Journal of Plant Growth Regulation (2024) 43:2137–2164
https://doi.org/10.1007/s00344-024-11266-2

Exploring Halobiome Resources for Developing Salt-Tolerant Crops: A Perspective Review

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Received: 21 June 2023 / Accepted: 1 February 2024 / Published online: 21 March 2024

Abstract

Hyper soil salinity is currently one of the major concerns for global agricultural yield as it directly hinders the qualitative and quantitative aspects of agronomic outcomes. Owing to ever-increasing food requirements and a vast proportion of saline agricultural land in the world, developing salinity-resilient crops is of utmost need. To address this issue, various approaches based on conventional breeding as well as biotechnological and omics-based strategies have been explored by researchers and plant breeders. Out of them, genetic engineering-based alterations of plant genomes via inserting/overexpressing beneficial salt-responsive genes originating from different organisms have shown great potential and thus explored heavily. Interestingly, a group of halotolerant organisms, plants, algae, fungi, and bacteria, collectively referred to as halobiome, holds advantageous physical, chemical, and molecular characteristics for survival in the hypersaline environment. These characteristics include effective distribution and compartmentalization of ions, elevated production of the osmoprotectants, improved activity of antioxidant machinery, and regulated synthesis of phytohormones. There are several genes from halobiome identified and successfully used to improve the salt tolerance level of glycophytic crops. However, the gene pool from the halobiome is far from its full-potential exploration. Besides, non-coding RNAs also present a potent resource to be utilized for enhancing the salinity tolerance in crop plants. Further, the use of priming agents and biofertilizers from the halobiome sources is also turning into an effective solution for plant growth enhancement and salinity tolerance. In the current review, we present the current status and recent developments in identifying and exploring halotolerant gene pools (coding and non-coding) from the constituent members of halobiome and their exploration in engineering salt-tolerant crops. Technological advancements and challenges for their full-potential exploration in crop improvement programs have been discussed. The review also provides futuristic insights about the unexplored organisms or genes from halobiome in developing salt resilience in crops.

Keywords Climate change · Crops · Halobiome · Halotolerance · Genetic engineering · Soil salinity · Transgenics

Introduction

Soil salinity, a condition with excessive amounts of water-soluble salts (predominantly sodium chloride, NaCl) in arable lands, has emerged as a key global challenge for crop productivity and consequently food security (Joshi et al. 2023). Hyper soil salinity negatively impacts plant production and leads to the degradation of arable lands, eventually turning them into non-arable. Recent years have witnessed an upward trend in coverage and severity of soil salinity. This is mainly due to non-sustainable agricultural practices including over- or under-irrigation and overuse of inorganic fertilizers leading to nitrification which in turn accelerates soil salinization and poor irrigation or drainage facilities (Haj-Amor et al. 2022). Besides, the extent of soil salinity

Handling Editor: Golam Jalal Ahammed.

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