1999

FINAL REPORT TO
COTTON RESEARCH & DEVELOPMENT CORPORATION

SOIL MANAGEMENT TRAINING COURSES 1997–99

Project codes and budget allocation:

DAN 111C	$31,810 (Courses 1–5 & 8)
MCK 1C	$38,790 (Courses 6, 7 & 9)
MCK 2C	$14,470 (Courses 10 & 11)

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Project highlights

<u>One hundred & seventy people were given training in soil assessment and management</u>

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 courses were held in the Narrabri, Warren, Moree, Emerald, Dalby, Wee Waa, Goondiwindi, Gunnedah, Theodore, Walgett and Bourke districts.

The main aim of the courses was to demonstrate how to use *'SOILpak for Cotton Growers, Third Edition'* *, with emphasis on soil sampling for yield map interpretation. Soil monitoring for farm accreditation schemes also was discussed. Most of the soil inspections were carried out via 1.5 metre deep backhoe pits, which usually were dug in

* McKenzie, D.C. (ed.) 1998. SOILpak for Cotton Growers, Third Edition. 395 pp. (NSW Agriculture, Orange.)

triplicate. The courses focussed on the needs of Private Consultants and Government Advisers associated with the cotton industry – a summary of course attendees is shown in Table 1. Details are in Appendix 1. David McKenzie also demonstrated soil description methods to the UNE Cotton Production Course at Narrabri on 12 February 1999.

Table 1. The numbers and types of trainees who attended the 11 soil management training courses. Course 1 at Narrabri was a 'Train-the-trainers' exercise.

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

<u>Major soil management problems still exist in the cotton industry</u>

Soil analysis – carried out by Queensland Department of Natural Resources Laboratory, 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),
- 15% had naturally saline subsoils,
- 9% had evidence of perched water tables.

More information about these soil limitations is given in Table 2. Details of the analytical data are presented in Appendix 1. 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.

<u>Soil used for cotton production tends to be in better condition than unfarmed soil</u>

Despite the soil problems that were identified, farmed soil tends to have better properties for plant growth than nearby unfarmed soil. Of the 7 farmed-unfarmed comparisons (one was a spade inspection only), 4 had better soil where cotton had been grown, 1 was about the same, and 2 had worse soil where cotton had been grown. See Appendix 1 for more details.

<u>Yield map information and soil data are strongly related</u>

Of the 13 "Yield Map" interpretation exercises, 12 clearly showed that yield variation was related to soil condition. Refer to Appendix 1 for details.

Publications arising from the project

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

Batey, T. & McKenzie, D. 1999. Letter to the editor: Deep subsoil compaction. *Soil Use and Management* **15**, 136.

McKenzie, D.C. 1998. Soil mapping prior to the development or re-development of cotton fields – some ideas from the wine industry. *The Australian Cottongrower* **19(6), 68-70.**

McKenzie, D.C. 1998. Possible future directions for SOILpak. In *Proceedings of Cropping Systems Forum, Narrabri*, eds. I. Rochester, D. Anthony & H. Dugdale.

Johnson, P. 1998. Croppers stuck in mud. *The Land*, p. 27, 3rd September 1998. (prepared in conjunction with D. McKenzie)

McKenzie, D.C. 1998. A new version of SOILpak for the cotton industry. In: *Proceedings of the 9th Australian Cotton Conference, Broadbeach, Qld., August 1998*, pp. 171-175. (also published as: McKenzie, D.C. 1998. A new version of SOILpak for the cotton industry. *The Australian Cottongrower 19(4)*, 66-68.)

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. 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 is greater than 15,
3. For this exercise, the topsoil is said to be sodic (dispersive) if Exchangeable Sodium Percentage 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.

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 in this report.

Research

1. Soil structural stability in water:
   - clearly define the effects of pH, ESI and $CaCO_3$ content, organic matter and clay mineralogy on soil dispersibility (which strongly influences crop performance),
   - clarify the role of calcium carbonate (nodular lime vs. fine earth lime),
   - determine if the ESI calculation (EC/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 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 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 can predict 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 and NUTRIpak).

2. Develop "LANDpak" manuals – for each district – that contain GIS-based information about geology, geomorphology, water table depth, irrigation water quality, soil-related biodiversity issues, etc. 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.

It is recommended that Cotton Research & Development Corporation (CRDC) provide funding to deal with all of the above issues. A tendering system should be introduced by CRDC so that the best available talent is chosen to complete each of the main tasks. This approach also would ensure that the researchers and extension leaders are given clear objectives that are consistent with the requirements of the Australian cotton industry and its associates.

David McKenzie

David McKenzie
26 November 1999

Appendix 1 – Confidential information

Details of Soil Management Training Courses, 1997–99

Funded by
Cotton Research & Development Corporation

(1) NARRABRI 'TRAIN-THE-TRAINERS' COURSE, 28–29 OCTOBER 1997

Participants

The trainees were advisory officers associated with the cotton industry, employed either by NSW Agriculture, QDPI or CRC for Sustainable Cotton Production.

Dallas Gibb	Narrabri
Susan Gunter	Tamworth
Mark Hickman	Gunnedah
David Kelly	Warren
Mike McCosker	Emerald
Greg McNamara	Dalby
James Quinn	Moree
Greg Salmond	Dalby

{Wendy Harris, Narrabri, Sonia Tassell, Moree and Gavin Inglis, Biloela received training at the Moree course (see below); Cameron Tonkin, Walgett and Jennie Spenceley, Moree received training at the Wee Waa course; Simon Whyte was trained at Walgett}.

Cooperating growers

Hugh Holland, 'Togo Station'
Phil Lawrence, 'Cumberdeen'
Andrew Campbell, 'Calatoota'
Stefan Henggeler, Auscott Narrabri

Course leaders

Dr David McKenzie, Soil Consultant, Orange
Dr Des McGarry, QDNR, Indooroopilly

Resource staff

Dr Pat Hulme, Soil Consultant, Warren
Mr David Larsen, ACRI, Narrabri
Dr Stephen Allen, ACRI, Narrabri
Dr Mike Bange, ACRI, Narrabri
Dr Alison Anderson, Soil Consultant, Sydney
Mr Broughton Boydell, ACRI, Narrabri
Mr Geoff Sharp, QDNR, Indooroopilly

Program

Tuesday 28 October

8.30 ACRI conference room
- (a) Welcome – Dallas Gibb
- (b) Evolution of SOILpak – David Larsen
- (c) Cotton soil management in relation to other industries – Des McGarry
- (d) 'Cotton SOILpak-3'; contents, methods – David McKenzie

10.30 Practice pit (in triplicate); grounds of ACRI
- learn about the new SOILpak scoring procedure

12.00 Lunch

1.00 'Togo', Field 34
- (a) Yield mapping for cotton growers – Broughton Boydell
- (b) Pit description at high-yielding end of field (grey clay)
- (c) Pit description at poor-yielding end of field (grey clay)
- (d) Farmer comments – Hugh Holland

4.00. 'Cumberdeen', Wee Waa
- (a) Red soil management, above-ground storages site selection – Pat Hulme
- (b) Pit description in a hardsetting field
- (d) Farmer comments – Phil Lawrence

Wednesday 29 October

8.30 'Calatoota', Edgeroi
- (a) Water management under dryland cotton - Mike Bange
- (b) Pit description in a dryland cotton field with controlled traffic
- (d) Farmer comments – Andrew Campbell

11.30 Auscott, Narrabri
- (a) Use of 2 m beds, management of surface mulches – Stefan Henggeler
- (b) Concluding comments – Dallas Gibb

Outcomes of the Narrabri course

- Cotton extension leaders from the main cotton growing districts were taught the latest field assessment procedures for use with the new 'Cotton SOILpak' manual. The value of this information in 'yield map interpretation' was emphasised. Other topics that received detailed attention included:
  - – assessment of the impact of controlled-traffic farming systems on soil structure
  - – management of sodic soil,
  - – risk of water loss by deep drainage under cotton,
  - – stubble management for erosion control,
  - – stubble management for the control of hardsetting on red soil used for cotton,
  - – the usefulness of soil data from laboratories.

- These leaders are now in a strong position to organise and assist with soil management training courses in their own districts.
- The methods section of the 'Cotton SOILpak' manual was thoroughly tested, allowing minor adjustments to be made to some of the procedures.

Field observations, laboratory data and management options (Narrabri)

'Togo' – 'good yield' (black cracking clay)

Field observations:

Wheat (sown by air) was growing after cotton. The beds had been knocked down by a scarifier, so it was difficult to locate the main wheel tracks from the previous cotton crop. Moderate wheel compaction was widespread. Bore water has been used for irrigation.

Soil test results (laboratory analysis carried out by QDNR, Indooroopilly):

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.2	8.7	0.23	134	41	6.3	1.8	0.036	0.85	3	19	21	58	21
Subsurface (0.15–0.25)	1.1	8.9	0.19	44	42	6.7	1.8	0.029	0.85	4	20	18	58	21
Upper subsoil (0.4–0.5)	1.2	9.0	0.24	52	41	11.2	1.9	0.021	0.65	3	20	21	58	22
Mid subsoil (0.7–0.8)	1.3	9.0	0.30	83	43	11.6	1.6	0.026	0.70	3	18	21	58	23

Spak score: SOILpak score (compaction severity under main plant lines); 0.0 = poor, 2.0 = excellent
pH: 1:5 soil:water
EC: dS/m; 1:5 soil:water
Cl: chloride; ppm; 1:5 soil:water
CEC, exchangeable cations: cmol(+)/kg, extracted using the Tucker method
ESP: exchangeable sodium percentage
Ca/Mg: calcium magnesium ratio (exchangeable cations)
ESI: electrochemical stability index, (EC/ESP); values less than 0.05 indicate dispersion problems
OC: Organic carbon (Walkley Black method)
Coarse sand (0.2–2 mm), fine sand (0.02–0.2 mm), silt (0.002–0.02 mm), clay (<0.002 mm), %
15 bar: % gravimetric water content, by pressure plate, at "wilting point"

Interpretation of laboratory data:

There are dispersion problems due to low ESI (less than 0.05) and moderately high ESP. The chloride results indicate mild salt accumulation at the soil surface. However, the soil has excellent potential for structural regeneration (CEC greater than 40 cmol(+)/kg).

Management options to consider:

Encourage the wheat to extract as much soil moisture as possible so that shrinkage cracks are formed, then re-assess the degree of compaction. Chisel ploughing may be required, provided that the soil is dry enough to shatter when tilled. Consider the application of gypsum, initially on test strips. Re-establish controlled traffic laneways.

'Togo' – 'poor yield' (black cracking clay)

Field observations:

Wheat (sown by air) was growing after cotton. The beds had been knocked down, so it was difficult to see previous wheel tracks. The soil was moist, and compaction damage was evident at a depth of 0–35 cm. There were field signs of dispersion at the soil surface, and many of the old cotton roots were bent. Bore water has been used to irrigate the field in the past.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	0.8	9.0	0.11	44	51	7.1	1.4	0.016	0.75	5	10	17	69	24
Subsurface (0.15–0.25)	0.9	9.0	0.15	23	50	7.6	1.4	0.020	0.75	5	10	17	70	27
Upper subsoil (0.4–0.5)	0.5	9.1	0.17	33	52	9.6	1.3	0.018	0.65	4	9	16	70	28
Mid subsoil (0.7–0.8)	0.5	9.1	0.23	69	50	13.2	1.0	0.017	0.65	3	9	17	73	29

Interpretation of laboratory data:

There is a dispersion problem (low ESI, high ESP, high pH) throughout the soil profile. However, the soil has excellent potential for structural regeneration (CEC >40 cmol(+)/kg).

Differences in soil factors between 'high' yielding and 'low' yielding parts of the field:

There is a greater risk of waterlogging at the 'poor' site – relative to the 'good' site at the other end of the field – due to more clay, greater dispersion and more-severe wheel traffic compaction.

Management options to consider:

Encourage the wheat to extract as much soil moisture as possible, then re-assess the degree of compaction (rip if dry). Consider the use of gypsum (the soil is too alkaline for lime to be effective). Re-establish controlled traffic laneways.

'Cumberdeen' – problem area (red soil)

Field observations:

A field pea crop (sown after cotton) was about to be ploughed-in, in preparation for cotton in 1998/99. Compaction was confined to the furrows between 2 metre wide beds. There was evidence of subsoil waterlogging (numerous manganese nodules were observed).

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.2	8.1	0.09	27	12	2.5	2.2	0.036	0.95	37	28	6	29	8
Subsurface (0.15–0.25)	1.5	7.8	0.07	25	13	2.7	2.1	0.026	1.00	34	28	6	29	9
Upper subsoil (0.4–0.5)	1.0	8.1	0.05	14	16	3.4	2.4	0.015	0.7	34	25	9	33	10
Mid subsoil (0.7–0.8)	1.0	8.1	0.08	34	13	5.0	1.6	0.016	0.6	37	25	8	29	11

Interpretation of laboratory data:

The soil is prone to dispersion (due mainly to very low electrical conductivity, rather than high ESP). CEC is low throughout profile, meaning that structural regeneration potential is poor.

Management options to consider:

The hardsetting topsoil is likely to respond well to minimum tillage. Look for the source of laterally flowing water that appears to be creating waterlogging problems in the subsoil, and develop a way of either sealing off the water or intercepting it.

'Calatoota' – dryland cotton (black cracking clay)

Field observations:

A wheat crop had been sprayed-out, in preparation for cotton in 1998/99. There was good surface protection by organic residues. The topsoil had excellent structure – compaction was restricted to narrow laneways.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.9	8.5	0.14	14	53	0.8	1.8	0.186	1.15	7	17	20	58	24
Subsurface (0.15–0.25)	1.8	8.7	0.18	21	52	1.5	1.5	0.117	0.95	7	17	19	59	26
Upper subsoil (0.4–0.5)	1.8	8.9	0.18	6	53	3.8	1.0	0.048	0.85	7	16	19	60	28
Mid subsoil (0.7–0.8)	1.6	9.2	0.28	12	52	9.2	0.7	0.030	0.8	5	16	19	60	31

Interpretation of laboratory data:

The soil is stable in water (high ESI, low ESP) and has excellent self-regeneration potential (CEC >40 cmol(+)/kg). Soil dispersibility becomes worse as depth increases, due to moderately-high ESP, but would only be a threat to productivity if the upper layers of soil were removed by erosion.

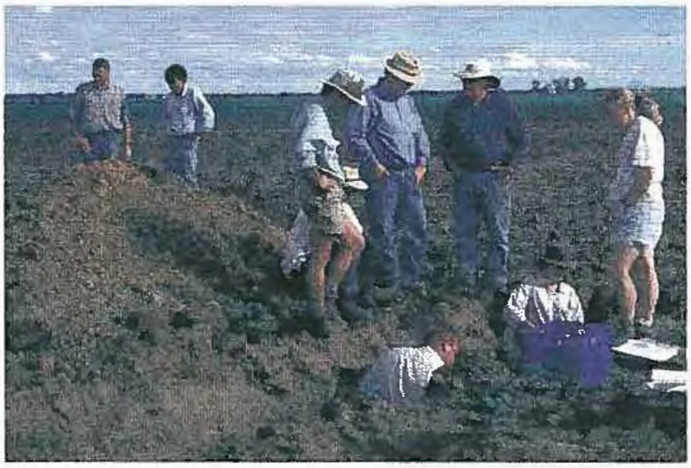
Management options to consider:

Continue with the present management system, although there is scope for further reduction of the proportion of the field compacted by wheel traffic. Consider replacement of the dual-wheeled tractor with a tracked machine.

'Cumberdeen', Wee Waa; October 1997

'Auscott Ltd.', Warren; November 1997

'Glen Prairie', Moree; November 1997



(2) WARREN SOIL MANAGEMENT COURSE, 12–13 NOVEMBER 1997

Participants

The trainees were consultants, company agronomists and leading growers in the Macquarie Valley.

