Mehlich No. 3 Soil Test - The Western Australian Experience

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Abstract

Agriculture is an integral component of the Western Australian economy and contributed 14% of the state's export earnings in 2003. In order to provide a sustainable industry, farming practices that have been handed down from generation to generation may no longer be sustainable. "Smart farming" is the way of the future. With the advent of new technologies coupled with routine soil testing, farmers can more accurately evaluate the production potential of their land.

Routine soil testing covers a limited range of tests and the number of samples analysed is usually based on price. Western Australian soils are among the oldest in the world and are generally nutrient deficient. With greater demand being placed profit and securing a financially viable future, coupled with increasing deficiencies of nutrients as soil reserves become depleted, it is inevitable that farmers will need to do more comprehensive soil testing.

An alternative soil test that has been used widely throughout the world for many years has been calibrated for Western Australian soil types. As most traditional soil tests are based on extracting either one or a small group of nutrients, the ability to test for an extended range of nutrients requires multiple individual tests at high cost to farmers. As will be discussed in this paper, the Mehlich No. 3 soil test provides a rapid and cost effective soil test for measuring up to 13 nutrients (B, Ca, Co, Cu, Fe, K, Mg, Mn, Mo, P, Na, S and Zn) simultaneously.

In order to calibrate the Mehlich No. 3 soil test, a representative set of 173 soil samples from the archives of the soil survey of WA were used. Results obtained from the Mehlich No. 3 soil test were highly correlated with traditional "single" element tests. The Mehlich No. 3 test was also capable of measuring concentrations of toxic metals such as cadmium and nickel and further work is planned to extend the range of elements to include aluminum, lead, selenium and arsenic.

Key Words

Mehlich No. 3, soil test, universal extractants, nutrients

Introduction

The application of both phosphorus and nitrogen fertilisers has proven to be very profitable for crop production in Western Australia. Unfortunately, increased yields result in nutrient depletion of the soil and this, coupled with greater reserves of phosphate in the soil over the years, increases the probability of deficiencies of other nutrients such as potassium, sulphur and trace metals. In many cases, the first method of identifying these deficiencies is by doing a soil test.

When agricultural soils are sent into a laboratory for testing, they more likely to be analysed for plant available nutrients. This type of analysis would typically involve extracting the soil with a specific chemical extractant for a given amount of time. Depending on the method, only one or a small group of closely related nutrients can be determined per extraction. The amount of information to be gained from a soil test is more likely to be driven by price, rather than experimental design. What would usually prove to be a costly and time-consuming exercise to test for an extended range of nutrients, can be simply overcome by using universal extractants. They are capable of simultaneously determining a multiple number of elements in a single step (Benton Jones 1990).

The Mehlich No. 3 universal extractant was chosen (pH = 2) based on its suitability towards acidic to neutral soils (Mehlich 1984), which form the majority of the soil types used for cropping in south-western Australia. Its suitability for measuring nutrients in other soil amending materials such as compost has also been investigated. In certain industries that produce compost and mulch for instance, there is interest in finding a tool to measure its quality by evaluating the nutrient and contaminant levels. As source material varies with each batch, determining what exactly is there, cost effectively, should encourage regular testing and improve initiate improved quality control in the industry.

The objective of this study is to investigate the relationships between currently used single extractant soil tests for a range of nutrients against the Mehlich No. 3 universal extractant. Its suitability for material such as compost will also be evaluated. Also, its application in extending the range of analytes to include possible toxic elements such as aluminium, selenium, cadmium, nickel, lead and arsenic will also be examined.

The adoption of cheaper soil testing methods can lead to more precise fertiliser applications, therefore reducing environmental impacts of excess use (Bolland *et al.* 2003). Expanding the soil materials analysed using the Mehlich No. 3 extractant and increasing the range of analytes to include those that pose possible health risk will have many benefits. It can help enable earlier diagnosis of soil degradation indicators, thereby reducing the environmental impacts of soil acidity, nutrient leaching, soil erosion and crop quality issues.

Methods

The soil samples used in this study were collected from the archives of the soil survey of Western Australia. They are a representative set of fertilised surface soils (0-10 cm).
The compost sample was a random specimen from a local supplier. Soil analysis was carried out on a <2 mm air-dried fraction and performed in duplicate when possible. Compost samples were air-dried only.

The samples were analysed for B, Ca, Co, Cu, Fe, K, Mg, Mn, Mo, Na, P, S and Zn using the Mehlich No. 3 procedure (Mehlich 1984). The ability of the Mehlich No. 3 to extract Al, As, Cd, Ni, Pb and Se was also investigated using the same procedure.
The samples were extracted (1:10 ratio) for 5 minutes, centrifuged then analysed directly on Varian Vista©Axial Inductively Couple Plasma – Atomic Emission Spectrometer.

