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Efficient Irrigation Management Tools for Agricultural Cultivations and Urban Landscapes

IRMA

WP5, Action 5

Deliverable 5.5.2. Case studies report

Upgrade of the web based irrigation management system - Testing of the Bluleaf DSS

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Upgrade of the web based irrigation management system - Testing of the Bluleaf DSS

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WP5, Action 5

Deliverable 5.5.2 Case studies report

Upgrade of the web based irrigation management system - Testing of the Bluleaf DSS

Involved partners:

ROP - Regione di Puglia

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Efficient Irrigation Management Tools for Agricultural Cultivations and Urban Landscapes (IRMA)

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INTRODUCTION

In the framework of the IRMA project, it has been experienced the integration (among the website services) of the **software "Bluleaf“** (www.bluleaf.it) (Fig. 1), a new **decision support system for irrigation management**, developed as a result of the “Hydrotech” project, recently promoted by a private-public partnership involving Sysman P&S, the Mediterranean Agronomic Institute of Bari and the CNR-ISPA Institute, and financed by the Apulia Region (www.hydrotech-project.it).

The BluLeaf DSS is composed by the following hardware e software components:

a) a **soil water balance module** based on FAO-56 approach, for the calculation of the daily crop water balance of each farm plot, based on available measured **climatic data** (e.g data provided by the ASSOCODIPUGLIA regional agro-meteorological Network), and further improved for the management of deficit irrigation strategies (based on crop sensitivity in different phenological stages);

b) **sensors** for the continuous monitoring of soil moisture at various depths (to be used for both real-time monitoring and model calibration);

c) a software tool for **multi-plot irrigation planning** and optimization, based on weather forecast, irrigation strategies and possible water/management constraints;

d) a software application for ***mobile devices*** (tablet, smartphones) to allow on-field accessibility to DSS functions and data;

e) hardware components to allow for **remote control** of the irrigation system (valves, hydrants, pumps, etc.).

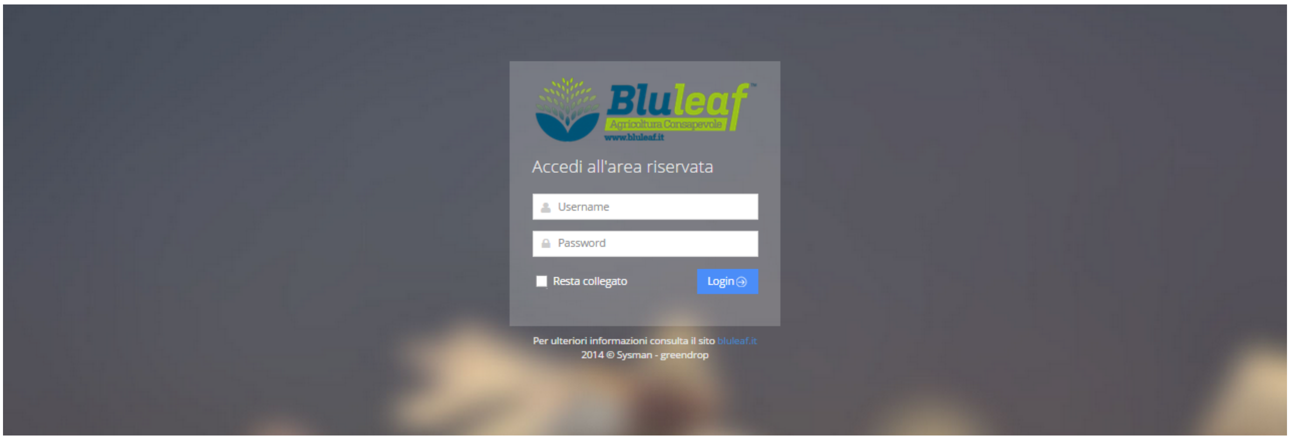


Fig. 1 – ***Screenshot of the reserved access area of the BLULEAF DSS web version, requiring a specific username and password to access the specific software tools. In the framework of the IRMA project, a link to the DSS has been inserted in the ASSOCODIPUGLIA website, and a selected group of users has been allowed to access the software for testing purposes***

Notes

FARM TESTING OF THE DSS

In collaboration with the Sysman company, ASSOCODIPUGLIA has tested the adoption of BLULEAF DSS in a selected group of pilot farms located at the regional scale. The main **technical and practical objectives** of the testing activity were:

- To test the connection of the ASSOCODIPUGLIA agro-meteorological station network with the BLULEAF climatic database;
- To evaluate the quality, the continuity and the reliability of the climatic data to be used for evapotranspiration estimation and water balance calculation;
- To test the application of the BLULEAF DSS in different pedoclimatic environments and with a different set of crops;
- To compare the irrigation scheduled with the BLULEAF DSS with the current strategy of the farmer (in terms of irrigation frequency and volumes);
- To receive observations from final users (farmers, technicians, consultants) about the potential usefulness of the DSS in the day-by-day practical use in farm management.

In the following table, the **list of the testing farms** is reported with their location, the most relevant crops and the name of the closest ASSOCODIPUGLIA meteo station. In the next pages, the **results of three relevant case studies** (Moccari, Amastuola and Syngenta farms) are described.

Table 1 – List of the farms selected for the testing activity of the BLULEAF DSS in the framework of the IRMA project.

Farm name	**Location**	**ASSOCODIPUGLIA Station name**	**Main crops**
Conti Zecca	Leverano (province of Lecce)	OPU40	Wine grape
Serini	Ginosa (province of Taranto)	OPU58	Table grape
Amastuola	Massafra (province of Taranto)	OPU46	Wine grape
Moccari	Mesagne (province of Brindisi)	OPU33	Peach, olives
Borracci	Rutigliano (province of Bari)	OPU27 – 0PU30	Table grape
Gigante	Conversano (province of Bari)	OPU52	Cherries, olives
Sempreverde	Molfetta – Terlizzi (province of Bari)	OPU19	Vegetables, potato
Syngenta exp. farm	Foggia	OPU38	Tomato

Case study 1 – Moccari Farm (Mesagne - BR)

In the Moccari farm (Mesagne – province of Brindisi) with about 80 hectares of extension, and producing high quality **fruits** (peaches, apricots, etc.), the testing process of Bluleaf yet started in 2013 with the calibration/validation on a peach orchard, and it has been extended in 2015 to consider up to 30 different combinations of crops/varieties. Daily **meteorological data** have been provided by the closest station of the ASSOCODIPUGLIA network (in this specific case hosted exactly within the farm area, Fig. 2), while soil properties have been defined with a field survey and the available laboratory analysis.

