Report on the evolution of the hydrogeological, meteo-climatic, and crop parameters in the Italian site over the project time span

Deliverable D_3.3.3

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1. INTRODUCTION

This report constitutes the project deliverable "Report on the evolution of the hydrogeological, meteo-climatic, and crop parameters in the Italian site over the project time span (D_3.3.3)" which is part of the WP3.3 Action (Monitoring network) of the WP3 "Studying". Specifically, this report includes: a) the measurements carried out in the new MoST wells (MoST1, MoST2, MoST3, MoST4, and MoST5) consisting in EC profiles and time series; and b) the groundwater and soil electrical conductivity and the crop status recorded in the five monitoring stations established in the farmland (Fig. 1). The data acquired over the project time span are representative of the hydrogeological evolution of the phreatic aquifer.

(a)

(b)

Fig. 1 – (a) Location of MoST wells and monitoring points in the Dead Channel, Bacchiglione and Brenta watercourses; (b) location of the five monitoring stations established in the farmland.

2. HYDROGEOLOGICAL EVOLUTION

2.1 Groundwater

2.2 Electrical Conductivity logs

Electrical conductivity (EC) profiles were acquired in MoST1, MoST2, MoST3 approximately quarterly, and in MoST4 and MoST5 with less regularity. It was decided to adopt this frequency for the following reasons.: each time the sensor is deployed into the well, the natural stratification of the water is broken, and the water column takes up to several weeks before EC values returns to undisturbed conditions. In addition, changes throughout the water column are very slow, and the frequency adopted for the campaigns is believed to be reasonably representative of seasonality of the salinity dynamics.

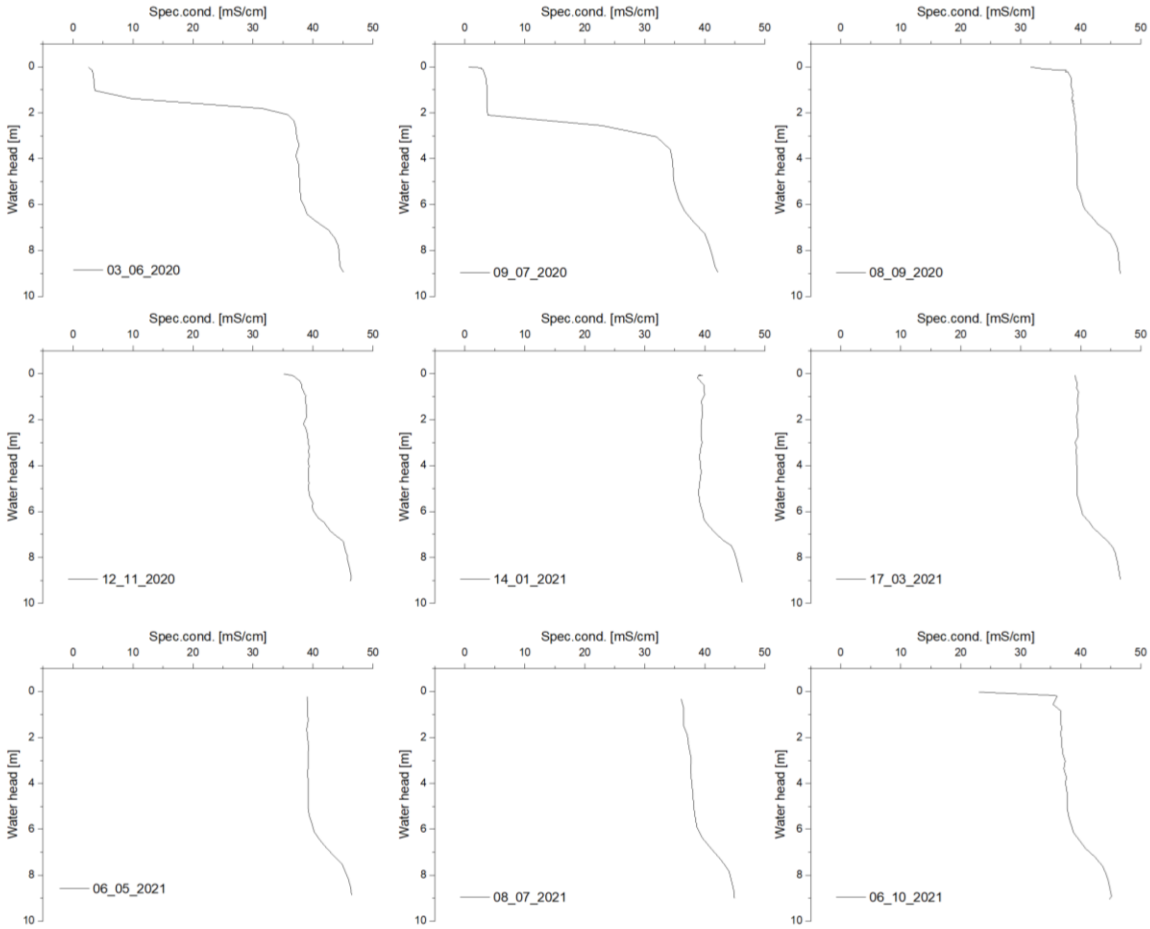

Fig. 2 - Electrical conductivity (EC) profile acquired in MoST1.

