Fertiliser Adviser Crops: an expert system for Tasmanian crops

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Abstract

Fertiliser Adviser Crops is an Expert System designed to advise consultants and sales staff about the appropriate fertiliser program for crops grown in Tasmania. Knowledge encoded in the program has been drawn from many sources, including results from fertiliser trials conducted in the State and elsewhere, and theoretical knowledge about nutrient removal and soil chemistry.

The information needed to operate the program is a soil test plus paddock history, soil, crop, and other information such as expected yield or time of planting. The single page output gives a fertiliser recommendation for that crop, including lime requirements, basal fertiliser application, topdressing and trace element advice where appropriate.

Key words

Expert systems, fertiliser, crops, lime.

Introduction

There is a long tradition within departments of agriculture to advise farmers about fertiliser use. Farmers like to have this advice because they regard it as impartial. There was a time when the Department of Primary Industries, Water and Environment (DPIWE) advised individual farmers, but changing times have made it difficult for demand to be met. Instead we now offer our advice using Expert Systems by licensing the application to fertiliser companies, consultants, and processors (all of whom deal directly with farmers).

Fertiliser Adviser Crops does what its name suggests, that is, it advises a fertiliser program for a particular crop on a given soil type with a particular soil test result. The advice includes suggested application rates of lime, basal nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) mixture, top-dressing of N, and information about trace elements where appropriate.

A rather new development in the fertiliser industry is that custom-made mixtures are now available from each fertiliser depot. This means that farmers can order a mixture to suit the special need of each crop on a particular field, given the soil test result for that field.

Knowledge acquisition

Despite the extensive research effort both within the State and elsewhere, plus the literature that has been produced on crop nutrition, there is never enough. For example, in Tasmania there are crops commonly grown (e.g. Brassicas, carrots, triticale, and buckwheat) for which there is scant local information on response to fertiliser. Even so, farmers will still apply fertiliser, because they know they will benefit.

To assemble the knowledge required for this application, we involved plant nutritionists who had special knowledge of the crops. Together we assembled tables on a spreadsheet of the responses for each crop and each nutrient against a soil test class, on each of the three main cropping soil types (krasnozem, clay loam, sandy loam). A spreadsheet is good for this type of problem because it can be passed around for comment and modification. For crops where the information was limited, the nutritionists could draw on

the literature and knowledge of the nutrients removed. You can imagine that this ends up being quite a large volume of detailed information.

When we built these tables, we found it useful to look at graphs of the nutrient application rate plotted against the soil test. An example of such a graph is shown in Figure 1 for two cultivars of potato. Russett Burbank is a late maturing cultivar with a long growing season that requires more fertiliser, Shepody and Kennebec on the other hand, are early maturing cultivars. We used the principals laid by Blair and Lefroy (1993) and Helyar and Price (1999) to make recommendations from the soil tests and crop information.