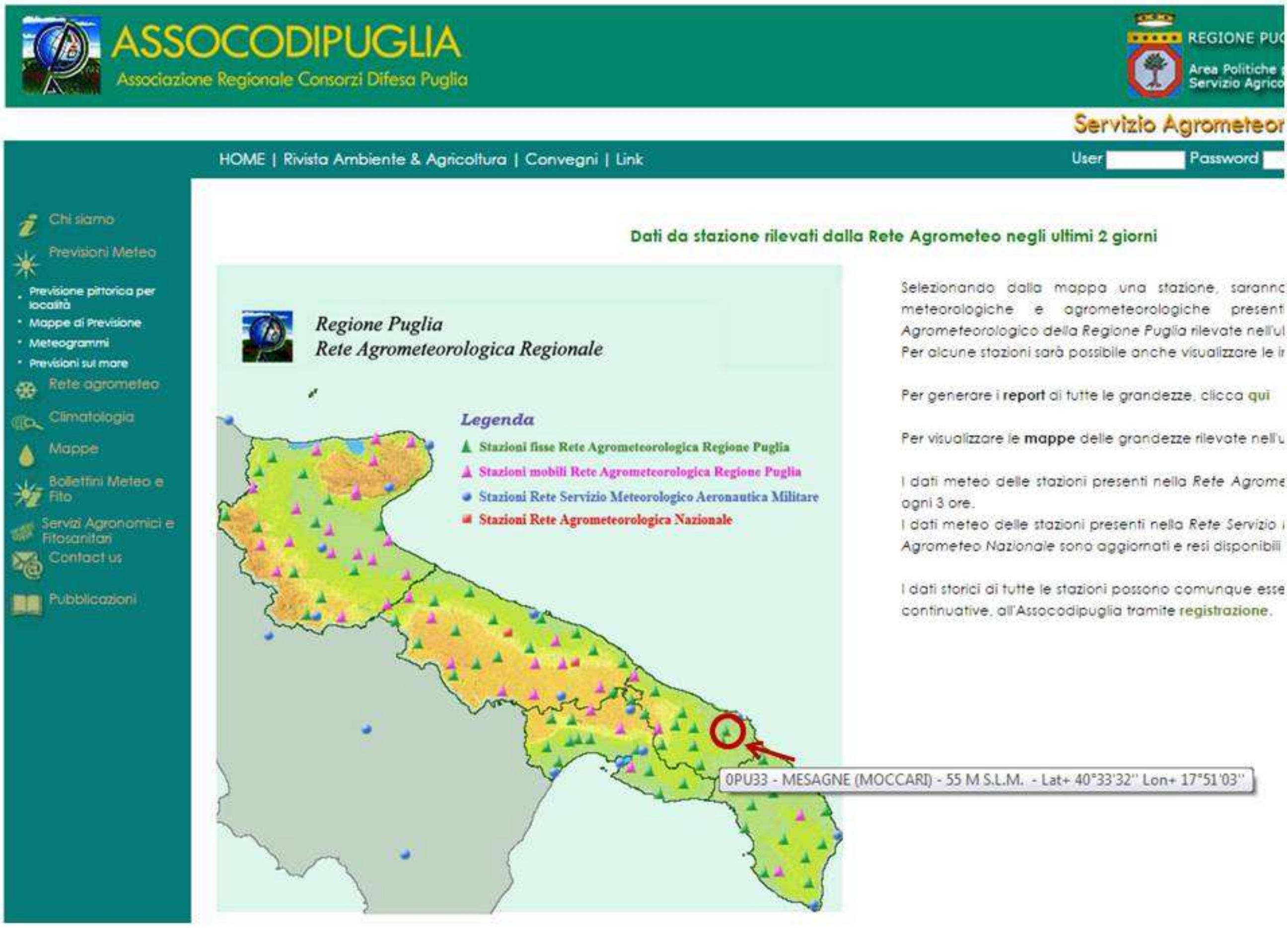
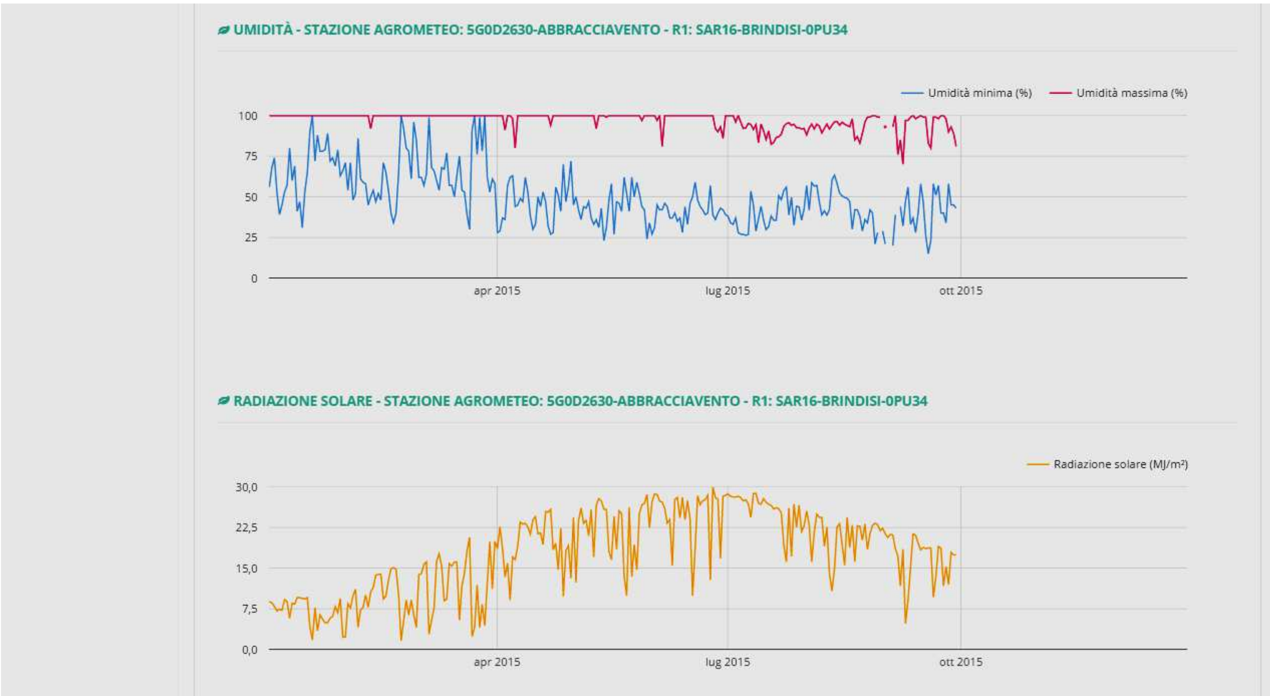


Fig. 2 – Map of the regional network of the ASSOCODIPUGLIA agro-meteorological field stations, with the specific location of the 'MOCCARI' station (OPU 33) in Mesagne (province of Brindisi)

'Raw' climatic data have been continuously acquired in the BLULEAF database and an appropriate post-processing has been programmed to obtain daily values of rainfall, minimum and maximum air temperature, relative humidity, solar radiation, wind speed (with all variable referred to the standard 2 m height). The test of the connection of the MOCCARI (OPU33) agro-meteorological station with the BLULEAF climatic database has provided good results in terms of the quality, the continuity and the reliability of the measured climatic data (Fig. 3), that have been used for the daily estimation of reference evapotranspiration at the local scale and the water balance calculation at the plot scale.


Dashboard
Pozzo 1 - Arboree
AB9-primitivo
AB13-leccino
AB3-albicocco medio-tard
AB5-albicocco-precoce
AB10-susino
AB21-susino
Pozzo1-Pesco
Pozzo1-ortive
Archivio
Oggetti aziendali
Amministrazione
Italiano
abbracciavento
AB9-primitivo Vite da vino
IRRIGest
Scenario
FERTIGest
Registro trattamenti
Registro fenologico
Dati meteo
Parametri Biosistema
Gestione irrigazioni
PIOGGIA - STAZIONE AGROMETEO: 5G0D2630-ABBRACCIAVENTO - R1: SAR16-BRINDISI-0PU34
Pioggia (mm)
60
45
30
15
0
apr 2015
lug 2015
ott 2015
TEMPERATURA - STAZIONE AGROMETEO: 5G0D2630-ABBRACCIAVENTO - R1: SAR16-BRINDISI-0PU34
Temperatura minima (°C)
Temperatura massima (°C)
45
30
15
0
-15
apr 2015
lug 2015
ott 2015


UMIDITÀ - STAZIONE AGROMETEO: 5G0D2630-ABBRACCIAVENTO - R1: SAR16-BRINDISI-0PU34
Umidità minima (%)
Umidità massima (%)
100
75
50
25
0
apr 2015
lug 2015
ott 2015
RADIAZIONE SOLARE - STAZIONE AGROMETEO: 5G0D2630-ABBRACCIAVENTO - R1: SAR16-BRINDISI-0PU34
Radiazione solare (MJ/m²)
30,0
22,5
15,0
7,5
0,0
apr 2015
lug 2015
ott 2015

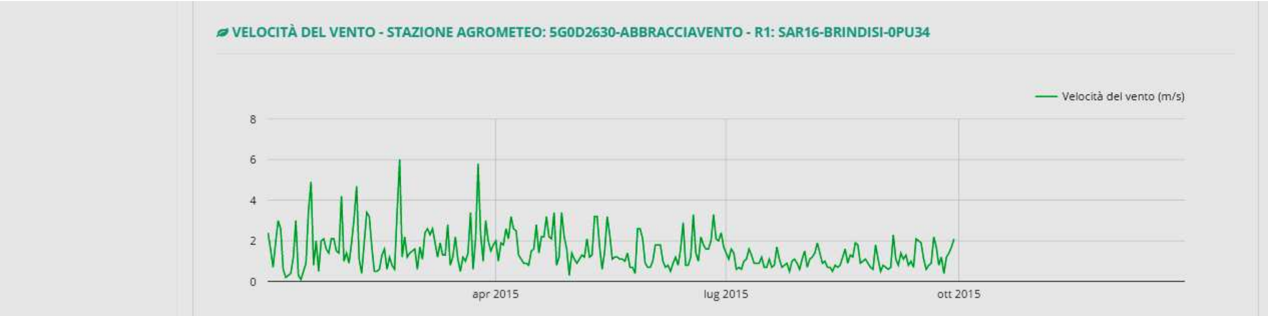


Fig. 3 – Graphs of the daily values of the main climatic variables recorded at the 'MOCCARI' meteorological station during the testing activity (year 2015), as displayed in the BLULEAF web software

In this farm, the complexity of the irrigation management is related with the very **different types of orchard cropping systems** (in terms of different varieties, plant density and age), together with the usually 'unclear' relationship between water regime and yield/quality for each crop/variety combination. The DSS has supported the **'multi-plot' irrigation management** Fig. 4) following the daily water balance of each plot, trying to consider the differences among them by selecting appropriate model parameters, and by using information about the crops' phenological development (updated directly by the end-user using the *mobile* application) to set specific irrigation strategies for each variety and phenological stage (Fig. 5), in order to manage 'flexible' irrigation priorities among plots during periods of high water demand but limited availability at the source.

