Interreg
Greece-Italy
IR2MA
European Regional Development Fund

EUROPEAN UNION

University of Ioannina | HELLENIC REPUBLIC REGION OF EPIRUS | ISPA ISTITUTO DI SCIENZE DELLE PRODUZIONI ALIMENTARI | CIHEAM IAM BARI | CONSORZIO PER LA BONIFICA DELLA CAPITANATA | Regione Puglia

Interreg V- A
Greece-Italy
Programme
2014 2020

www.greece-italy.eu

IR2MA
Large Scale Irrigation Management Tools for Sustainable Water Management in Rural Areas and Protection of Receiving Aquatic Ecosystems

Subsidy Contract No: I1/2.3/27

WP 5

Deliverable 5.3.4

Applied research and demonstration activities on the improvement of irrigation scheduling for under cover crops

Project co-funded by
European Union, European Regional Development Funds (E.R.D.F.) and by National Funds of Greece and Italy

Front page back [intentionally left blank]

Interreg V- A Greece-Italy Programme 2014 2020

www.greece-italy.eu

IR2MA

Large Scale Irrigation Management Tools for Sustainable Water Management in Rural Areas and Protection of Receiving Aquatic Ecosystems

Subsidy Contract No: I1/2.3/27

Partners

PB1/LB UNIVERSITY OF IOANNINA - Research Committee (UoI) http://www.rc.uoi.gr/

PB2 REGION of EPIRUS (ROE) http://www.php.gov.gr/

PB3 ISTITUTO SCIENZE DELLE PRODUZIONI ALIMENTARI (ISPA/CNR) http://www.ispacnr.it/

PB4 CIHEAM - ISTITUTO AGRONOMICO MEDITERRANEO – BARI (IAMB) http://www.iamb.it/

PB5 CONSORZIO PER LA BONIFICA DELLA CAPITANATA (CBC) http://consorzio.fg.it/

Associated partners

REGION OF PUGLIA (ROP) http://www.regione.puglia.it/

Project co-funded by European Union, European Regional Development Funds (E.R.D.F.) and by National Funds of Greece and Italy

Notes

Deliverable 5.3.4

Applied research and demonstration activities on the improvement of irrigation scheduling for under cover crops

Report on performed activities and main results

Involved partners:

PB3 ISTITUTO SCIENZE DELLE PRODUZIONI ALIMENTARI (ISPA/CNR, Bari, Italy) http://www.ispacnr.it/

Authoring team:

Massimiliano D'Imperio, Angelo Parente, Vito Cantore, Francesca Boari, Francesco Fabiano Montesano

Bari, June 30 2021

IR2MA
Project co-funded by European Union, European Regional Development Funds (E.R.D.F.) and by National Funds of Greece and Italy

Project co-funded by European Union, European Regional Development Funds (E.R.D.F.) and by National Funds of Greece and Italy

Notes

Contents

Introduction 8
Smart irrigation 9
The GICK2 system for the rational control of irrigation in greenhouses**Errore. Il segnalibro non è definito.**
Demonstrative applications on soilless crops 13
Demonstrative applications on soil-bound crops 18
Conclusions 21
Synopsis in English language 22
Σύνοψη στην ελληνική γλώσσα 23
Sinossi in lingua italiana 24

Introduction

The importance of the greenhouse sector for the production of vegetable species for fresh consumption is increasing, especially in suitable areas such as the Mediterranean. It has been widely demonstrated that the production of greenhouse vegetables can significantly increase the use efficiency of input resources, primarily water, if proper tools and strategies are adopted for the rational management of the production process.

In this context, soilless cultivation deserves special mention, characterized by intensive cultivation systems, potentially with very high efficiency in the use of water and fertilizers. The most widespread form of soilless cultivation in the Mediterranean area is the open cycle, in which a fraction of the supplied water/nutrient solution is released into the environment as drainage (on average 20-30% of the water supplied, but in common practice it can reach values close to 50% in case of use of brackish water).

Rational setting of the irrigation schedule, reducing the drainage fraction to a minimum, in order to save water and fertilizers, avoiding waste and the release of fertilizing substances harmful to the environment, is of paramount importance (Massa et al., 2020).

Smart Irrigation

Among the different approaches proposed to improve the automatic management of irrigation in greenhouses, the one based on the use of dielectric sensors for real-time measurement of the water status in the root-zone has proved to be particularly promising, both in soil-bound or soilless cultivation conditions.

