WP#3

Deliverable 3.4.1

Soil and water quantity and quality audits

Interreg V- A Greece-Italy Programme 2014 2020

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IR_2MA
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
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Partners

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Notes

Deliverable 3.4.1 - Soil and water quantity and quality audits

Soil-water quantity and quality of agricultural water systems in Southern Italy

Involved partners:

PB4 CIHEAM - ISTITUTO AGRONOMICO MEDITERRANEO – BARI (IAMB)

PB5 CONSORZIO PER LA BONIFICA DELLA CAPITANATA (CBC)

Authoring team:

Andi Mehmeti	CIHEAM-IAMB
Mladen Todorović	CIHEAM-IAMB

Contributors:

Nicoletta Noviello	CBC
Osvaldo Moro	CBC
Luigi Nardella	CBC
Carlo Ranieri	CIHEAM-IAMB
Pandi Zdruli	CIHEAM-IAMB
Giovanna Dragonetti	CIHEAM-IAMB

Place and time: Italy, 2020

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Contents

Figures

Tables

Summary

This report developed within IR2MA (Interreg V- A Greece-Italy Programme 2014 2020) project delivers the results of deliverable 3.4.1 focusing on the soil and water supply (quantity and quality) audits for Italian agricultural water systems under different water sources. The study area is irrigation district 17 (Trinitapoli) in the Sinistra Ofanto (Sx Ofanto) where tertiary treated wastewater reuse is implemented. The analysis covers the physical system and hydraulic infrastructures, the farming system, soil-water data quality, and monitoring of crop parameters under various sources of irrigation water. A soil sampling campaign was carried out where soil samples were collected and fully characterized by a large number of parameters. Further, a field experiment was established on an apricot orchard growing in a Mediterranean environment to investigate the effects of freshwater and treated wastewater on soil characteristics (soil temperature, soil salinity, and soil water content). For this, advanced network-based soil moisture sensors were installed and in-field real-time data were obtained during the cropping season. The results of this baseline study provide enhanced soil-water information and demonstrate the benefits of soil moisture monitoring for water-efficient crop management practices.

Keywords: IR2MA, soil, irrigation systems, sensor-based, Southern Italy, treated wastewater

Riassunto

Questo rapporto sviluppato nell'ambito del progetto IR2MA (Interreg V- A Programma Grecia-Italia 2014 2020) fornisce i risultati del deliverable 3.4.1 incentrato sugli audit del suolo e dell'approvvigionamento idrico (quantità e qualità) per i sistemi idrici agricoli italiani sotto diverse fonti d'acqua. L'area di studio è il distretto irriguo 17 (Trinitapoli) nella Sinistra Ofanto (Sx Ofanto) dove viene attuato il riutilizzo delle acque reflue trattate terziarie. L'analisi copre il sistema fisico e le infrastrutture idrauliche, il sistema agricolo, la qualità dei dati suolo-acqua e il monitoraggio dei parametri delle colture sotto varie fonti di acqua di irrigazione. È stata condotta una campagna di campionamento del suolo in cui sono stati raccolti campioni di suolo e completamente caratterizzati da un gran numero di parametri. Inoltre, è stato stabilito un esperimento sul campo su un frutteto di albicocche che cresce in un ambiente mediterraneo per studiare gli effetti dell'irrigazione con acqua dolce e delle acque reflue trattate sulle caratteristiche del suolo (temperatura del suolo, salinità del suolo e contenuto d'acqua del suolo). Per questo, sono stati installati sensori avanzati di umidità del suolo controllati a remoto e sono stati ottenuti dati in tempo reale sul campo durante la stagione del raccolto. I risultati di questo studio di base forniscono maggiori informazioni suolo-acqua e dimostrano i vantaggi del monitoraggio dell'umidità del suolo per pratiche di gestione delle colture efficienti dal punto di vista idrico.

Parole chiave: IR2MA, suolo, sistemi di irrigazione, sensoristica, Sud Italia, acque reflue affinate

1. Introduction

Water use and agricultural practices in the Mediterranean area are unsustainable (Saladini et al. 2018). The situation is more critical in the South of Italy where the intensive agricultural operations coupled with the climate change dynamics are triggering a multi-faceted crisis concerning sustainability, quantity, quality, and management of water resources (Polemio et al., 2010; Giordano et al., 2015). These complex factors are relentlessly pushing decision-makers toward evidence-based adaptation strategies and actions for agricultural sustainability. Two approaches that should be combined to properly tackle irrigation water management refer to (i) the improvement of resource management practices by balancing demand and supply, and (ii) the adoption of alternative water resources (Lonigro et al. 2015).

Smart-irrigation systems are a hot topic for better irrigation water management. Satellite imaging, sensors and controls, communication technologies, and irrigation decision models are readily available within reclamation consortia (Masseroni et al. 2020). On other hand, agricultural wastewater reuse has been recognized as the most effective short- and medium-term strategy to meet irrigation demand (Lopez and Vurro 2008). The Apulia region has been a pioneer in the field of wastewater reuse with 185 wastewater treatment plants designed for irrigation purposes with an upgrading capacity of up to 160 million m^3 (Arborea et al. 2017). However, sustainable irrigation water management should simultaneously achieve two objectives: sustaining irrigated agriculture for food security and preserving the associated natural environment (Cai X and Rosegrant 2001). The quality of water is an important component of the sustainable use of water for irrigated agriculture, especially when salinity development is expected to be a problem in an irrigated agricultural area (Zaman et al. 2018). In this regard, soil moisture monitoring technologies can make an important contribution to assist with irrigation management.

This report delivers the results of deliverable 3.4.1 focusing on the soil and water supply (quantity and quality) audit for Italian agricultural water systems under different water sources. The results discussed refer to the activities performed on irrigation district 17 (Trinitapoli, Southern Italy) part of the Sinistra Ofanto irrigation scheme managed by Consortium "Bonifica Della Capitanata" (CBC). The analysis includes all aspects from the irrigation scheme: the physical and the farming system including hydraulic characteristics and agronomic characteristics, water sources and quality, and the existing water reuse scheme. The study also used laboratory and sensor-based information for soil physicochemical properties, soil moisture, and environmental monitoring. This document serves as a guide for the water-energy-food (WEF) nexus report and development and validation of the decision support tool (DSS) tool. This deliverable was updated through the lifecycle of the project.

2.Soil properties

Soil properties such as soil structure, depth, texture, salinity, acidity, waterlogging, or compaction can limit plant growth even when the soil has adequate nutrients (Nawaz et al. 2013). Therefore, a soil analysis can provide important information about physical conditions, fertility (nutrient) status, and chemical properties that affect soil's suitability for growing plants. Soil characteristics of irrigation D17 were investigated by specific field studies to define the pedological and hydraulic characterization of soils.

Three steps associated with soil testing included 1) soil sample collection, 2) laboratory analysis, 3) soil sample results, and interpretation.

2.1 Soil Characterization in Irrigation district 17

The first step in soil analysis was soil sample collection. To define the pedological and hydraulic characterization of soils, a field survey was carried out on March 16, 2019 (Fig. 1). Twelve laboratory samples (Table 1) of about 1.5 kg of each composite were finally collected from randomly selected locations in the field to a depth of about 20 cm using a soil open-faced auger. Each number on the map indicates a soil sample. Each sample once collected was placed in labeled sample bags. Documentation of field sampling was recorded in a soil sample information sheet. As soon as the samples were collected was placed in immediately air-dried at room temperature using the same labeling system as recorded in the field. After drying, the samples are taken to the preparation room for standardized soil tests.

Fig. 1. Soil sample collection at irrigation district 17, March 2019.

Table 1. Soil sample data.

Sample No.	Label (District, Sector, Head Unit)	Main Crop	Coordinates
1	SO-D17-S3-P7/1	Olives	41°25'50" N / 16°3'8" E
2	SO-D17-S1-P4	Wine grapes	41°21'37.7" N / 16°2'46.8" E
3	SO-D17-S3-P7/1	Apricot	41°21'11.5" N / 16°2'45.6" E
4	SO-D17-S8-P2	Artichoke	41°21'16.3" N / 16°2'33.4" E
5	S0-D17-S7-P6	Arable land	41°21'18.9" N / 16°3'33.8" E
6	SO-D17-S5-P10/2	Almond	41°21'34.6" N / 16°2'27.7" E
7	SO-D17-S6-P5	Arable land	41°22'01.7" N / 16°3'18.6" E
8	SO-D17-S4-P8	Apricot	41°21'55.5" N / 16°2'10.1" E
9	SO-D17-S10-P9	Table grape	41°21'31.8" N / 16°1'51.8" E
10	SO-D17-S11-P9	Olives	41°21'31.8" N / 16°1'07.6" E
11	SO-D17-S12-P12	Artichoke	41°21'00.2" N / 16°1'55.3" E
12	SO-D17-S9-P15	Olives	41°21'43.3" N / 16°1'31.3" E

2.2 Soil samples results

After field collection, laboratory tests for textural classes (mechanical analysis for sand, clay, and silt), pH (H_2O and KCl, soil: solution=1:2.5), and electrical conductivity (estimated in the 1:2 soil-water extract) was carried out at the analytical laboratory of Mediterranean Agronomic Institute of Bari. Sand, silt, and clay contents were expressed as percentages by mass of the fine-soil fraction (<2 mm). The determination of the texture class was completed using the soil textural triangle proposed by the United States Department of Agriculture classification (USDA).

2.2.1 Soil texture and hydraulic properties

The soil has a clay-loam texture (U.S. Department of Agriculture classification) with average contents in the sand, silt, and clay 46.1%, 11.1%, and 42.8%, respectively (Fig. 2). These textural and hydrological characteristics do not change significantly with the horizontal and vertical dimensions. The mean altitude is 101 meters a.s.l. (std 93) while mean slope: 3% (std 5). The results of mechanical soil analysis and calculated hydraulic properties are presented in Table 2 and Table 3. Soil-water characteristics were generalized from texture using a hydraulic properties calculator (https://resources.hwb.wales.gov.uk/VTC/env-sci/module2/soils/soilwatr.htm). The results for soil water EC show that soils in the study area are dominated by non-saline soils. EC1:2 readings less than 2 dS/m, soil are considered non-saline and do not impact most crops and soil microbial processes. An experimental soil is classified as saline if its EC is higher than 4 dS m^{-1}. From twelve analyzed samples one sample is characterized as moderately saline (close to the sea) and one slightly saline. Soils are generally alkaline (high pH; pH 8.0 to 8.7), and, although pH adjustment is not a common practice, amendments containing sulfur can be used to lower pH levels. The pH levels range from 0 to 14, with 7 being neutral, below 7 acidic, and above 7 alkalines.

Table 2. Soil texture and pH from all samples.