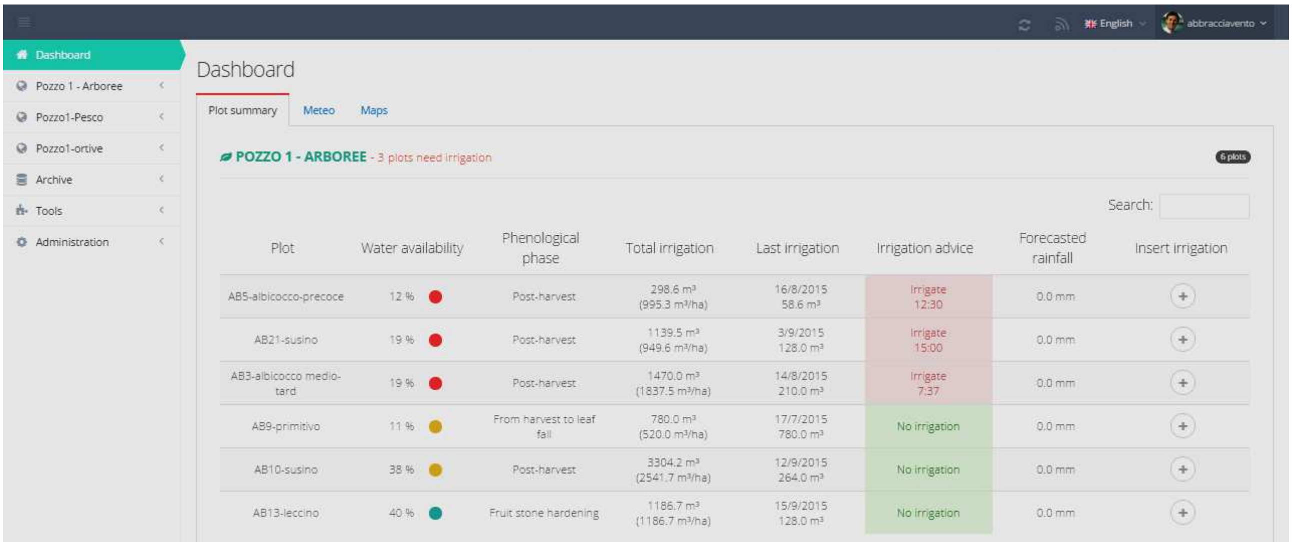


Fig. 4 – The BLULEAF 'dashboard' for the Moccari farm, showing (partially) a quick summary of plot status, with water availability, phenological phase, total irrigation applied, last irrigation event, irrigation advice and forecasted rainfall (forthcoming 3 days)

As an example, in tab. 2 a summary is reported concerning the irrigations scheduled by the DSS for some selected **peach plots** of the Moccari farm in 2014. The plots differ one another in terms of variety type (earliness, leaf/stem development), age of plantation, plant density, etc. The effect of these factors has been considered by selecting variable levels of the **Kc value** for the mid-season stage (that has to be related with the effective percentage of ground cover). Data from the table show clearly the **wide variation** of the total irrigations scheduled in 2014, going from **900 m^3 ha^{-1}** in the case of a 1-year medium-maturing variety (plot n. 15) to **4,200 m^3 ha^{-1}** in the case of a 10-years old late maturing one (plot n.7). For practical purposes, the application of the DSS in this farm has confirmed its reliability and flexibility in relation to the contemporary management of different crops/varieties, although an important technical effort is required because the configuration of numerous plots requires the appropriate selection of 'critical' **crop/soil parameters** for a more reliable simulation of the DSS, and the process of parameter selection could be further improved if additional field observations and/or data from crop/soil sensors will be included.

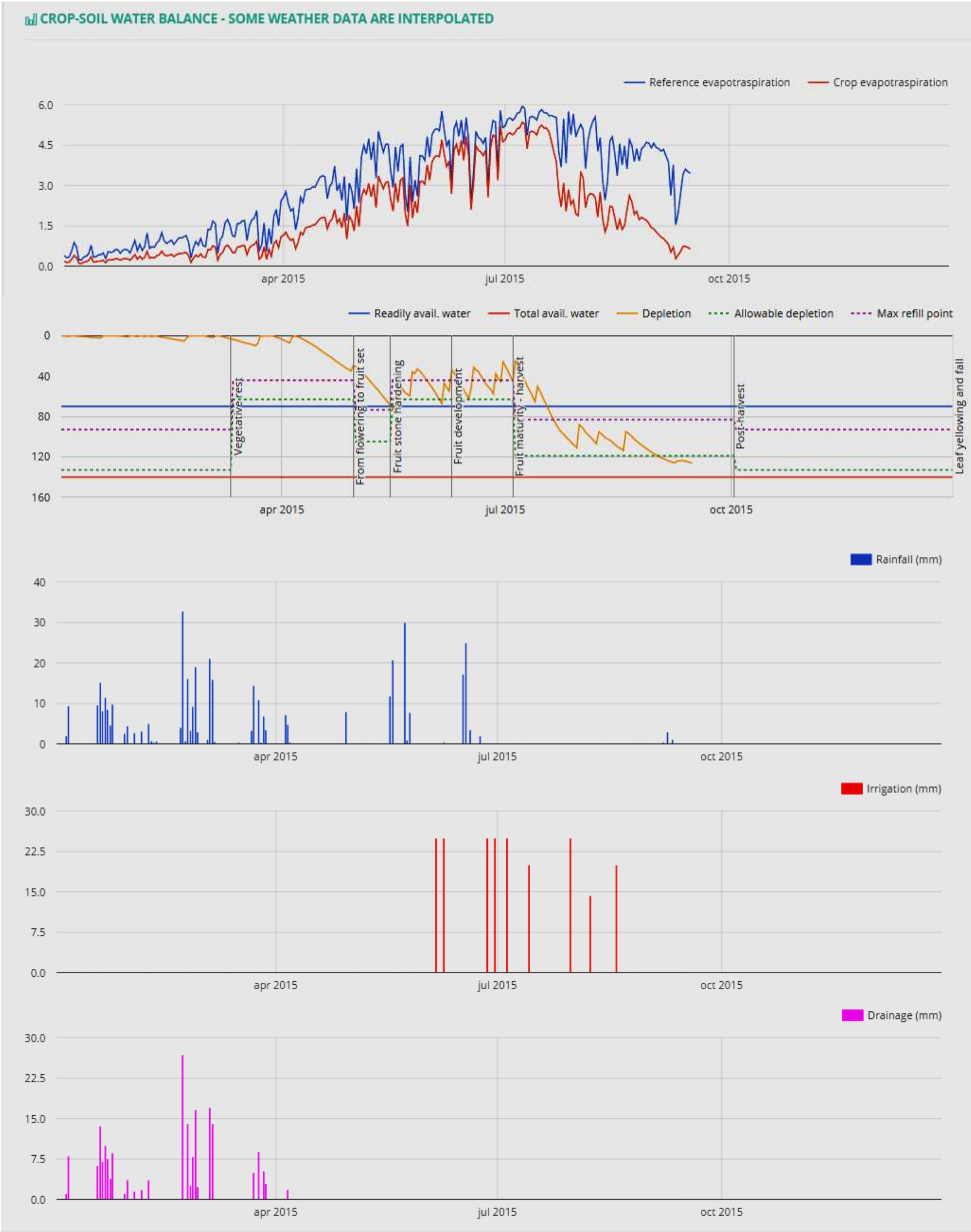


Fig. 5 – ***An example of application of deficit irrigation strategy by Moccari farm supported by BluLeaf DSS (current year 2015, medium-maturing peach variety). From top to bottom, the water balance components of a single irrigated plot: reference and crop ET; soil water depletion (with variable thresholds of maximum allowable depletion based on phenological stages); rainfall regime; irrigations; drainage. (All values in mm)***

Table 2 – Results of the irrigations scheduled with the support of BLULEAF DSS for different peach orchards (in terms of variety, age of plantation, density, etc.) (Moccari farm, year 2014).

