

Interpreting soil tests in the light of P, K and S research

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Take home message

Soil moisture is critical in determining when subsoil responses to applied P and K fertiliser are observed. Further work is necessary to confirm and refine the opinions presented in this paper!

Introduction

In recent times we have encouraged a soil testing regime that involves 0-10cm and 10-30cm testing for P and K because (i) they tend to be the most stratified nutrients (they are not mobile in the soil or water in Vertosols), and (b) the vast majority of uptake for those 2 nutrients occurs in those layers. However, the interpretation of the values generated from those soil tests has remained a dark art and this short paper hopes to summarise 'where we are at' with the principles we use to interpret all those soil tests that have been increasingly adopted by industrious agronomists and producers. The key principle we operate from when examining a soil test is "Will crops grown in this soil respond to surface or deep placement of P and/or K fertiliser?"

Phosphorus soil tests

The values listed below for P tests are the rules of thumb we operate on when selecting sites likely to respond. As Phil explains in his paper, Colwell and BSES pools are distinct. Colwell-P is measuring the labile, easily plant available P pool, whilst BSES-P measures not only this pool but also a pool that only releases P very slowly. The key difference is that this slow release pool will not release enough P within an annual crop cycle to sustain yield expectations. Over periods of years however, it may be able to partially replenish 'Colwell-P' reserves - although 'top up' P will be required to reach yield expectations.

Table 1 Critical P values used to determine likely response or drivers of P availability in northern Vertosols

	Surface (0-10cm)		Subsoil (10-30cm)	
Colwell P	<25 mg/kg	Likely to get a response to starter P	<10 mg/kg	Likely to get a response to deep P placements
	>60 mg/kg	Ensure good groundcover to limit erosion risk!	>100 mg/kg	Unlikely to see P deficiency in your lifetime
BSES P	<25 mg/kg	Limited evidence of residual fertiliser accumulation	<30 mg/kg	Limited reserves of slowly available P. Consider replacement of removed P once every 5 years.
	>100 mg/kg	High residual fertiliser load	>100 mg/kg	Potential to slowly replace Colwell P reserves

There is also variation in the critical Colwell values according to species planted. For example maize and wheat require between 25-30 mg/kg, however peanuts require only 12-15 mg/kg, with limited responses above that value. Although we have placed 'critical values' in the surface BSES tests in Table 1, we pay very little attention to these values. We are actually content with Colwell and PBI tests in 0-10 and 10-30, and BSES in the 10-30 only, at least once. Because BSES-P releases only slowly, movement in that value takes years, so does not need to be monitored annually.

Because P is an element that roots have to grow towards to maintain uptake, anything that limits the active extension and proliferation of roots will necessarily limit the accessibility of the P that is, at least in a soil test, considered available. Hence, soil conditions that inhibit root growth (sodicity, pH, salinity, nematode damage), necessarily increase the critical values because higher soil solution P concentrations are needed to match demand from a smaller root system. Under these circumstances we would encourage strips be laid down to determine if remediation is economic. We remain uncertain of the responsiveness of crops to intermediate soil P values, but would expect variation based on the moisture regime the crop experiences each year.

The lower critical values in the subsoil for available P (and available K, below) reflect the larger soil volumes in a 10-30cm depth increment. By the time a plant root system requires nutrients from these depths, many of the yield limits such as grain number have been established in response to early P status (starter P and 0-10cm P status). What is needed is a long, regular arrival of nutrients from a more extensive and established root system. Plants will only rely on the nutrient status in these subsoil levels when times are hard near the surface. Surface moisture conditions through a season determine the dependence on subsoil nutrient resources, and consequently responses to deep placement. The excellent residual value we have seen from deep P applications in trials in a number of sites suggests that deep P placement followed by a season where topsoil supply dominates does not represent a waste of money. That deep P will be available to subsequent crops in the rotation.

Potassium soil tests

Potassium availability is a little more difficult to establish rules of thumbs for, but Table 2 below summarises our current thinking. Again, there are species differences in these values too. For the majority of species these values are about where we think responses are likely, however, we know that cotton requires higher K availability and critical values in cotton can be almost twice those reported in Table 2.