Sample No.	Sand (%)	Silt (%)	Clay (%)	Soil pH (H_2O) 1:2.5
Average	46.1	11.1	42.8	8.2
Minimum	37.5	5.5	21.8	7.8
Maximum	72.3	15.3	52.3	8.7

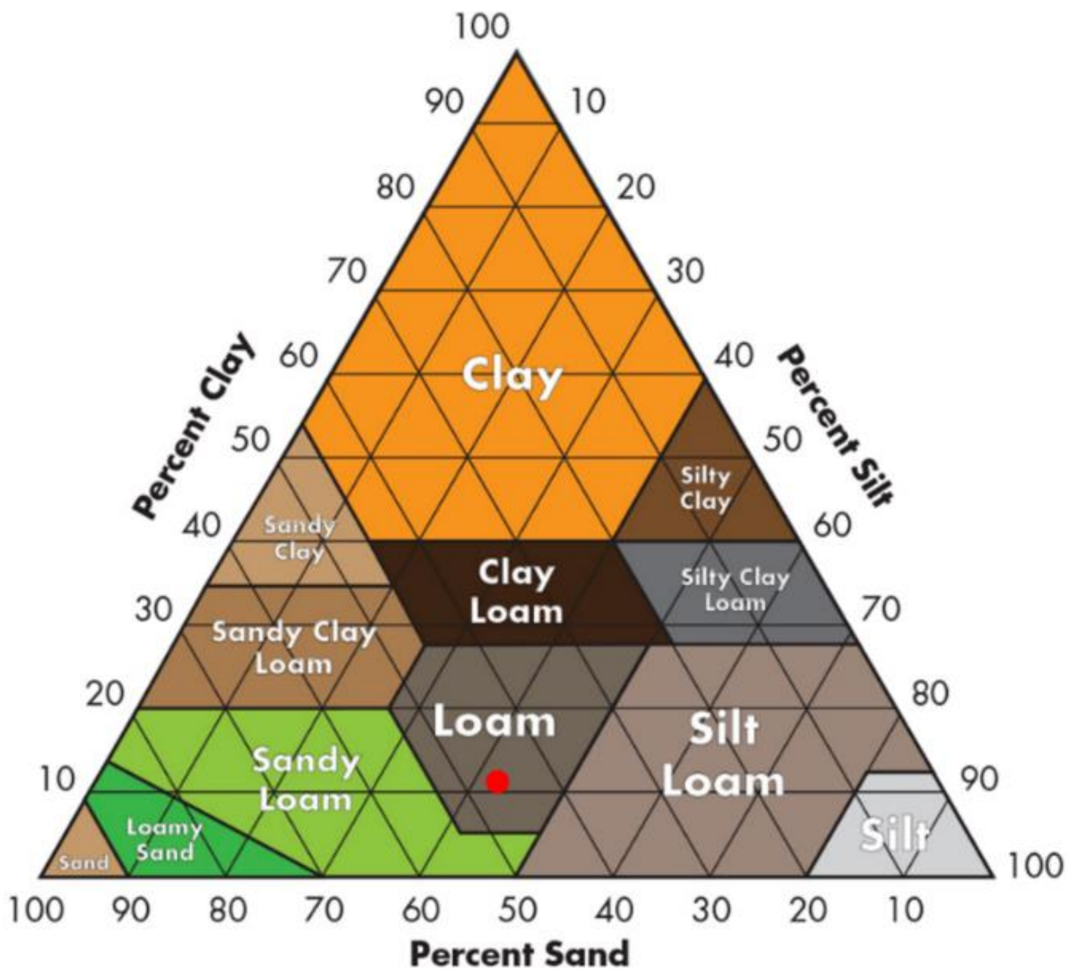


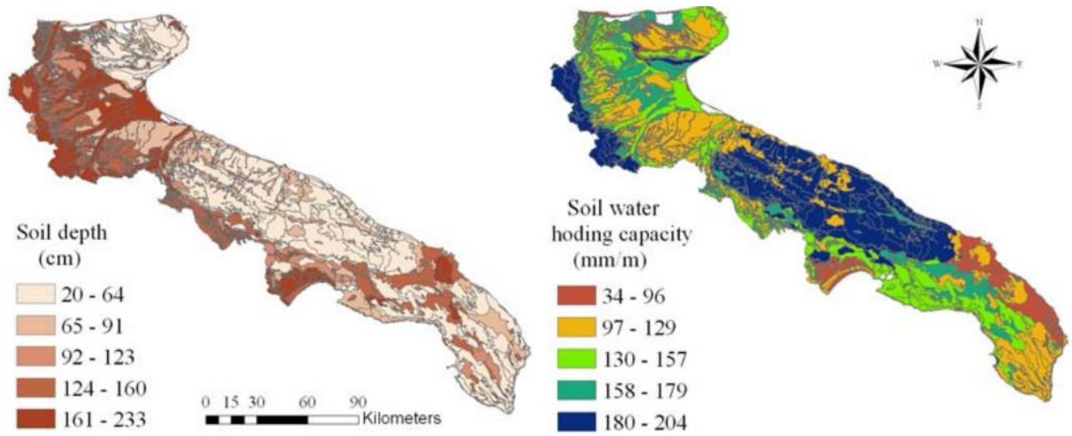
Fig. 2. Soil texture classification using USDA particle-size classification.

Table 3. Mechanical soil analysis - particle-size analyses: textural classes, pH, and soil water electrical conductivity and hydraulic properties for analyzed soil samples.

Sample No.	Sand	Silt	Clay	Soil Classification	Soil pH	Soil pH	Soil water EC_w	ECw Interpretation	Wilting point (cm^3 water/cm^3 soil)	Field capacity (cm^3 water/cm^3 soil)	Saturation (cm^3 water/cm^3 soil)	Drainage rate (cm/hr)	Available water (cm^3 water/cm^3 soil)
1	43.1	12.8	44.1	Loam	8.6	Alkaline	0.27	Non-Saline	0.24	0.348	0.51	0.14	0.107
2	42.5	12.8	44.7	Loam	8.4	Alkaline	0.24	Non-Saline	0.244	0.352	0.511	0.138	0.108
3	38.5	14.2	47.3	Loam	8.2	Alkaline	0.25	Non-Saline	0.259	0.372	0.517	0.137	0.112
4	37.8	15.3	46.9	Loam	8.1	Alkaline	0.45	Non-Saline	0.258	0.372	0.517	0.141	0.114
5	38.5	15.2	46.3	Loam	7.8	Neutral	0.95	Non-Saline	0.254	0.368	0.516	0.142	0.113
6	38.5	15.1	46.4	Loam	7.8	Neutral	2.5	Slight Saline	0.254	0.368	0.516	0.142	0.113
7	70.4	7.8	21.8	Sandy loam	8	Alkaline	0.15	Non-Saline	0.138	0.224	0.451	0.545	0.085
8	45.5	8.0	46.5	Loam	8.2	Alkaline	0.49	Non-Saline	0.252	0.353	0.511	0.123	0.101
9	72.3	5.5	22.3	Sandy loam	8.7	Alkaline	0.11	Non-Saline	0.141	0.223	0.451	0.508	0.082
10	45.5	8.0	46.5	Loam	8.3	Alkaline	0.22	Non-Saline	0.252	0.353	0.511	0.123	0.101
11	37.5	10.2	52.3	Silt loam	8.3	Alkaline	0.22	Non-Saline	0.287	0.397	0.524	0.127	0.109
12	43.5	7.8	48.8	Loam	8	Alkaline	0.3	Non-Saline	0.317	0.472	0.549	0.272	0.154

2.2.2 Soil depth and profiles

Soil depth can greatly influence the types of plants that can grow in them and is very critical for plant growth. Soil depth largely affects plant productivity and therefore farm income. Soils can be very shallow (less than 25 cm), shallow (25-50 cm), moderately deep (50-90 cm), deep (90-150 cm), and very deep (more than 150 cm). Deeper soils generally can provide more water and nutrients to plants than more shallow soils. The soil depth ranges from 124 to 233 cm while the water holding capacity ranges from 130 to 179 mm/m (Fig. 3).



Retrieved from Mataresse (2010).

Fig. 3. Soil depth (cm) and water holding capacity of the Apulia region.

The dominant soils are Cambisols, Luvisols, and Vertisols, characterized by Cretaceous limestone, marl, and clayey to sandy deposits (Fig. 4).

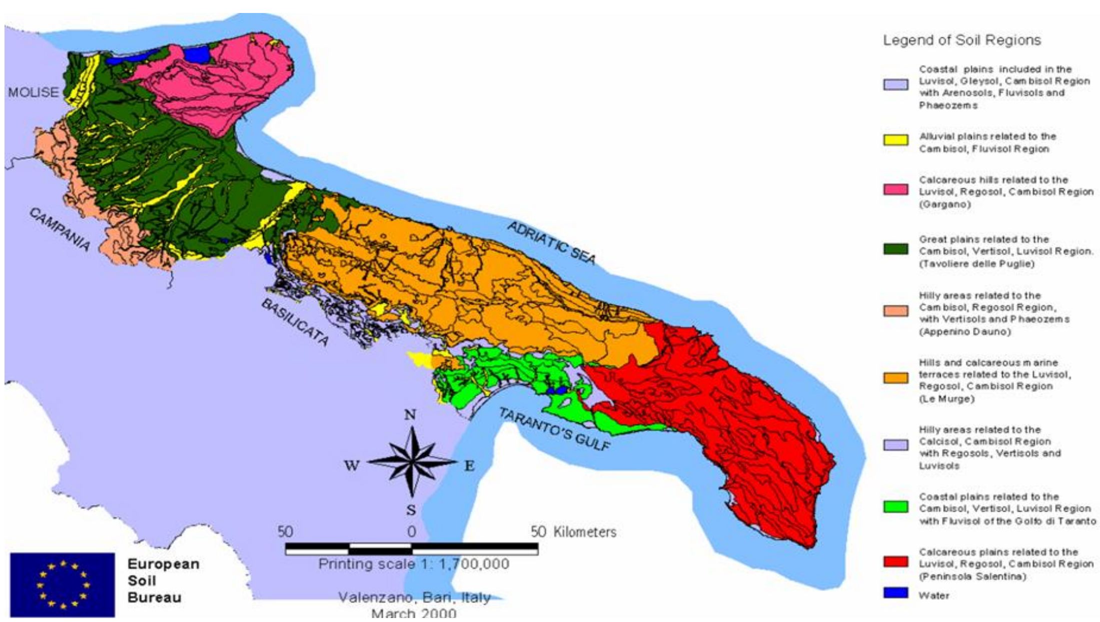


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Fig. 4. Soil regions of the Apulia region at the 1:250,000 scale.

3.Water service and use systems

The irrigation district 17 is served by 651 hydrants (Fig. 5) with a continuous flow rate of 0.202 l/s (reaching up to 0.303 l/s when operated 16/24) and minimum running pressure of 2 bars (20 meters). Irrigation permits the production of high-value crops, such as tomatoes, vineyards, and peaches.

