Part 1 - Summary Project Details

Final Report

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Project Title:
(< 15 words)

The development and adoption of a cross-platform computer program to quantitatively assess soil structural features

Output: Sustainability

Research Program: Soils

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Part 3 - Final Report

Background to the project

Soil structural form, or the "architecture" of soil, is known to be a crucial physical property of arable soil, due its influence on water and gas movement, and various biological processes. In irrigated cotton production, the soil's structure is particularly important, as, along with texture, it governs the behaviour of applied irrigation water and determines the extent to which cotton plants can effectively utilise any applied water.

Despite the undoubted importance of soil structural form, however, its assessment has been a largely subjective matter. For many years, structural assessment has been by way of visual inspection of soil in a pitface, leading to the identification of the size and shape of the predominant soil aggregate type. An improvement on this extremely subjective approach was that put forward by the authors of SOILpak, a soil management manual for cotton growers. SOILpak identifies a number of soil physical properties, such as shape of clods and ease of clod breakage, that growers can assess to make an overall judgement of structural condition. But even SOILpak offers few direct correlations with other important soil properties, such as hydraulic conductivity. To address this issue, an attempt was made in the mid-nineties to more thoroughly quantify the structural features of cotton-growing soil using an image analysis technique. The program *Solicon 3.0* was developed to analyse images of soil samples impregnated with resin containing UV-fluorescent dye; the analysis of these images produced a range of quantified structural features, including average porosity, average pore size, average solid size, and pore shape and connectivity variables. Such information has since been linked to soil hydraulic properties and has the potential to be of use in predictive models, whereas the traditional qualitative measures of structure does not offer the same potential.

A continuing problem of this more quantitative approach, however, was that *Solicon 3.0* was only compatible with Macintosh computers. With market-share of computers now dominated by non-Macintosh machines, it was clear that to ensure *Solicon's* future viability and attractiveness to potential users, "cross-platforming" of this program was required.

The objectives and the extent to which these have been achieved

The objectives of this project were:

(i.)   To modify the existing structure analysis program *Solicon 3.0* so that it is functional on all personal computers (PCs); and

(ii.)   To widely distribute and demonstrate the converted *Solicon 3.0* program to researchers linked with the cotton industry who have a need for accurate, quantitative measures of soil structural features.

Solicon-PC is now in use at The University of Sydney on Australian Cotton CRC projects and is soon to be distributed to a number of potential users who have expressed interest in the program. The program contains an in-built Help Manual, which details operational techniques as well as explanations of the structural parameters that may be assessed. All of the structural parameters that were available in the Macintosh-based *Solicon 3.0* are now fully functional in *Solicon-PC*, in addition to several specialised (fractal) parameters which were only programmed into *Solicon 3.0* for a small group of researchers in the mid-nineties. In all, there are 21 different structural parameters available for the analysis of horizontal images of soil, 4 fractal measures of horizontal images, and 4 continuous measures of vertical structural attributes. Furthermore, the user has considerable control over the processing and preparation of images prior to analysis, and can change various analysis settings.

The first demonstration of *Solicon-PC* was given by the Primary Researcher at the Cotton Industry Soils Research discipline Workshop at the ACRI on 23rd June 2000. Features of the program and case studies of structural data obtained from several cotton-growing soils were shown to around 25 researchers. The user-friendliness of the program, which includes an extensive help manual, will limit the need for further demonstrations, but further technical information on the preparation of samples may be warranted. Copies of the program will be distributed to interested researchers following the submission of this report.

The methodology and a justification for the methodology used

A computer programmer, Mr Robert Farrell was contracted to perform the conversion of *Solicon* from a Macintosh-based program to a PC-based software. This involved the writing of significant amounts of code in the Visual C++ 6 language, and considerable expertise in designing a user-friendly and functional "front-end" to the program. Mr Farrell

was approached to do this work because of his familiarity with the construction of *Solicon* (he wrote a large proportion of the original version) and the scientific analyses contained therein.

