applied sciences

MDPI

Editorial

Plant Management and Soil Improvement in Specialty Crop Production

Xunfeng Chen [1,2,3,*] and Linchuan Fang [4,*]

[1] Biofuels Institute, School of Environment and Safety Engineering, Jiangsu University, Zhenjiang 212013, China
[2] School of Emergency Management, Jiangsu University, Zhenjiang 212013, China
[3] Engineering Research Center of Groundwater Pollution Control and Remediation, Ministry of Education of China, Beijing Normal University, Beijing 100875, China
[4] Key Laboratory of Green Utilization of Critical Non-Metallic Mineral Resources, Ministry of Education, Wuhan University of Technology, Wuhan 430070, China
* Correspondence: chenxunfeng1991@163.com (X.C.); flinc629@hotmail.com (L.F.)

Specialty crops, which include fruits, vegetables, nuts, and ornamental plants, play a crucial role in global agriculture and nutrition [1]. Unlike commodity crops, specialty crops often require more intensive management practices to optimize quality, yield, and economic viability. Central to the success of specialty crop production are effective plant management strategies and sustainable soil improvement techniques. As the demand for specialty crops continues to rise, the need for sustainable and efficient plant management practices becomes increasingly crucial [2]. In this editorial, we explore the current practices, challenges, and innovations in these areas, aiming to highlight the importance of integrated approaches for enhancing productivity while minimizing environmental impact.

1. Importance of Plant Management in Specialty Crop Production

Effective plant management encompasses a range of practices aimed at maximizing crop health, yield, and quality. In specialty crop production, where market demands often emphasize superior taste, appearance, and nutritional value, precise management strategies are essential. Integrated pest management (IPM) is a cornerstone of sustainable specialty crop production. By combining biological, cultural, physical, and chemical control tactics, IPM minimizes the use of synthetic pesticides while effectively managing pests and diseases. Techniques such as crop rotation, beneficial insect releases, and monitoring systems are integral to successful IPM programs [3]. Meanwhile, precision agriculture technologies, including GPS-guided machinery, remote sensing, and data analytics, offer precise insights into soil variability, crop health, and water management. These technologies enable farmers to optimize input use, reduce resource wastage, and enhance overall productivity [4]. Also, efficient water management is critical for specialty crop production, particularly in regions prone to water scarcity. Techniques such as drip irrigation, soil moisture sensors, and deficit irrigation strategies help conserve water while maintaining optimal crop growth and yield [5]. It is worth noting that specialty crops often have specific nutrient requirements for optimal growth and quality. Precision fertilization based on soil testing, tissue analysis, and nutrient modeling ensures that crops receive adequate nutrients without excess, resulting in reduced environmental impacts such as nutrient leaching and runoff [6].

Despite advancements, several challenges persist in plant management for specialty crops. Such specialty crops are susceptible to a wide range of pests and diseases, necessitating vigilant monitoring and rapid response strategies. Many specialty crops require labor-intensive management practices, which can be costly and challenging in regions with labor shortages. At the same time, high temperatures, overuse of antibiotics, altered precipitation patterns, and extreme weather events pose risks to crop production, necessitating adaptive management practices [7]. Fortunately, recent innovations are transforming plant management into specialty crop production. Advances in biological control agents, such as

check for updates

Citation: Chen, X.; Fang, L. Plant Management and Soil Improvement in Specialty Crop Production. *Appl. Sci.* **2024**, *14*, 5915. https://doi.org/10.3390/app14135915

Received: 20 June 2024
Accepted: 4 July 2024
Published: 6 July 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

predatory insects and microbial biopesticides, offer effective alternatives to conventional pesticides [8]. Breeding for disease resistance, drought tolerance, and improved nutritional profiles through genetic technologies is enhancing crop resilience and quality. Moreover, robotics and automation technologies are revolutionizing labor-intensive tasks such as harvesting and precision application of inputs, resulting in reduced costs and improved efficiency [9].