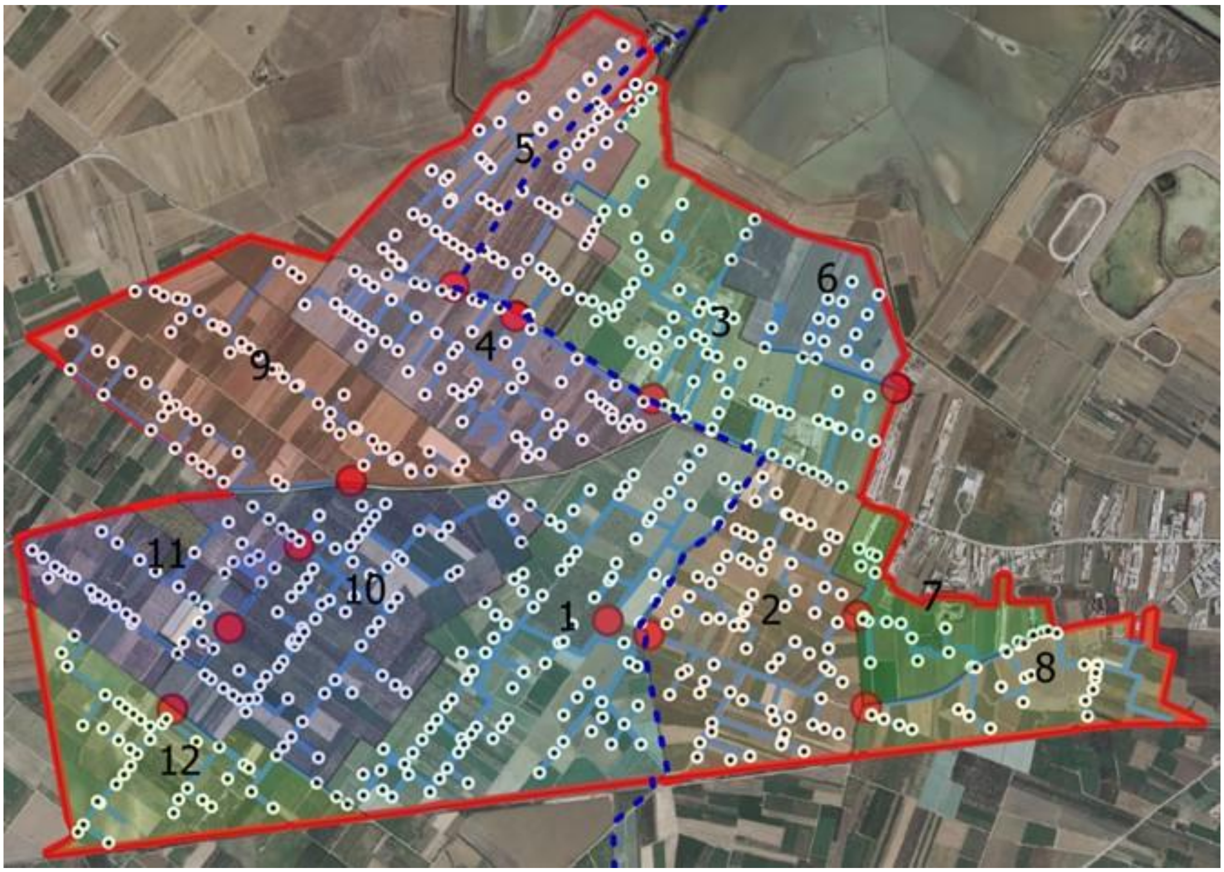

Fig. 5. The layout of hydrants and water distribution networks of irrigation district 17 (CBC).

The distribution networks are composed of a total of 2000 km of asbestos-cement and PVC pipes, with pipe size ranging between 350 and 90 mm. All irrigation sectors are equipped with hydrants and flow meters to measure the discharge. Each user at the hydrant level has a capacity of 10 l/s (2 modules with 5 l/s) with a diameter of DN 100. Hydrants are routinely placed at an average distance of 90 meters.

The precise estimation of water demand at large-scale irrigation perimeters is a key requirement for water management. Irrigation demand was determined with FAO CROPWAT software with inputs of climatic (Table 4), crop and soil data, and assumed that the irrigation techniques. The forecasting GIR for the cropping pattern distributed using GIS is presented in Fig. 6. The specific continuous discharge of the system is 0.4 l/s/ha or 34.5 m^3/day/ha. The annual irrigation demand of district 17 is about 1.57 Mm^3 whereas the measured annual irrigation supply is 0.97 Mm^3 or about 70% of district water demand. Availability may vary a lot over the year, or even between one year and another.

Table 4. Total irrigation water requirements within the irrigation district 17.

Crop	Average		
	NIR (m^3/ha)	GIR (m^3/ha)	Total scheme GIR (m^3)
Olive	1961	2389.561	256,479.59
Wine grape	2316	2642.164	456,204.80
Autumn-winter cereals	2154	2881.792	-
Artichoke	3708	4484.671	223,785.09
Early Peach	4213	4878.743	310,125.41
Table grape	950	1097.778	46,337.20
Apricot	3875	4476.082	89,969.25
Tomato	4639	5232.865	91,400.72
Almond	3711	4300.175	28,811.18
Late Peach	3846	4458.567	-
Melon	3483	4245.592	28,303.95
Mixed Orchard	3932	4549.971	8,326.45
Autumn vegetables	133	142.1528	-
Spring vegetables	4024	4896.966	-
Total			1,539,743
Water delivered from CBC 2016			833,531
Water delivered from CBC 2017			1,118,269

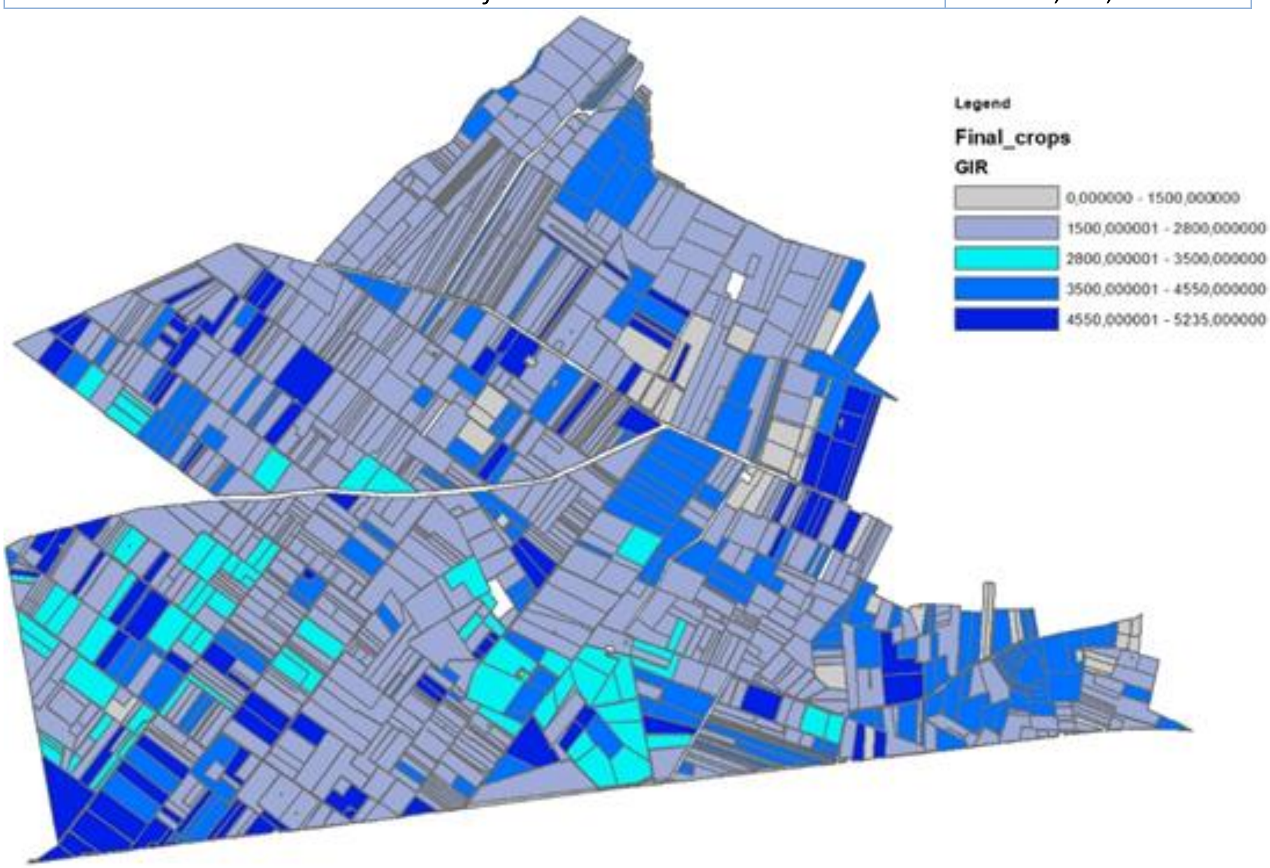

Fig. 6. Spatial gross irrigation water requirements, district 17, Sinistra Ofanto.

The main source of irrigation water is surface water managed by the Consorzio di Bonifica della Capitanata (CBC). Besides surface water from CBC, water supply sources include groundwater and treated wastewater.

3.1 Irrigation water quality

Monitoring irrigation water quality is crucial to the sustainability of crop production and productivity. Quality parameters of importance in agricultural use of wastewaters are of health and agricultural significance. The main constituents that must be removed from sewage effluent before it can be used for unrestricted irrigation are pathogenic organisms and organic chemicals. Other aspects of agricultural concern are the physical (e.g. temperature, Total dissolved solids, hardness, etc.) and chemical (anions and cations, nitrate-nitrogen, phosphorus, etc.) parameters.
The physicochemical characteristics of the surface water which represents the conventional water derived from the irrigation network system are reported in Table 5.

Table 5. Main physicochemical parameters for the freshwater (FW) from the irrigation network.

	L. 185/03*	FWW
pH	6-9.5	7.95
ECw (dS/m)	3	0.61
TSS (mg/l)	10	5.4
Na^+ (mg/l)	-	43.6
Ca^{2+} (mg/l)	-	53.65
Mg^{2+} (mg/l)	-	12.25
SAR	10	1.55
COD (mg/l)	100	11.6
BOD5 (mg/l)	20	8.5
NO_3-N (mg/l)	-	0.5
NH_4-N (mg/l)	2	0.585
Total N (mg/l)	15 (35)	1.85
Phenols (mg/l)	0.1	-
CO_3^- (mg/l)		174.4
HCO_3^- (mg/l)		241.9
PO_4-P (mg/l)	10 (2)	0.15
K^+ (mg/l)		8.1
Sulphates (mg/l)	500	71.4
Chlorides (mg/l)	250	62.85
Fluorides (mg/l)	1.5	0.55

The reuse of wastewater for irrigation purposes is regulated in the study area by the Inter-ministerial Decree no. 185 dated 12.06.2003 which dictates the technical rules for the reuse of wastewater, regulating the use and the related quality requirements. The long-term analysis previously carried out in the study area (Between July and November 2004) shows that the microbiological and chemical-physical characteristics of the effluent waters from the purification plant used in the municipality of Trinitapoli were suitable for agricultural re-use and that the quality parameters were within the limits imposed by

the current legislation (Table 6). Overall, the main physicochemical properties of the three types of water sources met the Italian standards for wastewater re-use for irrigation. If compared with GW, TWW is characterized by higher amounts of N (as NH_4-N and NO_2-N), PO_4-P, K_2^+, Ca2+, Mg2+, TSS, and OM (as indicated by the TSS, BOD5, and COD values).

Table 6. Main physicochemical parameters for the groundwater (GW) and tertiary (TWW)at Trinitapoli (Apulia region, southern Italy).

