Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 04, Issue: 03 (MAY-JUNE, 2024)
Available online at http://www.agriarticles.com

Strategies to Alleviate Salinity Stress in Plants

(*Shweta[1] and Ashish Kumar[2])
[1]Department of Botany and Plant Physiology, Chaudhary Charan Singh Haryana Agricultural University, Hisar-125004
[2]Subject Matter Specialist, Krishi Vigyan Kendra, Panipat 125004, Chaudhary Charan Singh Haryana Agricultural University, Hisar-125004
*Corresponding Author's email: rawalshweta25@gmail.com

Abstract
Soil salinization poses a significant threat to agriculture in arid and semiarid regions. In addition to identifying and using salt-tolerant plant species or cultivars in saline areas, employing treatments to mitigate the effects of salinity stress shows promise in ensuring crop production under such challenging conditions. Salinity stress is a major threat to crops, affecting their growth, development, and yield. Agricultural management practices have contributed to mitigating the effects of excessive salt accumulation in the soil. This chapter explores sustainable strategies to alleviate salinity stress in plants, including soil amendments, genetic improvement, irrigation management, crop rotation, biofertilizers, mulching, and integrated pest management.

Introduction
Soil salinization is a major threat to agriculture in arid and semiarid regions, where water scarcity and inadequate drainage of irrigated lands severely reduce crop yield (Hanin *et al.* 2016). Salinization can broadly refer to the accumulation of different salts, including potassium, magnesium, calcium and sodium carbonates, bicarbonates chlorides, and sulfates (Bockheim and Gennadiyev 2000). Consequently, this diverse ionic composition will result in a wide range of physiochemical properties. Under salt stress, concomitant accumulation of compatible solutes occurs with the accumulation of solutes in the cytosol. As a result of the salt accumulation over time, there is a slower inhibition of growth, occurring especially in older leaves, causing their senescence (Munns and Tester 2008). In contrast to young leaves, old leaves are not capable of diluting the salt that enters their cells, and this leads to their death. If the leaves death rate is higher than the leaves production rate, then the photosynthetic capacity will be impaired, leading to a reduced growth rate (Munns and Tester 2008; Nongpiur *et al.* 2016).

Plant morphology, biochemistry, and physiology also play a major role in shaping the different degrees of salinity tolerance (Nongpiur *et al.* 2016). Rice (Oryza sativa) has been described as one of the species most sensitive to salinity (Das *et al.* 2015). In the field, where the salinity can rise to 100 mM NaCl (about 10 dS m^{-1}), rice will die before maturity, while wheat (Triticum aestivum) will still be able to produce a reduced yield (Munns *et al.* 2006). Thus, wheat is considered a moderately salt-tolerant crop. High levels of salt in the soil and warter can disrupt plant growth, reduce yield, and negatively impact the quality of crops. Developing sustainable strategies to mitigate salinity stress in crops, therefore crucial for ensuring food security and maintaining agricultural sustainability.

Strategies to Alleviate Salinity Stress in plants

1. Soil Amendments: One effective strategy to alleviate salinity stress in crops is the use of soil amendments. Gypsum, for example, can help improve soil structure and reduce sodium levels, which can be beneficial in saline soils. Organic matter, such as compost, can also improve soil fertility and water-holding capacity, helping plants cope with salt stress.

2. Selection of Salt-Tolerant Varieties: Plant breeding programs have developed salt-tolerant crops that exhibit improved performance under saline conditions. By selecting cultivars with enhanced salt tolerance traits, growers can reduce the negative impact of salinity stress on crops. These varieties often possess traits such as efficient ion regulation, enhanced osmotic adjustment, and increased antioxidant activity, allowing them to maintain growth and productivity in saline soils.

3. Genetic Improvement: Genetic improvement is another important strategy for alleviating salinity stress in crops. Plant breeders can develop new varieties of crop that are more tolerant to salinity stress. This can be achieved through traditional breeding methods or modern biotechnological approaches, such as genetic engineering.

4. Irrigation Management: Proper irrigation management is crucial for mitigating salinity stress in crops. Drip irrigation and other water-saving techniques can help reduce the amount of salt that accumulates in the soil. Additionally, using saline water for irrigation should be avoided, as it can exacerbate salinity stress.

5. Crop Rotation and Intercropping: Crop rotation and intercropping can also help alleviate salinity stress in crops. Planting salt-tolerant crops in rotation with sensitive crop can help break the cycle of salt accumulation in the soil. Intercropping salinity sensitive crops with legumes, can also improve soil fertility and reduce salinity stress.

6. Biofertilizers and Biostimulants: The use of biofertilizers and biostimulants can help alleviate salinity stress in crops. These products contain beneficial microorganisms or compounds that can improve plant growth and stress tolerance. Rhizobacteria and mycorrhizal fungi, for example, can help improve nutrient uptake and reduce the effects of salinity stress.

