CHAPTER 1

GLOBAL IMPACT OF SALINITY AND AGRICULTURAL ECOSYSTEMS

MICHAEL G. PITMAN[1,†] and ANDRÉ LÄUCHLI[2]
[1] *Canberra, ACT, Australia*
[2] *Department of Land, Air and Water Resources*
University of California, One Shields Avenue, Davis, CA 95616, USA

Abstract

Agricultural losses caused by salinity are difficult to assess but estimated to be substantial and expected to increase with time. Secondary salinization of agricultural lands is particularly widespread in arid and semiarid environments where crop production requires irrigation schemes. At least 20% of all irrigated lands are salt-affected, with some estimates being as high as 50%. Whereas the world's population continues to rise, the total land area under irrigation appears to have leveled off. The need for increased food production therefore needs to be met by increases in yield per land area. To reach this goal, genetic engineering of crop plants for enhanced salt tolerance will be a very important approach. In dry regions where fresh water becomes a scarce commodity, irrigation of moderately salt tolerant crops with brackish water is feasible. Transgenic lines of some crop species have been generated which can grow and develop at fairly high salinity levels in controlled environments. These transgenics must be tested vigorously for yield potential under field conditions.

1.1 Introduction

Salinity is one of the most severe environmental factors limiting the productivity of agricultural crops. Most crops are sensitive to salinity caused by high concentrations of salts in the soil. The cost of salinity to agriculture is estimated conservatively to be about $US 12 billion a year, and is expected to increase as soils are further affected (Gnassemi *et al.,* 1995). In addition to this enormous financial cost of production there are other serious impacts of salinity on infrastructure, water supplies, and on social structure and stability of communities. Responses to salinization have been of two general kinds; engineering the environment to manage increased salt in the soil by

[†] Michael Pitman died March 30, 2000

A. Läuchli and U. Lüttge (eds.), Salinity: Environment - Plants - Molecules , 3–20.

irrigation and drainage management, or by "engineering" the plants to increase their salt tolerance. Salt tolerant plants may also ameliorate the environment by lowering the water table in salt affected soils.

This book is mainly about the contribution that scientific research has made to understanding basic mechanisms of salt tolerance of plants and progress made to developing salt tolerance in useful agricultural crops in order to make better use of salt affected soils. That it might be possible to increase salt tolerance of agriculturally useful plants is encouraged by the ability of many flowering plants to live in saline conditions at low water potentials. Mangroves have evolved the ability to grow – and may even require – high levels of salinity. Salt marsh plants grow with periodic inundation of seawater. Certain plants of the seastrand, and coral islands (e.g. *Wedelia biflora*) have the ability to grow in wide ranges of salinity and water potential caused by periodic droughts as well as salt stress. Certain semi-arid or arid species (e.g. *Atriplex* spp) are able to tolerate and use salt as an osmoticum, facilitating water extraction from the very low osmotic potentials of desert soils. Within agricultural species there are evident differences in salt tolerance between species and between varieties (Chapter 2, Table 9; Maas, 1990). In 1980 Emanuel Epstein wrote: "The principal responses of halophytes and other plants that tolerate saline environments are of necessity those that lead to osmotic adjustment. Unless that premier adaptation is accomplished existence in saline substrates is impossible." This is a useful reminder that salt tolerance involves interaction of many processes in the functioning system of the plant and in the ecosystem.

1.2 Global impact of salinization

Salinization commonly occurs as an outcome of agricultural practices, either associated with irrigation or due to long-term changes in water flow in the landscape that can follow land clearance or changed water management. Salinization associated with agriculture occurs when salts build up in the root zone, either because the soil is intrinsically saline, or because the drainage of water from the sub-soil is not sufficient to prevent saline waters rising into the root zone. It therefore tends to be common in arid and semi arid regions where leaching of salt is poor due to low rainfall; where there are strongly saline sub-soils formed from marine deposits or where irrigation changes water tables and salt flow. The ionic balance differs according to the salts in the sub-soils or water. However, Salinization also can be a part of natural landscapes and saline pockets may occur where poor drainage and high soil salinity come together. In these areas salt tolerant species have become established that may have other uses. For example, the salt tolerant grass species *Diplachne fusca,* used as cut fodder in Pakistan, grows naturally in subtropical saline areas in Australia from where it is believed to have been introduced to Pakistan.

In dryland salinity there is the possibility to lower saline water tables by planting trees in the landscape, using salt tolerant trees or deep-rooting shrubs. This possibility has also been considered where irrigation caused secondary salinization of the water table. Such a study was conducted on the western side of the San Joaquin Valley of California in the mid-to-late 1980's, where eucalyptus trees were planted with the intent to lower