Jim Bible	Agronomist, Agriland Narromine
Shane Bodiam	Agronomist, Auscott Warren
Andrew Cooper	Consultant, DQ Clark & Associates, Warren
Leonie Fisher	Consultant, DQ Clark & Associates, Warren
Ben Fleay	Agronomist, Twynam Cotton, Warren
Neville Gould	Research Engineer, NSW Agriculture, Trangie
David Hawkey	Macquarie Valley IAMA, Warren
Penny Heuston	Macquarie Valley IAMA, Warren
Robert Kelly	Salinity Officer, Landcare Trangie
Chris McCormack	Consultant, Hassall & Associates, Trangie
Amanda Mills	Agronomist, 'Wambandery', Warren
Chris Ramsey	Private Consultant, Warren
Michael Ryan	Manager, Twynam Cotton, Warren
Matt Seccombe	Manager, 'Wambandery', Warren
Nathan Soulsby	Agronomist, Twynam Cotton, Warren
Rachel Webb	Agronomist, Auscott Moree
Bill Williamson	Consultant, Hassall & Associates, Trangie

Cooperating growers

Chris Hogendyk, Auscott Warren
Mick Ryan, 'Elengerah'
John O'Brien, 'Bellevue'

Course leaders

Dr David McKenzie, Soil Consultant, Orange
Mr David Kelly, Cotton Development Officer, Warren

Resource staff

Mr Adam Kay, Cotton Seed Distributors, Wee Waa
Dr Pat Hulme, Soil Consultant, Warren
Dr Alison Anderson, Soil Consultant, Sydney
Ms Susan Gunter, NSW Agriculture, Tamworth

Program

Wednesday 12 November

8.30 Golf Club
- (a) Welcome – David Kelly
- (b) Evolution of SOILpak – Adam Kay
- (c) 'Cotton SOILpak-3'; contents, methods – David McKenzie

11.00 Practice pit; Auscott Warren
- learn about the new SOILpak scoring procedures

1.00 Lunch

2.00 Twynam Cotton, 'Elengerah'
- (a) Yield mapping for cotton growers – Alison Anderson
- (b) Pit description at high-yielding end of a field (silty grey clay)
- (c) Pit description at poor-yielding end of field (grey clay)
- (d) Farmer comments – Mick Ryan
- (e) Demonstration of surface mulch for cotton on hardsetting red soil – Mick Ryan

Thursday 13 November

8.00 'Bellevue', Warren
- (a) Red soil management, site selection for above-ground storages, drip irrigation – Pat Hulme
- (b) Pit description at high-yielding end of a hardsetting field
- (c) Pit description at poor-yielding end of a hardsetting field
- (d) Spade inspection in an adjacent unfarmed area (native trees and pasture)
- (e) Farmer comments – John O'Brien

11.30 Auscott Warren
- (a) Use of 2 m beds, management. of surface mulches – Chris Hogendyk
- (b) Concluding comments

Outcomes of the Warren course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of soil assessment in 'yield map interpretation' was emphasised. Other topics that received detailed attention included:
  - – assessment of the impact of controlled-traffic farming systems on soil structure,
  - – risk of water loss by deep drainage under cotton,
  - – stubble management for the control of hardsetting on red soil used for cotton,
  - – the usefulness of soil data from laboratories.
- The methods section of 'Cotton SOILpak-3' was thoroughly tested, which allowed minor adjustments to be made to some of the procedures.

Field observations, laboratory data and management options (Warren)

'Auscott Warren' – wheat after cotton (grey cracking clay)

Field observations:

Wheat (sown after an irrigated cotton crop) was about to be harvested. The soil still had excessively-coarse aggregates after drying/cracking (it appears to have had previous compaction damage), but was likely to become finer after re-moistening.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	8.2	0.08	8	34	1.2	2.2	0.068	0.75	9	21	15	55	-
Subsurface (0.15–0.25)	1.5	8.6	0.14	33	33	3.6	2.4	0.038	0.55	8	23	15	55	-
Upper subsoil (0.4–0.5)	1.5	8.7	0.19	55	35	4.2	1.8	0.045	0.40	8	23	12	58	-
Mid subsoil (0.7–0.8)	1.5	8.9	0.27	86	33	6.3	1.6	0.043	0.50	8	22	12	58	-

Interpretation of laboratory data:

Self-regeneration potential is moderate (CEC = 20–40 cmol(+)/kg), rather than being excellent, so the rate of recovery from mechanical compaction will be rather slow. The surface is not prone to dispersion (ESI >0.05), but the deeper layers are less stable in water (lower ESI, higher ESP).

Management options to consider:

Continue with controlled traffic farming. If a chisel plough is used to further decompact the soil, avoid the use of implements that bring subsoil material to the surface.

'Elengerah' – 'good yield' (grey silty clay)

Field observations:

The field was in bare fallow after irrigated cotton, with retained hills and controlled traffic farming – cotton is planned for 1998/99. In 1991/92, better cotton growth was observed at this 'silty' end of the field. In the pits there was evidence of subsoil waterlogging (manganese nodules in subsoil), possibly from laterally flowing water that originated in the head-ditch.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.8	7.3	0.18	51	18	3.1	2.2	0.059	1.65	5	19	40	40	-
Subsurface (0.15–0.25)	1.7	7.3	0.20	107	22	4.1	2.1	0.049	1.55	4	22	27	47	-
Upper subsoil (0.4–0.5)	1.4	7.2	0.11	78	19	4.0	2.0	0.028	0.85	5	30	23	46	-
Mid subsoil (0.7–0.8)	1.4	7.3	0.11	66	20	3.8	2.3	0.029	0.65	5	30	21	46	-

Interpretation of laboratory data:

The chloride bulge in the subsurface indicates impeded drainage. Dispersion is not a problem at the soil surface (ESI >0.05). Structural regeneration potential (CEC <20 cmol(+)/kg) is poor.

Management options to consider:

Attempt to provide more surface protection using organic mulch, and continue to restrict compaction to narrow laneways.

'Elengerah' – 'poor yield' (grey cracking clay)

Field observations:

The field was bare fallow after irrigated cotton, with retained hills and controlled traffic farming – cotton is planned for 1998/99. In 1991/92, poorer cotton growth was observed at this 'clay-rich' end of the field. There was evidence of waterlogging, due to poor surface drainage, during irrigation of cotton in earlier seasons.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	8.4	0.10	18	31	2.9	2.5	0.034	1.00	4	14	23	58	-
Subsurface (0.15–0.25)	1.5	8.4	0.17	71	31	3.9	2.1	0.044	0.95	4	15	23	59	-
Upper subsoil (0.4–0.5)	1.7	8.6	0.24	99	29	5.5	1.9	0.044	0.70	5	15	20	62	-
Mid subsoil (0.7–0.8)	1.6	8.7	0.28	116	28	10.0	1.4	0.082	0.65	5	16	21	60	-

Interpretation of laboratory data:

The soil will disperse in water (ESI <0.05), particularly in the upper half of the profile, and it has moderate regeneration potential (CEC = 20–40 cmol(+)/kg).

Differences in soil factors between 'high' yielding and 'low' yielding parts of the field:

Stability of surface soil in water is the main soil factor related to crop performance – dispersion makes the soil more prone to waterlogging. In recent seasons, cotton grown within this field has appeared very uniform, due apparently to the use of higher hills and more nitrogen fertiliser than in earlier seasons.

Management options to consider:

It is important to continue to restrict compaction to narrow laneways, and to maximise bed height. The soil is likely to benefit from gypsum applied at a rate of 5 t/ha – test strips should be used to check this.

'Bellevue' – 'good yield' (red soil)

Field observations:

Lucerne was being grown after cotton, and a coutrolled traffic system was in place. Shrinkage cracks were not obvious, although impregnation of the soil with a white paint solution indicated that they were the main macropores connecting the soil surface with the subsoil.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	7.4	0.15	35	9	1.1	2.4	0.135	1.10	21	29	24	26	-
Subsurface (0.15–0.25)	0.9	7.7	0.06	15	10	2.0	2.7	0.030	0.95	20	29	27	26	-
Upper subsoil (0.4–0.5)	1.4	8.5	0.22	57	21	3.3	2.1	0.066	0.50	8	16	30	47	-
Mid subsoil (0.7–0.8)	1.7	8.7	0.21	83	22	4.3	1.6	0.049	0.45	4	23	30	43	-

Interpretation of laboratory data:

The soil is unlikely to disperse in water (ESI >0.05), particularly at the soil surface, but has poor regeneration potential (CEC = 20–40 cmol(+)/kg).

Management options to consider:

It is important to continue to restrict compaction to narrow laneways. Tillage should be minimised, particularly when the soil is dry and prone to dust formation. As much organic mulch as possible should be maintained at the soil surface.

'Bellevue' – 'poor yield' (red soil)

Field observations:

Lucerne was being grown after cotton, with controlled traffic. Shrinkage cracks were not obvious, although impregnation of the soil with a white paint solution indicated that they were the main macropores connecting the soil surface with the subsoil.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.2	7.9	0.10	20	10	1.5	2.4	0.067	1.20	28	30	19	23	-
Subsurface (0.15–0.25)	1.3	7.8	0.07	15	8	1.3	2.9	0.056	1.15	27	31	18	22	-
Upper subsoil (0.4–0.5)	1.6	7.9	0.06	22	14	2.9	3.8	0.021	0.65	21	20	21	40	-
Mid subsoil (0.7–0.8)	1.8	8.0	0.04	15	18	2.8	2.8	0.014	0.55	16	16	25	44	-

Interpretation of laboratory data:

The soil is unlikely to disperse in water (ESI>0.05), particularly at the surface. It has poor structural regeneration potential (CEC = 20–40 cmol(+)/kg).

Differences in soil factors between 'high' yielding and 'low' yielding parts of the field:

The 'poor' site has more sand in the subsoil than the 'good' site, causing greater deep drainage of nutrients (as indicated by the chloride profiles) and water.

Management options to consider:

It is important to continue to restrict compaction to narrow laneways, and to minimise tillage (particularly when the soil is dry). As much organic mulch as possible should be maintained at the soil surface. Careful water management is required to minimise deep drainage.

Comparison with native pasture beyond a nearby fence-line:

A spade inspection (to a depth of 30 cm) clearly showed that nearby pasture soil had a much worse surface structure, due apparently to heavy grazing by sheep over many decades.

(3) MOREE SOIL MANAGEMENT COURSE, 18–19 NOVEMBER 1997

Participants

The trainees were consultants, company agronomists and leading growers in the Gwydir Valley. Three government advisers, who were unable to be at the earlier courses, also were in attendance.

Ross Beasley	Consultant, B&W Rural, Moree
Peter Birch	Consultant, B&W Rural, Moree
Peter Foreman	Agronomist, Auscott Moree
Harvey Gaynor	Manager, Auscott Moree
Wendy Harris	NSW Agriculture, Narrabri
Nathan Heeringa	Visiting Agronomist, Auscott Moree
Chris Humphries	Grower, Moree
Gavin Inglis	QDPI, Biloela
Rob Long	Consultant, B&W Rural, Moree
Chris Maunder	Consultant, B&W Rural, Moree
Kylie May	Agronomist, 'Norwood', Moree
Jorian Millyard	Consultant, McGregor-Gourlay, Moree
Steve Newberry	Consultant, McGregor-Gourlay, Moree
Tara O'Dea	Consultant, B&W Rural, Moree
Anna Swift	Consultant, B&W Rural, Moree
Sonia Tassell	NSW Agriculture, Moree

Cooperating growers

Chris Humphries, 'Lagoon'
Will Kirkby, 'Glen Prairie'
Harvey Gaynor, Auscott Midkin
John Mohr-Bell, 'Red Mill'

Course leaders

Dr David McKenzie, Soil Consultant, Orange
Dr Des McGarry, QDNR, Indooroopilly
Mr James Quinn, Cotton Development Officer, Moree

Resource staff

Mr David Larsen, ACRI, Narrabri
Dr Alison Anderson, Soil Consultant, Sydney
Mr Geoff Sharp, QDNR, Indooroopilly

Program

Tuesday 18 November

8.30 Conference room

(a) Welcome – James Quinn
(b) Development of SOILpak, future trends – David Larsen
(c) Cotton soil management in relation to other industries – Des McGarry
(d) 'Cotton SOILpak-3'; contents, methods – David McKenzie
(e) Interpretation of laboratory data – Geoff Sharp

10.30 Practice pit – unfarmed site, 'Lagoon' (grey clay)
- learn about the new SOILpak scoring procedures

12.00 Lunch

1.00 'Lagoon'

(a) Yield mapping for cotton growers – Alison Anderson
(b) Pit description at high-yielding end of field (grey clay)
(c) Pit description at poor-yielding end of field (grey clay)
(e) Farmer comments – Chris Humphries

4.00. 'Glen Prairie'

(a) Red soil management, site selection for above-ground storages – David McKenzie
(b) Pit description in a hardsetting field
(c) Farmer comments – William Kirkby, Peter Glennie

Wednesday 19 November

8.30 'Auscott Midkin'

(a) Use of 2 m beds, management of surface mulches – Harvey Gaynor

11.30 'Colane'

(a) Water management under dryland cotton – Des McGarry
(b) Pit description in a dryland cotton field with controlled traffic
(c) Farmer comments – John Mohr-Bell
(d) Concluding comments

Outcomes of the Moree course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of soil assessment in 'yield map interpretation' was emphasised. Other topics that received detailed attention included:
  – management of sodic soil,
  – assessment of the impact of controlled-traffic farming systems on soil structure,
  – risk of water loss by deep drainage under cotton,

– stubble management for the control of hardsetting on red soil used for cotton,
– the usefulness of soil data from laboratories.

- The methods section of the new 'Cotton SOILpak' manual was thoroughly tested.

Field observations, laboratory data and management options (Moree)

'Lagoon', 'unfarmed' (grey cracking clay)

Field observations:

The soil was under native pasture, located between the road and the cotton field described below. It appears to have never been ploughed.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.8	7.1	0.06	9	28	3.2	2.3	0.018	1.55	19	15	13	51	21
Subsurface (0.15–0.25)	1.5	8.9	0.14	8	34	5.9	2.2	0.023	0.70	18	16	16	51	18
Upper subsoil (0.4–0.5)	1.1	9.3	0.25	21	33	14.8	1.5	0.016	0.65	18	15	16	52	21
Mid subsoil (0.7–0.8)	0.9	9.4	0.45	133	36	26.7	1.1	0.016	0.65	17	15	16	54	25

Interpretation of laboratory data:

Well-structured topsoil overlies a dispersive (ESI <0.05, ESP >5), alkaline subsoil. Self-regeneration potential is moderate (CEC = 20–40 cmol(+)/kg).

Management options to consider:

If this site were to be developed for farming, efforts should be made to avoid exposure of the dispersive subsoil.

'Lagoon', 'high yield' (grey cracking clay)

Field observations:

Cotton had been grown in this field using controlled traffic and precision deep tillage, but there was evidence of the hills having been moved sideways over old wheel tracks. Cotton is planned for 1998/99.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.6	8.7	0.09	16	30	2.9	1.4	0.030	0.85	10	19	27	47	16
Subsurface (0.15–0.25)	1.6	8.5	0.16	48	29	4.0	1.5	0.039	0.75	11	18	27	47	18
Upper subsoil (0.4–0.5)	1.3	8.1	1.07	14	31	8.0	1.3	0.127	0.70	10	18	26	47	18
Mid subsoil (0.7–0.8)	1.2	8.0	1.80	26	34	11.3	1.3	0.158	0.60	7	17	30	50	20

Interpretation of laboratory data:

Slightly dispersive topsoil overlies a non-dispersive (ESI >0.05) but saline subsoil. Root growth by cotton is likely to be restricted below a depth of 0.7 m because of salinity. Structural regeneration potential is moderate (CEC = 20–40 cmol(+)/kg).

