Hill Laboratories
BETTER TESTING **BETTER RESULTS**

TECHNICAL NOTES

SOIL PHOSPHORUS TESTS

Farmers and their advisors want a soil test to report 'plant available' phosphorus (P) so that the amount of P fertiliser required to achieve maximum plant growth or crop yield can be calculated.

The fact that several different soil test methods are available and report different levels of 'available' P for the same soil is confusing, so why have different tests? Are some soil tests 'right' and others 'wrong'? These differences must appear very confusing for farmers and growers.

Background to soil P tests:

Soil P exists in several chemical forms in the soil. This includes both inorganic complexes (with calcium, iron, aluminium) and organic forms. The immediately available P is the inorganic form occurring in the soil solution and is exclusively orthophosphate. Other inorganic forms are largely unavailable although changes in pH can render some available. Many organic forms of P are potentially available, and these are the main source of orthophosphate other than direct fertilization with soluble phosphate. Roughly equal proportions exist in the inorganic and organic forms.

A simple water extraction test is not the total answer, as P is absorbed by plants from soil in close proximity to roots, by mechanisms that involve exudation of carbohydrates by roots and the associated activity of soil microbes creating a chemical micro-environment that facilitates the absorption of P by plant roots. P absorbed by plant roots is not just 'water soluble' P.

Soil test extraction procedures attempt to extract a similar fraction of P that is accessible to plants. Considering that different plant species growing in the same soil and similar plants growing in different soils are all inherently different, designing a universal soil test to measure 'plant available P is virtually impossible.

Calibration of a soil P test generally involves setting up a P fertiliser trial, where responses to known additions of P can be determined. Different soil tests can then be performed on these soils to identify the best performer (i.e. the test that most accurately predicts the observed P responses). A robust test should be evaluated over a wide range of soil types and several seasons. Such a process was conducted during the 1970's in NZ, and several recognized soil P tests were evaluated. These tests showed varying degrees of success, but it was decided that the Olsen P test best predicted fertiliser P response for NZ ryegrass and clover pasture soils. It is also widely accepted that plant uptake of soil P is significantly influenced by soil quality, root structure and root zone depth, which should also be considered in addition to the soil P test result.

Soil P tests provide index levels of plant available P rather than precise measurements and are an indication of soil P status. Regular annual soil testing from identified transect lines (the monitoring approach) will indicate changes in soil nutrient status from year to year, essential for accurate nutrient budgeting.

The Olsen P test method has now been used in trials on a wide range of crops and is widely regarded as the standard P test method for NZ soils.

Soil P test methods:

Many soil P test methods have been developed during the last 80 years and debates continue as to their relevant strengths and weakness. This section describes those tests most commonly performed.

Olsen P* is a bicarbonate extraction (30 mins.) at pH 8.5 and is used extensively throughout the world, dating back to 1954. Issues with this test include underestimation of plant available P following recent lime application or historical use of Reactive Phosphate Rock (RPR) fertiliser and overestimation of P in low pH soils and also high P Retention (ASC) soils.

Resin P* is a water extraction at field pH using an ion exchange membrane to 'extract' P from solution as it becomes solubilised. NZ research reported in 1990-1992 that this test is less affected by issues that can complicate interpretation of the Olsen P test, especially where RPR fertiliser applications have been made. A limitation is that there is much less interpretive information available for the Resin P test.

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Truog P was the standard soil P test in NZ before being superseded by the Olsen test in the mid 70's. This was a dilute acid extraction (pH 3) and suffered the limitation of all acid extractants, i.e. a tendency to underestimate plant available P in high pH or recently limed soils, and overestimate plant available P in soils that contain phosphate minerals such as apatite.

Bray P is another acid extractant that has been used primarily in NZ for the forestry industry and still continues today. Bray 1 uses dilute HCl and ammonium fluoride and is slightly less aggressive than the mehlich 3 extractant. Bray 2 has a stronger acid concentration than Bray 1.

Mehlich 3 (M3)* is a test gaining popularity around the world, primarily as it is a 'multi-element' extraction, including major cations and trace metals. The m3 extracting solution includes acetate, ammonium nitrate, ammonium fluoride, nitric acid and EDTA, at ~pH 2.6. Being an acid extractant, it suffers the same limitations for P as the Bray and Truog tests.

Colwell P also uses a bicarbonate extraction at pH 8.5 but with a 16hr extraction time so usually extracts a larger amount of P than the Olsen method. Issues with high and low pH soils as for Olsen.

Modified Morgan P (Reams) uses either dilute ammonium or sodium acetate buffered to pH 4.8, with a 1:5 soil:extractant ratio, shaken for 15mins. Used widely in USA but not calibrated for NZ soils.

Total Phosphorus (TP)* reports P extracted by hot, concentrated acid and includes unavailable inorganic and organic forms of P. This result is not well correlated to plant available P but does indicate the amount of P in the soil Phosphorus cycle. In a normal soil environment there are equilibriums between different pools of soil P (inorganic and organic forms) that are either labile or non-labile.

*Denotes tests currently requestable from Hill Laboratories

Interpretation of Soil Phosphorus tests:

Soil tests all have inherent limitations as predictors of plant available P and also how effectively plants can utilize 'available' soil P. The best approach to interpret soil P test results is firstly to have an understanding of the inherent limitations of the test method and then to consider other information including soil pH, P Retention (ASC), lime or RPR fertiliser application history, soil quality, root zone depth and root structure of pasture or crop plants. The 'soil monitoring' approach is now widely used where regular soil testing from the same sampling transects can enable the advisor to see whether current practices are causing available P levels to increase, decrease or remain static.

Remember also that the soil test result represents the concentration of nutrient in the soil as sampled, so where the plant root zone is deeper than the sampling depth, the soil test may underestimate available nutrients on a per hectare basis.

NZ research has estimated maintenance requirements (to compensate for production removal and other losses) for fertiliser P for a range of pasture and cropping situations. The purpose of the P soil test for low P soils is to provide a basis for calculating the capital fertiliser requirement to increase the P status of soil, or if soil P is high to give confidence that a 'less than maintenance' fertiliser application may be appropriate to achieve economic or environmental benefits.

Relationships between different soil P tests

Because of the large number of soil tests undertaken at Hill Laboratories, we can provide typical ratios observed between soil test results. These are given below:

Olsen P = Resin P x 0.45 (caution advised as relationship varies with pH and P Retention of soil)

Olsen P = m3 P x 0.45 (caution advised as highly variable relationship observed – soil type and pH effects)

Olsen P = 1.4% of Total P for high ASC soil

= 2.2% of Total P for medium ASC soil

= 3.0% of Total P for low ASC soil

= 6.0% of Total P for organic soil

The Olsen P test is included in the Hill Laboratories Basic Soil test profile, and other soil P tests are 'additional'. The ratios between Olsen P and Resin P, M3 P or Total P tests have been calculated and from this, the calibration behind the Olsen P test can be used to generate generalized guidelines for interpreting the alternative tests. The Resin P test especially is known to overcome some specific shortcomings of the Olsen P test, and this exercise enables us to use alternative soil P tests when the need arises.

In general it is not possible to convert results from different laboratories test methods as differences in procedures (including soil:extractant ratios, extraction times, filter papers, instrumentation etc.) mean the results will not be comparable.

References

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