Plot n.	Variety type	Age of the orchard (years)	Plant density (plants/ha)	Selected Kc-mid	Total irrigation events (n.)	Total irrigation volumes (m3/ha)
22	Very early	3	670	0.75	7	1450
16	Early	13	700	1.05	14	2950
2	Medium	3	445	0.7	14	2950
15	Medium	1	500	0.6	6	900
7	Late	10	625	1.0	20	4200
8	Very late	7	444	0.9	18	3800

Case study 2 – Amastuola Farm (Massafra - TA)

Similarly to the Moccari farm, in the Amastuola farm (Massafra – province of Taranto) the testing process of Bluleaf yet started in 2013 with the calibration/validation of the DSS on three **wine grape** plots, and it has been extended in 2015 to consider up to 23 different irrigated plots, with a corresponding number of about 10 different wine-grape varieties. Daily **meteorological data** have been provided by the closest station of the ASSOCODIPUGLIA network (Fig. 6), while soil properties have been defined with a field survey and the available laboratory analysis.

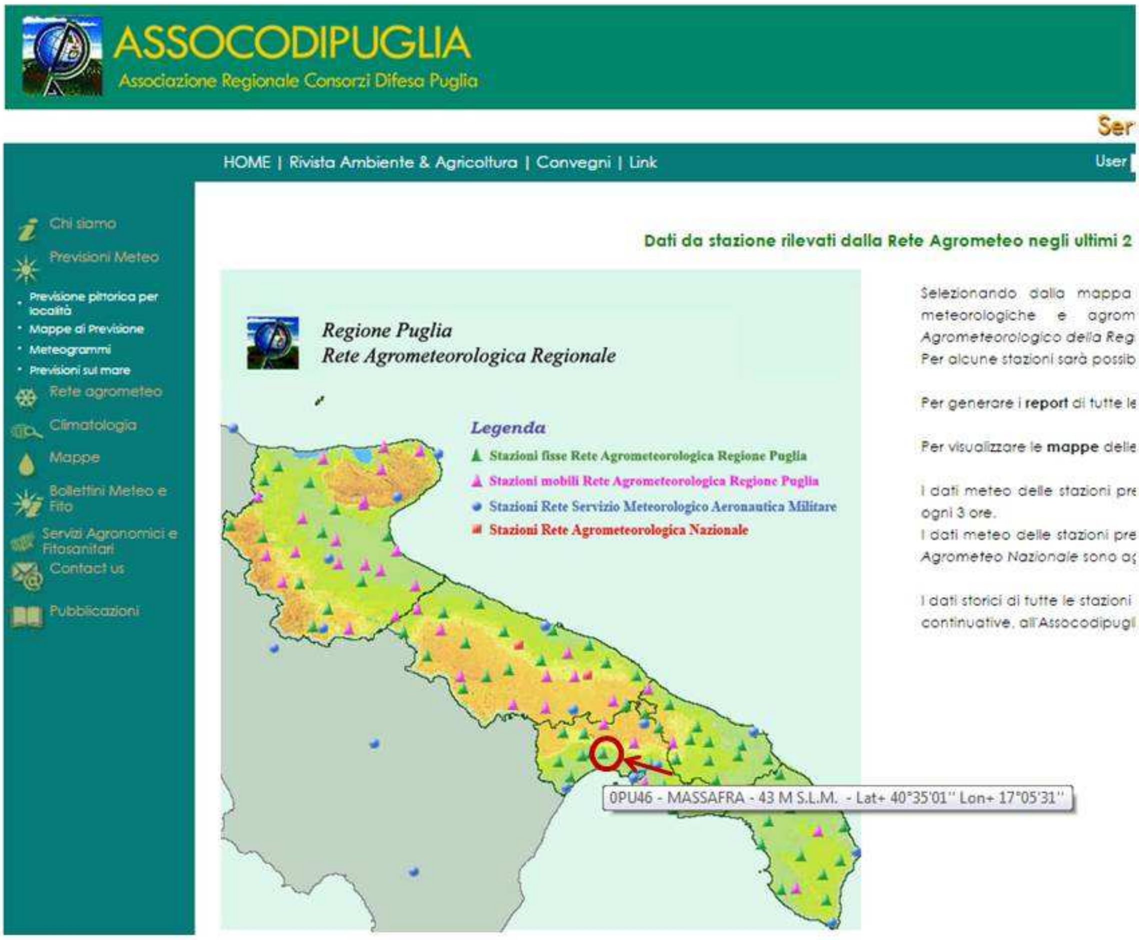


Fig. 6 – ***Map of the regional network of the ASSOCODIPUGLIA agro-meteorological field stations, with the specific location of the 'MASSAFRA' station (OPU 46) in Massafra (province of Taranto)***

'Raw' climatic data have been continuously acquired in the BLULEAF database and an appropriate post-processing has been programmed to obtain daily values of rainfall, minimum and maximum air temperature, relative humidity, solar radiation, wind speed (with all variable referred to the standard 2 m height). Also in this case study, the test of the connection of the 'MASSAFRA' (OPU 46) agro-meteorological station with the BLULEAF climatic database has provided good results in terms of the quality, the continuity and the reliability of the measured climatic data (Fig. 7), that have been used for the daily estimation of reference evapotranspiration at the local scale and the water balance calculation at the plot scale.

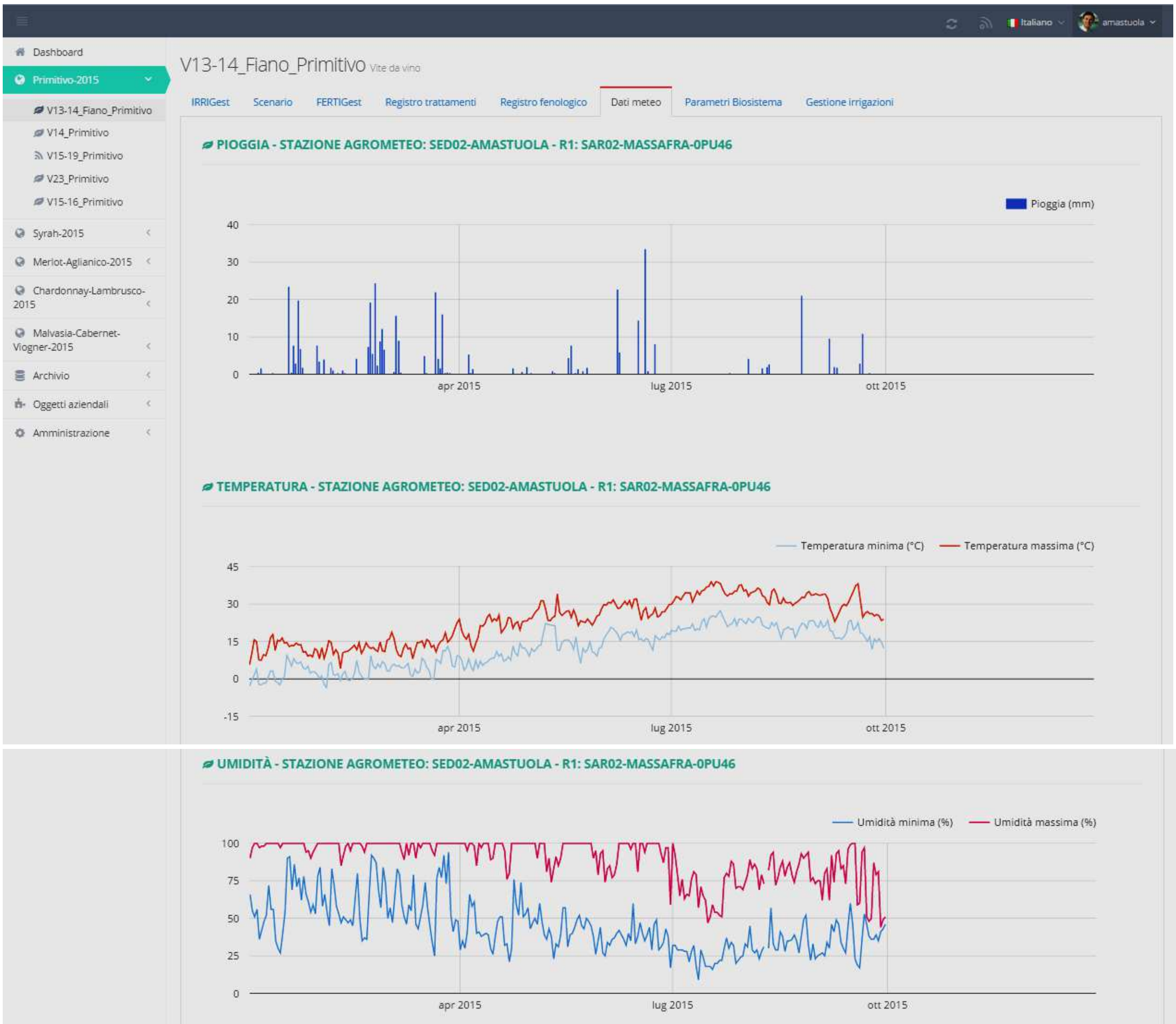


Fig. 7 – ***Graphs of the daily values of some of the main climatic variables recorded at the 'MASSAFRA' meteorological station during the testing activity (year 2015), as displayed in the BLULEAF web software***

