Conversion of Soil Data

The sense and non-sense of conversion studies

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At AgroCares we convert spectral data of a particular medium (soil, crop, feed, etc) into nutrient contents of that product. This is what we do and many of our customers appreciate and recognise the advantages of sensor technology over conventional technology, where sensor technology is fast, affordable, realtime and easy. One of the complexities, however, is that sensor technology performs best for total contents of nutrients, in stead of the more commonly known available parameters. This is due to the nature of the technology, which is based on the binding energy between atoms, which is relatively strong for elements attached to the soil organic carbon.

We often get the question from customers how to use the reported parameter in already existing recommendation modules using another parameter; i.e. how to convert from one P fraction (or 'pool') into another P fraction. Examples are to convert from P-Mehlich (a generic P extraction for available P) to P-Olsen (an extraction for high pH soils for available P). Before answering this question, let's first look why there are so many different methods to determine soil nutrient contents.

Available, exchangeable and total contents of nutrients

Soil nutrient data can be used to develop fertiliser recommendations as they reflect the stock of nutrients in the soil that the crop can take up. Conventional laboratories try to mimic this available pool by using specific extracting reagents. One of the most critical aspects in conventional soil laboratories is the choice of the most relevant extraction method, i.e. reagent. Notably, certain fractions of the nutrient pool are readily available (i.e. already in solution). Other fractions are sorbed to the soil complex and can become available after desorption. Crops can, to some extent, stimulate the desorption of nutrients from the soil complex. Hence, the challenge of conventional laboratories is to use an extraction method that indicates the availability of nutrients in the soil for crop uptake at several time scales. There are libraries filled with publications on the best extraction methods for a specific purpose and science is far from consensus on this topic.

What extraction represents the availability of nutrients best?

Extractants are solutions which separate nutrients from the sorption complex. Hence, the extractant increases the concentration of a specific element in the solution which can subsequently be detected by laboratory equipment. Extractants differ in their strength, a weak extractant represents the readily available pool of a certain nutrients, whereas a very strong reagent represents a more stable pool of that nutrient. Imagine a very weak extractant (for example. water or calcium chloride). It will desorb only a very small fraction of the adsorbed nutrients, whereas a very strong extractant will solubize a much higher fraction. Scientists have been arguing for decades about what reagent best represents the availability of nutrients during a cropping season and can thus be of best use for developing fertiliser recommendations. Science is far from consensus and consequently a vast amount of different extraction methods are currently used, each representing a very specific pool of nutrients.

The problem with many reagents is that they indicate very dynamic, i.e. unstable pools. Nitrate, for instance, is often used by advisors, notwithstanding the enormous variability and instability of nitrate in place and in time. In other words, a measurement of nitrate is only valid at the time and place of sampling (e.g. Lilburne et al., 2002). Science has shown repeatedly the limitations of using availability parameters (e.g. Bockstaller et al., 2008; Smethurst, 2000). However, the alternative of using a parameter that reflects a more stable pool also has its limitations as it is only related to some extend to the uptake potential of the crop. Hence, there is a trade-off between the wish to have a stable indicator and the wish to have an indicator that reflects crop uptake. Those two objectives do not unite.

So, putting a long story short, the trade-off is between:

1. an indicator that reflects crop availability very well, but is very heterogenous in time and space and is affected by root processes, or
2.an indicator that is very stable in time and space, but is indicative for crop availability.

Conversion of data

For historical reasons, most extensionists are used to work with availability parameters and they take the associated uncertainties for granted, when assuming the availability parameter is a constant indicator of the actual availability of that nutrient during the cropping season. However, for technical reasons, AgroCares preferably reports bounded elements, because they are most accurate. So here is a problem.

Luckily, there are also some solutions, which are briefly presented below:

1. Conversion of one parameter into another: In short, a regression model is built to calculate one parameter into the other. These models are sometimes purely empirical, others include co-variables like pH. This option has frequently been tested, but often gives poor results. Exceptions are conversion Organic Carbon into Soil Organic Matter where a consensus conversion factor of 1.72 is widely accepted and the conversion from pH-KCl to pH-water where a conversion factor of 1.2 is widely accepted (Bonten and Römkens, 2006). However, also these conversions are sometimes debated (e.g. Pribyl, 2010). For other conversions, correlation coefficients are often between 0.7 and 0.9 (Nesse et al., 2008) and hence have adverse effects on the accuracy of the measurements.

2. Interpretation in classes: many recommendation systems actually require interpretation of the information instead of the exact information. I.e. although different methods give different values, their interpretation (e.g. low, medium, high) is often similar. Hence, the interpretation of different methods can often be replaced without much problems.

3. Replacing fertiliser recommendation factors. Many fertiliser recommendations systems basically look like this: Fertiliser recommendation = (crop uptake + unavoidable losses - soil stock)*α where the factor α represents all kinds of fertiliser efficiencies and crop uptake efficiencies. If the soil stock is determined with a weak extractant, α will become larger and when the soil stock is determined with a strong extractant, α will become smaller. This means, amongst others, that field trials are needed to validate the fertiliser recommendation, no matter what parameter is used. This is something scientists all over the world agree on.

Conclusion

In conclusion, every parameter is an indicator of a certain pool of nutrients in the soil and every parameter has its pros and cons. A perfect solution does not exist, one thing we can all agree on is that many samples of a certain field will give a better indication of the status of that field. In that case, a low cost, in field and fast methodology is preferred.

References

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