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P-Cycle in soils and the optimal P uptake by plants

Phosphate plays an important role in the photosynthesis process of plants as well as in the conversion of carbohydrates and energy transfer within the plant, the metabolism of amino acids, fats and the formation of seeds.

The phosphate abundance in agricultural soils is far less than that of nitrogen and potassium. The amount of phosphate in soils only consists of 0.005% to 0.0015% of the total soil volume. The fact that the phosphate in the soil is not always plant available also contributes to the fact that we need to take notice of the plant available P levels when considering a fertilization program. Plant available phosphate is influenced by the different soil nutrient ratios, the different forms of P in the soil, and the micro-organism activity in the soil.

The majority of P lost from soils is due to plant uptake of P from the plant available pool of phosphate in the soil. Wind and water erosion also contribute to P losses from soils. The plant available P in soil is taken up by plant roots after it was made plant available by the soil organisms that “mine” the non-plant available P pools and release these “mined” P fractions into the plant available pool.

Soils with a low pH and a high acid saturation will cause the plant available P to react and bind with aluminium and iron to form non-plant available precipitations. In soils with a high pH, the plant available P will react and bind with calcium to form calcium phosphate precipitations, these precipitations are not plant-available and will need to be dissolved by lowering the soil pH as well as correcting the soil nutrient ratios.

There are three pools of phosphate in the soil: labile phosphate, non-labile phosphate, and soil solution phosphate. The soil solution phosphate is immediately plant available. The labile and non-labile consist of the organic as well as the inorganic phosphate fractions in the soil. The labile phosphate is the partial plant available P in the soil that will supply phosphate to the dissolved phosphate within the soil solution due to the high dissociation rate of the labile P towards the soil solution phosphate. As the labile P decreases the non-labile P will supply the labile P slowly until a state of equilibrium has been reached.

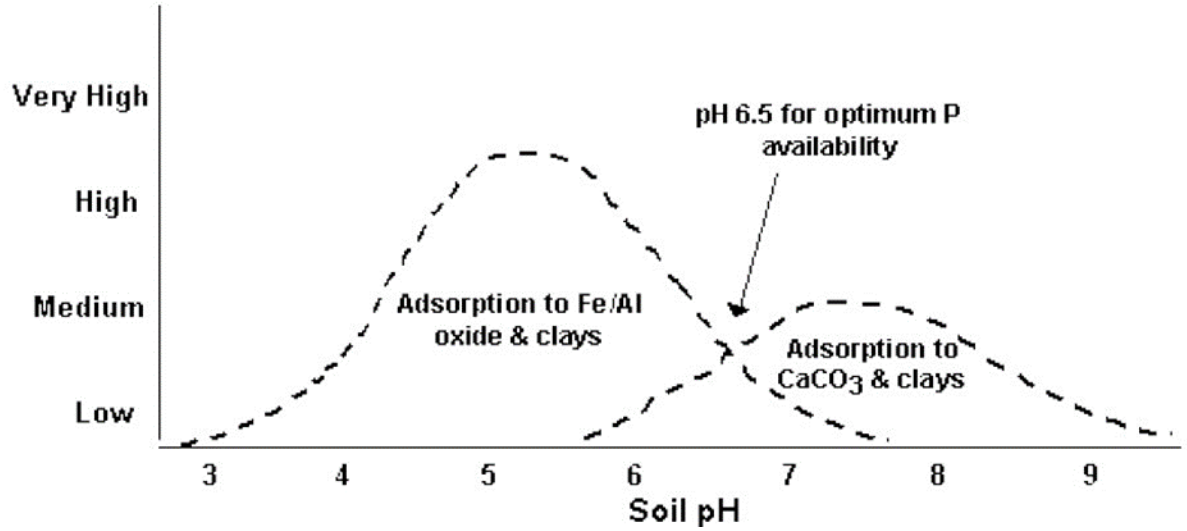

Figure 1 Availability of phosphate at different soil pH levels

Phosphate is taken up by plants in two forms known as $H_2PO_4^-$ (dihydrogen phosphate) or HPO_4^{2-} (hydrogen phosphate) or commonly referred to as orthophosphate ions. In soils with a pH of 4-7 the $H_2PO_4^-$ orthophosphate ion will be preferred and taken up by plants whereas at a pH above 8.5 the HPO_4^{2-} ion will be preferred for uptake by plants.[1]

