



PLANT-BASED BIOSTIMULANTS FOR SUSTAINABLE CROP PERFORMANCE



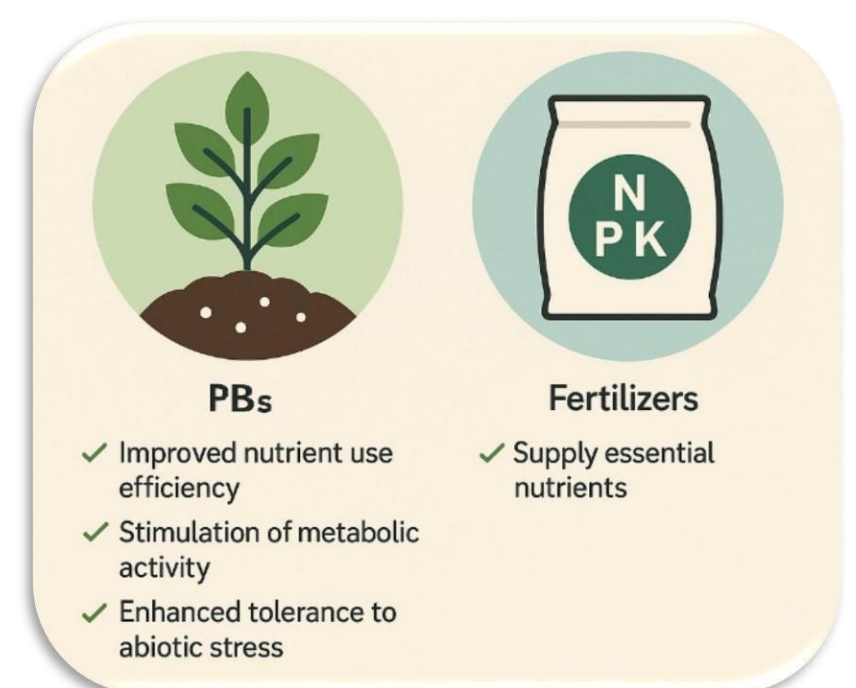
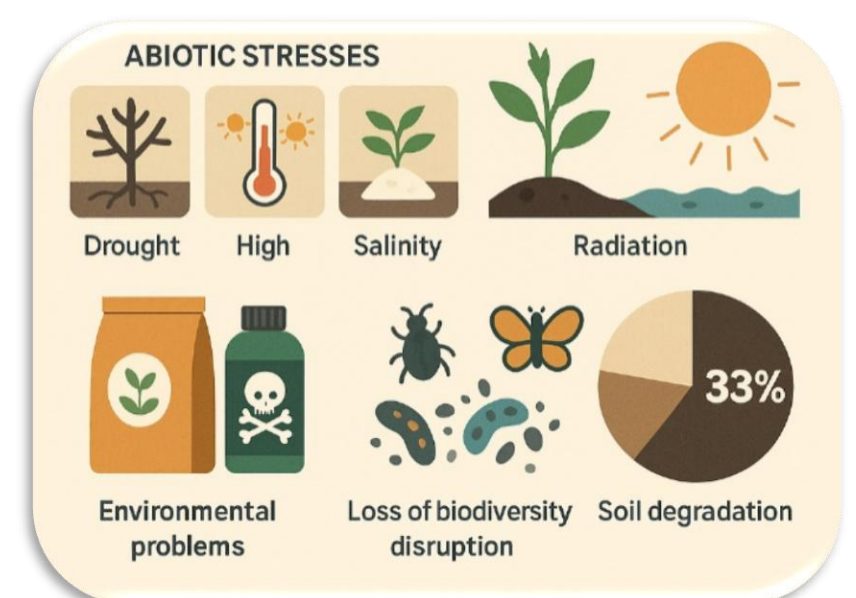
Modern agriculture challenges and the rise of biostimulants