Reliable and cost-effective sensors are now available, suitable of combining the measurement of different parameters (volumetric water content, electrical conductivity and substrate temperature). Irrigation management using these sensors is based on constant monitoring of changes in water availability in the root-zone (portion of soil or growing media explored by roots), determined by the evapotranspiration of the crop, allowing automatic programming based on the real water needs of the plant.

With this approach, it is possible to reduce water consumption and significantly increase its use efficiency. Of no secondary importance is the possibility of reducing the drainage fraction to minimum values (<10%), with obvious repercussions on improving the environmental sustainability of the production process. On the other hand, empirical forms of irrigation management, such as that based on the use of a simple timer, are still widely adopted in low-tech greenhouses widespread in the Mediterranean area (Montesano et al., 2018).

As part of the international cooperation project (Interreg Greece-Italy 2014-2020) IR2MA (www.interregir2ma.eu), the CNR-ISPA of Bari carried out an activity that involved:

1) the design and construction of a prototype capable of acquiring data from a wireless sensor network, processing decisions and autonomously controlling irrigation;

2) the implementation of demonstrative tests aimed at acquiring scientific evidence on the benefits deriving from the application of this irrigation strategy on greenhouse horticultural crops.

In particular, tests were conducted both at the La Noria Experimental Farm of the CNR-ISPA in Mola di Bari (BA, Italy), and at commercial greenhouse farms focused on vegetables production located in the area of the project execution (Apulia region).

The common denominator of the tests was the comparison between the empirical management of irrigation, i.e. based on the use of timers with programming of the interventions carried out on the basis of the common practice or the personal experience of the operator, and the rational and automatic management based on the use of sensors.

The GICK2 system for the rational control of irrigation in greenhouses

The research group of the CNR-ISPA of Bari, in collaboration with Sysman Progetti & Servizi Srl, a company operating in the sector of digital technologies in agriculture, within the IR2MA project carried out an experimental activity aimed at setting up the system GICK2, evolution of the GICK system (Greenhouse Irrigation Control Kit) developed in the previous IRMA project concluded in 2015 (Montesano et al., 2018).

The 'upgrade' activity was aimed at
- updating the wireless transmission technologies used (LoRa)
- developing specific software functions aimed at increasing the versatility of use of the system, ensuring the possibility of integrating different irrigation management strategies .

A schematic representation of the GICK2 is provided in Figure 1.

Briefly, the system acquires data from wireless sensor networks, which "feed" a decision algorithm which, in turn, automates the irrigation of plants, resulting in “*on demand*” irrigation. Using the system's connection to the cloud, the operator can monitor the trends of the parameters of interest, and set and modify the irrigation strategy in real time. The "actuation" section allows the automatic management of devices (pumps, solenoid valves, ...) for the execution of the irrigation intervention.