Physical-chemical parameters	Unit	Limit (DM 185/2003)	TWW	GW
pH	-	6-9,5	7.75	7.05
SAR	-	10	6.99	9.84
Total suspended solids	mg/L	10	13.22	2.85
BOD5	mg O_2/L	20	19.29	-
COD	mg O_2/L	100	79.27	-
Total phosphorus	mg P/L	2	0.21	Absent
Total nitrogen	mg N/L	15	6.05	0.30
Ammoniacal ammonia	mg NH_4/L	2	2.03	0.15
Electrical conductivity	ıS/cm	3000	1456.77	7289.75
Aluminum	mg/L	1	0.06	-
Barium	mg/L	10	0.36	-
Beryllium	mg/L	0.1	0.01	-
Boron	mg/L	1	0.03	0.01
Total chrome	mg/L	0.1	0.03	-
Iron	mg/L	2	0.36	Absent
Manganese	mg/L	0.2	0.01	-
Nickel	mg/L	0.2	0.13	-
Lead	mg/L	0.1	Absent	-
Copper	mg/L	1	0.07	50.00
Tin	mg/L	3	0.02	-
Zinc	mg/L	0.5	0.11	48.78
Sulfates	mgSO_4/L	500	142.43	180.17
Active chlorine	mg/l	0.2	0.53	-
Chlorides	mg Cl/L	250	160.9	18.82
Fluoride	mg F/L	1.5	0.03	-
Animal / vegetable fats and oils	mg/L	10	10.86	-
Total surfactants	mg/L	0.5	0.22	-
Total Coliforms	UFC/100mL	-		37.50
Faecal Coliforms	UFC/100mL			19.30
Faecal Streptococci	UFC/100mL			100.45
Escherichia coli	UFC/100mL	100	15041.27	26.67
Salmonella typhosa	UFC/100mL	Absent	Absent	Absent

* Limit concentration for total nitrogen and total phosphorus (in brackets the limit concentration for vulnerable areas to nitrate and phosphate)

The higher levels of these chemical parameters in wastewater are particularly important from an agronomic point of view since they act as a source of plant nutrients. Also, other valuable micronutrients and the organic matter contained in the effluent will provide additional benefits. It was recommended to slightly raise the limit threshold of some parameters as specified below: i) The limit of B.O.D.5 should be raised to 40 mgO_2/l; ii) The concentration limit of Total Suspended Solids should be raised from 10 to 20 mg/l; iii) The tolerable concentration limit of active chlorine at the outlet of the recovery system should be raised to 0.4 mg/l.
District 17 includes a reservoir for water storage. Four random water samples (Fig. 7) were collected at the main storage reservoir of district 17 for analysis of various physicochemical and biological characteristics namely, temperature, total dissolved solids, electrical conductance, and pH (Table 7).

Fig. 7. Water samples and the storage reservoir of D17, Trinitapoli, Foggia.

The electrical conductance of water samples was measured by using a Water Quality Analyser. EC of irrigation water is expressed in deci Siemens per meter at 25 °C (dS/m). TDS means total dissolved solids, reported in milligrams per liter (mg/l). Waters that have ECw over 0.7 dS/m (corresponding to a TDS of about 450 mg/L) full yield potential is still possible but care must be taken to achieve the required leaching fraction to maintain soil salinity within the tolerance of the crops. A salt content exceeding 3 dS/m may cause severe problems to crops. The results show that irrigation water stored in the reservoir is highly saline with EC > 20 dS/m. This high ECw indicates that the impact of seawater intrusion is moderately higher. High salinity has been a concern in Trinitapoli where the water tables are shallow. The inflowing water is saltier than the stored treated water in the reservoir contributing significantly to the overall salinity/sodicity development of water stored in the reservoir.

Table 7. Water salinity of samples at the storage reservoir of D17, Sinistra Ofanto.

Sample	ECw* (dS/m)	Salt concentration mg/l	Water class
S1	21.3	7000-15.000	Highly saline
S2	21.2	7000-15.000	Highly saline
S3	21.1	7000-15.000	Highly saline
S4	20.8	7000-15.000	Highly saline

* >0.7 None; 0.7– 3 Slight to Moderate; >3 Severe

Streamflow salinity fluctuation in the reservoir storage was reduced by the technical measures (two washout processes) carried out by the CBC (Fig. 8). However, it is shown that within time reservoir salt storage is increased. The salinity of the outflow from the storage reservoir, for example, changed from 5 to 12 ds/m in one month, due to permeable soil layers and intrusion of seawater. It is recommended to perform the conjoint use of the surface and wastewater to keep the salinity at the acceptable limits.

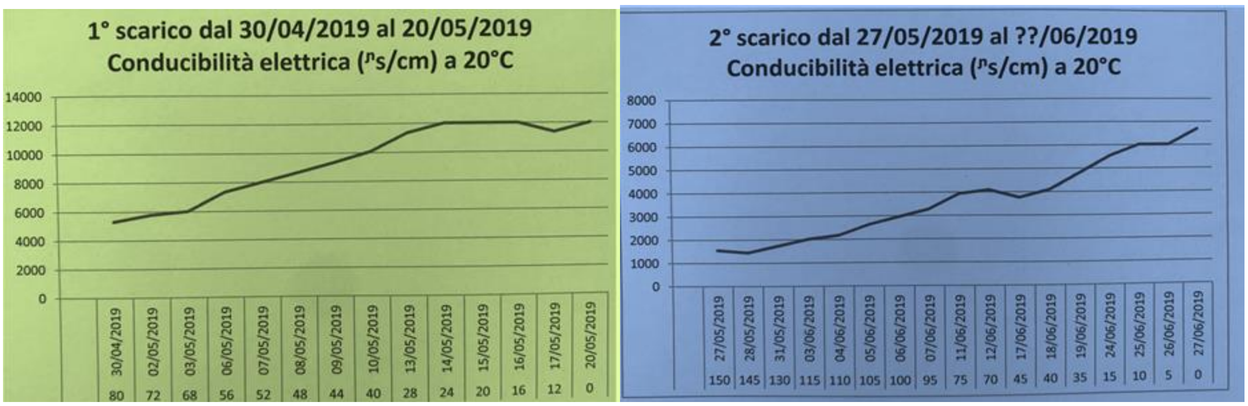

Fig. 8. Variation of the ECw at the storage basin of the Trinitapoli wastewater reuse scheme.

Using

4. Irrigation water sources and effects on soil characteristics: field evaluation and performance comparison using soil moisture sensors

Soil moisture and salinity measurement are the essential factors for crop irrigation to reduce adverse impacts on surface and groundwater quality as well as to increase the yield (Jabro et al. 2020). Several advanced technologies are available to assist with achieving and implementing optimized irrigation management. They include weather stations, air- and space-borne remote sensing platforms, computer models, plant feedback sensors, and soil moisture sensors (Datta et al. 2018). The use of soil moisture monitoring probes has continued to increase in popularity in the design, monitoring, and control of irrigation systems. They assist irrigation management to improve yields, quality, conserve water and energy, and reduce nutrient leaching. Some example of capacitance-based sensors includes EnviroScan, Decagon 5TE, Decagon 10HS, Delta-T PR1/PR2 probes, Sentek TriScan, or other types (Sharma et al. 2018). One of the goals of the IR2MA project was the implementation of sensor-based irrigation systems to monitor soil-water relation parameters of crop growth under conventional groundwater and treated wastewater. In July 2019 a total of eight (8) Sentek Drill & Drop sensors equipped with data loggers (Fig. 9) was installed at an apricot tree field in Southern Italy [40.936598 N, 16.822319E] using Sentek's installation manual. Sentek Drill & Drop™ soil measurement probes provided a complete picture of what's happening in the soil profile by combining soil Water Content (SWC), Volumetric Ion Content (VIC), and soil temperature (ST) readings at several depths in the soil profile (5, 15, 25, 35, 45, 55 cm). The probes were situated 5-12 m apart in different orchard rows. Sensor 1, 2, 3 were installed at FW plots while 4, 5, 6 at the TWW plots (Fig. 10). The monitoring period of the in-situ observational system was from 01 April

2020 to 15 September 2020, and data were recorded over 10-minute intervals on a data-logger. The data was assessed in real-time and processed using the IrriMAX software, a web-based platform where one can access the output data measured by the Sentek Multi system. Additional data analysis and mapping were performed by using Excel 2013 (Microsoft, Redmond, USA). The data are available on the IR2MA website as excel files. The values were calculated using the default calibration curve parameters from the supplier, so no site-specific soil calibration procedures were performed.

Fig. 9. Drill&Drop automated sensors installed in an Apricot farm, Southern Italy.

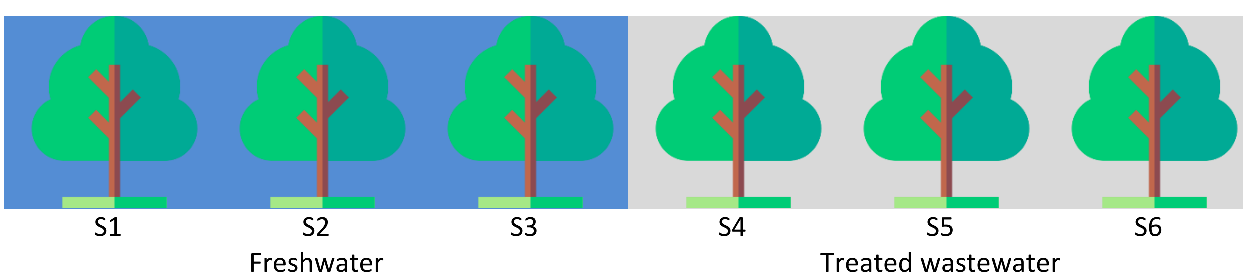

Fig. 10. The layout of sensors installed in an Apricot farm, Southern Italy.

Additionally, laboratory testing of physical samples was carried out to determine soil pH, texture, and soil salinity. Samples were usually collected in situ (Fig. 11) and transported to a laboratory for analysis. Soil salinity is generally measured by ECe in the laboratory following the standard method. Additional soil-water characteristics were generalized from texture using a hydraulic properties calculator (https://resources.hwb.wales.gov.uk/VTC/env-sci/module2/soils/soilwatr.htm).

Fig. 11. Soil samples collection.

4.1 Results and discussion

4.2 Mechanical soil analysis

The physical soil characteristics are shown in Table 8. The soil pH was found to be normal, hovering around neutrality. Hand texturing tests performed on both surface soil and deep 50 cm samples determined that both sites could be classified as having Sandy Loam textures. The electrical conductivity (ECe) of soil samples analyzed ranged from 0.165 to 0.67 ds/m with an average value of 0.46 ds/m. No effects are usually noticed for water below 0.75 dS/m. Yield loss of apricot begins at 1.3 ds/m. Indeed, the trees were looking very healthy, and the crop potential was very good.

Table 8. Mechanical soil analysis - particle-size analyses: textural classes, pH, and soil water electrical conductivity and hydraulic properties for analyzed soil samples in an Apricot orchard farm, Southern Italy.

Sample*	pH	Sand:Silt: Clay	Soil water EC_w (dS/m)	ECw Interpretation	Wilting point (cm^3 water/cm^3 soil)	Field capacity (cm^3 water/cm^3 soil)	Saturation (cm^3 water/cm^3 soil)	Drainage rate (cm/hr)	Available water (cm^3 water/cm^3 soil)
1	7.97	62:14:24	0.5	Non Saline	0.146	0.241	0.463	0.453	0.0948
2	7.81	52:18:30	0.67	Non Saline	0.171	0.276	0.482	0.286	0.105
3	7.93	68:8:24	0.52	Non Saline	0.148	0.235	0.459	0.431	0.086
4	7.65	58:28:13	0.165	Non Saline	0.163	0.26	0.474	0.317	0.097

*Note: Analysis for samples 1, 2, 3 were retrieved from CNR-ISPA while S4 reports the average of three samples analyzed from CIHEAM-IAMB.