Management options to consider:

Gypsum application (5 t/ha) is an option that should be assessed via the use of test strips. Improve the guidance of traffic so that furrows remain narrow and in the same position. Schedule irrigations so that deep drainage is minimised.

'Lagoon', 'poor yield' (grey cracking clay)

Field observations:

The three observation pits were on a small sub-section of the field that had been heavily cut during field development. A controlled traffic had been used, after precision deep tillage, but there was evidence of hills having been moved sideways over old wheel tracks. Cotton is planned for 1998/99.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.0	9.3	0.24	8	31	12.7	1.8	0.018	0.65	16	19	16	51	20
Subsurface (0.15–0.25)	0.8	9.4	0.32	54	29	16.8	1.6	0.019	0.60	16	17	13	54	19
Upper subsoil (0.4–0.5)	0.5	8.4	2.09	84	32	22.3	1.8	0.093	0.40	15	15	16	55	22
Mid subsoil (0.7–0.8)	0.7	8.7	2.12	217	34	40.7	1.0	0.052	0.45	13	14	12	59	26

Interpretation of laboratory data:

Strongly dispersive topsoil (ESI <0.05, ESP>5, high pH) overlies a non-dispersive (ESI >0.05) but strongly saline subsoil. Root growth by cotton is likely to be restricted below a depth of 0.3 m because of salinity. Structural regeneration potential is moderate (CEC = 20–40 cmol(+)/kg).

Differences in soil factors between 'high' yielding and 'low' yielding parts of the field:

The 'poor' site is more sodic and saline than the 'good' site.

Management options to consider:

Gypsum application (5 t/ha, possibly with 2.5 t/ha follow-up doses) is an option that should be assessed via the use of test strips. The soil is too alkaline for lime application to be successful. Improve the guidance of traffic so that furrows remain narrow and in the same position. Manage water application so that subsoil salt is pushed deeper (by no more than about 1 m). If sufficient summer rain falls, consider planting forage sorghum to improve the excessively-coarse tilth by shrink-swell processes.

Comparison between native pasture and the cotton field:

The pasture soil is slightly better than the cotton soil, due to less-severe alkalinity and more organic matter near the soil surface. Subsoil conditions are very similar.

'Glen Prairie' – problem area (red soil)

Field observations:

Cotton was being grown using controlled traffic after deep tillage. The cotton had been replanted because of hardsetting problems at the soil surface, and had only recently emerged. The well-structured subsoil appears likely to transmit water easily. One of the 3 pits had sandier subsoil than the other two pits, due apparently to the presence of an old stream channel.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.1	7.1	0.18	25	9	2.7	2.4	0.067	0.80	36	25	15	26	7
Subsurface (0.15–0.25)	1.4	6.1	0.12	14	8	2.8	2.5	0.042	0.60	37	23	18	23	11
Upper subsoil (0.4–0.5)	1.7	7.7	0.11	13	21	3.4	2.0	0.031	0.50	26	16	11	48	19
Mid subsoil (0.7–0.8)	1.6	7.9	0.12	21	22	4.9	1.9	0.024	0.55	22	15	12	52	19

Interpretation of laboratory data:

Non-dispersive topsoil (ESI >0.05) overlies a dispersive subsoil (ESI <0.05). Structural regeneration potential is poor near the soil surface (CEC <20), but moderate in the subsoil (CEC = 20–40 cmol(+)/kg). The almost-equal proportions of coarse sand, fine sand, silt and clay in the topsoil and subsurface mean that the soil has a concrete-like pore space distribution when wet. Small clay and silt particles fill many of the spaces between the sand grains, which gives the soil great strength when dry. The sub-surface pH value indicates that some of the soil is mildly acidic.

Management options to consider:

Consider the use of a 'slip plough' to bring subsoil clay to the surface from a depth of 0.45 m, followed with the application of a blend of gypsum (2.5 t/ha) and lime (1.5 t/ha). Schedule irrigations so that deep drainage of water below the root zone is minimised. Beware of leakage from channels and reservoirs on this soil type.

'Colane' – dryland cotton (grey silty clay)

Field observations:

Wheat had just been harvested; dryland cotton is planned for 1998/99. There was excellent protection of the soil surface by stubble, but there was evidence of a smeared layer in the sub-surface, due apparently to sweeps on the wheat planting equipment. As seen in most dryland paddocks in northern NSW, previous traffic appears not to have been controlled in a systematic fashion.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.6	6.2	0.19	94	21	0.3	2.6	0.630	1.40	22	24	16	35	12
Sub-surface (0.15–0.25)	0.5	6.5	0.06	18	22	0.7	2.7	0.086	1.20	19	20	20	42	14
Upper subsoil (0.4–0.5)	0.9	7.0	0.04	8	27	2.6	2.0	0.015	0.85	16	17	20	49	18
Mid subsoil (0.7–0.8)	0.7	8.2	0.06	6	27	8.4	1.5	0.007	0.50	17	17	20	49	18

Interpretation of laboratory data:

A non-dispersive topsoil (ESI much greater than 0.05) overlies a dispersive subsoil (ESI >0.05, ESP >5). This soil has moderate structural regeneration potential (CEC 20–40 cmol(+)/kg) throughout the profile. The topsoil is slightly acidic.

Management options to consider:

Consider deep ripping the soil (to a depth of about 0.25 m, using a chisel plough that does not bring dispersive subsoil to the surface. Dryness of the subsoil. Structural improvement by shrink-swell processes, on their own, would take too long. If a skip-row planting configuration is to be used, only chisel plough under the intended plant lines – this will leave strips of soil between the plant lines that are well protected from water erosion by the wheat stubble. Erosion control at this site is particularly important because the subsoil material, if exposed, would be expensive to improve using gypsum. Aim for a more accurate control of traffic. Because the topsoil is slightly acidic, trial some test strips with lime application.

(4) EMERALD SOIL MANAGEMENT COURSE, 3–4 JUNE 1998

Participants

Scott Black	Grower, Emerald
Ken Dixon	Soil Conservationist, Emerald
Dwayne Evans	Consultant, Emerald
David Field	Extension Officer, QDNR
Bruce Forster	Senior Land Resources Officer, QDNR, Rockhampton
Scott Frome	Land Resources Officer, QDNR, Emerald?
Scott Irvine	QDNR, Emerald
Sue McCarroll	Land Resources Officer, QDNR, Biloela
Kevin McCosker	Agronomist, QDPI, Emerald
Amanda Noone	Consultant, Emerald
Dave Pellado	Consultant, Emerald
Bill Wilkinson	Soil Conservationist, QDNR, Emerald

Cooperating growers

Scott Black
Trevor Elsden
Harvey Rich, 'Killara'

Course leaders

Dr Des McGarry, QDNR, Indooroopilly
Dr David McKenzie, Soil Consultant, Orange
Mr Mike McCosker, QDPI, Emerald

Resource staff

Dr Alison Anderson, Soil Consultant, Orange
Mr Geoff Sharp, QDNR, Indooroopilly
Mr Ken Rohde, Research Officer, QDNR, Emerald
Dr Don Yule, Research Officer, Rockhampton

Program

Wednesday 3 June

8.30 QDPI, Emerald

(a) Welcome – Mike McCosker
(b) Evolution of SOILpak – David McKenzie
(c) Cotton soil management in relation to other industries – Des McGarry
(d) 'Cotton SOILpak-3'; contents, methods – David McKenzie
(e) Interpretation of laboratory data – Geoff Sharp

11.00 Scott Black's farm
- (a) Learn about the new SOILpak scoring procedures
- (b) Pit description in high-yielding field
- (c) Farmers comments – Scott Black

1.00 Lunch

1.30 Scott Black's farm
- (a) Yield mapping for cotton growers – Alison Anderson
- (b) Pit description in low-yielding field

3.30 Trevor Elsden's farm
- (a) Pit description in a dryland, controlled traffic farming QDNR experimental site
- (b) Farmers comments – Trevor Elsden
- (c) Comments on the controlled traffic farming experiment – Don Yule

Thursday 4 June

9.00 'Killara'
- (a) Pit description in an unfarmed site
- (b) Pit description in adjoining field
- (c) Assessing salinity in the field using the NSW Salt Action Field Kit – Alison Anderson
- (d) Concluding comments

Outcomes of the Emerald course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of site assessment in 'yield map interpretation' was emphasised. Other topics that received detailed attention included:
  - – assessment of the impact of controlled traffic farming systems on soil structure,
  - – stubble management for erosion and Heliothis control,
  - – the usefulness of soil data from laboratories.
- The methods section of the new 'Cotton SOILpak' manual was thoroughly tested.

Field observations, laboratory data and management options (Emerald)

'Scott Black' – 'high-yielding field' (black cracking clay)

Field observations:

Beds have been in place for 5 years, with conversion from 6-row equipment to 8-row gear about 2 years earlier. There was evidence of the hills having been moved sideways, but overall the structural condition of the subsoil was exceptionally good. The performance of the recently harvested cotton crop was very good.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.8	8.7	0.15	33	69	1.3	1.8	0.115	0.80	4	21	15	64	27
Subsurface (0.15–0.25)	1.8	8.9	0.14	8	63	2.5	1.3	0.055	0.65	3	20	14	65	28
Upper subsoil (0.4–0.5)	1.9	9.0	0.19	27	68	5.3	1.0	0.036	0.65	3	18	11	68	29
Mid subsoil (0.7–0.8)	1.9	9.0	0.22	71	69	7.2	0.8	0.030	0.55	2	16	12	72	30

Interpretation of laboratory data:

The subsoil is likely to disperse if exposed (ESI < 0.05, ESP > 5). The soil is alkaline throughout. Self-regeneration potential is excellent (CEC > 40 cmol(+)/kg).

Management options to consider:

Continue with the present management system, but ensure that hills do not move laterally onto old furrows. Avoid the use of implements that bring subsoil material to the surface. Continue with growing wheat and retaining stubble to prevent erosion.

'Scott Black' – 'low-yielding field' (black cracking clay)

Field observations:

Cotton yields in the 1997/98 season were less in this field than in the 'high-yielding' site (see above). This low-yielding area was 200 metres up-slope, just above a road and ditch that separates the two fields. There was evidence of waterlogging in the up-slope area, apparently because the lateral flow of water through the subsoil (lying just above the basaltic parent material) was impeded by the ditch and roadway.

The hills had recently been knocked down – this made it difficult to locate the main wheel tracks from the previous cotton crop. However, the SOILpak score indicates that the soil is well-structured throughout (negligible compaction).

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.8	8.6	0.18	50	67	2.5	2.1	0.071	1.05	3	17	15	65	28
Subsurface (0.15–0.25)	1.7	8.8	0.15	12	69	1.9	1.5	0.080	0.85	3	17	11	69	32
Upper subsoil (0.4–0.5)	1.8	9.0	0.19	38	75	3.5	1.1	0.055	0.75	2	16	14	69	34
Mid subsoil (0.7–0.8)	1.8	8.9	0.25	76	70	5.1	0.8	0.049	0.60	11	17	15	58	32

Interpretation of laboratory data:

The subsoil (below 60 cm) is likely to disperse if exposed (ESI < 0.05, ESP > 5). The soil is alkaline throughout. Self-regeneration potential is good (CEC > 40 cmol(+)/kg).

Differences in soil factors between 'high-yielding' and 'low-yielding' fields

The laboratory data show that soil in the 'high' and 'low' yielding areas had similar properties.

Management options to consider:

Continue with controlled traffic farming. Monitor the subsoil water content of the 'poor yielding' area to test the theory that cotton growth has been retarded by poor drainage of water in the subsoil. If so, subsoil drains may have to be installed.

'Trevor Elsden' – dryland field; site of QDNR controlled traffic farming experiment (black cracking clay)

Field observations:

Wheat was being grown after dryland cotton on 2 metre wide beds. The SOILpak score indicated that the topsoil under the beds was not as well-structured as would be expected, given that it had been under controlled traffic, and had excellent soil chemical properties (see below). Moderately compacted topsoil was found right across the beds. The sub-surface soil was slightly compacted in some sections of the bed. Below 30 cm the soil was well-structured. The near-surface compaction appears to have been caused by press-wheels and drive wheels on the planter, and by the use of plot harvesting equipment with a wheel spacing that was slightly less than 2 metres.

Soil test results

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	8.0	0.11	9	71	0.9	3.2	0.121	0.80	2	19	19	64	26
Subsurface (0.15–0.25)	1.6	8.3	0.10	12	71	1.8	2.5	0.055	0.70	2	20	19	61	27
Upper subsoil (0.4–0.5)	1.9	8.5	0.12	8	70	3.1	2.1	0.038	0.70	2	18	18	65	28
Mid subsoil (0.7–0.8)	1.9	8.9	0.15	–	66	4.8	2.3	0.031	0.45	21	29	19	35	24

Interpretation of laboratory data:

The subsoil has ESI values less than 0.05 (indicating possible dispersion) even though ESP values are less than 5. The low ESI values are a result of low values of EC (when EC is low, dispersion can occur even when ESP values are less than 5). The soil is alkaline throughout. Self-regeneration potential is good (CEC > 40 cmol(+)/kg).

Management options to consider:

Restrict the wheels of all field traffic to the permanent wheel tracks beside the 2 metre wide beds. Because of its high CEC (associated with a high shrink-swell capacity), the soil has the ability to quickly regenerate structure under the beds if it is not recompacted. Ensure that the press-wheels on planting equipment are configured and adjusted to prevent compaction across the bed.

'Killara', 'unfarmed' (brown silty clay)

Field observations:

Even though this unfarmed site had always been under native pasture and brigalow trees, topsoil structure was poor. There was evidence of hardsetting. The soil had been dried throughout the profile, and was very hard. There were abundant tree roots in the top 50 cm of soil.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	0.8	7.9	0.13	12	24	2.3	3.4	0.057	0.85	18	44	11	27	12
Subsurface (0.15–0.25)	1.6	9.1	0.18	25	29	7.9	2.7	0.023	0.60	17	38	11	35	14
Upper subsoil (0.4–0.5)	1.5	9.4	0.48	420	29	18.6	1.8	0.026	0.50	20	32	10	37	15
Mid subsoil (0.7–0.8)	1.5	9.3	0.68	599	24	22.1	1.5	0.031	0.35	23	34	14	31	13

Interpretation of laboratory data:

The particle-size distribution of the soil indicates that it is prone to hardsetting when dry (clay content < 35%, high percentage of fine sand). Below the topsoil the soil is dispersive (ESI < 0.05, ESP > 5). The EC of the subsoil will be limiting for some plants. The soil is alkaline throughout. Self-regeneration potential is moderate (CEC 20–40 cmol(+)/kg).

Management options to consider:

If this soil were to be developed in the future for farming, efforts should be made to avoid exposure of dispersive sub-surface soil and subsoil. A minimum tillage system with stubble retention would be the best option for managing the hardsetting topsoil.

'Killara' – cotton field adjoining unfarmed site (brown silty clay)

Field observations:

The field was under bare fallow after irrigated cotton, with retained hills. Compaction was confined to the wheel tracks. Stones were scattered over the soil surface. The pits were located approximately 200 metres from the unfarmed site described above.

The SOILpak scores (see below) indicate that the soil is not compacted. Cultivation has improved the structure of the topsoil at this site, compared to the unfarmed site.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.5	8.5	0.12	25	23	2.0	3.1	0.061	0.90	20	35	11	34	12
Subsurface (0.15–0.25)	1.7	8.8	0.14	8	24	5.0	2.4	0.028	0.75	19	33	14	34	13
Upper subsoil (0.4–0.5)	1.8	9.3	0.40	128	30	14.0	1.4	0.029	0.60	18	29	12	41	16
Mid subsoil (0.7–0.8)	1.8	8.2	2.81	485	31	18.1	1.3	0.156	0.45	16	30	15	41	16

Interpretation of laboratory data:

As for the unfarmed site, the particle-size distribution of the soil indicates that it is prone to hardsetting when dry (clay < 35% in the topsoil, high percentage of fine sand). For depths between 10 cm and 60 cm the soil is dispersive (ESI < 0.05, ESP > 5). The ESP of the subsoil is very high but the ESI value is greater than 0.05 (indicating that the soil is not dispersive). This is because of the high EC value. EC will be very limiting to root growth below 60 cm. Between 30 and 60 cm the EC will limit the growth of some plants, but not cotton. The soil is alkaline throughout. Self-regeneration potential is moderate (CEC between 20 and 40 cmol(+)/kg).

