PHOSPHORUS (P)

THE ROLE OF PHOSPHORUS IN THE PLANT

Phosphorus (P) plays a central role in conserving and transferring energy in cell metabolism. P deficiency causes a reduction in seedling vigour, plant establishment and root development. Deficient plants are usually stunted, dark green in appearance and exhibit delayed flowering, boll set and maturity.

In short or cool, wet seasons, good P nutrition is essential to avoid delayed crop maturity.

Both phosphorus and potassium are important in late-season crop nutrition, as they are implicated in the premature senescence syndrome. As the crop matures, phosphorus is translocated from the leaves to the developing bolls. Where crop P uptake is reduced through waterlogging or overcast weather during boll filling, there may be insufficient P in the leaves to support the demand for P from the bolls. This reduces P in the leaves so that photosynthesis and plant metabolism declines and the crop prematurely senesces.

UPTAKE AND REMOVAL OF PHOSPHORUS

High yielding cotton crops typically take up 25-30 kg P/ha and remove about 20-25 kg P/ha in the seed cotton, equivalent to approximately 2 kg P/bale. On soils with a long history of cotton production, this amounts to a substantial reduction in soil P reserves. Peak P uptake (0.3-0.6 kg P/ ha per day) occurs between mid-flowering and boll filling.

PHOSPHORUS DEFICIENCY SYMPTOMS

P deficiency symptoms for cotton include stunted plants with dark green foliage, which may later become discoloured. Where the deficiency is not corrected, fruiting is delayed and restricted.

CRITICAL P LEVELS IN THE PLANT

Plant tissue tests can also assess crop P status. The concentration of P in the youngest mature leaf (YML) is relatively independent upon the stage of crop development and is normally around 0.33% P for healthy cotton crops.

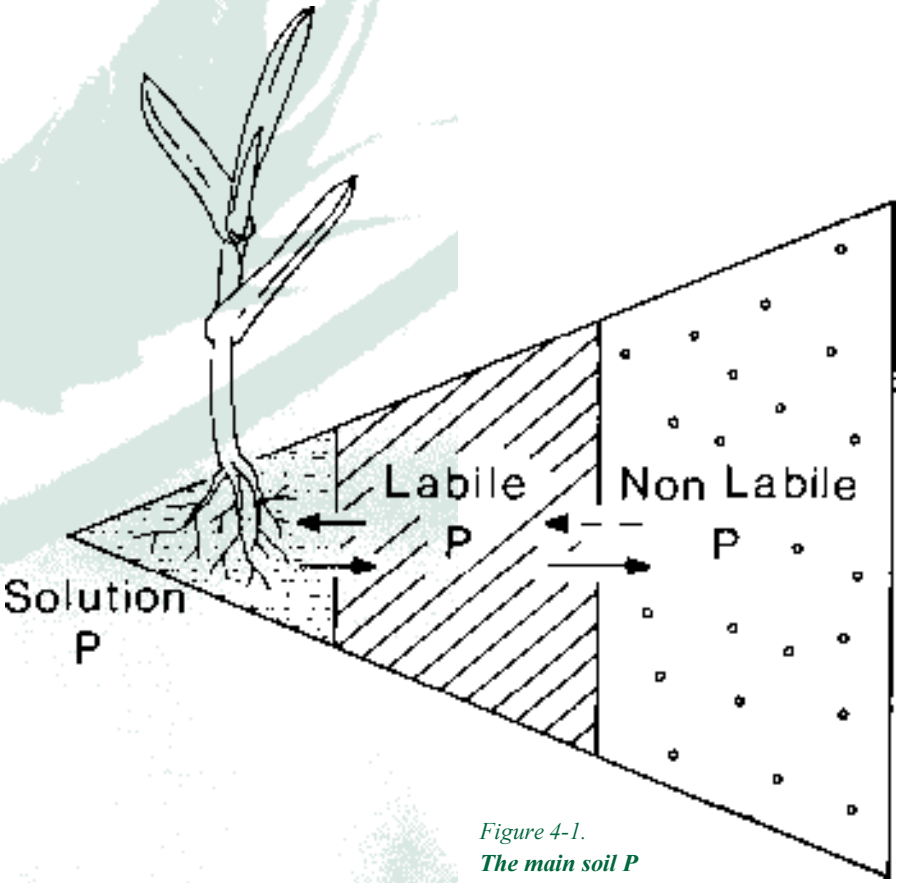


Figure 4-1.
The main soil P pools.

