

Irrigation Management of Cotton at Emerald

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Background

This project was prompted by disappointingly low cotton yields at Emerald and other Central Queensland centres. The aims of the project are to provide a basis for sound irrigation management of cotton through studies of

- (i) Crop response to a range of irrigation management options in terms of crop irrigation efficiency (yield per unit water applied) and plant fruiting development.
- (ii) Soil water balance in relation to irrigation application efficiency (infiltration per unit water applied), crop water use, ground-water accessions and model predictions of all these factors.

Methods

Experiments have been conducted over 3 seasons (82/83 - 84/85) on the BUs cracking clay on the Emerald Research Station and over one season (84/85) on the AUs cracking clay on the east bank of the Emerald Irrigation Area. Data from the complementary project cotton response to nitrogen and irrigation are also relevant to irrigation management of cotton. All these experiments have measured crop response, soil water balance, irrigation application efficiency and crop water use under a range of irrigation management options. Other aspects considered are soil loss, soil aeration and cultivar response.

The irrigation schedules were based on potential crop water use estimated by a crop factor - Class A pan evaporation model.

Yield Results - Irrigation Management

The number of irrigations and lint yields for three irrigation deficits tested over three seasons on the Emerald Research

Station are presented below:

Irrigation Treatment	Number of Irrigations			Lint Yields Bales/ha		
	82/83	83/84	84/85	82/83	83/84	84/85
Very Frequent (45mm)	11	7	8	8.4	8.3	7.8
Frequent (75mm)	7	5	6	8.9	9.1	8.3
Very Infrequent (150mm)	3	3	2	7.0	8.8	5.6

An obvious feature of these results is the consistently high yields of the frequent (75mm deficit) treatment over three seasons of differing rainfall patterns requiring different numbers of irrigations. The lower yields in 84-85 were partly associated with a 14 day wet period in December when 144mm of rain fell on eight days. At this site over the three seasons the very frequent (45mm deficit) treatment had consistently lower yields than the frequent (75mm deficit) treatment. At some sites in some seasons the reverse applied depending on rainfall incidence in relation to irrigation. Yields from the very infrequent (150mm deficit) treatment were also closely related to rainfall and irrigation timing.

Year	Rainfall greater than 7mm		
	Sowing to one flower/metre	One flower/metre + 28 days	One flower + 28 days to 5 open bolls/metre
82/83	29	148	Nil
83/84	132	32	74
84/85	144	0	0
85/86 (Oct.sow)	125	18	91
85/86 (Nov.sow)	144	0	91

Lowest yields were obtained in the 150mm deficit treatment in the 84/85 and 85/86 seasons when there was negligible rainfall during flowering.

The total infiltration (water application minus runoff) approximated the predicted deficit in the 45mm and 75mm treatments. In less frequently irrigated treatments, total infiltration was less than the predicted deficit due to water stress effects. With

surface irrigation this is not an important limitation as the soil water status and irrigation layout dictate the volume of water applied. For different yield goals or irrigation strategies, the deficit at which irrigation is required varies with soil type.

Yield Results - Cultivar Response

In 82/83 there were some exploratory cultivar comparisons under different irrigation strategies. From 83/84 to 85/86 there was a more detailed evaluation with 6 cultivars suggested by Dr. P. Lawrence. The yields of Deltapine 90 which was included for the first time in 85/86 are compared with yields of Deltapine 61 and SIOKRA for an October sowing.

	Yields bales (225 kg) per ha			Sowing 29-10-85
	Water deficit (mm)			
Cultivar	45	75	150	R.G.
Deltapine 61	9.7 (206) ¹	9.0 (191)	4.7	2.1
Deltapine 90	10.1 (180)	9.4 (168)	5.6	2.4
SIOKRA	10.3 (219)	9.2 (196)	4.7	2.0

¹ () = % increase over yield at 150 mm deficit.

SIOKRA responded more than both Deltapine 90 and Deltapine 61 to optimum (75mm) and low (45mm) water deficits. The greatest difference in response was between SIOKRA and Deltapine 90 with Deltapine 90 giving a 180% increase at 45mm deficit over the yield achieved at 150mm deficit, compared with 219% for SIOKRA.

