Phosphorus and VAM

Role in plants and animals

Phosphorus is a critical element for the growth and development of both plant and animals, and is often one of the limiting factors to agriculture in Australia. Phosphorus is involved in the transfer of energy within cells, and as such it is vital for photosynthesis, respiration, energy storage, cell division and growth and reproduction. It is also important for proper bone structure in animals. In plants, phosphorus deficiency generally shows up as a lack of vigour, and purple colouring of the leaves. Phosphorus is often recognised as being important early on for crop and pasture establishment and root growth, mostly due to its role in photosynthesis and growth in both shoots and roots. However the need for phosphorus doesn't stop after establishment – adequate phosphorus is important for growth and development at all stages of the plant's (or animal's) life.

Phosphorus deficient corn.

Reactions in the soil

Phosphorus is an extremely reactive element and forms a large number of different compounds and associations in the soil. These vary in their solubility and in their availability to plants. Some of the most common phosphorus compounds in the soil are insoluble or sparingly soluble Aluminium and Iron Phosphates in acid soils and Calcium Phosphates in alkaline soils. Phosphates also bind or 'adsorb' to the edges of clay particles and other soil minerals, and are present as organic forms. Thus there are a number of different 'pools' of phosphorus in the soil.

In order for phosphorus to be taken up by the plant it must first come into the soil solution. Generally, only a small amount of the phosphorus in the soil is in solution at any one time because it exists in such sparingly soluble forms. Once this soluble portion of phosphorus is taken up by the plant more phosphate can dissolve and become available. The phosphorus which will easily dissolve is termed the 'labile' pool and the speed with which this can dissolve is a critical factor in determining the amount of phosphorus available to the plant over its life cycle. This labile phosphorus can come from different sources depending on the properties of the soil, for example the adsorbed forms are often more important in neutral and alkaline soils, and in acid soils the aluminium and iron compounds may often be the biggest source of labile P.

On the other hand, when phosphorus is applied in a soluble form the soil becomes quickly saturated, and the phosphorus will begin to react and become insoluble.

Measuring

When we measure soil phosphorus we generally try to get a measure of 'available' Phosphorus, which is the amount which will come into the soil solution and be a ble to be taken up by the plant during its growth cycle. There are a number of different tests for available phosphorus, with the main difference between them being the extraction solution which is used to remove phosphorus from the soil. Tests such as the Olsen and Colwell tests use a carbonate exchange mechanism to replace adsorbed phosphate and are ideal on neutral to alkaline soils. Other tests such as the Bray and Mehlich 3 use an acid extract to solubilise phosphorus compounds, and are more suitable for acidic soils.

Fertilising

Phosphate can be applied in a number of forms, but generally these can be classified as either a soluble salt (eg MAP, DAP, super), an insoluble compound (rock phosphate), an organic form, or as a colloidal form.

Soluble salts are of course the most popular forms of phosphate fertiliser, and deliver a very rapidly available form of phosphorus. The main problem with these fertilisers is the length of time they are available to the plant. As mentioned above, these fertilisers saturate the soil solution and begin to lock up in the form of insoluble compounds. Once the levels of phosphorus in solution are lowered sufficiently, these phosphates may begin to come back into solution, but generally very slowly, and often the supply of phosphorus is no better than before fertiliser was applied.

Other sources of phosphorus such as hard rock phosphate are naturally very insoluble in the soil. In this case phosphate will only become soluble very slowly, depending on pH, with the availability increasing in acid soils.

Organic phosphorus is a very valuable form of phosphorus, which will become available to the plant as the organic matter is broken down in the soil. For this reason organic matter is a wonderful storage mechanism for phosphorus as well as other nutrients.

The other option for phosphorus fertilisers is soft rock phosphate, which is a slow release, colloidal form. This means that phosphorus won't saturate the soil solution, but is able to replenish soluble phosphorus as it is taken up by the plants. This is the key to long term phosphorus nutrition because the phosphorus won't lock up.