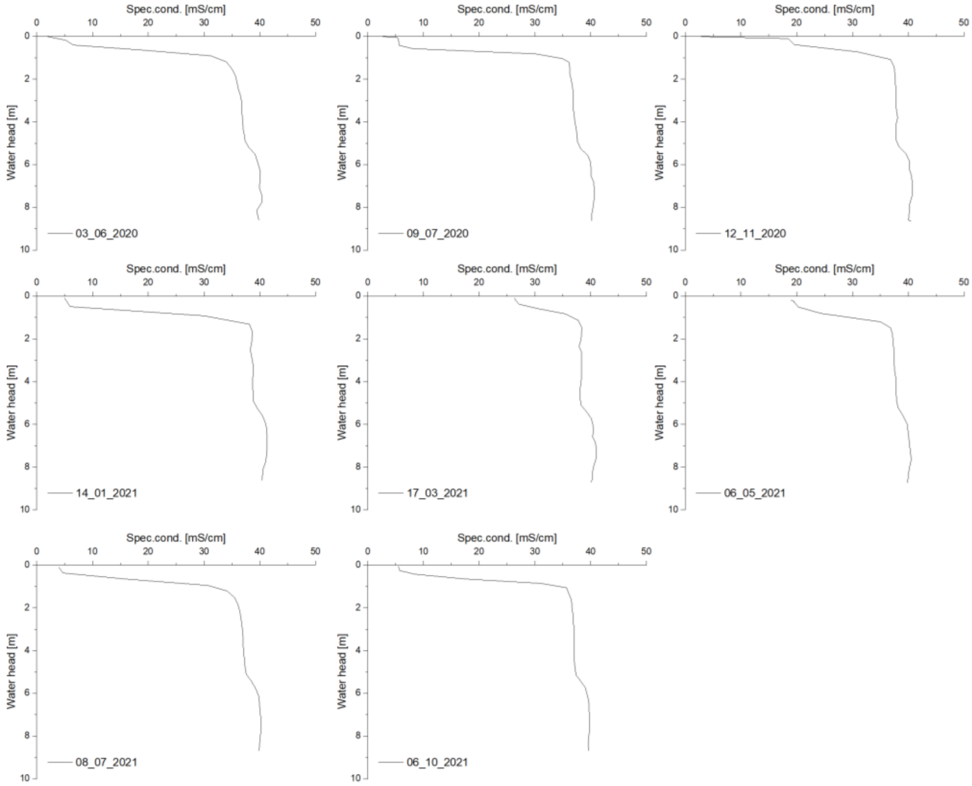

Fig. 3 - Electrical conductivity (EC) profile acquired in MoST2.

