ELSEVIER Scientia Horticulturae 78 (1999) 1–4

SCIENTIA HORTICULTURÆ

Preface

Salinisation and horticultural production

Salt-affected soils are a natural phenomenon on earth and this should not be surprising on a planet where approaching three-quarters of the surface is covered with sea-water – a half-molar solution dominated by the soluble chlorides of sodium, magnesium and potassium. Plants have evolved to colonise these saline habitats, yet such plants have little place in agricultural systems. In times past, the presence of relatively unproductive salt-affected soils must have been apparent to farmers, but was rarely of consequence for the production of food, as communities were much smaller than at present and did not require the use of these poor soils for growing crops (but see Jacobsen and Adams, 1958). During the nineteenth and twentieth centuries, however, the human population has risen dramatically. While there were about one billion people in 1850, there were 2.5 billion a century later (Salk and Salk, 1981) and the current total is more than five billion. It is expected that the population will exceed six billion by the year 2000. With such a huge rise in population, there are, naturally, concerns over the ability of the world's agricultural systems to deliver sufficient food, without deprivation for the poorest people (Conway, 1997). The huge rise in the population has had consequences for agriculture beyond simply raising the amount of food that needs to be produced. This special issue of *Scientia Horticulturae* is directed at a review of the effects of secondary salinisation on horticultural crops.

Horticulture, according to the Shorter Oxford English Dictionary, is "the art or science of cultivating or managing gardens, including the growth of flowers, fruit, and vegetables." (see also the review by Shannon and Grieve). Horticulture is a specialist form of agriculture carried out by a diversity of people, from subsistence farmers and amateur gardeners to professional growers whose organisations range in size from small family concerns to large businesses. The scale of production is often smaller than that for the main agricultural crops, but more intense and, frequently, undertaken in a protected environment – generally a glass- or plastic-house. Whether the crop is grown under glass or plastic or in a field, the requirement for an adequate water supply is paramount. The supply of water for horticultural crops is frequently through irrigation: for those crops grown in a protected environment, irrigation is essential. One of the most worrisome consequences of irrigation is secondary salinisation.

Irrigation has increased dramatically in the last two hundred years: from around 8 Mha in 1800 to more than 255 Mha at present (Ghassemi et al., 1995;

PII: S0304-4238(98)00188-5

FAOSTAT, 1997). Irrigation is rarely performed with water that does not contain some salts, so that, eventually, these salts build-up in the soil unless the management of the irrigation system can bring about their leaching from the soil profile. Salinisation is likely to have increased over the period in which irrigation has increased, although it is much more difficult to quantify areas of land that are salt-affected than areas that are irrigated. Ghassemi et al. (1995) tabulate, for the late 1980s, the proportion of salt-affected irrigated land for eleven countries that contained (in 1987) 70% of the world's irrigated land. Salt-affected irrigated land ranged from about 9% in Australia to nearly 34% in Argentina, with an average figure of 20%. Other estimates suggest that 50% of all irrigation schemes are affected (Szabolcs, 1992). World-wide, it has been suggested that by the year 2000 about 60% of currently irrigated crop-land will suffer reduced productivity due to excess soil salinity (Buras, 1992).

There have, unfortunately, been few recent attempts at assessing the degree of human-induced or secondary salinisation and this creates a problem for evaluating the importance of salinity to future agricultural productivity (cf. Flowers and Yeo, 1995). There has, for example, been no comprehensive reassessment of the maps of salinisation in Europe produced by Szabolcs (1974) more than twenty years ago. Nevertheless, reports of secondary salinisation continue to appear in the literature. For example, Banin and Fish (1995) reported the recent salinisation of the Yizre'el Valley, a 20 000 ha intensively irrigated region in Israel developed since the 1940s. In Turkmenistan, salinisation and water-logging are recorded as increasing, as irrigation expanded since the 1950's (Ohara, 1997). In the Shanxi province in China, more than one-third of its total area of irrigated land is said to have become salinised (Qiao, 1995). Xiong et al. (1996) report that "Soil salinity has plagued irrigated lands along the Yellow River in the arid Ningxia Hui Autonomous Region of China since shortly after the first canal was built in BC 214. By 1985, approximately 40% of the 300 000 ha of irrigated land was adversely affected by salt accumulation."

Irrigation is not the sole reason for salinisation of land. In coastal regions, where horticulture is often practised, there is a risk of sea-water incursions if abstraction of water, be it for irrigation or human use, leads to tidal intrusion of saline water into rivers (e.g. Cyrus et al., 1997; Ebraheem et al., 1997) or aquifers (e.g. Howard and Mullings, 1996). Around Murcia in Spain, for example, of the nearly 6000 analyses on irrigation water made over the pase five years, about 8% had an EC$<$1.5 dS m^{-1}, 37% between 1.5 and 3.5, and 55%$>$3.5 dS m^{-1} (Cerdá, personal communication). With an EC of 3.5, there would be few moderately tolerant crops that could be grown and these would require a considerable proportion (ca. 20–40%) of the water to be leached through the soil profile (Pratt and Suarez, 1990). Almeria and Valencia suffer from similar problems. Deforestation is also now recognised as a major cause of salinisation. In Australia, a country where one-third of the soils are sodic and 5% saline (Fitzpatrick et al., 1994), there is a serious risk of salinisation if land with shallow unconfined aquifers containing water with more than 0.25% total soluble salts is cleared of trees (Bui et al., 1996).

