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EDITORIAL

Green technology for high yield and nutrient use efficiency

Wen-Feng CONG, Hao YING, Jianbo SHEN, Fusuo ZHANG (✉)

State Key Laboratory of Nutrient Use and Management, National Academy of Agriculture Green Development, College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, China.

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Correspondence: zhangfs@cau.edu.cn

China and other rapidly developing economies face multiple challenges including food security, resource conservation and environmental protection. Innovating and applying green technologies to boost grain crop production and efficiency—achieving coordinated multi-objectives of yield increase, efficiency gains, carbon sequestration, emission reduction, and quality improvement—represents a major national priority and scientific challenge for agricultural green development. Sustainable food production necessitates a fundamental transformation in routine farming practices. The green technology approach for enhancing crop production and efficiency, pioneered by Prof. Fusuo Zhang of China Agricultural University, offers an innovative model for greater grain production with lower input and less pollution. This article introduces the context-driven agricultural research paradigm, further advancing its scientific principles, systemic methodologies, novel green technologies and regional application models for improving grain crop production and nutrient use efficiency in China. It also examines pathways to broaden its impact on food security in China and globally. The objectives of this special issue are to synthesize recent progress in: (1) innovations in agricultural research paradigms, theoretical principles and methodologies; (2) technological breakthroughs and product development; and (3) representative application models for maize, rice and wheat across China's major grain-producing regions.

Existing agricultural scientific schemes often misalign with practical production realities, necessitating paradigm innovation. Cong et al. (DOI: 10.15302/J-FASE-2025630) proposed the next-generation "12345" agricultural research paradigm, grounding studies in agricultural development contexts and linking knowledge-to-action through multi-stakeholder, cross-disciplinary systematic research. *Green Technology for Increasing Grain Crop Production and Efficiency* exemplifies the implementation of this paradigm for food and environmental security. Traditional research—typically focusing on single processes within narrow disciplines and objectives—fails to meet agricultural green development requirements. Addressing this, Fan et al. (DOI: 10.15302/J-FASE-2025628) advocated an integrated agricultural systems approach combining interdisciplinary research with top-down and bottom-up strategies. For future green technology innovation, Zhao et al. (DOI: 10.15302/J-FASE-2025633) recommend precise organic manure management, enhanced-efficiency fertilizers, and novel techniques like high-yielding population construction, rhizosphere nutrient regulation, and intelligent nutrient management.

Maize, wheat and rice—China's three main staple cereal crops—account for over 90% of total cereal production. Maize, the highest-yielding and most extensively cultivated food crop, has the greatest yield potential. Ji et al. (DOI: 10.15302/J-FASE-2025601) developed quantitative design methods by aligning planting density with solar radiation, matching population structure to maize cultivars, and synergizing plow layer-root-canopy functions to sustainably boost grain yield and resource efficiency. For sustainable rice production, Gu et al. (DOI: 10.15302/J-FASE-2025610) proposed three key strategies: optimizing grain-leaf ratio, enhancing sugar-spikelet ratio and increasing productive tiller ratio. They also recommended green technologies including alternate wetting-drying

irrigation, three-criteria nitrogen application (soil-, leaf color- and cultivar-based) and water-nitrogen coupling regulation. Zhong et al. (DOI: 10.15302/J-FASE-2025631) promoted a *three-stage theory* for wheat based on yield levels, promoting novel techniques: rational dense planting, wide-space drilling sowing, appropriately delayed sowing, optimized nitrogen management and deep plowing with straw returns.

Technology transfer and adoption by smallholder farmers are critical for boosting regional and national cereal production. Li et al. (DOI: 10.15302/J-FASE-2025615) integrated regionalized fertilizer application with a government-enterprise-university-research-application collaborative model centered on Science and Technology Backyards, aiming to facilitate sustainable, efficient, scaled and modernized development across China's major maize-growing regions. He et al. (DOI: 10.15302/J-FASE-2025606) established a multi-stakeholder joint innovation model to bridge agricultural technology and regional wheat production. Huang et al. (DOI: 10.15302/J-FASE-2025636) identified three pillars for sustainable rice production—nutritional physiology, cultivation management and soil fertility enhancement—developing localized modular technical systems and implementation models to drive large-scale adoption in rice-growing regions. Ning et al. (DOI: 10.15302/J-FASE-2025618) proposed pathways for annually achieving 22.5 $t \cdot ha^{-1} \cdot yr^{-1}$ through winter wheat-summer maize rotation on the North China Plain, while reducing resource inputs, mitigating greenhouse gases and enhancing soil carbon sequestration. Collectively, green technology for increasing grain crop production and efficiency emerges as an effective scientific paradigm ensuring food and environmental security, offering a replicable model for global food security.

Wen-Feng Cong is a Professor of Plant Nutrition, College of Resources and Environmental Sciences, China Agricultural University. He obtained his Ph.D degree from Wageningen University in the Netherlands. His research mainly focuses on regulation mechanisms and technology innovation of high yield and efficient nutrient use, particularly those related to crop diversification and nutrient management. He has published more than 60 peer-reviewed papers in international high-profile journals such as *PNAS*, *Trends in Plant Science*, *Trends in Ecology & Evolution*, and *Global Change Biology*. He is currently Dean of Sino-France Agroecology-Agriculture Green Development International Associated Laboratory, and Vice Chair of Nutrient Cycling Professional Committee of the Chinese Society of Plant Nutrition and Fertilizer Science.

Hao Ying is an Associate Professor of Plant Nutrition, College of Resources and Environmental Sciences, China Agricultural University. He obtained his Ph.D degree from China Agricultural University. His research mainly focuses on nutrient management, technology innovation of high yield and efficient nutrient use. He has published more than 10 peer-reviewed papers in international high-profile journals such as *Nature Food*, *Global Change Biology*, and *Environmental Science & Technology*. He is currently the member of Nutrient Cycling Professional Committee of the Chinese Society of Plant Nutrition and Fertilizer Science.

Jianbo Shen is a Professor of Plant Nutrition, College of Resources and Environmental Sciences, China Agricultural University. He has been engaged in studies on plant–soil interactions and interventions aimed at enhancing resource use efficiency and food security, particularly focusing on root/rhizosphere nutrition and management. He is a recipient of the National Outstanding Youth Fund of China. He won the second prizes of the State Natural Science Award and State Science and Technology Progress Awards. He has published more than 170 peer-reviewed papers in international journals. He is a Fellow of the African Academy of Sciences. He is currently an Associated Editor of *Food and Energy Security*, and a Guest Editor of *Frontiers of Agricultural Science and Engineering*.

Fusuo Zhang is a Professor of Plant Nutrition, College of Resources and Environmental Sciences, China Agricultural University. He is Academician of the Chinese Academy of Engineering and serves Dean of National Academy of Agriculture Green Development. His group has developed a series of integrated crop and nutrient management technologies to increase crop yield and improve nutrient use efficiency, while reducing environmental pollution. He has published over 800 peer-reviewed papers, including the prestige *Science*, *Nature* and *PNAS*, and received many national awards and international prizes. In 2018, he received honorary doctorate from Wageningen University and Lancaster University.