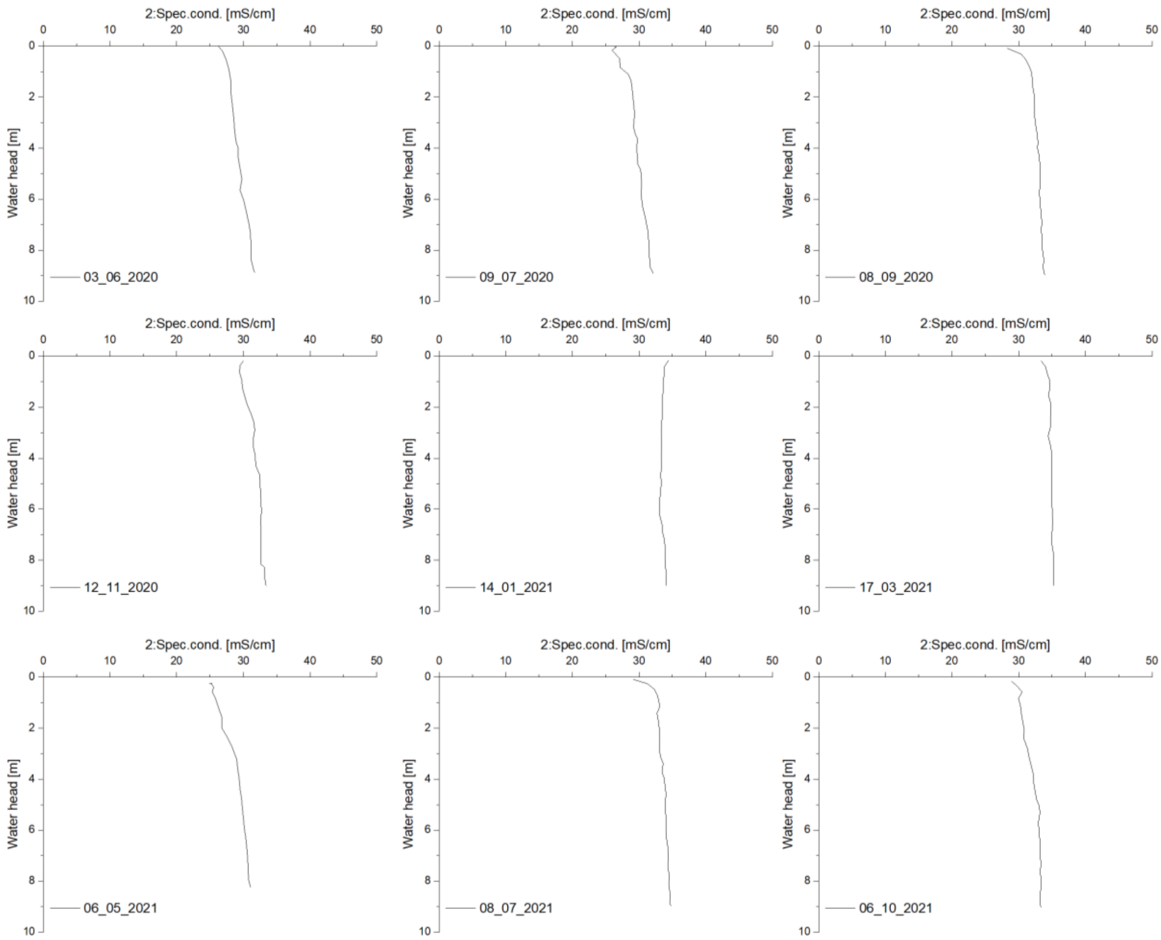

Fig. 4 - Electrical conductivity (EC) profile acquired in MoST3.

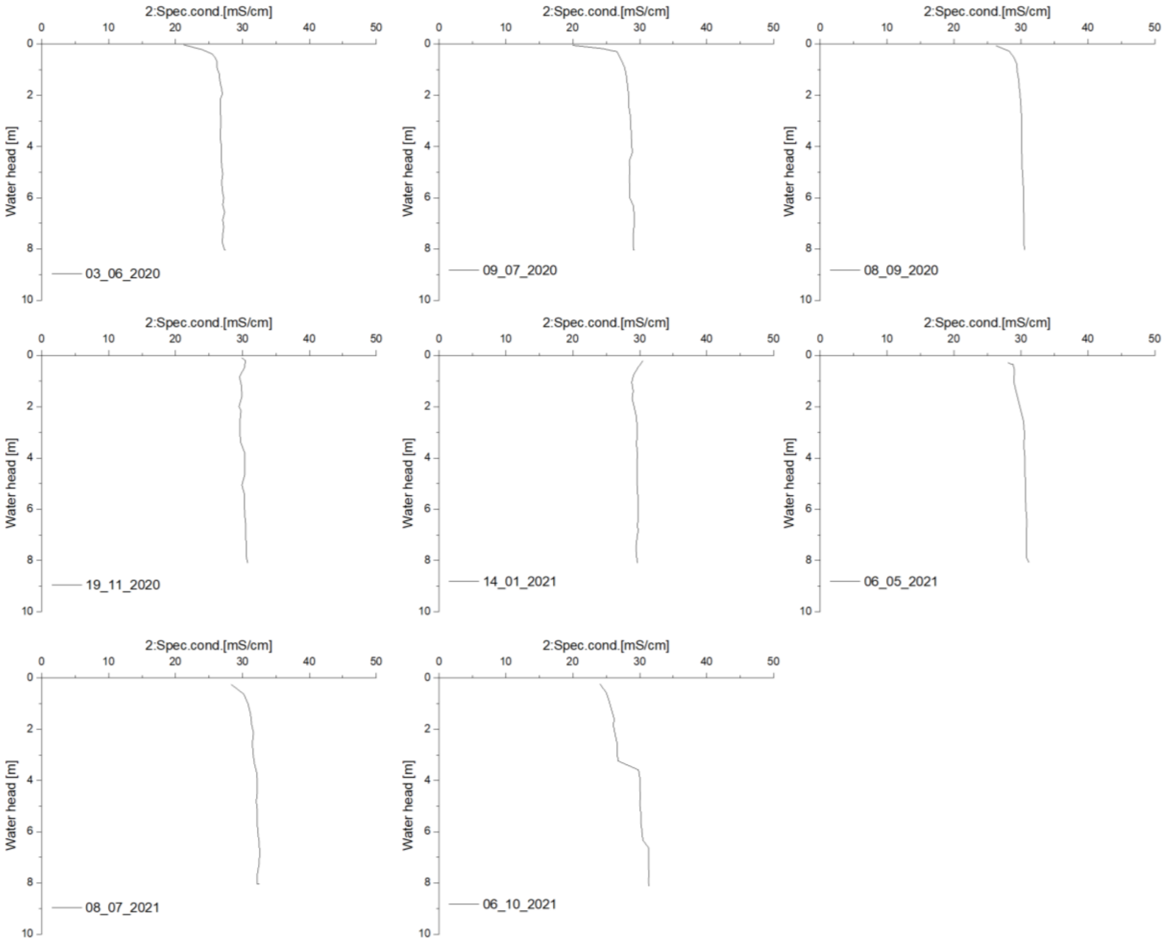

Fig. 5 - Electrical conductivity (EC) profile acquired in MoST4.