Figure 4-2.
Phosphorus is cycled between soil and crop pools.

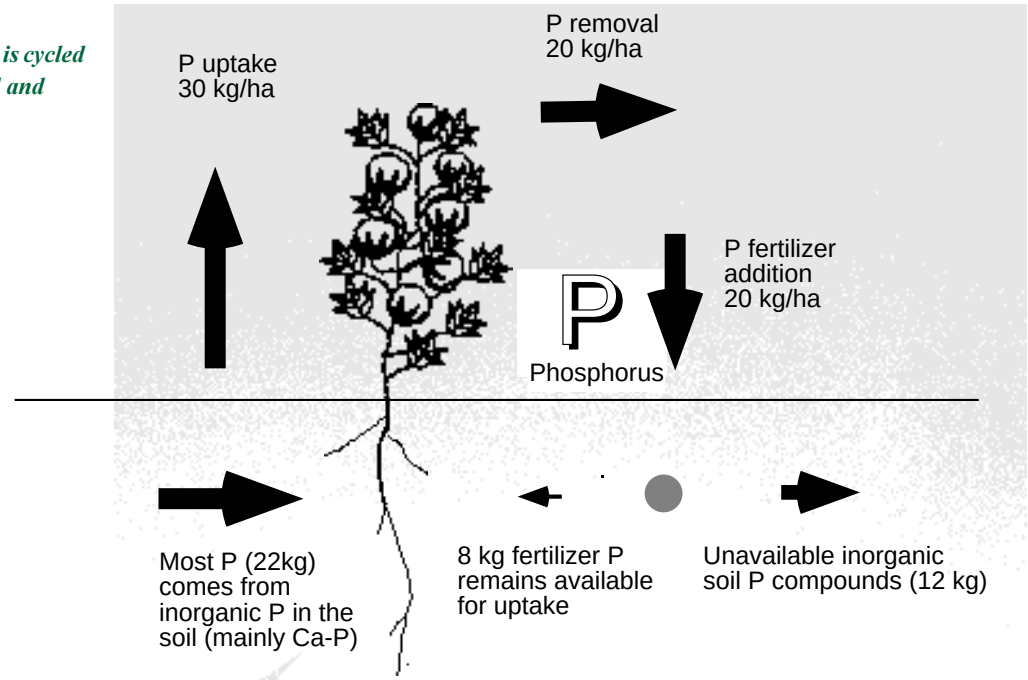
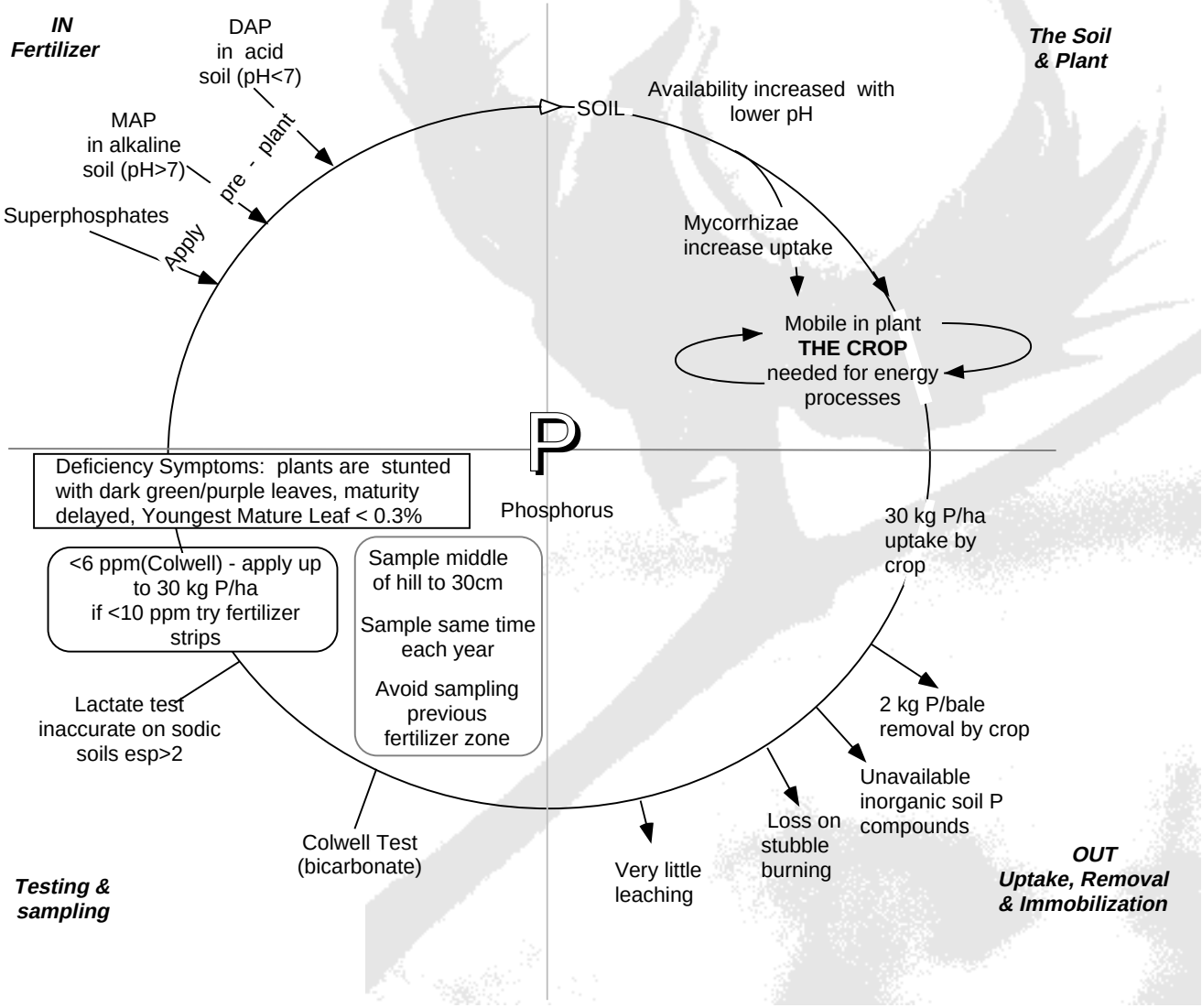


