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Biofertilizers: A Sustainable Shift from Conventional Fertilizers – an Overview

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Abstract

The past century's agricultural advancements, notably characterized by fertilizer utilization, have brought unprecedented crop yields and emergent challenges. While synthetic fertilizers spearheaded global food security, their ecological and health implications have become evident. As we look towards the future, issues like diminishing returns, soil degradation and concerns about the environmental impact of synthetic fertilizer have called for sustainable alternatives for delivering these nutrients and increasing crop yields. This review delves into the opposite narratives of synthetic fertilizers and their bio-derived counterparts, accentuating their potential in sustainable agriculture. The review illuminates the transformative role of biofertilizers - organic substances with living microorganisms in soil fertility through the lens of microbial free living and symbiotic relationships. The assessment seeks to chart a scientifically informed path toward sustainable agriculture practices in an era demanding ecologically responsible solutions.

Introduction

► Synthetic fertilizers have been a instrumental in boosting crop yields, but their ever-increasing use poses ecological and health challenges like soil degradation, water contamination, or economic considerations.

► Biofertilizers, containing living micro- organisms, offer a possible paradigm shift for increasing soil fertility.

Benefits of Biofertilizers

► Biofertilizers deliver nutrients in a way which augments the microbiome and soil vitality, reduces erosion and mitigates the environmental issues common with their synthetic counterparts.

► They also come with other benefits not found in synthetic fertilizers, like bioactive compounds and hormones which promote plant growth and resilience against pathogens, which can reduce pesticide use and reduces toxic residues in crops.

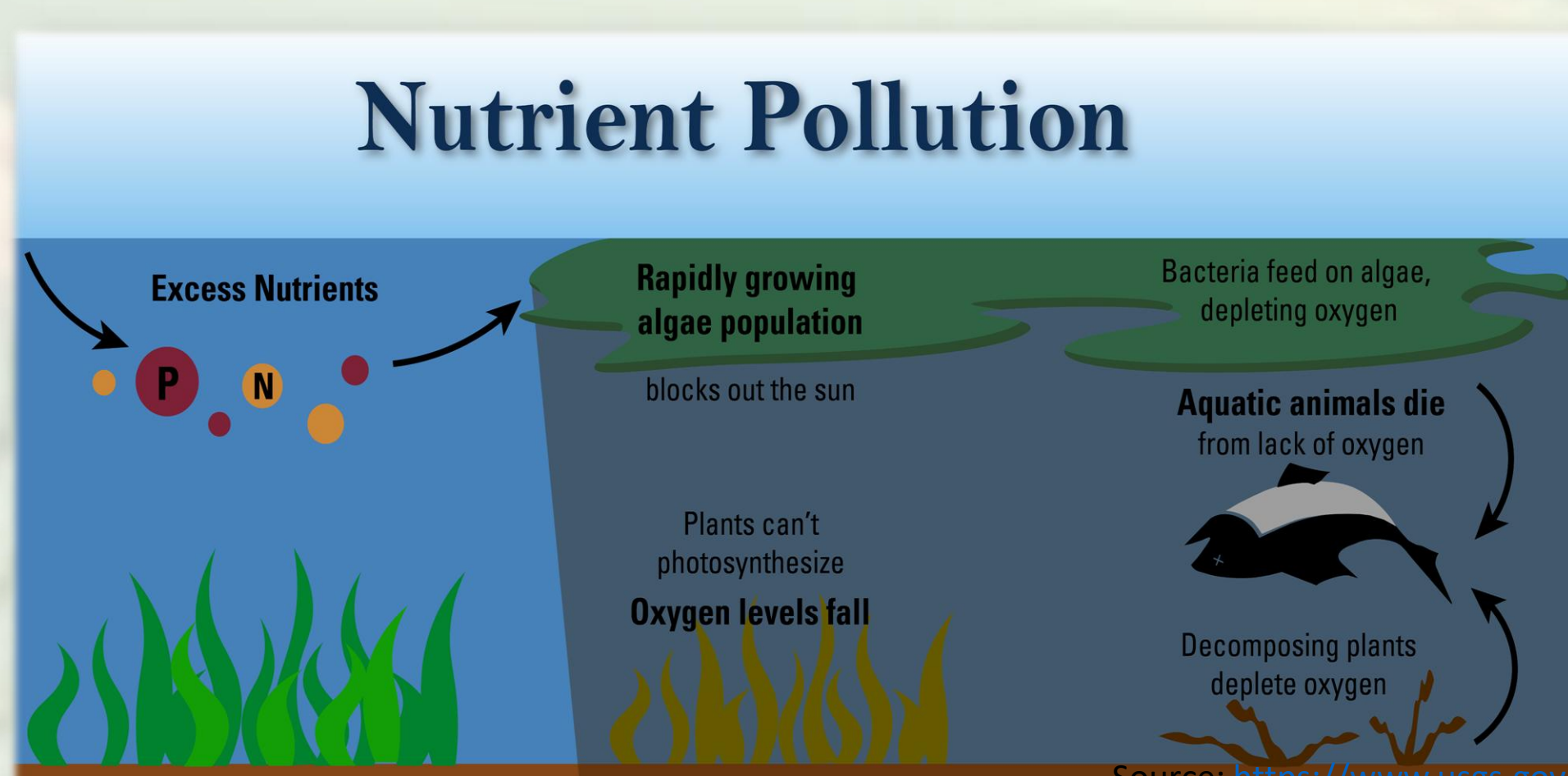
Roles of bacteria as potent biofertilisers