Management options to consider:

Continue with controlled traffic farming. The hardsetting topsoil is likely to respond well to minimum tillage (and stubble retention). Tillage should be minimised, particularly when the soil is dry and prone to dust formation. Avoid exposure of soil below 10 cm because it is susceptible to dispersion. Because of the presence of salinity in the subsoil, careful water management is required to avoid salt movement to the surface layers. However, deep drainage has to be minimised so that watertables do not rise quickly. On-going monitoring is required to assess possible changes in water table depth and rootzone EC.

Comparison between native woodland and the cotton field:

The farmed soil was better than the pristine soil. Under cotton, the soil has become less compact and less sodic, but is slightly more alkaline at the soil surface.

Elsden's farm, Emerald; June 1998

'Glen Idol', Dalby; July 1998

' Togo Station', Wee Waa; May 1999

(5) DALBY SOIL MANAGEMENT COURSE, 16–17 July 1998

Participants

John Adriaans	Agronomist, IAMA, Pittsworth
Murray Boshammer	Agronomist, Total Ag Services, Dalby
Justin Claridge	Soil Scientist, QDNR, Indooroopilly
Liz Cowlishaw	Extension Officer, QDPI, Dalby
Andrew Dieckmann	Sales Agronomist, Downs Fertiliser Co. Pty. Ltd., Pittsworth
Chris Grant	Trainee Agronomist – Graham Boulton, Brookstead
Paul Harris	Extension Officer, QDNR, Dalby
Andrew Johnston	Agronomist, Cottco Ag Sales, Dalby
Rick Kowitz	Project Officer, Murilla Landcare, Miles
Anthony McNabb	Agronomist, IAMA, Pittworth
Greg Mills	Agronomist, Primac, Dalby
Tim Neale	Extension Officer, QDPI, Miles
Graham Powell	Extension Officer, QDPI, Dalby
Aaron Prendergast	Agronomist, IAMA, Pittsworth
Bill Welch	Agronomist, Tatzenko Consultancies, Pittsworth
John Willcox	Private Agronomist, Dalby
Jeffrey York	Agronomist, Primac, Dalby

Cooperating growers

Leigh Johnston, 'Glen Idol'
Stuart Ledbetter, 'Cabarita'

Course leaders

Dr Des McGarry, QDNR, Indooroopilly
Dr David McKenzie, Soil Consultant, Orange
Mr Greg Salmond, QDPI, Dalby

Resource staff

Mr Dennis Baker, QDNR, Indooroopilly
Dr Alison Anderson, Soil Consultant, Orange
Mr Geoff Sharp, QDNR, Indooroopilly
Mr Greg McNamara, Technical Officer, QDPI, Dalby

Program

Thursday 16 July

8.30 Community Centre, Dalby
(a) Welcome – Greg Salmond

(b) Evolution of SOILpak – David McKenzie
(c) Cotton soil management in relation to other industries – Des McGarry
(d) Interpretation of laboratory data – Geoff Sharp
(e) 'Cotton SOILpak-3'; contents, methods – David McKenzie

11.00 'Glen Idol'
(a) Learn about the new SOILpak scoring procedures
(b) Pit description along unfarmed fence line

1.00 Lunch

1.30 'Glen Idol'
(a) Pit description in field where cotton yields had been disappointing
(b) Farmer's comments – Andrew Johnston
(c) Assessing salinity in the field using the NSW Salt Action Field Kit – Alison Anderson
(d) Pit description in a field where sorghum recently had been grown after cotton
(e) Group summation of the soil structure on 'Glen Idol'

Friday 17 July

9.00 'Cabarita'
(a) Yield map for Cabarita – Des McGarry, John Adriaans, Stuart Ledbetter
(b) Pit description in low-yielding section of a field
(c) Pit description in high-yielding section of a field
(d) Yield mapping for cotton growers – Alison Anderson
(e) Group summation of possible soil factors affecting yield

12.00 'Melrose'
(a) Pit description in field with 25 year old beds
(b) Group summation of the course

Outcomes of Dalby course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of site assessment in 'yield map interpretation' was emphasised. Other topics that received detailed attention included:
  – assessment of the effects of controlled traffic farming systems on soil structure,
  – the impact of pupae busting on the structure of wet soil,
  – the relationship between bore water quality and soil structure,
  – the effect of crop rotation on soil structure,
  – the usefulness of soil data from laboratories.
- The methods section of the new 'Cotton SOILpak' manual was thoroughly tested.

Field observations, laboratory data and management options (Dalby)

'Glen Idol' – 'fence-line' (black cracking clay)

Field observations:

The site of the 'fence-line' pits on 'Glen Idol' had recently been cultivated. Prior to the cultivation and removal of the fence the site had been unfarmed. The site therefore gives an impression of the initial condition of the soil on 'Glen Idol'.

There was evidence of wheel-track compaction as a result of the cultivation. However, the SOILpak scores indicated that the soil has negligible compaction. The topsoil was friable – small, shiny-faced natural aggregates dominated the soil profile. Biopores were found in the topsoil. Despite the relatively large amounts of soil organic matter, all layers of the soil slaked when added to distilled water. No dispersion was observed. The soil was moist in the topsoil and wet below 10 cm.

Soil test results

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.9	7.1	0.10	21.9	50	1.1	1.20	0.091	1.35	9	18	16	57	25
Subsurface (0.15–0.25)	1.8	6.7	0.14	42.4	49	1.0	1.10	0.140	1.25	9	18	19	54	24
Upper subsoil (0.4–0.5)	2.0	6.4	0.18	458.7	56	2.7	0.79	0.070	0.90	6	13	13	69	31
Mid subsoil (0.7–0.8)	1.8	7.1	0.24	1809	61	4.3	0.67	0.067	0.70	4	12	16	69	31

Interpretation of laboratory data:

The soil is unlikely to disperse (ESI > 0.05, ESP < 5) and is neutral to slightly acid throughout. Self-regeneration potential of the soil is good (CEC > 40 cmol(+)/kg). Salinity hazard is very low (EC_e < 1.5 dS/m).

Management options to consider:

There are no plans to crop this soil in the future. The soil has no major limitations to crop growth but if the site was to be developed for farming in the future, a controlled traffic system should be implemented. The soil is prone to damage if traffic passes over it whilst wet.

'Glen Idol' – 'irrigated cotton' (black cracking clay)

Field observations:

The field was underbare fallow after irrigated cotton, with hills retained. The pits were located approximately 500 m from the 'fence-line' pits. Cotton lint yield had been less than expected for the last few crops. Bore water had been used to irrigate the cotton. With an EC of 1.06 dS/m, and a SAR value of 4.16, structural stability problems are unlikely. However, the use of high quality irrigation water (or rainfall) after the use of this bore water may cause dispersion problems.

Roots on old cotton plants indicated that their growth had been limited. The SOILpak scores showed that soil under the plant lines was moderately compacted. There were signs that the hills had moved laterally. A 6-row system was being used, in conjunction with 2-row cotton pickers that had a single rear wheel. Pupae busting had taken place the day before sampling. Although the soil was moist, damage from pupae busting was not too great because the working had been shallow (approximately 10 cm). However, the end result was a series of narrow smeared grooves down the centre of each hill, with slabs of smeared soil lying on bed shoulders that mostly remained undisturbed.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	0.5	8.4	0.12	27	48	3.1	1.3	0.038	1.00	8	22	13	58	28
Subsurface (0.15–0.25)	1.1	8.9	0.17	49.2	49	6.7	1.4	0.025	0.50	7	19	11	61	28
Upper subsoil (0.4–0.5)	1.4	8.6	0.39	222	56	8.2	0.92	0.048	0.75	6	19	12	62	30
Mid subsoil (0.7–0.8)	1.4	8.5	0.47	484	58	9.0	0.81	0.052	0.80	4	15	10	68	31

Interpretation of laboratory data:

The soil above 60 cm is likely to disperse if exposed (ESI < 0.05, ESP > 5 below 10 cm). Even though the ESP of the topsoil is < 5, the ESI of the topsoil is < 0.05 because EC is so low. The soil is alkaline throughout. Self-regeneration potential of the soil is good (CEC > 40 cmol(+)/kg). Salinity hazard is low.

Management options to consider:

Ensure that hills do not move laterally onto old furrows. Consider changing from 6-row to 8-row equipment, and avoid the use of pickers that compact every furrow. Avoid deep tillage operations when the soil is moist. Carry out pupae busting operations as soon as possible after harvest to minimise the risk of cultivation damage under wet conditions. Damage to the soil will be greater when the soil is wet, compared to when the soil is at the plastic limit or drier. If it is necessary to carry out pupae busting when the soil is moist, make sure that soil disturbance is only in the top 10 cm. Consider using a rotation crop to dry and crack the soil, which will help to repair compaction under the hills.

'Glen Idol' – 'sorghum' (black cracking clay)

Field observations:

The field was under bare fallow following sorghum, with hills retained. The pits were located between the 'fence-line' and 'cotton' pits. Sorghum had been grown to improve the soil for cotton production (cotton had been grown before the sorghum crop). Compacted clods remained in the topsoil under the hills but they had been penetrated by sorghum roots . Biopores were found throughout the soil. All layers of soil slaked when added to distilled water. The topsoil also dispersed.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.4	8.6	0.09	23.5	56	3.2	1.24	0.028	1.20	8	15	16	62	27
Subsurface (0.15–0.25)	1.7	8.8	0.12	49.6	60	4.3	1.13	0.028	0.95	6	13	13	66	31
Upper subsoil (0.4–0.5)	2.0	8.5	0.21	111.6	59	7.0	0.89	0.030	0.80	6	14	16	66	31
Mid subsoil (0.7–0.8)	1.8	8.4	0.31	243	56	7.5	0.85	0.041	0.95	6	13	16	67	31

Interpretation of laboratory data:

The soil is likely to disperse in water (ESI < 0.05, ESP > 5 below 30 cm). The ESI values in the top 30 cm of soil are low because of low EC values. The soil is alkaline throughout. Self-regeneration potential of the soil is good (CEC > 40 cmol(+)/kg). Salinity hazard is low.

Management options to consider:

Restrict traffic to wheel-tracks and prevent soil disturbance when the soil is wetter than the plastic limit. Apply a test strip of gypsum (5 t/ha) to determine if soil instability in water can be overcome economically.

Differences in soil factors between 'fence-line', 'cotton' and 'sorghum' sites

Cropping has caused the soil to become more compact, dispersive and alkaline. Compaction apparently is due to poor control of traffic, and the use of cotton pickers that traffic every furrow. Dispersibility of the soil appears to have heen aggravated by the use of a slightly sodic bore water. The increase in alkalinity may be associated with a reduction in soil organic carbon content.

Fortunately, the soil at all sites has an excellent self-regeneration potential. This means that compaction problems can quickly he overcome by using crops that dry and crack the soil.

'Cabarita', 'low-yielding area' (black cracking clay)

Field observations:

The field was under bare fallow after irrigated cotton, with retained hills. Cotton stalks had been raked and burned. A yield estimation map (obtained in January) indicated that this section of the field had a lower yield than the rest of the field. The soil pit was relatively shallow – below a depth of approximately 100 cm the soil was very hard.

Compaction was mainly confined to the wheel tracks, with some encroachment of compaction into the sides of hills. The SOILpak scores indicated that soil under the hills was well-structured throughout the profile. Below 90 cm, the soil was dispersive.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.8	7.9	0.08	24.3	54	0.9	1.6	0.089	1.25	10	8	26	55	26
Subsurface (0.15–0.25)	2.0	8.0	0.10	61.1	56	1.7	1.6	0.059	1.35	9	8	27	55	29
Upper subsoil (0.4–0.5)	2.0	8.4	0.11	84.6	59	1.3	1.3	0.041	1.00	6	7	27	57	31
Mid subsoil (0.7–0.8)	1.9	8.6	0.12	103.6	59	1.2	1.2	0.044	1.05	5	6	27	62	33

Interpretation of laboratory data:

The soil below 30 cm is likely to disperse if exposed (ESI <0.05), due to low EC values rather than high ESP values (ESP <3). The soil is alkaline throughout. Self-regeneration potential of the soil is good (CEC > 40 cmol(+)/kg). Salinity hazard is very low.

Management options to consider:

Continue with controlled traffic farming, ensuring that hills do not move laterally onto old furrows.

'Cabarita' – 'high-yielding area' (black cracking clay)

Field observations:

The field was under bare fallow after irrigated cotton, with retained hills. Cotton stalks had been raked and burned. A yield estimation map (obtained in January) indicated that this section of the field had a higher yield than the rest of the field. The slope of the field at this site was greater than at the 'low-yielding' site. The soil pit was again relatively shallow (~ 100 cm deep). The soil was very hard at the bottom of the pit. Compaction was mainly confined to the wheel tracks, with some encroachment of compaction on the sides of hills. The soil was moist throughout the profile.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	2.0	7.7	0.06	20.7	55	0.6	1.8	0.100	1.10	7	10	28	54	2[illegible]
Subsurface (0.15–0.25)	1.7	7.3	0.07	30.2	62	1.3	1.8	0.054	1.15	5	10	26	58	28
Upper subsoil (0.4–0.5)	1.9	8.3	0.10	59.2	57	2.1	1.7	0.048	1.10	4	9	28	59	30
Mid subsoil (0.7–0.8)	1.7	8.4	0.10	53.9	60	2.7	1.3	0.037	1.15	3	9	30	58	26

Interpretation of laboratory data:

The SOILpak scores indicate that the soil is well structured throughout the profile. The soil below 30 cm is likely to disperse if exposed (ESI < 0.05), due to low EC values, rather than high ESP values (ESP < 3). Self-regeneration potential of the soil is good (CEC > 40 cmol(+)/kg).

Management options to consider:

Continue with controlled traffic farming, ensuring that hills do not move laterally onto old furrows.

Differences in soil factors between 'high-yielding' and 'low-yielding' sites

Field observations and the laboratory data show no obvious differences between the two sites. The yield contrast may have been due to variation in field slope – the slope is greater in that part of the field with a higher yield, so the risk of waterlogging would have been less. Also it appears that the irrigation of the high-yielding area during a very hot period in January was more timely than for the poor-yielding area, which was moisture stressed when watered.

'Melrose' – hills retained for 25 years (black cracking clay)

Field observations:

The field was under bare fallow after dryland cotton, with hills retained. The hills had been in place for 25 years old.

Old cotton plants indicated that root growth had been severely restricted in the topsoil. Most were deflected at right-angles at a depth of approximately 15 cm. The roots however had developed some laterals that had grown through the compacted layer. Their water extraction apparently had regenerated a smeared zone that had been created by 'Delta wing' sweeps used for the injection of anhydrous ammonia. Only a few platey fragments of this layer remained when the soil was examined. The SOILpak scores indicate that the soil is well-structured throughout the profile, under the hills.

There had been a problem with getting irrigation water to the part of the field where the pits were located so the last cotton crop had been dryland. The soil was wet throughout the profile at the time of sampling.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.7	8.6	0.09	23.5	56	1.1	1.8	0.082	1.05	4	13	26	55	27
Subsurface (0.15–0.25)	1.8	8.6	0.10	29.8	61	1.6	1.5	0.063	0.90	3	14	26	57	30
Upper subsoil (0.4–0.5)	1.7	8.9	0.17	67.6	61	4.6	1.1	0.037	0.85	3	12	23	59	31
Mid subsoil (0.7–0.8)	1.7	9.0	0.21	46.4	62	6.6	0.9	0.032	1.00	3	12	25	59	31

Interpretation of laboratory data:

The soil below 30 cm is likely to disperse if exposed (ESI < 0.05). The subsoil is prone to dispersion because of low EC values, rather than high ESP values. The soil is moderately alkaline throughout. Self-regeneration potential of the soil is good (CEC > 40 cmol(+)/kg).

