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Guest Articles

Salt Stress: An Invisible Threat to Global Food Production

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Introduction

Imagine living in a world where once fertile farmlands turn dry and lifeless, and the crops we rely on struggle to grow. This is not something that will happen far in future, it is happening right now due to increasing soil salinity. Salt stress is a growing crisis that's making it harder for farmers to grow food, pushing both them and consumers into a tough spot. Despite its seriousness, this issue is still overlooked, even as fertile lands slowly turn into salty wastelands. If we don't take action, salt stress will continue to threaten agriculture and put countless livelihoods at risk.

The consequences of ignoring salt stress are severe, potentially leading to widespread food shortages,

economic instability, and rising social unrest. Climate change and unsustainable agricultural practices will only make the situation worse. Addressing salt stress is no longer just an agricultural issue; it is a critical global challenge that requires urgent attention to ensure food security for a growing population.

How Does This Salty Stress Occur

Salt stress occurs when excessive salts accumulate in the soil, hindering plant growth. According to Munns and Tester (2008) and Zörb *et al.* (2019), sodium ions (Na⁺) are the primary contributors to soil salinity, while Cl⁻, Mg²⁺, SO₄²⁻, and HCO₃⁻ play a minor role.

Salt stress arises from various sources. Natural

processes like weathering of rocks can release salts into the environment over time. Unfortunately, our own actions are making the problem even worse. In dry regions, poor irrigation causes water to evaporate too quickly, leaving excess salt behind in the soil. Climate change is also playing a role, as rising sea levels push salty water into coastal farmlands, turning once-fertile fields into lifeless wastelands. On top of that, the excessive use of certain fertilizers adds to the problem, making it even harder for farmers to grow healthy crops and sustain their livelihood.

How Salt Stress Affects Crops & Food Production

High salt levels prevent crops from absorbing water properly, causing dehydration, nutrient imbalances, reduced photosynthesis and ultimately reduced the yield. Staple crops like rice, wheat, and maize, which feed billions, are especially at risk.

Salinity not only lowers crop yields but also impacts the quality of the produce, making it less marketable and harder to consume. Excessive salt alters the nutrient composition of crops, resulting the reduction of their nutritional value. Also can cause physiological disorders in fruits and vegetables which affect their taste, texture, and marketability.

As a result of salt buildup, soil fertility is drained, eventually turning once-productive farmland into barren land. This will be the foremost reason for the reduction of the amount of land available for food production. This issue is particularly severe in arid and semi-arid regions, further limiting the land available for cultivation.

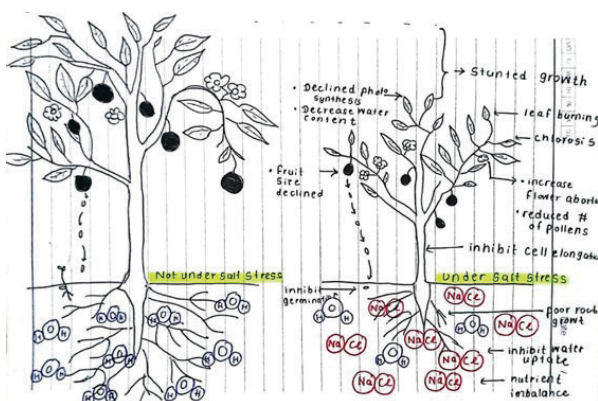


Figure 1: Schematic representation of plant response to salt stress

When salt washes away from affected areas, it can contaminate rivers and lakes like freshwater sources, putting fish and other aquatic life at risk. This not only harms the environment but also affects fishing and aquaculture, making it harder to produce food. The utilization of saline water for both the cultivation of forage crops and as a drinking source for livestock can harm their health and ultimately affect meat and dairy production.

The Global Impact on Food Production

The United Nations Food and Agriculture Organization (FAO) predicts that global food production will increase significantly over the next 50 years due to the ongoing growth in the human population, expected to rise by 2.3 billion. To meet this demand, agriculture will need to produce 70% more food. Addressing soil salinity is essential to safeguarding future food security and ensuring a stable food supply for generations to come.

Between 1986 and 2016, the land area affected by soil salinity increased from 915 million hectares to 1,069 million hectares. This trend highlights the growing problem of land degradation due to salt, with more and more soil becoming unfit for farming each year. Countries like India, China, Pakistan, Australia, and parts of the Middle East face severe challenges due to salt-affected lands. Coastal areas, where contaminate with seawater are especially at a risk. If left unaddressed, salt stress could significantly reduce food availability and increase prices, putting pressure on both farmers and consumers.

Innovative Solutions and Future Prospects

Since salt stress is a serious challenge, it is not impossible to overcome. A combination of technological, biological, and management solutions is essential to reduce its impact and secure food supplies for the future:

- **Salt-Tolerant Crops:** Developing and cultivating crop varieties that can withstand salt stress is vital. Ongoing research in this field is showing promising results, offering hope for more resilient crops in the future.
- **Improved Irrigation Techniques:** Precision irrigation and rainwater harvesting can help

minimize salt buildup. By adopting to efficient irrigation techniques, like drip irrigation, can significantly reduce water waste and help prevent salt accumulation in the soil. This method delivers water directly to the plant roots, aiding in minimizing evaporation and runoff while ensuring optimal moisture levels for crops.

