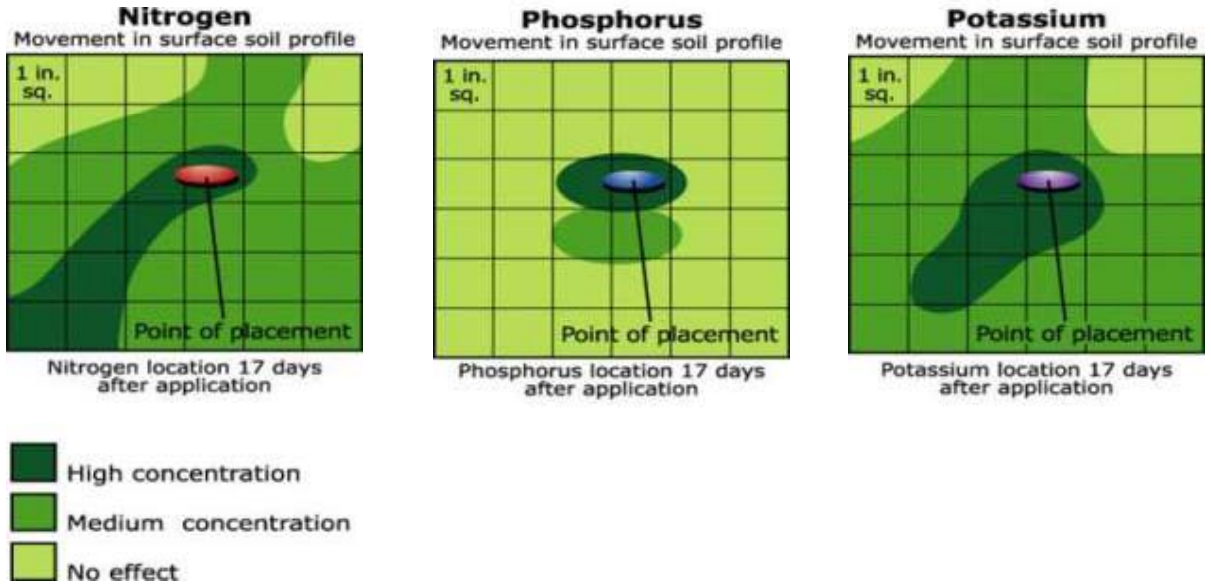
Agronomic problems with P

- Need adequate for growth
- Needs to be near the roots
- Poor P mobility compared to other nutrients