Management options to consider:

Continue with controlled traffic farming, ensuring that hills do not move laterally onto old furrows. Avoid the use of 'Delta wing' sweeps when the soil is wetter than the plastic limit.

(6) WEE WAA SOIL MANAGEMENT COURSE, 14 MAY 1999

Participants

Tony Bennett	Jack Murray Ag., Narrabri
Mike Carberry	Grower, Narrabri
Helen Dugdale	CRDC, Narrabri
Dean Goddard	Elders, Narrabri
Andrew Greste	Grower, Burren Junction
Catherine Hare	Cotton CRC, Narrabri
Stefan Henggeler	Auscott Ltd., Narrabri
Laurie Kaelin	Geoff Brown Consulting, Wee Waa
Vicky Kuhn	Total Ag Services, Wee Waa
Amanda McCalman	National Mutual Cotton, Wee Waa
Tom McGuire	Cotton Grower Services, Wee Waa
Stuart Murray	Goddard Agricultural Services, Narrabri
Drew Penberthy	Glencoe IAMA, Narrabri
Adrian Schwager	Grower, Wee Waa
Jennie Spenceley	NSW Agriculture, Moree
Cameron Tonkin	NSW Agriculture, Walgett

Cooperating growers

Hugh Holland, 'Togo Station'
Phil Lawrence, 'Cumberdeen'
Andrew Campbell, 'Calatoota'

Course leaders

Dr David McKenzie, Soil Consultant, Orange
Ms Wendy Harris, District Agronomist, Narrabri

Resource staff

Dr Alison Anderson, Soil Consultant, Orange
Dr Mike Bange, ACRI, Narrabri
Dr John Triantafilis, Soil Scientist, Narrabri

Program

Friday 14 May

8.00 ACRI Conference room
(a) Welcome – Wendy Harris
(b) 'Cotton SOILpak' manual; contents, methods – David McKenzie

9.00 'Togo Station'
(a) Pit description at high-yielding end of field (black clay)
(b) Pit description at poor-yielding end of field (black clay)
(c) Yield mapping for cotton growers – Alison Anderson
(d) Farmer comments – Hugh Holland

12.15 'Cumberdeen'
(a) Pit description at high-yielding end of field (red soil)
(b) Pit description at poor-yielding end of field (red soil)
(c) Use of EM equipment to assess salinity problems – John Triantafilis
(d) Farmer comments – Phil Lawrence

3.30 'Calatoota'
(a) Pit description in a dryland cotton field
(b) Water management for dryland cotton – Mike Bange
(c) Farmer comments – Andrew Campbell
(d) Concluding comments

Outcomes of Wee Waa course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of soil assessment in 'yield map interpretation' was emphasized. Other topics that received detailed attention included:
  - management of sodic soil,
  - assessment of the impact of controlled-traffic farming systems on soil structure,
  - risk of water loss by deep drainage under cotton,
  - stubble management for erosion control under dryland conditions.

Field observations, laboratory data and management options (Wee Waa)

'Togo Station' – 'high yield' (black cracking clay)

Field observations:

The field had been re-levelled the previous year under dry conditions, just before cotton planting. Bore water has been used in some years to irrigate the cotton. There was evidence of compaction from previous seasons in the sub-surface.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.6	8.5	0.08	27	47	6.9	2.0	0.01	0.80	5	13	17	66	25
Subsurface (0.15–0.25)	1.1	8.6	0.11	37	50	9.1	2.1	0.01	0.75	6	13	17	65	27
Upper subsoil (0.4–0.5)	1.8	8.9	0.15	43	44	6.6	1.9	0.02	0.65	4	13	17	66	25
Mid subsoil (0.7–0.8)	1.8	8.9	0.23	58	49	8.5	1.8	0.03	0.55	4	13	19	67	26

Interpretation of laboratory data:

The profile is sodic throughout (ESI < 0.05, ESP >5). Self-regeneration potential is excellent (CEC > 40 cmol(+)/kg).

Management options to consider:

It is recommended that the subsoil be de-compacted by thorough drying and cracking with a well-fertilized rotation crop. The soil is very prone to compaction, so careful control of traffic is important. The soil is likely to respond well to gypsum application, so test strips should be applied. Due to the high pH, lime application is unlikely to provide major benefits. The sodicity problem appears to be due to the use of sodic bore water, so salt inputs and outputs sbould be monitored if it is used again for future crops.

'Togo Station' – 'poor yield' (black cracking clay)

Field observations:

The field had been re-levelled the previous year under wet conditions, just before cotton planting. Bore water has been used in some years to irrigate the cotton. There was evidence of serious compaction below the topsoil. Most of the cotton roots were concentrated above a depth of 60 cm.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.5	8.9	0.11	28	44	4.3	2.0	0.03	0.70	4	19	16	62	21
Subsurface (0.15–0.25)	1.0	9.0	0.14	40	44	5.1	2.1	0.03	0.70	5	19	19	59	22
Upper subsoil (0.4–0.5)	0.7	9.2	0.18	30	45	9.3	1.9	0.02	0.50	4	15	17	62	22
Mid subsoil (0.7–0.8)	1.1	9.2	0.12	31	42	15.1	1.8	0.01	0.45	3	19	16	62	26

Interpretation of laboratory data:

The profile is sodic below the topsoil (ESI < 0.05, ESP >5), and strongly alkaline. Self-regeneration potential is excellent (CEC > 40 cmol(+)/kg).

Differences in soil factors between the 'high' yielding and 'low' yielding parts of the field:

The 'poor' site is more compacted than the 'good' site.

Management options to consider:

It is recommended that the subsoil be de-compacted by thorough drying and cracking with a well-fertilized rotation crop. Follow-up deep tillage may be required. The soil is very prone to compaction, so careful control of traffic is important. The soil is likely to respond well to gypsum application, so test strips should be applied. Due to the high pH, lime application is unlikely to provide major benefits. The sodicity problem appears to be due to the use of sodic bore water, so salt inputs and outputs should be monitored if it is used again for future crops. Aim to accumulate as much organic matter as possible so that the pH begins to decrease.

'Cumberdeen' – 'high yield' (red soil)

Field observations:

The field was in bare fallow after irrigated cotton. Cotton growth at this site during the previous season was excellent. The soil has a very light texture, and is not well aggregated, but cotton root growth was prolific. The controlled traffic system appears to have worked well, with compaction restricted to narrow laneways.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	5.4	0.19	71	9	2.1	3.4	0.09	0.70	52	25	6	20	7
Subsurface (0.15–0.25)	1.5	7.3	0.08	64	10	3.4	3.5	0.02	0.70	44	29	7	23	7
Upper subsoil (0.4–0.5)	1.5	7.8	0.06	38	8	3.9	3.6	0.02	0.45	42	28	4	27	8
Mid subsoil (0.7–0.8)	1.2	7.9	0.04	35	9	4.5	4.3	0.01	0.40	39	24	6	33	11

Interpretation of laboratory data:

The profile is slightly dispersive below the topsoil (ESI < 0.05). It is acidic in the topsoil, but slightly alkaline in the sub-surface and subsoil. Self-regeneration potential is poor (CEC < 20 cmol(+)/kg).

Management options to consider:

The aim at this site should be to minimize tillage (particularly under dry conditions), conserve organic matter, and continue with the careful control of traffic. Lime application is recommended to overcome the surface acidity problem, after mapping of the condition across the field to determine its extent. An additional benefit of lime is that it will make the sub-surface and subsoil less dispersive.

'Cumberdeen' – 'poor yield' (red soil)

Field observations:

The field was in bare fallow after irrigated cotton. Cotton growth at this site during the previous season was poor, apparently because of subsoil waterlogging induced by a perched watertable. The water may be coming from a nearby above-ground storage. There was evidence of salt accumulation in the top few millimetres of soil. The controlled traffic system appears to have worked well, with compaction restricted to narrow laneways. The soil has a very light texture.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	8.3	0.13	44	10	3.3	3.8	0.04	0.80	37	37	7	20	6
Subsurface (0.15–0.25)	1.1	8.4	0.10	34	9	4.8	3.4	0.02	0.65	45	31	10	17	6
Upper subsoil (0.4–0.5)	1.3	8.3	0.10	75	9	8.0	2.8	0.01	0.70	35	37	10	20	6
Mid subsoil (0.7–0.8)	1.3	8.4	0.24	190	15	12.2	1.2	0.02	0.40	31	25	6	40	14

Interpretation of laboratory data:

The profile is dispersive throughout the profile (ESI < 0.05, ESP > 5), and alkaline. Self-regeneration potential is poor (CEC < 20 cmol(+)/kg).

Differences in soil factors between the 'high' yielding and 'low' yielding parts of the field:

The 'poor' site has a perched watertable, and is more waterlogged than the 'good' site.

Management options to consider:

The aim at this site should be to minimize tillage (particularly under dry conditions), conserve organic matter, and continue with the careful control of traffic. The source of water creating the perched watertable needs to be determined, via the use of an EM survey and piezometer installation. Steps can then be taken to intercept this water, which should reduce waterlogging severity.

'Calatoota' – dryland cotton (black cracking clay)

Field observations:

The field was in bare fallow after dryland cotton and wheat. The soil surface was well protected by wheat stubble. The controlled traffic system appears to have worked well, with compaction restricted to narrow laneways. Soil structural condition was excellent. Large numbers of earthworms were observed.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.7	8.5	0.11	23	42	1.3	1.9	0.08	1.00	7	20	21	55	22
Subsurface (0.15–0.25)	1.9	8.8	0.16	30	55	2.4	0.9	0.07	0.75	5	18	19	60	23
Upper subsoil (0.4–0.5)	1.9	9.1	0.20	23	47	7.2	1.0	0.03	0.75	5	17	23	59	25
Mid subsoil (0.7–0.8)	1.6	9.3	0.31	56	51	12.1	0.9	0.03	0.70	5	17	23	59	25

Interpretation of laboratory data:

Tbe profile is slightly dispersive in the subsoil (ESI < 0.05), and is alkaline throughout. Self-regeneration potential is excellent (CEC > 40 cmol(+)/kg).

Management options to consider:

The aim at this site should be to continue with careful control of traffic so that the excellent conditions for root growth can be maintained. The emphasis on erosion control needs to be maintained, because the subsoil is sodic and must never be exposed.

(7) GOONDIWINDI-BOGGABILLA SOIL MANAGEMENT COURSE, 20 MAY 1999

Participants

Sally Boardman	Stewart Ag Services South
Dean Booth	Total Ag Services
Jemma Castor	Michael Castor & Associates
Michael Castor	Michael Castor & Associates
Brad Cogan	IAMA
Jeremy Dawson	MacPherson Ag Consultants
Sally Fields	QDPI
Fred Ghirardello	Farm Tech P/L
Kate Gordon	McGregor Gourlay
Ian Heiner	QDNR, Toowoomba
Andrew Hoffman	North West Seeds
Leisa Holden	Stewart Ag Services North
Troy Hunt	IAMA
Patrick Jones	Patrick Jones Agronomy Services P/L
Tom Lees	CGS
David Lester	Incitec, Toowoomba
Iain MacPherson	MacPherson Ag Consultants
David Manneg	QDNR, St George
Bernie Paesler	Stewart Ag Services South
Anna Ponting	Michael Castor & Associates
Richard Routley	Primac Elders
Pablo Vega	Vega Agricultural Services
Ross Warren	Incitec
Richard Wright	G. J. Kauter P/L

Cooperating Growers

Rob Newell, 'Royston', Boggabilla
Rod Haire, 'South Giddi Giddi', Gooray
Tom Woods, 'Billa Billa Station', Goondiwindi

Course leaders

Dr David McKenzie, Soil Consultant, Orange
Dr Des McGarry, QDNR, Indooroopilly
Mr Steve Parker, Cotton Development Officer, Goondiwindi

Resource staff

Dr Alison Anderson, Soil Consultant, Orange
Mr Geoff Sharp, QDNR, Indooroopilly

Program

Thursday 20 May

8.00 QDPI Conference room
(a) Welcome – Steve Parker
(b) Evolution of SOILpak – David McKenzie
(c) Cotton soil management in relation to other industries – Des McGarry
(d) 'Cotton SOILpak' manual; contents, methods – David McKenzie

9.00 'Royston'
(a) Pit description at poor-yielding end of field (grey clay)
(b) Pit description at high-yielding end of field (grey clay)
(c) Farmer comments – Rob Newell

12.15 'South Giddi Giddi'
(a) Pit description in problem area (red soil)
(b) Yield mapping for cotton growers – Alison Anderson
(c) Farmer comments – Rod Haire

3.30 'Billa Billa Station'
(a) Pit description in a dryland cotton field
(b) Consultant comments – Michael Castor
(c) Treeline comparison
(d) Concluding comments

Outcomes of Goondiwindi course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of soil assessment in 'yield map interpretation' was emphasized. Other topics that received detailed attention included:
  - management of sodic soil,
  - assessment of the impact of controlled-traffic farming systems on soil structure,
  - methods for improving water penetration into hardsetting red soil,
  - risk of water loss by deep drainage under cotton,
  - stubble management for erosion control under dryland conditions.

Field observations, laboratory data and management options (Goondiwindi)

'Royston' – 'poor yield' (grey cracking clay)

Field observations:

The field was in bare fallow after a wheat-cotton-cotton rotation. Before that, it was laser-leveled under wet conditions. The pits were in a 'cut' area. Recent wheel traffic had been well directed, but there was evidence of remnant compaction in the subsoil from the land forming operations. Very few roots penetrated deeper than 45 cm. Cotton performance during the pervious season was poor.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	8.7	0.38	55	29	7.0	3.3	0.05	0.45	16	16	15	55	21
Subsurface (0.15–0.25)	1.5	8.4	1.12	57	30	15.1	2.0	0.08	0.35	17	17	14	51	22
Upper subsoil (0.4–0.5)	1.2	8.0	3.54	382	32	33.5	1.0	0.11	0.25	14	16	15	54	24
Mid subsoil (0.7–0.8)	1.1	6.9	3.33	924	30	39.0	1.1	0.09	0.15	15	17	15	52	25

Interpretation of laboratory data:

The profile is sodic throughout (ESP >5), but the presence of soluble salts prevents it from dispersing badly. The subsoil is strongly saline, which would prevent cotton roots from flourishing. Leguminous rotation crops would not survive the salinity. Self-regeneration potential is moderate (CEC 20 – 40 cmol(+)/kg).

Management options to consider:

It is recommended that the subsoil be de-compacted by thorough drying and cracking with a well-fertilized rotation crop such as wheat. A follow-up chisel ploughing may also be required. The soil is likely to respond well to gypsum application (approx. 5 t/ha), so test strips should be applied. Due to the high pH, lime application is unlikely to provide major benefits. The soil needs to be irrigated in a way that pushes the soluble salts to a depth of about 2 metres. However, the salt should not be allowed to move any deeper. Otherwise, there may be major contributions to the underlying watertable, which may then rise nearer the surface.

'Royston' – 'high yield' (grey cracking clay)

Field observations:

The field was in bare fallow after a wheat-cotton-cotton rotation. Before that, it was laser-leveled under wet conditions. The pits were in a 'fill' area. Recent wheel traffic had been well directed, but there was evidence of remnant compaction in the subsoil from the land forming operations. Cotton performance during the pervious season was acceptable. However, the presence of a blue/grey subsoil below a much browner topsoil and subsoil (due, apparently, to seepage from a nearby above-ground storage) suggests that yields could be improved further.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.6	8.7	0.18	36	26	3.3	3.3	0.06	0.7	18	20	17	48	18
Subsurface (0.15–0.25)	1.6	8.8	0.15	11	24	3.9	2.0	0.03	0.6	19	21	17	46	20
Upper subsoil (0.4–0.5)	1.1	8.8	0.18	9	27	7.3	1.0	0.03	0.55	9	16	20	57	23
Mid subsoil (0.7–0.8)	1.1	8.9	0.23	23	29	13.9	1.1	0.02	0.3	7	12	17	64	25

Interpretation of laboratory data:

The profile has a sodic subsoil (ESI < 0.05, ESP >5). There is no evidence of a salinity problem. Self-regeneration potential is moderate (CEC 20 – 40 cmol(+)/kg).

