ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/228456411

Biosaline agriculture in Pakistan

Article · January 2007

CITATIONS
3

READS
1,069

1 author:

M. Ajmal Khan
University of Karachi
314 PUBLICATIONS 8,552 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Project Roles of reactive oxygen species (ROS) and antioxidants in seed biology and salt tolerance of halophytes View project

Project Ecophysiology of sub-tropical halophytes View project

All content following this page was uploaded by M. Ajmal Khan on 28 May 2014.

The user has requested enhancement of the downloaded file.

CHAPTER 16

BIOSALINE AGRICULTURE IN PAKISTAN

M. AJMAL KHAN

Department of Botany, University of Karachi-75270, Pakistan
Phone: (9221) 4820922, Fax: (9221) 9243976
E-mail: halophyte_ajmal@yahoo.com
ajmalk@super.net.pk

Abstract: Fresh water resources are under severe pressure along with the agricultural irrigation system which suffers from a steady increase in salinity. In order to maintain good supply of water for human consumption and for agriculture, efforts should be made to find alternate source of water and utilization of saline land for economic benefits. A number of halophytes could be used as cash crop (forage, fodder, fuel, medicine, chemicals, ornamentals etc). Pakistan spans a distance of 1,600 kilometers from the Arabian Sea to plains and prairies, the playas of temperate northern mountains across deserts, covering an area of 800,000 square kilometers. The varied climatic conditions have resulted in a rich diversity of flora including halophytes. Compared to the total 2500 species reported worldwide, Pakistan alone has about 410 halophytes and 178 of them have not been reported before. The efforts made to combat salinity and utilization of halophytes as cash-crop in Pakistan would be discussed.
Key words: brackish water, forage, fodder, halophyte, oil-seed, salinity.

1. INTRODUCTION

The rapidly increasing human population in the arid and sub-arid regions of the world has tremendously increased the pressure on the availability of good quality water for human consumption, industry and for agriculture. In addition, defective irrigation practices have increased the level of under ground water and large areas have become water logged which eventually results into higher salinities of the soil (Yensen, 2006). It is becoming increasingly difficult to grow any conventional crop in hyper saline soils and therefore, it is imperative to look for other solutions. In this paper I will discuss in reference to the Pakistan about the extent of degradation due to salinity, various approaches adopted to address salinity problems and efforts to introduce cash crop halophytes to sustained management of saline areas.

Pakistan covers an area of about 796,100 million hectares, stretching about 1600 kilometers from north to south and about 900 kilometer from east to west

M. Kafi & M.A. Khan (eds.), Crop and Forage Production using Saline Waters. Vol: X, 5-10
© 2007 NAM S&T Centre. Printed in India.

(Agricultural Statistics of Pakistan, 2004). The country can be divided into seven major landscape units: 1. Coast, 2. Balochistan Plains, 3. Indus Plains, 4. Potwar Plateau, 5. Deserts including Thal, Thar and Cholistan, 6. Arid and Semi-arid Mountains including the northern Balochistan, Sulemania range, Waziristan, Kurram agency, Gilgit, and Chitral (Hindukush) and 7. Moist Mountains including the Western Himalayas, Swat, Kashmir, Murree and Kaghan (Khan, 2003). The Indus is a major river, which passes through Pakistan with an approximate annual water flow of 115 billion cubic meters (Ahmed and Chaudhary, 1988). It originates from the Tibetan plateau at an altitude of about 5500 meters and flows south to the Arabian Sea. In addition other major tributaries, the Chenab, the Jehlum, the Sutlej, the Beas, and the Ravi join the Indus at the upper Indus plain.

Pakistan is primarily arid and semiarid, except for a narrow belt in the north, with low and variable rainfall. Annual precipitation ranges from 1500 mm on the southern step of the Himalayas to less than 100 millimeters on the south western Balochistan. About 69 % of the country receives rainfall of less than 250 millimeters per year. Most of the rains take place during the monsoons (June – September). However, the southwestern Balochistan receives winter rain with a Mediterranean trend, and some northwestern areas have both winter and summer rains. The areas which receive more than 500 millimeters of rains are about 9 % of the country’s area. Pan evaporation ranges from 2800 mm in Sindh to 1300 mm in Punjab which is lowest in winter and highest in summer. The rainfall in most part of the Pakistan is not sufficient and often erratic; therefore, about 75 % of the agricultural land is irrigated through canals.