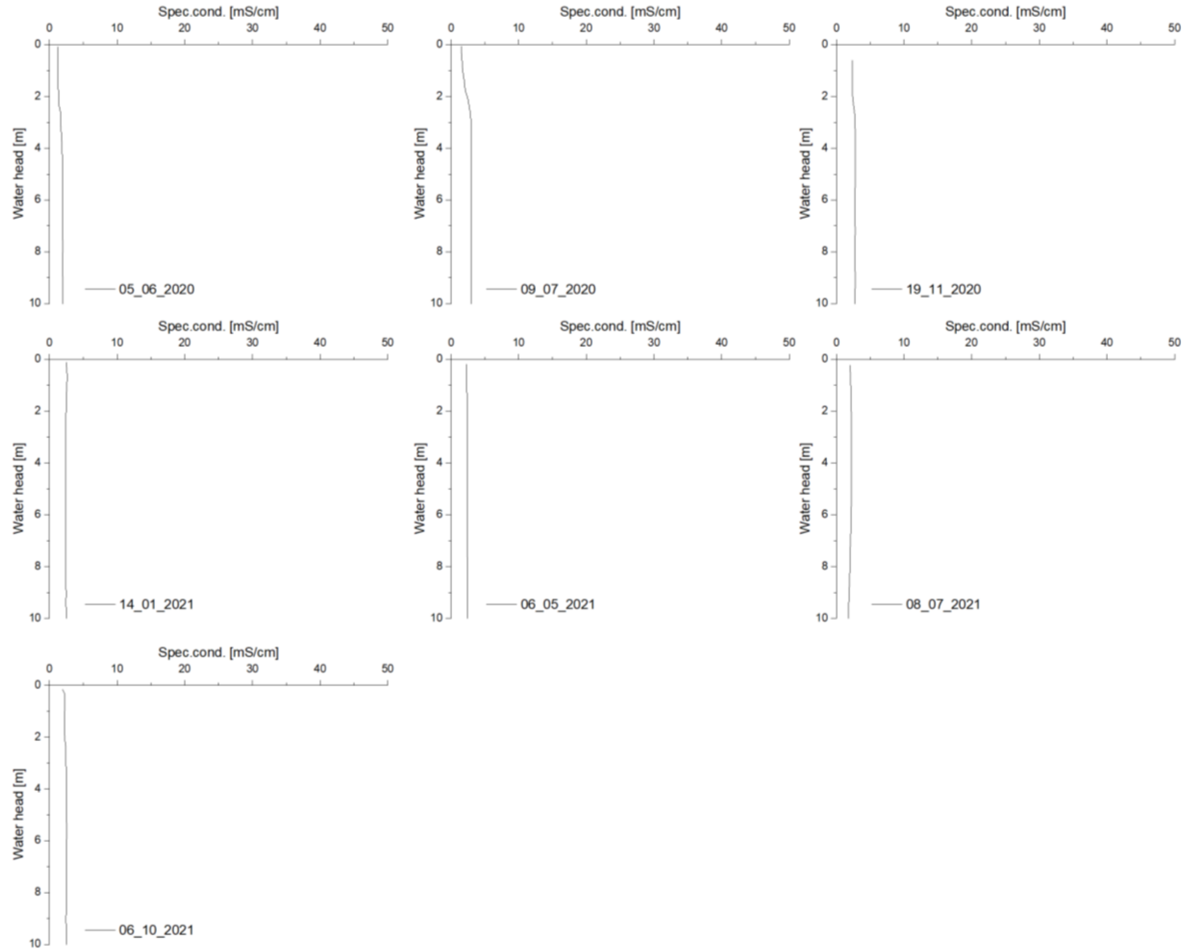

Fig. 6 - Electrical conductivity (EC) profile acquired in MoST5.

2.3 Time series

The time series data consist of EC, T and water head recordings acquired from sensors installed at fixed depth in well MoST1, MoST2, MoST3 and MoST4.

The time series data representative of summer (2020, 2021, 2022) and winter (2020, 2021) seasons are shown below.

