Developing a searchable national database of grain soil test - crop response information for Australia

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Abstract

An online national database is being constructed to house historic cereal, pulse and oilseed soil test–crop response data from across Australia's diverse cropping regions. The database will include field trials conducted over the last five decades for four key nutrients: nitrogen (N), phosphorus (P), potassium (K) and sulphur (S). A Microsoft Access data-entry tool has been developed for the consistent collation of trial results. It recognises that these trials were conducted to meet a range of objectives and that included variable quantities of trial data and metadata. The data are being stored in a national MySQL database for interrogation and approved future use by the grains and fertiliser industries and by research and extension agencies. Known as the Making Better Fertiliser Decisions for Cropping Systems in Australia (BFDC) database, it will be able to be interrogated via a web-based, spatially-enabled interactive user interface (the BFDC Interrogator) that will be refined during the life of the project and made available as part of the final online database. This paper reports on the development of the Microsoft Access data-entry tool, database, and BFDC Interrogator using an initial test set of 123 N response trials from South Australia.

Key Words

Fertiliser trial, nutrient, cropping, spatial

Introduction

Since the early 1960's, more than 4000 soil test–crop response trials have been conducted across Australia for the main nutrient inputs in broadacre cropping: nitrogen (N), phosphorus (P), potassium (K) and sulphur (S). These trials contain variable amounts of data and metadata and have been undertaken by government agencies, the fertiliser and grains industries, universities and private consultants. The trial data encompasses a range of crop types, field measurements, soil testing methods and reporting units thus resulting in difficulties for collation and interpretation. A substantial number of these trials have been published in the peer-reviewed literature.

Even though Holford (1997) highlighted the need to collate and re-evaluate the large amount of soil test–crop response data nationally, until now no project has endeavoured to undertake this daunting task. Furthermore, these data have yet to be collated to a central digital repository by the creators of the data. In seeking to establish such a database, this project will enable the establishment of more reliable critical soil test ranges and help to provide the grains industry with greater certainty and confidence in the fertiliser nutrient rate recommendations provided to grain producers.

This paper describes the development of an online database that will house historic cereal, pulse and oilseed soil test–crop response data from across Australia's diverse cropping regions. It includes a description of the data capture process using a data-entry template and presents the online database interrogator tool that has been established to search the trial results that will be housed in the database. The interrogator tool is demonstrated using a subset of data currently held in the database, but finalised soil test–crop response calibrations are not presented. The online database and the interrogator will be publicly launched for access by approved users during 2012.

Methods

Through the development of a database of soil test–pasture response data (Gourley *et al.* 2007) two requirements for repositories storing variable quantities of trial data became evident:

- The requirement for consistent and manageable data entry (e.g. a controlled and consistent data-entry template).
- The data repository must be easily accessible to next users (e.g. researchers and advisors).

Database establishment

Data from soil test–crop response trials have been identified for irrigated and dryland grain crops across Australia. To facilitate the collation of an estimated 4000 sets of single-year trial data into a clean and consistent form, a standard Microsoft Access data-entry template was developed. The template has been developed to accommodate the entry of trials where variable quantities of data and metadata have been reported. In the current study, the template was assessed by each of the collaborators prior to being used for data entry. Trial data entered using the template, are transferred to a national online MySQL database.

Database interrogation

A tool is being developed to enable users to interrogate the national database. The BFDC Interrogator will enable selected calibration relationships to be developed between relative grain yields (100 x control yield/maximum yield achieved) (RY%) and the soil test results (N, P, K or S) for a given method of analysis, sampling depth and its reported units. Statistically derived critical soil test ranges at 85%, 90% and 95% of RY can be derived using the tool. This is done using data transformations to suppress the effects of scattered outliers. The regressions are therefore performed on an inverted plot of the natural logarithm of the soil test value and the arcsin of the square root of the RY divided by 100.

Data test set

A test set was entered onto the database to assess the suitability of the data-entry tool and to review the performance of the data interrogator tool. The test set consisted of 123 nitrogen response trials conducted in South Australia for wheat (65 trials) and barley (58 feed and malting barley trials) and was supported by extensive metadata. These trials were performed between 1990 and 1992, years marked by large differences in seasonal rainfall, across a range of soil types (including sodosols, chromosols and calcarosols). Nitrate N and nitrate+ammonium (mineral N) levels in the 0–10, 10–20, 20–40 and 40–60cm soil layers were measured at sowing. The BFDC Interrogator was used to develop relationships between RY% and soil nitrate and mineral N status (kg N/ha). The preliminary findings of this analysis are discussed below.