Soil tests and predicted P responses

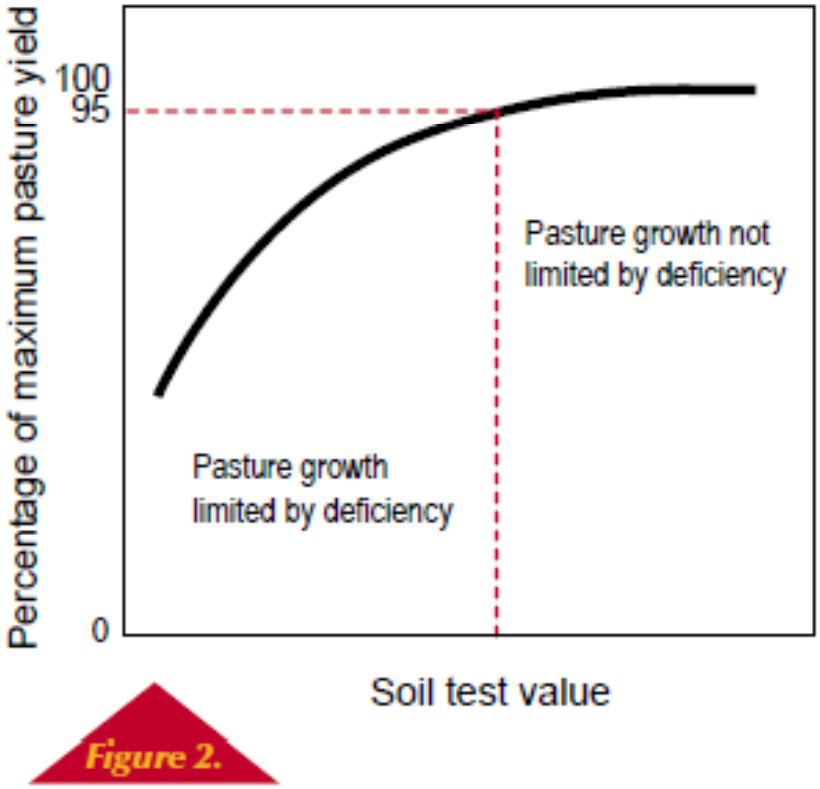


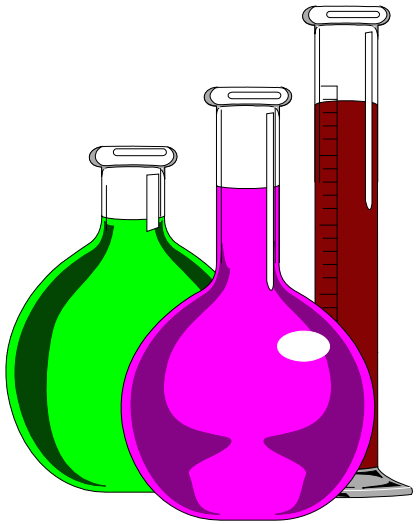
Figure 2.

A generalised calibration relationship between relative pasture production and soil test value.

- A soil test aims to give a value that indicates how limiting the nutrient is.
- Law of diminishing returns
  - Higher soil test value gives a lower relative response.
- At a critical level (95% of potential), pasture is not limited by the supply of that nutrient
  - Rainfall, other nutrients, drainage, light

Soil tests to predicting soil P availability

Test Name	Extractant & conditions	Reference
Olsen P	0.5M sodium bicarbonate (pH 8.5) 0.5 h extraction in 1:20 soil:solution.	Olsen et al. 1954. USDA Circular No.939.
Colwell P	0.5M sodium bicarbonate (pH 8.5) 16 h extraction in 1:100 soil:solution.	Colwell 1963. Aust.J.Exp.Agric.Anim.Husb. 3, 190-198.
Lactate P	0.02M calcium lactate 1.5 h extraction in 1:50 soil:solution	Colwell 1970. Aust.J.Exp.Agric.Anim.Husb. 10, 774-782.
Bray 1 P	0.03M Ammonium Flouride in 0.025M HCl 1 min. extraction in 1:7 soil:solution	Bray & Kurtz 1945. Soil Sci. 59, 39-45.
Dilute $CaCl_2$ P	0.005M Calcium chloride in 18 h extraction for 1:5 soil:solution	Moody et al. 1988. Aust.J.Exp.Agric. 23, 38-42
Acid extractable P	0.005M sulphuric acid for 16 h extraction in 1:200 soil:solution	Kerr & von Steiglitz 1938. BSES Tech.Comm. No 9.



Comparison of the extractants used, the time for extraction and the ratio of soil to extractant specified by six calibrated soil P tests.

Colwell P and plant responses

- A critical P test value depends on soil chemistry – P buffering capacity
- PBI is a measure of how much applied P is transfered to the low availability pools
- Scale 0 to 1000
- Critical value is 95% of potential