4.3 Sentek drill and drop results

4.3.1 Soil water content (SWC) profile

Table 9 presents the minimum, maximum, and average SWC measured at each soil depth by the various soil moisture sensors at various depths at discrete times. A detailed presentation of readings for each sensor is given in Appendix 1. The simulation period is from the 1st of April 2020 to 24th September 2020. The results revealed that SWC in the TWW plots is generally higher than in FW plots. Similar findings have been observed in orchards by other authors (Albalasmeh et al. 2020; Assouline et al. 2016; Bardhan et al. 2016; Rahav et al. 2017). Generally, the higher water content in the TWW-irrigated soil profile could be attributed to reduced root water uptake, reduced evaporation through the soil surface, or both (Rahav et al. 2017). TWW irrigation is likely to decrease the soil infiltration rate and diminish its saturated hydraulic conductivity (Albalasmeh et al. 2020; Assouline et al. 2016) leading to reduced water-uptake rate, despite the assumption that high water content increases water availability for root uptake (Rahav et al. 2017).

Table 9. Soil water content (SWC) at different soil depths using Drill&Drop sensors for freshwater (FW) and treated wastewater (TWW) irrigated plots on an apricot orchard.

		Soil water content [mm] at different depth						
Water source	Sensor parameter/depth	5 cm	15 cm	25 cm	35 cm	45 cm	55 cm	Cumulative
		0 ÷ 5	5 ÷ 15	15 ÷ 25	25 ÷ 35	35 ÷ 45	45 ÷ 55	0-55
FW	Avg_season	10.9	18.0	20.7	27.8	18.8	17.0	113.2
	Min_season	5.4	13.5	16.0	23.8	15.4	14.5	88.6
	Max_season	43.6	38.4	35.3	38.0	30.3	27.5	213.0
	AvgSpring	12.9	20.1	23.6	29.8	20.5	18.2	125.0
	AvgSummer	9.9	16.9	18.9	26.8	17.9	16.4	106.7
TWW	Avg_season	19.2	25.2	27.8	31.4	25.5	25.3	154.5
	Min_season	11.4	20.8	24.1	27.5	21.1	22.3	127.1
	Max_season	41.5	36.8	40.4	40.9	35.5	33.0	228.1
	AvgSpring	23.7	28.1	30.2	34.2	28.8	27.3	172.3
	AvgSummer	16.8	23.7	26.6	29.9	23.8	24.3	145.0

Fig. 12 shows the total amount of water (mm) present in the soil (0-55 cm) and each depth measured by the various soil moisture sensors at various depths at discrete times (Example of sensor 1, freshwater).

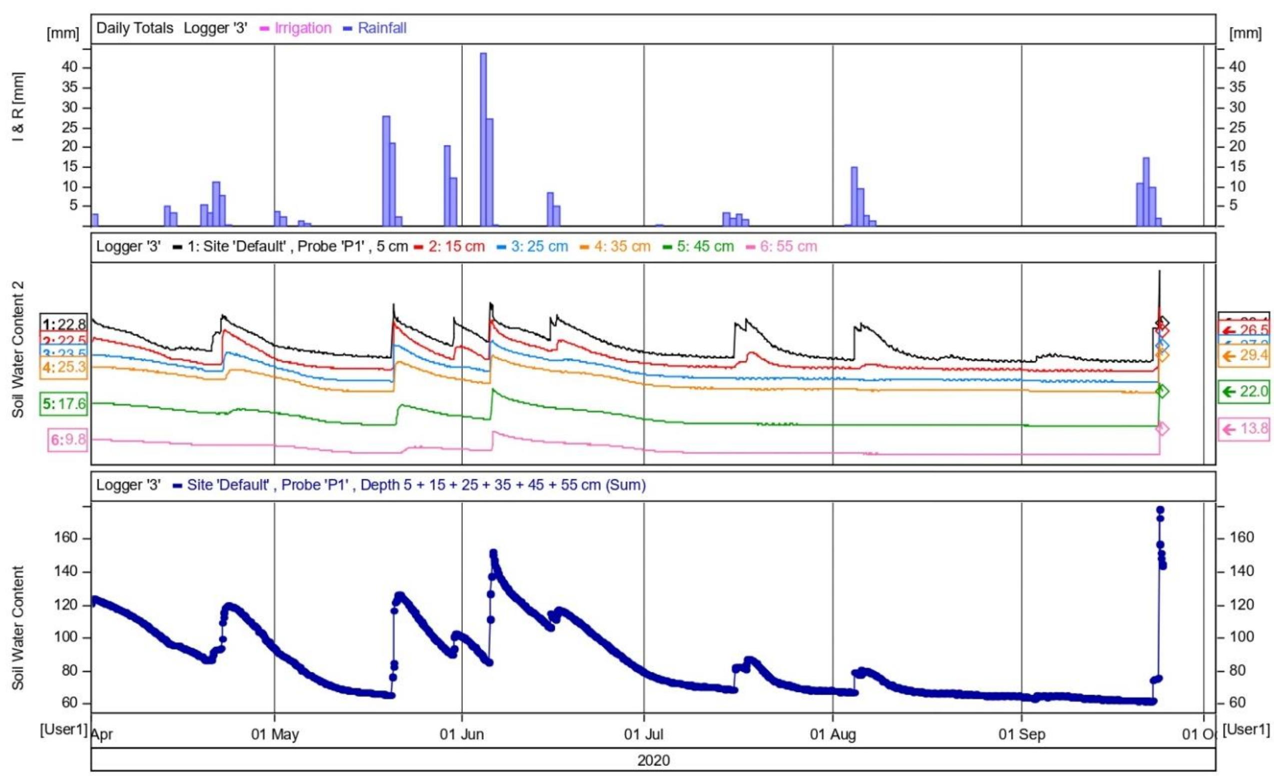

Fig. 12. Total soil moisture (mm) present in the 0-60 cm layer and soil moisture content (mm) at different depths in the soil profile.

The soil moisture at the upper layers shows larger dynamics than the soil moisture at deeper layers. In the upper soil layer or T1 (0-5 cm), the SWC was lower than those of T2 (5-15 cm) and T3 (15-25 cm).

Indeed, one can expect the topsoil to be drier than the deeper parts due to infiltration and evapotranspiration. The upper layers are mainly controlled by precipitation and evapotranspiration, which are variable in time. Ranges of SWC increase in T1, T2, and T3 (0-35 cm) and decrease in soil depth above 35 cm.

Fig. 13 shows the 2-dimensional visualization of water content throughout the soil profile over the selected period. On the seasonal scale, SWC shows a decreasing trend from spring to summer. SWC at different depths in the summer period was lower than spring with the highest difference for T1 reduced by more than 20% (Table 9).

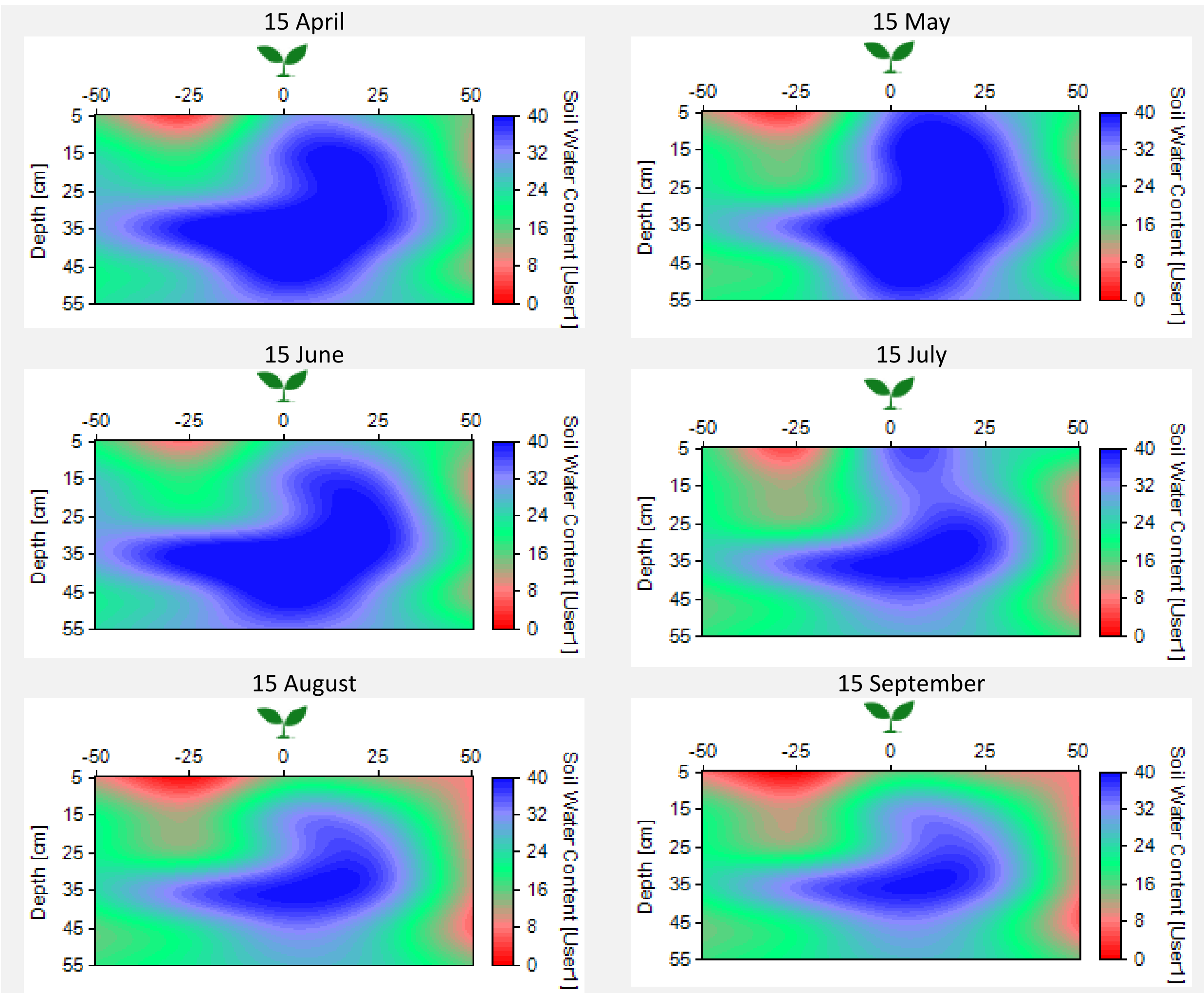

Fig. 13. Soil Water content (SWC) present at different depths in the soil profile at different days of the growing season.

SWC losses in other layers ranged from 10% to 20%. As illustrated in Fig. 12 and Fig. 13 the soil moisture dynamics demonstrated a fluctuation change law with time, and the fluctuation change decreased gradually with increasing depth. The SWC increased after water application (irrigation or rainfall) and then gradually decreased over time under the effects of soil evaporation and root water uptake. For example, after the rainfall events between 5 and 8th of June 2020, the SWC in the upper 15 centimeters of the soil

first increases sharply, followed by a steep decrease. The high sand content soil layer contributed to the poor SWC holding capacity, resulting in a larger variability of SWC. The changes in the moisture content of different layers were different: the response of moisture content at deeper soil layer was slow while the response of moisture content at the upper soil layers was quick. The SWC of the first three layers (0 ÷ 35 cm) of the soil profile responded strongly to precipitation, whereas the SWC in deeper soil (35 ÷ 50 cm) could only be recharged markedly after continuous precipitation. This indicates that moisture content in the upper soil layer is influenced by the precipitation earlier than the soil in the deeper layer. The moisture content values of sensors were different because of were at different measuring depths. The S1 is closer to the surface (0- 5 cm) than S5 (45-55 cm) and the soil moisture at point S1 is higher than S5. The results indicated that the different distances from the surface also can affect the SWC. The absence of a steep decrease indicates that water is stored in that zone and that deeper layers are unaffected by the water application, thus no or little drainage occurs below the root zone. The graph also shows the biggest difference in soil moisture content at each measuring depth. For deeper soil layers, the soil water content generally tended to be more stable and it was not influenced by precipitation directly.