Table 2 Critical K values used to determine likely response or drivers of K availability in northern Vertosols

CEC	Surface (0-10cm)		Subsoil (10-30 cm)	
	ExK (cmol/kg)	High Mg (>30% CEC) or Na (>6% CEC)	ExK (cmol/kg)	High Mg (>30% CEC) or Na (>6% CEC)
<30 cmol/kg	0.2	0.4	0.1	0.2
30-60 cmol/kg	0.4	0.7	0.3	0.5
>60 cmol/kg	0.6	1.0	0.5	0.8

Considerably more work is required to improve the precision of these critical values, and to understand the mechanism behind the increase in those values where soil Na or Mg status is high. The two main mechanisms are direct competition at the root surface between these cations and K or changes in soil physical structure and aggregation that results in slower root extension and proliferation in the soil volume. It is highly likely that both are important in determining the availability of K to plants, but as yet we are only taking early steps in separating out these effects and understanding which plays a more significant role. Sorting out the importance of each of these mechanisms greatly affects how you manage them. Whether you attempt to broadcast K widely and enrich a much larger soil volume a little, or whether you concentrate your K in multiple bands at various row spacing. These will be discussed by Craig and Mike in their papers.

The reason the critical value increases with CEC in Table 2 is because as the CEC of a soil increases, the buffer capacity of the soil for K increases along with it (Figure 1). In essence, the rate at which K is released from the soil to replace that taken up by a plant root is slower than the rate required by the plant root to maintain adequate K status, as the CEC increases. It is very similar to the way a high PBI in a soil increases the critical Colwell P value. *{For those curious enough to read this far, the rule of thumb- for PBI is <300, don't worry about it, P is relatively available. Between 300 and 600, the buffering of the soil will affect the critical values used. Above 600 and you will always be wrestling with the soil to release P to the plant, and strategies to minimise P-Soil contact should be considered, particularly increasing the proportion of P cycling through organic pools. In practice, once PBI goes above 300, adjust the critical Colwell value to the PBI of the soil divided by 10 (i.e PBI of 850; response to applied P when Colwell is <85). This is entirely personal and has no scientific basis, but works in observation! The PBI values of most northern Vertosols however are well below 300, hence the residual value and availability of applied fertiliser is high.}*

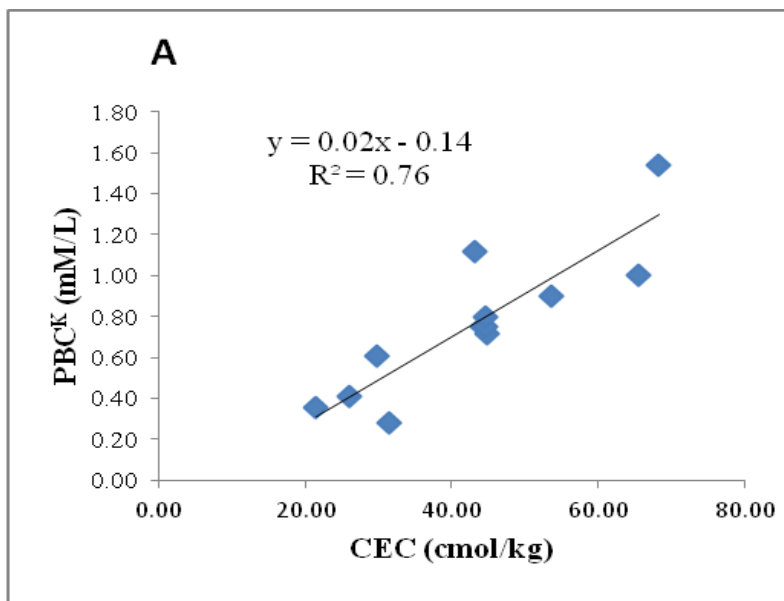


Figure 1 Relationship between the CEC of twelve northern Vertosols soils, and their initial PBC^K derived from the slope of K activity ratio and exchangeable K curves.

We have been working on a method to estimate the reserves of K available in each soil and the results of this research have been presented in previous Updates. The tetra-phenyl borate extractable K (TBK) method has been finalised, and is repeatable and relatively interpretable. However, it is still a way from being commercially viable.

Sulfur soil tests

Critical values for S responses in the surface are around 6 mg/kg of KCl40 extractable S. In the subsoil, this would fall to around 4 mg/kg. However, we are currently recommending taking a deeper subsoil test for S, from 30-60cm depth. This is simply because S is far more mobile in the soil profile of heavier clay soils than either P or K, and hence, depending on rainfall, can move vertically in the soil column and be found at deeper depths. Responsiveness to S, where subsoil S is low, is also affected by soil moisture status. A dry topsoil, where organic S reserves accumulate, limits the mineralisation and release of S associated with that organic matter. Often a transient S deficiency can occur in prolonged dry periods, but is relieved with rainfall. At the very least, we are advocating monitoring S levels through the surface 60 cm.

Conclusion

Progress is being made in tightening up the critical values for responses to P and K in northern grain soils, but further work is necessary to confirm the conditions which shift those critical values. Further work on integrating soil S results from the different soil layers is also planned.

Responses to deeper fertiliser placement in any season will depend on rainfall frequency and surface soil moisture.

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