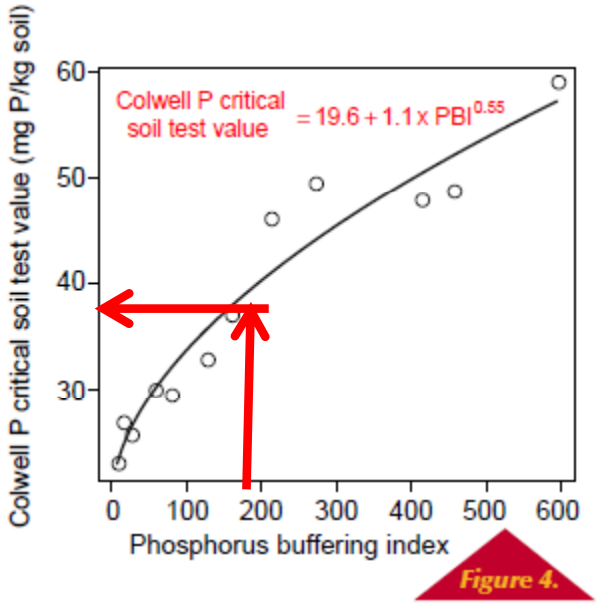


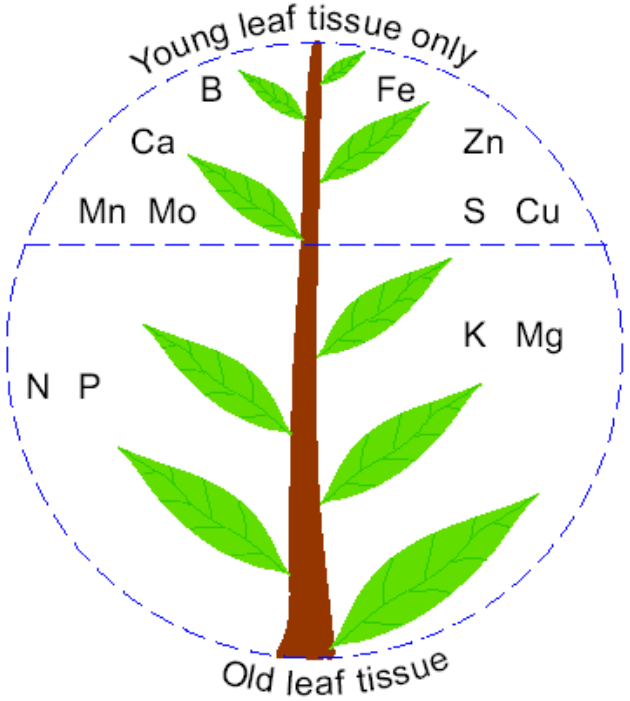
Figure 4.

The relationship between critical Colwell P value and soil P buffering index. The critical Colwell P value is the soil test value predicted to produce 95% of maximum pasture yield.

PBI Category		Critical Range
<15	Extremely Low	20-24
15-30	Very very low	24-27
36-70	Very low	27-31
71-140	Low	31-36
141-280	Moderate	36-44
281-840	High	44-64

Spotting P deficiency

- P is relatively mobile in the plant
- So – *shows up first in older leaves*
- Plants dark green with purple tinge
- Leaves and plants small and thickened



