White Paper

Measuring Phosphorus in Soils when using Reactive Phosphate Rock Fertilisers

A key part to improving farm productivity is measuring soil phosphorus (P) levels.

Overview of Phosphorus

Phosphorus (P) is an important element for normal plant growth and is often limiting nutrient for plants. There could be different reasons in the agricultural practice, but mainly this is due to the challenges in the management of soil phosphorus.

To understand soil tests for plant available P it is important to understand the basics of P reactions in the soil.

Plant roots take up phosphorus in the phosphate form (orthophosphates H2PO4- and HPO42-) but can also absorb certain forms of organic phosphorus.

The phosphate in fertilisers comes in different forms. Phosphate (the oxide anion in chemical fertilisers) is quite reactive.

Water soluble P is the most reactive form of P in fertilisers and in the presence of moisture in the soil will bind with antagonists or be transported by moisture until it can bind with an antagonist or is leached through the root zone (typically only in sandy soils).

The non-water soluble P in fertilisers is present in a bound form.

In phosphate rock based fertilisers, the phosphate is bound in a mineral apatite. Being a mineral, the strength of these bonds varies between rock types and sources. The ability of plants to utilise the phosphorous is defined by the reactivity of the phosphate rock (refer BioAg RPR white paper).

Antagonists in soils are typically iron (Fe), aluminium (Al), calcium (Ca) and organic compounds in the soil. Phosphate is an anion, it will form strong bonds with oxides or hydroxides of Al of Fe or displace carbonates in calcium carbonate minerals. Other cations such as manganese (Mn) and magnesium (Mg) can also fix phosphate.

Other anions (e.g. sulphates, carbonates, molybdate) can displace and liberate phosphate, increasing phosphate availability in the soil. Organic compounds can increase soil P availability. For example, humus binds with Al and Fe oxides, which reduces phosphate binding.

Alternatively, organic acids produced in the soil displace phosphate bound to antagonists and digest reactive phosphate rock. By displacing or digesting phosphate, it becomes available to plants, or will bind to other antagonists.

Measuring Plant Available P

To optimise yields growers need to know how much fertiliser to apply. To do this a grower first needs to know the level of P in soils.

This is achieved through soils test. Soil tests for P use an acid extractant for a set period of time to liberate P from the antagonists it is bound to. The liberated P is then measured to give a P content in the soil. The stronger the acid extractant (lower pH) or longer the period of time the more P will be liberated and therefore measured.

Test	Olsen	Colwell	Bray 1	Bray 2	Total
Extractant	Sodium Bicarbonate	Sodium Bicarbonate	Ammonium Fluoride and Hydrochloric Acid	Ammonium Fluoride and Hydrochloric Acid	Hydrochloric Acid
Solution pH	8.5	8.5	2.7	1.0	<1.0
Time	30 Minutes	16 Hours	1 Minute	40 Seconds	16 Hours

The table above shows the extractant used and time period for a number of commonly used test methods.

However, measuring the level of P in a soil is only the first step. To know if the P measured is adequate for optimal production requires correlation of the measurement with soil types and yield data. This is built up through research and trials correlating soil measurements for different soil types with yield results and observations. Without in field correlation a soil test result is just a number.

Significantly the majority of infield correlation of measured soil P and yield has been performed when applying water soluble P. As such the optimal levels of P do not correlate with the levels of P measured when using Reactive Phosphate Rock (RPR) as a fertiliser.

Phosphate Buffering Index (PBI)

The PBI is a measure that provides an indication of the soils capacity to fix / lock up P when it is available. For water soluble fertilisers this is when it is applied, for other forms of P this is when the P is liberated by soil acids or other mechanisms. It is a measure of the antagonists that are available in the soil to lock up P.

While the P in reactive phosphate rock fertilisers is not bound up immediately, soils with high PBI and free calcium will compete strongly against root systems for P as it is liberated during the breakdown of RPR by organic acids.

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So which Soil Test is Best for Reactive Rock Phosphate?

The Olsen and Colwell soil tests are strongly correlated when using water soluble/ chemical fertilisers and if your paddock has a history of using traditional chemical P fertilisers these along with PBI will provide a strong correlation to plant available P. However, given the use of a weaker extractant acid they underestimate plant available P when fertilising with RPR.

If transitioning to or having applied fertilisers containing RPR it is important to analyse soils using Bray 1, Bray 2 and PBI.

Bray 1 is correlated for chemical fertiliser. When using Bray 1 it can underestimate available P when fertilising with Reactive Phosphate Rock, though is better than both Olsen and Colwell results. However, in soils with a relatively high PBI it can overestimate available P from RPR.

However, Bray 1 has been shown to correlate well when comparing year on year or different soils that have used RPR as a P fertiliser. I.e. fertility increases or decreases with the correlating change in Bray 1.

Bray 2 is commonly used in highly acidic soils in regions such as Malaysia, however the test extracts significant amounts of P in soil samples and typically overestimates available P when using RPR. It does however capture all the P that is plant available in the soil and provides an indication of the P reserve in the soil, and if low highlights a potential P shortfall.

By assessing these three parameters along with the soil content of antagonists; iron, aluminium, calcium and beneficial soil components sulphur and organic carbon levels, assessments can be made on plant available P, and by performing year on year tests P accumulation or consumption can be monitored.

References

Phosphate rocks for direct application. Rajan etal 1996

Food and Agriculture Organization of the United Nations (FAO) 2004 Use of phosphate rocks for sustainable agriculture.

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