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SALINITY TOLERANCE BY MYCORRHIZA AND PLANT GROWTH

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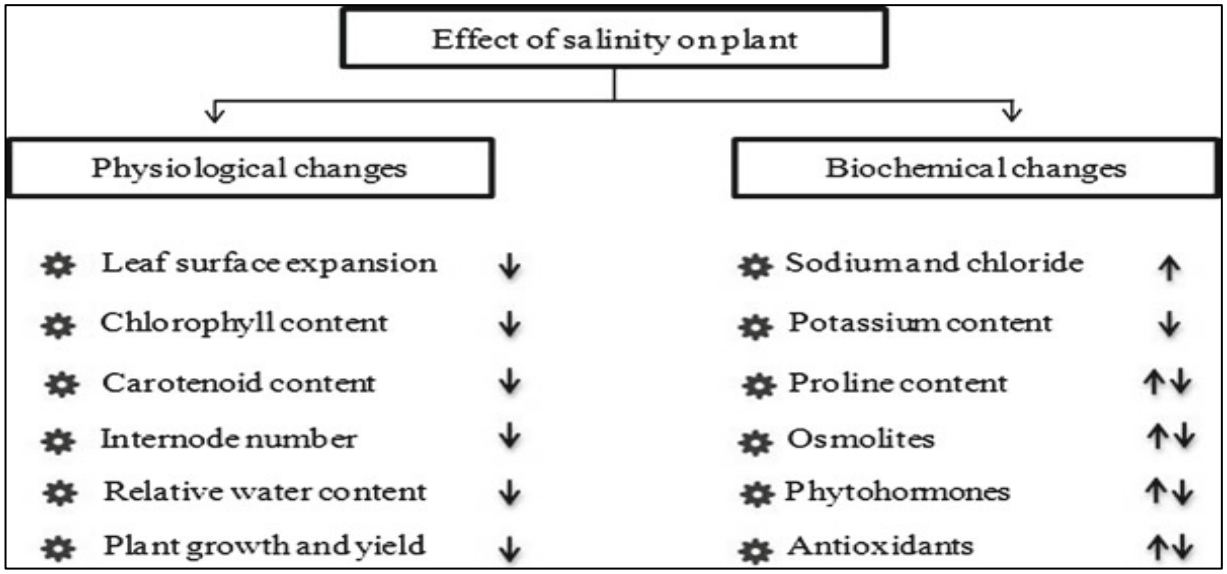
Modern agriculture is facing twin challenge of ensuring global food security and executing it in a sustainable manner. Salinization occurs naturally in arid and semiarid regions where evaporation is higher than rainfall. In India nearly 6.74 million ha area is occupied by salt-affected soils out of which 2.96 million ha are saline soils (including coastal) and 3.79 million ha are alkali soils (CSSRI, 2020). In the natural environment, plants can be colonized both by external and internal microorganisms. The activity of soil microbial communities is considered the lifeline of global ecosystem productivity and sustainability. (AM) are considered as bio-ameliorators of saline soils and could develop salinity tolerance in crop plants. Indeed AMF improve physiological processes and general metabolic activities of the plant and helps in the mitigation of salinity. It enhance the production of Strigolactones in root system, Abscisic acid, Jasmonic acid, Glomalin and helps the roots in uptake of water and other nutrient under saline condition. Hence, the Mycorrhizal fungi offers a potential solution to combat salinity problem, helps to mitigate from the stress and increase crop growth under adverse condition.

In India, around 6.74 Mha (million hectares) of the land area is covered with salt-affected soils, which is expected to reach up to 20 Mha by 2050 (Sharma and Singh, 2015; Bhattacharyya *et al*.,2015). Salt affected soil areas are also found on the west and east coasts of Gujarat, Orissa, Karnataka, Kerala, Tamil Nadu, Maharashtra, Andhra Pradesh, and the Andaman and Nicobar Islands. Out of the total salt-affected areas in the country, 80% of saline and sodic soils are contributed by six states: Gujarat, Uttar Pradesh, Maharashtra, West Bengal, Rajasthan, and Tamil Nadu. To overcome this, plants must refrain from losing water from their roots to the soil by maintaining lower osmotic potential (Feng *et al.*, 2002; Jahromi *et al.*, 2008). Also prevailing soil microorganisms are abundant in soil environment.

By utilizing these, we can able to overcome salinity problem, thereby plants produce better yield.

