Understanding deep drainage in Grey Vertosols of the Moonie and Condamine catchments of south east Queensland

Vic French[1], Jeremy Whish[2], Philippa Tolmie[3], Rowland Cook[4] and Philip Egan[5]

[1] Department of Primary Industries and Fisheries, PO Box 61, Miles Q 4415 Email vic.french@dpi.qld.gov.au
[2] CSIRO Sustainable Ecosystems, PO Box 102 Toowoomba Q 4350 Email jeremy.whish@csiro.au
[3] Department of Natural Resources, Mines and Water, PO Box 102, Toowoomba Q 4350 Email philippa.tolmie@nrm.qld.gov.au
[4] Trenmore, Meandarra Q 4422 Email racookco@bigpond.com
[5] Traighli, Moonie Q 4406 Email phil_egan@bigpond.com

Abstract

The mobilisation of depositional salt as a result of deep drainage is a major concern to farmers and land managers in southern Queensland. The identification of productive agricultural land as an area of high potential salinity hazard, and the "high" estimated drainage values calculated from accepted simulation models, stimulated two groups of farmers to join with researchers in a participatory research project. The research project has concentrated on identifying how much deep drainage is occurring under different farming systems, how farm management decisions impact on drainage and if profitable and flexible cropping systems could be developed to manage the salinity risk. Deep soil coring, and numerical and simulation modelling were combined with detailed farm management records and observations to understand the deep drainage processes in these soils. Preliminary results suggest that initial drainage can be used to increase the plant available water content (PAWC) of these soils by 60 mm, and modern farming practices can minimise the mobilisation of depositional salt by reducing the current rate of drainage by 50%. Despite the Moonie and Condamine catchments being in a high potential salinity hazard area, careful management can improve the water holding capacity of the soils and minimise the impact of deep drainage.

Key Words

Salinity, deep drainage, melonholes, participatory research, transient salt mass-balance, modelling

Introduction

Dryland salinity has long been a major problem in Australian agriculture. About 48000 ha was estimated to be affected by induced salinity in Queensland (NRM 2002*c*) and there is the potential for this area to increase substantially in the next 30 to 50 years (NRM 2002*b*). The salinity hazard map for the Queensland Murray Darling Basin (QMDB), released in 2002 (NRM 2002*a*) indicate that a large area of the basin has the potential to develop salinity problems sometime in the future. Salinity hazard maps are based on information on groundwater flow systems, climatic zones and landscape characteristics. The three requirements for salinity to occur are: (a) a source of salt (b) a soil or groundwater flow system that can move water and salt to the land surface or stream and (c) a change in hydrology. Excessive deep drainage mobilises stored salts by leaching or ground water rise.

A large conspicuous area of potentially high salinity hazard on the QMBD salinity map includes the farming and grazing districts of Moonie and Condamine. Two farmer groups in this area were concerned firstly that salinity was a potential problem on their land, and secondly that as a result legislation may be enacted requiring them to change management practices to combat salinity without any evidence of salinity occurring.

This paper reports on a participatory research project with the aim of determining how much deep drainage occurs under the different farming and grazing systems in the Moonie and Condamine catchments, how farm management systems impact on drainage and salinity, and identifying profitable and flexible cropping systems that can help manage potential salinity risk.

Methods

The concerns and experiences of two farmer groups in the Moonie and Condamine districts were the catalyst for initial discussion, research team selection and project design. Moonie and Condamine are located in southern Queensland in the Murray Darling Basin about 200 km west of Toowoomba. The participatory approach taken was the action research cycle (Plan, Act, Observe and Reflect: Zuber-Skerritt 2000) and involved researchers from CSIRO Sustainable Ecosystems, QNRM&W, QDPI & F and two farmer groups.

In 2001 the Moonie farmer group questioned the accuracy of deep drainage figures from an APSIM (Agricultural Production Systems Simulator) simulation scenario presented to them. From their experiences they believed there was very little, if any, deep drainage under their present farming system. The Condamine farmer group were also sceptical that deep drainage occurred in their clay soils. They based their scepticism on experience – “We have melonholes in native scrub that have held water for six months but are dry within 90 cm of the surface”. Both groups, however commented that Brigalow soils produce better crops after about five years of cultivation than during the first few years following clearing. The interest of the groups and the controversial nature of the problem presented an ideal opportunity for a participatory research project.

The initial data collection involved identifying five sites with natural timber, long term pasture and long term cropping in close proximity and on the same soil type. The soils were sampled to approximately four metres under each vegetation type based on a semi-structured sampling approach to account for the variability associated with the gilgai nature of this soil. The natural vegetation was Brigalow (*Acacia harpophylla*) and Belah (*Casuarina cristata*) and initial clearing took place approximately 40 to 50 years ago. The soils are Grey Vertosols and all have gilgai (melonhole) micro relief (Isbell 1996).