Figure 4-3.
Summary of Phosphorus management issues.



PHOSPHORUS FERTILIZERS

If P deficiency is suspected, either due to declining soil P levels or poor crop vigour, then P fertilizer may be required. P can be applied in small test strips to assess the need for P. Mono-Ammonium Phosphate (MAP - N:P:K - 9:22:0) is the most common P fertilizer used since it forms a slightly acidic product and remains in solution longer than superphosphate. Recommended rates are 10-20 kg P/ ha (45-90 kg MAP/ha). This should be banded to a depth of 10 cm and 10 cm off the planting line, close to sowing. If P fertilizer is applied over the whole field, leave a nil strip to determine if P application can improve crop growth.

Banding is more effective than broadcast application since soil/fertilizer contact is reduced which increases the availability of the fertilizer P. Plant roots proliferate around the band of P fertilizer.

Low rates of P can be applied with the seed (up to 9 kg P/ha or 40 kg MAP/ha) where there is good seedbed moisture. There is a danger that the ammonia released from the MAP will affect germination and seedling establishment. For this reason, DAP (18:20:0) should not be applied with seed. Side-dressing P fertilizer between sowing and squaring may not be as effective as applying P pre-sowing.

Foliar P fertilizers are not commercially available in Australia.

MONITORING SOIL P

The highest concentrations of P occur in the surface 30 cm of soil but significant amounts may also be found in the subsoil. Cultivation, land forming and laser levelling will affect the distribution of P within the profile. The tests most commonly used to determine plant-available soil P are the Colwell (bicarbonate extractant) and Lactate (more acidic extractant) tests. The Colwell P test gives the better indication of P availability to cotton. P fertilizer should be applied when Colwell P is less than 10 ppm. When Colwell P is less than 6 ppm, higher rates of P fertilizer may be warranted.

