Estimation of long term average groundwater recharge rates under cotton irrigation in the Lower Macquarie Valley.

TM. Willis and SJ. Jenkins.

Introduction

Watertable rises resulting from irrigation are evident in several areas in the Murray Darling Basin, with groundwater level rises of up to 70 cm per year being reported in the Riverina and 50 cm in the Lower Macquarie Valley. The Department of Water Resources initially reported rising groundwater in the Lower Macquarie Valley about 7 years ago, and it was predicted that large areas north and west of Narromine may become waterlogged within the next 15 - 25 years. Current aquifer pressures indicate watertables may rise to within 2 m of the soil surface in some areas, eventually resulting in salinisation. Groundwater recharge in the Macquarie region seems to be effected by a number of factors including; floods, seepage from the river bed; leakage from weirs; storage dams and irrigation channels; and intensive irrigation.The aim of this study was to identify potential rates of groundwater recharge under irrigated cotton.

A change in soil chloride distribution over time is indicative of the amount of deep percolation that has occurred. Chloride mass balance modelling (Slavich *et al.*, 1992) allowed rates of deep percolation to be estimated on four soils in the Macquarie Valley; a cracking grey clay (GC), red brown earth (RBE), red duplex soil (DS) and silty levee soil (LS). Northcote (1979) soil classifications are Ug 5.25, Dr 2.13, Dr 2.42 and Gn 4.13 respectively. Irrigated and non-irrigated sites were used to represent chloride profiles separated in time.

Model input parameters.

Bulk density was measured to a depth of 2 m on each soil. The gravimetric soil water content at which leaching occurs was assumed to be saturation. Saturated bulk density and gravimetric soil water content were directly measured on the GC. Unsaturated bulk

density was measured on the other soils with saturated gravimetric water content calculated as 93% of total porosity (Williams *et al.* ,1989). Following laboratory analysis of soil samples, mean depth weighted soil chloride concentration and concentration of chloride in the draining soil water were calculated at each depth using equations of Slavich *et al.*, (1992).

Historical data (Table 1) used in the model include time since irrigation commenced, irrigation application rate and chloride concentration of irrigation water. Irrigation water obtained from the Macquarie River was assumed to have a chloride concentration equivalent to that of river water since irrigation commenced and was determined using data collected by Department of Water Resources from 1976 to 1992. The infiltration of rainfall was not considered as both sites received equal rainfall and therefore chloride displacement, allowing the effect of irrigation to be isolated from that of rainfall.

Table 1: Infiltration and time data derived from historical records.

Soil	Time since irrigation commenced (years)	Irrigation application rate* (mm yr^{-1})	Chloride concentration of irrigation water (Meq L^{-1})
GC	23	491	0.83
DS	10	400	0.77
RBE	9	811	0.77
LS	5	860	0.70

* based on assumption that 100 mm was applied each irrigation

Long term average deep percolation rates for soils of the Macquarie Valley

Steady state conditions exist where no significant change in mean stored soil chloride occurred over time, while a transient model is required in the event of significant changes. The model was used to calculate deep percolation over a depth range of 1 to 2m where plant uptake was assumed to be negligible.

Estimated deep percolation rates represent an average rate over the entire period since the development of irrigation on a particular field. Hence these rates will tend to under estimate deep percolation occurring under cotton in a given year, and over estimate that occurring in a year in which irrigation does not occur, or is less than that required by a cotton crop. The results, however, give a general overview of relative deep percolation rates on four soils, allowing comparison of soils and assessment of associated salinity hazards. These results are presented in Figure 1.