Effect of Salinity on Plants



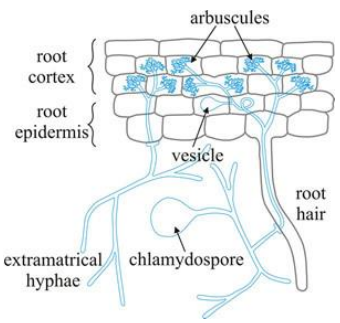
(Feng *et al.*, 2002)

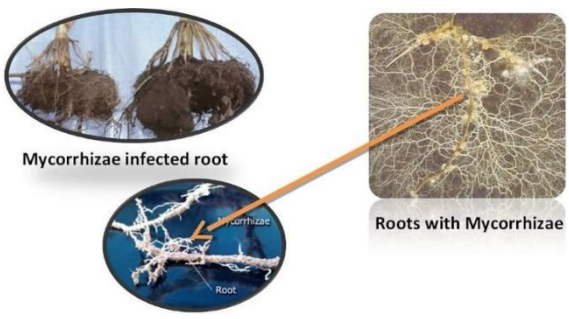
Role of Micro-Organism Alleviating Soil Salinity and Improves Plant Growth

Salinity affects plants physiologically and biochemically and it triggers production of various enzymes and hormones. In the natural environment, plants can be colonized both by external and internal microorganisms. To overcome this, the biotic approach ("Plant-microbe interaction") for overcoming salinity/sodicity problems has recently received considerable attention throughout the world. Recently, the use of arbuscular mycorrhizal (AM) fungi as a practical way to alleviate soil stresses on plant growth has received increased attention (Al-Karaki 2006; Sannazzaro and others 2006; Miransari and others 2007, 2008).

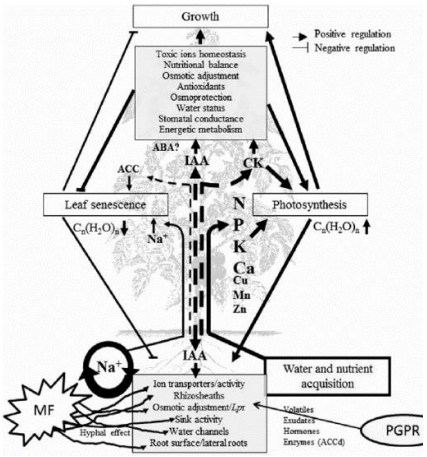
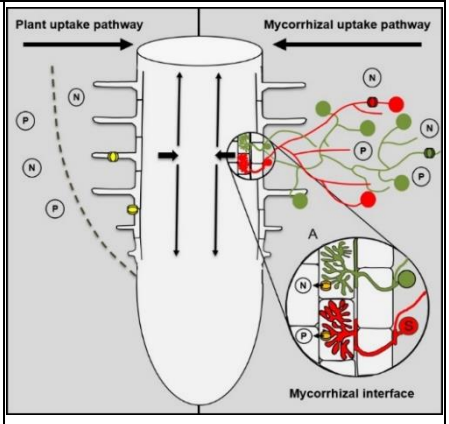
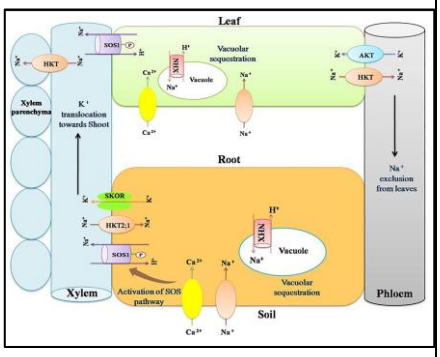
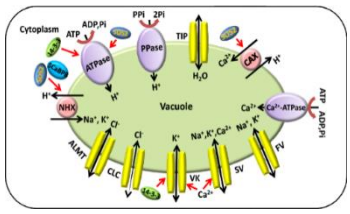
AM Fungi

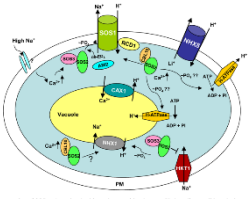
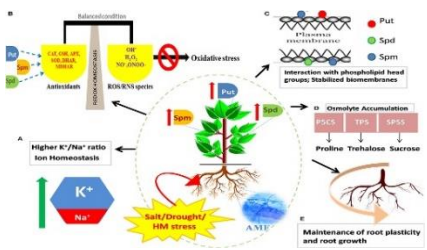
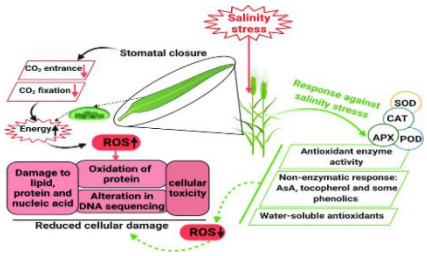
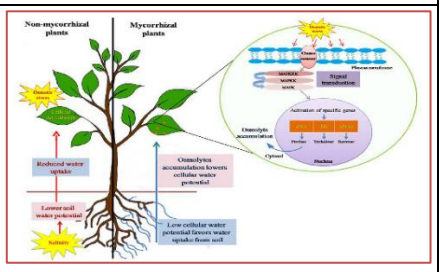
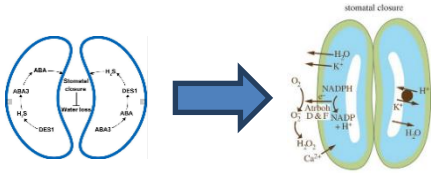
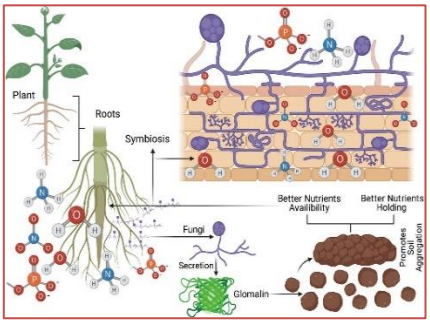
Mycorrhizae are the mutualistic symbiotic associations between soil fungi and the roots of most plant species According to the carbohydrate theory Bjorkman (1949) the plants that grow in soils deficient in P and N, and high intensity light develop mycorrhizas.