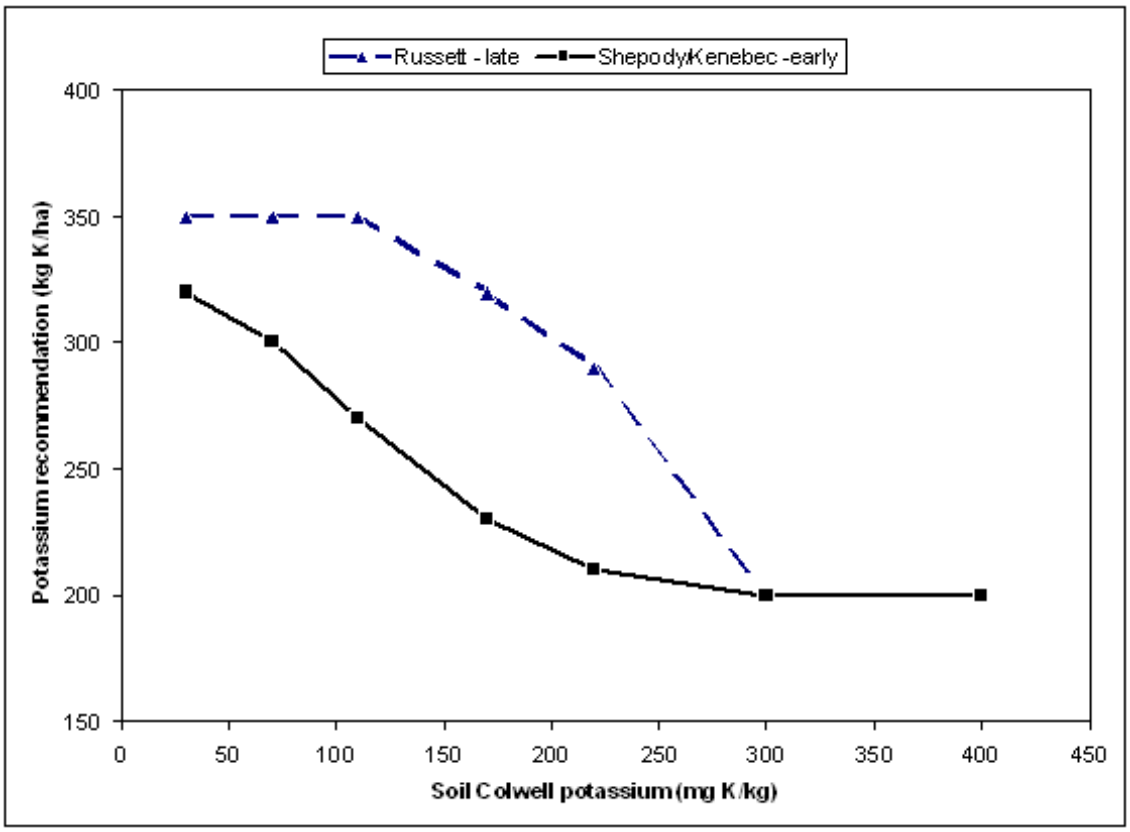

Figure 1: The recommended rate of K fertiliser (kg K/ha) as influenced by soil Colwell K test result (mg K/kg) for an early (solid line) and late maturing potato cultivars (broken line) on krasnozem soils.

Crops and soil tests

The crops that the program will give fertiliser advice for are shown in the table below.

Vegetable crops	Brassicas	Field crops	Other
Potatoes	Brussels sprouts	Poppies	Feed barley
Peas	Cauliflower	Barley	Forage Brassicas

Onions	Swedes	Wheat
Carrots	Cabbage	Oats
Green beans		Triticale
Broad beans		Buckwheat
Squash		
Sweet corn		

The soil test information required is for P, K and pH. The tests for P can be either the Colwell test, or the Olsen test. Although the program has been designed around information from the Colwell test, results from the Olsen test are converted using conversion factors that depend on the soil type. The program uses paddock crop history as a paradigm for soil nitrogen, with users selecting from "long pasture" through to "continuous cropping without green manure". The program does not require a sulphur test, but users are asked if they require sulphur in the mixture, and there is a prompt that indicates the sulphur demand for the crop selected.

Implementation

The application has been developed on XpertRule from Attar Software in the UK. It uses a mixture of forward and back chaining. The large volume of information is divided into “Tasks” of a manageable size. The program proceeds from the start task in a series of forward chains. Where the task is large or complex some information is contained in a back chain that feeds into the forward chain. Code in Pascal is used to perform the calculations, and the report is published on a browser.

