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Editorial: Biopesticides: their contributions towards achieving Sustainable Development Goal (SDG-2)

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Editorial on the Research Topic
Biopesticides: their contributions towards achieving Sustainable Development Goal (SDG-2)

Global hunger is escalating due to interconnected factors such as climate change, environmental degradation, pest proliferation, and rapid population growth, highlighting the urgent need for sustainable food systems. The United Nations positions sustainable agriculture as a cornerstone of Sustainable Development Goal 2 (SDG-2), which seeks to eradicate hunger, improve nutrition, and promote environmentally responsible farming by 2030 (Hiywotu, 2025). The Green Revolution significantly boosted food production through high-yield crops, synthetic inputs, and mechanization (Chao et al., 2025), but its chemical-intensive model has caused soil and water contamination, biodiversity loss, pesticide resistance, and health risks (John and Babu, 2021). These externalities have driven a shift toward ecologically sound practices. Biopesticides offer targeted pest control with reduced non-target impacts and alignment with sustainability principles (Fenibo et al., 2023). The benign modes of action of biopesticides are transferable to insects and pests implicated in zoonotic disease transmission, thereby linking biopesticides to the One Health agenda. For example, mosquitoes and tsetse flies are major vectors of zoonotic and vector-borne diseases and pose health risks to both farming and non-farming populations (Ahmed et al., 2025). Despite this potential, biopesticide adoption remains constrained by variable efficacy, higher costs, limited shelf life, and challenges associated with large-scale deployment. Overcoming these barriers through continued scientific innovation, integration of digital technologies, and supportive policy frameworks (Khan and Iqbal, 2026) is critical to advancing biopesticide integration and achieving SDG-2.

Achieving SDG-2 requires more than incremental yield improvements; it calls for a structural transformation toward sustainable, resilient, and inclusive agricultural systems. Central to this transition is reducing reliance on synthetic agrochemicals, which erode soil health, destabilize ecosystems, compromise food safety, and threaten farmer livelihoods. Contributions in this thematic Research Topic demonstrate how biopesticides, organic inputs, and digital technologies can function as complementary pillars of sustainable intensification. Collectively, they advance a clear narrative: ecological innovation, supported by policy incentives and robust information infrastructure, is indispensable for food security. A core challenge lies in sustaining productivity while restoring agroecosystem integrity. Liao et al. explore this tension through China's shift from chemical to organic fertilizers, situating fertilizer use within broader political-economic and behavioral contexts. While chemical fertilizers boosted yields, their overuse has caused non-point source pollution and soil degradation. Organic fertilizers, by contrast, enhance soil structure, nutrient cycling, and environmental health, yet adoption remains uneven due to higher costs, uncertain yield outcomes, and pervasive risk aversion.

By extension, Liao et al., applying evolutionary game theory under bounded rationality, reveal that farmers' decisions are dynamic, influenced by income disparities, social learning, herd behavior, and external interventions. Without policy or technological support, adoption trajectories diverge: higher-income farmers gradually transition to organic fertilizers through imitation, while lower-income farmers remain dependent on chemical inputs, exacerbating inequality. This insight is critical for SDG-2, which prioritizes both productivity and equity. The study further shows that financial subsidies and government promotion can accelerate organic adoption but are costly and unsustainable. Digital technologies emerge as a transformative complement, reducing learning and transaction costs, improving access to technical guidance, fostering ecological awareness, and strengthening market connectivity. By enabling sustained adoption without continuous subsidies, digitalization can shift sustainability from an externally imposed obligation to an internally motivated choice, aligning farmer behavior with long-term soil health and food system resilience.

The enabling role of digital technology is examined in greater depth by Yin et al., who investigate farmers' adoption of Green Control Technology (GCT) for pest management in Sichuan Province, China. Pest pressure remains a major threat to food security, while excessive pesticide use perpetuates resistance, environmental contamination, and health risks. GCT, rooted in Integrated Pest Management (IPM), offers a pathway to reduce chemical dependence, yet adoption is uneven in regions marked by information asymmetries and high perceived risk. Using household survey data and rigorous econometric analysis, the authors show that digital technology significantly influences adoption decisions. Access to smartphones, internet platforms, and online agricultural services increases GCT uptake by enhancing perceived usefulness and ease of use while reducing perceived risk. Beyond transmitting technical guidance, digital tools mitigate uncertainty, enable peer-to-peer learning, and bridge the gap between policy objectives and on-farm practice.