2. Soil-Improvement Strategies

Healthy soils are fundamental to sustainable specialty crop production, providing essential nutrients, water, and support for plant growth. Soil-improvement strategies aim to enhance soil health, fertility, and resilience to environmental stresses. Cover crops improve soil structure, suppress weeds, and enhance nutrient cycling through biomass incorporation [10]. Increasing soil organic matter content through composting, green manures, and crop residue management enhances soil fertility, water retention, and biological activity [11]. Adoption of soil health assessment tools and indicators helps farmers evaluate soil quality and make informed management decisions [12]. In addition, the use of nanomaterials for soil improvement and remediation is also a very effective and promising approach [13,14]. Reduced tillage and conservation tillage practices minimize soil disturbance, erosion, and carbon loss, preserving soil structure and biodiversity [15].

However, many challenges in soil improvement for specialty corps still remain. The process of balancing nutrient inputs to meet crop demand without causing environmental harm requires precise management and monitoring. Intensive rain events and sloped terrain can lead to soil erosion, necessitating erosion control measures. Heavy machinery and traffic can compact soils, reducing water infiltration and root growth. Increasing prevalence of nanoplastics could negatively impact agricultural production and soil health [16]. Meanwhile, innovative approaches are addressing these challenges and advancing soil improvement techniques. Biochar, a stable form of carbon produced from biomass, improves soil fertility, water holding capacity, and nutrient retention, which can be beneficial to soil improvement [17]. Application of beneficial microbes enhances nutrient availability, disease suppression, and overall soil health [18,19]. In addition, use of gypsum, lime, and other soil amendments corrects pH imbalances and enhances nutrient availability for specialty crops [20].

Effective plant management and soil improvement are critical for sustainable specialty crop production. Advances in integrated pest management, precision agriculture, and soil health enhancement are enhancing productivity while reducing environmental impacts. However, challenges such as pest pressures, labor intensity, and climate change require ongoing innovation and adaptation. By embracing technological advancements, biological control methods, and sustainable practices, growers can optimize crop quality and yield while safeguarding soil health for future generations. Going forward, ongoing new improvements in plant management and soil improvement will lead to more opportunities for accelerated development of specialty crop production.

Funding: This work was supported by the National Agricultural Science and Technology Major Project of China (No. NK202214030304), the National Natural Science Foundation of China (No. 62101216), and the Key Research and Development Program of Zhenjiang (No. SH2023105), and the Open Project Program of Engineering Research Center of Groundwater Pollution Control and Remediation, Ministry of Education of China (GW202406), and Special Research Project of Emergency Management School, Jiangsu University, China (KY-D-19).

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Vuppalapati, C. *Specialty Crops, in Specialty Crops for Climate Change Adaptation: Strategies for Enhanced Food Security by Using Machine Learning and Artificial Intelligence*; Vuppalapati, C., Ed.; Springer Nature: Cham, Switzerland, 2023; pp. 35–197.
2. Zhao, S.; Yue, C. Risk preferences of commodity crop producers and specialty crop producers: An application of prospect theory. *Agric. Econ.* **2020**, *51*, 359–372. [CrossRef]

