Soil Management Training Courses: Recent Progress and Possible Future Directions

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Introduction

Hands-on training in soil management was given to one hundred & seventy members of the Australian cotton industry at a series of 11 courses between October 1997 and September 1999. The main aim of the courses was to demonstrate how to use *'SOILpak for Cotton Growers, Third Edition'* *. They were held in the Narrabri, Warren, Moree, Emerald, Dalby, Wee Waa, Goondiwindi, Gunnedah, Theodore, Walgett and Bourke districts.

Course description

The initial course at Narrabri was a 'Train the Trainers' exercise for Extension Leaders. Subsequent courses were led by the authors, with assistance from local extension staff, cotton farmers and a number of invited resource staff. A summary of course participants is shown in Table 1. The following topics were discussed:

- Soil sampling for yield map interpretation;
- Matching bed architecture with farming machinery to minimise compaction problems;
- Compaction repair;
- Strategies to deal with dispersive (sodic) soil;
- Management of organic mulches produced by rotation crops;
- Options for the prevention of salinity problems;
- Water management under dryland cotton;
- Challenges associated with the management of hardsetting red soil;
- Soil monitoring as part of Quality Assurance programs.

Most of the time allocated to each course was spent in and around backhoe inspection pits (1.5 metres deep, usually dug in triplicate) in commercial cotton fields. This ensured that the information exchange remained practical and interactive.

Important soil management problems still exist in the cotton industry

Soil analysis – carried out by Queensland Department of Natural Resources Analytical Centre, Indooroopilly – and field examination showed that of the 47 cotton production sites examined during the training courses:

- 64% had structure-related problems (mainly dispersion) that were associated with poor cotton yield,
- 51% had a pH imbalance (one-quarter of these were affected by acidity),

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* People associated with the Australian cotton industry can obtain their copy of the Cotton SOILpak manual via the Technology Resource Centre, ACRI, Narrabri (02 6799-1500). Others can buy the manual from NSW Agriculture, Information Delivery Unit, Orange (02 6391-3458).

Table 1. The numbers and types of trainees who attended the eleven soil management training courses.

Course	Date	Trainers, Resource staff	Extension leaders	Farm Agronomists	Private Consultants	Sales Agronomists	Growers	TOTAL
1. Narrabri	Oct 1997	9	8	–	–	–	–	17
2. Warren	Nov. 1997	6	2	6	5	2	2	23
3. Moree	Nov. 1997	6	3	3	–	8	2	22
4. Emerald	June 1998	7	8	–	3	–	1	19
5. Dalby	July 1998	7	6	–	3	8	–	24
6. Wee Waa	May 1999	5	4	2	4	3	3	21
7. Goondiwindi	May 1999	5	3	–	13	8	–	29
8. Gunnedah	June 1999	4	–	–	7	5	–	16
9. Theodore	July 1999	4	–	–	4	1	10	19
10. Walgett	Aug. 1999	4	2	–	3	3	9	21
11. Bourke	Sept. 1999	3	–	7	–	5	4	19
TOTAL			36	18	42	43	31	**170***

* Not including Trainers and Resource Staff

- 15% had naturally saline subsoils,
- 9% had evidence of perched water tables.

More information about these soil limitations is given in Table 2. Four depths (Topsoil, 0–10 cm; Sub-surface, 15–25 cm; Upper subsoil, 40–50 cm; Mid subsoil, 70–80 cm) were sampled.

It is important to note that the sample size for this analysis is very small, with emphasis on problem areas. Nevertheless, the study gives a clear impression of the ***nature*** of soil management problems throughout the cotton industry.

Table 2. Proportion of farmed sites in each of the districts that had soil factors likely to restrict cotton growth if left untreated.

Soil problem	District – % of farmed sites affected by each soil condition											Overall affected sites, %
	Narrabri (4 sites)	Warren (5 sites)	Moree (4 sites)	Emerald (4 sites)	Dalby (4 sites)	Wee Waa (5 sites)	G'windi (4 sites)	Gunnedah (4 sites)	Theodore (5 sites)	Walgett (4 sites)	Bourke (4 sites)	
Soil compaction – topsoil	25	0	0	0	25	0	25	25	20	25	25	15
Soil compaction – subsoil	25	20	50	0	0	20	0	0	50	0	25	17
Natural sodicity in subsoil	0	0	25	25	0	20	80	25	20	100	50	30
Topsoil sodicity, apparently induced by the use of bore water	66	0	0	0	25	50	0	0	0	0	0	11
Lack of electrolyte in low ESP soil (causes dispersion)	25	60	50	0	50	60	0	50	0	50	50	36
TOTAL STRUCTURE LIMITATIONS	***50***	***60***	***75***	***25***	***50***	***60***	***75***	***75***	***40***	***100***	***75***	***64***
Acidity	0	0	25	0	0	20	0	25	40	0	0	13
Alkalinity	50	0	25	25	0	40	50	50	20	100	75	38
TOTAL pH LIMITATIONS	***50***	***0***	***50***	***25***	***0***	***60***	***50***	***75***	***60***	***100***	***75***	***51***
Excess subsoil salinity (natural)	0	0	50	25	0	0	25	25	20	25	0	15
Evidence of perched water table	25	0	0	25	0	20	25	0	0	0	0	9