Differences in soil factors between the 'high' yielding and 'low' yielding parts of the field:

The 'poor' site is much more sodic and saline than the 'good' site.

Management options to consider:

It is recommended that the subsoil be de-compacted by thorough drying and cracking with a well-fertilized rotation crop such as wheat. A follow-up chisel ploughing may also be required. A piezometer network should be installed between the sampling site and the water storage to see if there are lateral seepage problems.

'South Giddi Giddi' – problem area (red soil)

Field observations:

The field was in bare fallow after 11 years continuous cotton. The grower had problems with poor water penetration. The pit inspections showed that the soil had very poor structure in the upper subsoil. The aggregates were large and platy. This field generally is the first to become trafficable after wet weather, so many operations would have been carried out when the soil was too wet. There was evidence of poor control of wheel traffic position when re-establishing the field for the next cotton crop.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	7.9	0.06	12	11	6.8	2.5	0.01	0.25	5	69	11	16	7
Subsurface (0.15–0.25)	0.7	7.8	0.05	10	10	13.2	1.7	0.00	0.20	5	71	11	16	7
Upper subsoil (0.4–0.5)	1.0	9.3	0.12	18	14	26.2	1.4	0.01	0.15	2	66	8	25	13
Mid subsoil (0.7–0.8)	1.2	9.5	0.47	353	16	33.8	1.0	0.01	0.15	2	61	11	20	13

Interpretation of laboratory data:

The profile is strongly sodic (ESI < 0.05, ESP >5), and has a very low organic matter content. Below 50 cm, the subsoil is moderately saline. Self-regeneration potential is poor throughout the profile (CEC < 20 cmol(+)/kg).

Management options to consider:

It is recommended that the subsoil be deep ripped at a water content just below the 'plastic limit'. This should be followed by the application of coarse-grade (mined) gypsum at a rate of approximately 5 t/ha. The soil may also respond to the application finely ground limestone. Test strips are recommended. Having carried out these operations, set up controlled traffic lane-ways with a 'Beeline' navigation system, and always stay on these wheel tracks. Establish an organic surface mulch, and irrigate the soil as slowly as possible to encourage good water penetration. Because salts are present in the subsoil, install piezometers to monitor the groundwater height.

'Billa Billa Station' – dryland cotton (grey cracking clay)

Field observations:

The field was in fallow shortly after the harvest of a dryland skip-row cotton crop. Parts of the field are relatively steep, and prone to water erosion. Soil structure was in good condition, and the old cotton plants had strong, straight taproots.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.6	7.6	0.06	0	24	5.5	2.6	0.02	1.1	3	45	14	40	15
Subsurface (0.15–0.25)	1.5	9.1	0.25	7	35	11.9	2.8	0.02	0.75	1	34	13	54	23
Upper subsoil (0.4–0.5)	1.4	8.9	0.21	0	36	8.4	2.2	0.03	0.7	1	36	13	50	22
Mid subsoil (0.7–0.8)	1.2	9.2	0.52	223	36	26.5	1.5	0.02	0.4	2	34	13	54	25

Interpretation of laboratory data:

The profile is dispersive throughout the profile (ESI < 0.05, ESP >5). Below 50 cm, the subsoil is slightly saline. Self-regeneration potential is moderate throughout the profile (CEC 20 – 40 cmol(+)/kg).

Management options to consider:

The soil is likely to respond well to the application of coarse-grade (mined) gypsum at a rate of approximately 3 t/ha. The soil may also respond to the application finely ground limestone. Test strips are recommended. Continue with the effective control of wheel traffic. Grow a cereal crop as soon as possible to provide a protective mulch on the soil surface. Otherwise, there is a strong risk of soil loss by water erosion. Because of the erosion hazard, and the presence of what appears to a substantial store of salt in the subsoil, it is recommended that a crop be planted once store water amounts to about 80% of storage capacity. Maintaining a full profile of water under fallow may lead to excessive deep drainage and/or runoff.

'Billa Billa Station' – treeline comparison (grey cracking clay)

Field observations:

The tree-line comparison was located about 50 metres from the pits in the dryland cotton filed. The trees are mostly brigalow and belah, and it appeared that the vegetation had not been grazed by hooved animals for many years.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.5	7.1	0.17	64	17	7.4	2.7	0.02	1.6	4	48	20	29	11
Subsurface (0.15–0.25)	1.3	8.4	0.10	28	26	8.6	3.0	0.01	0.85	2	40	18	43	18
Upper subsoil (0.4–0.5)	0.9	9.1	0.42	248	34	17.4	1.8	0.02	0.8	1	34	17	50	22
Mid subsoil (0.7–0.8)	0.9	8.5	1.62	2275	36	28.1	1.6	0.06	0.5	2	31	17	54	23

Interpretation of laboratory data:

The profile is dispersive throughout the profile (ESI < 0.05, ESP >5). Below 50 cm, the subsoil is moderately saline. Self-regeneration potential is poor to moderate throughout the profile.

Management options to consider:

In the unlikely event of the tree-line being developed for cropping, it is likely to respond well to the application of coarse-grade (mined) gypsum at a rate of approximately 3 t/ha. The soil may also respond to the application finely ground limestone. Continue with the effective control of wheel traffic. Grow a cereal crop as soon as possible to provide a protective mulch. Otherwise, there is a strong risk of soil loss by water erosion.

Comparison between native woodland and the cotton field::

The cotton field has better subsoil structure than the native woodland, and has less salt in the subsoil. However, the pristine site has more organic matter at the soil surface.

'Royston', Boggabilla; May 1999

'Lou's Place', Gunnedah; June 1999

'Gibahgunyah', Theodore; July 1999

(8) GUNNEDAH SOIL MANAGEMENT COURSE, 4 JUNE 1999

Participants

Shaun Bailey	Queensland Cotton
Graham Bourke	Glencoe IAMA, Gunnedah
Paul Conradt	Cotton Grower Services, Gunnedah
Rob Duns	Goddard Agricultural Services
Greg Gibblet	Crop Tech P/L, Tamworth
Mark Goddard	Goddard Agricultural Services
Warren Lang	Lang Crop Management Services
Sam Leys	Seed & Grain IAMA, Quirindi
Malcolm McNiven	McNiven Ag. Services
Ian Murray	Glencoe IAMA, Gunnedah
Matthew Thomas	Thomas Consulting Service
Rick Thomas	Thomas Consulting Service

Cooperating growers

Andrew Pursehouse, 'Breeza Station'
Rick Thomas, 'South Side Irrigation'
Geoff Hood, 'Lou's Place'

Course leaders

Dr David McKenzie, Soil Consultant, Orange
Mr Mark Hickman, Cotton Development Officer, Gunnedah

Resource staff

Dr Alison Anderson, Soil Consultant, Orange
Mr James Quinn, Cotton Development Officer, Moree

Program

Friday 4 June

8.00 NSW Agriculture Conference room
(a) Welcome – Mark Hickman
(b) 'Cotton SOILpak' manual; contents, methods – David McKenzie

9.30 'Breeza Station'
(a) Pit description in dryland cotton field (black cracking clay)
(b) Farmer comments – Andrew Pursehouse

11.30 'South Side Irrigation'

(a) Pit description at high-yielding end of field (silty brown soil)
(b) Pit description at poor-yielding end of field (silty brown soil)
(c) Farmer comments – Rick Thomas

2.30 'Lou's Place'
(a) Pit description in an irrigated field with hardsetting red soil
(b) Farmer comments – Geoff Hood
(c) Concluding comments

Outcomes of Gunnedah course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of soil assessment in 'yield map interpretation' was emphasized. Other topics that received detailed attention included:
  - assessment of the impact of controlled-traffic farming systems on soil structure,
  - the impact of groundwater on soil structure,
  - methods for improving hardsetting soil.

Field observations, laboratory data and management options (Gunnedah)

'Breeza Station' – dryland cotton (black cracking clay)

Field observations:

The field has been farmed since 1994. It was under bare fallow following a dryland wheat-wheat-cotton rotation. Roots were observed to a depth of about 90 cm. An effective controlled traffic system was in place.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	8.4	0.18	12	52	3.8	1.4	0.05	1.34	0	7	21	73	33
Subsurface (0.15–0.25)	1.4	9.1	0.27	28	54	10.7	1.0	0.03	0.77	1	6	18	78	34
Upper subsoil (0.4–0.5)	1.6	9.3	0.54	281	61	19.7	0.8	0.03	0.60	1	6	18	77	33
Mid subsoil (0.7–0.8)	1.4	9.1	1.02	956	58	25.9	0.7	0.04	0.60	1	4	22	76	33

Interpretation of laboratory data:

The profile is sodic below the topsoil (ESI < 0.05, ESP >5), and moderately saline below 50 cm. Self-regeneration potential is excellent (CEC > 40 cmol(+)/kg).

Management options to consider:

There is no need for deep tillage. This is fortunate, because such an operation is likely to bring sodic clods to the soil surface. Continue to control the wheel traffic via the tram-line system. The subsoil is strongly sodic and alkaline, and may respond to applied gypsum – test strips are recommended. Lime application is unlikely to be effective because of the high pH values. The presence of a moderate salinity problems in the subsoil suggest that piezometers should be used to monitor the groundwater height.

'South Side Irrigation' – 'high yield' (brown silty soil)

Field observations:

The field was in bare fallow after irrigated cotton. The previous cotton crop was planted soon after a major flood, so machinery had to be driven on the soil when it was very wet. The pits were in a 'fill' area, where the better yielding cotton was grown. Recent wheel traffic had been well directed, but there was evidence of remnant compaction in the subsoil from previous operations. Under the main wheel tracks, compaction extended to a depth of about 80 cm. Bore water has been used to irrigate this field.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	7.1	0.11	26	17	1.2	2.3	0.09	1.49	2	24	43	32	14
Subsurface (0.15–0.25)	1.5	6.2	0.15	55	14	2.1	2.1	0.07	1.29	2	23	42	33	16
Upper subsoil (0.4–0.5)	1.4	7.6	0.11	47	31	1.5	1.5	0.08	0.60	1	15	26	60	21
Mid subsoil (0.7–0.8)	1.3	8.8	0.19	40	26	1.7	0.9	0.11	0.43	2	21	29	50	19

Interpretation of laboratory data:

The profile is stable in water (ESI > 0.05, ESP <5). There is no evidence of a salinity problem, but the sub-surface soil is mildly acidic. Self-regeneration potential is poor near the surface, but moderate in the subsoil. The chemical properties of the bore water (EC = 0.61 dS/m, SAR = 0.66) are favorable, although regular leaching of the profile will be necessary to flush out the salts that accumulate.

Management options to consider:

Mixing of lime into the sub-surface soil is likely to be beneficial – the pH needs to be increased. The surface soil is prone to hardsetting because of the high proportion of fine sand and silt, so a cereal crop should be grown to provide an organic mulch. Continue with the good control of wheel traffic.

'South Side Irrigation' – 'poor yield' (brown silty soil)

Field observations:

The field was in bare fallow after irrigated cotton. The previous cotton crop was planted soon after a major flood, so machinery had to be driven on the soil when it was very wet. The pits were in a 'cut' area, where the poorer yielding cotton was grown. Recent wheel traffic had been well directed, but there was evidence of remnant compaction in the subsoil from previous operations.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	0.5	6.6	0.22	78	16	2.2	1.7	0.10	1.11	5	16	43	36	14
Subsurface (0.15–0.25)	1.6	7.1	0.09	32	25	2.6	1.4	0.03	0.77	4	11	36	50	19
Upper subsoil (0.4–0.5)	1.3	8.6	0.35	66	35	6.4	1.1	0.05	0.60	2	8	26	64	22
Mid subsoil (0.7–0.8)	1.2	9.1	0.31	54	31	9.9	1.0	0.03	0.51	4	8	34	56	20

Interpretation of laboratory data:

The profile has a mildly sodic subsoil (ESI < 0.05, ESP >5). There is no evidence of a salinity problem. Self-regeneration potential is poor near the surface, but moderate in the subsoil.

Differences in soil factors between the 'high' yielding and 'low' yielding parts of the field:

The 'poor' site is more sodic than the 'good' site, and has less organic matter near the soil surface. Also, the 'poor' area has worse internal drainage because of a bigher clay content.

Management options to consider:

It is recommended that a gypsum-lime blend be used to overcome the subsoil sodicity problem. A follow-up chisel ploughing may also be required to thoroughly mix the lime and soil. The surface soil is prone to hardsetting because of the high proportion of fine sand and silt, so a cereal crop should be grown to provide an organic mulch. Continue with the good control of wheel traffic.

'Lou's Place' – 'problem area' (red soil)

Field observations:

The field was in bare fallow after irrigated cotton. Recent wheel traffic had been well directed, but there was a continuous compact layer that extended under all the hills at a depth of 30–40 cm. It may be due to compaction from previous wheel tracks that are now located under hills. Bore water has been used to irrigate this field. There have been problems with poor water penetration during the growth of previous cotton crops.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.1	6.5	0.05	15	11	1.9	1.8	0.03	1.20	6	25	39	29	11
Subsurface (0.15–0.25)	1.1	6.7	0.05	17	16	2.5	1.6	0.02	0.83	5	19	39	39	15
Upper subsoil (0.4–0.5)	1.3	8.3	0.10	62	32	3.1	1.4	0.03	0.63	2	9	23	67	24
Mid subsoil (0.7–0.8)	1.0	8.8	0.23	51	29	4.9	1.1	0.05	0.51	3	15	34	50	21

Interpretation of laboratory data:

Although the ESP values are rather low, the soil is dispersive because of very low EC values. The topsoil and sub-surface soil are mildly acidic. Self-regeneration potential is poor near the surface, but moderate in the subsoil. The chemical properties of the bore water (EC = 0.54 dS/m, SAR = 1.11) are favorable, although regular leaching of the profile will be necessary to flush out the salts that accumulate.

Management options to consider:

Mixing of lime into the topsoil and sub-surface soil is likely to be beneficial – the pH and ESI values need to be increased. The surface soil is prone to hardsetting because of the high proportion of fine sand and silt, so a cereal crop should be grown to provide an organic mulch. Ensure that wheel traffic is confined to narrow lane-ways.

(9) THEODORE SOIL MANAGEMENT COURSE, 8 JULY 1999

Participants

Harrod Anderson	Grower
Brett Austin	Grower
Greg Austin	Grower
Barry Braden	Queensland Cotton
Trevor Brownlie	Grower
Wayne Chesher	Primac Elders
Grant Colquhoun	Queensland Cotton
Errol Conachan	Grower
Damien Erbacher	Grower
Peter French	Grower
Peter Gee	Grower
Gladstone Holmes	Grower
Robert Hutchinson	Grower
Stuart Olsson	Cotton Consulting Services P/L
Simon Struss	Cotton Consulting Services P/L

Cooperating growers

Peter French, 'Nandina'
Harrod Anderson, 'Small Thorns'
Greg Austin, 'Gibahgunyah'

Course leaders

Dr David McKenzie, Soil Consultant, Orange
Dr Des McGarry, QDNR, Indooroopilly
(the course was planned in conjunction with Mr Gavin Inglis, Cotton Development Officer, Biloela, and Mr David Kelly, Cotton Development Officer, Emerald)

Resource staff

Sue McCarroll, QDNR, Bundaberg
Rachael Cull, QDNR, Indooroopilly

Program

Thursday 8 July

8.00 Hotel Theodore Conference room
(a) Welcome – David McKenzie
(b) Cotton soil management in relation to other industries – Des McGarry
(c) 'Cotton SOILpak' manual; contents, methods – David McKenzie

9.15 'Nandina'
(a) Pit description in an irrigated field under permanent beds (black cracking clay)
(b) Farmer comments – Peter French

12.15 'Small Thorns'
(a) Pit description in high-yielding end of field (red soil)
(b) Spade inspection in a poor-yielding section (red soil)
(c) Farmer comments – Harrod Anderson

2.00 'Gibahgunyah'
(a) Pit description in high-yielding end of field (grey cracking clay)
(b) Pit description in poor-yielding end of field (grey cracking clay)
(c) Farmer/Consultant comments – Greg Austin, Simon Struss
(d) Concluding comments

Outcomes of Theodore course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of soil assessment in 'yield map interpretation' was emphasized. Other topics that received detailed attention included:
  - management of sodic soil,
  - assessment of the impact of controlled-traffic farming systems on soil structure,
  - risk of water loss by deep drainage under cotton,
  - management of cotton soil that has become acidic.