1 Adapted from soil science class notes for SOIL3714 of the UFS department of agriculture

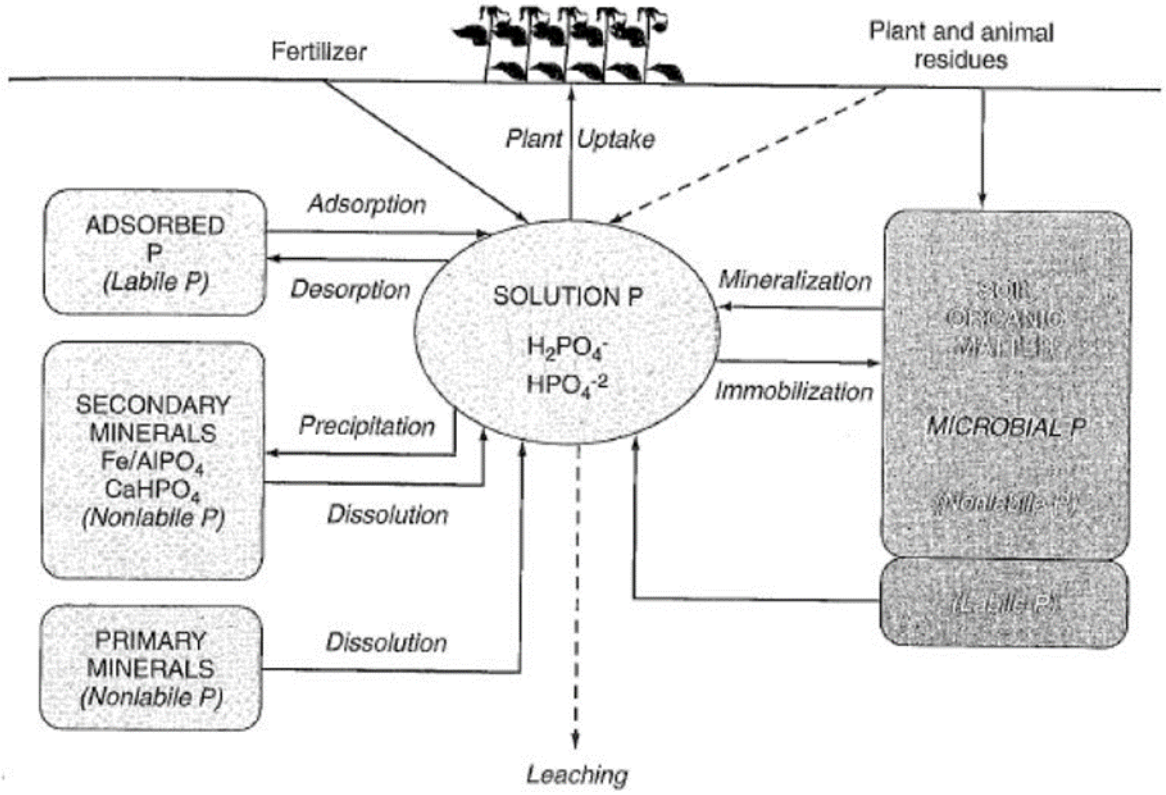

Figure 2 Schematic illustration of the phosphate cycle in soil

The most effective way to increase the availability and uptake of soil phosphate for plants is by managing the soil pH as well as the calcium and magnesium ratios in the soil to prevent these levels and ratios to get out of hand and suppress the phosphate levels in the soil as well as favouring the formation of phosphate precipitations within the soil.

The biggest results and success are achieved when liming of soils are implemented with the CORRECT lime source that will include calcitic as well as dolomitic lime at the **correct rate** at the **correct place** and the **correct time**. Slower results can be achieved through the stimulation and improvement of the microbiological activity in the soil. Mycorrhiza in the soil will assist in the “mining” of unavailable phosphate and release these “fixed/unavailable” phosphates to be taken up by the plant roots.

The optimal phosphate management together with the correct liming practices will result in the highest possible results for the producer regarding phosphate uptake.

The four most important phosphate management practices in soil are:

- *pH management through liming to achieve a pH between 6.5 and 7.*
- *Small amounts of P fertilization constantly.*
- *When soil P levels are below 20ppm*
    - *Do a band placement of P correction to limit phosphate fixation.*
- *When soil P levels are above 20ppm*
    - *Broadcast your P correction to improve the overall P status of your soil.*