Definitions:

1. In this study, a soil is referred to as being compacted if the lowest SOILpak score under the plant lines is less than 1.0,
2. For this exercise, the subsoil is said to be sodic (excessive swelling, dispersive) if exchangeable sodium percentage (ESP) is greater than 15,
3. For this exercise, the topsoil is said to be sodic (dispersive) if ESP is greater than 5,
4. Soil with ESP less than 5, but electrochemical stability index (ESI) less than 0.05, is said to be lacking in electrolyte – this condition causes soil dispersion (demonstrated in field),
5. Acidity is defined as pH (water) less than 6.5; Alkalinity is defined as pH (water) greater than 9.0,
6. Excess salinity is associated with a subsoil electrical conductivity value (1:5 soil:water, dS/m) greater than 1.0.

Yield map information and soil data are strongly related

Of the thirteen yield map interpretation exercises, twelve clearly showed that variation in lint yield was related to soil condition. The main yield-limiting factor was soil dispersion. The only site that did not have soil-related problems associated with yield decline experienced difficulties with the timely delivery of irrigation water to some parts of the field. Three of the comparisons have been described by McKenzie and McGarry (1999). Further details are contained within a final report to Cotton Research & Development Corporation entitled 'Soil Management Training Courses, 1997–99'.

Soil used for cotton production tends to be in better condition than unfarmed soil

Despite the soil problems that were identified, farmed soil (under the plant lines) tended to have better properties for plant growth than unfarmed soil nearby. Of the seven farmed-unfarmed comparisons (one was a spade inspection only), four had better soil where cotton had been grown, one was about the same, and two had poorer soil. Some of the unfarmed areas with soil problems appeared to have been damaged by sheep and cattle grazing. Others had inherent limitations.

Future research and extension needs

The following research and extension needs were identified whilst producing *'SOILpak for Cotton Growers, Third Edition'*, and during the training course program described above.

Research

1. Soil structural stability in water:
   - clearly define the effects of pH, electrochemical stability index (ESI), lime content, organic matter and clay mineralogy on soil dispersion (which strongly influences crop performance),
   - examine the extent to which irrigation scheduling can be modified to minimise the problem of inadequate electrolyte in the soil (a lack of electrolyte in irrigated soil suggests that excessive deep drainage is occurring),
   - clarify the role of calcium carbonate (nodular lime versus fine earth lime),
   - determine if the ESI calculation ($EC_{1:5}$ / ESP) needs to be refined,
   - assess the agronomic importance of organic matter (including synthetic polymers) for reducing slaking in hardsetting soil.

2. Soil resilience ("rebound potential"):
   - refine the critical limits, with emphasis on the 'coefficient of linear extensibility' (COLE) test,
   - assess the possible adverse effect of organic matter on soil shrink-swell potential.

3. Soil compaction severity
   - provide reference 'SOLICON' images that relate to the root growth of cotton and associated crops, and to soil water movement,
   - develop a 'SOLICON' procedure that quantifies the effectiveness of tillage for Heliothis pupae control.

4. Define optimal bed architecture and stubble cover for a broad range of soil structural conditions, slope and irrigation method (with emphasis on waterlogging reduction).

5. Assess the need for raised beds under rain-fed conditions.

6. Refine agronomic procedures for 'biological middle-busting'.

7. Determine the irrigation scheduling requirements of fields with subsoil containing excess salt.

8. Develop recommendations about ground-water monitoring systems for leaky irrigation fields.

9. Define the within-field variation in soil water-holding capacity at which drip irrigation becomes preferable to furrow irrigation.

10. Quantify relationships between salt composition and soil electrical conductivity (EC), and characterise the imports and exports of salt across the cotton industry.

11. Establish management trials to assess methods for improving cotton soil with yield-restricting extremes of alkalinity or acidity.

12. Develop management techniques for the optimisation of soil temperature.

13. Define soil management systems that encourage beneficial organisms, eg. mycorrhiza, ants, earthworms.

14. Refine remote sensing procedures that allow prediction of key soil properties.

Promotion of new technologies

1. Document on-farm case studies, with $/ha information (maybe publish them in magazines such as 'The Australian Cottongrower' before placing them in SOILpak, NUTRIpak and/or MACHINEpak).

2. Develop "LANDpak" manuals – for each district – that contain GIS-based information about topics such as geology, geomorphology, water table depth, irrigation water quality, soil-related biodiversity issues and carbon balances. It may be possible to provide this information via the ACRI Website.

3. Encourage laboratories servicing the cotton industry to become NATA accredited.

4. Encourage laboratories to provide the following soil tests:
   – Tucker procedure when measuring exchangeable cations in cotton soil containing lime and/or gypsum,
   – ESI calculation,

– labile organic carbon,
– calcium carbonate content,
– COLE data to assess soil resilience.

5. Investigate the possibility of having an accreditation scheme for soil surveyors within the cotton industry.

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Reference

McKenzie, D.C. & McGarry, D. 1999. Soil assessment and yield map interpretation: some case studies. *The Australian Cottongrower* **20(2)**, 46–51.