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A Telemetry-Based Precision Agriculture System for the Sustainable Cultivation of *Stevia rebaudiana*

feka.a.maria@gmail.com
tsoukas.v1@gmail.com
kakarountas@dib.uth.gr
paikonom@uth.gr

Maria Feka, Panagiotis Oikonomou*, Vasileios Tsoukas, Athanasios Kakarountas

Department of Computer Science and Biomedical Informatics, Intelligent Systems Laboratory, University of Thessaly , Lamia, 35131, Greece

***Department of Informatics and Telecommunications, University of Thessaly, 3rd km Lamia – Athens, Lamia, 35100, Greece**

INTRODUCTION & AIM

The cultivation of *Stevia rebaudiana*, a plant of increasing nutritional and economic value, requires strict control of environmental conditions to ensure high leaf quality and glycoside content. The TELEMETRY project aims to develop a remote telemetry system for the precision monitoring of Stevia cultivation, enabling sustainable agricultural practices through real-time decision support.

METHOD

A telemetry network was established in *Stevia rebaudiana* fields (4 ha, Stevia Hellas Coop) using NB-IoT wireless sensors to monitor soil and microclimatic parameters (temperature, humidity, rainfall, soil moisture, CO_2, and light). Sensor data were transmitted to local LoRa/NB-IoT gateways, relayed to cloud-based storage, and visualized through a FastAPI web platform. A PostgreSQL database enabled automatic logging and processing of measurements collected from Feb 2024 – Mar 2025. A parallel manual dataset was used for sensor calibration and validation, ensuring uniformity across replicated plots. Data analysis included descriptive statistics, seasonal variation, and outlier detection. A PyTorch-based predictive model generated automated alerts for environmental deviations. The system achieved high reliability (≤ 6 % error) and supports sustainable, precision-driven Stevia cultivation.

RESULTS & DISCUSSION

Initial deployments confirmed the robustness of the telemetry system under real field conditions. Continuous sensor-based monitoring enabled early detection of disease-favoring microclimates (e.g., elevated dew point and humidity), allowing timely phytosanitary interventions. Comparison with manual measurements showed strong correlations ($R^2 > 0.9$) for soil temperature and moisture, validating sensor precision. Telemetry-guided irrigation scheduling resulted in significant water savings while maintaining optimal plant growth and yield. Seasonal data trends revealed that deviations in soil microclimate could be promptly identified and corrected through localized management actions. Overall, the integrated NB-IoT telemetry framework demonstrated high reliability, predictive capacity, and practical value for precision management and sustainable cultivation of *Stevia rebaudiana*.

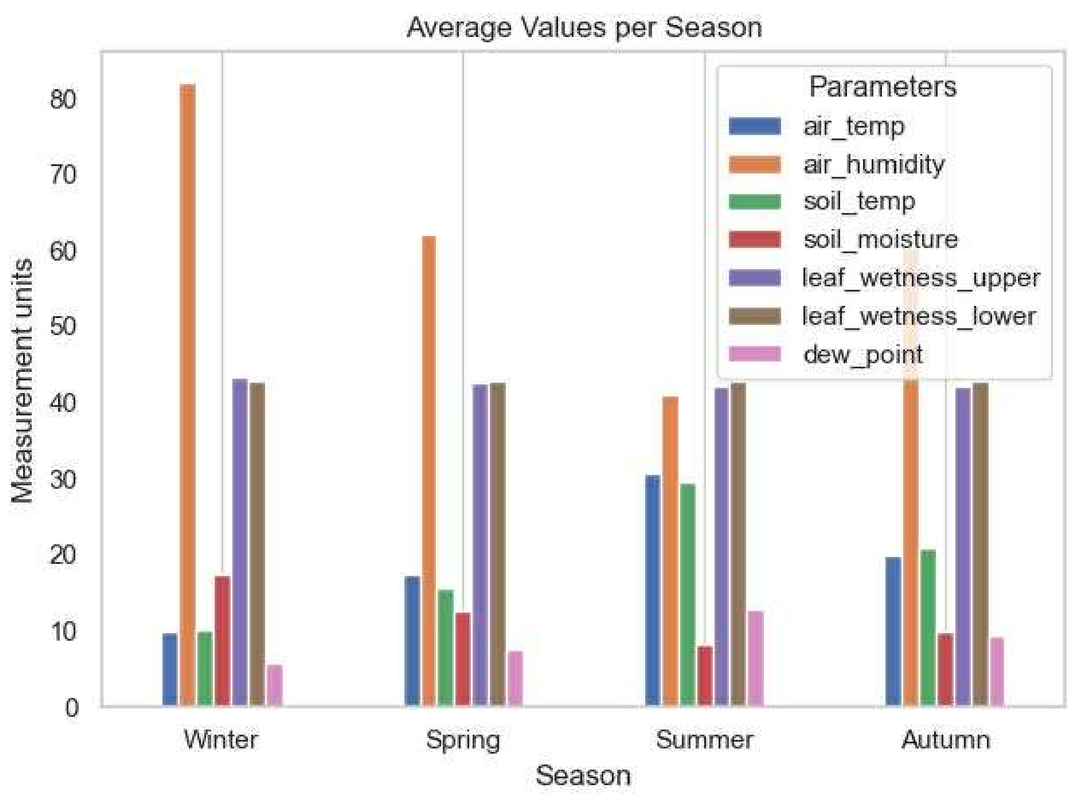

Fig. 1. Mean values of the parameters recorded by the NB-IoT telemetry system across four seasons (Spring, Summer, Autumn, Winter). Data illustrate clear seasonal variation and confirm the reliability and continuity of sensor performance under real cultivation conditions.