Comparable data for the second sowing follows:

	Yields bales (225 kg) per ha			Sowing 20-11-85
	Water deficit (mm)			
Cultivar	45	75	150	R.G.
Deltapine 61	5.2	6.1	5.2	2.0
Deltapine 90	6.9	6.9	5.8	2.6
SIOKRA	8.6	8.3	7.1	2.7

The yields from the November sowing were much lower than yields from the late October sowing. Bacterial blight was present in the

first sowing but was mainly confined to the leaves and there was little boll damage. Bacterial blight was much more severe on sowing two. Detailed counts of diseased and damaged bolls were made on the 45 and 150 mm deficit treatments with the following results:

	Percentage Diseased Bolls	
	45mm deficit	Sowing 20-11-85 150 mm deficit
Deltapine 61	24	36
Deltapine 90	13	23
SIOKRA	4	1

While SIOKRA is not infected by the present race of blight, there was some boll rot. The blight incidence was much higher on the less frequently irrigated plots of Deltapine 61 and Deltapine 90. This supports the conclusion that blight is more severe on plants which are stressed because of water or nutrient deficiencies or which are damaged by hail. Even the yields of SIOKRA, which was not affected by blight were lower in sowing two than in sowing one which supports previous observations that yields are generally reduced as sowing is delayed beyond October.

The yields of Deltapine 61 and SIOKRA for October sowings over the three seasons are compared below:

		Water Deficit (mm)	
Cultivar		75	150
	1983/84	12.4 (125) ¹	9.9
SIOKRA	1984/85	11.4 (165)	6.9
	1985/86	9.2 (196)	4.7
	1983/84	9.7 (108)	9.0
Deltapine 61	1984/85	11.5 (164)	7.0
	1985/86	9.0 (191)	4.7

¹ () = yield at 75mm as % of yield at 150 mm.

The response of SIOKRA at the 75mm deficit was equal to or greater than that of Deltapine 61 over the three years, indicating that the difference in cultivar response is probably a real one. This is supported by results from commercial management trials

comparing SIOKRA with Deltapine 90 and Deltapine 61. In some of these, total water use of SIOKRA was similar to that of the normal leaf cultivars but occurred over a shorter time, indicating that more frequent irrigation was required for SIOKRA.

Conclusions

Some of the detailed data collected needs to be further developed and evaluated but the experiments have:-

- * quantified plant and soil responses to irrigation management - on the BUs soil consistently high yields of 8 to 8.5 bales lint per ha were obtained by irrigating at a 75mm deficit. For maximum yields on the AUg soil more frequent irrigation at a lower deficit is required while on the TbUg soil less frequent irrigation still produces maximum yields.
- * quantified cotton cultivar response to irrigation management - SIOKRA responded more than Deltapine 90 and Deltapine 61 to irrigation at a 75mm deficit but the Deltapines outperformed SIOKRA at higher deficits or under raingrown conditions.
- * highlighted both the benefits of appropriate irrigation schedules and the costs of poor irrigation timing - an irrigation schedule which achieves maximum yields produces the best economic result.
- * demonstrated to the industry that reliable irrigation scheduling techniques are available.
- * provided data which enable decisions to be made on the irrigation management best suited to a particular farm situation.
- * shown that furrow irrigation management can be highly efficient and productive on these soils - application efficiencies of 85-90% are attainable.

As a consequence irrigation management in the Emerald Irrigation Area is now generally soundly based and farm production is showing the benefits. The Emerald model has performed so well that its

widespread testing in the industry is warranted.

Acknowledgements The results discussed are from a cooperative project involving D.Yule, G.Keefer, J. Ladewig, D. Nickson, A. Mich. The support of the Cotton Growers Research Committee is gratefully acknowledged.

REDUCED SEED BED COSTS: THE ROLE OF MINIMUM TILLAGE

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Introduction

Recent studies in cracking clays of the Macquarie Valley have investigated the effect upon soil structure and cotton growth of the following tillage and rotation treatments:

- (1) Deep ripping, mouldboard ploughing, chisel ploughing and shallow cultivation, with or without gypsum, under a rotation of cotton, wheat and safflower (known as the Field 24 experiment).
- (2) Permanent beds (direct listing), deep ripping and chisel ploughing, under a rotation of cotton and wheat (Field 30 experiment).
- (3) Permanent beds growing rotation crops of wheat and safflower compared to bare fallow, kept weed free by discing (Field 34 experiment).

