Saudi Journal of Biological Sciences (2015) 22, 123–131

King Saud University

Saudi Journal of Biological Sciences

www.ksu.edu.sa
www.sciencedirect.com

REVIEW

Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation

Pooja Shrivastava *, Rajesh Kumar

Department of Environmental Microbiology, Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow, Uttar Pradesh 226025, India

Received 8 September 2014; revised 1 December 2014; accepted 2 December 2014
Available online 9 December 2014

KEYWORDS

Salinity;
Salt-tolerant;
PGPR;
Microorganisms

Abstract Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil, and the area of land affected by it is increasing day by day. For all important crops, average yields are only a fraction – somewhere between 20% and 50% of record yields; these losses are mostly due to drought and high soil salinity, environmental conditions which will worsen in many regions because of global climate change. A wide range of adaptations and mitigation strategies are required to cope with such impacts. Efficient resource management and crop/livestock improvement for evolving better breeds can help to overcome salinity stress. However, such strategies being long drawn and cost intensive, there is a need to develop simple and low cost biological methods for salinity stress management, which can be used on short term basis. Microorganisms could play a significant role in this respect, if we exploit their unique properties such as tolerance to saline conditions, genetic diversity, synthesis of compatible solutes, production of plant growth promoting hormones, bio-control potential, and their interaction with crop plants.

Contents

* Corresponding author.
E-mail address: pooja.nbaim@gmail.com (P. Shrivastava).
Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.sjbs.2014.12.001

1. Introduction

The beginning of 21st century is marked by global scarcity of water resources, environmental pollution and increased salinization of soil and water. Increasing human population and reduction in land available for cultivation are two threats for agricultural sustainability (Shahbaz and Ashraf, 2013). Various environmental stresses *viz*. high winds, extreme temperatures, soil salinity, drought and flood have affected the production and cultivation of agricultural crops, among these soil salinity is one of the most devastating environmental stresses, which causes major reductions in cultivated land area, crop productivity and quality (Yamaguchi and Blumwald, 2005; Shahbaz and Ashraf, 2013). A saline soil is generally defined as one in which the electrical conductivity (EC) of the saturation extract (EC_e) in the root zone exceeds 4 dS m^{-1} (approximately 40 mM NaCl) at 25 °C and has an exchangeable sodium of 15%. The yield of most crop plants is reduced at this EC_e, though many crops exhibit yield reduction at lower EC_es (Munns, 2005; Jamil et al., 2011). It has been estimated that worldwide 20% of total cultivated and 33% of irrigated agricultural lands are afflicted by high salinity. Furthermore, the salinized areas are increasing at a rate of 10% annually for various reasons, including low precipitation, high surface evaporation, weathering of native rocks, irrigation with saline water, and poor cultural practices. It has been estimated that more than 50% of the arable land would be salinized by the year 2050 (Jamil et al., 2011).

Water and soil management practices have facilitated agricultural production on soil marginalized by salinity but an additional gain from these approaches seems problematic (Zahir et al., 2008). Impacted soils are a major limiting production factor worldwide for every major crop (Bacilio et al., 2004; Shannon and Grieve, 1999). A significant increase (an estimated 50%) in grain yields of major crop plants such as rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) is required to fulfill the food supply requirements for the projected population by 2050 (Godfray et al., 2010). The urgency of feeding the world's growing population while combating soil pollution, salinization, and desertification has given plant and soil productivity research vital importance. Under such circumstances, it requires suitable biotechnology not only to improve crop productivity but also to improve soil health through interactions of plant roots and soil microorganisms (Lugtenberg et al., 2002).

Salt stressed soils are known to suppress the growth of plants (Paul, 2012). Plants in their natural environment are colonized both by endocellular and intracellular microorganisms (Gray and Smith, 2005). Rhizosphere microorganisms, particularly beneficial bacteria and fungi, can improve plant performance under stress environments and, consequently, enhance yield both directly and indirectly (Dimkpa et al., 2009). Some plant growth-promoting rhizobacteria (PGPR) may exert a direct stimulation on plant growth and development by providing plants with fixed nitrogen, phytohormones, iron that has been sequestered by bacterial siderophores, and soluble phosphate (Hayat et al., 2010). Others do this indirectly by protecting the plant against soil-borne diseases, most of which are caused by pathogenic fungi (Lutgtenberg and Kamilova, 2009). The problem of soil salinization is a scourge for agricultural productivity worldwide. Crops grown on saline soils suffer on an account of high osmotic stress, nutritional disorders and toxicities, poor soil physical conditions and reduced crop productivity. The present review focuses on the enhancement of productivity under stressed conditions and increased resistance of plants against salinity stress by application of plant growth promoting microorganisms.

2. Problem of soil salinization

Soil salinity is an enormous problem for agriculture under irrigation. In the hot and dry regions of the world the soils are frequently saline with low agricultural potential. In these areas most crops are grown under irrigation, and to exacerbate the problem, inadequate irrigation management leads to secondary salinization that affects 20% of irrigated land worldwide (Glick et al., 2007). Irrigated agriculture is a major human activity, which often leads to secondary salinization of land and water resources in arid and semi-arid conditions. Salts in the soil occur as ions (electrically charged forms of atoms or compounds). Ions are released from weathering minerals in the soil. They may also be applied through irrigation water or as fertilizers, or sometimes migrate upward in the soil from shallow groundwater. When precipitation is insufficient to leach ions from the soil profile, salts accumulate in the soil resulting soil salinity (Blaylock et al., 1994). All soils contain some water-soluble salts. Plants absorb essential nutrients in the form of soluble salts, but excessive accumulation strongly suppresses the plant growth. During the last century, physical, chemical and/or biological land degradation processes have resulted in serious consequences to global natural resources (e.g. compaction, inorganic/organic contamination, and diminished microbial activity/diversity). The area under the affected soils continues to increase each year due to introduction of irrigation in new areas (Patel et al., 2011).

Salinization is recognized as the main threats to environmental resources and human health in many countries, affecting almost 1 billion ha worldwide/globally representing about 7% of earth's continental extent, approximately 10 times the size of a country like Venezuela or 20 times the size of France (Metternicht and Zinck, 2003; Yensen, 2008). It has been estimated that an approximate area of 7 million hectares of land is covered by saline soil in India (Patel et al., 2011). Most of which occurs in indogangetic plane that covers the states of