Results and discussion

Capturing response data

The quantity of data and metadata collected for different trials is extremely variable. The Microsoft Access BFDC data entry tool contains 13 individual data entry forms. This enables recording of all compulsory (Table 1) and non-compulsory data. Input data includes site characteristics, trial descriptors, individual treatment yield and statistical analyses, soil physico-chemical descriptors and paddock history. Examples of non-compulsory data include tillage system, stubble management, crop variety, climate factors and grain quality indicators.

To facilitate management, each data enterer has been given a uniquely identifiable template that can be continually uploaded to the MySQL database. Nationally there are 22 data enterers contributing data from fertiliser companies, government agencies and from universities. The use of the Microsoft Access BFDC data-entry tool improves the ability to manage large quantities of variable trial data being provided. A

summary of the total number of trials currently held in the MySQL database is given in Table 2. Data will continue to be added to the online database until early 2011. Once this is completed, collaborators will be convened to examine and define soil test-crop response recommendations.

Interrogation

The web-based, BFDC Interrogator interface displays mapped trial locations and is used to generate critical soil test values for N, P, K and S for different areas/regions, soil types and properties, growing season rainfall, trial year, soil test and measures of statistical quality. Interrogation criteria are entered through two stages (Figure 1). Initially the user defines the nutrient and crop of interest, and can also specify soil type, farming system, growing season/s or region. The second stage of interrogation allows the user to assess the summary data obtained from the initial inquiry. Once satisfied with the initial selection, the user identifies a soil test and sampling depth of interest. The query is subsequently refined by soil texture, growing season rainfall parameters and previous landuse. An example of a response curve for nitrate N, drawn from the 123 test set, is shown in Figure 2. Responsiveness calibrations of RY% against soil test value are performed for the selected dataset. Other functions of the Interrogator include:

- displaying summary data for a series of trials identified through a given query; and
- displaying individual trial data and metadata by clicking the trial position on the map, a point on a calibration graph or a link in a summary trial list.

Table 1. Compulsory data for the entry of crop nutrient–soil test response trials.

Background descriptors	Trial descriptors	Soil descriptors	Statistical analysis
Data owner (organisation) Data custodian Trial location	Crop type Experimental design Nutrient treatment rates (kg/ha)	Soil type Sampling depth (cm) Test method Test values Test units	Treatment grain yields (t/ha) Y_0 and Y_{max}

Table 2. Summary of current trials entered to the national MySQL[?] database (September 2010).

Trial type		New South Wales	South Australia	Queensland	Western Australia[1]	Victoria	Tasmania[2]
Nitrogen	Wheat	45	166	60	52	107	-
	Other Cereals	5	150	-	1	-	-
	Oilseeds	12	-	-	-	-	-
Phosphorus	Wheat	107	168	60	12	108	24

	Other Cereals	4	4	-	-	-	50
	Oilseeds	1	-	-	-	-	-
	Pulses	8	3	-	1	-	-
Potassium	Wheat	-	-	-	10	107	-
	Other Cereals	-	-	-	1	-	-
	Oilseeds	-	-	-	-	-	-
	Pulses	-	-	-	-	-	-
Sulphur	Wheat	8	-	-	-	107	-
	Other Cereals	-	-	-	-	-	-
	Oilseeds	5	-	-	-	-	-
	Pulses	-	-	-	-	-	-
Total trials		195	491	120	77	429	74
Total estimated trials		800	800	500	?2000	150	74

[1] The Department of Agriculture and Food Western Australia and Murdoch University are collating all available trials through a separate agreement with GRDC. These trials will be entered to the BFDC database.

[2] All available Tasmanian trials have been entered to the database.

Preliminary calibration findings:

The 123 trial test set was used to review the performance of the data interrogator tool. Using the BFDC Interrogator, relationships were obtained between RY% and Nitrate N or mineral N status (kg N/ha) for the 85%, 90% and 95% critical soil nutrient levels for grain yield. The critical levels were established for the purposes of testing the interrogator and are not reported. Preliminary interrogation of the trial test set showed, for Nitrate N and mineral N, that soil nutrient critical levels (85%, 90% and 95% RY):

- increased with depth of soil sampling;
- appeared to be similar in drier to normal seasons, but were greater in the wet season of 1992;
- generally increased as the mean seasonal rainfall increased from <250mm through 250–450mm to >450mm;
- appeared to be similar for calcarosols, chromosols and sodosols (for nitrate N at 0–60cm only);
- were similar for surface soil texture grading from sandy loams to clay loams (0–60cm); and
- were highly variable for relationships between organic carbon (0–10cm) and relative yield.