- **Soil Management Strategies:** Using organic matter, cover crops, phytoremediation and crop rotation can significantly improve soil health and help reduce salinity. Establishing effective drainage systems is essential to maintain soil health and minimize the accumulation of salt over time. Moreover, application of biostimulants is making another avenue of upbringing the salt stress tolerance in plants.
- **Microbial Solutions:** Beneficial bacteria (plant growth-promoting rhizobacteria (PGPR) and cyanobacteria), mycorrhizal fungi can enhance plant resilience to salt stress.
- **Advanced Technologies:** Working hand in hand with nanotechnology, mutation breeding, marker assisted breeding, genetic engineering, CRISPR/CAS system like novel technologies offer promising results.
- **Policy and awareness:** Government must implement policies that encourage sustainable land management practices. Raising the awareness of the public and stakeholders about its impact will help to obtain long-term solutions.

The Way Forward

Protecting and restoring soil health is not solely the responsibility of farmers. It requires a concerted effort from governments, researchers, consumers and the entire food industry. Investing in sustainable farming practices and innovative agricultural technologies is essential to overcoming this challenge. Governments can play a key role by offering incentives, subsidies, and

regulations that promote sustainable farming practices. Researchers can contribute by developing innovative technologies and strategies to improve soil quality. Meanwhile, consumers can also make a difference by choosing to buy from farmers who are dedicated to sustainable agriculture. It is a shared responsibility to ensure healthy soil and a secure food future. With such proactive measures, we can protect our farmlands and ensure a future where food remains plentiful and accessible for all.

Salt stress is an urgent yet frequently underestimated challenge to global food security. By understanding its impact and implementing effective solutions, we can safeguard agriculture for generations to come. The moment to act is now—before more fertile lands turn to barren, salt-ridden wastelands.

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Next-Generation Emerging Perovskite Solar Cells: Shaping the Future for Clean and Sustainable Energy

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Perovskite solar cells (PSCs) have emerged as a revolutionary technology in the renewable energy sector, offering a unique combination of high efficiency, low production costs, and versatile applications. Over the past decade, the efficiency of PSCs has emerged from an initial 3.8% to an impressive 27.3%, surpassing traditional silicon-based solar cells in certain configurations (Basumatary & Agarwal, 2022). This rapid progress is attributed to the exceptional optoelectronic properties of perovskite materials, such as their high absorption coefficients, tunable bandgaps, and excellent charge carrier mobility (Jošt et al., 2020). These properties enable PSCs to achieve high power conversion efficiencies (PCE) while maintaining low material and manufacturing costs.

One of the most compelling advantages of PSCs is their compatibility with flexible and lightweight designs, making them suitable for a wide range of applications, including building-integrated photovoltaics (BIPV), portable electronics, and even wearable devices (Mishra et al., 2021). Additionally, PSCs can be fabricated using low-temperature, solution-based processes, which significantly reduce energy consumption and production costs compared to the high-temperature processes required for silicon solar cells (Ibn-Mohammed et al., 2017). Despite these advantages, challenges remain, particularly in improving the long-term stability and durability of PSCs under real-world conditions. Issues such as sensitivity to moisture, heat, and UV radiation have hindered their commercialization (Arora et al., 2019). However, ongoing research is focused on developing advanced encapsulation techniques, stable perovskite compositions, and innovative device architectures to address these challenges. With continued advancements, PSCs have the potential to revolutionize the solar energy industry, making clean

and sustainable energy more accessible and affordable worldwide.

The Sun's Potential: Unlocking a Greener Tomorrow

The global energy landscape is undergoing a profound transformation as the world tackles with the dual challenges of rising energy demand and the depletion of finite fossil fuel resources. According to the International Energy Agency (IEA), global energy consumption is projected to increase by nearly 50% by 2050, driven by population growth, urbanization, and industrialization (Bilgili et al., 2015). This escalating demand, coupled with the environmental impact of fossil fuel combustion, has underscored the urgent need for renewable energy solutions.

Solar energy, in particular, has emerged as a cornerstone of the global transition to sustainable energy. The sun provides an abundant and virtually infinite energy source, capable of meeting the world's energy needs many times over (Ray, 2019). Solar photovoltaic (PV) technology, which converts sunlight directly into electricity, has seen remarkable advancements in recent years, with significant reductions in costs and improvements in efficiency. The levelized cost of electricity (LCOE) from solar PV has dropped by over 80% since 2010, making it one of the most cost-competitive energy sources available today (Liu et al., 2023).

In addition to its economic viability, solar energy offers significant environmental benefits. Unlike fossil fuels, solar power generation produces no greenhouse gas emissions, helping to mitigate climate change and reduce air pollution (Bilgili et al., 2015). Furthermore, solar energy systems can be deployed at various scales, from small rooftop installations to large utility-