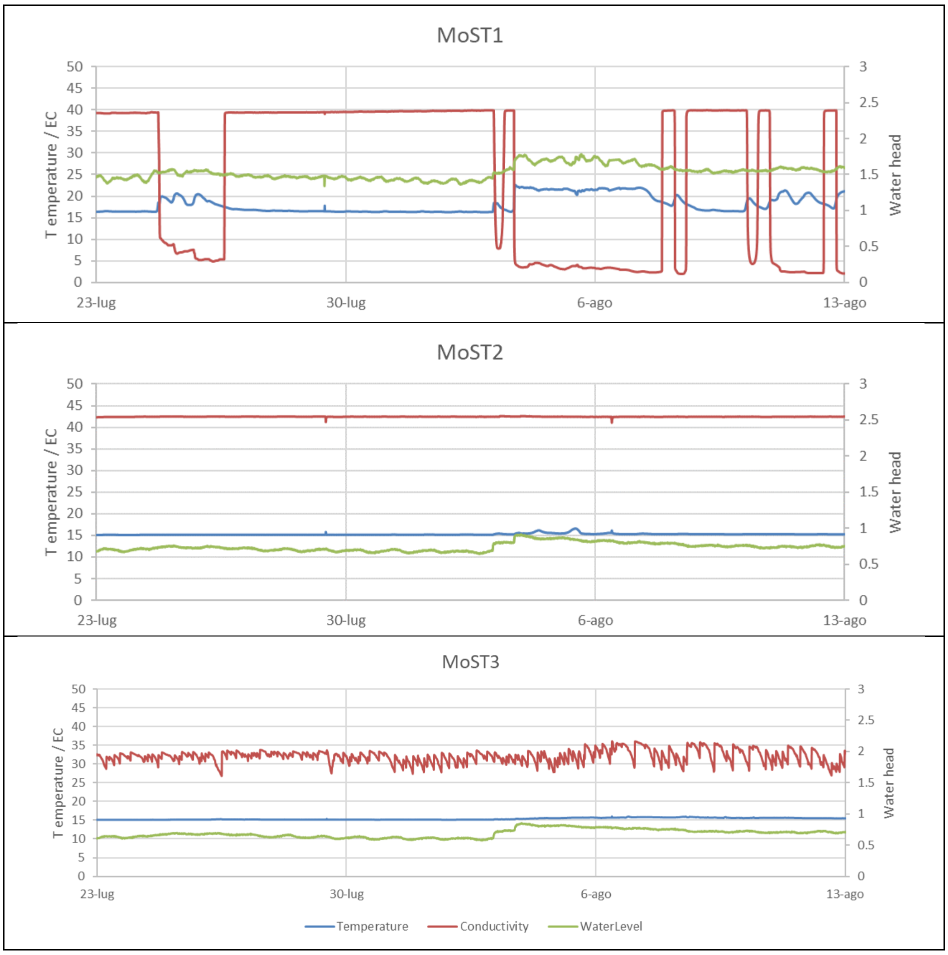

Fig. 7 – Electrical conductivity, Temperature and Water head representative of Summer 2020 detected in MoST1, MoST2 and MoST3 wells.

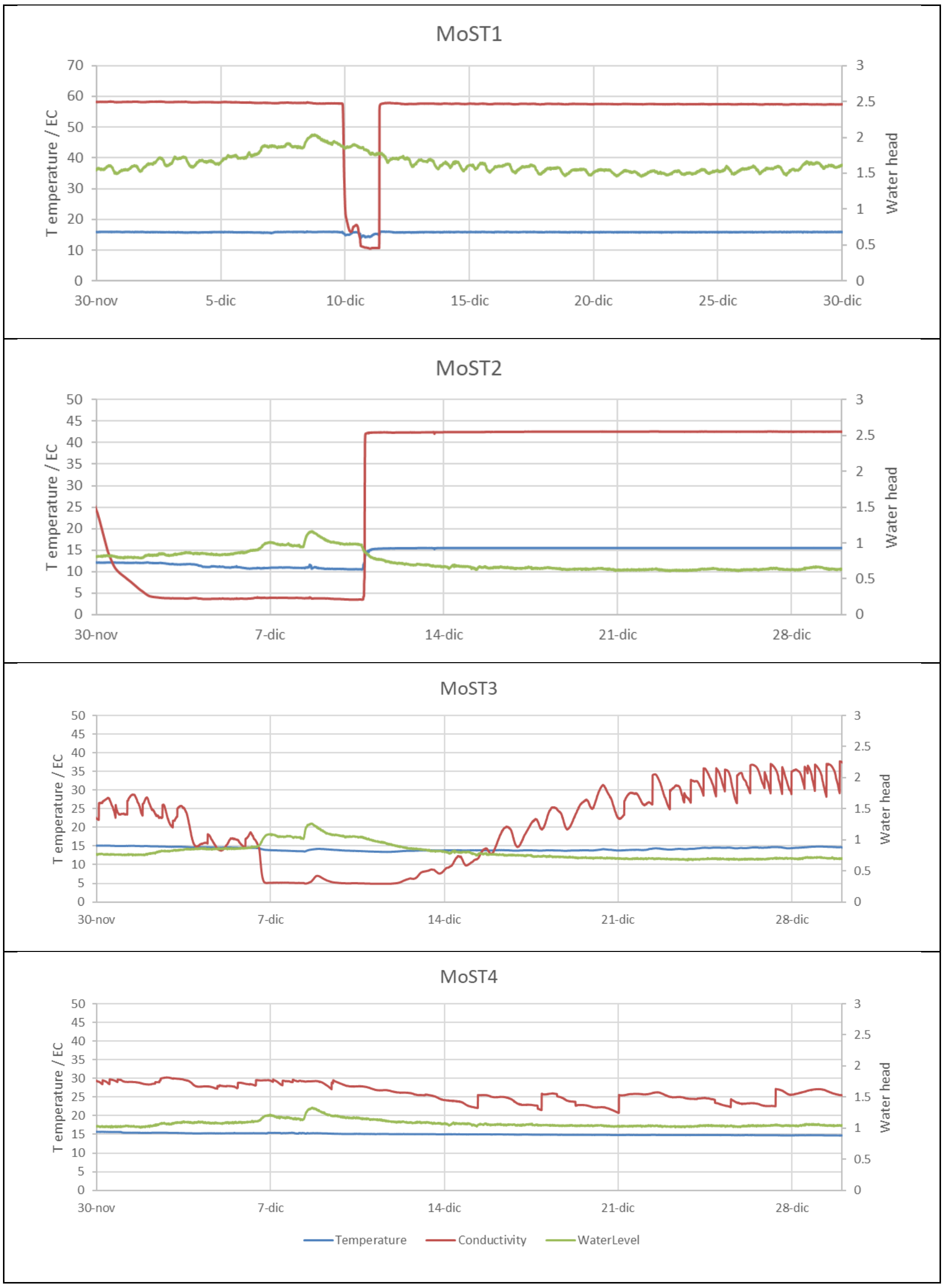

Fig. 8 – Electrical conductivity, Temperature and Water head representative of Fall-Winter 2020 detected in MoST1, MoST2, MoST3, and MoST4 wells.