1.1. Status of Salinization in Pakistan

Surface and ground water in agricultural areas in Pakistan is rapidly becoming saline. Furthermore, salt deserts (caused by a lack of fresh water) and saline inland basins (caused by the rising level of saline ground water as a result of leakage of drainage water) are being created. About 6.2 out of 23 million hectares of cultivable lands are affected by salinization where 2.8 million hectares have some kind of cultivation while 3.4 million hectares could not sustain any conventional crops (Agriculture Statistics of Pakistan 2004). Salinization is caused by either natural cause (Primary salinity) or due to human activities (Secondary salinity). Primary salinity is a minor player in creating salinity problems in Pakistan. Modern irrigation system is a major cause of the secondary salinities in Pakistan through 1. Seepage from irrigation canals, 2. High salt concentrations in irrigation water, 3. Insufficient leaching of salt, and 4. Type of salts in the irrigation water. The soil salinity increase thus results into the following type of soils. Slightly saline and sodic (0.2 MH), moderately saline (2.3 MH), highly saline (1.5 MH), and very highly saline (2.0 MH).

1.2. Approaches to manage saline, sodic and water-logged soil

There are several strategies involved in the management of the saline soils like engineering approach, reclamation approach and Bio-saline agriculture approach (Qureshi and Barrette-Lennard, 1998). In Pakistan all these approaches were practiced, with varied results.

1.3. Engineering approach

Where logic behind was that the salinization of the soil could be reversed by various kinds of drainages: a. Proximity of irrigation canals results in seepage of about 0.21 million cubic meters of waters per day. This increase in water table ultimately causes soil salinization. Three major techniques were used in Pakistan 1. Surface drainage; 2. Lining of canals, and 3. Pumping of ground water known as SCARP (Salinity Control and Reclamation Projects) they helped in pumping out ground water work however, the disposal of this water of usually bad quality, posed serious questions on the sustainability of the program. b. With the help of USDA a project was initiated in 1957 to install tube wells for pumping underground water; c. Left bank outfall drain. A canal was dug in the lower Indus valley in order to dump saline waters collected from tube wells or by shallower surface drains to 290 kilometers away in the sea. This project had a cost 26 billions Pakistani rupees and expected to dump 25-30 million tones of salt into the sea each year. This project has questionable success record. It was a complete failure in sodic soils which allows little penetration, caused destruction of good quality soil, advantage gained in some areas were short lived and expensive.

1.4. Reclamation approach

This includes small interventions at a local scale to leach out the surface salts. Tactics used were: a. leaching with higher level of irrigation: It is least cost effective, inefficient, and may convert saline soil into sodic soil. b. Use of gypsum or acids: Generally used in sodic soil is cost effective, efficient, with rapid response. The gypsum is getting more expensive and it requires extra irrigation water for washing and soils rapidly goes back to the saline state in few years time. Acid are effective but expensive and could leach important nutrients.

1.5. Bio-saline Agriculture

This approach was to utilize saline soils by growing genetically manipulated salt tolerant crops. A number of conventional method using radiation, breeding etc. were used widely to introduce salt tolerant cultivars of wheat, barley, rice, cotton, mustard and other crops. The salt tolerant varieties were able to produce better crop in the soil with very low salinity, therefore providing relative better production in comparison to their salt sensitive cousins. However, the soil salinity of about 3.4 million hectare of agricultural land is in the range that is beyond the capacity of any conventional salt tolerant crop plants (Agricultural Statistics of Pakistan, 2004).

