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EDITED AND REVIEWED BY
Marco Bindi,
University of Florence, Italy

*CORRESPONDENCE
Pratap Bhattacharyya
pratap162001@gmail.com

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Editorial: New generation agronomy for net-zero greenhouse gas emissions

Pratap Bhattacharyya[1]*, Binoy Sarkar[2] and Koushik Singha Roy[3]

[1]Crop Production Division, Indian Council of Agricultural Research (ICAR) - National Rice Research Institute, Cuttack, Odisha, India, [2]Future Industries Institute, University of South Australia, Mawson Lakes, SA, Australia, [3]Nature Based Solutions, Shell India, Bangalore, India

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Editorial on the Research Topic
New generation agronomy for net-zero greenhouse gas emissions

Introduction

With the entire global community increasingly grappling with the mounting challenges posed by climate change, the relevance of agronomy in addressing these environmental emergencies also increases. The scientific consensus could not be clearer – while continuing with business as usual, agriculture needs to strive for a net-zero emission aspiration. This editorial goes on to examine the transformative promise of agronomy, discussing pioneering methodologies that entirely redefine the agricultural status quo. It focuses on the use of cutting-edge technology and progressive practices that reduce emissions and sustain food security in the face of climatic adversities. This editorial tries to establish a fine line between progress and tradition to ensure that the future of agronomy addresses the net-zero GHGs emissions and hopes to facilitate global conversation regarding the role and possibilities of agronomic innovation in the fight against climate change.

Agriculture is a contributor to greenhouse gas (GHGs) emissions, notably through methane from rice paddies and livestock, and nitrous oxide from fertilizers. Research indicates that methane emissions have increased with the rising use of fertilizers in rice production (Bodelier et al., 2000; Zhang et al., 2020). Soil nitrous oxide emissions are another significant addition to the greenhouse gas footprint of agriculture. On the other hand, the agricultural sector has immense potential for emission reductions. Major sources of emissions include irrigation, mechanical disturbance of soil, fertilizer application, livestock, or rice cultivation, whereas intensified trade in agricultural products increases these impacts. Possible ways of mitigating methane and nitrous oxide emissions encompass improving farming systems, managing microbial communities in rice fields, or residue retentions in fields to reduce the GHGs. In conclusion, addressing methane and nitrous oxide emissions is essential for transitioning towards more sustainable agricultural practices and enhancing environmental protection.

Innovative agronomic practices for sustainability

Modern agronomy focuses on environmental sustainability by strategically applying advanced agricultural inputs to effectively reduce greenhouse gas emissions. Research from East Java by Slameto et al., shows that tailored fertilizer mixes, especially those including chicken manure, can significantly reduce methane and nitrous oxide emissions—two potent greenhouse gases. This study underscores the benefits of precise input management and the importance of selecting crop varieties to enhance yield and sustainability. Implementing these practices offers agronomists a viable path to balance productivity with ecological responsibility.

Equally transformative is the valorization of agro-biomass, an approach that integrates agricultural byproducts back into the economy, thus supporting a circular bioeconomic model (Hanumante and Maitre). According to the study, the valorization process converts agricultural residue into a range of bio-based products, one of which is energy, and cuts waste, which contributes to enhanced resourcefulness. Given the complexities related to the process and the interconnectedness between several Sustainable Development Goals, the valorization of agro-biomass may be deemed as a primary proponent in the transition to sustainability. The systemic operation of agro-biomass within bioeconomic cycles is an essential leap forward in the pursuit of optimal utilization and environmental protection.

Zhang et al. demonstrate through the eddy-covariance method how optimized planting patterns and precise fertilizer management significantly affect carbon dioxide flux, evapotranspiration, and crop efficiency. These agronomic innovations are crucial for dual strategic purposes: they enhance the efficient use of essential resources like water and carbon while boosting agricultural productivity. This is vital for supporting the increasing global population amid climate change threats.

Water-use efficiency and crop production

Water-use efficiency (WUE) is crucial for the sustainable management of agriculture, particularly under the stresses of climate change. Research by Bogati et al. highlights the effectiveness of strip tillage over conventional tillage, demonstrating its superior water efficiency and carbon dioxide uptake, especially under extreme weather conditions. These findings emphasize the benefits of conservation tillage not only in enhancing WUE but also in bolstering the resilience of agricultural systems against climatic fluctuations. This research advances our understanding of optimizing agronomic practices to conserve water and reduce greenhouse gas emissions. By improving water use efficiency, agronomists can develop methods that not only increase crop yields but also support a broader environmental sustainability agenda, crucial for global food security.

Challenges in implementing sustainable practices

Sustainable agriculture faces challenges across technology, infrastructure, and policy, particularly in maximizing agro-biomass use, improving water efficiency, and adopting advanced agronomic methods. A key obstacle is the inefficiency and limited versatility of existing biorefinery technologies, which struggle to convert various biomass types into energy and bio-products. This highlights the urgent need for technological advancements to enhance biomass conversion rates and economic viability. Infrastructure-wise, there's a shortage in systems for efficient biomass collection, transportation, and processing. Many agricultural areas lack the logistics and facilities needed for large-scale biomass valorization, hindering the implementation of sustainability projects and reducing potential economic gains.

On the policy front, there are considerable barriers due to the lack of supportive frameworks and incentives to promote the adoption of sustainable practices. Policies often lag behind technological advancements and fail to provide the necessary support for research and development. Moreover, there is a need for coordinated policy efforts that align local, national, and international regulations and incentives to facilitate the broader adoption of these practices.

Exploring the relationships between agro-biomass valorization, energy supply, and Sustainable Development Goals (SDGs) is another crucial research area. Understanding these relationships can help in designing agronomic practices that not only contribute to energy sustainability but also advance broader environmental and social goals. This kind of research would provide valuable insights into how best to balance the competing demands of increasing agricultural output, reducing greenhouse gas emissions, and achieving economic viability.

Addressing these challenges requires a multi-faceted approach in future research. Developing integrated biorefineries that process various biomass types in one facility could cut costs and enhance resource efficiency. Additionally, there is a pressing need for long-term studies that assess the impacts of various agricultural practices on carbon sequestration. Such studies would provide empirical data to inform and refine practices that optimize both yield and environmental sustainability.

Collectively, overcoming these challenges requires innovative thinking, sustained investment in technology and infrastructure, and the development of supportive policy environments that encourage the adoption of sustainable practices. Such efforts are essential for realizing the potential of modern agronomy to contribute effectively to global sustainability targets.

Conclusion

The urgency to adopt new-generation agronomic practices is paramount in our quest for net-zero greenhouse gas emissions and sustainable agricultural systems. With ongoing research and supportive policy frameworks, the agricultural sector can significantly contribute to mitigating the adverse effects of climate change. This journey requires not only scientific innovation but also collaborative efforts across various sectors to overcome the prevailing challenges and navigate toward a sustainable future.

Author contributions

PB: Conceptualization, Supervision, Validation, Writing – original draft, Writing – review & editing. BS: Data curation, Writing – review & editing. KR: Formal analysis, Software, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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