SOILpak - a Decision Support System for Extending Controlled Traffic Information to Irrigated Cotton Growers

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Introduction

Soil compaction can greatly reduce cotton lint yield on intensively cropped Vertisols (McGarry 1990; McKenzie *et al.* 1990). Crop managers with a soil compaction problem have several options (Vomocil and Flocker 1961):

- techniques for avoiding excessive compaction in the future;
- procedures for reducing excessive compactness (e.g. use of rotation crops to create numerous vertical cracks; shattering of dry soil with deep ripping tines), preferably in a more than temporary manner, and;
- management strategies for the upcoming crop, in cases where prevention or amelioration of compaction is uneconomic.

The phrase 'Custom Prescribed Tillage' (CPT) has been coined by Johnson *et al.* (1982) to describe an approach which encompasses this philosophy. CPT encourages the selection of tillage systems, sometimes in conjunction with the development of improved tillage equipment, that match the soil conditions at a specific location. Combined with CPT is a need to define the ideal levels of soil physical properties for each land use (Tisdall and Adem 1988).

'Controlled Traffic - Reduced Tillage' (CT-RT) has become a popular soil management option for Australian cotton farmers. Most of these growers produce their crops on furrow-irrigated Vertisols. CT-RT restricts compaction to narrow laneways. It usually is a less expensive and more flexible option than the alternative land preparation techniques such as regular deep tillage. CT-RT will become easier to use once improvements such as tractor guidance systems (Schoenfisch and Billingsley 1994), and the standardisation of wheel spacings of all farm machinery used in cotton farming systems, are introduced throughout the industry.

However, CT-RT cannot be expected to provide good results all of the time. For example, crop growth may be restricted when farming tools or tractor tyres have created compaction under the plant rows, or where there has been a failure to prevent the movement of ridges or beds onto previous wheel-tracks. The continued separation and maintenance of cropping and traffic zones is critical in CT-RT systems. If soil beneath the plant lines is compacted, CT-RT should be preceded by biological and/or mechanical loosening of the soil.

Numerous scientific papers have been written about sub-sections of the topic of soil structure management for irrigated cotton. However, none thoroughly and clearly integrate all of the available information into a form which can be used routinely by farm managers, and which can

account for risk, particularly in relation to the weather, and economic constraints (Arkin and Taylor 1981). The ideal tool for farm managers would be an accurate model which quantitatively describes the relationships between soil, plant, weather and management inputs in all cotton growing districts. Unfortunately, complexity of the farming system has delayed progress towards this goal.

Farmers using 'best practice' soil management techniques cannot wait for the development of a flawless computer-based model, and need an interim decision support system. Letey (1991) therefore expressed the hope that, through 'practical wisdom', soil structure information and knowledge can be coordinated and systemised so that the knowledge may have real value.

This paper describes a successful attempt to develop such a system within the Australian cotton industry.

The SOILpak System

The SOILpak decision support system (Daniells and Larsen 1991) has been developed to encourage Australian cotton growers to assess the physical condition of their soil before making a choice about tillage, gypsum application, etc.. It was based on results from problem-oriented soil structure research in the Macquarie Valley of NSW, but eventually included much information from experiments in the nearby Namoi Valley, and from scientific literature published elsewhere.

SOILpak evolved through a cooperative and practical process that involved cotton farmers, researchers and advisory staff. In the 1980s, growers generally believed that soil-related research information was poorly collated, and directed at research publications rather than at production people. It was thought that a central working manual for the industry would provide an important link between research projects and field problems. Cotton producers, aware of the complexity of the problems that needed to be addressed, believed that such a manual would be the catalyst for better coordination and focus of the soil management investigations that they were supporting.

The main aims of SOILpak are to:

1. Provide an easily accessible and clearly presented `central repository' for research results, and expert opinion, to assist with the objective measurement and management of soil structure;

2. Assist research administrators by highlighting research gaps; this process also reduces the risk of repeating work that has already been done;

3. Allow a group of widely situated soil experts to deliver their skills to on-farm decision makers through industry information networks;

4. Encourage everyone associated with soil management in the cotton industry to develop a holistic view of their work that considers both the short-term financial viability of growers and long-term sustainability of the natural resource base;

5. Present soil management information in a form that can quickly adapt to the latest available information-delivery technology.