A transient salt mass-balance approach (Rose *et al.* 1979; Thorburn *et al.* 1990; 1991) was used to track water movement in the soils by comparing samples from the cleared sites with samples from the timbered sites. This approach relies on the water soluble nature of chloride and assumes complete mixing of the soil and water. The results from these comparisons indicate the different rates of water movement that has occurred since the land was cleared for farming or grazing.

Detailed paddock histories of the farmers’ cropping sequences, rainfall and land management methods were collected to help interpret drainage calculations. These histories were also used as a basis for simulation modelling to further understand the drainage process and help identify suitable management strategies to profitably farm with reduced drainage (Whish *et al.* 2006).

Results

Initial results displayed a consistent pattern of reduced electrical conductivity (EC) and chloride between the natural vegetation and the cropping soils, suggesting an increase in water movement or drainage since the vegetation had been cleared. The change in EC (1:5 soil/water) and chloride levels as a result of this water movement can have significant consequences for farming, increasing the PAWC of the soils by approximately 60 mm. This increase is calculated from the difference in chloride concentration between the natural vegetation and the cropping soils, assuming minimal plant water uptake from concentrations > 1000 ppm. This result supports the farmer observation that cropping on newly cleared country improves over time.

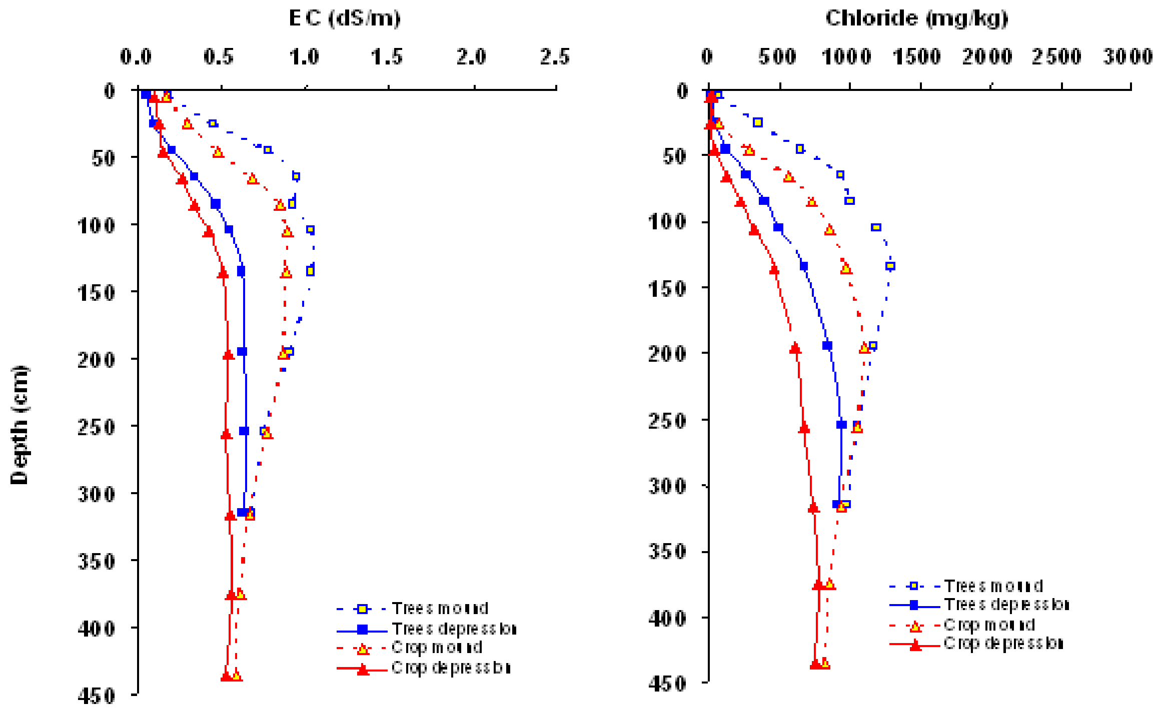

Figure 1 Electrical conductivity (EC) and chloride levels for a representative site at Moonie showing differences between the natural vegetation and long term cropping treatments.

Average drainage rates for long term crop, long term pasture and native vegetation site were consistent with those reported in a review of past research (Tolmie and Silburn 2003) and showed that in general cropping soils have drained at twice the rate of soils under pastures while drainage under native vegetation is virtually negligible (Table 1).

Table 1 Median drainage since clearing over all sites in mm/year

Treatment	Crop	Pasture	Native Vegetation*
Drainage (mm/yr)	8	3	<1

* Drainage from steady-state mass balance

Cropping histories

Cropping histories, farm management history and historical rainfall records were collected for each site with the aim of reproducing the complete cropping sequence from clearing. In general the cropping sequence between 1960 and 1990 was continuous wheat interspersed with irregular lucerne leys. There was little if any summer crop grown and some long fallowing was practiced. During the 1990s all of the farmers moved to include summer crops in the rotation and some opportunistic cropping of pulses and oilseeds was occurring. An example of the cropping sequence from one site at Moonie is presented in Table 2.

