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Evaluation of an operational participatory system for irrigation recommendations - Case study for kiwifruit crop in Greece

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Cultivation of kiwifruit (*Actinidia deliciosa*) is of major interest for the plain of Arta (Region of Epirus / NW Greece). The crop covers about 1.200 ha, most of which regard the variety 'Hayward' (OPEKEPE, 2016).

Kiwifruit crop has high irrigation water requirements when cultivated in Mediterranean regions, while it is easily susceptible to water stress (Dichio et al., 2013; Torres-Ruiz et al., 2016).

This study presents the evaluation of a web-based participatory system for irrigation management when used for the case of kiwifruit orchards.

MATERIALS AND METHODS

Evaluation for three irrigation periods: 2016, 2017 and 2018 (from 1/4 up to 30/9)

Commercial 1,3 ha orchard of kiwifruit 'Hayward'(Clone 8) located at the plain of Arta, Region of Epirus, Greece

39º06'09''N, 20º59'14''E (WGS84), 15m height

Soil: silt loam type

Vines: 5 years old in 2016
spaced 2.5 x 5 m (distance between vines on the row x distance between rows) and trained to a pergola type structure of 1.9 m height

Irrigation: one micro-sprinkler of 90 Lh^{-1} per plant

Irrigation recommendations for the orchard were generated using a web-based participatory system for irrigation management (http://arta.interregir2ma.eu/, the system hereafter) that covers 46432.5 ha at the plain of Arta.

The system, provides real time forecasts for soil moisture and generates recommendations for future irrigation applications, based on the outcomes of a water balance model that follows the principles of FAO's paper 56 (Allen et al., 1998).

The model takes into account (Malamos et al., 2016):
a) measurements of weather parameters from agro-meteorological stations in the area
b) soil, crop and irrigation system parameters
c) time and volume of the actual irrigation applications
d) weather data forecasting

Parameters for modeling the specific orchard:
- irrigated area: 0.65 ha
- soil moisture at saturation (S): 0.43 (v/v); field capacity (FC): 0.24 (v/v); permanent wilting point (PWP) (v/v): 0.16
- maximum root depth: 0.65 m
- maximum allowable depletion of the available soil moisture (MAD): 0.33
- length of growth stages (initial, crop-development, mid-season, late-season) starting from March 16th: 23, 86, 120 and 45 days respectively
- Kc for the growth stages (Kc_{ini}, Kc_{mid}, Kc_{end}): 0.38, 1.1 and 1.1
- irrigation system efficiency: 0.65
- irrigation optimization factor (IRT) = 0.5 to 1 (IRT=1 meant that the goal of each irrigation recommendation was to refill soil moisture up to the field capacity) .

The grower had access to the system and received recommendations but he was allowed to follow his own decisions regarding irrigation applications.
All the irrigation applications that have been actually performed were manually registered to the system.

MEASUREMENTS

Soil moisture: dielectric capacitance sensors (type 10HS, METER Group, Inc. USA, accuracy ±0.03 $m^3 m^{-3}$) at a depth of 15 and 30 cm. Soil moisture was consider uniform through the whole soil depth under consideration

Water usage by the irrigation system: 25mm volumetric dry dial water meters (type DS-TRP, Madalena S.P.A., Italy, accuracy 1L)

RESULTS, DISCUSSION, CONCLUSIONS

For the evaluation of the system:
a) the system's model was applied during the irrigation period using the actual irrigation applications and the soil moisture that was generated by the system's model was compared against the monitored soil moisture using Mean Bias Error (MBE, %), Mean Absolute Error (MAE, %) and Root Mean Square Error (RMSE, %)
b) the actual number of irrigation applications and the relevant water depth (mm) were compared against the relevant values that were recommended by the system's model for IRT = 0.5 and 1 as well as for the optimum IRT value. The optimum IRT value was considered to be the one that did not allowed soil water stress to be developed (water stress coefficient Ks = 1).

Figure 1 presents the water balance parameters (effective rainfall, irrigation applications, soil moisture levels (FC, MAD and PWP) and the variation of the monitored soil moisture and the variation of soil moisture as calculated by the system's model during the irrigation period of 2018.

Table 1 presents the yield, the evaluation indices for the comparison of the soil moisture that was generated by the system's model against the monitored soil moisture at the orchard, the number of irrigation applications and the relevant water depths that were actually applied by the grower as well as those that were generated by the system's model for the case of IRT=1.