1.6. Utilization of halophyte as non-conventional cash-crops

Given the submissions made above we are left with little choices but to seek alternate methods to ease the pressure on the requirement of good quality water and the utilization of the land degraded by high soil salinity. There are growing indications that cultivation of crops with a high salt tolerance can be realized as an economically feasible option for utilizing saline soils and conserving fresh water (Boyko, 1964; Glenn et al., 1998; Aronson, 1991; Lieth, 1994). Potential halophytic crops could be broadly grouped into three categories 1. Plants with a high salt tolerance: they grow in water with salt contents equal to or even higher than that of seawater; 2. Crops with an average salt tolerance: they grow in brackish water and 3. Crops with a moderate salt tolerance: they grow in slightly brackish water that is not suitable for conventional agriculture. Khan and Qaiser (2006) reported that 410 halophytic species are distributed in Pakistan. Considering that about 2500 halophytes are reported for the world (Aronson, 1985, 1989; Menzel and Lieth, 1999) 410 in Pakistan indicate a higher diversity as well as great opportunity to find cash crop halophytes (Khan, 2003).

Utilization of halophytes in Pakistan is not a new concept. Groups in various parts of Pakistan have been trying to find cash-crop halophytes with limited success. Research groups from NWFP Agricultural University, Forest Research Institute from Peshawar, Soil Salinity Research Institute, Pindi Bhattian, International Waterlogging and Salinity Research Institute, Lahore; Nuclear Institute for Agriculture and Biology, University of Agriculture, Faisalabad, Nuclear Institute for Agriculture, Tandojam and Department of Botany, University of Karachi have been active in exploring the potential of various plant species and conducting applied ecological/ecophysiological studies in this context. The research work done in these laboratories varies from the utilization of salt tolerant conventional crops, non-conventional forage and fodder plants including grasses, shrubs and trees.

Research on salt tolerant trees was conducted in different parts of Pakistan with the help of Council of Scientific and Industrial Research Organization (CSIRO), Australia. Many species and provenances of Australian salt tolerant *Acacia*, *Casuarina* and *Eucalyptus* species were cultivated in saline areas with few local control species. It was found that *Acacia ampliceps*, *Casuarina equisetifolia* and *Eucalyptus occidentalis* were more salt tolerant and relatively better adapted to various ecological systems in Pakistan (Marcar et al., 2003). *Prosopis juliflora* was also grown successfully in Bhawani, near coast of Balochistan and it was argued it could be utilized as source of fuel wood (Khan et al., 1986). In a parallel project CSIRO also provided funding to grow several Australian *Atriplex spp.* at various locations in Pakistan. *Atriplex amnicola, A. lentiformis* and *A. nummularia* were relatively more salinity tolerant and produced higher biomass in comparison to other *Atriplex spp.* studied (Davidson and Gallaway, 1993).

Kallar grass (*Deplachne fusca*) is big success story for waterlogged saline soils of central Punjab. Malik et al. (1976) have done a series of experiments and successfully demonstrated that the species could be grown in highly saline waterlogged soil and arguably used as fodder.

Halophyte Biology Laboratory in the University of Karachi is also involved in developing the technology to provide complete feed for the live stock production using brackish water irrigation (Khan and Ungar, 1995; Khan and Weber, 2006; Khan et al., 2006; Ozturk et al., 2006). We have successfully demonstrated that high quality fodder grass could be raised by controlled brackish water irrigation. In addition we are using leaf succulent salt sucking halophytes to remove the salt from the system. Succulent halophytes are harvested periodically and burned to produce soda which is utilized in soap industry. Through managing the use of brackish water using drip irrigation and succulent species to achieve salt balance in the soil we believe that we have created a sustainable system for green fodder production. We have learned that ration for the animals require dry fodder more than the green fodder. There are few grass candidates available in the area that could produce high biomass with brackish water irrigation. Experiments are under progress to produce a large amount of grass to use as dry fodder. We know that their nutrition level is quite high. We also need to provide some high sugar and protein source to make a balance meal. We are investigating the possibility to grow fruit trees with brackish water irrigation and use them as sugar source. At the same time we are working with an industry and their involvement forces us to think about the economic viability of the project. The process of taking laboratory research to mass scale profitable industrial production is long, arduous and painful. However, one has to go through this patiently. We believe that most of the failure lies in crossing this bridge.

2. REFERENCES

Ahmed, N. and G.R. Chaudhary. 1988. Irrigated Agriculture of Pakistan. Shahzad Nazir Publications, Lahore. 810 pp.

Aronson, J. 1989. HALOPH; Salt Tolerant Plants for the World - A Computerized Global Data Base of Halophytes with Emphasis on their Economic Uses. University of Arizona Press. Tucson, USA.