This was demonstrated in a recent trial conducted by the South West Slopes Merino Breeders Association, comparing a range of fertiliser strategies and measuring phosphorus availability 12 months after application. An annual application of soft rock maintained available phosphorus levels in the soil at much higher levels than single super when measured 12 months after application.

The result is that phosphorus is used efficiently rather than being locked up, and the plant is able to access phosphorus right through its growth cycle. This leads to healthier, better balanced plants which are able to effectively capture sunlight and produce yield.

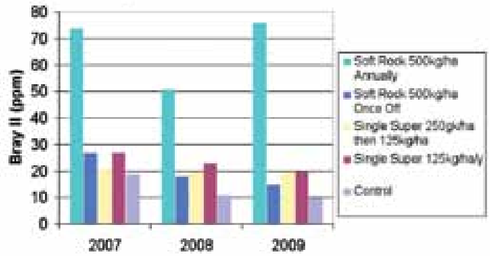
Phosphorus and biology

Typically phosphorus nutrition is thought of as a chemical process, through the mechanisms described above. However, one of the most important considerations for phosphorus nutrition of the plant is the biological aspect. Although phosphorus is taken up directly from solution, there are a number of important biological processes which will increase the amount of phosphorus the plant can access.

Firstly, plants need to be able to explore large areas of soil in order to access more phosphorus in a given time. Even if the total amount of phosphorus in a small area is sufficient for plant growth, this often won't become available quickly enough to support plant growth. Therefore it is important to consider the tilth and structure of the soil to allow healthy root growth.

Plants with healthy root systems will also manipulate the rhizosphere to improve the availability of phosphorus and other nutrients, eg. by the release of organic acids which can solubilise phosphorus compounds. Many legumes are particularly effective at this, forming special root arrangements which solubilise and capture phosphorus in a localised area. Other species may excrete acids throughout the rhizosphere to solubilise phosphorus from soil reserves.

SW Slopes Merino Breeders Trial

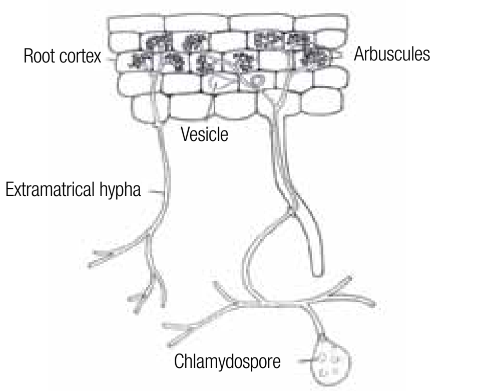


Many plants are also able to form symbiotic relationships with microorganisms to increase phosphorus nutrition. The most important of these in broadacre crops and pastures are the Vesicular-Arbuscular Mycorrhizal (VAM) fungi. This group of organisms colonise inside the plants roots and spread hyphae into the soil. In effect this forms an extension of the plant's roots and means the plant is able to access phosphorus in a greater area of soil, often several cm out from the root. This also applies to a number of other nutrients such as Zinc and Copper. In return the VAM are fed with sugars from the plant. In soils with excessive phosphorus levels there is often little incentive for the plant to form this symbiosis, and the levels of VAM colonisation may decrease. Since VAM are dependent on the relationship with the plant for survival this can lead to poor VAM populations in soils which are over fertilised. This is exacerbated by the often toxic effect of soluble phosphorus on VAM, as well as other farm operations such as cultivation. Long fallows and crops which do not form relationships with VAM (eg. Canola) can also reduce VAM populations in agricultural soils.

VAM trials at 'Mildagara', Young.

Because of the negative effect farming practices have on VAM populations it can often be beneficial to inoculate with VAM fungi. The inoculum can be applied as a seed dressing prior to sowing to ensure it is present near the growing roots. This is an economical way to improve the phosphorus efficiency of your farming system and promote healthy plant growth.

Illustration of VAM in a plant root



For more information on incorporating VAM into your cropping system speak to the team at YLAD.

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