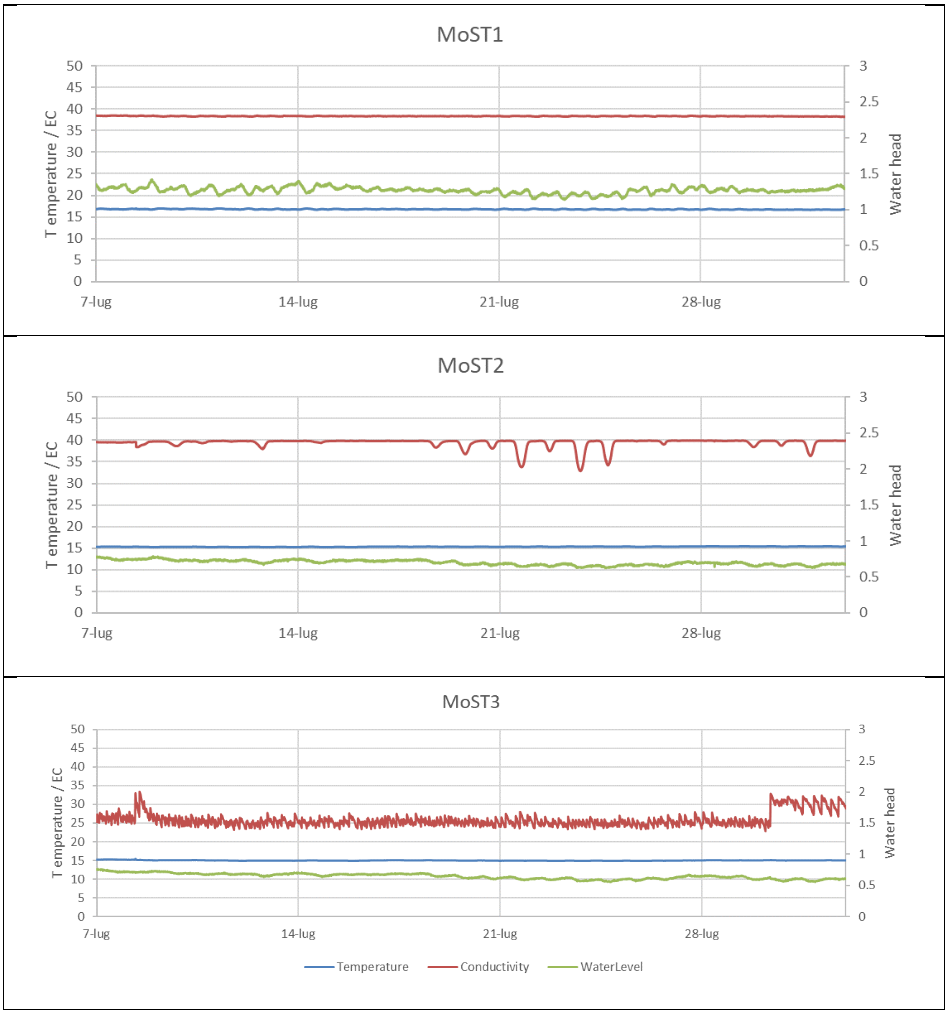

Fig. 9 – Electrical conductivity, Temperature and Water head representative of Summer 2021 detected in MoST1, MoST2, and MoST3 wells.

