Development of an Australian Soil Test Calibration Database

By Simon Speirs, Mark Conyers, Doug Reuter, Ken Peverill, Chris Dyson, Graeme Watmuff, and Rob Norton

Almost 6,000 fertilizer response experiments were collated and made available through a web-based tool. Advisers can use this tool to estimate soil test critical ranges by crop, region, soil type and nutrient.

Soil testing remains a most valuable tool for assessing the fertilizer requirement of crops. The relationship between soil tests (generally taken from surface soil) and relative yield (RY) response to fertilizer is subject to the influence of environment (e.g., water, temperature) and management (e.g., cultivation, sowing date).

The traditional way to determine soil test critical values is from experiment-specific critical values that are season and soil type-specific and lack statistical power to make reliable estimates. In many cases, the experiments used to define critical values are only ones where significant responses are seen; so non-responsive sites are not represented. As such, the degree of precision is often low when the soil test calibration is based on a wide range of independent experiments conducted on many soil types, over many years, by many different scientists.

To aggregate existing soil test and crop response data, an online MySQL database of historic fertilizer response trials has been developed for cereals, pulses and oilseed crops in Australia's diverse cropping regions. The data includes 5,420 single and multiple nutrient field experiments from five decades of research. It consists of data from all available N (1,709 experiments), P (2,281 experiments), K (356 experiments), and S (270 experiments) trials. Minimum data trial requirements were applied, which stipulated that the soil type was recorded, a recognized soil test had been undertaken, and that an estimate of crop yield with no fertilizer (Y_0) and the maximum yield (Y_{max}) could be obtained from the rate range used. Crop grain yield responses were fitted with either Mitscherlich, quadratic or logistic functions to estimate Y_0 and Y_{max}, and the percentage of RY as $100*Y_0/Y_{max}$.

Using the trial data, soil test critical values can be derived online through the Better Fertilizer Decisions for Cropping Interrogator Tool, which was specially developed for manipulating, sorting and searching the database. A trained and registered user is able to filter the data by attributes that include crop type, soil type, soil test, yield, and growing season rainfall. Fertilizer response criteria are obtained by fitting an inverted plot of the natural logarithm for the soil test and the arcsin of the square root of RY. From these curves, critical soil test values and confidence limits for 80%, 90% and 95% of RY can be derived.

