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Dry drainage: A sustainable solution to waterlogging and salinity problems in irrigation areas?

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ABSTRACT

Estimates of the global extent of irrigation-induced soil salinity vary, but there is widespread agreement that the twin menaces of waterlogging and salinisation represent serious threats to the sustainability of irrigated agriculture in many arid and semi-arid regions. In certain circumstances, the conventional drainage solution may be questionable due to economic and/or environmental limitations and "*dry drainage*" has been postulated as an alternative. It involves the allocation of areas of fallow land, which operate as evaporative sinks drawing a stable flux of water and salt from irrigated areas. An evaluation of the merit of this approach requires answers to three key questions: (i) What is the limiting crop intensity? (ii) What is the limiting watertable depth? (iii) What is the long-term impact of salt accumulation in the drainage sink area? A simulation model was developed to investigate these questions for a dry-drainage system with a wheat–cotton cropping pattern using published data for the Lower Indus Basin in Pakistan, where shallow saline watertables, intensive irrigation, high evaporative demand and natural dry drainage exist. The simulation results showed that dry drainage could satisfy the necessary water and salt balance when the cropped area and sink area were approximately equal and watertable depth was around 1.5 m. The long-term impact of salt accumulation on the performance of the system was also considered.

1. Introduction

The introduction of irrigation in arid and semi-arid environments inevitably leads to watertable rise and often to problems of waterlogging and salinisation. Hoffman and Durnford (1999) reported how these twin problems have developed worldwide since recorded history, and the speed with which they are advancing at present. Ghassemi et al. (1995) reviewed various estimates of the global extent of salinisation of land and water resources and concluded that, of the total of 230 million ha of irrigated land around the world, some 45 million ha suffer from severe irrigation-induced salinity problems.

Conventional wisdom holds that the best solution to dealing with the twin menace of salinity and waterlogging, is to maintain a net flux of salt away from the rootzone and to control the watertable by means of artificial drainage. There is a widespread acceptance that irrigation without drainage is not sustainable, but it is necessary to consider also whether conventional technical fixes are themselves sustainable. While this approach may be suitable for local circumstances, within large contiguous irrigation systems significant economic and environmental limitations may arise (van Schilfgaarde, 1994; Kijne et al., 1998; Ayars and Tanji, 1999; Smedema, 2000; Saysel et al., 2002; Sonuga et al., 2002).

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In recent years, the assumption that irrigation is a public good has become questionable and there has been growing recognition of the importance of farmer participation. Poor performance in many large-scale irrigation schemes has been attributed to the failure of public sector management, a significant factor being the inability to provide adequately for the cost of operation and maintenance. The problem is even more severe in public drainage schemes (Gowing and Wyseure, 1992), as drainage does not generate more income, but simply aims to protect existing income, so farmers are reluctant to pay much to support such schemes. Economic sustain ability is therefore open to question.

Concern over environmental sustainability arises from the need to dispose off saline drainage effluent from irrigated land. Problems include (i) availability of main/public drains, (ii) high cost involved in connecting individual farm drainage systems to the public drain, (iii) resistance by neighbouring land owners to drainage effluent passing across their fields, (iv) environmental concerns, (v) salt loading of rivers and (vi) availability of drainage sinks in closed basins.

In recent years, there have been attempts to identify solutions, which will work within environmental constraints and will also be economically viable (Hanson, 1989; Gowing and Wyseure, 1992; Asghar, 1996; Sharma and Tyagi, 2004). Improved on-farm water management combined with disposal by means of evaporation ponds is seen as the optimal strategy, but with some environmental risks. Subirrigation facilities for watertable management with some limitations have been discussed by Skaggs (1999) and Fouss et al. (1999a,b). Another alternative is the control of the water level with irrigation management. A shallow watertable can be considered as a valuable resource for meeting part of the crop requirement for water (Ragab and Amer, 1986) and studies have shown that salt-tolerant crops (e.g., cotton, alfalfa and barley) are capable of extracting significant quantities of water from groundwater (Ayars and Schoneman, 1986). Therefore, shallow groundwater may be used as a resource when the salt content of the water does not lead to unmanageable rates of salinisation (Qadir and Oster, 2004). However, in arid and semi-arid regions, the evaporative demand and the salinity of groundwater may be high and the upward evaporative flux from a saline watertable may result in the accumulation of salt to a very high concentration at or near the soil surface. This can occur seasonally on fallow fields or continuously on unirrigated (abandoned) land.

The beneficial use of this process to control salinity by means of managed evaporative sink areas within a ‘‘dry-drainage’’ scheme was first proposed by Gowing and Wyseure (1992).

1.1. *Concept of dry drainage*

There is a tendency to view drainage in terms of controlling watertable depth, and therefore, to be misled by the notion of a ‘‘critical depth’’ for salinity control. In fact, salinity control depends upon establishing a time-averaged net downward flux through the rootzone, therefore, it is the water balance that is important (Smedema, 1990). Disturbance of the natural balance by introducing irrigation causes a rising watertable, where natural drainage sinks cannot cope with the increase in groundwater recharge (Gowing and Wyseure, 1992).

Within a given area, if inflow (rainwater excess, field application losses, watercourse and/or canal seepage losses) balances outflow (supply to crops from watertable, evaporation from uncropped areas, artificial and/or natural drainage sinks), then the watertable will be stable. If the uncropped area is large enough and evaporation from this area is fast enough, then the necessary balance can be achieved without artificial drainage. This is the concept of dry drainage. It means that part of the available land is set-aside as a sink for excess groundwater and for salt transported with the groundwater. The groundwater system provides the pathway for the movement of the excess water from the irrigated land to the fallow land (Fig. 1).

There is evidence that some parts of the Indus Basin in Pakistan have already benefited from dry-drainage systems and the practical significance of this mechanism has been recognised for some time (Middleton et al., 1966). It has also received some attention in field studies in Australia

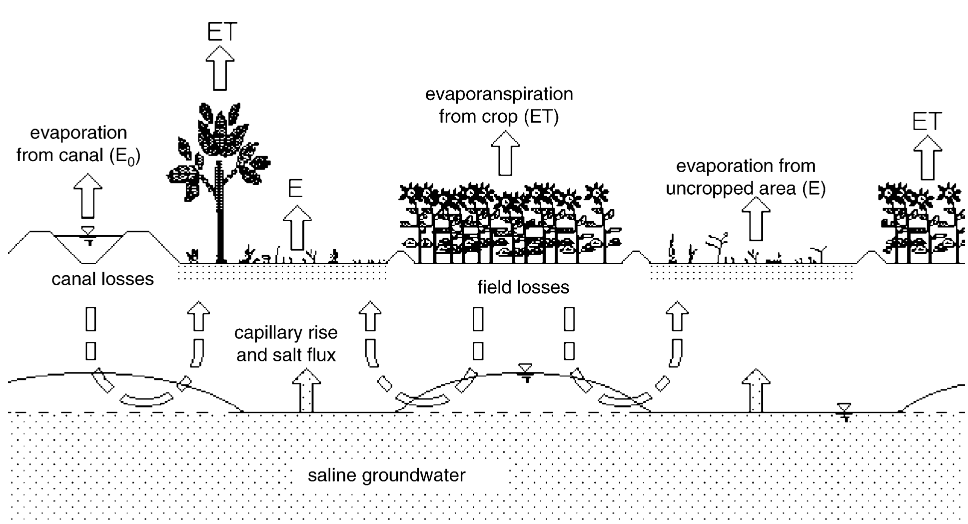

Fig. 1 – Schematic section of a dry-drainage system.