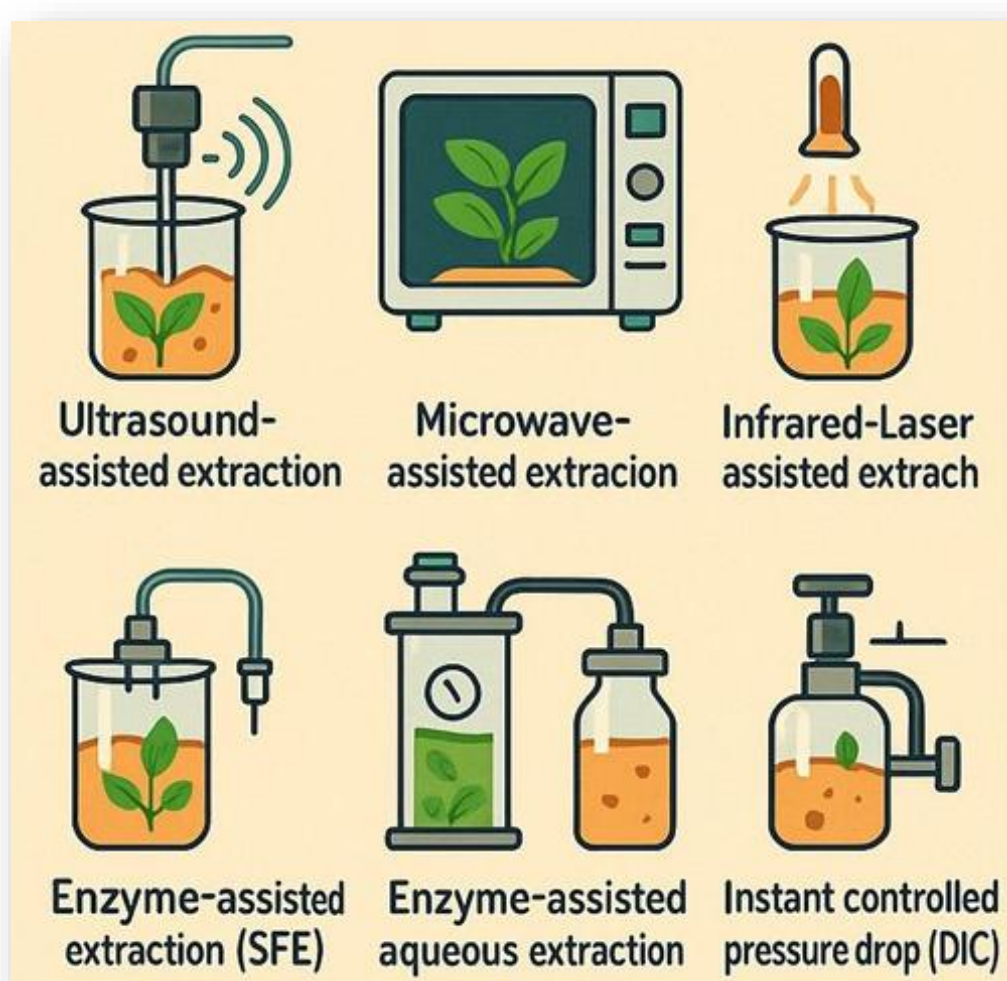
Modern agriculture faces mounting challenges from climate change, soil degradation, and the overuse of synthetic agrochemicals, which contribute to environmental pollution, biodiversity loss, and the emergence of more resistant pests and diseases. Plant-derived biostimulants (PBs) have emerged as sustainable tools to improve crop productivity while mitigating ecological impacts [1].

Mechanisms of action and current limitations

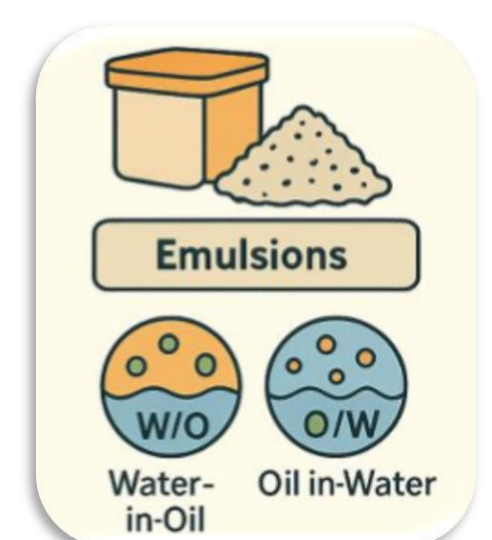
Unlike conventional fertilizers that primarily supply nutrients, PBs act through diverse physiological and molecular mechanisms, including phytohormone regulation, activation of antioxidant defenses, and modulation of the soil microbiome. These actions enhance nutrient use efficiency, strengthen tolerance to abiotic stresses such as drought and salinity, and improve crop quality traits. Plant extracts rich in bioactive compounds, such as polyphenols and signaling compounds, have demonstrated strong potential to stimulate root development, increase photosynthetic activity in crops like tomato and wheat, and promote soil health. Despite these benefits, several barriers hinder their large-scale adoption, including the need for standardized extracts, consistent field performance, and harmonized regulatory frameworks.



Circular economy and innovative production



This review highlights successful applications of PBs in major food crops and explores recent innovations in their production from agri-food by-products, with particular focus on advanced extraction methods (intensified by enzymes, microwaves, and ultrasound) and formulation strategies (such as emulsification).



Impact on food quality and sustainability

PBs can modulate the phytochemical profile and nutritional composition of food crops, contributing to improved food quality. Overall, this work underscores the potential of PBs to support sustainable food production systems, offering ecologically sound solutions aligned with global food security and safety objectives.

REFERENCES

- [1] S. Chaudhry, G.P.S. Sidhu, Plant Cell Reports, 41 (2021) 1–31.
- [2] F. Zulfiqar, A. Moosa, H.M. Ali, N.F. Bermejo, S. Munné-Bosch, Plant Physiology and Biochemistry, 211 (2024) 108699.

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