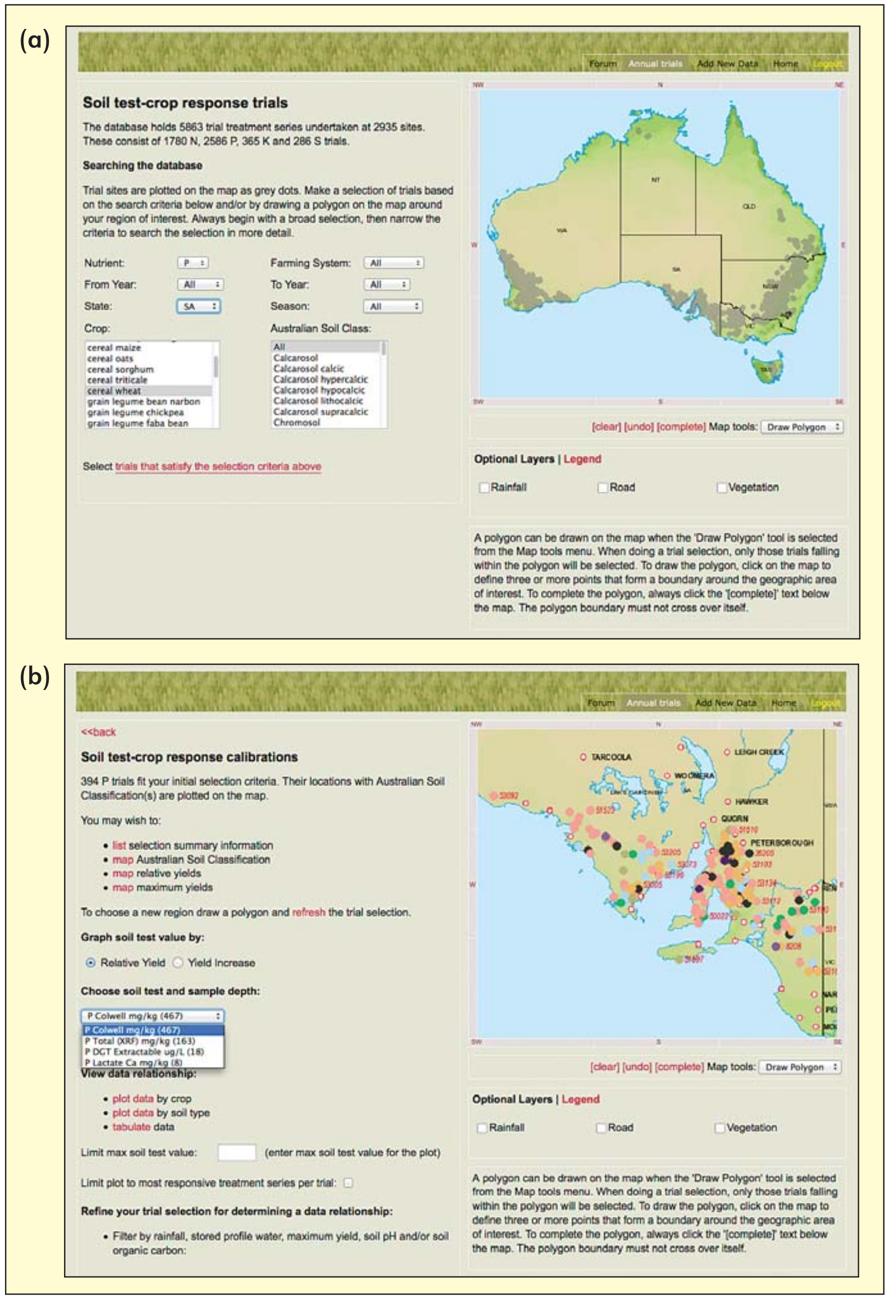

Figure 1. An example of the online Interrogator interface at the first (a) and second stages (b) of database interrogation.

Figure 1 shows two screen shots from the web-based interface. The first screen (**Figure 1a**) allows the user to select trials based on the nutrient (N, P, K, or S), the crop, the soil types of interest, a state or a selected region, a time scale, and from irrigated or dryland farming systems. The second screen (**Figure 1b**) allows a soil test and sampling depth to be selected from the database, as well as some additional filters such as soil pH, soil texture, drought, etc. The fertilizer response

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulfur; BFDC = Better Fertilizer Decisions for Cropping.

