AI-powered DSS for resource efficient nutrient, irrigation and microclimate management in greenhouses

Nora Ibáñez Otazua¹, María Blázquez Sánchez¹, Oscar Ruíz Yarritu¹, Idoia Unzueta Balmaseda¹, Aser Moreno Emborujo², Cristina Martín Andonregui², Jesús Oroya Villalta³

1. INIKA SISTEMAS, SL, Ribera de Aste 11, Edificio D1, Dpto 208, 48950 Erandio (Spain)
2. UNIVERSITY OF DEusto, Facultad de Ingeniería. Avda. Universidades, 24, 48007 Bilbao (Spain)

*Email of corresponding author: nihesa@inioka.com

INTRODUCTION & OBJECTIVE

- A primary challenge for the horticultural industry is to ensure high yield and product quality while using resources in an efficient and sustainable way. Decision Support Systems (DSS) are important tools to manage greenhouses and significantly affect resource efficiency and environmental impacts, but are not extensively used due to their complexity and lack of easy-to-use interfaces. Besides, greenhouses are complex dynamic non-linear systems with different simultaneous physical, chemical and biological processes and with different timescales, difficult to control with conventional control techniques. The overarching aim of the HortiMED H2020 PRIMA funded project is to improve resource efficiency in greenhouses through an innovative and easy-to-DSS supported by Artificial Intelligence (AI). HortiMED DSS integrates sensors, smart algorithms and efficient greenhouse control procedures, and applies AI techniques to deliver (i) expert advisory services to help farmers in intensive knowledge tasks where climatic, crop & nutrient variables decisively influence crop growth & productivity (e.g. precise water & fertilisers’ needs), and (ii) Cost-effective partial or full automation of greenhouses (e.g. fertigation, ventilation, heating).

- The target of the present study is to introduce the general architecture of HortiMED DSS in order to integrate all relevant variables in the decision making process moving from an input-intensive to a knowledge-intensive farming. HortiMED is implemented in three demonstrative greenhouses located in Spain, Algeria and Egypt representing High, Medium and Low Technology greenhouses, respectively; specific features and different data sources feeding the DSS of the High Technology Greenhouse (HTG) in Mefiaka, Bizkaia (Spain) are also presented. Finally, AI Hybrid Models are introduced.

MATERIALS & METHODS

- The HTG in Mefiaka is used for the cultivation of tomato (Solanum lycopersicum). The tomato is grown in a soil-less system consisting of expanded perlite substrate grow bags with drip irrigation. The cultivation area comprises two sectors of + 1.540 and 1.600 m² each; in each sector fertigation is controlled independently. Climate control system is operated by Sysclima (NTA Crop) which collects and stores in a SQ database data of several variables including, among others: (i) temperature (T) and (ii) relative humidity (RH) (inside greenhouse) and (iii) T (iv) RH, (v) radiation, (vi) wind speed and (vii) rain through a meteorological station located outside the greenhouse. Actuators for climate control inside the greenhouse include ventilation and shading systems. The heating system, composed of four pellet boilers located at different parts of the greenhouse, is automatically activated and/or deactivated based on the value of air temperature inside the greenhouse (the T set point is usually 12°C). Nutrient management is done through an autonomous fertigation system (Agronic 5000, Sistemas Electrónica Progr). Rainfall is measured by a rain gauge (Model 100, Darena) and a pH and an EC probe (Models HI3001 and HI3001, respectively, both from Hanna). In order to quantify the drainage water a prototype (not off-the-shelf) system was developed consisting of a PVC drain tray placed under the substrate bag to collect the excess irrigation water that flows through a drainage hole created in the lower part of the substrate bag (Figure 2). Complementarily, a reference measurement point was selected, where the drippers were removed from the substrate bag and placed inside a plastic tray so that the irrigation inflow could be measured with a rain gauge and the pH and EC could be monitored too to compare such values with those obtained in the drain trays 1-3. All sensors were connected to a data logger (TM221 Logic Controller from Schneider Electric) and data registered with a 10 minutes periodicity.

- Complementary sensors to those of Sysclima were deployed including: (i) a solar radiation sensor (Model 06350012, Progris), (ii) a T & RH probe (Model HMDBB, Vaisala) and (iii) a CO₂ probe (Model GM020, Vaisala). The T & RH probe was enclosed in an aluminium pipe of 120 mm diameter equipped with a fan (Model 8314U, Elnapap) in order to increase the accuracy of the measured values taken. The pipe was placed in a central position in the greenhouse, hanging from the roof at a distance of + 1 m from the floor (Figure 3). Likewise, 3 monitoring points for drainage water were selected (Drain tray 1, Drain tray 2 and Drain tray 3). Each drain was equipped with a rain gauge (Model 100, Darena) and a pH and an EC probe (Models HI3001 and HI3001, respectively, both from Hanna). In order to quantify the drainage water a prototype (not off-the-shelf) system was developed consisting of a PVC drain tray placed under the substrate bag to collect the excess irrigation water that flows through a drainage hole created in the lower part of the substrate bag (Figure 2). Complementarily, a reference measurement point was selected, where the drippers were removed from the substrate bag and placed inside a plastic tray so that the irrigation inflow could be measured with a rain gauge and the pH and EC could be monitored too to compare such values with those obtained in the drain trays 1-3. All sensors were connected to a data logger (TM221 Logic Controller from Schneider Electric) and data registered with a 10 minutes periodicity.

RESULTS

- The general architecture of HortiMED DSS has been introduced (Figure 3).
- The different data sources for the Mefiaka HTG have been described. In detail those include open data sources for meteorological data, manually collected data (and recorded in a digital FieldBook) and variety of IoT sensors comprising those of Sysclima and complementary sensors deployed in novel (prototype) systems specifically designed within HortiMED.
- Data collected are used to feed innovative AI hybrid models. AI hybrid models are capable to well describe the HTG system behaviour. Additional work aiming at the validation of HortiMED’s DSS is currently in progress, including the testing of different advanced control strategies to improve resource efficiency and circularity in HortiMED demonstrative greenhouses.

CONCLUSIONS

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Acknowledgments

The HortiMED project (Grant Number 1915) is part of the PRIMA Programme supported by the European Union. The contents of this poster are the sole responsibility of the consortium and the PRIMA Foundation is not responsible for any use that may be made of the information it contains.