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Editorial

Integration of Multi-Omics and Artificial Intelligence in Plant Sciences for Precision Agriculture

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The combination of multi-omics approaches-such as genomics, transcriptomics, proteomics, metabolomics, and phenomics-with artificial intelligence (AI) is transforming plant sciences and precision agriculture. This integration provides remarkable insights into plant biology, allowing researchers and agronomists to improve crop productivity, resilience, and sustainability in response to global climate challenges.

Multi-omics strategies provide a comprehensive understanding of plant growth, development, and stress responses at various molecular levels. However, the complexity and volume of omics data present significant analytical challenges. This is where artificial intelligence (AI), particularly machine learning (ML) and deep learning (DL), plays a transformative role. AI-driven models can process vast datasets, uncover hidden patterns, and accurately predict phenotypic outcomes. These insights facilitate targeted breeding programs, optimized resource management, and improved crop disease resistance

Recent advancements in AI-powered phenotyping platforms, including high-throughput imaging and sensor-based monitoring, significantly improve our ability to analyze plant traits in real time. AI-driven tools also enable the early detection of plant stress and disease outbreaks, allowing for proactive interventions and reducing yield losses. By integrating AI with crop models and climate forecasting, we can enhance precision agriculture, optimizing irrigation, fertilization, and pest management strategies.

Despite these promising developments, challenges still exist in harmonizing multi-omics datasets, ensuring data standardization, and developing explainable AI models. Additionally, ethical considerations and data privacy concerns must be addressed to promote transparency and responsible AI implementation in agriculture. Future research should concentrate on improving AI algorithms, integrating diverse data sources, and making these technologies accessible to farmers and researchers around the globe.

As the field continues to evolve, collaborations between plant biologists, data scientists, and agronomists will be essential for harnessing the full potential of AI and multi-omics in sustainable agriculture. This special issue examines recent advancements, challenges, and future directions in this rapidly growing area, offering a platform for cutting-edge research and innovative applications in plant sciences and precision agriculture.