In this farm, the complexity of the irrigation management is related with the **different types of grape varieties** and the specific irrigation strategy selected by the farmer for each them. Similarly to the 'Moccari farm' case-study, the DSS has supported the **'multi-plot' irrigation management** (Fig. 8) following the daily water balance of each plot, trying to consider the differences among them by selecting appropriate model parameters, and by using information about the crops' phenological development (updated directly by the end-user using the *mobile* application) to set specific **deficit irrigation strategies for each variety and phenological stage**, in order to manage 'flexible' irrigation priorities in relation to the expected relationship between **water stress and grape quality**.

In Fig. 8 the BLULEAF 'dashboard' for the Amastuola farm is shown, and farm plots have been organized in groups (called "areas") in relation to the main cultivated variety: 1) 'Primitivo'; 2) 'Syrah'; 3) 'Merlot-Aglianico'; 4) 'Chardonnay-Lambrusco'; 5) 'Malvasia-Cabernet-Viogner'.

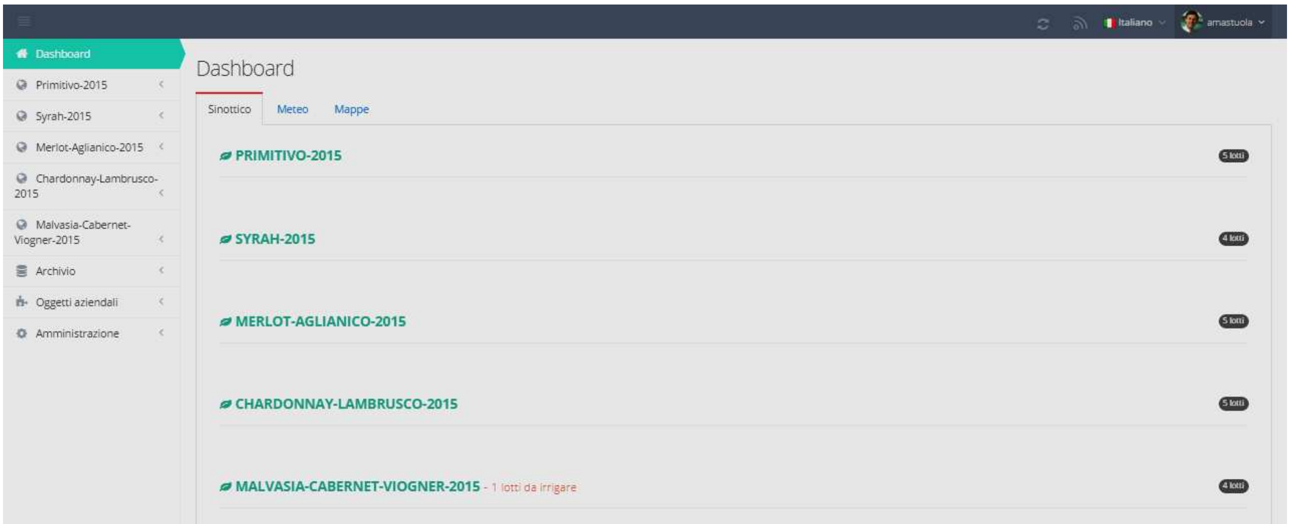


Fig. 8 – ***The BLULEAF 'dashboard' for the Amastuola farm, showing the list of the 5 farm "areas", organizing the different irrigated plots in relation to the cultivated variety***

As an example, in the **'Primitivo'** area, 5 plots have been included (Fig. 9). Data from the dashboard table show the variation of the total irrigations scheduled in 2015, going from **1,012 m^3 ha^{-1}** in the case of plot V13-14 to **2,150 m^3 ha^{-1}** in the case of plot V23. In this case, the wide variation of irrigation requirements among plots cultivated with the same variety has been related to differences in the soil properties among plots (water holding capacity and depth) and consequently a different set of soil parameters has been selected for each plot, resulting in the different total irrigation requirements.

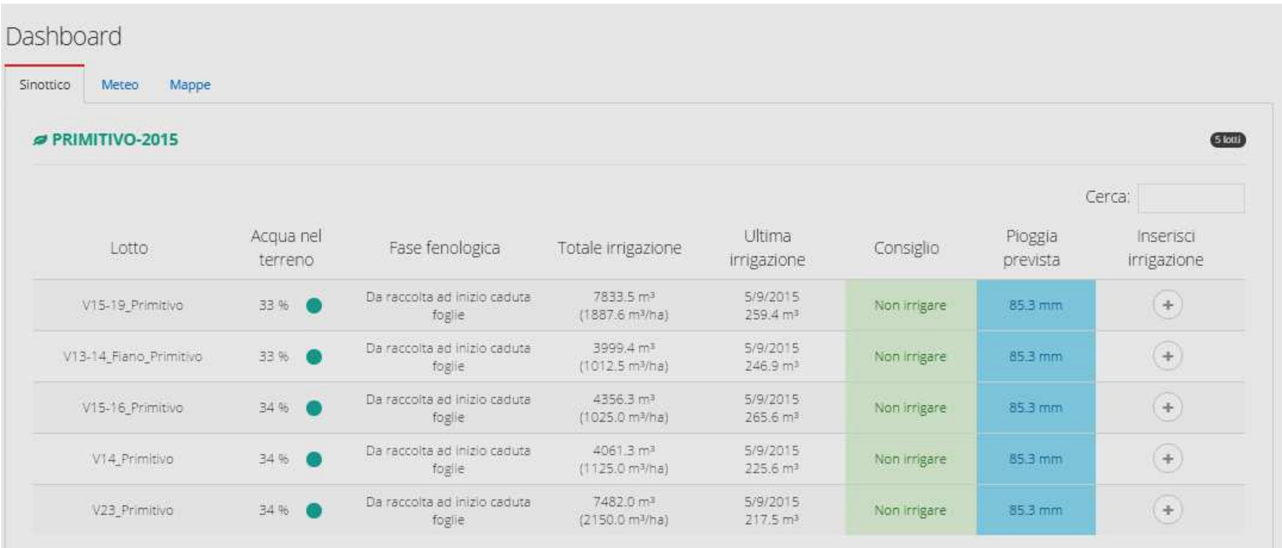


Fig. 9 – ***The BLULEAF 'dashboard' for the Amastuola farm, showing a quick summary of plot status in the 'Primitivo' area, with water availability, phenological phase, total irrigation applied, last irrigation event, irrigation advice and forecasted rainfall (forthcoming 3 days)***

In Fig. 10, an example of the water balance of a 'Primitivo' plot is reported. The depletion curve shows clearly the irrigation strategy selected by the farmer, allowing **increasing soil water deficit and crop stress** going towards grape ripening and maturity, with a few number and limited volumes of irrigations (for a better quality of the berries, with less yield but higher sugar content).