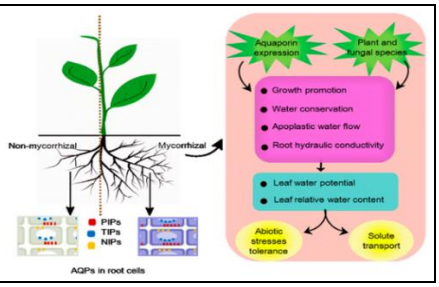




Mechanisms of Alleviating Salt Stress

Sl No	Mechanism	Outcome from AM fungi / Function	Documentary
1.	Plant growth and biomass	➢ AM symbiosis raised the leaf concentrations of soluble sugars, reducing sugars, soluble protein, total organic acids, oxalic acid, fumaric acid, acetic acid, malic acid, and citric acid, and decreased the concentrations of MDA, H_2O_2, etc.	
2.	Nutrient uptake (N,P,K) by mycorrhizal roots	➢ AM fungi, - colonize the roots of most plants and those extraradical mycelium reaches the soil and to uptake N for the plant. Increase in absorption of P - mycorrhizal plants - attributed - increase in surface area - absorption.	
3.	K^+: Na^+ ratio	➢ AM has ability to sequester Na^+ into the vacuoles or exclude it from the cytosol	
4.	Chloride ion	➢ Cl^- ions can be compartmentalized in vacuolar membranes	

5.	Ca^{2+}: Na^{+} and Ca^{2+}: Mg^{2+} ratio	➢ Activates SOS1, a Na^{+}/H^{+} antiporter on the plasma membrane responsible for extrusion of Na+ out of the cell.	
6.	Biochemical changes	➢ Active accumulation of organic ions like K^{+} and Cl^{-} or solutes such as proline, glycine, betaine, souble sugars, pinitol and mannitol	
7.	Anti-oxidant mechanism	➢ Superoxide dismutase (SOD), catalase (CAT), peroxidase (POD) and ascorbate peroxidase (APX) – Helps in detoxification of ROS.	
8.	Photosynthetic pigment	➢ In the presence of mycorrhiza, the antagonistic effect of Na^{+} on **Mg^{2+} uptake** is counterbalanced and suppressed	
9.	Phytohormones	➢ **Production of ABA** helps to close stomata to reduce transpiration loss during stress condition	
10.	Water homeostatis (Aquaporins) & Glomalin production	➢ Aquaporins have a role in passive movement of water molecules following a water potential gradient and maintaining cellular osmoregularity ➢ **Glomalin** - Extra radical Hyphae for absorbing more	

		water ➢ Improving soil aggregate formation and structure ➢ Promoting SOC (carbon sequestration)	

Recent Advancement in Fungal Studies Characterisation

The advancement of Metagenomics and Next Generation Sequencing technologies will characterized the AMF into a single clade, the phylum Glomeromycota, a sister group of Ascomycota and Basidiomycota on the basis of ribosomal RNA phylogeny (Kruger et al., 2012; Lanfranco and Young, 2012). Lee and Young (2009) have demonstrated a high-quality sequence in which both the nucleus and mitochondria after whole genome amplification of DNA from AM spores. It helps us to study the genetic constituent and function over crop plants under salt stress thereby help us to reduce research trail.

Conclusion

- For effective crop growth under salt stress, it is better to give tolerance than resistant mechanism. Microbial load / population pertaining towards soil is huge. To take study over **plant – microbe interaction** is helpful in mitigating all the biotic / abiotic stress, since they does not cause any harm to plants and surrounding environment.
- Bio fertilizers are easily available and they are to be living entity. Indian research on metagenomics study was less when compared with other countries.
- Therefore the utilization of effective AMF strains for the amelioration of plant growth under salt stress is a potential approach which can be used in synergy with other known technologies to increase crop productivity in salt-affected areas.

Reference

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