Aronson, J. 1991. The present and future roles of salt tolerant trees and their associated microsymbionts in arid lands. In: Choukr-Allah, R. (ed.), Plant Salinity Research - New Challenges. pp. 363-376. Proc. Intnl. Conf. Agril. Mgt. Salt Affected Areas, Agadir, Morocco.

Aronson, J.A. 1985. Economic halophytes - a global review. In: Wickens, G.E., Goodin, J.R. & Field, D.V. (eds.), Plants for arid lands, pp. 177-188. George Allen and Unwin, London.

Boyko, H. 1964. Principles and experiments regarding irrigation with highly saline and seawater without desalinization. In: Transactions of the New York Academy of Sciences Series II /26. pp. 1087-1102. New York Academy of Sciences.

Davidson, N. and R. Gallaway. 1993. Productive use of saline land. Proceeding of a Workshop held at Perth, Western Australia, 10 – 14 May 1991. ACIAR Proceedings No. 42, 124.

Glenn, E.P., R. Tanner, M. Miyamoto, K. Fitzsimmons and J. Boyer. 1998. Water use productivity and forage quality of the halophyte Atriplex nummularia grown on saline waste water in a desert enviroment. Journal of Arid Environment 38: 45-62.

Khan, D., R. Ahmad and S. Ismail. 1986. Case history of Prosopis juliflora plantation at Makran coast raised through saline water irrigation. In: R. Ahmad & A. San Pietro (eds.), Prospect for Biosaline Research, Proceeding of US-Pak Bio-saline Research Workshop. Department of Botany, University of Karachi.

Khan, M. A. 2003. Halophytes of Pakistan: Distribution and Ecology. In H. Lieth & M. Moschenko. Cash crop halophytes: Recent Studies: 10 years after the Al-Ain meeting (Tasks for Vegetation Science, 38). 167-188. Kluwer Academic Press, Netherlands.

Khan, M. A. and M. Qaiser. 2006. Halophytes of Pakistan: Distribution, Ecology, and Economic Importance In: M. A. Khan, H. Barth. G. C. Kust & B. Boer (eds.), Sabkha Ecosystems: Volume II: The South and Central Asian Countries. pp. 129-154. Kluwer Academic Press, Netherlands

Khan, M.A. and Ungar, I.A. 1995. Biology of Salt Tolerant Plants. Department of Botany, University of Karachi, Pakistan. 424 pp.

Khan, M. A. and D. J. Weber. 2006. Ecophysiology of High Salinity Tolerant Plants. Springer, Netherlands.

Khan, M. A., Barth, H., Kust, G. C. and Boer, B. 2006. Sabkha Ecosystems: Volume II: The South and Central Asian Countries. Springer, Netherlands.

Malik, K.A., Aslam, Z. and Naqvi, M. 1986. Kallar grass: a plant for saline land. Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan, 93 pp.

Marcar, N.E., Ansari, R., Khanzada, A.N., Khan, M.A. and Crawford, D.F. 2003. Performance of several tree species on a saline site in southern Pakistan Journal of Tropical Forestry Science 15: 457-468.

Menzel, U. and Lieth, H. 1999. Halophyte Database Vers. 2.0. Halophyte Uses in different climates I: Ecological and Ecophysiological Studies. Progress in Biometeriology, Vol. 13. pp. 77-88. In: H. Lieth, M. Moschenko, M. Lohman, H. –W. Koyro & A. Hamdy (eds.), Backhuys Publishers, The Netherlands.

Ozturk, M., Waisel, Y., Khan, M.A. and Gork, G. 2006. Biosaline Agriculture and Salinity Tolerance in Plants. Birkhuser, Germany.

Qureshi, R.H. and Barrett-Lennard, E.G. 1998. Saline agriculture for irrigated land in Pakistan: A handbook. Australian Centre for International Agricultural Research Canberra, Australia.

Yensen, N.P. 2006. Halophyte uses for the twenty-first century. In: M. A. Khan, & D. J. Weber (eds.), Eco-physiology of High Salinity Tolerant Plants. pp. 367-396. Springer, Netherlands.

View publication stats