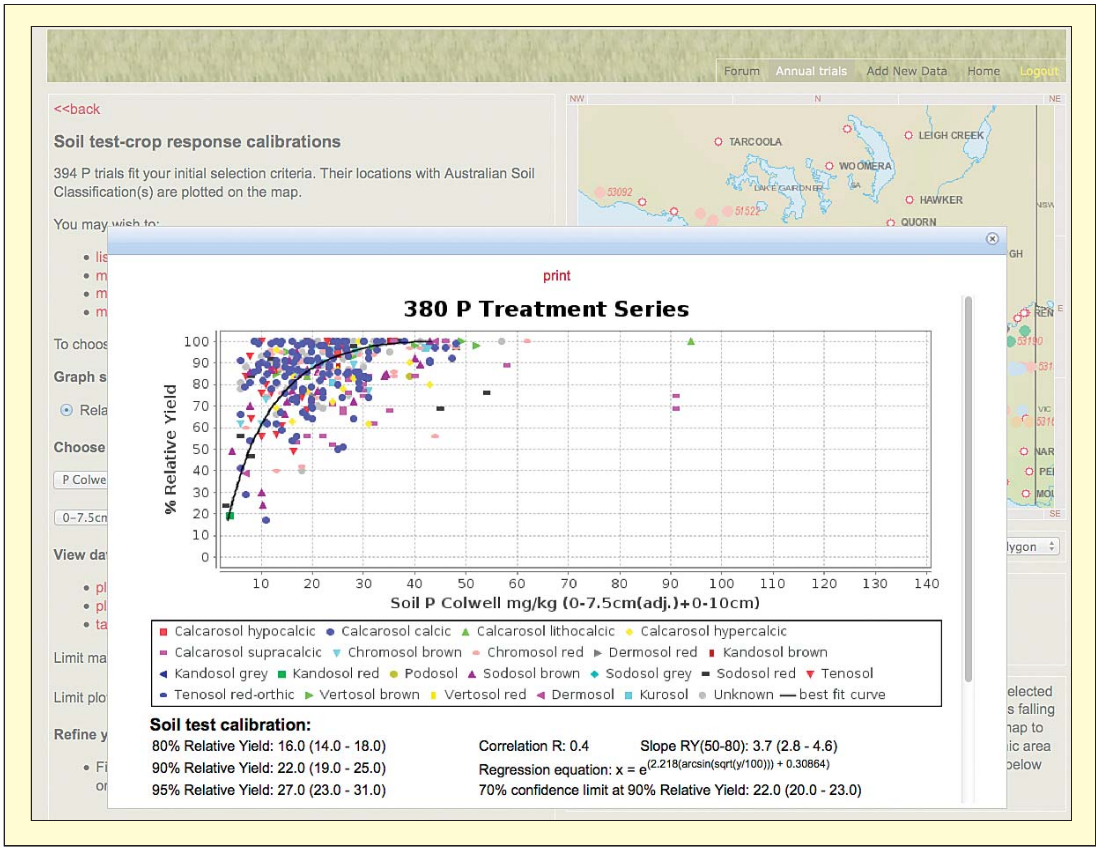

Figure 2. An example final report on the derived critical soil test value.

curve against soil test value is presented to the user on the screen, with these values indicated as well as the correlation values for the relationship (**Figure 2**).

The Interrogator enables users from the grains and fertilizer industries to better estimate soil test critical values for their particular situations, and to improve fertilizer management. The database underpins the Australian fertilizer industry's Fertcare program for advisers making recommendations to grain growers. It also assists and directs future research to address any identified knowledge gaps. The Interrogator was commissioned in March 2012 and can be found at www.bfdc.com.au.

As well as developing the database and training users in extracting and interpreting the information, the core scientific group published a series of papers to document the processes undertaken, and the outcomes in terms of the reliability and critical values of particular soil tests. A special edition of Crop and Pasture Science (CSIRO, 2013) was devoted to soil test interpretation as well as procedures and lessons learnt from the project.

The process of collating and entering data was very time consuming and relied on a lot of unpublished data provided personally by soil fertility researchers as well as through published information. A large amount of institutional input was required as well as good faith and trust among organizations and researchers on how the data were to be handled.

A second major issue was a lack of standardized metadata for sites within the database, which makes it generally impossible to isolate the effects on critical values of the specific management or environmental factors that are therefore best determined by specific studies. The database provides guidance, but in general—even with the large set collated here—specific issues such as the impact of stubble retention or the effect of zero-tillage can not be addressed.

Finally, the database is dominated (60%) by responses of wheat to N and P, meaning that relatively few studies are available for responses by pulses (other than narrow leaf lupins) or oilseeds (other than canola), especially for K and S. Moreover, limited data are available for current cropping systems and varieties. However, the identification of these gaps can now be used to focus future research on the crops, nutrients, soils, regions, and management practices where data are lacking.

The BFDC National Database and BFDC Interrogator is an approach that is worth examining for those nations that have a legacy of fertilizer response experiments, but have not used "information technology" tools to assemble their data. In those nations that are still conducting many fertilizer response experiments, the approach outlined for standardizing protocols and developing a database and an interrogator should be of great value for capturing long-term benefits from present investments. BC

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Simon Speirs and Mark Conyers (e-mail: mark.conyers@industry.nsw.gov.au) are Research Scientists with the New South Wales Department of Primary Industries at Wagga Wagga. After retiring from CSIRO 10 years ago, Doug Reuter became a respected consultant who sadly passed away late in 2013. Ken Peverill is a soil fertility consultant with K I P Consultancy Services, Melbourne. Chris Dyson is a biometrician with the South Australian Research and Development Institute, Adelaide South Australia. Graeme Watmuff is an information technology consultant with Geographic Web Solutions in Adelaide South Australia. Rob Norton is Director, IPNI Australia and New Zealand Program.

References

CPS - Special Issue: Making Better Fertiliser Decisions for Cropping Systems in Australia. 2013. http://www.youtube.com/watch?v=4bhuZV9Pop8 (verified 05/27/14).

CSIRO. 2013. K. Peverill, D. Reuter, M. Conyers, and R. Norton eds. Crop Pasture Sci. 64:5.