Figure 1 An example of the online Interrogator interface at (a) the first interrogation interface is used to establish an initial query of the database and (b) the second interrogation interface allows the user to identify specific trial attributes to refine a query.

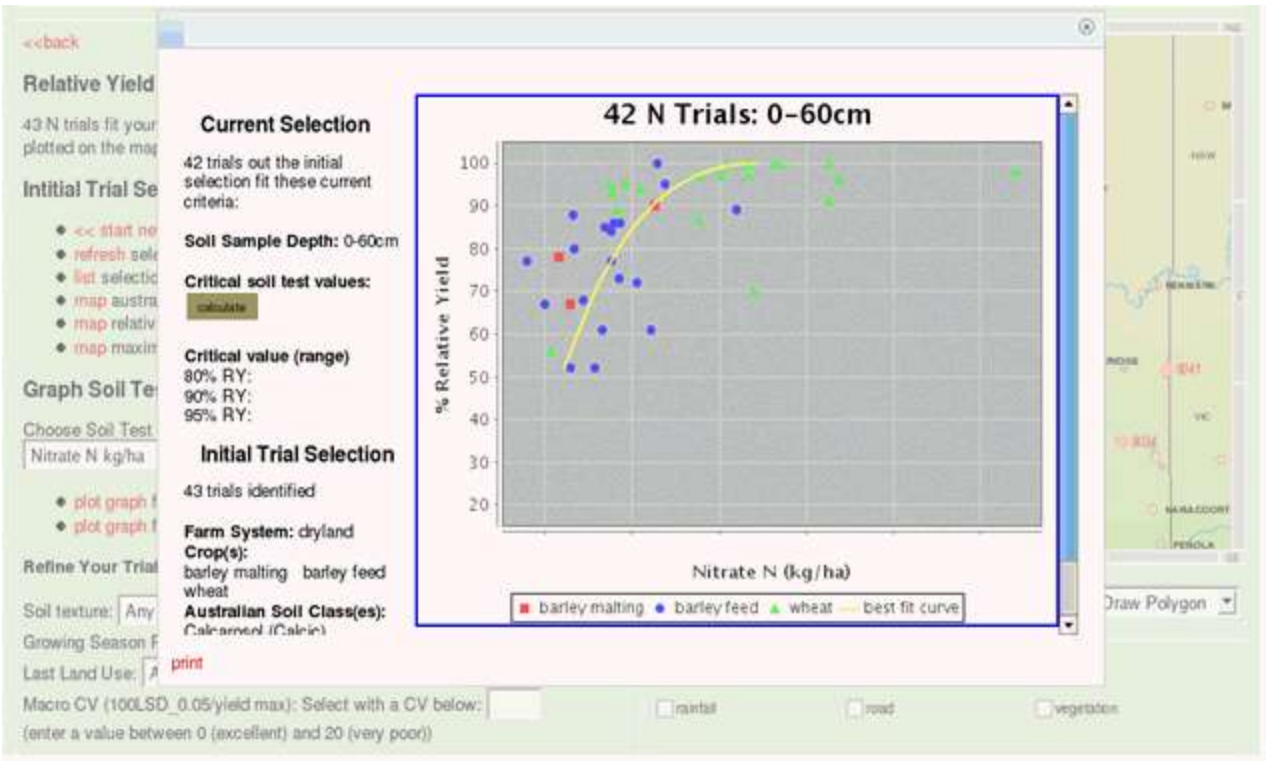

Figure 2 Example of a response calibration that can be obtained for a given selection of trials. 80%, 90% and 95% RY and soil Nitrate N values have been excluded for this preliminary data.

Conclusions

The online national database currently contains 1386 trials representing 35% of the total estimated number of trials that have been conducted nationally. Using the trial test set, the Microsoft Access® data-entry tool has proved to be an efficient method for compiling the type of data sought. The BFDC Interrogator is also shown to be a rapid means of developing soil test-crop response calibrations. Further preliminary examples will be presented at the conference.

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References

Holford ICR (1997). Soil phosphorus: its measurement and its uptake by plants. Australian Journal of Soil Research 35, 227-240.

Gourley CJ, Melland AR, Waller RA, Awty IM, Smith AP, Peverill KI, Hannah MD (2007) Making Better Fertiliser Decisions for Grazed Pastures in Australia. Department of Primary Industries, Victoria.