Table 2 Historic cropping sequence from one participating farmer

Year	Crop	Year	Crop
1968	pulled	1991	sorghum
1974	raked	1992	fallow
1976	oats	1993	fallow
1977	oats	1994	sorghum
1978	wheat	1995	fallow
1979	wheat	1996	wheat
1980	fallow	1997	wheat
1981	wheat/lucerne	1998	wheat
1982	lucerne	1999	wheat
1983	lucerne	2000	fallow
1984	lucerne	2001	sorghum
1985	fallow	2002	fallow
1986	cotton	2003	barley
1987	wheat	2004	wheat
1988	wheat	2005	sorghum
1989	wheat		
1990	wheat		

Simulation modelling of the historic sequences using APSIM showed good correlation between recorded and simulated yields (Whish *et al.* 2006) and highlighted the episodic nature of drainage. Summer rainfall and a full soil profile were identified as the catalysts of large drainage events. Reflecting on the results, the group conceded that drainage may be occurring in these soils but felt that historic simulation was not representative of their current farming methods. The group from Moonie developed a sequence based on their current farming knowledge and monthly rainfall totals. The new sequence was not developed to reduce drainage but to better represent the group's current farming practices. The new sequence was simulated and the total drainage was reduced by 50% (Hochman 2005).

New questions

Two new questions were posed at a review of the project with members of the farmer groups and the research team: (a) Where is the salt and water going? (b) How much drainage is sustainable and/or acceptable?

To answer the first question the following hypothesis was proposed: if our drainage estimates of about 8 mm/year under crops are correct and assuming a uniform water holding capacity of soil below 2 m of

100 mm for each 1 m and no water tables exist, over the 30 to 40 years since clearing, the water and salt front should be found at a depth between 5 and 6 m. This hypothesis is currently being tested and results from two exploratory cores suggest that the initial calculations are correct. This means with more detailed sampling a complete water balance accounting for unused soil water since clearing is possible. Implications of this work could be that, because these Brigalow soils are relatively deep, there is the potential to relocate surface salt below the crop root zone and maintain it there by tactical management of the cropping sequence. The use of deep rooted perennials (maybe lucerne) to access the deep water store is also a possibility that may reduce the rate of drainage through the soil profile. These results are an exiting extension of the initial project and will contribute significantly in identifying how to manage crop production in these areas while minimising environmental impacts.

Conclusions

This research has demonstrated that deep drainage has occurred on the Moonie and Condamine soils, and that cropping soils drain more readily than pasture or natural vegetation, but it has not identified the consequences of this drainage. The long term simulations have shown that they can adequately reproduce historic crop yields, but the drainage figures are volatile with soil management practices having a major impact on the values. Despite this, the use of modelling to investigate the impact of cropping sequences has shown that current opportunity cropping options used by farmers can reduce drainage by up to 50%. Current zero till and reduced tillage farming practices improve water infiltration and reduce evaporation, effectively increasing potential drainage if historic cropping sequences are maintained. The key to reducing drainage in this environment is to utilise the additional water for crop growth by opportunistically growing crops, thus converting the excess water into profit before it is lost.

Acknowledgement

This project was part of the Eastern Farming Systems Project funded by GRDC.

References

Hochman Z (2005) A virtual meeting space- supporting farmers learning about natural resource management RIRDC Final Report project No. CSW40A

Isbell RF (1996) The Australian soil classification. CSIRO Publishing, Melbourne.

NRM (2002*a). '*Salinity hazard map'. Queensland Government, Department of Natural Resources and Mines: Brisbane

NRM (2002*b*) NRM Facts, L51 Salinity in Queensland, Queensland Government, Department of Natural Resources and Mines, 021000, Brisbane

NRM (2002c) NRM Facts, L57 Salinity hazard mapping in Qld, Queensland Government, Department of Natural Resources and Mines, 02099.

Rose CW, Dayananda DR, Nielsen DR and Biggar JM (1979) Long-term solute dynamics and hydrology in irrigated slowly permeable soils. Irrigation Science 1 77-87.

Thorburn PJ, Rose CW, Shaw RJ and Yule DF (1990) Interpretation of solute profile dynamics in irrigated soils. 1. Mass balance approaches. Irrigation Science 11, 199-207.

Thorburn PJ, Cowie BA and Lawrence PA (1991) Effect of land development on groundwater recharge determined from non-steady chloride profiles. Journal of Hydrology 124, 43-58.

Tolmie PE, Silburn DM, Biggs AJW (2003) Estimating deep drainage in the Queensland Murray-Darling Basin using soil chloride. Department of Natural Resources and Mines, QNRM03020, Coorparoo, Queensland.

Whish JPM, French Vic, Tolmie P and Silburn M (2006). Simulating historic cropping systems to understand the interaction between crop choice and deep drainage. Proceedings of the 13th Australian Agronomy Conference, Perth WA. Australian Society of Agronomy.

Zuber-Skerritt O (2000) Action learning and action research: Paradigm, praxis and programs, in Effective change management through action research and action learning: Concepts, perspectives, processes and applications, eds. S Sankara, B Dick and R Passfield, Southern Cross University Press, Lismore, Australia.