Type	Importance	Mechanism	Genera
Nitrogen-fixing Bacteria	Essential for amino acids, proteins, chlorophyll, and nucleic acids.	Convert atmospheric nitrogen (N ₂) into ammonia (NH ₃) via nitrogenase enzymes.	<i>Rhizobium</i> , <i>Azotobacter</i>
Phosphorus-solubilizing Microorganisms	Essential for energy transfer (ATP), nucleic acids, cell structure, and enzyme production.	Release organic acids and enzymes that solubilize inorganic phosphorus.	<i>Pseudomonas</i> , <i>Bacillus</i>
Potassium Microorganisms	Critical for osmoregulation, enzyme activation, and nutrient uptake.	Improve the solubility of potassium in the soil.	<i>Bacillus</i> , <i>Arthrobacter</i>
Siderophore Producing Bacteria	Improves iron intake, essential for chlorophyll formation and photosynthesis.	Secrete siderophores that chelate iron and make it available for plant uptake.	<i>Burkholderia</i> , <i>Enterobacter</i>
Disease Suppressive Bacteria	Protect plants from pathogens, preventing diseases and nutrient deficiencies.	Produce antimicrobials to compete with pathogens, or induce plant defenses.	<i>Paenibacillus</i> , <i>Pseudomonas</i>
Growth-Promoting Bacteria	Modulate growth-promoting hormones (auxins and cytokinins) for plant development.	Produce growth-stimulating substances that influence plant hormone levels.	<i>Azospirillum</i> , <i>Rhizobium</i>
Mycorrhiza Assisting Bacteria	Enhance the absorption of water and nutrients	Facilitate and support mycorrhizal fungi.	<i>Pseudomonas</i> , <i>Streptomyces</i>

Current State & Future Prospects

► As long as the human population continues to increase the world will have to deal with an escalating demand for food.

► Biofertilizer use is increasing steadily, but not significant enough, and more policy-making action is needed promoting them is needed to reap the full benefits of Biofertilizers.



Conclusions

- Over-dependence on chemical fertilizers, in terms of both cost and environmental impact, is not a viable strategy in the long run.
- Biofertilizers are likely to play a pivotal role in the future, as the technology matures, production scales up and more information about them is available to the farmers.