After planting (potato)	60	90	115
Petiole P	3500	2200	1000

Location, Timing, Cultivar

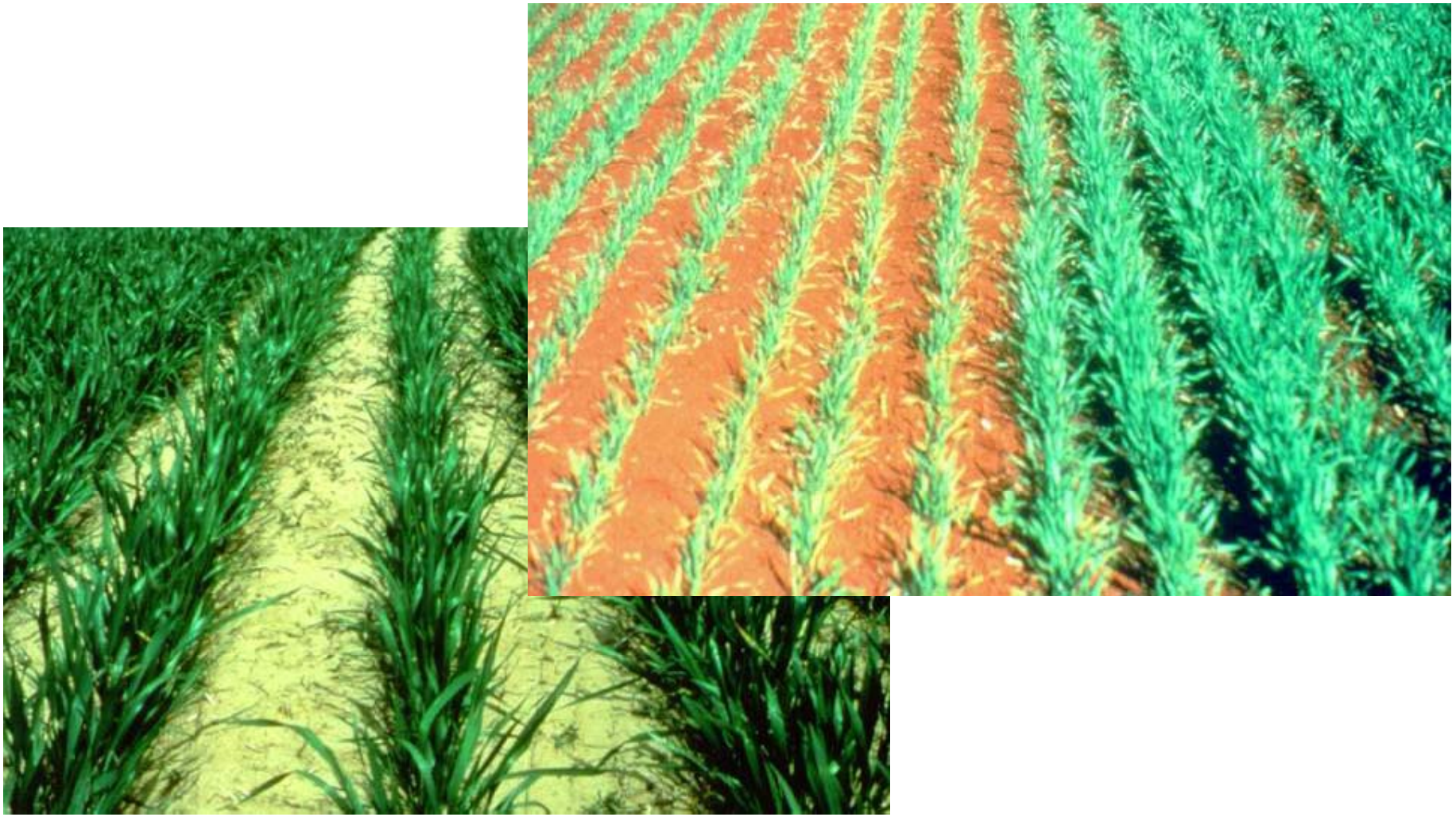
	Deficient	Marginal	Adequate	High	Toxic
P (%)	<0.2	0.2-0.24	0.25-0.50	>0.50	

Vine petiole values)

P deficiency

… purpling of leaves / stems

P deficiency



… stunted growth

Major P containing fertilizers

Fertilizer	%P			%S	%N	%Ca	Kg to apply 10 kg Pav
	Total	Water	Citrate				
Rock Phosphate	*11.9*	0	2.5	-	-	-	400
Reactive RP	*13.0*	0	5.0	1	0	38	200
Superphosphate	8.8	8.0	0.6	11.0	0	19	115
TSP	20.7	16.1	4.0	1.0	0	15	30
Phos Acid	25.6	25.6					
DAP	20.0	17.8	2.0	1.6	18	-	30
MAP	21.9	18.1	3.7	1.5	10	-	30
Pig Bedding (40% mc)	0.45	?			0.75		2200

Also a range of fluid P sources – require specialised application equipment, but the grains industry have recognized that fluids are never worse than granulated P sources, and in some cases better.

Developing a P strategy

- Important to know soil reserves – calibrated soil tests
- P should be matched to potential demand
- P is immobile and quickly bound – so at planting is most efficient
- In high PBI soils or soils with low soil test values banding may be more effective than incorporation.
- P in fertilizers is not all equally available – water & citrate soluble P forms important.
- Fluid P could offer some value – especially on soils with free carbonate.
- Fertigation offers some in-crop flexibility and should improve efficiency (blockages). Tech MAP, PhosAcid.

Phosphorus and the environment

- Eutrophication- the natural aging of lakes or streams by nutrient enrichment
- Nutrient additions can accelerate the process
- P is often the limiting element
- Dissolved oxygen is depleted by excessive plant growth
- BMPs can help minimize P runoff from fields