

# Value of Salt and Nutrient Leaching under Irrigated Cotton

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## Introduction

Cotton production in Australia occurs mainly in cracking clay soils. In the past, it was widely assumed that deep drainage was negligible in these soils (Hearn, 2000). Recently, however, several researchers have contradicted this view. Deep drainage rates between 9 and 146 mm/yr, nitrate and chloride fluxes of 227 and 3272 kg/ha/yr, respectively, have been reported from southern Queensland and NW New South Wales (Moss *et al.*, 1999; Zischke and Gordon, 2000). Willis and Black (1996) reporting from central-western New South Wales observed that deep drainage was 17 mm/yr when a soil had 53% clay, whereas when it had 35% clay drainage increased to 202 mm/yr. These soils tended to have shallow water tables, and they suggested that drainage and leaching of salts from the profile could increase the salinity and decrease the depth to the watertable, with associated capillary rise resulting in salinization of productive soils.

In this paper we report our observations on deep drainage and nutrient leaching evaluated in three irrigated sites during the 2000-2001 cotton-growing season in NW New South Wales. An attempt has been made to evaluate in \$ terms the benefits and costs of the salts and nutrients leached out of the root zone.

## Materials and methods

Nutrient leaching and drainage were measured during the 2000-01 cotton season across diagonal transects in a plot (400 m x 24 m) sown with an intensively-tilled wheat-cotton sequence at Wee Waa (30°13'S, 149°27'E), a no-tilled plot (200 m x 16 m) of wheat-cotton at the ACRI (Australian Cotton Research Institute) (30°13'S, 149°27'E), and three reduced-tilled plots (430 m x 24 m) of continuous cotton, wheat-cotton and dolichos-cotton at Merah North (30°11'S, 149° 18'E). Crop stubble was incorporated at Wee Waa and Merah North before sowing cotton, whereas cotton was sown into standing wheat stubble at ACRI. Nutrient leaching was monitored with 5-cm diameter P80 semi-permeable ceramic-cup water samplers installed at depths of 60, 90 and 120-cm. Soil water was extracted at 7-10 day intervals. Water was also sampled from the head-ditch during each irrigation at each site. The water samples were analysed for chloride, nitrate-N, Ca, Mg, K and Na (Rayment and Higginson, 1992). Soil was sampled from the 0-120 cm depth, before (October 2000) and after (April-May 2001) the cotton season, across the same transects and analysed for chloride (Rayment and Higginson, 1992). A steady state chloride mass balance model was used to determine deep drainage, with a correction factor being used to account for dilution due to seasonal rainfall. The costs and benefits of nutrients and salts leached out of the cotton root zone were quantified by equating them to the value of a specific fertiliser or soil amendment (Tables 2 and 3). For example, the amount of nitrate-N leached was calculated in terms of its equivalent amount in anhydrous ammonia, K in terms of KNO<sub>3</sub>, and calcium, magnesium and sodium in terms of their gypsum equivalents. Cl was equated to the amount of yield increase which could be expected due to the observed amount of Cl being leached out of the soil profile. This was done by deriving a soil

Cl-cotton lint yield response curve across all sites. The net differences (\$/ha) between the costs (nutrients lost) and benefits (salts leached) were the estimated net value of nutrients and salts leached through in deep drainage.

## Results and discussion

Deep drainage, nutrient losses and salt leaching (Table 1) were significant under irrigated cotton. Seasonal deep drainage at Merah North was 98 mm with continuous cotton, 76 mm with wheat-cotton and 19 mm with dolichos-cotton; 118 mm with wheat-cotton at Wee Waa; and 151 mm with wheat-cotton sown into standing wheat stubble at ACRI. Differences in stubble management, subsoil structure, texture and sodicity caused these differences. Total water inputs (rainfall + irrigation) were 1000 mm in both Wee Waa and Merah North, and 700 mm at ACRI. Yield variation in transects across the field at Wee Waa and ACRI were due mainly to nitrate-N leaching and waterlogging (ACRI only), whereas salinity was the main cause at Merah North.

**Table 1.** Nutrients and salts leached out of the 120 cm depth during the 2000-01 cotton season (kg/ha)

Cl	NO <sub>3</sub> -N	K	Ca	Mg	Na
<u>ACRI (Cotton sown into standing wheat stubble)</u>					
2491.3	199.7	7.8	26.8	79.3	416.7
<u>Wee Waa (Cotton-wheat, stubble incorporated)</u>					
1145.9	130.4	4.8	21.7	64.4	286.2
<u>Merah North (Cont. cotton, stubble incorporated)</u>					
10456.9	173.7	4.9	70.4	77.1	1102.1
<u>Merah North (Cotton-wheat, stubble incorporated)</u>					
3528.5	128.5	3.0	19.2	70.5	598.7
<u>Merah North (Cotton-dolichos, stubble incorporated)</u>					
3708.6	22.9	1.2	31.9	30.4	264.4

Benefit-cost analyses (Table 4) showed that where water and soil salinity was low, nutrient and salt leaching resulted in a net cost, whereas when soil and water salinity were high and because deep drainage was involved in salt leaching, a net benefit occurred. This was in spite of the fact that some nutrients like N and K were leached out of the cotton root zone. In general a minimum deep drainage of 5-10% of total water inflow (rainfall and irrigation) is needed to maintain the soil in a non-saline condition.