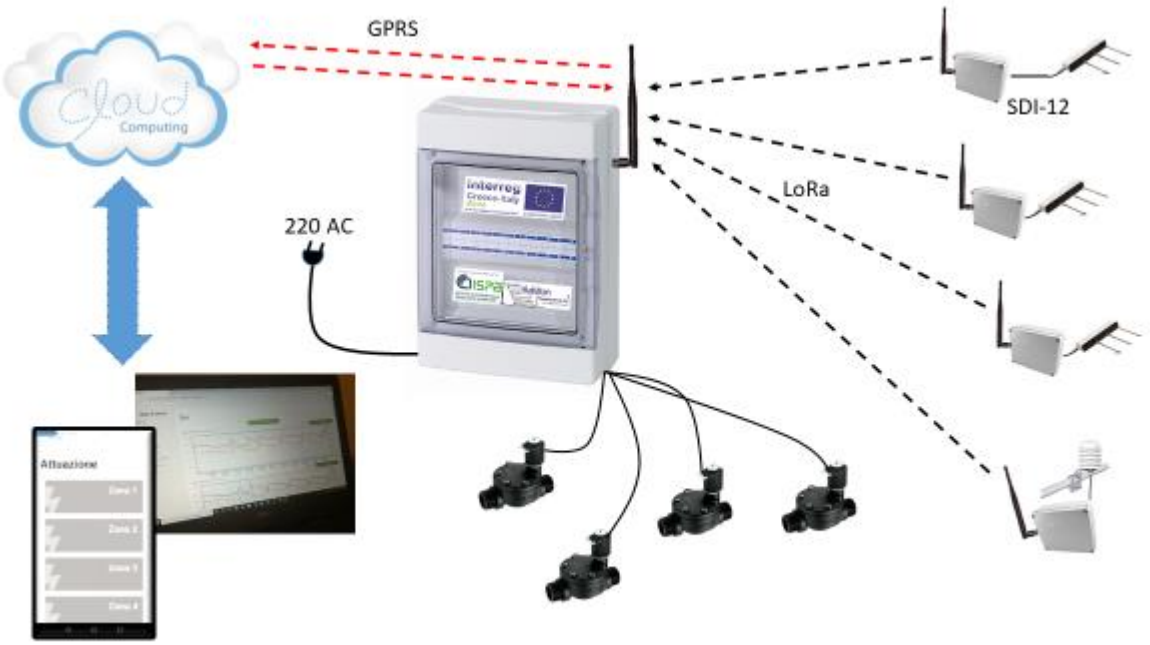

Figure 1: Representation of the GICK2 system for sensor-based irrigation management of greenhouse crops

Demonstrative applications on soilless crops

In the period **June - October 2018**, an experiment on **basil** took place at the La Noria Experimental Farm (Picture 1).

Plants of the ‘Gigante Classico Italiano' cultivar (Tesoro della Terra - Ingrosso Sementi di Francesco Fuscello, Andria) were grown in 2 L pots on a substrate based on peat and perlite in the ratio 3:1 by volume, added with Osmocote Bloom fertilizer at a dose of 2 g / L + Osmocote CalMag at a dose of 1 g / L (ICL - SF, Divisione Italia, Treviso). In one group of plants, irrigation was carried out using a timer, according to common practice. The others were irrigated with an automatic experimental system consisting of a CR1000 datalogger (Campbell Scientific, USA) programmed to continuously acquire the measurement of the substrate moisture carried out by GS3 sensors (Decagon Devices, USA) positioned inside the container (Picture 2), and to automatically activate irrigation according to moisture variations, keeping it constantly close to predetermined irrigation set-points, between values of 20 - 40% volumetric water content, corresponding to different levels of available water for plants.

Picture 1: Cultivation trial of basil at the Experimental Farm La Noria (June-October 2018).

Picture 2: Positioning of soil moisture sensors in a basil containerized culture.

The management of irrigation with the timer resulted in substrate moisture conditions constantly close to the maximum water retention capacity of the substrate, resulting in abundant drainage (> 30% of the water distributed) and consequently a high water consumption. The management of irrigation with sensors, on the other hand, made possible to keep the substrate volumetric water content constantly close to the irrigation thresholds defined by the established set points. When the humidity of the substrate was kept at values between 40 and 30%, in an interval defined as "easily available water", the plants at commercial maturity did not show significant differences between the treatments in comparison to the control managed with the timer, in terms of growth and physiological parameters, but an average **water saving of 42% was obtained**.

However, plants grown in conditions of sub-optimal water availability (<30% volumetric water content) showed a significant decrease in growth, confirming the importance of

proper choice of the irrigation set-point to be adopted in case of automatic management of irrigation based on sensors. The water use efficiency (fresh biomass produced per unit of water consumed) was on average equal to 16 g / L with the sensors, while the use of the timer reduced it by 57%.

Similar results were obtained in a **green bean** cultivation trial, held at the La Noria Experimental Farm in the period **June - October 2019** (Picture 3).

Green bean plants of the 'Maestrale' cultivar (Seminis - Monsanto Agricoltura Italia SpA) were grown in 4.5 L pots filled with a mixture of peat and perlite similar to that used for the basil test previously described, also added with a similar mixture of controlled release fertilizers.

Also in this case, with the same conditions of availability of water in the substrate, the use of the sensors has allowed a **water saving of about 36%** compared to the timer. The use of sensors and the irrigation set-point corresponding to the humidity level of the substrate highest among those tested (35% by volume) put the plants in optimal production conditions. The substantial water savings obtained through the use of sensors appears even more interesting in the face of a qualitative profile of the pods not dissimilar to that obtained with the traditional irrigation approach based on the use of the timer.

Picture 3: Cultivation trial of green bean at the Experimental Farm La Noria (June-October 2019).

In the period **August-December 2020**, sensor-based irrigation was applied on a **cherry tomato** cultivation trial at the Experimental farm La Noria, grown on perlite substrate (Picture 4).