The research is being undertaken in response to the need of farmers to; (1) overcome soil structural problems that are restricting crop growth, and; (2) minimize tillage costs without suffering a yield penalty, once desirable soil conditions have been achieved.

A summary of results presented previously (McKenzie, Abbott

and Higginson 1983, Hulme et al. 1986), and recent findings from the Field 24 and Field 34 experiments, are discussed in this paper, with emphasis on the economics of the different tillage alternatives.

Minimum tillage, deep tillage and rotation crops - which is most profitable?

The effect of deep tillage and gypsum on the yield of irrigated cotton, wheat and safflower from a compacted grey clay is shown in Table 1. In dry years, yield increases due to deep ripping, chisel ploughing and gypsum application were related mainly to improved subsoil water storage, higher air-filled porosity (20-50 cm depth), and lower soil resistance to root growth. In wet years there was little difference between treatments, except where ripping under moist conditions caused a slight yield decline. Most of the benefits from deep tillage were short-lived, unlike those from gypsum which lasted much longer.

Table 1. The effect of deep tillage and gypsum on the yield of cotton, wheat and safflower.

Treatment	Crop Yield (kg ha ⁻¹)				
	Cotton	Wheat	Cotton	Safflower	Cotton
	1981/82	Grain 1982	Lint 1983/84	Grain 1984	Lint 1985/86
Shallow Cultivation (Discing: 15cm)	1178	1280	809	842	1276
Shallow Cultivation + Gypsum (7.5 t/ha)	1326	1380	810	796	1380
Chisel Ploughing (25cm)	1201	1280	905	717	1832
Chisel Ploughing + Gypsum	1310	1520	821	676	1300
Mouldboard Ploughing (40cm)	1222	1260	832	811	1220
Mouldboard Ploughing + Gypsum	1351	1520	816	874	1303
Deep Ripping (70cm)	1338	1720	800	888	1202
Deep Ripping + Gypsum	1419	1760	792	811	1384
Deep Ripping + Gypsum repeated every four years					1428
Deep Ripping + Gypsum repeated every 2 years			746	941	1435

However, on a nearby well-structured soil (Field 30), direct listed cotton yielded 5% and 2% more, respectively, than on the chisel ploughed and deep ripped areas, mainly as a result of more rapid plant growth early in the season.

Rather than being contradictory, these results demonstrate that yield increases after deep tillage can be expected only if the soil has a compacted layer that can be shattered. Otherwise, it is preferable to use minimum tillage techniques which encourage the development and preservation of vertical channels (cracks, old root channels).

Table 2. Economic impact of deep tillage and minimum tillage, as influenced by cotton price.

(a) Deep tillage (Field 24 results, 1981-86)

Treatment Ploughing(\$ha ⁻¹)	Profit Compared to Chisel	
	\$200 bale ⁻¹	\$400 bale ⁻¹
Shallow	- 85	-271
Shallow + Gypsum	- 77	- 86
Chisel	0	0
Chisel + Gypsum	-173	-138
Mouldboard	-259	-427
Mouldboard + Gypsum	-276	-274
Deep ripping	+ 14	+ 6
Deep ripping + Gypsum	- 70	+ 65
Reripping (4 yearly)	-450	-386
Reripping (2 yearly)	-578	-580

(b) Minimum tillage (Field 30 results, 1984-85)

Treatment (\$ha ⁻¹)	Profit Compared to Chisel Ploughing	
	\$200 bale ⁻¹	\$400 bale ⁻¹
Direct List	+124	+192
Chisel (25cm)	0	0
Ripping (40cm)	+ 46	+ 89

- Notes. 1. No discount rates have been applied.
 2. In part (a), all extra returns (including cotton seed, \$0.10/kg; wheat, \$0.15/kg; safflower, \$0.20/kg) have been included in the analysis.