Field observations, laboratory data and management options (Theodore)

'Nandina' – irrigated cotton under permanent beds (black cracking clay)

Field observations:

The field was in bare fallow after 25 years of continuous cotton. Permanent beds were introduced 5 years ago. Bore water has been used in some years to irrigate the cotton. Despite all the years of farming, the subsoil structure was excellent. Only in the top 30 cm was there evidence of compaction damage, due apparently to wet harvests and slight bed movement to the side.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	9.7	0.15	12	64	2.8	3.3	0.05	1.25	2	6	15	76	25
Subsurface (0.15–0.25)	1.0	9.7	0.23	26	64	4.8	3.0	0.05	1.1	2	6	16	77	26
Upper subsoil (0.4–0.5)	1.7	9.9	0.27	35	59	9.2	2.5	0.03	0.9	2	6	13	79	28
Mid subsoil (0.7–0.8)	1.9	8.8	0.54	308	70	14.0	2.0	0.04	0.85	2	6	14	76	28

Interpretation of laboratory data:

The profile is sodic in the subsoil (ESI < 0.05, ESP >5). Below 50 cm, the salt concentration is high enough to adversely affect leguminous rotation crops, but not cotton. Self-regeneration potential is extremely good (CEC >> 40 cmol(+)/kg). The pH of the profile is too high, meaning that the availability of some trace elements such as zinc may be sub-optimal.

Management options to consider:

The control of traffic needs to be improved so that a smaller percentage of the soil surface is under the threat of soil compaction from farm machinery. Use of wider equipment would help to achieve this goal. Gypsum test strips are recommended to determine if subsoil sodicity can be reduced in a cost-effective way. To reduce pH, use acidifying N fertilizer (eg. ammonium sulfate) and accumulate as much organic matter as possible.

'Small Thorns'– 'high yield' (red soil)

Field observations:

The field was in bare fallow after irrigated cotton. Cotton had been grown continuously at the site for about 20 years. Gypsum had been applied recently in an attempt to improve water penetration.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.5	6.7	0.72	9	27	0.6	5.4	1.2	1.1	2	40	26	36	11
Subsurface (0.15–0.25)	1.3	6.3	0.36	26	29	1.1	3.7	0.33	1.0	2	39	24	36	13
Upper subsoil (0.4–0.5)	0.8	7.9	0.30	24	31	2.4	3.2	0.13	0.75	1	35	20	44	15
Mid subsoil (0.7–0.8)	1.0	8.6	0.27	26	31	7.7	2.4	0.04	0.55	2	37	16	44	16

Interpretation of laboratory data:

The profile is very stable in water (ESI >> 0.05, ESP < 5). There is no evidence of a salinity problem, although legume seedlings may struggle in the topsoil due to the moderately high EC induced by gypsum application. Self-regeneration potential is moderate throughout. The sub-surface layer has a mild acidity problem.

Management options to consider:

It is recommended that lime be applied to overcome the sub-surface acidity problem. The surface soil is prone to hardsetting because of the high proportion of fine sand and silt, so a cereal crop should be grown to provide an organic mulch. Continue with the good control of wheel traffic.

'Small Thorns'– 'poor yield' (red soil)

Field observations:

The field was in bare fallow after irrigated cotton. Cotton had been grown continuously at the site for about 20 years. Gypsum had been applied regularly over several years in an attempt to improve water penetration.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.3	6.9	0.75	7	21	0.6	4.1	1.25	1.00	4	48	17	33	9
Subsurface (0.15–0.25)	1.5	5.3	0.33	17	22	1.4	3.5	0.24	0.85	3	45	20	36	11
Upper subsoil (0.4–0.5)	–	7.0	0.22	23	30	3.0	2.9	0.07	0.70	2	40	13	43	15
Mid subsoil (0.7–0.8)	–	8.3	0.18	21	24	5.8	2.5	0.03	0.45	3	49	13	36	13

Interpretation of laboratory data:

The profile is very stable in water (ESI >> 0.05, ESP < 5). There is no evidence of a salinity problem, although legume seedlings may struggle in the topsoil due to the moderately high EC induced by gypsum application. Self-regeneration potential is moderate throughout. The sub-surface layer has a serious acidity problem.

Differences in soil factors between the 'high' yielding and 'low' yielding parts of the field:

The 'poor' site contains more fine sand than the 'good' site, and has less organic matter near the soil surface. The chloride data indicates that more water passes through the 'poor' soil, which apparently has created a soil acidity problem. Both sites have an acidic sub-surface, but the problem is more serious at the 'poor' site. Cotton has a very poor tolerance of the soluble aluminium that is released under acidic conditions.

Management options to consider:

It is recommended that lime be applied to overcome the sub-surface acidity problem. The surface soil is prone to hardsetting because of the high proportion of fine sand and silt, so a cereal crop should be grown to provide an organic mulch. Continue with the good control of wheel traffic. There is no need to apply more gypsum.

'Gibahgunyah'– 'high yield' (grey cracking clay)

Field observations:

The field was in bare fallow after irrigated cotton. Prior to growing the recently harvested cotton crop, the field had been land-formed under wet conditions. The pits are located in a 'fill' area, where the best cotton is grown within this field. Before the land-forming took place, the cotton hills ran at right-angles to the existing hills. Dual-wheeled 4-row pickers are used for harvest, whilst the other operations are 6-row. The pit inspection showed that there was moderate compaction throughout much of the profile. This damage apparently was associated with the landforming operations, and had been partially ameliorated by shrink-swell cycles induced by the extraction of water by cotton roots.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.2	8.3	0.19	16	40	1.6	3.8	0.12	1.1	2	31	19	50	17
Subsurface (0.15–0.25)	1.6	8.4	0.18	14	40	2.0	4.3	0.09	1.1	2	31	20	51	18
Upper subsoil (0.4–0.5)	1.0	8.4	0.30	35	36	4.7	3.5	0.06	0.7	3	38	16	47	16
Mid subsoil (0.7–0.8)	1.2	8.9	0.34	168	38	10.5	2.4	0.03	0.6	2	35	13	51	18

Interpretation of laboratory data:

The soil is stable in water to a depth of 50 cm (ESI > 0.05, ESP < 5). Self-regeneration potential is moderate throughout.

Management options to consider:

The soil has favorable chemical properties, but is limiting cotton growth because of residual compaction problems. Thorough drying of the soil with well-fertilized wheat (safflower would be even better) would be very beneficial. Follow-up deep tillage (at a water content just below the 'plastic limit') may be needed to thoroughly de-compact the root zone. Once these operations bave been completed, re-establish permanent wheel tracks as soon as possible, and maintain the improved soil structure.

'Gibahgunyah'– 'poor yield' (grey cracking clay)

Field observations:

The field was in bare fallow after irrigated cotton. Prior to growing the recently harvested cotton crop, the field had been land-formed under wet conditions. The pits are located in a 'cut' area, where the worst cotton is grown within this field. The pit inspection showed that there was severe compaction throughout much of the profile. This damage apparently was associated with the landforming operations, and had been aggravated by machinery operation and cultivation under wet conditions. The previous cotton crop had hegun to ameliorate the compacted soil via shrink-swell processes, but the roots were very deformed. They were unable to extract large amounts of water from a large proportion of the potential root zone.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.4	8.7	0.22	12	38	2.6	3.5	0.09	0.85	4	33	19	48	9
Subsurface (0.15–0.25)	0.5	8.5	0.31	26	37	4.1	3.7	0.08	0.9	3	32	16	50	11
Upper subsoil (0.4–0.5)	0.3	9.0	0.41	119	37	10.5	2.2	0.04	0.6	3	30	16	54	15
Mid subsoil (0.7–0.8)	0.8	8.1	2.52	950	39	23.6	1.4	0.11	0.4	2	29	47	23	13

Interpretation of lahoratory data:

The subsoil is dispersive (ESI < 0.05, ESP > 5). Salinity is likely to restrict the growth of cotton roots below a depth of 0.7 cm. Self-regeneration potential is moderate throughout. The sub-surface layer has a serious acidity problem.

Differences in soil factors between the 'high' yielding and 'low' yielding parts of the field:

The 'poor' site is more dispersive, saline and compacted than the 'good' site.

Management options to consider:

Gypsum application (5 t/ha, possibly with 2.5 t/ha follow-up doses) is an option that should be assessed via the use of test strips. The soil is too alkaline for lime application to be successful. Consider growing rotation crops for a year, rather than cotton, so that the soil is de-compacted by shrink-swell processes. Follow-up deep tillage (at a water content just below the 'plastic limit' may also be required to complete the loosening. Improve the guidance of traffic so that furrows remain narrow and in the same position. Manage water application so that suhsoil salt is pushed deeper (by no more than about 1 m).

(10) WALGETT SOIL MANAGEMENT COURSE, 12 AUGUST 1999

Participants

David Allston	Grower
Clive Brownlie	Grower
Brad Coleman	Walgett Sustainable Ag. Group
Wal Friend	Grower
Greg Hannaford	Grower
Ian Hannaford	Grower
Ackham Harkie	Grower
James Moore	Grower
Alex Murray	NSW Agriculture, Tamworth
Ed Redfern	IAMA
Greg Rummery	Walgett Sustainable Ag. Group
Melinda Smith	B&W Rural
Tony Taylor	Taylor Ag P/L
David Toohey	IAMA
Simon Whyte	Cotton Development Officer, Bourke
John Withers	Grower
Malcolm Wright	Grower

Cooperating growers

Wal Friend, 'Talbarear'
James Duncan
Ian Hannaford, 'Crossdale'

Course leaders

Dr David McKenzie, Soil Consultant, Orange
Mr Cameron Tonkin, District Agronomist, Walgett

Resource staff

Dr Nilantha Hulugalle, ACRI, Narrabri
Mr Luke Pearce, Soil Advisory Officer, Walgett

Program

Thursday 12 August

8.00 Walgett District Sporting Club
(a) Welcome – Cameron Tonkin
(b) 'Cotton SOILpak' manual; contents, methods – David McKenzie

9.00 'Talbarear'
(a) Pit description on a typical Walgett cotton soil (grey cracking clay)
(b) Pit description in an adjacent pristine area
(c) Farmer comments – Wal Friend

11.30 Duncans
(a) Pit description in a dryland cotton field (grey cracking clay)

2.00 'Crossdale'
(a) Pit description at high-yielding end of field (grey cracking clay)
(b) Pit description at poor-yielding end of field (grey cracking clay)
(c) Farmer comments – Ian Hannaford
(d) Concluding comments

Outcomes of Walgett course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of soil assessment in 'yield map interpretation' was emphasized. Other topics that received detailed attention included:
  - management of sodic and alkaline soil,
  - assessment of the impact of controlled-traffic farming systems on soil structure,
  - risk of water loss by deep drainage under cotton,
  - stubble management under dryland conditions.

Field observations, laboratory data and management options (Walgett)

'Talbarear' – 'typical Walgett cotton soil' (grey cracking clay)

Field observations:

The field was in bare fallow after irrigated cotton. The rotation program is 2 years cotton, 1 year wheat. The field was developed for cotton production about 15 year ago. There were no major compaction problems under the plant lines, due to excellent control of the wheel traffic.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.6	8.6	0.13	26	51	3.3	1.5	0.04	0.74	3	10	15	75	28
Subsurface (0.15–0.25)	1.6	8.9	0.17	50	57	6.7	1.5	0.03	0.57	3	9	13	79	31
Upper subsoil (0.4–0.5)	1.5	9.2	0.27	37	54	20.2	0.9	0.01	0.46	3	9	11	79	30
Mid subsoil (0.7–0.8)	1.3	9.2	0.41	115	61	22.2	1.1	0.02	0.49	2	8	9	79	31

Interpretation of laboratory data:

The topsoil is mildly sodic (ESI < 0.05), whilst the subsoil is strongly sodic (ESI < 0.05, ESP >5). Self-regeneration potential is excellent (CEC > 40 cmol(+)/kg). The profile is strongly alkaline.

Management options to consider:

The soil is likely to respond well to gypsum application, so test strips should be applied. Due to the high pH, lime application is unlikely to provide major benefits. To reduce pH, use acidifying N fertilizer (eg. ammonium sulfate) and accumulate as much organic matter as possible. Continue with the effective control of field traffic.

'Talbarear' – 'unformed comparison' (grey cracking clay)

Field observations:

Even though this unfarmed site had always been under native pasture and scattered trees, subsoil structure was poor. The soil had been dried throughout the profile, and was very hard. There were abundant roots in the top 50 cm of soil.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.5	8.5	0.09	15	49	4.5	1.8	0.02	0.77	3	11	13	73	28
Subsurface (0.15–0.25)	1.3	8.7	0.20	136	58	7.4	1.7	0.03	0.62	3	12	13	75	28
Upper subsoil (0.4–0.5)	1.4	9.2	0.22	15	62	21.4	1.5	0.01	0.57	3	12	13	75	30
Mid subsoil (0.7–0.8)	1.2	9.4	0.25	6	54	19.3	1.3	0.01	0.51	3	11	13	76	27

Interpretation of laboratory data:

The topsoil is mildly sodic (ESI < 0.05), whilst the subsoil is strongly sodic (ESI < 0.05, ESP >5). Self-regeneration potential is excellent (CEC > 40 cmol(+)/kg). The profile is strongly alkaline.

Management options to consider:

If developed for cotton, the soil is likely to respond well to gypsum application. Due to the high pH, lime application is unlikely to provide major benefits. To reduce pH, use acidifying N fertilizer (eg. ammonium sulfate) and accumulate as much organic matter as possible.

Comparison between native pasture and the cotton field:

The farmed soil was better than the pristine soil. Under cotton, the soil has become less compact and less sodic and saline, but is slightly more alkaline near the soil surface.

Duncans – 'dryland cotton' (grey cracking clay)

Field observations:

The field had been used to grow dryland cotton the previous summer, on the flat. There were no major compaction problems under the plant lines, due to excellent control of the wheel traffic. The old cotton plants had strong, straight root systems.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.8	8.9	0.13	10	52	4.4	2.2	0.03	0.62	2	16	17	69	26
Subsurface (0.15–0.25)	1.7	9.1	0.22	13	54	7.0	1.9	0.03	0.47	2	15	16	70	29
Upper subsoil (0.4–0.5)	1.5	9.3	0.25	7	53	11.1	1.7	0.02	0.51	2	15	16	69	28
Mid subsoil (0.7–0.8)	1.2	9.4	0.39	13	52	26.1	1.1	0.01	0.51	2	15	13	71	30

Interpretation of laboratory data:

The topsoil is mildly sodic (ESI < 0.05), whilst the subsoil is strongly sodic (ESI < 0.05, ESP >5). Self-regeneration potential is excellent (CEC > 40 cmol(+)/kg). The profile is strongly alkaline.