The structural assessment procedure recommended by SOILpak is usually based upon the assessment of soil profiles in backhoe pits. The key measurement is the SOILpak score, which is a semi-objective measure of the ability of a soil to allow unimpeded root growth and function. Improved soil structure assessment methods are being developed (Greenhalgh 1994).

Although the knowledge base for SOILpak is far from complete, it provides useful "best-bet" land management options for growers and their advisers, based on the results of the structural assessment procedure. No attempt is made to enforce a particular option; the landholder makes the final decision.

Surveys of SOILpak users have indicated that they are happy to receive information which reflects the latest thinking about soil management, but which does not neccessarily have detailed answers for all of the relevant scientific questions. The loose-leaf format of the manual allows the management recommendations to be updated easily when new information becomes available. Surveys of potential users showed that a manual is preferred to computer-based packages such as the SIRATAC pest management system described by Hearn (1987). Despite having reduced pesticide use by the entire Australian cotton industry, SIRATAC failed to be directly adopted by most growers in the early 1980s because of perceived problems that included excessive complexity (Macadam *et al.* 1990).

SOILpak will be updated in the near future, and is likely to be accompanied by extra manuals such as MACHINEpak (which would contain detailed information about land preparation equipment options), and NUTRIpak (a detailed outline of techniques for dealing with cotton nutrition problems). New information about controlled traffic farming has become available since production of the second edition of SOILpak in 1991, and will be included in the next version. CD-ROM versions will be produced if there is sufficient demand.

Controlled Traffic Research Data Used in SOILpak

The CT-RT recommendations in SOILpak are based upon the data of Hulme (1987) (obtained under commercial conditions) and Constable *et al.* (1992). They proved the financial viability of CT-RT farming systems. Grower trials in several districts confirmed these results.

However, CT-RT has not been tested under all possible combinations of irrigation frequency, climatic conditions and raised bed architecture - there is a role here for modelling, in conjunction with the establishment of some new, well-monitored, tillage/raised bed experiments.

Impact of SOILpak on Farm Productivity

SOILpak has allowed cotton farmers to become more aware of soil management issues, and has boosted the confidence of those changing from traditional tillage systems to CT-RT. Since the widespread introduction of CT-RT to the Australian cotton industry in the late-1980s, land preparation costs have decreased. Large regional lint yield losses no longer occur after wet harvests.

Controlled Traffic Information Needs for the Next Version of SOILpak

Intensity of tillage of the topsoil is likely to increase in some areas due to the introduction of transgenic cotton varieties. This is because the insect resistance strategy required to ensure long-term viability of the genetically engineered cotton will not succeed unless the overwintering *Heliothis* pupae that burrow into the soil are disturbed by tillage. Soil issues associated with the new *Heliothis* management strategy will be presented in the next version of SOILpak.

Several other soil management issues need to be emphasised:

- "Moderate" compaction under CT-RT systems may lead to poor efficiency of use of applied N, even though lint yields are acceptable, so the nitrogen management strategies need to be refined;

- Once serious compaction problems have been controlled by the use of CT-RT, other soil-related factors such as sodicity may have to be dealt with. In fields where the severity of sodicity is not uniform, site specific farming procedures can be used to deliver the appropriate amounts of a treatment to different parts of a field via variable-input row-crop equipment (Robert 1989; McBratney and Whelan 1995);

- The implications of CT-RT on deep leaching and salt movement of Australian cotton soil have not been documented. Research currently being supported by the Cotton CRC into the hydrology of various wheel track and raised bed configurations is likely to provide solutions to any problems that may exist. However, we need to learn more about the interaction of these factors with other management variables such as slope, irrigation water application rate and quality, and severity of soil compaction;

- Contrasting land preparation techniques need to be evaluated in terms of their ability to maximise water use efficiency.