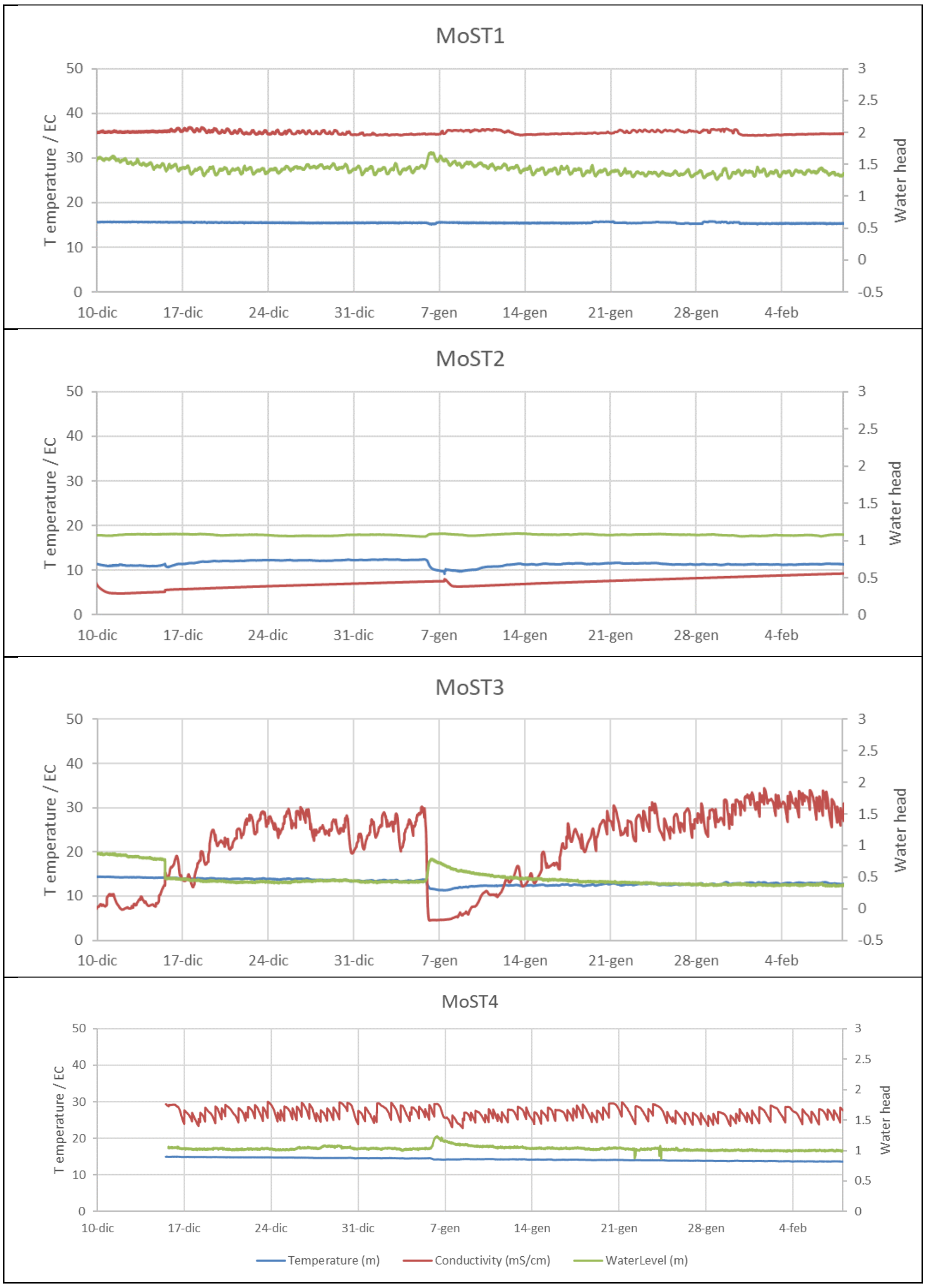

Fig. 10 – Electrical conductivity, Temperature and Water head representative of Winter 2021-2022 detected in MoST1, MoST2, MoST3 and MoST4 wells.

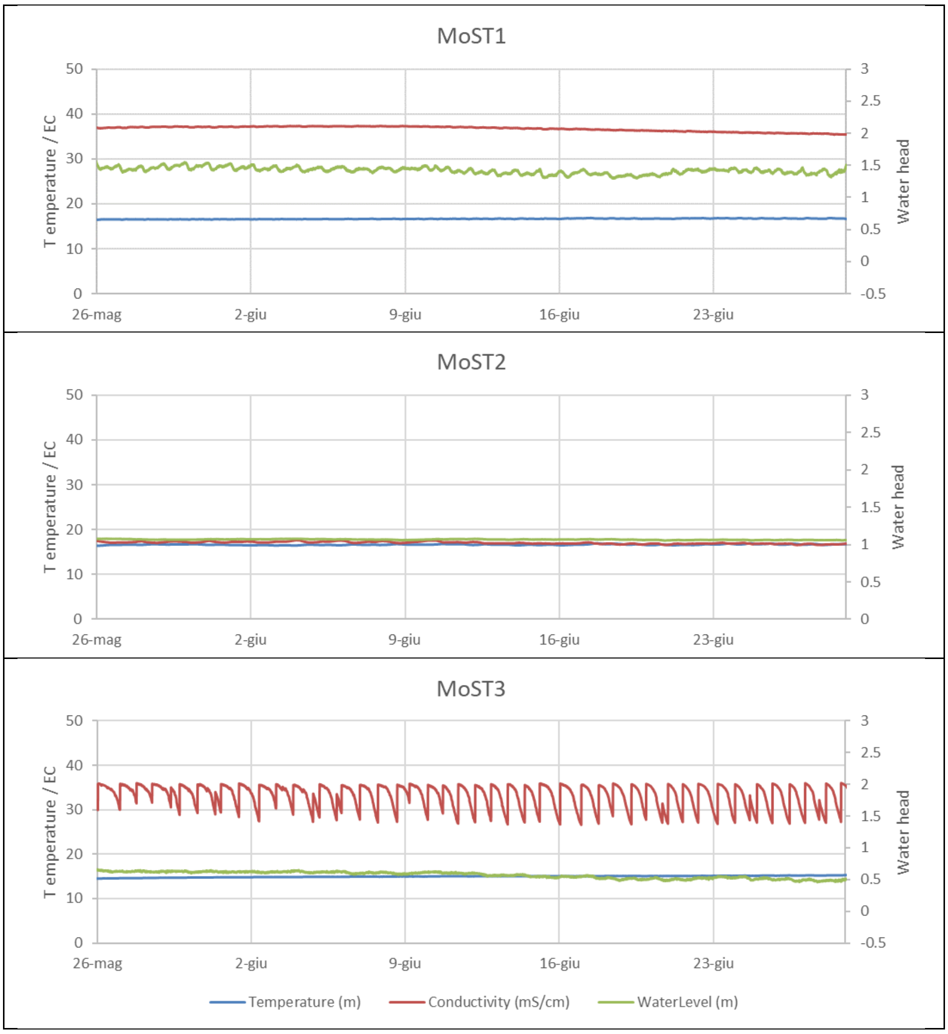

Fig. 11 – Electrical conductivity, Temperature and Water head representative of early Summer 2022 detected in MoST1, MoST2, and MoST3 wells.