4.3.2 Volumetric ion content (VIC) profiles (Salinity)

Table 10 presents the minimum, maximum, and average volumetric ion content (VIC) measured at each soil depth by the various soil moisture sensors at various depths at discrete times. The sensor produces an output of salinity in VIC a surrogate measure for soil EC. Measured VIC will increase with increasing irrigation water electrical conductivity (EC). Acceptable VIC data range from 1000 to 17,000. Values above 5000 VIC are generally considered to be causing significant plant stress and loss of yield, but this degree of risk is dependent upon soil type (Dalton et al. 2018). The results revealed that the high salt concentrations in the TWW induce high average salinity. Similar results were reported by other authors (Kaboosi 2017; Lyu and Chen 2016; Rahav et al. 2017). The VIC of TWW irrigation was valued between 1371.1 and 2191.1 with an average of 1585 VIC. The VIC of FW irrigation was valued between 1104.7 and 2002.1 with an average of 1526.6 VIC. The numerical results show that the soil salinity in the wastewater-irrigated area is little more (<10%) than freshwater irrigated land. Table 10 also shows that the application of wastewater did not lead to an increase in soil salinity beyond the threshold (>5000 VIC).

Table 10. Volumetric ion content (VIC) at different soil depth using Drill&Drop sensors for freshwater (FW) and treated wastewater (TWW) irrigated plots on an apricot orchard.

		Volumetric ion content (VIC) at different depth						
Water source	Sensor parameter/depth	5 cm 0 ÷ 5	15 cm 5 ÷ 15	25 cm 15 ÷ 25	35 cm 25 ÷ 35	45 cm 35 ÷ 45	55 cm 45 ÷ 55	Cumulative 0-55
FW	Avg_season	1526.6	1526.8	1775.6	1569.7	1692.9	1780.6	1526.6
	Min_season	1104.7	1358.5	1531.9	1458.4	1463.9	1433.7	1104.7
	Max_season	2002.6	1794.1	2286.0	1686.5	1865.7	2416.8	2002.6
	AvgSpring	1514.8	1471.8	1678.2	1533.3	1567.6	1593.2	1514.8
	AvgSummer	1532.8	1556.0	1827.1	1589.1	1759.2	1879.9	1532.8
TWW	Avg_season	1585.1	1610.8	1841.3	1618.8	1839.8	1689.4	1585.1
	Min_season	1371.1	1434.9	1599.1	1465.6	1469.8	1517.7	1371.1
	Max_season	2191.1	2588.7	3623.8	1953.1	2633.8	2969.7	2191.1
	AvgSpring	1530.8	1588.7	1832.9	1572.6	1759.6	1654.2	1530.8
	AvgSummer	1613.8	1622.5	1845.7	1643.2	1882.4	1708.0	1613.8

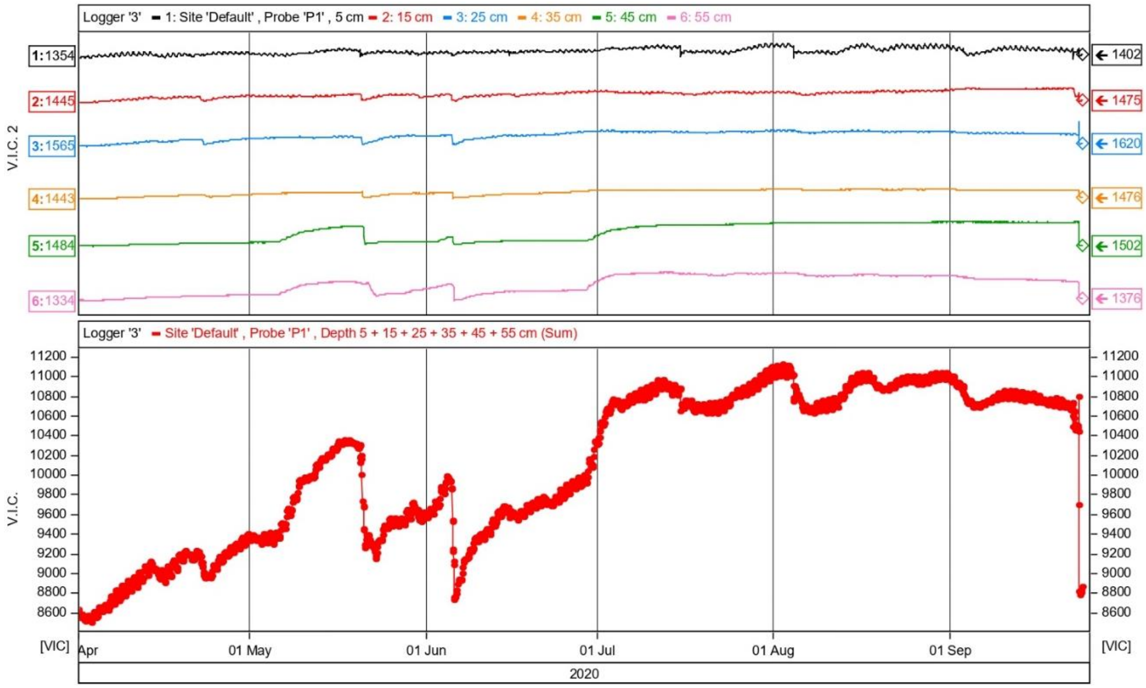

Fig. 14. Total VIC present in the 0-60 cm layer and VIC at different depths in the soil profile.

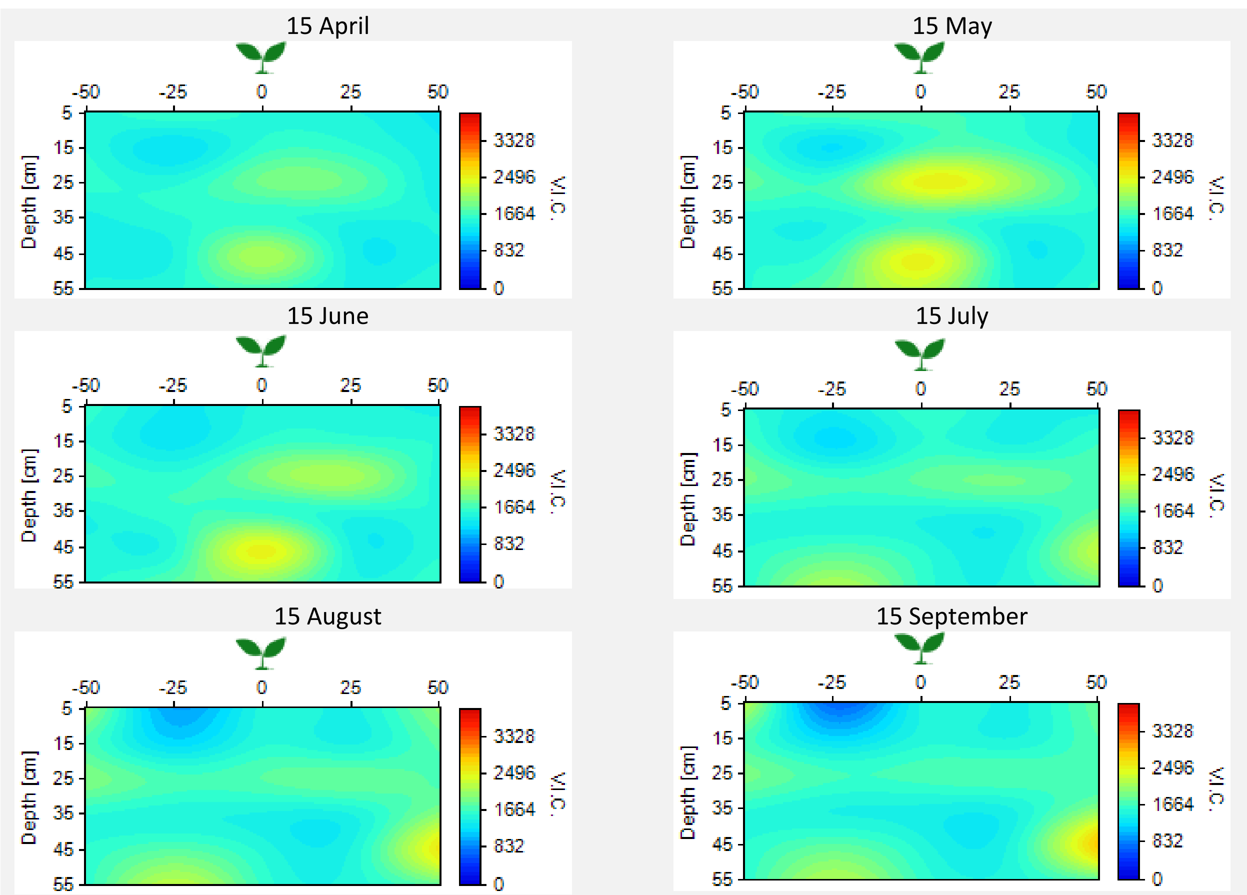

Fig. 15. VIC at different depths in the soil profile at different days of the growing season.

Fig. 14 shows a dynamic change of salinity level at multiple depths. Fig. 15 shows the 2-dimensional visualization of VIC throughout the soil profile over a selected period. The general patterns indicate that VIC increased with depth and with a decrease in soil water content. Salt accumulation mainly occurred in the middle layers. In the upper soil layers of T1 (0-5 cm) and T2 (5-15 cm) the VIC was lower than those of T3, T4, and T5. Fig. 14 and Fig. 15 shows a gentle increasing trend in salinity over summer.

4.3.3 Soil Temperature (ST) profiles

The measurement of soil temperature (ST) is often needed in understanding its impact on these various processes and in turn the plant growth and crop yields. Soil temperature affects soil water retention, transmission, and availability to plants (Onwuka 2018). The ST may influence the water movement in the soil because the higher the soil temperature occurs the higher evaporation of soil water. Higher temperature enhances physiological activity, thus promoting ion uptake, including salt ion(s) uptake resulting in more serious salt damage to crops (Bai et al. 2017). Ideal soil temperatures for planting most plants are 18-24 ^{o}C. Table 11 shows ST measured at each soil depth by the various soil sensors at various depths at discrete times. Soil temperature was quite similar at both monitoring irrigated plots. The estimated annual average ST for FW ranged from 7.8 to 36 ^{o}C with an average of 22.7 ^{o}C. On other hand, the estimated annual average ST for TWW ranged from 8.6 to 35.5 ^{o}C with an average of 22.7 ^{o}C.

Table 11. Soil temperature (ST) at different soil depth using Drill&Drop sensors for freshwater (FW) and treated wastewater (TWW) irrigated plots on an apricot orchard.