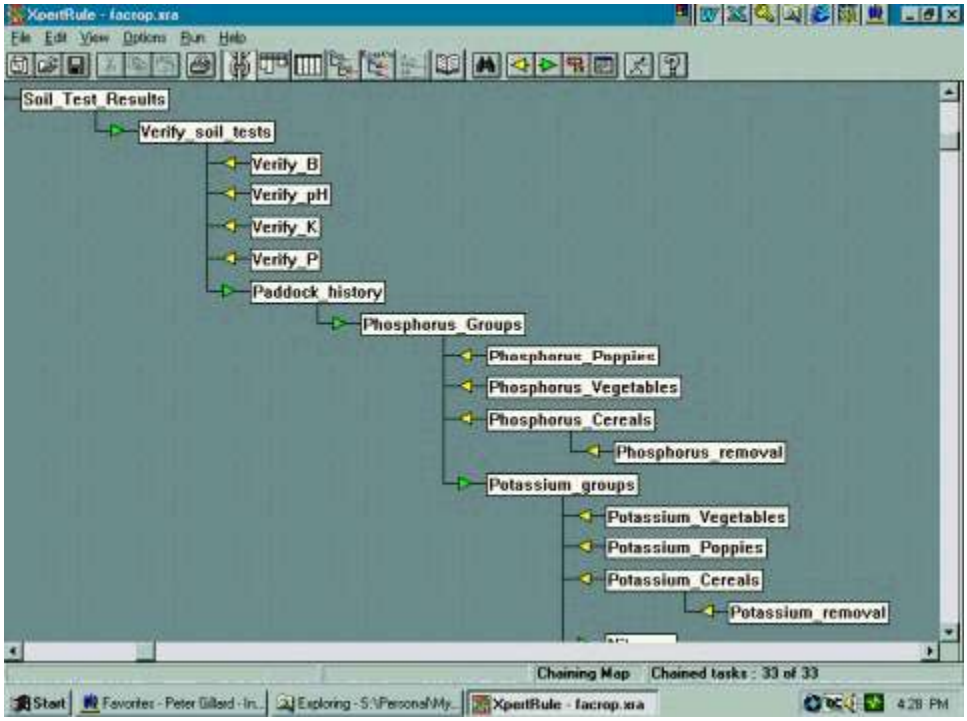

Figure 2. Layout of part of the chain of tasks. Arrows pointing right indicate the forward chain and arrows pointing left indicate backward chains.

The price list for fertilisers contains pre-mix fertilisers and base ingredients, for each depot. Because the prices are constantly updated, this information is held in a text file outside of the application so that it can be updated when necessary.

Once the nutrients required for a crop has been determined, simultaneous equations are solved to derive potential mixtures from each of the six possible combinations of source materials from which fertilisers are made (di-ammonium phosphate, di-ammonium phosphate with S, triple superphosphate, sulphate of ammonia, muriate of potash). This output is a table showing the N, P, K, and S % content of the three cheapest mixtures, their required application rates (kg/ha), the mix rate of each of the ingredients (kg/tonne), the application rate of the mixtures, and their costs.

It is not possible to give advice on the trace elements in this way. The application interprets the boron test where it is necessary (for Brassicas and poppies) and gives advice in a single sentence string: "Apply boron 1.4 kg/ha if it has not been applied recently". There is no reliable soil test for molybdenum (Mo). A recommendation for Mo is generated when crops sensitive to Mo (Brassicas) are requested.

Advice on lime application rate is derived in the same way as for the major nutrients, based on soil test and crop response. In addition there is a single sentence string that offers extra information about how urgent or otherwise the application of lime might be.

Value to farmers

Fertiliser Adviser Crops was introduced to industry in 1995 and has been loaded on about 30 computers in Tasmania, including those of fertiliser sales staff, consultants, processing companies, and DPIWE officers. Farmers have been happy with the recommendations of the program, and we have never had any reports of crops that suffered nutrient deficiencies. We have found that farmers prefer third parties to operate this type of application, and sometimes the third party is able to add value to the advice in some way. Most farmers will have used the program when they contact sales staff to buy fertiliser.

From the DPIWE's point of view, we are able to reach a wider audience that we once did. With rigorous knowledge acquisition, plus procedures to calculate complex mixtures, the advice is more comprehensive than it has ever been.

The program is maintained annually. Sometimes new crops have been added, or new procedures in fertiliser application for certain crops taken into account.

Conclusion

The delivery of advice through Expert Systems has enjoyed a deal of success in the DPIWE. This is at least in part due to the fact that the applications are built with the problem to be answered strongly in focus. We ask only questions for which the user has an answer readily at hand. Sometimes we have had to wrestle with complex concepts, perhaps through the use of paradigms, to cut through complexity in order to allow simple questions drive the knowledge towards a useful answer.

We have found that few farmers want to operate these Expert Systems themselves, and they hate onerous inputs. Where we want to change a farming practice, computers are not able to give the same level or confidence as contact with a professional, either a department officer or consultant, and the software in the hands of a third party is more effective.

Acknowledgments

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