Until there are easy methods of mapping salt-affected land our information will remain dominated by estimate and anecdote. Difficulties with assessing the extent will hopefully be improved in the future by remote-sensing systems. The late Professor Szabolcs, who unfortunately died in August 1997, was an advocate for new surveys using such systems. They have been used in a limited way to determine the extent of salinisation in regions of India and China (e.g. Raina et al., 1993; Dwivedi, 1994; Qiao, 1995) and new developments in the use of techniques such as scanning low-frequency microwave radiometry (Goodberlet et al., 1997) might improve ease and reliability in the future. Without reliable estimates of the extent and spread of salinisation, it will remain difficult to evaluate the extent of the problem facing agriculture, in general, and horticulture, in particular, in the future.

Underlying this volume is my judgement that salinisation will become a significant issue in world agriculture during the twenty-first century. Horticulture, even if hard to define precisely, is a significant part of world agriculture. Since much research on the effects of salinisation is currently aimed at the major agricultural (and particularly cereal) crops, it is time to widen our horizon. Reviews in this volume survey the effects of salinity on horticultural crops, in general (Shannon and Grieve), and the tomato (Cuartero and Fernández-Muñoz) and citrus (Storey and Walker), in particular. A pertinent observation from these papers is how little is known about the environmental interactions between the growth of horticultural crops and salinity. Grattan and Grieve address the interaction of salinity and nutrition, one of the three underlying causes (with water stress and salt toxicity) used to explain the detrimental effects of salt-affected soils on plant growth (Greenway and Munns, 1980). The consequences of climate change and the interactions between crop growth, salinity and the rising atmospheric concentration of carbon dioxide is reviewed by Yeo. Once again the dearth of information regarding horticultural crops is highlighted. The final part of the volume is devoted to underlying physiology and biochemistry. A review of the importance of ion channels in salt tolerance by Tyerman and Skerrett is followed by papers that address the possibilities of manipulating genetic traits in the generation of salt tolerance through plant transformation – particularly the ability to produce compatible solutes (Bohnert and Shen), and to incorporate genes from yeast (Serrano, Culiañez-Maciá, and Moreno).

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References

Bannin, A., Fish, A., 1995. Secondary desertification due to salinization of intensively irrigated lands: The Israeli experience. Environ. Monit. Asses. 37, 17–37.

Bui, E.N., Smettem, K.R.J., Moran, C.J., Williams, J., 1996. Use of soil survey information to assess regional salinization risk using geographical information systems. J. Environ. Qual. 25, 433–439.

Buras, N., 1992. Efficient irrigation, environmental effects, and its long term sustainability. ICID 3rd Pan American Regional Conf.

Conway, G., 1997. The Doubly Green Revolution. Food for All in the 21st Century. Penguin Books, London, pp. 335.

Cyrus, D.P., Martin, T.J., Reavell, P.E., 1997. Salt-water intrusion from the Mazingazi River and its effects on adjacent swamp forest at Richards Bay, Zululand, South Africa. Water SA 23, 101–108.

Dwivedi, R.S., 1994. Study of Salinity and Waterlogging in Uttar Pradesh (India) Using Remote-Sensing Data. Land Degradation and Rehabilitation 5, 191–199.

Ebraheem, A.A.M., Senosy, M.M., Dahab, K.A., 1997. Geoelectrical and hydrogeochemical studies for delineating ground-water contamination due to salt-water intrusions in the northern part of the Nile Delta, Egypt. Ground Water 35, 216–222.

FAOSTAT, 1997. Statistics database. http://apps.fao.org/cgi-bin/nph-db.pl.

Fitzpatrick, R.W., Boucher, S.C., Naidu, R., Fritsch, E., 1994. Environmental consequences of soil sodicity. Aust. J. Soil Res. 32, 1069–1093.

Flowers, T.J., Yeo, A.R., 1995. Breeding for salinity resistance in crop plants: Where next? Aus. J. Pl. Physiol. 22, 875–884.

Ghassemi, F., Jakeman, A.J., Nix, H.A., 1995. Salinisation of Land and Water Resources. Human Causes Extent Management and Case Study. CAB International, Oxford, pp. 526.

Goodberlet, M.A., Swift, C.T., Kiley, K.P., Miller, J.L., Zaitzeff, J.B., 1997. Microwave remote sensing of coastal zone salinity. J. Coastal Res. 13, 363–372.

Greenway, M., Munns, R., 1980. Mechanisms of salt tolerance in non-halophytes. Ann. Rev. Plant Physiol. 31, 149–190.

Jacobsen, T., Adams, R.M., 1958. Salt and slit in ancient Mesopotamian agriculture. Science 128, 1251–1258.

Howard, K.W.F., Mullings, E., 1996. Hydrochemical analysis of ground-water flow and saline incursion in the Clarendon Basin, Jamaica. Ground Water 34, 801–810.

Ohara, S.L., 1997. Irrigation and land degradation: implication for agriculture in Turkmenistan, Central Asia. J. Arid Environ. 37, 165–179.

Pratt, P.F., Suarez, D.L., 1990. Irrigation water quality assessments. Agricultural Salinity Assessment and Management, American Society of Civil Engineers, New York, pp. 220–236.

Qiao, Y.L., 1995. An application of aerial remote-sensing to monitor salinization at Xinding Basin. Space Research 18, 133–139.

Raina, P., Joshi, D.C., Kolarkar, A.S., 1993. Mapping of soil degradation by using remote sensing on alluvial plain, Rajasthan, India. Arid Soil Research and Rehabilitation 7, 145–161.

Salk, J., Salk, J., 1981. World population and human values: a new reality. Harper and Row, New York.

Szabolcs, I., 1974. Salt Affected Soils in Europe, Martinus Nijhoff, The Hague, pp. 63.

Szabolcs, I., 1992. Salinization of soils and water and its relation to desertification. Desertification Control Bulletin 21, 32–37.

Xiong, S.Y., Xiong, Z.X., Wang, P.W., 1996. Soil salinity in the irrigated area of the Yellow River in Ningxia. China Arid Soil Research and Rehabilitation 10, 95–101.