Management options to consider:

The soil is likely to respond well to gypsum application, so test strips should be applied to determine which rate is appropriate for the farming system that is being used. Due to the high pH, lime application is unlikely to provide major benefits. To reduce pH, use acidifying N fertilizer (eg. ammonium sulfate) and accumulate as much organic matter as possible. Continue with the effective control of field traffic.

'Crossdale'– 'high yield' (grey cracking clay)

Field observations:

The field was in bare fallow after irrigated cotton. Prior to growing the recently harvested cotton crop, the field had been land-formed under wet conditions. The pits are located in a 'fill' area, where the best cotton is grown within this field. The pit inspection showed that there was an obvious compacted layer across much of the profile at a depth of about 15–40 cm. This damage apparently was associated with the landforming operations, and had been aggravated by the inadvertent sideways movement of the hills onto old furrows (wheel tracks).

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.7	8.7	0.13	10	40	1.8	2.5	0.07	0.67	5	30	13	56	20
Subsurface (0.15–0.25)	1.1	8.9	0.17	28	43	3.5	2.3	0.05	0.54	5	29	13	57	22
Upper subsoil (0.4–0.5)	1.3	9.2	0.20	26	48	6.8	2.3	0.03	0.57	3	25	13	62	25
Mid subsoil (0.7–0.8)	1.4	9.4	0.33	23	47	21.9	1.5	0.02	0.47	2	24	13	64	27

Interpretation of laboratory data:

The subsoil is dispersive (ESI < 0.05, ESP > 5) and strongly alkaline. Self-regeneration potential is excellent throughout.

Management options to consider:

Gypsum application is an option that should be assessed via the use of test strips. The soil is too alkaline for lime application to be successful. Consider growing rotation crops for a year (eg. well-fertilized wheat), rather than cotton, so that the soil is de-compacted by shrink-swell processes. Follow-up deep tillage (at a water content just below the 'plastic limit') may also be required to complete the loosening. Improve the guidance of traffic so that furrows remain narrow and in the same position.

'Crossdale'– 'poor yield' (grey cracking clay)

Field observations:

The field was in bare fallow after irrigated cotton. Prior to growing the recently harvested cotton crop, the field had been land-formed under wet conditions. The pits are located in a 'cut' area, where the worst cotton is grown within this field. The pit inspection showed that there was a very obvious compacted layer across much of the profile at a depth of about 15–40 cm. This damage apparently was associated with the landforming operations, and had been aggravated by the inadvertent sideways movement of the hills onto old furrows (wheel tracks). The surface soil had a very coarse tilth, and the separation of fine sand and silt from clay on the clod surfaces indicated that it was sodic.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.2	9.0	0.13	20	33	5.1	1.3	0.03	0.53	5	32	12	53	18
Subsurface (0.15–0.25)	0.9	9.4	0.43	63	38	18.2	0.9	0.02	0.47	5	33	12	54	23
Upper subsoil (0.4–0.5)	1.2	9.7	0.47	71	46	25.9	1.1	0.02	0.36	5	32	11	55	24
Mid subsoil (0.7–0.8)	1.3	9.8	1.61	375	62	20.6	2.2	0.08	0.28	5	31	11	55	22

Interpretation of laboratory data:

The whole profile is dispersive (ESI < 0.05, ESP > 5) and strongly alkaline. Self-regeneration potential is moderate to good throughout. Below 70 cm, the subsoil is saline. However, pit observations (and the chloride data) indicated that much of the salt in the subsoil was gypsum rather than sodium chloride.

Differences in soil factors between the 'high' yielding and 'low' yielding parts of the field:

The 'poor' site is more dispersive, saline and compacted than the 'good' site.

Management options to consider:

Gypsum application (5 t/ha, possibly with 2.5 t/ha follow-up doses) is likely to greatly improve the soil structure. The soil is too alkaline for lime application to be successful. Consider growing rotation crops for a year, rather than cotton, so that the soil is de-compacted by shrink-swell processes. Follow-up deep tillage (at a water content just below the 'plastic limit') may also be required to complete the loosening. Improve the guidance of traffic so that furrows remain narrow and in the same position. Manage water application so that subsoil salt is pushed deeper (by no more than about 1 m).

'Talbarear', Walgett; August 1999

'Janbeth', Bourke; September 1999

(11) BOURKE SOIL MANAGEMENT COURSE, 16 SEPTEMBER 1999

Participants

Mitch Abbo	Clyde Agriculture
Trevor Banfield	Afterhours Agriculture
Angus Blair	Clyde Agriculture
Jeremy Brown	Darling Fertilisers
Jason Fritsch	Darling Farms
Mark Fulton	MTF Cotton Co.
Norm Hopper	Darling Farms
Dale Hyland	Clyde Agriculture
Des Linneman	Warrego Farming
Trevor Lollback	Grower
Paul Marett	Afterhours Agriculture
Daniel Moore	Clyde Agriculture
Angus Peacocke	Afterhours Agriculture
Kirrily Quade	Clyde Agriculture
Tony Thompson	Afterhours Agriculture
Will Turnbull	Grower

Cooperating growers

Mitch Abbo, 'Latoka'
Dale Hyland, 'Janbeth'
Peter van Beuzekom, Enbros Pty. Ltd.

Course leaders

Dr David McKenzie, Soil Consultant, Orange
(the course was planned in conjunction with Mr Simon Whyte, Cotton Developemnt Officer, Bourke)

Resource staff

Mr Cameron Tonkin, District Agronomist, Walgett
Mr Luke Pearce, Soil Advisory Officer, Walgett

Program

Thursday 16 September

8.00 'Port of Bourke Hotel' Conference room
(a) Welcome – David McKenzie
(b) 'Cotton SOILpak' manual; contents, methods – David McKenzie

9.00 'Latoka
(a) Pit description on a typical Bourke cotton soil (grey cracking clay)
(d) Farmer comments – Mitch Abbo

12.15 'Janbeth'
(a) Pit description at high-yielding end of field (brown cracking clay)
(c) Pit description at poor-yielding end of field (brown cracking clay)
(d) Pit description in an adjacent unfarmed area (brown cracking clay)
(d) Farmer comments – Dale Hyland

3.30 Enbros P/L
(a) Pit description in a red soil used for irrigated cotton
(b) Concluding comments

Outcomes of Bourke course

- The trainees have the knowledge to accurately assess soil condition on commercial cotton farms.
- The value of soil assessment in 'yield map interpretation' was emphasized. Other topics that received detailed attention included:
  - management of sodic soil,
  - assessment of the impact of controlled-traffic farming systems on soil structure,
  - risk of water loss by deep drainage under cotton,
  - management of water penetration problems in red soil.

Field observations, laboratory data and management options (Bourke)

'Latoka' – typical Bourke cotton soil (grey cracking clay)

Field observations:

The field was in bare fallow after an irrigated wheat-cotton rotation. Under the main wheel tracks, compaction extended to a depth of about 50 cm. Under the hills, there was a continuous compacted layer (between a depth of 25 cm and 40 cm). It appears to have been caused by the lateral movement of hills onto old wheel tracks. Land-forming under wet conditions several years earlier may also have contributed to the problem. It appears, however, that the previous cotton crop had partially loosened the compacted layer by shrink-swell processes. Gypsum has been applied to the soil in previous seasons.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.5	8.4	0.42	79	35	4.9	1.9	0.09	0.59	1	29	19	55	20
Subsurface (0.15–0.25)	1.2	8.3	0.45	116	41	4.0	1.9	0.11	0.56	1	29	19	55	21
Upper subsoil (0.4–0.5)	1.7	9.2	0.32	62	44	11.1	1.4	0.03	0.39	1	28	13	61	23
Mid subsoil (0.7–0.8)	1.3	9.5	0.41	29	44	28.7	1.1	0.01	0.34	1	27	13	61	24

Interpretation of laboratory data:

The subsoil is sodic (ESI < 0.05, ESP >5) and strongly alkaline. Self-regeneration potential is moderate to good. Salt concentration throughout the profile is high enough to adversely affect the growth of leguminous rotation crops, but cotton is unlikely to be affected. The chloride profile indicates that there is restricted drainage at a depth of about 30 cm, due presumably to the compacted layer.

Management options to consider:

It is recommended that the subsoil be de-compacted by thorough drying and cracking with a well-fertilized rotation crop. One option is to sow wheat in the furrows (but not on the hills) immediately after cotton harvest. If there is enough moisture to establish the wheat, crack-lines should form along the hills as water is extracted from the soil. This process is referred to as "biological middle-busting". Follow-up chisel ploughing may be required (at a water content just below the 'plastic limit') to complete the de-compaction process. The next step is to establish controlled traffic laneways which, if properly maintained, should prevent major compaction problems in the future.

'Janbeth' – 'high yield' (brown cracking clay)

Field observations:

The field was about to be planted to cotton, after cotton in the 1998-99 season. The pits are located in a 'fill' area, where the best cotton is grown within this field. Under the hills, there was a continuous compacted layer (between a depth of 20 cm and 45 cm). It appears to have been caused by the lateral movement of hills onto old wheel tracks. Land-forming under wet conditions several years earlier may also have contributed to the problem. It appears, however, that the previous cotton crop had partially loosened the compacted layer by shrink-swell processes. Recent middle-busting operations had not penetrated deeply into the compact layer, and the soil was too moist to be shattered. Gypsum has been applied to the soil in previous seasons.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.4	8.7	0.14	14	38	2.1	3.0	0.07	0.56	4	44	11	44	16
Subsurface (0.15–0.25)	1.3	8.6	0.19	9	40	1.8	3.8	0.10	0.59	4	44	5	47	17
Upper subsoil (0.4–0.5)	1.4	8.7	0.13	19	38	3.6	2.2	0.04	0.38	2	35	8	54	20
Mid subsoil (0.7–0.8)	1.7	9.0	0.25	39	39	11.0	1.8	0.02	0.33	2	34	11	55	24

Interpretation of laboratory data:

The subsoil is dispersive (ESP >5 below 50 cm, ESI < 0.05). Self-regeneration potential is moderate (CEC = 20–40 cmol(+)/kg).

Management options to consider:

It is recommended that the subsoil be de-compacted by thorough drying and cracking with a well-fertilized rotation crop. One option is to sow wheat in the furrows (but not on the hills) immediately after cotton harvest. If there is enough moisture to establish the wheat, crack-lines should form along the hills as water is extracted from the soil. Follow-up chisel ploughing may be required (at a water content just below the 'plastic limit') to complete the de-compaction process. The next step is to establish controlled traffic laneways which, if properly maintained, should prevent major compaction problems in the future.

'Janbeth' – 'poor yield' (brown cracking clay)

Field observations:

The field was about to be planted to cotton, after cotton in the 1998-99 season. The pits are located in a 'cut' area, where the poorest cotton is grown within this field. Under the hills, there was a continuous compacted layer (between a depth of 20 cm and 45 cm). It appears to have been caused by the lateral movement of hills onto old wheel tracks. Land-forming under wet conditions several years earlier may also have contributed to the problem. Recent middle-busting operations had not penetrated deeply into the compact layer, and the soil was too moist to be shattered. Gypsum has been applied to the soil in previous seasons.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.2	8.9	0.14	16	36	3.8	2.7	0.04	0.44	3	34	9	54	19
Subsurface (0.15–0.25)	0.9	8.8	0.20	14	40	3.4	2.7	0.06	0.46	3	34	8	54	20
Upper subsoil (0.4–0.5)	0.6	9.3	0.27	39	42	9.4	2.1	0.03	0.31	3	36	9	54	23
Mid subsoil (0.7–0.8)	1.2	9.4	0.43	145	38	17.9	1.5	0.02	0.29	3	35	6	58	25

Interpretation of laboratory data:

The subsoil is dispersive (ESI < 0.05, ESP >>5) and strongly alkaline. The subsoil is mildly saline below a depth of 70 cm. Self-regeneration potential is moderate to good.

Differences in soil factors between the 'high' yielding and 'low' yielding parts of the field:

The 'poor' site is more dispersive and saline than the 'good' site, and may be more prone to waterlogging because of a greater clay content near the soil surface.

Management options to consider:

It is recommended that the subsoil be de-compacted by thorough drying and cracking with a well-fertilized rotation crop. One option is to sow wheat in the furrows (but not on the hills) immediately after cotton harvest. If there is enough moisture to establish the wheat, crack-lines should form along the hills as water is extracted from the soil. The wheat can be sprayed out in time for the planting of back-to-back cotton crops. Follow-up chisel ploughing may be required (at a water content just below the 'plastic limit') to complete the de-compaction process. The next step is to establish controlled traffic laneways which, if properly maintained, should prevent major compaction prohlems in the future. Gypsum at a rate of 5 t/ha is also recommended.. Piezometers should installed to ensure that the improvement of soil infiltration rates by gypsum application does not lead to groundwater rises.

'Janbeth' – 'unfarmed site' (brown cracking clay)

Field observations:

The unfarmed site was adjacent to the 'high yielding' site described above. It was used to grow several crops of cotton about 10 years earlier, but had never been landformed. It had reverted to native grassland, and was not being grazed. The profile had an excellent surface structure, but the subsoil aggregates were very large and hard.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.4	8.8	0.10	9	32	2.4	3.3	0.04	0.66	3	46	9	44	15
Subsurface (0.15–0.25)	1.1	9.0	0.13	11	35	3.8	3.0	0.03	0.51	3	46	9	44	16
Upper subsoil (0.4–0.5)	1.0	9.4	0.24	13	34	11.5	1.9	0.02	0.36	3	44	9	47	20
Mid subsoil (0.7–0.8)	1.1	9.3	0.42	179	35	19.5	1.7	0.02	0.33	3	43	9	47	21

Interpretation of laboratory data:

The profile is dispersive throughout, particularly in the subsoil, and strongly alkaline. The subsoil is mildly saline below a depth of 70 cm. Self-regeneration potential is moderate to good.

Management options to consider:

In the unlikely event of the unfarmed soil being developed for irrigated cotton production, deep cutting should be avoided. A positive response to gypsum application is likely.

Comparison between native pasture and the cotton field:

The farmed and unfarmed sites generally were very similar. The unfarmed soil had more organic matter at the soil surface, but was more dispersive in water. The 'good' farmed site had a better subsoil structure for root growth than the unfarmed area, but the 'poor' farmed soil was worse.

'Enbros' – 'irrigated cotton' (red soil)

Field observations:

The field had been used for irrigated cotton production for several years, but was about to be planted to peanuts. The soil had an excellent, well-drained reddish topsoil overlying a deep subsoil that was dominated by the presence of gypsum crystals (~60% gypsum, 40% soil). Between depths of 30 cm and 120 cm, lime nodules were present. A nearby deep excavation showed that drainage at a depth of about 2.5 metres was being impeded by a sodic clay layer. It appeared that wind-blown gypsum and lime deposited on the soil over the centuries had not leached deeply because of this drainage impedance. Although the topsoil had favorable characteristics when inspected under moist conditions, it is prone to dust formation if tilled under dry conditions, and sets hard when wet and dried. The structure under the hills is favorable for root growth – the wheel compaction is confined to narrow laneways.

Soil test results:

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay	15 bar
Topsoil (0–0.1)	1.2	8.5	0.31	92	27	3.0	4.0	0.10	0.67	3	53	10	36	14
Subsurface (0.15–0.25)	1.4	8.4	0.25	56	23	3.6	3.2	0.07	0.60	3	52	13	33	15
Upper subsoil (0.4–0.5)	1.5	8.3	0.13	47	26	4.9	2.0	0.03	0.33	2	49	16	30	18
Mid subsoil (0.7–0.8)	1.8	9.1	0.28	63	28	11.9	1.4	0.02	0.26	2	52	20	26	17

Interpretation of laboratory data:

The mid-subsoil is dispersive and strongly alkaline. Self-regeneration potential is moderate.

Management options to consider:

Establish an organic surface mulch via the use of a rotation crop such as wheat, and irrigate the soil as slowly as possible to encourage good water penetration. Because salts are present in the deep subsoil, install piezometers to monitor the groundwater height.