## Conclusions

Deep drainage and nutrient leaching were significant under irrigated cotton. In saline soils, high deep drainage resulted in leaching of excess salt out of the root zone soil, and was thus, beneficial. In non-saline soils deep drainage resulted in a net loss of nutrients, and hence, was costly to the cotton grower. The relatively high rates of nutrient and salt leaching may result in groundwater quality deteriorating in the long-term.

## References

Hearn, B. 2000. The science of water balance: Why do we need to know? In 'Proc. 10<sup>th</sup> Australian Cotton Conference, 16-18 August 2000, Brisbane, Qld., Australia', pp. 351 -360. (ACGRA: Orange, NSW, Australia)

**Table 2.** Estimated values of nutrients leached out of 120 cm depth (costs)

Site and cropping system	N value*		K value <sup>#</sup>		Ca value**	
	Equiv. in anhydrous, kg/ha	\$/ha	Equiv. in KNO <sub>3</sub> , kg/ha	\$/ha	Equiv. in gypsum, kg/ha	\$/ha
ACRI (Cotton sown into standing wheat stubble)	243.58	170.51	20.32	23.97	115.18	8.51
Wee Waa (Cotton-wheat, stubble incorporated)	158.97	111.28	12.46	14.66	93.30	6.90
Merah North (Cont. cotton, stubble incorporated)	211.84	148.29	12.81	15.67	302.17	22.36
Merah North (Cotton-wheat, stubble incorporated)	156.76	109.73	7.77	8.88	82.39	6.10
Merah North (Cotton-dolichos, stubble incorporated)	27.87	19.51	3.01	3.76	137.02	10.14

\* assuming 1 t anhydrous ammonia = \$700

# assuming 1 kg potassium nitrate = \$1.18

\*\* assuming gypsum = \$70/t + spreading = \$10/ha at a rate of 2.5 t/ha

**Table 3.** Estimated values of salts leached out of 120 cm depth (benefits)

Site and cropping system	Mg value <sup>φ</sup>		Na value***		Cl value <sup>^</sup>	
	Equiv. in gypsum, kg/ha	\$/ha**	Equiv. in gypsum, kg/ha	\$/ha**	Estimated increase in future lint yield due to Cl leaching, ba/ha	\$/ha
ACRI (Cotton sown into standing wheat stubble)	340.29	25.18	894.16	66.17	0.30	105.00
Wee Waa (Cotton-wheat, stubble incorporated)	276.35	20.45	614.18	45.45	0.00	0.00
Merah North (Cont. cotton, stubble incorporated)	330.83	24.48	2,364.93	175.00	3.00	1,050.00
Merah North (Cotton-wheat, stubble incorporated)	302.77	22.41	1284.78	95.07	2.70	945.00
Merah North (Cotton-dolichos, stubble incorporated)	130.47	9.65	567.42	41.99	0.00	0.00

\*\* assuming gypsum = \$70/t + spreading = \$10/ha at a rate of 2.5 t/ha

φ assuming 1 Ca = 1 Mg; this underestimates the benefit of gypsum re. ionic strength increase; other costs as before

\*\*\* assuming 1 Ca = 2 Na; this underestimates the benefit of gypsum re. ionic strength increase. other costs as before

^ Value of a bale of cotton lint = \$350

Moss, J., Gordon, I., Zischke, R. 1999. Vertosols do “leak”! – Water and solute movement below irrigated cotton. In ‘Proc. Murray-Darling Basin Groundwater Workshop, 14-16 September 1999, Griffith, NSW, Australia’, pp. 298-303. (MDBC: Griffith, NSW, Australia)

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**Table 4.** Estimated net value of nutrients and salts leached out of 120-cm depth.

Site and cropping system	Benefits-Costs (\$/ha)
ACRI (Cotton sown into standing wheat stubble)	-7
Wee Waa (Cotton-wheat, stubble incorporated)	-67
Merah North (Cont. cotton, stubble incorporated)	1063
Merah North (Cotton-wheat, stubble incorporated)	938
Merah North (Cotton-dolichos, stubble incorporated)	18