



Synergizing Artificial Intelligence and Remote Sensing for Enhanced Crop Growth Parameter Estimation and Yield Prediction in Mediterranean Agroecosystems: A Systematic Literature Review

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The agricultural sector faces increasing pressure to meet global food demand due to population growth. Challenges such as climate change, resource scarcity, and environmental degradation will further increase this problem. These issues are particularly critical in the Mediterranean region, which is characterized by water-limited conditions and soils poor in organic matter and mineral nutrients. As a step toward ensuring food security, optimized resource utilization strategies and actionable plans for stakeholders are necessary. Reliable estimation of crop growth parameters and yield prediction under different climatic and agronomic scenarios have emerged as critical tools in driving these changes.

Various conventional crop growth parameter estimation and yield prediction methods have emerged as methods for optimizing resource utilization, identifying risks, and enabling effective decision-making. However, conventional methods, including empirical, statistical, and process-based models, often face limitations such as co-linearity among predictor variables, assumptions of stationarity, and the inability to capture complex biophysical and biochemical interactions at large scales. These shortcomings highlight the need for more robust and adaptable approaches. Advanced technologies, particularly Artificial Intelligence (AI) and Remote Sensing (RS) have revolutionized agriculture by uncovering hidden patterns, enabling large-scale monitoring, and improving prediction accuracy. This research evaluates the state-of-the-art in the synergized use of AI and RS for crop growth parameter estimation and yield prediction in Mediterranean agroecosystems.

A systematic literature review was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. Keywords and Boolean operators were used to search titles, abstracts, and keywords in selected databases, including Web of Science and Scopus. The review included English and French publications focusing on the Mediterranean region, encompassing Southern European, Middle Eastern, and North African countries bordering the Mediterranean Sea. Publications that were duplicated, unrelated to the study objectives, or outside the geographical focus were excluded. Out of 551 initial publications retrieved, 117 met the inclusion criteria and were selected for detailed review.

The findings reveal a rising interest in integrating AI and RS for estimating crop growth parameters

and predicting yield. Multispectral RS products, such as Landsat-8 and Sentinel-2, are the most frequently utilized data sources. Additionally, Sentinel-1 microwave sensors and Unmanned Aerial Vehicle (UAV)-based imagery are increasingly employed alongside ground-based sensors. Among AI methodologies, Machine Learning (ML) algorithms like Random Forest (RF), Artificial Neural Networks (ANN), and Support Vector Machines (SVM) dominate, while Deep Learning (DL) techniques such as Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks have gained prominence since 2020. Most publications were produced between 2020 and 2024, with Italy, Spain, and France being the most studied regions.

The study underscores the transformative potential of integrating AI and RS for crop growth parameter estimation and yield prediction in Mediterranean agroecosystems. By leveraging diverse data sources, algorithms, and sensor technologies, these advancements address the limitations of traditional models, enhance scalability and accuracy, and support sustainable agriculture in resource-limited environments.

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