The samples were also measured using classical standard methods where possible. This included the Colwell test for phosphorus, Bicarbonate extractable K, 1 M NH_4Cl (pH 7.0) for exchangeable cations (Ca, Mg, Na and K), DTPA for trace metals (Cu, Mn, Fe, Zn), 0.01 M $CaCl_2$ ("Hot Water") for B (Rayment and Higginson 1992) and the Blair Test 0.25 M KCl for S (Blair *et al.* 1991).

Results

The properties of the 173 soils used in this study are summarised in Table 1. The elements, wavelengths and reporting limits using the Mehlich No. 3 method are summarised in Table 2. These values show that they are well within the range of levels expected in Western Australian soils. Where there are no data available for expected levels, only the detection limits are stated.

The results for Mehlich Ca, Mg, K and Na were highly correlated with both the ammonium chloride and bicarbonate-K procedure. The Mehlich trace elements, Cu, Zn, Mn and Fe, were also well correlated when compared to DTPA-Cu ,Zn, Mn and Fe results, however the Mehlich extractant was 30-50% more efficient in extracting these elements. The Mehlich results for S and B were also well correlated with the KCl-S and hot water tests respectively. Examples of the relationships between the techniques are shown in Figure 1. The Mehlich No. 3 results for phosphorus were well correlated with the Colwell-P results. As illustrated in Figure 1 d. the slope of the regression equation can be improved slightly if other soil properties, notably phosphate adsorption is considered. The Mehlich No. 3 method however, is not suitable for soils or composts treated with rock phosphate.

The levels of arsenic, selenium and lead in soil were below the detection limits, using the Mehlich test. The test can however detect low levels of these elements in compost. Further work is required to correlate these levels with bioavailability.

Table 1. Summary of the range of soil properties analysed

Property	Units	Range
pH (CaCl2)		4.0 – 8.1
Organic Carbon #	%	0.27 –

		7.32
Clay Content	%	0.5 – 48.3
PRI[+]	mL/g	-1.0 - 900
CEC[++]	cmol (+)/kg	0.94 – 45.4

[#] Walkley and Black [++] Cation Exchange Capacity (Rayment and Higginson 1992)
[+] Phosphorus Retention Index (Allen *et al.* 2001)

Table 2. The ICP wavelengths, reporting limits for Mehlich No. 3 and "extractable" ranges for each element in Western Australian soils.

Element	Wavelength λ (nm)	Range in WA soils (mg/kg)	Reporting limit (mg/kg)
Aluminium	396.152	0 - 2000	0.8
Arsenic	188.980		0.01
Boron	208.956	0.1 – 5.7	0.2
Calcium	370.602	100 - 6000	0.2
Cadmium	214.439		0.01
Cobalt	228.615		0.01
Copper	327.395	0.0 – 8.2	0.01
Iron	234.350	1.9 - 400	0.03
Lead	220.353		0.1
Potassium	766.491	10 - 1600	0.06
Magnesium	383.829	15 - 1600	0.2
Manganese	257.611	0.2 - 180	0.003
Molybdenum	202.032		0.01
Nickel	216.555		0.05
Phosphorus	178.222	1 - 130	0.9
Selenium	196.026		0.2
Sodium	330.230	2 - 440	6
Sulphur	181.972	1 - 81	0.8
Zinc	213.857	0.07 - 16	0.05