Soil pH, texture and buffering capacity influence soil P availability and the likelihood of crop response to P fertilizer application. Most Australian cotton soils have sufficient P to meet the P requirements of cotton. Available P may fluctuate during the year depending on soil temperature and moisture status. Hence, soil samples should be collected at the same time of year and under similar soil conditions to assess soil P status over seasons.

Soil samples should be taken during the fallow prior to sowing to determine whether P fertilizer is required for the next cotton crop. Soil samples should be taken from the top of the hill to a depth of 30 cm, which represents the rooting zone of young cotton plants. Several samples should be taken across the field or area within a field (see section on soil sampling and analysis in this manual).

SOIL P AVAILABILITY

Approximately 40% of the area planted to cotton in Australia receives some P fertilizer. However, the response to fertilizer P is often variable, even in the same field over seasons.

Australian cotton-growing soils have a high clay content, high cation exchange capacity (CEC) and are alkaline (pH > 7.5). Under alkaline conditions, P availability is often low, despite the soil having high total P content. Soil P can be classified into three pools:

- available P (P as phosphate in the soil solution is available to plants)
- labile P (moderately available P, that moves in and out of solution depending on soil pH, temperature, moisture and removal by plant roots)
- poorly available P (comprises very insoluble P minerals and organic P that is not available to plants)

The three pools are linked, but the first two are the most important when considering P nutrition of cotton (Figure 4-1). As plants grow, their roots deplete the available P in the soil solution. P from the labile fraction moves into solution, thereby maintaining the concentration of available P in the soil. When the soil solution P concentration is increased (as after application of P fertilizer), some available P will be transferred into the labile pool until the system is again in balance (Figure 4-2).

Australian cotton soils have a high P buffering capacity. This means that:

- as cotton plants grow and remove P from the soil solution, this pool of P is quickly replenished from the labile P pool
- when P fertilizers are applied to alkaline soils, much of the fertilizer P moves into the labile P pool

With continued cotton cropping, the labile P pool may be depleted quickly (unless P fertilizer is added), reducing the ability of the soil to maintain adequate available soil P levels.

MYCORRHIZAE (VAM) AND P UPTAKE

Phosphorus is an immobile element within the soil and so increasing soil/root contact can increase uptake of P by a crop. Many crops, including cotton, achieve this through an association with mycorrhizal fungi. The fungal hyphae infect the root and accumulate nutrients for the plant. The fungi increase the volume of soil accessible to the crop several fold and are essential for cotton plants to accumulate sufficient P (and zinc) from the soil.

The response of cotton to P fertilizer is more likely where mycorrhizal colonisation is reduced with low soil temperatures or following long fallow periods. *Long fallow disorder* has been associated with poor mycorrhizal colonisation, since long periods of bare, weed-free fields, or growth of non-mycorrhizal crops, such as Canola, reduce the amount of VAM in the soil. The critical soil P limits may be higher where mycorrhizal colonisation is reduced (Colwell P 10-15 ppm).

SUMMARY OF P MANAGEMENT ISSUES

- most Australian cotton soils have sufficient P to meet the P requirements of cotton
- crop response to P fertilizer is likely where Colwell P concentrations are less than 6 mg/kg
- where Colwell P levels are between 6-10 mg/kg to determine if P fertilizer is required, nil strips should be left in the field
- banding 20-40 kg P/ha close to planting is the most effective means of applying P if soil P is limiting to plant growth.

PHOSPHORUS

CHAPTER 4

Cotton leaf showing advanced phosphorus deficiency - note red/purplish colour. Photo Philip Wright.

P-deficient cotton. Older leaves are dark red/purplish coloured, new leaves are light green. Photo Ian Rochester.

CHAPTER 4

PHOSPHORUS

Growth response of cotton to P fertilizer. Plant on right was grown in unfertilized soil (Colwell P - 6 mg/kg). Photo Chris Dorahy.

P-deficient cotton plants have purple/red leaves, bolls are fewer and smaller and maturity is delayed. Photo Chris Dorahy.