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DETERMINATION OF THE PRODUCTIVITY AND CROP YIELD OF SALINE SOILS ON THE BASIS OF ADVANCED TECHNOLOGIES AND THE DEVELOPMENT OF AGROTECHNOLOGY OF THE APPLICATION OF FERTILIZERS IN OPTIMAL QUANTITIES

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Abstract
Salinization of soils remains one of the major threats to global agricultural productivity, especially in arid and semi-arid regions. This article explores the assessment of productivity and crop yield potential on saline soils by integrating advanced technologies, such as remote sensing, precision agriculture, and soil mapping. Additionally, the paper presents the development of agrotechnology focusing on the optimized application of fertilizers tailored to saline conditions. The results highlight that technological intervention and calculated fertilizer management can significantly enhance crop yields and rehabilitate saline soils.

Keywords: Saline soils, productivity, crop yield, advanced technologies, agrotechnology, fertilizer optimization, soil salinity management, sustainable agriculture.

Introduction

Soil salinity, the accumulation of soluble salts in the soil profile, poses a serious constraint to sustainable agricultural development across the globe. Over 800 million hectares of land are affected by salinity, leading to reduced soil fertility, plant growth, and crop productivity. The effective management of saline soils is essential not only for food security but also for the preservation of soil health and environmental sustainability.

Recent advancements in technology and agronomy offer new tools and approaches to manage and rehabilitate saline soils. These include site-specific nutrient management, remote sensing for salinity detection, and the precise application of fertilizers. This article investigates the productivity and crop yield determination of saline soils using advanced tools and elaborates on developing effective agrotechnology for fertilizer application in optimal quantities.

Soil salinization poses a significant challenge to global agriculture, affecting approximately 10% of arable land and limiting crop productivity due to high salt concentrations that disrupt water and nutrient uptake. Advanced technologies and optimized agrotechnological practices, particularly in fertilizer application, can significantly enhance productivity and crop yield in saline soils. Below is a detailed exploration of strategies to address this challenge, grounded in current research and practices.

Advanced Technologies for Improving Productivity in Saline Soils

Integrated Soil-Crop System Management (ISCM):

- ISCM combines soil and crop management strategies to improve soil quality and crop yields in saline-alkaline soils. Field experiments (2015–2019) in coastal saline regions demonstrated that ISCM, incorporating gypsum, cattle manure, optimized crop varieties, and adjusted sowing densities, reduced soil sodium content by 51.5–60.2%, increased soil organic carbon by 31.9%, and boosted maize yield by 37.2% while reducing nitrogen fertilizer use by 28.6%. This approach enhances nutrient efficiency and mitigates environmental impacts.

Biochar and Organic Amendments:

- Biochar, due to its water and nutrient retention properties, improves soil structure and reduces sodium uptake, enhancing crop tolerance to salinity. Studies show biochar increases available phosphorus and supports nutrient release under salt stress. Organic fertilizers, such as farmyard manure and compost, improve soil organic matter (SOM), aggregate stability, and microbial activity, leading to better water-holding capacity and nutrient uptake. These amendments have been shown to increase yields in crops like tomato, maize, and rice while reducing salinity stress.

Nanotechnology:

- Nano-fertilizers, such as nano-zinc oxide (ZnO) and nano-silicon dioxide, address micronutrient deficiencies in saline soils. For instance, nano-Zn application improved cotton yield under salinity stress by enhancing zinc availability despite high calcium levels. Similarly, nano-silicon dioxide alleviated salt stress in strawberries, improving growth and yield.

Precision Irrigation and Fertigation:

- Efficient irrigation management, such as drip irrigation combined with fertigation, optimizes water and fertilizer use, reducing salt accumulation. Fertigation minimizes fertilizer-related salinity by delivering nutrients in precise, fractional doses, improving water-saving, reducing pollution, and increasing farmer net returns.

Subsurface Drainage Systems:

- Installing subsurface drains at depths of 1.5–2.0 m with 50–75 m spacing in alluvial soils or 12–24 m in vertisols facilitates salt leaching, enabling crop growth on previously barren saline lands within 2–3 years. Combining drainage with leaching during monsoon rains minimizes water use.

Phytoremediation and Crop Rotation:

- Phytoremediation uses salt-tolerant plants to extract salts from soil, increasing biomass and yield, though its impact on soil salinity varies by location. Crop rotation, as opposed to monoculture, maintains soil health and reduces salinity buildup, sustaining long-term productivity.

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Mulching and Biological Conditioners:

- Mulching with straw or organic materials reduces soil salinity and preserves productivity by improving soil structure and water retention. Biological soil conditioners, such as endophytic microbes and symbiotic fungi, enhance nutrient availability and induce stress-tolerant genes, boosting yields in saline conditions.

Agrotechnology for Optimal Fertilizer Application

Optimized Fertilizer Selection and Dosing:

- Limiting fertilizer salts, such as potassium chloride, which exacerbates salinity, and opting for less impactful options like potassium sulfate, reduces salt accumulation. Fractional fertilization programs, where nutrients are applied in small, targeted doses, prevent groundwater salinization and improve nutrient use efficiency. For example, reducing nitrogen fertilizer by 28.6% in ISCM trials increased maize yield by 33.7% and nitrogen partial productivity by 88.0%.

Integrated Nutrient Management (INM):

- Combining organic (e.g., cowdung at 5 t/ha) and inorganic fertilizers enhances soil fertility and crop resilience. A study in Bhola, Bangladesh, showed that raised bed planting with integrated nutrient management and straw mulching increased potato tuber yield by 75.1% compared to flat planting without mulch.

Foliar Application:

- Foliar application of nutrients bypasses soil salinity barriers, ensuring direct nutrient uptake by plants. This method is particularly effective for micronutrients like zinc in saline soils with high pH, where soil application is less effective.

Crop-Specific Fertilization:

- Tailoring fertilizer types and quantities to specific crops and their salt tolerance levels is critical. For instance, excessive nitrogen can reduce fruit quality, while balanced fertilization supports both yield and quality under saline conditions.

Practical Implementation and Considerations

- Crop Selection: Choose salt-tolerant crops (e.g., barley, quinoa) or varieties adapted to local conditions to maximize yields. Adjusting sowing dates and densities optimizes resource use.
- Monitoring and Precision Tools: Use soil sensors and remote sensing to monitor salinity levels and adjust fertilizer and irrigation schedules dynamically.
- Challenges: High costs of drainage systems, water scarcity, and safe disposal of saline drainage water are significant barriers. Social and political factors also influence large-scale adoption.

Conclusion

Advanced technologies like ISCM, biochar, nanotechnology, and precision irrigation, combined with agrotechnological practices such as optimized fertilizer dosing, integrated nutrient management, and foliar applications, significantly enhance crop productivity in saline soils. These strategies reduce salinity, improve soil health, and increase yields by up to 37.2% (e.g., maize) or

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75.1% (e.g., potato) in field studies. For sustainable outcomes, farmers should prioritize site-specific solutions, balancing technological investments with environmental and economic considerations.
Saline soils exhibit high spatial variability and require precise diagnosis for effective management.
The integration of remote sensing and fertilizer optimization significantly boosts crop productivity on saline lands.
Optimal fertilizer application tailored to soil salinity conditions is more effective than conventional uniform dosing.
Sustainable rehabilitation of saline soils requires a combination of technology, local knowledge, and capacity building.

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