7. Mulching: Mulching can also help alleviate salinity stress in crops. Mulching of the soil surface, using materials such as crop residues or plastic, is considered to be one of the main options to mitigate the toxic effects of soil salinization, promoting soil quality and consequently increasing crop yield (Bezborodov *et al.* 2010; Zhang *et al.* 2014; Xie *et al.* 2017). Mulches can reduce soil evaporation and improve soil moisture retention, which can be beneficial in saline soils. Organic mulches, such as straw or compost, can also improve soil structure and fertility, helping plants cope with salinity stress.

8. Integrated Pest Management: Plants are capable of recruiting and forming mutualistic associations with a number of soil microorganisms, with beneficial effects on the plants productivity and resilience in harsh conditions (De-La-Pena and Loyola-Vargas 2014; Munns and Gilliham 2015; Kasim *et al.* 2016). The contribution of a specialized microbiome in assisting plants to withstand salinity is often overlooked; however, it can be used as an alternative to the development of salt-tolerant crops through genetic modification (Yuan *et al.* 2016). Salinity stress weakens the defense mechanisms of crops, making them more susceptible to pests and diseases. Effective pest management is essential for reducing stress on crops, especially under salinity stress. Integrated pest management (IPM) strategies can help reduce the impact of pests and diseases on crops, thereby reducing stress on plants.

9. Nutrient Management: Balanced nutrient management is crucial for minimizing the effects of salinity stress on crops. Optimal fertilization practices, based on soil testing and crop nutrient requirements, ensure that plants receive essential nutrients in the right proportions. Adequate levels of nitrogen, phosphorus, potassium, and micronutrients help maintain plant vigor and resilience, enabling crops to withstand salinity stress more effectively.

10. Monitoring and Adaptation: Regular monitoring of soil salinity levels and plant health is essential for timely intervention and adaptation to changing conditions. Soil testing and plant tissue analysis provide valuable insights into nutrient status and salinity levels, enabling growers to adjust management practices accordingly. By staying vigilant and proactive, growers can mitigate the impact of salinity stress on crops and optimize yield and quality.

Conclusion

Implementing sustainable strategies is key to mitigating salinity stress in plants. By focusing on soil management, variety selection, nutrient management, biostimulants, integrated pest and disease management, and monitoring, growers can enhance the resilience and productivity of crops in saline environments. Adopting these practices not only ensures the sustainability of crop production but also contributes to environmental and food security for future generations.

References

1. Bezborodov GA, Shadmanov DK, Mirhashimov RT et al (2010) Mulching and water quality effects on soil salinity and sodicity dynamics and cotton productivity in Central Asia. Agric Ecosyst Environ 138:95–102.
2. Bockheim JG, Gennadiyev AN (2000) The role of soil-forming processes in the definition of taxa in Soil Taxonomy and the World Soil Reference Base. Geoderma 95:53–72
3. Das P, Nutan KK, Singla-Pareek SL, Pareek A (2015) Understanding salinity responses and adopting "omics-based" approaches to generate salinity tolerant cultivars of rice. Front Plant Sci 6:712.
4. De-la-Peña C, Loyola-Vargas VM (2014) Biotic interactions in the rhizosphere: a diverse cooperative enterprise for plant productivity. Plant Physiol 166:701–719.
5. Hanin M, Ebel C, Ngom M et al (2016) New insights on plant salt tolerance mechanisms and their potential use for breeding. Front Plant Sci 7:1787.
6. Kasim WA, Gaafar RM, Abou-Ali RM et al (2016) Effect of biofilm forming plant growth promoting rhizobacteria on salinity tolerance in barley. Ann Agric Sci 61:217–227.
7. Munns R, Gilliham M (2015) Salinity tolerance of crops—what is the cost? New Phytol 208:668– 673.
8. Munns R, James RA, Läuchli A (2006) Approaches to increasing the salt tolerance of wheat and other cereals. J Exp Bot 57:1025–1043
9. Munns R, Tester M (2008) Mechanisms of salinity tolerance. Annu Rev Plant Biol 59:651–681.
10. Nongpiur RC, Singla-Pareek SL, Pareek A (2016) Genomics approaches for improving salinity stress tolerance in crop plants. Curr Genomics 17:343–357.
11. Xie W, Wu L, Zhang Y et al (2017) Effects of straw application on coastal saline topsoil salinity and wheat yield trend. Soil Tillage Res 169:1–6.
12. Zhang P, Wei T, Jia Z et al (2014) Effects of straw incorporation on soil organic matter and soil water-stable aggregates content in semiarid regions of Northwest China. PLoS One 9:1–11.