

Climate Resilience and Carbon Footprinting of Millet Crops

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Abstract

As climate change intensifies, global agricultural systems are increasingly vulnerable to extreme weather events such as rising temperatures, erratic rainfall, and prolonged droughts. Millets, a group of small-grain cereals including pearl millet, sorghum, and finger millet, are emerging as climate-resilient crops with the potential to enhance food security and mitigate environmental impacts. Millets are well-adapted to arid and semi-arid regions, excelling in drought and heat tolerance, efficient water use, and a short growing cycle. These crops require fewer inputs and resources, resulting in a lower carbon footprint compared to other staple crops like rice and maize. Millets' ability to grow in poor soils, coupled with their carbon sequestration potential, further reduces greenhouse gas emissions. Their minimal need for irrigation and chemical inputs makes them a sustainable alternative to high-input crops, offering a promising solution to the challenges posed by climate change. Promoting millet cultivation could significantly improve food security, reduce agricultural emissions, and contribute to sustainable, climate-smart agricultural systems globally.

Key words: Millets, Climate change, Climate-resilient crops, Carbon footprint

Introduction

As the impacts of climate change intensify, global agricultural systems are increasingly vulnerable to rising temperatures, erratic rainfall, and prolonged droughts. In this context, millets-small-grain cereals such as pearl millet, sorghum, finger millet and other small millets-are emerging as climate-resilient crops that offer a promising solution to enhance food security while mitigating environmental impacts. Millets are known for their ability to thrive in harsh, water-scarce, and nutrient-poor environments, making them highly adaptable to the changing climate conditions predicted for many regions of the world.

Climate Resilience of Millets

Millets are particularly well-suited to arid and semi-arid regions, where they have been cultivated for centuries. These crops exhibit remarkable resilience to climate stressors such as drought, heat, and poor soil quality, which makes them an ideal candidate for sustainable agricultural systems. Their unique physiological and anatomical characteristics allow them to withstand extreme environmental conditions and still produce viable yields.

Drought and Heat Tolerance: Millets such as sorghum and pearl millet are known for their deep root

systems, which allow them to access water from deeper soil layers during dry spells, a characteristic that other crops, like rice and wheat, lack. This drought tolerance is particularly valuable in regions where rainfall is unpredictable, and water resources are scarce. In addition, millets are heat-resistant, able to withstand high temperatures (up to 42°C during flowering) without significant yield loss, a trait that is increasingly important in the face of rising global temperatures (Gupta et al., 2015). In contrast, crops such as rice and maize suffer from decreased yields when exposed to high heat, particularly during the reproductive stages (Jagadish et al., 2007).

Efficient Water Use: Unlike other staple crops, millets require significantly less water, making them highly water-efficient. Their C₄ photosynthetic pathway enables them to use water more efficiently than C₃ crops like wheat and rice, allowing them to thrive in regions with limited water availability. This is crucial as climate models predict significant reductions in water availability for agriculture in many regions (Saxena et al., 2018).

Short Growing Cycle: Millets have a shorter growing period compared to other cereal crops, ranging from 70 to 120 days depending on the variety. This allows for quicker harvesting, reducing the time that crops are exposed to extreme weather events such as droughts and heatwaves. This short life cycle also enables millets to be cultivated in multiple cropping systems, providing more resilient farming options in the face of changing seasonal patterns.

Carbon Footprinting of Millets

In addition to their climate resilience, millets also offer environmental advantages, particularly in terms of their carbon footprint. Carbon footprinting refers to the assessment of the total greenhouse gas (GHG) emissions associated with the production of a crop. Millets are characterized by a relatively low carbon footprint compared to other major crops, making them a sustainable option for mitigating climate change.

Low Input Requirements: Millets generally require fewer chemical inputs (fertilizers and pesticides) compared to high-input crops like rice and maize. For instance, millets need less nitrogen fertilizer, which is a significant contributor to nitrous oxide emissions-one of the most potent greenhouse gases. Their resistance to pests and diseases means that millets can often be grown with minimal chemical interventions, further reducing their carbon footprint.

Efficient Use of Resources: Millets' ability to grow in poor, degraded soils imply they require less land preparation and less energy-intensive farming practices. Their minimal

water requirements and low dependence on irrigation systems further reduce the energy and carbon emissions associated with their cultivation. In contrast, crops like rice require flooded fields, leading to significant methane emissions, while millets, grown in non-flooded conditions, do not contribute to this issue.

Carbon Sequestration Potential: Millets contribute to carbon sequestration due to their ability to grow in less disturbed, low-input environments. Their deep root systems help store carbon in the soil, further reducing the overall carbon emissions from agricultural systems. In fact, millets can help increase soil organic carbon content, which serves as an effective means of mitigating climate change by capturing carbon from the atmosphere.

Lower Emissions in Comparison to Other Crops: Studies have shown that the carbon footprint of millet cultivation is significantly lower than that of crops like rice and maize. For instance, rice cultivation, with its heavy reliance on water and fertilizers, is associated with higher methane emissions, while millets-requiring less water and fertilizer-emit fewer GHGs. Furthermore, their adaptation to low-input farming systems and reduced need for mechanized equipment contribute to a smaller overall carbon footprint (Swinnen & Vos, 2020; Tiwari et al., 2022).

Conclusion

Millets represent potential crops in the effort to address the dual challenges of climate change and food security. Their inherent resilience to drought, heat, and poor soil conditions, combined with their low carbon footprint, makes them a key crop for sustainable agricultural systems. As global temperatures rise and water resources become scarcer, millets offer a viable, low-environmental-impact alternative to more water- and input-intensive crops like rice and maize.

By promoting millet cultivation, we can reduce agricultural emissions, enhance soil carbon sequestration, and improve global food security. In regions vulnerable to climate stress, millets could become a cornerstone of climate-smart agriculture, offering a sustainable solution that benefits both farmers and the environment. As the world adapts to a changing climate, millets stand out as an important crop in ensuring a resilient and sustainable future for global agriculture.

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