The economic impact of these effects is presented in Table 2. It can be seen that even under difficult economic conditions (cotton \$200/bale), deep tillage to disrupt a compacted layer can be profitable. Reripping, however, can be highly uneconomical unless there is a genuine need for it (i.e. serious recompaction after the first ripping), and if the soil is sufficiently dry. Overall, chisel ploughing to 30 cm depth appears to be the safest alternative for compacted clays.

When soil structure allows unrestricted root growth, profitability can be greatly improved by the use of minimum tillage (Table 2).

Gypsum provides long-term yield improvement in clays with sodic (exchangeable sodium percentage greater than 5) subsoils, but profits can be expected only when cotton prices are around \$400/bale (if applied at 7.5 t ha^{-1}). In contrast, if the problem is a hard-setting surface crust due to sodicity, it is unlikely that gypsum will improve profitability over a large range of cotton prices. The effect of different rates and frequencies of gypsum application requires further investigation in these soils.

Table 3 The effect of safflower, wheat and fallow on soil structure and plant growth.

Soil and Plant Measurements	Treatment		
	Fallow	Wheat	Safflower
<u>Soil measurements</u>			
Bulk Density (gcm^{-3})	1.48	1.43	1.43
Air-filled Porosity ($\text{cm}^3 \text{ cm}^{-3}$)	0.086	0.102	0.092
Water Content (gg^{-1})	0.249	0.256	0.264
<u>Plant measurements</u>			
Early-season plant growth			
. Height, 10/12/85 (cm)	19	24	24
. Squares, 10/12/85 (m^{-1})	9	15	16
Lint yield (kgha^{-1})	109	95	94

* taken at a depth of 15 cm, 5 days after an irrigation in February 1986.

Wheat and safflower have been shown to improve soil structure and early-season crop performance (Table 3). However, unless extra soil nitrogen is added to allow for uptake and tie-up by the rotation crops, yield of the following cotton can be depressed (Table 3), despite structural improvement. Failure to replenish deep subsoil moisture reserves can also be a problem. The evidence suggests that rotation crops, like deep tillage, will only improve both soil structure and cotton production (in the absence of disease problems) if the soil is seriously restricting the performance of cotton roots.

The need for objective measurements

The results presented clearly show the need for objective measurements of soil structure, therefore allowing more sensible tillage decisions. The use of instruments and techniques such as neutron probes, backhoe pit examination, penetrometers and dyes should be considered by all growers - they are discussed by Ian Daniells. Such an approach does much to prevent "crazes" about one particular approach, which may only be appropriate in a small number of circumstances.

Likely trends

In general, the chances of success with 'minimum tillage' are becoming better and better as: (1) most equipment becomes wider, and; (2) farmer awareness of the consequences of damaging soil structure become better understood (e.g. the dangers associated with discing, landplaning and/or harvesting under wet conditions).

However, minimum tillage should not be considered a magic solution, even under tough economic conditions. Flexibility is required. For example, with a combination of minimum tillage, wide gear (8 or 12 row) and dry harvests, it should be possible to avoid deep tillage, except maybe near heavily-used wheel tracks. When wet harvests inevitably occur, or if the beds are run-over or moved sideways onto wheeltracks, the use of well-fertilized rotation crops (summer and/or winter) to dry the soil, followed by chisel ploughing (after checking structural improvement with the rotation crop alone) is likely to be profitable. However, we still have much to learn about optimal

implement designs and water contents for tillage. Although the use of gypsum is unfashionable at present, there are situations where its use is profitable. Soil testing to determine gypsum requirement is recommended.

Acknowledgements

We thank the staff of Auscott Warren for their excellent co-operation, and Kate Hucker, David Hall and Ian Toole for assistance in the field and laboratory. Much of the work has been funded by the CRC, ACGRA and WIRC of NSW.

References

Hulme, P., Anthony, D., Cass, A., McKenzie, D. and MacLeod, D.

(1986). Is ripping necessary? - less cultivation may be more profitable. The Australian Cottongrower. 7, 20-25.

McKenzie, D.C., Abbott, T.S. and Higginson, F.R. (1983).

Improving the structure of irrigated grey clays in the lower Macquarie Valley. The Australian Cottongrower 4, 22-26.