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Editorial: Mitigation and adaptation strategies involving nitrogen management for enhancing agro-ecosystem productivity and resilience to future climate change

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Editorial on the Research Topic
Mitigation and adaptation strategies involving nitrogen management for enhancing agro-ecosystem productivity and resilience to future climate change

In this editorial, we focussed on prospect of several nitrogen management options for enhancing crop productivity and farming resilience toward future global climate change. Nitrogen management and climate change are closely linked due to the role of nitrogen in various environmental processes. It is an essential nutrient for plant growth and is often a limiting factor in agricultural crop production systems. To meet the growing demand, farmers often use synthetic nitrogen fertilizers, which increase reactive nitrogen concentration into the environment. This can lead to several environmental issues. One major concern is the release of nitrous oxide (N_2O) during the microbial processes of nitrification and denitrification in soils. Increased nitrogen deposition (NH_3 and NOx) also contribute to air pollution and the formation aerosols which causes adverse effects on human health. Nitrogen runoff and leaching from agricultural fields contaminate water bodies, lead to eutrophication. This process results in excessive algal growth, oxygen depletion, and the death of aquatic organisms. Climate change itself influences nitrogen cycles. As our world grapples with the realities of negative consequences of global climate change, agriculture remains as a paramount challenge to feed our ever-growing population. In order to increase net agro-ecosystem productivity coupled with limited cultivable land area availability, increasing nitrogen use efficiency became a major challenge to maintain the steady growth in agriculture and allied sectors. Nitrogen fertilizers are often applied in an unwise manner, resulting in loss of reactive forms of nitrogen such as ammonia volatilization, nitrate leaching, and nitrous oxide emissions (Chatterjee et al., 2018). Crop management options aimed to improve nitrogen use efficiency and limit reactive nitrogen loss could likely be the driving force for climate change resilience in forthcoming future. For instance, use of nitrification inhibitors to mitigate N_2O emission by 10–42% is reported by Pathak et al. (2019). Similarly, deep placement of urea briquette reduced N_2O emission to the tune of 6–13% over prilled urea broadcasting and manual placement (Chatterjee et al., 2018). Nitrogen efficient management improves functioning of agro-ecosystem, thus increasing resilience toward climate change in long run.

Chen et al. studied the impact of agricultural production outsourcing service and land fragmentation on agricultural non-point source pollution in Jiangxi Province, China. Non-point source of pollution are primarily caused by agricultural activities and became the significant environmental concern leading to water quality deterioration and ecological degradation. They assessed how land fragmentation, division of farmland into smaller parcels, influences non-point source of pollution. The findings revealed a positive correlation between agricultural production outsourcing and non-point source pollution as reliance on external services may contribute to increased environmental pollution. Similarly, land fragmentation is identified as a contributing factor to non-point source pollution, as smaller land parcels lead to inefficient resource uses and suboptimal land management practices. The research emphasizes the need for targeted policies to address these challenges and mitigate non-point source pollution in the region. Therefore, promotion of sustainable agricultural practices and land consolidation could play a significant role in reducing pollution levels.

Alam et al. investigates the implementation of environmentally friendly nitrogen management practices in wetland paddy cultivation. It highlights the crucial role of nitrogen in rice production and the potential adverse consequences of excess nitrogen fertilizer application on the environment. The study explores various sustainable nitrogen management strategies, including controlled-release fertilizers, alternate wetting and drying techniques, and the incorporation of nitrogen-fixing plants in crop rotations. By examining the effectiveness of these practices, the research underscores their potential to reduce nitrogen losses, improve soil health, and mitigate environmental impacts, such as water pollution and greenhouse gas emission. The findings and recommendations of this study are valuable to promote ecofriendly wetland paddy cultivation and efficient utilization of nitrogenous fertilizers.

Controlled Environment Agriculture (CEA) systems are means to grow crop under protected environment irrespective of prevailing adverse weather conditions, in order to achieve future food security and climate resiliency (Cowan et al.). The loss of N_2O in this system is very minimum, as it uses inert materials without any microbes that engage in nitrification and denitrification process. This study evaluates the benefits of CEA systems, including year-round crop production, reduced water usage, and minimal reliance on pesticides in horticultural crops viz. tomatoes, potatoes, beans, etc. The challenges and limitations of implementing CEA on a large scale, including high initial costs and energy consumption were explored. The research highlights the environmental importance of integrating CEA with renewable energy sources and waste recycling to enhance sustainability through optimized nutrient, water and energy usage.

The effectiveness of coated urea fertilizers in enhancing nitrogen use efficiency, soil fertility status, and nutrient use efficiency in a test crop were studied against conventional urea application (Abdullah et al.). Coated urea resulted in higher plant uptake and improved nitrogen use efficiency significantly, by minimizing nitrogen losses through volatilization and leaching. Moreover, the application of coated urea positively influences the soil's status through promoting better nutrient retention and plant availability. The study concludes that coated urea offers a promising solution to enhance agricultural sustainability by maximizing crop productivity through zinc nutrition, while gelatin coating became an economic and feasible option for minimizing adverse environmental impacts associated with excess nitrogen fertilization.

Excessive and inefficient use of nitrogen fertilizers often leads to environmental degradation, while proper management practices offer opportunities to improve crop productivity and environmental resilience. The net impact of climate change is already being evident worldwide. Being a vulnerable sector, agricultural crop production system must act swiftly to adapt. In this epilog, we are reminded of the responsibility and share in safeguarding the ecosystem health toward securing the prospects of our future crop production. Embracing environment-friendly nitrogen management practices is not just an option; it is a necessity of time to slow down the pace of anthropogenic global climate change. By taking action now, we will pave the way for a more resilient, productive, and sustainable agricultural sector and ensure that our present day agro-ecosystem functioning will thrive amidst the climate change uncertainties.

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