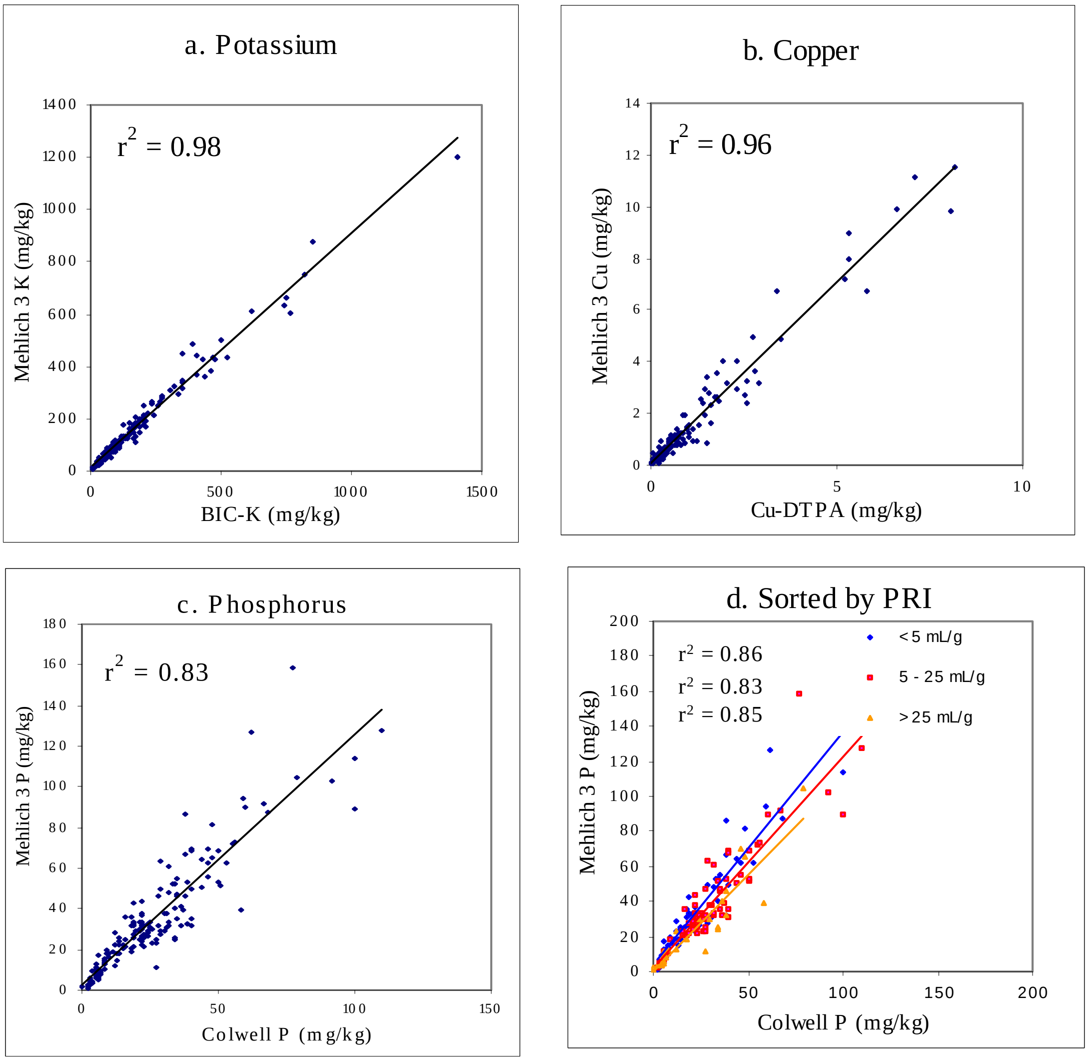

Figure 1. Relationships between a. Bicarbonate-K and Mehlich-K, b. DTPA-Cu and Mehlich Cu, c. Colwell-P and Mehlich-P and d. Colwell-P and Mehlich-P sorted by Phosphorus Retention Index.

Table 3. Conversion factors to calculate from Mehlich 3 result to standard test

Nutrient Method	P Bic	K Bic	Ca **Ex**	Mg Ex	Na Ex	K Ex	S KCl	Cu DTPA	Fe DTPA	Mn DTPA	Zn DTPA	B HW
Factor	0.72	1.15	1.00	0.93	1.08	1.06	0.82	0.68	0.44	0.64	0.67	1.02
r^2	0.83	0.98	0.93	0.95	0.89	0.98	0.80	0.96	0.77	0.82	0.87	0.67

Bic = 0.5 M $NaHCO_3$, Colwell procedure
Ex = Exchangeable, with 1 M NH_4Cl, pH 7.0

Conclusion

This study confirms that the Mehlich No. 3 soil test is an effective and cost efficient means for evaluating the nutrient status of Western Australian soils. However, it is only suitable for acidic to neutral surface soils, and soils that have not had rock phosphate applied. It shows strong correlations when compared to “traditional” methods of analysis.

It can provide information of some nutrients not currently covered by the “traditional” soil tests. With further work there are positive data to suggest that the element range could be extended to include analytes such as aluminium, selenium, arsenic and lead, and that the Mehlich No. 3 may also be useful for evaluating composting material. It could be used by farmers who may wish to do fertility mapping, or it could aid them in identifying nutrient deficiencies not previously recognised

Agronomists, farmers and the like would need to be educated on how to interpret this new information, and it would be imperative that if routine testing laboratories were to adopt this new methodology, that they are capable of producing data that are meaningful and valid.

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