		Soil Temperature [°C] at different depth						
Water source	Sensor parameter/depth	5 cm	15 cm	25 cm	35 cm	45 cm	55 cm	Cumulative
		0 ÷ 5	5 ÷ 15	15 ÷ 25	25 ÷ 35	35 ÷ 45	45 ÷ 55	0-55
FW	Avg_season	22.7	22.2	22.1	21.6	21.4	21.2	22.7
	Min_season	7.8	9.5	10.5	10.5	10.9	11.2	7.8
	Max_season	36.0	30.9	29.5	28.4	27.8	27.1	36.0
	AvgSpring	17.0	16.6	16.6	16.1	16.0	15.8	17.0
	AvgSummer	25.8	25.3	25.1	24.6	24.3	24.0	25.8
TWW	Avg_season	22.7	22.3	22.1	21.4	21.2	20.5	22.7
	Min_season	8.6	9.9	10.8	10.7	11.0	10.8	8.6
	Max_season	35.5	31.1	29.5	28.2	27.7	26.7	35.5
	AvgSpring	16.9	16.6	16.5	15.8	15.7	15.1	16.9
	AvgSummer	25.8	25.3	25.0	24.3	24.1	23.3	25.8

Fig. 16 shows the variation of soil temperature with depth. Fig. 17 shows the 2-dimensional visualization of ST throughout the soil profile over the selected time. The increase in soil temperature followed a T1 < T2 < T3 < T4 < T5 pattern (decreases with an increase in depth). The results from soil temperature sensor readings indicated that both the highest and lowest observed soil temperatures occur at the surface and the largest depth.

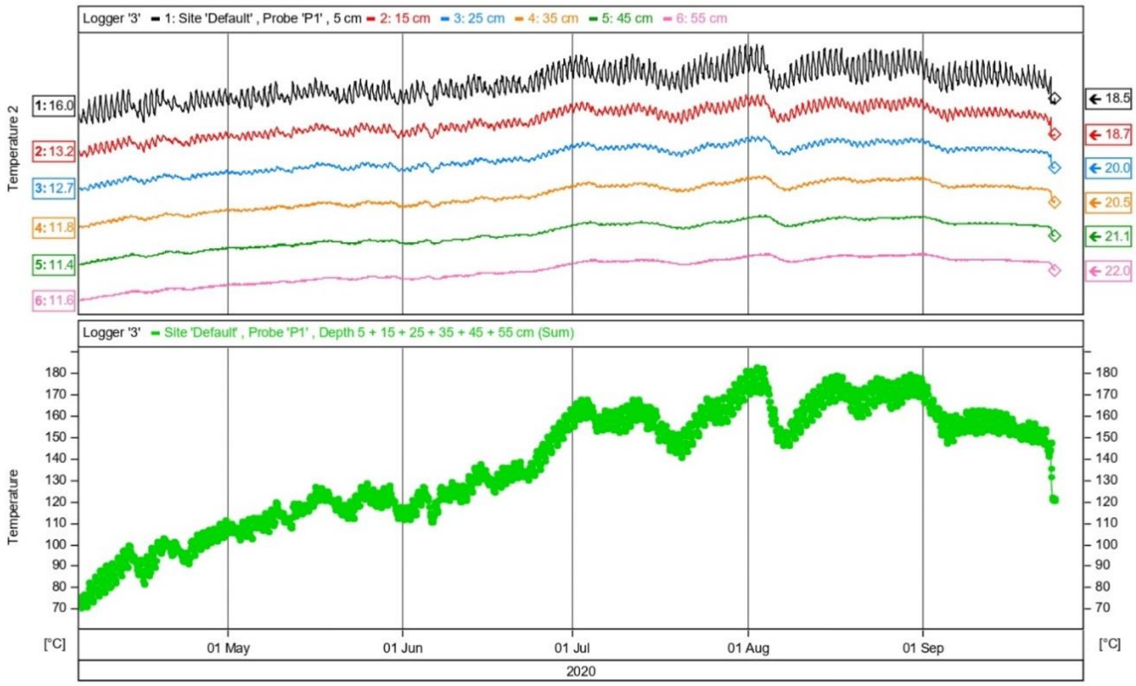

Fig. 16. Soil temperature (ST) in the 0-55 cm layer and at different depths in the soil profile.

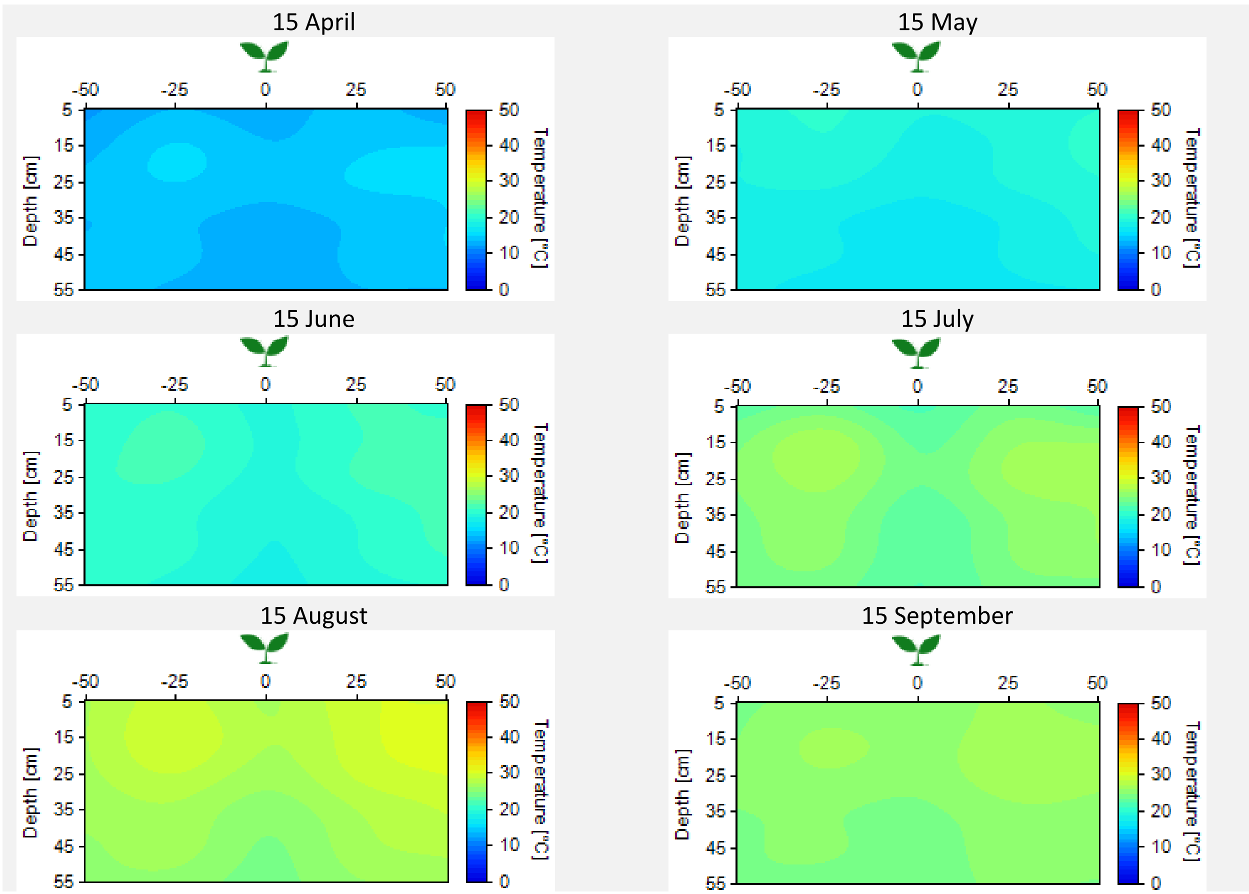

Fig. 17. Soil temperature at different depths in the soil profile at different days of the season.

The fluctuations of soil temperature are more regular in the topsoil than in the lower soil layers, because soil temperature variations are primarily driven by the fluctuating temperature of the soil surface (Zou 2012). As the depth of soil increases, the amplitude of temperature decreases, and soil temperature variability is low. After a depth of 35 cm, the soil temperature tends to become constant. Changes in temperature around deep roots can change moisture uptake.

4.3.4 Trend and relationship between rainfall, SWC, salinity, and soil temperature

Fig. 18 shows the variation of rainfall, SWC, VIC, and ST soil temperature at discrete times (Example of sensor 1, freshwater). The results indicate a clear correlation between moisture and salinity. They show that an increase in moisture content decreases the VIC and soil temperature. Soil moisture gradually or sharply increases after rainfall events while VIC and soil temperature would decrease. Soil moisture tends to decrease in summer due to the higher solar energy available.

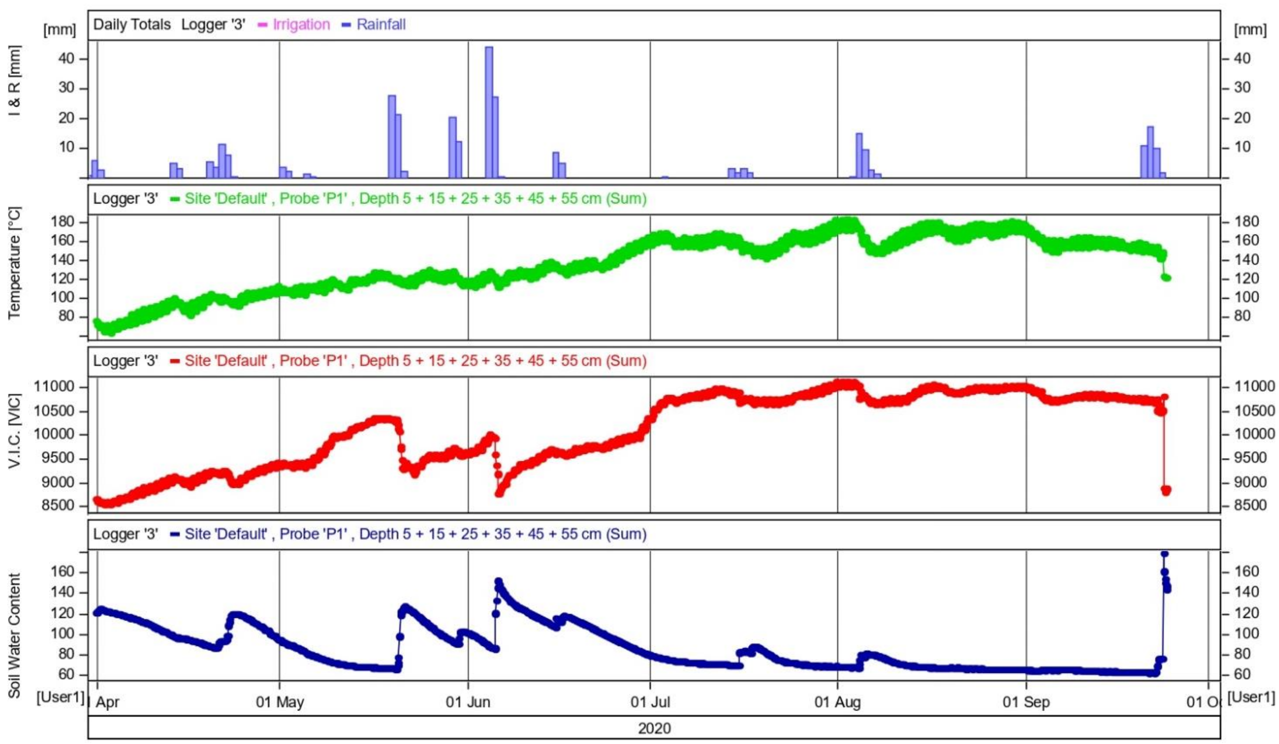

Fig. 18. Rainfall, SWC, VIC, and ST time evolution within the soil profile (Example of sensor 3).