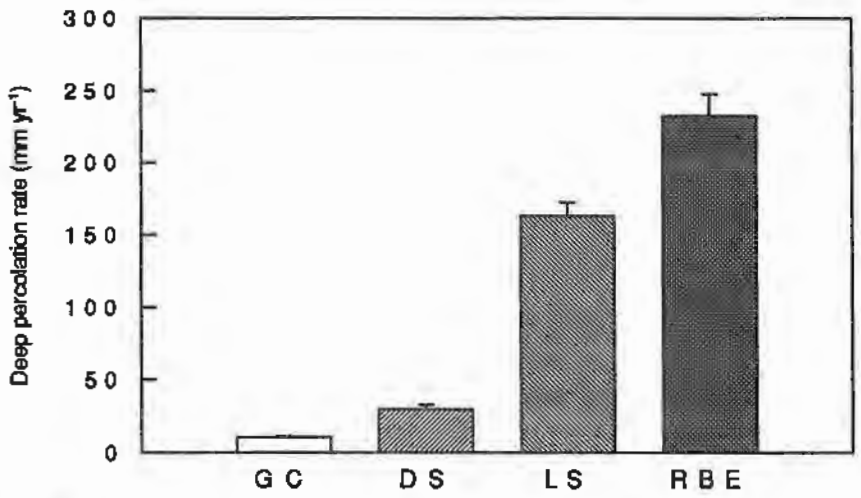

Figure 1: Long term average deep percolation rates of 4 soils from 1 - 2 m calculated using chloride mass balance modelling

The lowest deep percolation rate was observed on the GC (10.3 ± 1.1 mm yr^{-1}) and may be attributed to the high clay percentage throughout the profile. The DS exhibited a slightly higher deep percolation rate (29.5 ± 3.1 mm yr^{-1}), percolation being inhibited by a relatively impermeable sodic B horizon characterised by a high clay content and bulk density. Higher permeability of the RBE (232.7 ± 14.9 mm yr^{-1}) and LS (163 ± 9.5 mm yr^{-1}) resulted from comparatively lower clay percentages in the B horizon. The lower percolation rate on the LS may be due to the higher silt and clay percentage in the topsoil, resulting in a higher water holding capacity and utilisation in the root zone, thus

reducing groundwater accessions in comparison to the RBE.

Irrigated crops grown on the RBE and LS represent potential groundwater recharge sites assuming the drainage water reaches the underlying aquifer. Where the rate of lateral groundwater flow is less than the rate of recharge, aquifer pressure will increase. Sufficient increases in aquifer pressure caused by other sources of recharge will also cause groundwater to rise in these soils first, as they are the most permeable. With continued accessions, the watertable may rise within the zone of capillary rise and salinisation will occur. Alternatively high rates of deep percolation may reach an impermeable layer at some depth and a perched watertable may form. Percolation rates greater than the hydraulic conductivity of this layer will result in a rising perched watertable, and eventually salinisation.

The GC and DS have comparatively lower percolation rates. The salinity hazard of these soils arises from insufficient leaching of salts added in irrigation water. This problem will be exacerbated in the event of an increase in irrigation water salinity. Higher salt concentrations in these soil types has developed due to lower percolation rates. A greater salinity hazard exists in the event of a rising watertable as a higher concentration of salts are present to be mobilised.

Irrigation practices to minimise losses to deep percolation, through over-irrigation, will minimise groundwater recharge and rising watertables. Avoiding under-irrigation is also important to prevent the accumulation of salts in the root zone. Investigation of irrigation and management practices to minimise groundwater recharge while maintaining desirable root zone salinity will aid to minimise salinisation of soils used for cotton production.

Conclusions

A reconnaissance study of deep percolation rates, indicated that the RBE and LS are sites of highest groundwater recharge under irrigated cotton in the Lower Macquarie Valley. The DS exhibited a lower rate of recharge, while the GC was lowest of all. Assessment of chloride profiles has enabled estimation of potential rates of groundwater recharge and the associated salinity hazards of different soils. Other cotton growing areas, such and Bourke and the Namoi and Gwydir Valleys, would benefit from such studies to assess the salinity hazards of soils in these areas.

References

Slavich, P.G., Petterson, G.H., & Griffin, D. (1992) The effect of gypsum on deep drainage from clay soils used for rice. In *Proceedings of national workshop on sodic soils*. Adelaide, S.A.

Williams, J., Ross, P., & Bristow, K. (1989) Prediction of the Campbell water retention function from texture, structure and organic matter. In. *Proceedings of the international workshop on indirect methods for estimating the hydraulic properties of unsaturated soils*, ed. M. Th. van Genucthen and F.J. Leij, Riverside, California.

Northcote, K.H. (1971) *A factual key for the recognition of Australian soils.* 3rd edn, Rellim Technical Publications: Glenside, SA.