From an SDG-2 perspective, these findings highlight the importance of information equity. Yet, persistent heterogeneity remains: younger farmers, smallholders, and those near service centers benefit most from digitalization, while older farmers and remote communities are marginalized. This reinforces a critical lesson echoed by Liao et al.: technological solutions must be paired with targeted capacity building and inclusive design to reduce, rather than deepen, structural inequalities in food systems. While policy frameworks and digital infrastructure create enabling conditions, the success of sustainable agriculture ultimately depends on effective, field-ready tools. Fenibo and Matambo address this dimension by providing a comprehensive synthesis of biopesticides within the contexts of green chemistry, One Health, and IPM. They emphasize that biopesticides comprise a diverse suite of microbial, biochemical, macrobial, and plant-incorporated solutions with complementary modes of action. This diversity is a strategic asset for resistance management, an urgent priority as conventional pesticides lose credibility among stakeholders and environmental advocates.

Beyond resistance control, biopesticides deliver broader agronomic and societal benefits by conserving beneficial organisms, improving soil health, and reducing human exposure to toxic residues, advancing productivity, sustainability, and public health simultaneously. The authors adopt a balanced perspective, noting limitations such as inconsistent field performance, narrow host ranges, regulatory complexity, and limited farmer awareness. Emphasis is placed on low-cost, low-tech options suited to smallholders, aligning biopesticide deployment with SDG-2′s inclusion goals. Innovation pathways (advanced formulations, smart delivery systems, and biological optimization) are identified as critical for improving reliability and scalability. This argument is illustrated by Chem et al.'s study on the diamondback moth (*Plutella xylostella*), a globally significant pest with high resistance potential. Their findings confirm the insecticidal efficacy of non-*Bacillus thuringiensis* bacterial strains, with strong synergistic effects observed in bacterial consortia. Mechanistic evidence, including midgut damage visualized via scanning electron microscopy, reinforces the viability of these organisms as practical solutions rather than experimental curiosities.

Collectively, these contributions demonstrate that biopesticides and organic fertilizers provide a viable pathway to strengthen food security and biodiversity while reducing reliance on synthetic pesticides. Realizing this potential, however, will depend on continued advances in formulation technologies, supported by coordinated policy reform, market incentives, capacity building, and locally adapted deployment strategies. Such efforts are essential to address variable field performance and the persistent regulatory, sociocultural, income disparity, and climate-related constraints that limit wider adoption. In biopesticide-driven sustainable agriculture, digital technologies are foundational, enabling precision, adaptive learning, monitoring, and system-level coordination that enhance both ecological integrity and productivity in support of SDG-2. When embedded within integrated pest management frameworks and reinforced by digital decision-support tools, biopesticides can reduce chemical inputs without compromising yield stability. Building on demonstrated progress, future research should prioritize formulation innovation to enhance efficacy across diverse agroecological contexts, optimization within IPM systems, digital alignment, and funding/government intervention models, while recognizing the broader relevance of biopesticides to One Health-oriented agricultural transitions.

Author contributions

EF: Conceptualization, Project administration, Validation, Writing – review & editing, Writing – original draft, Resources. AD: Conceptualization, Resources, Writing – review & editing, Writing – original draft, Validation. WT: Validation, Writing – review & editing, Writing – original draft. TM: Resources, Conceptualization, Writing – review & editing, Writing – original draft, Validation, Supervision.

Conflict of interest

The author(s) declared that this work 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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References

Ahmed, A., Siddig, E. E., and Mohamed, N. S. (2025). Arthropod-borne zoonotic parasitic diseases in Africa: existing burden, diversity, and the risk of re-emergence. *Parasitologia* 5:29. doi: 10.3390/parasitologia5030029

Chao, Z., Zhu, Z., and Li, Y. (2025). Spatial-temporal characteristics and influencing factors of farmland carbon emissions in Guangdong Province, China. *Front. Environ. Sci.* 12;1515571. doi: 10.3389/fenvs.2024.1515571

Fenibo, E. O., Christian, R., and Matambo, T. S. (2023). "Biopesticide commercialization in African countries: successful case studies," in *Development and Commercialization of Biopesticides*, ed. O. Koul (Academic Press), 297-328. doi: 10.1016/B978-0-323-95290-3.00006-6

Hiywotu, A. M. (2025). Advancing sustainable agriculture for goal 2: zero hunger-a comprehensive overview of practices, policies, and technologies. *Agroecol. Sust. Food Syst.* 49, 1027–1055. doi: 10.1080/21683565.2025.2451344

John, D. A., and Babu, G. R. (2021). Lessons from the aftermaths of green revolution on food system and health. *Front. Sust. Food Syst.* 5:644559. doi: 10.3389/fsufs.2021.644559

Khan, M. R., and Iqbal, S. (eds). (2026). "Harnessing Earth observation for sustainable agriculture: integrating research, technology, and decision support systems," in *Utilizing Earth Observation Data in Reaching Sustainable Development Goals*, (Amsterdam: Elsevier), 47-62. doi: 10.1016/B978-0-443-30204-6.00022-X