The overall results of this experiment indicated that irrigation water quality influences the physical and chemical properties of the soil. The use of TWW can lead to a decrease in soil infiltration rate, an increase in soil water content but slightly higher salinity. As noted earlier, higher levels of salinity in the irrigation water are not dangerous, however, water delivery and distribution systems must be operated efficiently to facilitate the timely supply of water in the right quantities and to avoid waterlogging and salinity build-

up in irrigated lands, especially when saline waters are involved. The use of saline water needs to utilize in combination with other water of low salinity or adopting a "dual-rotation" strategy.

5. Concluding remarks

This deliverable report is the summary of processes and activities for soil and water quantity and quality audits performed by PB4 for Italian agriculture systems. The information on data collection was extensive and included lots of specific information including the hydraulic characteristics, agronomic characteristics, and technical descriptions of the relevant stages of the wastewater treatment and reuse, and soil mechanics, and water quality analysis. Overall, this particular data collection process proceeded organized and without great problems. Alongside data gathered from field visits, provided by partners and experts, this report has especially focused on the data collection via sensors and sampling. Remote sensing surveys via automated instruments were conducted over field sites during the irrigation season to collect quantitative information on soil water content, temperature, and salinity. The results from the sensors installed in the field show that they provide valuable information for irrigation and salinity management, at least in a qualitative and relative sense. Also, field data were collected and samples were analyzed for soil texture, salinity, and water quality. The datasets will serve as a guide for the present and future activities i.e. will be used to quantify water-energy-environment nexus by life cycle impact assessment indicators, quantify the eco-efficiency of the whole investigated system/s with environmental and economic data, and support the development and validation of DSS which will be performed in the next steps (deliverables) of the project. The conclusions and final results will be presented in the Final Report.

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APPENDIX

Table A1. Detailed analysis of soil samples.

SAMPLE	*SAND*					SAND	LOAM	CLAY	USDA CLASS.
	VERY FINE SAND	*FINE SAND*	*MEDIUM SAND*	*COARSE SAND*	*VERY COARSE SAND*				
S1	47.85	11.80	0.40	0.23	0.17	60.45	27.23	12.32	SANDY LOAM
S2	37.28	9.30	0.47	0.38	0.28	47.71	35.71	16.58	LOAM
S3	43.90	16.38	2.95	2.05	1.78	67.06	21.41	11.53	SANDY LOAM

Table A2. Soil water content (SWC) in mm at different soil depth using Drill&Drop sensors.

Water source	Sensor	SWC (mm)	At 5 cm 0 ÷ 5	At 15 cm 5 ÷ 15	At 25 cm 15 ÷ 25	At 35 cm 25 ÷ 35	At 45 cm 35 ÷ 45	At 55 cm 45 ÷ 55	Cumulative 0-55 cm
FW	S1	Avg_season	14.47	15.37	17.07	19.19	11.83	6.09	84.0
		Min_season	8.24	10.77	13.00	15.28	8.56	4.11	60.0
		Max_season	43.32	35.05	32.97	34.54	25.31	16.79	188.0
		AvgSpring	16.24	17.35	19.17	21.2	13.68	7.19	94.8
		AvgSummer	13.54	14.32	15.16	18.3	10.85	5.51	77.7
	S2	Avg_season	14.19	23.31	24.77	26.88	18.70	20.42	128.3
		Min_season	7.48	18.63	20.18	22.80	15.31	17.68	102.1
		Max_season	41.09	37.43	35.94	36.00	28.58	29.15	208.2
		AvgSpring	16.60	25.56	27.37	29.02	20.67	21.81	141.0
		AvgSummer	12.91	22.11	23.39	25.75	17.66	19.69	121.5
	S3	Avg_season	4.10	15.3	20.2	37.3	25.8	24.6	127.3
		Min_season	0.58	11.0	14.9	33.3	22.4	21.6	103.8
		Max_season	46.32	42.6	37.1	43.4	36.9	36.6	242.9
		AvgSpring	5.92	17.3	24.2	39.1	27.1	25.5	139.1
		AvgSummer	3.13	14.3	18.1	36.3	25.1	24.1	121.0
TWW	S4	Avg_season	23.83	33.3	33.0	42.1	37.7	30.3	200.2
		Min_season	15.05	29.1	30.2	39.1	32.0	27.2	172.7
		Max_season	46.20	44.8	44.4	47.5	45.9	40.0	268.8
		AvgSpring	29.29	35.9	35.1	44.4	42.1	32.7	219.5
		AvgSummer	20.94	31.9	31.9	40.9	35.3	29.0	189.9
	S5	Avg_season	21.20	32.2	37.5	37.7	28.8	27.0	184.4
		Min_season	11.12	25.8	33.1	34.5	25.3	24.6	154.4
		Max_season	44.32	43.5	45.0	44.9	39.3	33.2	250.2
		AvgSpring	26.85	36.5	39.6	39.5	31.0	27.9	201.4
		AvgSummer	18.21	29.9	36.4	36.7	27.7	26.5	175.4
	S6	Avg_season	12.54	10.2	12.9	14.5	10.1	18.7	78.9
		Min_season	7.89	7.4	8.9	8.9	6.0	15.1	54.2
		Max_season	34.09	22.0	31.8	30.3	21.4	25.7	165.3
		AvgSpring	14.90	11.9	15.9	18.8	13.2	21.3	96.0
		AvgSummer	11.29	9.3	11.4	12.1	8.4	17.3	69.8

Table A2. Volumetric ion content (VIC) at different soil depth using Drill&Drop sensors.

Water source	Sensor	VIC	At 5 cm	At 15 cm	At 25 cm	At 35 cm	At 45 cm	At 55 cm	Cumulative
			0 ÷ 5	5 ÷ 15	15 ÷ 25	25 ÷ 35	35 ÷ 45	45 ÷ 55	0-55 cm
FW	S1	Avg_season	1481.66	1628.37	1816.59	1604.03	1824.46	1737.33	10092
		Min_season	1281.74	1404.42	1537.06	1430.35	1474.09	1311.13	8439
		Max_season	1685.60	1781.92	2166.52	1692.40	2100.37	2055.70	11483
		AvgSpring	1418.03	1545.5	1702.10	1534.12	1623.66	1518.12	9342
		AvgSummer	1515.34	1672.3	1877.20	1641.04	1930.76	1853.36	10490
	S2	Avg_season	1797.3	1666.0	1829.9	1539.8	1562.5	1593.1	9989
		Min_season	1412.3	1451.7	1568.8	1454.4	1422.8	1458.0	8768
		Max_season	2317.4	1823.4	2607.8	1626.0	1630.3	1666.4	11671
		AvgSpring	1576.6	1581.2	1696.4	1487.5	1504.1	1535.3	9381
		AvgSummer	1914.1	1710.9	1900.5	1567.6	1593.5	1623.7	10310
	S3	Avg_season	1481.66	1628.37	1816.59	1604.03	1824.46	1737.33	10092
		Min_season	1281.74	1404.42	1537.06	1430.35	1474.09	1311.13	8439
		Max_season	1685.60	1781.92	2166.52	1692.40	2100.37	2055.70	11483
		AvgSpring	1418.03	1545.5	1702.10	1534.12	1623.66	1518.12	9342
		AvgSummer	1515.34	1672.3	1877.20	1641.04	1930.76	1853.36	10490
TWW	S4	Avg_season	1588.5	1634.2	1957.0	1577.6	1948.4	1808.9	10515
		Min_season	1415.2	1536.2	1677.4	1461.4	1538.7	1579.5	9208
		Max_season	2489.9	3389.5	4839.2	1982.4	3219.0	5419.0	21339
		AvgSpring	1625.2	1673.4	2065.0	1652.7	2267.5	1849.1	11133
		AvgSummer	1569.0	1613.5	1899.8	1537.9	1779.4	1787.6	10187
	S5	Avg_season	1519.7	1585.9	1963.6	1517.4	1492.8	1526.3	9606
		Min_season	1418.6	1483.5	1756.2	1479.5	1436.6	1447.1	9022
		Max_season	1982.4	2532.9	4195.7	1803.2	1745.5	1622.4	13882
		AvgSpring	1536.0	1651.5	1973.7	1530.7	1464.0	1500.6	9657
		AvgSummer	1511.0	1551.2	1958.2	1510.3	1508.1	1539.8	9579
	S6	Avg_season	1647.2	1612.3	1603.2	1761.3	2078.3	1733.0	10435
		Min_season	1279.6	1285.1	1363.7	1455.9	1434.0	1526.4	8345
		Max_season	2101.1	1843.7	1836.4	2073.7	2937.0	1867.7	12660
		AvgSpring	1431.3	1441.2	1460.0	1534.4	1547.2	1613.0	9027
		AvgSummer	1761.5	1702.9	1679.1	1881.5	2359.6	1796.5	11181

Table A3. Soil temperatures (ST) in °C at different soil depth using Drill&Drop sensors.

Water source	Sensor	ST	At 5 cm 0 ÷ 5	At 15 cm 5 ÷ 15	At 25 cm 15 ÷ 25	At 35 cm 25 ÷ 35	At 45 cm 35 ÷ 45	At 55 cm 45 ÷ 55	Cumulative 0-55 cm
FW	S1	Avg_season	23.50	23.06	22.90	22.42	21.84	21.70	135
		Min_season	7.87	9.62	10.73	10.76	10.84	11.27	61
		Max_season	37.28	32.22	30.53	29.32	28.21	27.55	185
		AvgSpring	17.80	17.46	17.44	16.95	16.45	16.44	103
		AvgSummer	26.52	26.02	25.79	25.32	24.69	24.49	153
	S2	Avg_season	21.40	20.95	21.30	21.16	21.07	21.15	127
		Min_season	7.39	8.73	9.97	10.30	10.89	11.48	59
		Max_season	31.80	28.57	28.03	27.54	27.15	26.96	170
		AvgSpring	15.79	15.48	15.93	15.69	15.72	15.94	95
		AvgSummer	24.36	23.84	24.15	24.05	23.90	23.90	144
	S3	Avg_season	23.3	22.7	22.2	21.3	21.4	20.6	132
		Min_season	8.2	10.0	10.7	10.4	11.1	10.7	61
		Max_season	38.8	31.9	29.9	28.3	27.9	26.7	184
		AvgSpring	17.3	16.8	16.5	15.6	15.8	15.1	97
		AvgSummer	26.5	25.9	25.3	24.3	24.3	23.5	150
TWW	S4	Avg_season	21.5	21.0	20.9	20.1	19.8	19.6	123
		Min_season	8.8	9.7	10.5	10.2	10.3	10.6	60
		Max_season	31.9	28.4	27.5	26.4	26.0	25.6	166
		AvgSpring	16.2	15.8	15.7	14.9	14.6	14.5	92
		AvgSummer	24.3	23.8	23.6	22.9	22.6	22.3	140
	S5	Avg_season	22.9	22.5	22.5	21.5	21.5	20.9	132
		Min_season	9.7	10.5	11.4	10.7	11.4	11.1	65
		Max_season	34.0	30.9	29.9	28.4	28.0	27.3	179
		AvgSpring	16.9	16.5	16.6	15.7	15.7	15.3	97
		AvgSummer	26.2	25.6	25.6	24.6	24.5	23.8	150
	S6	Avg_season	23.6	23.3	22.8	22.5	22.3	21.0	136
		Min_season	7.3	9.6	10.5	11.1	11.3	10.6	60
		Max_season	40.7	33.9	31.1	29.8	29.0	27.3	192
		AvgSpring	17.7	17.5	17.1	16.9	16.7	15.5	101
		AvgSummer	26.8	26.4	25.9	25.4	25.2	23.9	154