The evaluation indices MBE, MAE and RMSE ranged from -7.1 to 0.2%, 3.2 to 7.3% and 3.9 to 5.1% for the irrigation periods of 2016, 2017 and 2018 (Table 1).

The number of irrigation applications that were recommended by the system for IRT = 1 was significantly lower than what was actually performed by the grower for all the irrigation periods under consideration (Table 1) while the relevant amount of irrigation water was up to 74% less (Table 1).

Figure 2. The optimum IRT for 2018 was found to be equal to 0.943. For this IRT value the system's model would recommend 25 irrigation applications and 694 mm of water to be applied.

The results are very promising regarding the ability of the system's model to reflect the soil moisture at the field. The evaluation revealed the potentials of the system to contribute to water, energy and labour savings.

Literature cited

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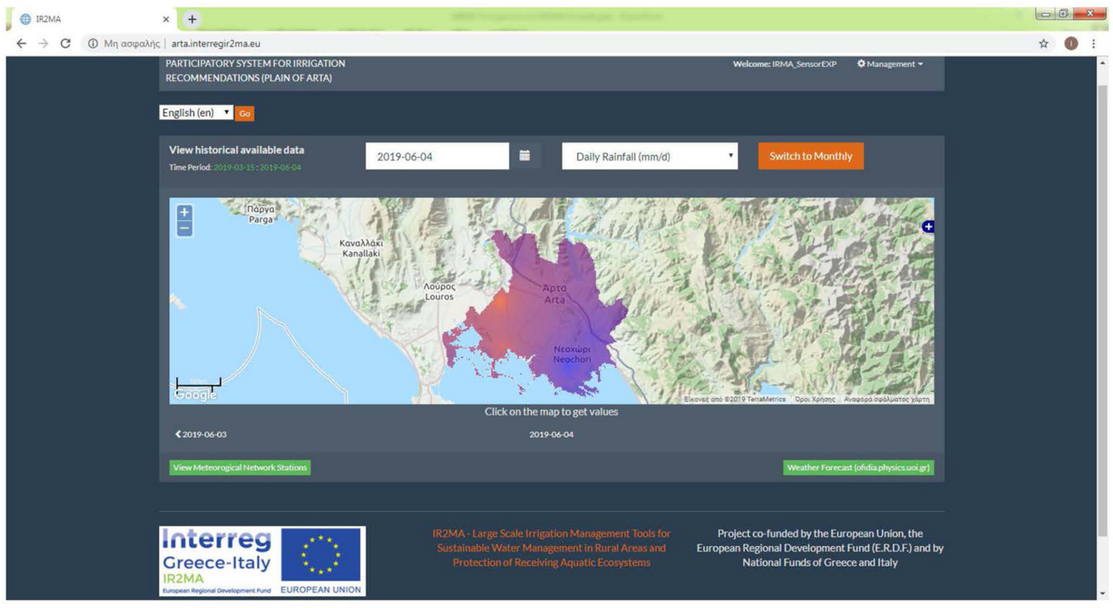
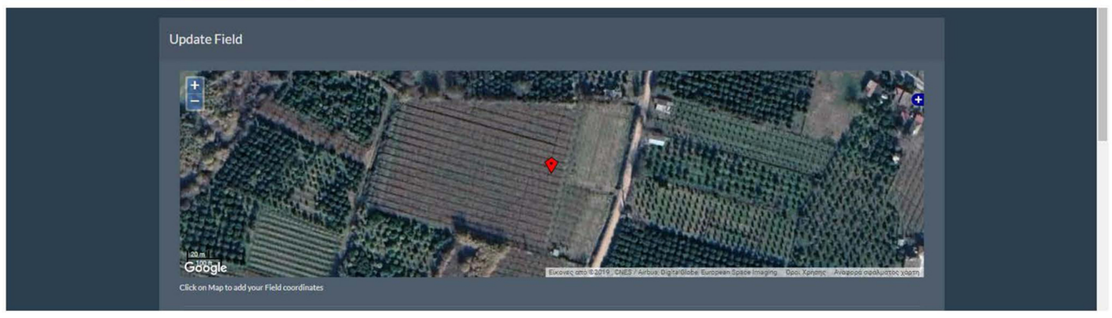
TYPICAL SCREENSHOTS OF THE SYSTEM





