The College of Graduate Studies and the College of Agriculture and Veterinary Medicine

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PhD Dissertation Defense

Entitled

UTILIZATION OF THE ENDOPHYTIC FUNGUS PIRIFORMOSPORA INDICA TO IMPROVE SALINITY STRESS TOLERANCE: AN INSIGHT INTO THE DATE PALM'S TRANSCRIPTOMIC AND FUNCTIONAL GENOMIC APPROACHES

by

Miloofer Sabeem

Faculty Advisor

Dr. Khaled Masmoudi, Department of Integrative Agriculture

College of Agriculture and Veterinary Medicine

Date & Venue

20 November 2023, Monday 10 AM

F3, Room 110 (Cinema Hall)

Microsoft Teams meeting

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Abstract

Sustainable agriculture in arid and semi-arid regions depends on managing soil salinity, which is a major environmental issue and a critical component of sustainable food production. Salinity has a significant impact on date palm growth and physiological functions. Plant growth promoting microbiota has become a viable option to improve plant growth and performance under salt stress. *Piriformospora indica* is a highly versatile root endophyte in agricultural fields capable of coping with salinity. Its role in increasing abiotic stress tolerance has been reported in several plant species, but not in date palms. This research study investigated the growth, biochemical and molecular properties of *Phoenix dactylifera* colonized with the mutualistic fungus *P. indica* under control and salinity stress. The research findings indicated enhanced levels of antioxidant enzymes such as catalase, superoxide dismutase, and peroxidase, decreased Na+/K+ ratio in leaves and roots, increased ion content, and improved physiological parameters in date palm plants colonized with *P. indica* under salinity stress conditions. Transcriptome profiling of date palm roots grown under salt stress (250 mM) with or without inoculation of *P. indica* revealed that 6,836 genes were differentially expressed, with 3,153 up-regulated genes and 3,683 down-regulated genes. The DEGs were specifically involved in phenylpropanoid biosynthesis, plant-pathogen interaction, plant hormone signal transduction, metabolic pathway, ABC transporters, MAPK signaling pathway, cutin, Suberin and wax biosynthesis, and glutathione metabolism, as revealed by gene ontology (GO) and EuKaryotic Orthologous Groups (KOG) enrichment analysis in colonized date palms exposed to salt stress. There are 62 LEA 2 genes in date palms that are speculated to retain water molecules and prevent crystallization of cellular components under conditions of drought, heat, and high salinity. We functionally characterized three date palm *LEA2* genes, *PdLEA2.2, PdLEA2.3,* and *PdLEA2.4,* with respect to their effects on the thermostability of two different enzymes, lactate dehydrogenase (LDH) and β-glucosidase (bglG), *in vitro*. Under heat stress, the purified recombinant PdLEA2 proteins showed elevated LDH activity and reduced aggregate formation, as well as the ability to maintain and stabilize the enzymatic activity of bglG. Finally, the study investigated the role of the *PdLEA2.2* gene by analyzing its ectopic pattern (overexpression) in *Arabidopsis thaliana* plants under salinity stress. Transgenic Arabidopsis plants showed higher salt tolerance with respect to the optimal Na^+/K^+ ratio and increased antioxidant activity. Based on these findings, date palm production can be improved by exploiting the *P. indica* fungus as a plant symbiont, increasing its economic sustainability in marginal environments. In addition to demonstrating that date palm LEA2 proteins can act as molecular chaperones for the development of new thermoresistant enzymes with better reaction rates and specificities, *PdLEA2* genes would provide the basis for the development of salt stress tolerant plants that are more resilient and productive.

Keywords: Salt stress, Date palm, *LEA2*, *P. indica*, Enzyme thermostability, RNA-seq analysis