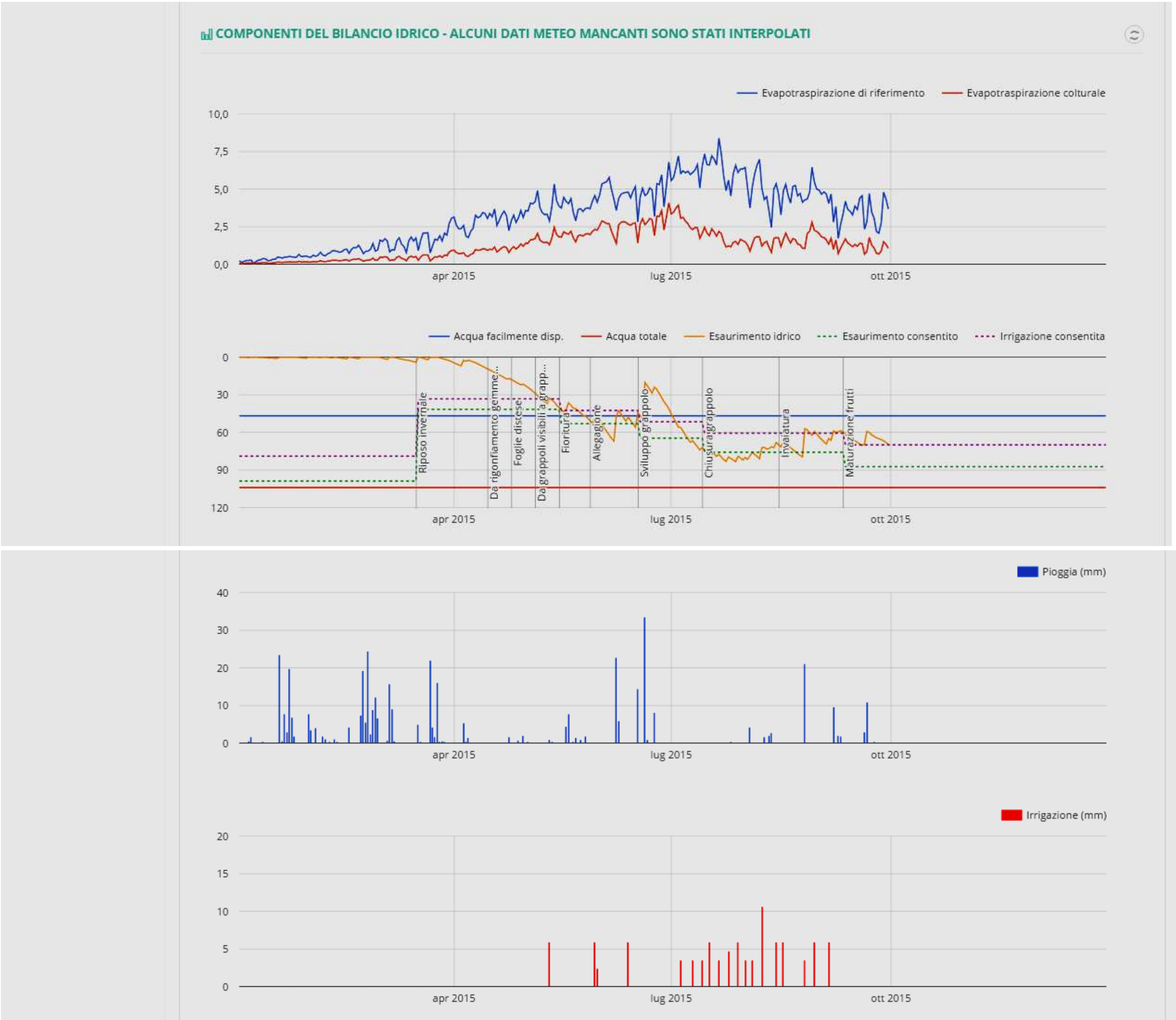
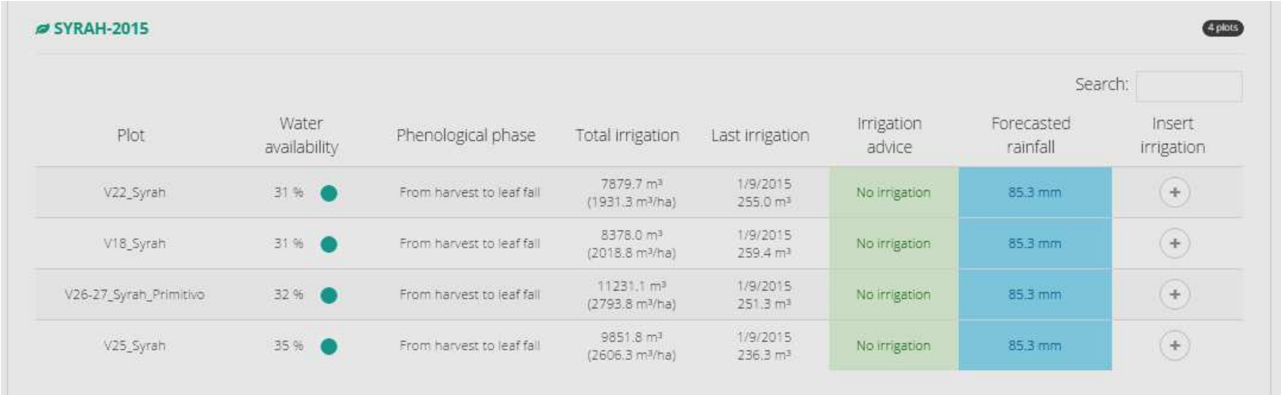


Fig. 10 – ***An example of application of deficit irrigation strategy by Amastuola farm supported by BluLeaf DSS (current year 2015, Primitivo variety). From top to bottom, the water balance components of a single irrigated plot: reference and crop ET; soil water depletion (with variable thresholds of maximum allowable depletion based on phenological stages); rainfall regime; irrigations (All values in mm)***

In the **'Syrah'** area, 4 plots have been included (Fig. 11). Data from the dashboard table show the variation of the total irrigations scheduled in 2015, going from **1,930 m^3 ha^{-1}** in the case of plot V22 to **2,600 m^3 ha^{-1}** in the case of plot V25. In this area, the variation of irrigation requirements among plots (cultivated with the same variety) is less relevant with respect to the 'Primitivo' area, but it has been managed considering slight differences in soil properties among plots (water holding capacity and depth), together with possible differences in the crop vegetative development depending on a different level of soil fertility between plots (and consequently to the maximum Kc values selected for the intermediate stage).


SYRAH-2015

4 plots

Search:

Plot	Water availability	Phenological phase	Total irrigation	Last irrigation	Irrigation advice	Forecasted rainfall	Insert irrigation
V22_Syrah	31 %	From harvest to leaf fall	7879.7 m³ (1931.3 m³/ha)	1/9/2015 255.0 m³	No irrigation	85.3 mm	+
V18_Syrah	31 %	From harvest to leaf fall	8378.0 m³ (2018.8 m³/ha)	1/9/2015 259.4 m³	No irrigation	85.3 mm	+
V26-27_Syrah_Primitivo	32 %	From harvest to leaf fall	11231.1 m³ (2793.8 m³/ha)	1/9/2015 251.3 m³	No irrigation	85.3 mm	+
V25_Syrah	35 %	From harvest to leaf fall	9851.8 m³ (2606.3 m³/ha)	1/9/2015 236.3 m³	No irrigation	85.3 mm	+

Fig. 11 – ***The BLULEAF 'dashboard' for the Amastuola farm, showing a quick summary of plot status in the 'Syrah' area, with water availability, phenological phase, total irrigation applied, last irrigation event, irrigation advice and forecasted rainfall (forthcoming 3 days)***