Scan the QRcode to connect to http://arta.interregir2ma.eu/

EVALUATION FIGURES AND TABLES

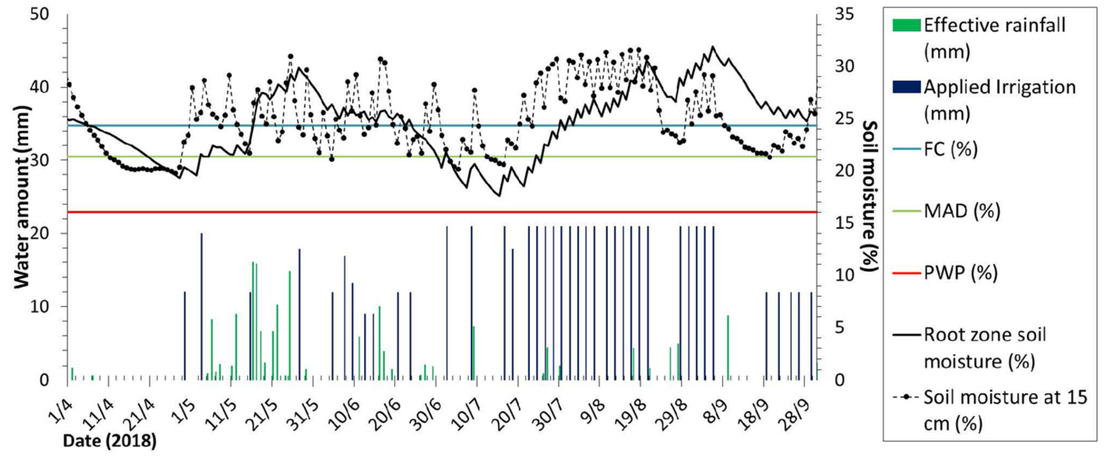


Figure 1. Monitored soil moisture and soil moisture generated by the system's model for 2018, based on actual irrigation applications and effective rain

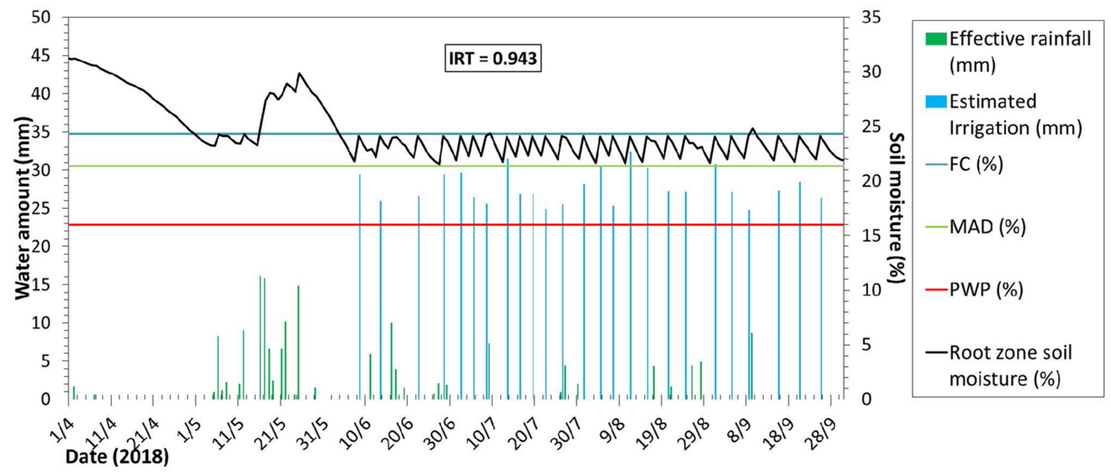


Figure 2. Recommended irrigation applications and soil moisture generated by the system's model for 2018, for IRT = 0.943 (optimum value)

Table 1. Comparison of evaluation indices for the irrigation periods 2016, 2017 and 2018.

		Model error			Irrigation water amount (mm)		Number of irrigation applications	
Year	Yield (t ha^{-1})	MBE (%)	MAE (%)	RMSE (%)	Grower's practice	Recommended (IRT =1)	Grower's practice	Recommended (IRT =1)
2016	13.8	-7.1	7.2	3.9	857	645	58	28
2017	22.6	0.2	3.2	5.1	1497	861	104	39
2018	54.6	-0.2	3.3	4	704	703	40	24

ACKNOWLEDGEMENTS
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