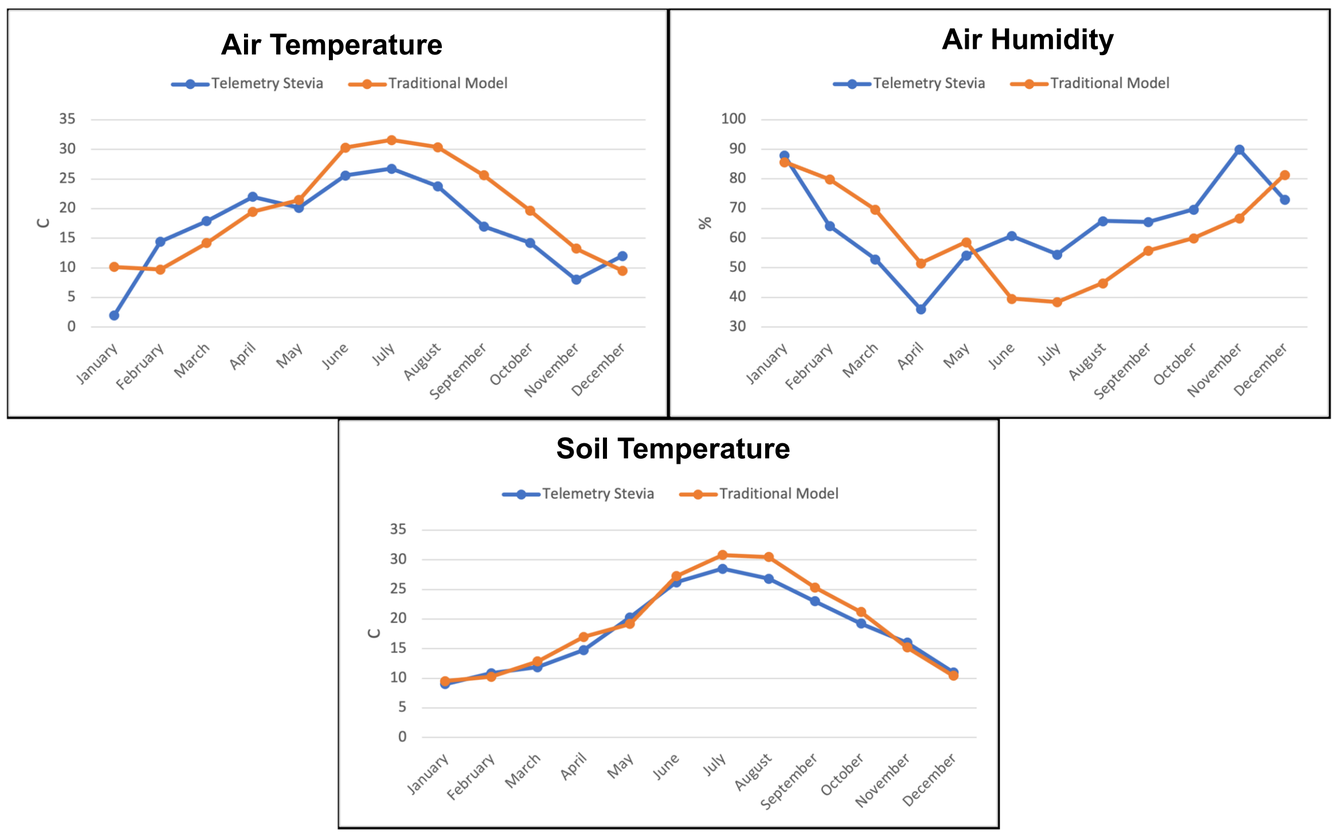

Fig. 2. Validation of telemetry sensor data against manual field measurements for air temperature and humidity and soil temperature. Strong correlation ($R^2 > 0.9$) confirms the precision and reliability of the monitoring system.

CONCLUSION

The NB-IoT telemetry system proved reliable and effective for real-time monitoring of *Stevia rebaudiana* cultivation. Continuous sensing and data analysis enabled timely irrigation and phytosanitary decisions, reducing water use while maintaining optimal plant growth. Integration of predictive alerts supports proactive management and sustainability. Overall, the system provides a scalable digital framework for precision and climate-smart stevia production.

FUTURE WORK

Future developments will focus on sensors for soil nutrients and canopy monitoring, enhancing predictive models for irrigation and disease alerts, and developing a mobile app interface. These upgrades aim to improve decision support and promote wider adoption of telemetry-based precision farming in *Stevia rebaudiana* cultivation.

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