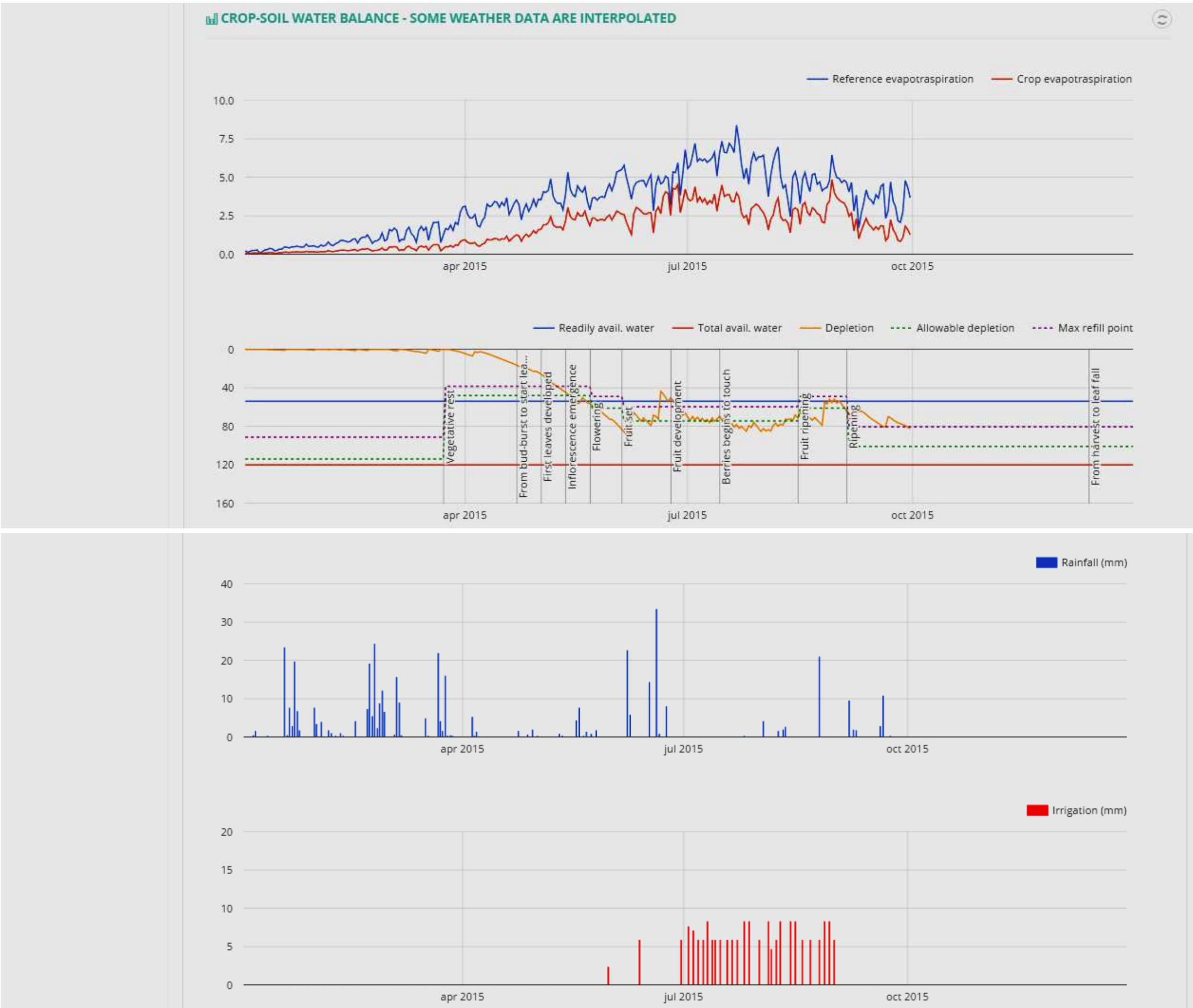


Fig. 12 – ***An example of application of deficit irrigation strategy by Amastuola farm supported by BluLeaf DSS (current year 2015, Syrah variety). From top to bottom, the water balance components of a single irrigated plot: reference and crop ET; soil water depletion (with variable thresholds of maximum allowable depletion based on phenological stages); rainfall regime; irrigations (All values in mm)***

In Fig. 12, an example of the water balance of a ‘Syrah’ plot is reported. In this case, the irrigation strategy is significantly different with respect to the ‘Primitivo’ one. The depletion curve shows clearly the irrigation strategy selected by the farmer, **reducing soil water deficit and crop stress** going towards grape ripening and maturity, increasing the frequency of irrigations in the last weeks of fruit developement.

For practical purposes, the application of the DSS in this farm has confirmed its reliability and flexibility in relation to the management of deficit irrigation strategies. Again, an important technical effort is required for the configuration of different varieties/plots with a more appropriate selection of ‘critical’ **crop/soil parameters** to match the irrigation strategies desired by the farmer.

Case study 3 – Syngenta Experimental Farm (Foggia)

The third case-study has been selected in the northern part of the Apulia Region, in the Syngenta Experimental Farm (Foggia) for the testing of BLULEAF DSS on field crops, and more specifically on **processing tomato** which is highly important for the local economy. The testing activity has been done in 2015 considering 2 experimental plots, with a different level of irrigation management: full irrigation (100%) and deficit irrigation (75%). Also in this case-study, daily **meteorological data** have been provided by the closest station of the ASSOCODIPUGLIA network (Fig. 13), while soil properties have been defined with a field survey and the available laboratory analysis.

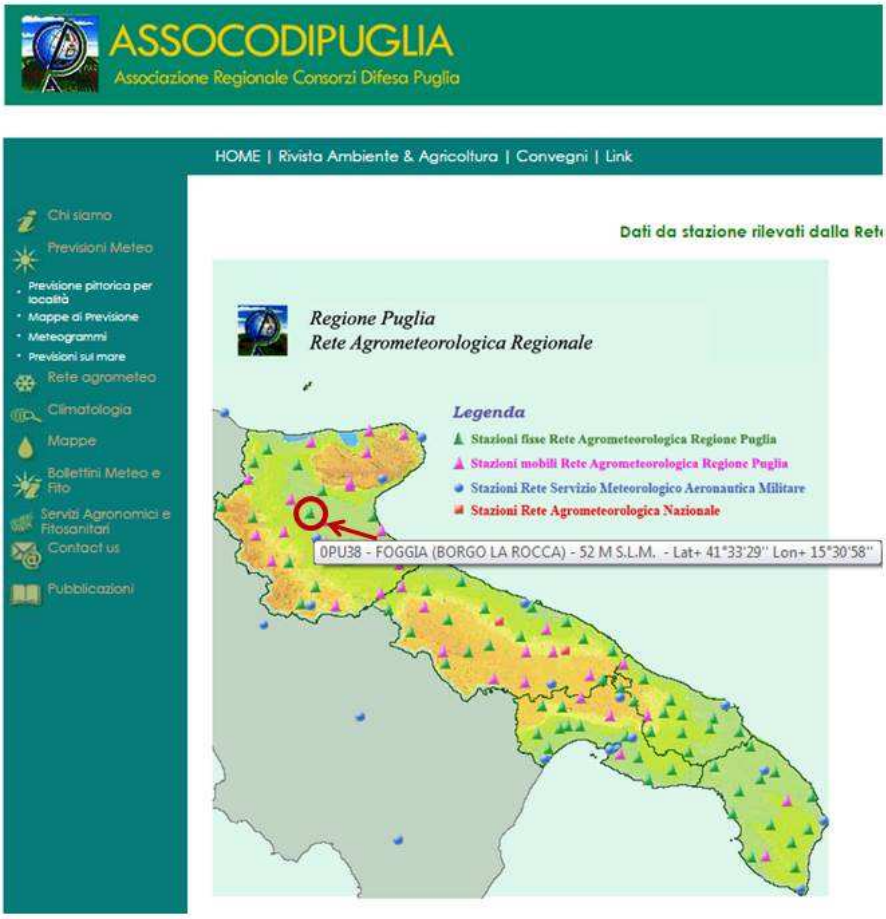


Fig. 13 – ***Map of the regional network of the ASSOCODIPUGLIA agro-meteorological field stations, with the specific location of the 'LA ROCCA' station (OPU 38) in Foggia***

'Raw' climatic data have been continuously acquired in the BLULEAF database and an appropriate post-processing has been programmed to obtain daily values of rainfall, minimum and maximum air temperature, relative humidity, solar radiation, wind speed (with all variable referred to the standard 2 m height). Also in this case study, the test of the connection of the 'LA ROCCA' (OPU 38) agro-meteorological station with the BLULEAF climatic database has provided good results in terms of the quality, the continuity and the reliability of the measured climatic data (Fig. 14), that have been used for the daily estimation of reference evapotranspiration at the local scale and the water balance calculation at the plot scale.

Fig. 14 – ***Graphs of the daily values of some of the main climatic variables recorded at the 'LA ROCCA' meteorological station during the testing activity (year 2015), as displayed in the BLULEAF web software***

In this farm, the complexity of the irrigation management is related with the **necessity to avoid water stress during fruit development**, otherwise resulting in yield reduction and affecting the quality of the final product. For this reason, the DSS has been integrated with the **continuous soil moisture/tension monitoring** at different soil depths, in order to evaluate the root extraction pattern and the possible occurrence of plant stress at the lowest level of soil water content.

