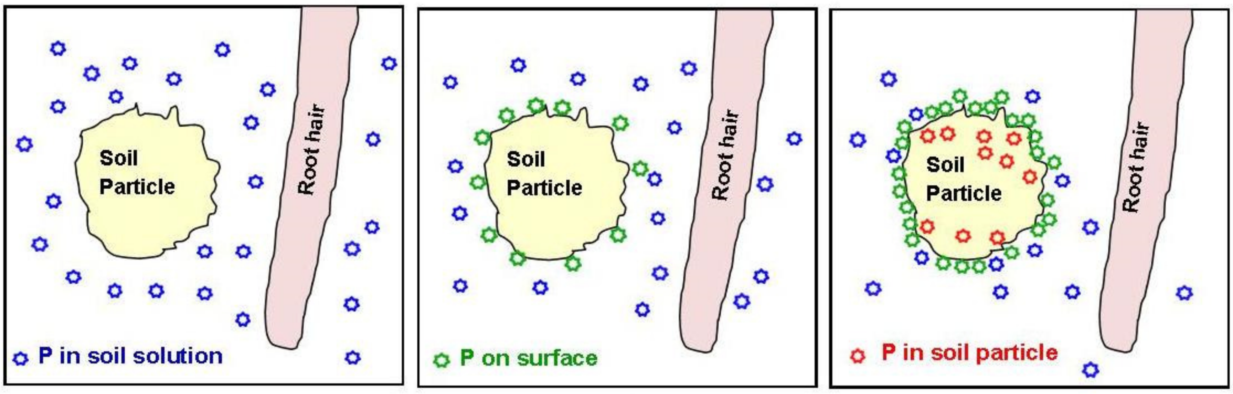
Soil Phosphorus (Part 4) – **P Fixation**

In Part 2 in this series on Soil Phosphorus (P) we looked at some of the processes/products involved in the P cycle, and noted that at any point in time, P can exist in a variety of different forms in the soil, depending on the prevailing soil conditions (pH, moisture, temperature, concentration of ions present etc). In Part 3 we looked at soil tests - tools to help determine the amount of P in the soil.

Plant available P generally corresponds with the P in soil solution and other readily available P which in essence means P loosely held on the surface of soil particles/minerals or P which has precipitated out of soil solution into temporary P compounds (of which some are able to re-dissolve to release additional P to the plant roots).

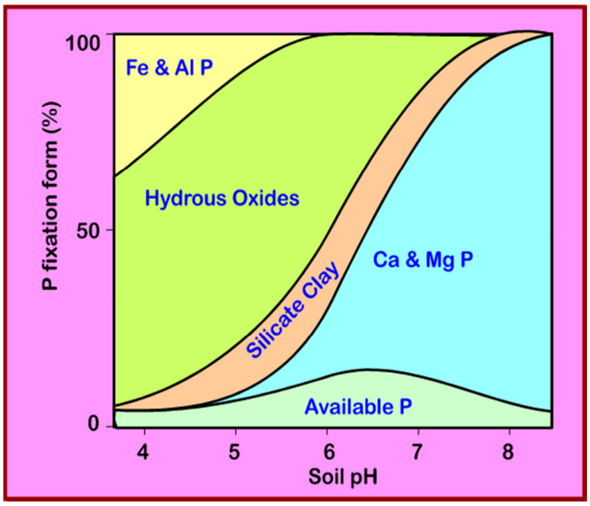
P fixation is a term that is used in a couple of different ways. Firstly, it refers to a specific property of a soil, namely its inherent ability to bind with/hold onto negatively charged ions (anions) – this property is also called anion sorption capacity (ASC) or P retention. Secondly, P fixation is also a more general term which describes the processes that take place within the soil, that cause plant available P to gradually become more and more unavailable as it is converted into less plant available forms.

In this article, P fixation refers to the second usage. Though P fixation involves both organic and inorganic forms of P, we are only considering the inorganic processes of P fixation, and in particular, those processes which occur in an acidic soil environment (which is typical of most NZ soils).



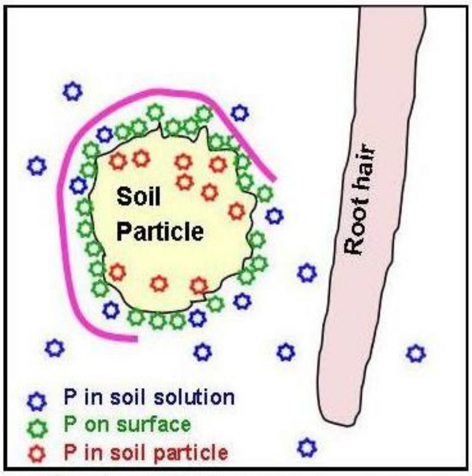
P Fixation - P molecules in soil solution initially become attached to the surface of soil particles and eventually embedded within them

Some of these processes are simplified into diagrammatic form in the figure above. In essence, the P in soil solution becomes loosely bonded on the surface of various soil particles and minerals. As more time elapses, much of the surface bound P becomes embedded within the structure of soil minerals and increasingly unavailable as a source of P for plants.



As mentioned earlier, the form of P present in soil at any point in time is dependent on a variety of other soil conditions. Chemical properties are very important and influential in this regard, and particularly the soil pH. The figure to the left illustrates how the various P fixation forms change as pH changes.

In most agricultural situations, the soil pH is in the range of 5.8 – 6.2 and plant available P is close to its maximum. But even in this range, P fixation reactions are taking place, forming or reforming the products listed in the figure. The net result is that the P fixation processes reduce the availability of plant available P. (N.B. “hydrous oxides” is a technical name to describe water molecules attached to metal oxide compounds).



Occluded P - P that is buried beneath secondary compounds

When the pH of either the bulk soil or the various soil pores drops lower, then iron, aluminium and manganese phosphate form, further reducing levels of plant available P. Together with the hydrous oxides and other secondary compounds, these precipitates can form coatings (cf pink line on figure to left) which bury the plant available P, also rending it unavailable. Such “buried” P is called occluded P.

In the past, it was thought that the P fixation processes always resulted in P becoming less plant available. As a result, there was an associated high ongoing requirement for P fertiliser to offset these (and other) P losses within the soil. It is now increasingly recognised that P fixation is not completely permanent and that the soil physical and biological environment plays a particularly important role in this regard i.e. in a well-structured, well-functioning soil, with good biology, some “fixed P” can be recovered to once again become plant available.

Sometimes other similar terms are used to describe the P fixation reactions and P availability in the soil. P in soil solution and on the surface of the soil particles is sometimes called “labile P” to indicate that it is plant available. On the other hand, P which becomes embedded and/or part of the structure of the soil minerals and other secondary compounds that form in the soil, or which becomes buried or occluded is called “non-labile” or “inert” P, to indicate it is essentially unavailable to plants.

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