Conclusions

- Compaction can be a major problem when growing irrigated cotton on Vertisols;

- 'Controlled traffic - reduced tillage' (CT-RT) has become a popular technique for minimising compaction within the Australian cotton industry;

- Because CT-RT often is preceded by profile modification, procedures have had to be developed for assessing soil physical condition prior to the selection of a soil management option;

- The SOILpak decision support system was developed to organise available facts and opinions about soil profile assessment and management technique selection. It has helped growers to reduce their land preparation costs through the introduction of CT-RT, and has prevented major lint yield declines in the seasons following wet harvests;

- An improved version of SOILpak is planned, and research is continuing within the cotton industry to refine the CT-RT recommendations.

References

Arkin, G.F. & Taylor, H.M. 1981. Root zone modification: systems considerations and constraints. In: *Modifying the Root Environment to Reduce Crop Stress* (eds. G.F. Arkin & H.M. Taylor), pp. 393-401. American Society of Agricultural Engineers, St Joseph, MI.

Constable, G. A., Rochester, I.J. & Daniells, I.G. 1992. Cotton yield and nitrogen requirement is modified by crop rotation and tillage method. *Soil & Tillage Research*, **23**, 41-59.

Daniells, I.G. & Larsen, D. (eds.) 1991. *SOILpak$_b$: A Soil Management Package for Cotton Production on Cracking Clays.* NSW Agriculture, Narrabri.

Greenhalgh, S.E. 1994. *An evaluation of field soil structural assessment techniques for grey cracking clays under irrigated cotton production.* M. Rur. Sci. thesis, University of New England, Armidale.

Hearn, A.B. 1987. SIRATAC: a decision support system for cotton management. *Review of Marketing and Agricultural Economics*, **55**, 170-173.

Hulme, P.J. 1987. *An evaluation of seedbed preparation methods for growing irrigated cotton in grey clays.* PhD thesis, University of New England, Armidale.

Johnson, C.E., Schafer, R.L. & Elkins, C.B. 1982. Prescribed tillage for clay soils. *Tropical Agriculture (Trinidad)*, **59**, 92-96.

Letey, J. 1991. The study of soil structure: science or art? *Australian Journal of Soil Research*, **29**, 699-707.

Macadam, R., Britton, I., Russell, D., Potts, W., Baillie, B. & Shaw, A. 1990. The use of soft systems methodology to improve the adoption by Australian cotton growers of the Siratac computer-based crop management system. *Agricultural Systems*, **34**, 1-14.

McBratney, A.B. & Whelan, B.M. 1995. *The Potential for Site-Specific Management of Cotton Farming Systems*. Cooperative Research Centre for Sustainable Cotton Production, Narrabri.

McGarry, D. 1990. Soil compaction and cotton growth on a Vertisol. *Australian Journal of Soil Research*, **28**, 869-877.

McKenzie, D.C., Abbott, T.S., Anthony, D.T.W., Hulme, P.J., MacLeod, D.A. & Higginson, F.R. 1990. Management of subsoil degradation in an Australian Vertisol used for irrigated cotton production. *Transactions of 14th International Congress of Soil Science, Kyoto.* Vol. VI, pp. 176-181.

Robert, P.C. 1989. Land evaluation at farm level using soil survey information systems. In: *Land qualities in Space and Time* (eds. J. Bouma & A.K. Bregt), pp. 299-311. Pudoc, Wageningen.

Schoenfisch, M. and Billingsley, J. 1994. Automatic guidance for farming tractors. In: *Proceedings of 7th Australian Cotton Conference, Broadbeach, Qld.*, pp. 303-308. Australian Cotton Growers Research Association, Wee Waa.

Tisdall, J.M. & Adem, H.H. 1988. An example of Custom Prescribed Tillage in south-eastern Australia. *Journal of Agricultural Engineering Research*, **40**, 23-32.

Vomocil, J.A. & Flocker, W.J. 1961. Effect of soil compaction on storage and movement of soil air and water. *Transactions of the American Society of Agricultural Engineering*, **4**, 242-246.