Saline water (containing 1 g/L NaCl) was used, in order to simulate a common problem in Mediterranean area. However, it is important to outline that if irrigation is properly managed, the use of saline water could be of benefit for the quality of fruits. In this case, the GICK2 prototype system realized in the framework of IR2MA project was used. The treatments consisted in timer-based irrigation (the adjustment of the irrigation scheduling was applied on the periodic measurement of the drainage fraction, with a 50% as a target according to the common practice when saline water is used) compared with smart sensor-based irrigation operated by the GICK2 system. In this case, the irrigation strategy consisted in the automatic application of irrigation only when the volumetric water content in the substrate dropped below a predetermined set-point, resulting in *on-demand* irrigation. At each irrigation, the system checked the substrate EC measured real-time by sensors and decided between a low-leaching irrigation (<10% target) when substrate EC was <5dS/m, and a high-leaching irrigation (≈30% target) with rain water (with the aim to leach out salts in excess) when substrate EC was >5dS/m.

Sensor-based irrigation allowed for a **water saving of approximately 58% and a WUE increase of approximately 73%** compared with timer-based irrigation. Moreover, optimal irrigation management allowed to apply a controlled saline stress resulting in **improved fruit quality** (9.0 compared to 7.5% dry matter content and 7.8 compared to 6.8 °Bris total soluble solids content, on average, in sensor-based and timer-based treatment, respectively).

Picture 4: Cultivation trial of cherry tomato at the Experimental Farm La Noria (August-December 2020).

Demonstrative applications on soil-bound crops

In the period September - December 2019, a demonstration activity was carried out with the general objective of testing, in real cultivation conditions, the innovative smart technologies and strategies aimed at rationalizing the irrigation management of greenhouse horticultural crops. The test was carried out with the collaboration of the Consorzio per la Bonifica della Capitanata (Foggia), partner of the IR2MA project, within an agricultural company associated to the consortium and located in the countryside of Ascoli Satriano (FG).

The company management of irrigation, based on the operator's experience, was compared with two irrigation scheduling automation strategies: one based on the soil moisture measurements performed by a wireless sensor network set in the greenhouse, with automatic activation of the irrigation intervention when a certain critical moisture set-point defined on the basis of the hydrological characteristics of the soil was reached; another based on the calculation of evapotranspiration performed by the BluLeaf® system (www.bluleaf.it).

The GICK2 system (Picture 5) was installed inside the greenhouse which, during the trial period, housed a zucchini crop (cultivar 'Velvia', Syngenta), interfaced with both a wireless network of sensors for measuring soil moisture (SMT100, TRUEBNER GmbH, Germany), positioned in several points of the greenhouse at two depths (25 and 40 cm) (Pictures 6), and with the BluLeaf® system and the related micro-meteorological sensors functional to the calculation evapotranspiration. The GICK2 has been programmed to activate two solenoid valves serving two distinct crop plots, based on the two 'smart' irrigation strategies described above. The data obtained at the end of the cycle showed an average water saving of 38% compared to the total water supplied to the crop at the farm level, in the face of yield and qualitative results not different from the crop performance obtained with irrigation managed by the farmer’s experience.

Picture 5: The GICK2 system installed in a commercial greenhouse for demonstrative activities (September-December 2019).

Picture 6: sensors positioned at different depths in a zucchini crop cultivation.

Conclusions

The activities carried out have shown that the use of modern sensors for measuring the water status of the soil and the automatic management of irrigation is a viable and easily applicable approach even in low-tech greenhouses, those in which the greater is the margin to improve the use efficiency of water and fertilizers.

Further actions are needed to develop reliable technologies, easy to use and an affordable price. It is worthy to outline, however, that it will be important to put in place actions to establish an extended service to support the transition to more sustainable irrigation management approaches.

Synopsis in English language

The automatic management of irrigation based on the use of dielectric sensors for the measurement of soil/substrate parameters (moisture, electrical conductivity, temperature, matric potential) allows significant water savings and increases in water use efficiency. This is demonstrated by the results of the experimental and demonstrative activities conducted by CNR-ISPA on greenhouse horticultural crops of Mediterranean interest, in the framework of IR2MA project.

Sinossi in lingua italiana

La gestione automatica dell'irrigazione basata sull'utilizzo di sensori per la misura dello stato idrico del substrato consente significativi risparmi idrici e incrementi dell'efficienza d'uso dell'acqua. Lo dimostrano i risultati di alcune esperienze condotte in serra su colture orticole di interesse mediterraneo.

Back page inside part [intentionally left blank]

Interreg V- A Greece-Italy Programme 2014 2020

www.greece-italy.eu

IR2MA

Large Scale Irrigation Management Tools for Sustainable Water Management in Rural Areas and Protection of Receiving Aquatic Ecosystems

Subsidy Contract No: I1/2.3/27

Project co-funded by European Union, European Regional Development Funds (E.R.D.F.) and by National Funds of Greece and Italy