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Role of Biotechnology in climatic changes

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Abstract:
Climate changes pose significant challenges to global Ecosystem, Agriculture and Human health. In this Biotechnology play a crucial role in addressing these challenges by offering innovative solutions for climate adaptation and mitigation. Advances in genetic engineering, synthetic biology, and microbial biotechnology contribute to reducing greenhouse gas emission, enhancing carbon sequestration and improving crop resilience to extreme weather conditions. And also in biofuels, biodegradable plastics and bioremediation techniques help reduce dependence on fossil fuels and mitigate environmental pollution. In these paper diverse applications of biotechnology in combating climate change, emphasizing its potential to create sustainable solution for resilient future.

Key word- Biotechnology, Genetic engineering, Microbial biotechnology, Mitigation, Synthetic biology.

Introduction-
Climate change poses a significant threat to ecosystems, economies, and human societies, driven by rising greenhouse gas emissions, deforestation, and unsustainable industrial practices. Addressing this global crisis requires innovative and sustainable solutions, and biotechnology has emerged as a powerful tool in mitigating its impact. By biological system biotechnology offer or support by groundbreaking approaches to reducing carbon emissions, improving energy efficiency, and promoting environmental sustainability. From bioengineered crops that enhance carbon sequestration to microorganisms that break down pollutants, biotechnology presents scalable and effective strategies for climate change mitigation. And for waste treatment also the human activities have not only increased by many orders of magnitude the amount of wastes and pollutant that have always existed, eg. Human refuse, etc. The magnitude of problem may appreciated by big expenditure required for waste management and for remedying other environmental problem in European Union and USA.
The AIM of Biotechnology should be develop such processes and products, which minimize the damage to the environment and at the same time compatible with a high quality of life (BD.Singh 2012).

1.1 Contribution of Biotechnology to waste treatment and Environmental Management

This technology for the degradation and conversion of readily biodegradable wastes, Cleaner technology of production, which generate less number of pollutant and much lower pollution, sensitive and rapid detection techniques for a variety of pollutant these techniques are generally based on either enzymes or antibodies(ELISA, Biosensors). Microorganism strains with novel capabilities of degradation of especially xenobiotic compound.

1.2 **In the Agricultural sector faces unprecedented challenges** –

Rising temperatures, erratic rainfall patterns, and the proliferation of pests and diseases threaten global food security and agricultural sustainability. In this context, biotechnology has emerged as a crucial ally in developing climate-resilient agricultural practices that can withstand these environmental stresses. Climate-resilient agriculture refers to farming practices and systems designed to withstand and adapt to the challenges posed by climate change. This includes the ability to cope with extreme weather events, such as droughts, floods, and heatwaves, as well as shifting pest and disease patterns. Biotechnology encompasses a range of techniques, including genetic engineering, molecular markers, and genome editing, aimed at enhancing the performance of crops and livestock. Through these innovations, scientists can create varieties that are not only more productive but also better equipped to handle extreme weather conditions. For instance, drought-resistant crops can thrive in water-scarce environments, while heat-tolerant varieties can maintain yield levels in the face of rising temperatures.

It can contribute to sustainable farming practices by reducing reliance on chemical inputs. Biopesticides and biofertilizers derived from biotechnological processes can enhance soil health and promote crop resilience, supporting a more integrated approach to agriculture. By integrating biotechnology with traditional farming methods and precision agriculture technique.

Biotechnology involves transferring genetic material from one crop to another to increase yield and resilience to biotic and abiotic challenges. On-farm and small-plot research has shown that biotechnology interventions can enhance crop output, nutrient quality, and weed control without negatively impacting the ecosystem or environment.

Crop Engineering can reduce the need for synthetic pesticides by improving disease resistance. Crops may be biofortified by adding genes that target certain metabolic pathways. For example, Golden Rice can be fortified with genes that produce beta-carotene.

Advances in OMICS approaches, particularly CRISPR genome editing, offer potential for developing biotechnological products in sustainable agriculture.

1.3 Agricultural revolution

It has improved crop production, but climate change, biodiversity loss, and soil degradation may impact yields, necessitating further outreach and extension.

Purpose:

As climate change increasingly impacts food production through extreme weather events, shifting growing seasons, and changing pest dynamics, biotechnology offers innovative solutions to enhance crop resilience.

And this study aim to-

1) Identify the specific biotechnological interventions that improve resilience in agricultural system.
2) Analyze the effectiveness of these intervention in various environmental and socio-economical contexts.
3) Genetic modification development of crops with enhance traits (eg,drought,flood) and benefit of the techniques is in the improvement in yield and survival in adverse conditions.(Dhanya C.Mathay et.al)
4) Assess challenges and barriers to the adoption of biotechnological solution in agriculture.
5) Provide evidence base recommendation,policymakers, farmer and researcher to enhance the integration of biotechnology in climate adaptation strategies.

Climatic changes in Rajasthan-

The average rainfall of Rajasthan is approx 5700 mm compared to the all India average of 1,100mm and significant variation seen different region. The annual spatially averaged rainfall is highly variable and it most erratic in the western region with frequent dry spells,(Rathore,2004) and the state has maximum probability of occurrence of drought in India (RPCB,2010). So from the environment changes in the Rajasthan there is many loss or impact in the agriculture sector. So from that we can uses the biotechnology applications like genetic engineering, plant tissue culture, Molecular techniques.

Like there is a micropropagation, as its seed germination is problematic this micropropagation is an efficient method for mass propagation. In fact this method is perfect method for mass propagation of threatened plants via direct and indirect organogenesis under in vitro condition for ex-situ conservation, genetic improvement and commercial application without any seasonal limitations.

Case studies:

Pest- resistant cotton in India-

Overview: Cotton production in India has been challenged by pests, leading to significant crop losses

Biotechnology Application: Introduction of Bt cotton, which is genetically engineered to express a bacterial toxin that is harmful to certain pests.

Results: Adoption of Bt cotton led to an average yield increase of 25% and a significant reduction in pesticide use, resulting in lower production costs.

Drought-Resistant Crops Development

Objective: Examine the development and impact of drought-resistant genetically modified (GM) crops on agricultural productivity in arid regions.

Using genetic engineering techniques to create that thrive with limited water availability, essential for the arid region of Rajasthan, Gujarat etc.

Heat Stress tolerance-

Engineering crop with higher tolerance to extreme heat, which is becoming increasingly common in Rajasthan. In Rajasthan there is government sites for the climate changes and Also have the State Action Plan on Climate Change.(https://environment.rajasthan.gov.in)

Conclusion:

Biotechnology has emerged as a crucial ally in the quest for climate-resilient agriculture, providing innovative solutions to enhance crop productivity and sustainability in the face of climate change. The development of genetically modified crops that withstand drought, salinity, and pests has demonstrated significant improvements in yields and reduced reliance on chemical inputs. Additionally, biotechnological advancements in nutrient use efficiency and climate adaptation traits have further bolstered agricultural resilience. As the global population continues to grow and climate challenges intensify, the role of biotechnology becomes increasingly vital. It not only supports food security but also contributes to the economic stability of farming communities. However, the success of these innovations relies on continued research, effective communication with the public and equitable access for all farmers, particularly smallholders in developing regions.

Embracing biotechnology in agriculture is essential for building a sustainable and resilient food system that can adapt to an uncertain future. By fostering collaboration among scientists, policymakers, and communities, we can harness the full potential of biotechnology to ensure a stable and sustainable food supply for generations to come.

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