3. Abrol, D.P. *Integrated Pest Management: Current Concepts and Ecological Perspective*; Academic Press: Cambridge, MA, USA, 2013.
4. Karunathilake, E.M.B.M.; Le, A.T.; Heo, S.; Chung, Y.S.; Mansoor, S. The path to smart farming: Innovations and opportunities in precision agriculture. *Agriculture* **2023**, *13*, 1593. [CrossRef]
5. Baligar, V.; Fageria, N.; He, Z. Nutrient use efficiency in plants. *Commun. Soil Sci. Plant Anal.* **2001**, *32*, 921–950. [CrossRef]
6. Williams, Z.F. *Evaluation of Sustainable Fertilizers on Soil Health and Yield of Specialty Crops Grown on the Delmarva Peninsula*; University of Maryland Eastern Shore: Princess Anne, MD, USA, 2021.
7. Hu, X.; Zhou, Q.; Luo, Y. Occurrence and source analysis of typical veterinary antibiotics in manure, soil, vegetables and groundwater from organic vegetable bases, northern China. *Environ. Pollut.* **2010**, *158*, 2992–2998. [CrossRef] [PubMed]
8. Dara, S.K. The new integrated pest management paradigm for the modern age. *J. Integr. Pest Manag.* **2019**, *10*, 12. [CrossRef]
9. Mahmud, M.S.A.; Abidin, M.S.Z.; Emmanuel, A.A.; Hasan, H.S. Robotics and automation in agriculture: Present and future applications. *Appl. Model. Simul.* **2020**, *4*, 130–140.
10. Wood, S.A.; Bowman, M. Large-scale farmer-led experiment demonstrates positive impact of cover crops on multiple soil health indicators. *Nat. Food* **2021**, *2*, 97–103. [CrossRef] [PubMed]
11. Shinde, R.; Shahi, D.K.; Mahapatra, P.; Singh, C.S.; Naik, S.K.; Thombare, N.; Singh, A.K. Management of crop residues with special reference to the on-farm utilization methods: A review. *Ind. Crops Prod.* **2022**, *181*, 114772. [CrossRef]
12. Guo, M. Soil health assessment and management: Recent development in science and practices. *Soil Syst.* **2021**, *5*, 61. [CrossRef]
13. Chen, X.; Chu, S.; Chi, Y.; Wang, J.; Wang, R.; You, Y.; Hayat, K.; Khalid, M.; Zhang, D.; Zhou, P.; et al. Unraveling the role of multi-walled carbon nanotubes in a corn-soil system: Plant growth, oxidative stress and heavy metal (loid) s behavior. *Plant Physiol. Biochem.* **2023**, *200*, 107802. [CrossRef] [PubMed]
14. Chen, X.; Wang, J.; Wang, R.; Zhang, D.; Chu, S.; Yang, X.; Hayat, K.; Fan, Z.; Cao, X.; Ok, Y.S.; et al. Insights into growth-promoting effect of nanomaterials: Using transcriptomics and metabolomics to reveal the molecular mechanisms of MWCNTs in enhancing hyperaccumulator under heavy metal (loid) s stress. *J. Hazard. Mater.* **2022**, *439*, 129640. [CrossRef] [PubMed]
15. Kopittke, P.M.; Menzies, N.W.; Wang, P.; McKenna, B.A.; Lombi, E. Soil and the intensification of agriculture for global food security. *Environ. Int.* **2019**, *132*, 105078. [CrossRef] [PubMed]
16. Shi, R.; Liu, W.; Lian, Y.; Wang, X.; Men, S.; Zeb, A.; Wang, Q.; Wang, J.; Li, J.; Zheng, Z.; et al. Toxicity mechanisms of nanoplastics on crop growth, interference of phyllosphere microbes, and evidence for foliar penetration and translocation. *Environ. Sci. Technol.* **2023**, *58*, 1010–1021. [CrossRef] [PubMed]
17. Brtnicky, M.; Datta, R.; Holatko, J.; Bielska, L.; Gusiatin, Z.M.; Kucerik, J.; Hammerschmiedt, T.; Danish, S.; Radziemska, M.; Mravcova, L.; et al. A critical review of the possible adverse effects of biochar in the soil environment. *Sci. Total Environ.* **2021**, *796*, 148756. [CrossRef] [PubMed]
18. Jansson, J.K.; Hofmockel, K.S. Soil microbiomes and climate change. *Nat. Rev. Microbiol.* **2020**, *18*, 35–46. [CrossRef] [PubMed]
19. Naz, M.; Dai, Z.; Hussain, S.; Tariq, M.; Danish, S.; Khan, I.U.; Qi, S.; Du, D. The soil pH and heavy metals revealed their impact on soil microbial community. *J. Environ. Manag.* **2022**, *321*, 115770. [CrossRef]
20. Bamdad, H.; Papari, S.; Lazarovits, G.; Berruti, F. Soil amendments for sustainable agriculture: Microbial organic fertilizers. *Soil Use Manag.* **2022**, *38*, 94–120. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.