Detailed results including the statistical analysis of results

Not applicable

Discussion of results including an analysis of research outcomes compared with objectives

In addition to containing all the analytical capabilities of the Macintosh-based *Solicon 3.0* program, plus the addition of 4 four new analyses not widely available previously, *Solicon-PC* analyses soil images considerably faster than its predecessor. This is partly a reflection of improved computer performance since the mid-nineties when *Solicon 3.0* was developed, and partly a consequence of moving to the PC platform, but gives potential users greater analytical flexibility when using the program. It is envisaged that the successful transition of this program into a rapid, PC-based software will make it more attractive to researchers. Initial users of Solicon-PC at The University of Sydney, predominantly undergraduate students, have indicated that the ease-of-use of the program is a particular feature. Interest in the program following the June soil discipline meeting in Narrabri indicates that adoption of the program by relevant researchers should be good.

Assessment of the likely impact of the results and conclusions of the research project for the cotton industry

The conversion of *Solicon* to a PC-based program will initially be of greatest benefit to researchers and extension officers in the cotton industry who require quantitative information on soil structural properties. Those research projects funded by the Australian Cotton CRC which are investigating linkages between soil structural properties and soil hydraulic properties have already made use of the program, and other research groups with similar interests have expressed interest in obtaining this software. Also, due to the close interaction of soil structure, soil water movement and storage, and cotton plant water use efficiency, it is expected that as pedotransfer functions are developed to predict hydraulic behaviour from structural properties, researchers investigating cotton crop physiology may

also benefit from the more quantitative data obtained using *Solicon-PC*. The speed and utility of *Solicon-PC* compared to the older Macintosh version of the program will also make the technology far more attractive to researchers.

Description of the project technology

Solicon-PC was written using Visual C++ 6 code, and is a Windows 32 application, meaning that it will run under Windows 95, Windows 98 or Windows NT operating systems. Captured images of soil must be made compatible for *Solicon-PC* analysis by being presented as 8-bit binary (black and white) image files (e.g. .TIFF format). Processing of raw images may be carried out in an imaging program (such as Adobe Photoshop, for example), or within the *Solicon-PC* program itself. All analytical results may be saved to a text file, which can then be opened by a variety of software packages. The program's Help Manual runs under Microsoft's Internet Explorer software. Regarding transportation and storage, the entire *Solicon-PC* program requires only 2 Mb of hard disk space, while for transportation, compression of the program using software such as WinZip reduces its space requirements to less than 500 kb.

A technical summary of any other information developed as a part of the research project including discoveries in methodology, equipment design, etc.

Not applicable

Recommendations on the activities or other steps the may be taken to further develop, disseminate, or to Exploit the Project Technology

It is recommended that *Solicon-PC* be made freely available and readily accessible to researchers and other potential users in the cotton industry by making it downloadable from the CRDC's webpage. The program will shortly be installed on the Department of Agricultural Chemistry & Soil Science webpage (at The University of Sydney) for interested researchers to download. The Primary Researcher also intends to publish several journal papers over the next 6-12 months, which will include significant components of *Solicon-PC* analyses. Such papers will serve to highlight the capabilities and merit of using *Solicon-PC* as a quantitative soil structural measurement tool.

A list of publications arising from the research project

The citation to be used when publishing results acquired using *Solicon-PC* is as follows:

Cattle, S.R., Farrell, R.A., McBratney, A.B., Moran, C.J., Roesner, E.A. & Koppi, A.J. 2000. © Solicon - PC Version 1.0. The University of Sydney & Cotton Research and Development Corporation.

(This citation information is presented to the user on opening the program)

It is envisaged that the number of research papers which use the *Solicon-PC* software will increase over the next few years, as the program becomes more widely utilised by researchers.

Final Report on: *The development and adoption of a cross-platform computer program to quantitatively assess soil structural features*

Plain English summary

Soil structure is an important property which affects water infiltration and storage, soil oxygen content and root growth patterns. It has typically been assessed using subjective description techniques, such as that contained in SOILpak. Such assessments are appropriate for general indications of structural condition, but are not precise enough for use in scientific models which attempt to predict processes such as water uptake by roots, or water infiltration rates. A computer program was developed in the mid-1990s to analyse images of soil samples that have impregnated with fluorescent resin, and to numerically estimate the amount, size and shape of soil pores and soil solids. Data from these analyses are more useful for scientists, as they can be used in predictive models. The computer program developed in the mid-1990s, however, could only be run on Macintosh computers, which limited the potential usage of the program by researchers. This project sought to convert the original program into one which could run on any personal computer (PCs). This has now been achieved, with the new program, *Solicon-PC*, now ready for release. It contains all the analytical features of the original program, plus some new analyses, and is much faster in operation and easier-to-use than the original version.