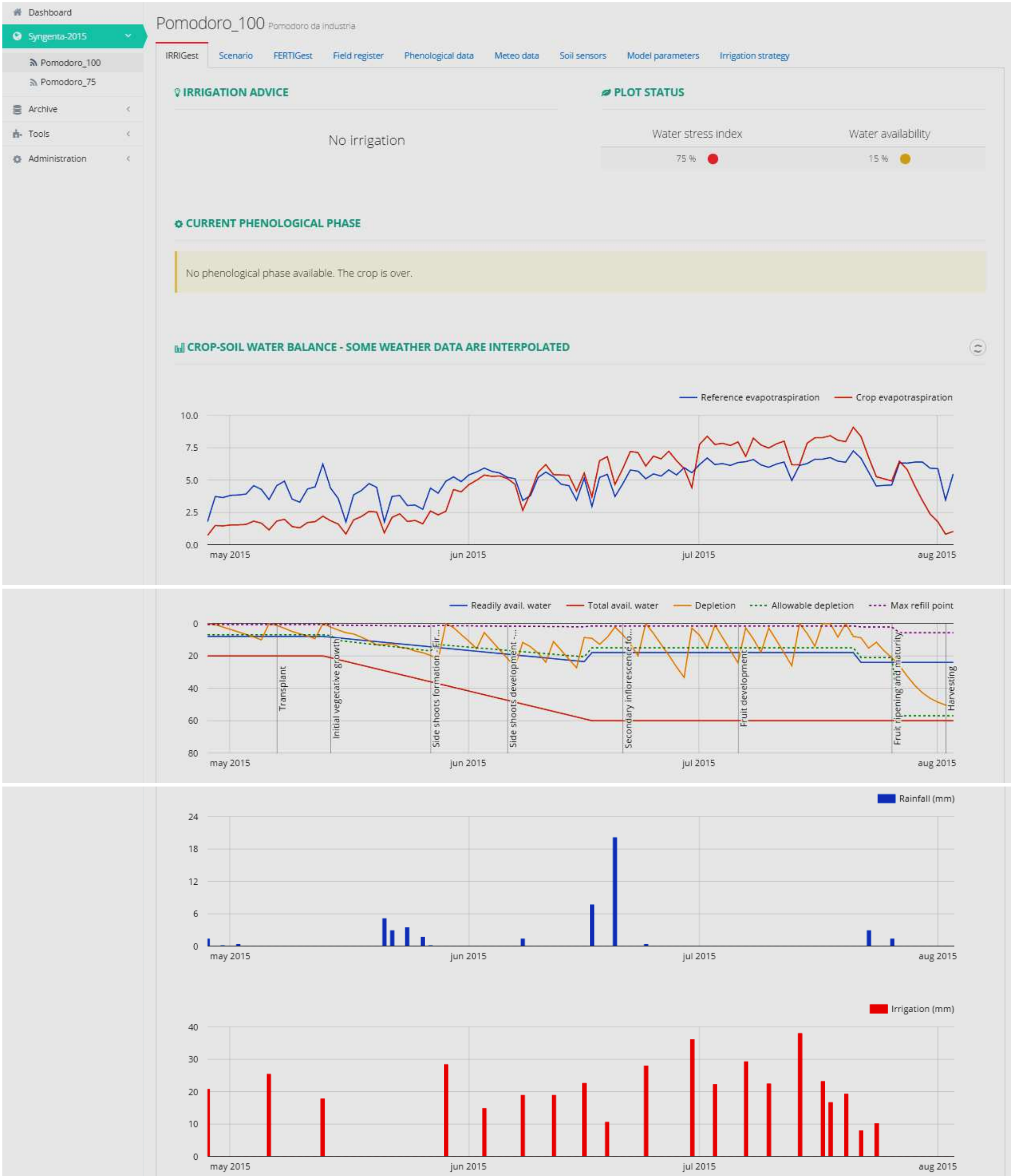


Fig. 15 – ***Soil water balance components for tomato crop in the Syngenta farm. From top to bottom: reference and crop ET; soil water depletion; rainfall regime; irrigations (All values in mm)***

Continuous soil moisture/tension measurements (Fig. 16) provide very useful information that has been used in this case to 'calibrate' relevant crop parameters, in order to 'fit' the irrigation strategy to the effective rate of plant transpiration. The Kc_mid (during the intermediate stage of development) and the maximum rooting depth have been evaluated as the most 'sensitive' parameters for tomato crop, to be locally calibrated against a set of field measurements.

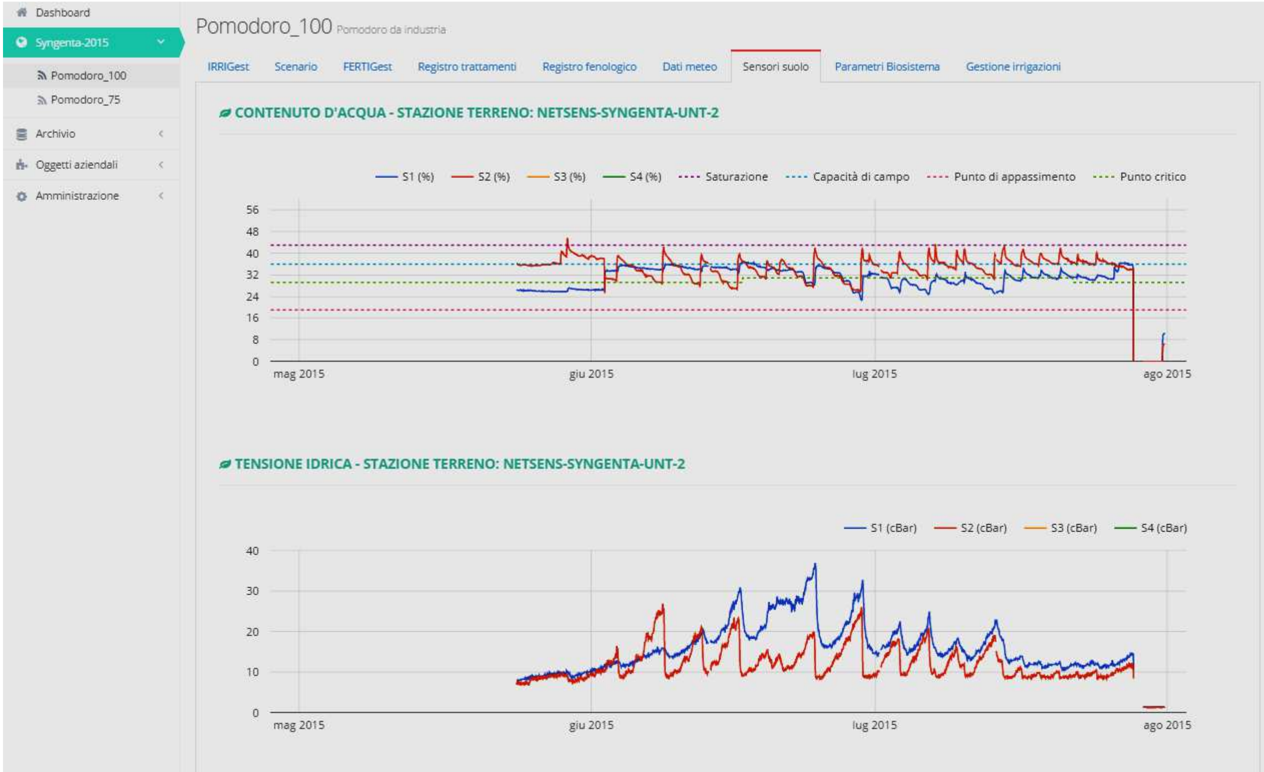


Fig. 16 – ***Soil water content (top) and tension (bottom) measured at two depth in the tomato field of the Syngenta Experimental farm***

Notes

CONCLUSIONS

The wide experimental activity conducted in the framework of the IRMA project has allowed an appropriate testing of the strengths and weaknesses of the BLULEAF DSS inserted in the ASSOCODIPUGLIA website as a new management tool for farmers and technicians.

Among the **main strengths** of the DSS:

- The complete, efficient and automatic **integration of the ASSOCODIPUGLIA weather stations** in the BLULEAF climatic database, that can be used for the daily estimation of reference evapotranspiration at the local scale and the water balance calculation at the plot scale;

- The ‘flexible’ application of the BLULEAF DSS in **different pedoclimatic environments, farm types and crops**, thanks to a wide range of parameters that can be chosen in relation to local specific conditions;

- The good level of agreement of the irrigation scheduled with the BLULEAF DSS with the current strategy of the farmer (in terms of irrigation frequency and volumes), and a **generalized good ‘perception’ of potential final users** (farmers, technicians, consultants) about the potential usefulness of the DSS in the day-by-day practical use in farm management

Among the **main weaknesses** of the DSS:

- For practical purposes, the application of the DSS in this farm has confirmed its reliability and flexibility in relation to the contemporary management of different crops/varieties, although an **important technical effort is required for the configuration** of numerous plots;

- the appropriate selection of ‘critical’ crop/soil parameters for a more reliable simulation of the DSS normally **requires a higher level of scientific and technical expertise**, that is not usually common among farmers and technicians, thus some training should be planned;

- **additional field observations and/or data** from crop/soil sensors are normally required for a more appropriate calibration of the DSS to the very specific local condition.

Notes

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