2.4 Watercourses

The salinity of water in the Morto Canal and the Brenta and Bacchiglione rivers was measured at Cà Pasqua where a bridge crosses the three streams (**Errore. L'origine riferimento non è stata trovata.**). Specifically, EC profile were carried out in the water column (Fig. 12).

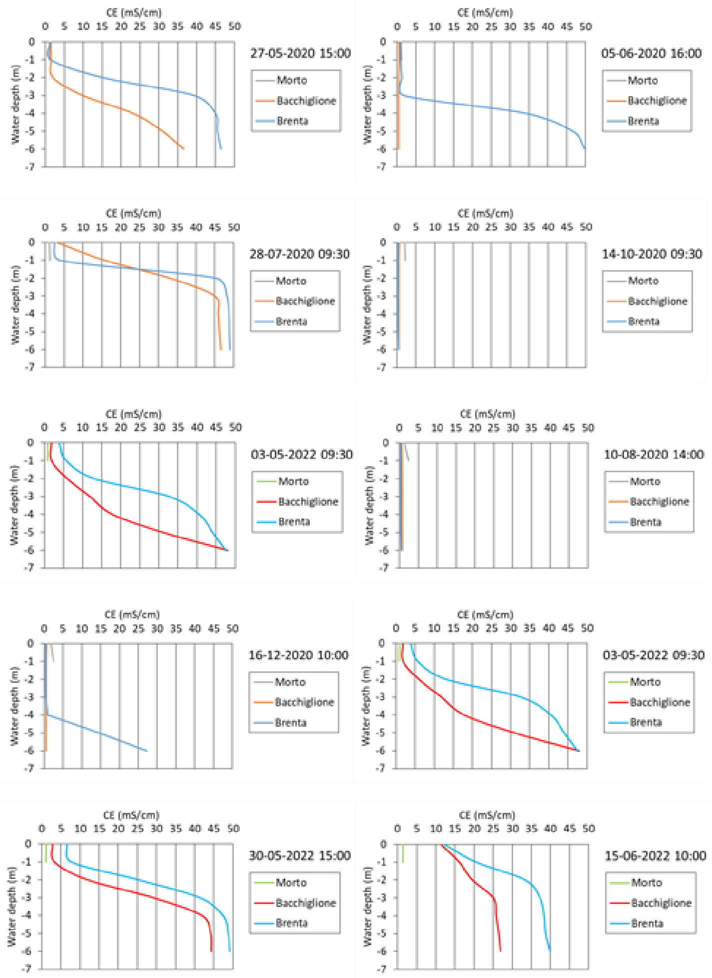

Fig. 12 - Electrical conductivity (EC) profile recorded in Morto channel, Bacchiglione and Brenta rivers at Cà Pasqua bridge.

2.5 Remarks

Groundwater dynamics is influenced by several mechanisms, including precipitation, leakages from river and channel beds, drainage regimes, and sedimentological constraints. All these mechanisms, together with climatic conditions, such as sea level, temperature, and evapotranspiration, describe the short- and long-term hydrogeological evolution.

The EC profiles acquired in the MoST wells allowed the following remarks.

MoSTl, MoST2, MosT3, and MoST4 wells are generally characterized by high EC values, ranging from 30 to 50 mS/cm. In the surface part, MoST1 and MoST2 wells show the presence of a low-salinity lens almost concurrently with rainfall events. The water stratification is influenced by the presence of sedimentological constraints, as demonstrated by detailed reconstruction of subsurface architecture. MoST5 is the only well characterized by the constant presence of fresh water.

The data sets recorded by the sensors fixed in the most superficial part of the aquifer allowed the following observations.

MoST1 well shows background EC values ranging from 35 to 50 mS/cm, which decrease to 5 mS/cm in concomitance of local rainfall events.

MoST2 well has highly variable season-dependent EC background values ranging from 10 to 40 mS/cm. Sudden decreases in EC have been observed during rainfall events.

EC values from the MoST3 well show high-frequency variability around a background value of about 30 mS/cm. This well is also susceptible to precipitation during which EC often decreases.

MoST4 is the outermost at the pilot site. It was drilled with the main objective of extending the subsurface model. For this reason, time series acquisition was limited to aquifer characterization in terms of average values. This well maintained a background value of EC of 25-30 mS/cm and showed no significant changes during rainfall events.

The encroachment of seawater along streams depends on the relationship between upstream flow, which in turn depends on precipitation, and tidal flow. Changes in EC in the water column are thus governed by the combination of these two flows. Depending on meteo-mareographic conditions, the salt wedge can rise up the mouths for several kilometers and the freshwater-saltwater interface vary significantly in depth.

3. GROUNDWATER AND SOIL ELECTRICAL CONDUCTIVITY AND CROP STATUS IN THE FARMLAND

3.1 Groundwater and soil EC

Fig. 13 shows the time behavior of the rainfall, evapotranspiration and soil electrical conductivity measured in the monitoring stations established in the farmland.

Notice:

- the decrease in soil ECb at the deepest layer of S5 in 2020:
- a similar ECb at S2 but the salinity of the deepest layers was slightly lower in 2020;
- a great effect of rainfall events on the parameters.

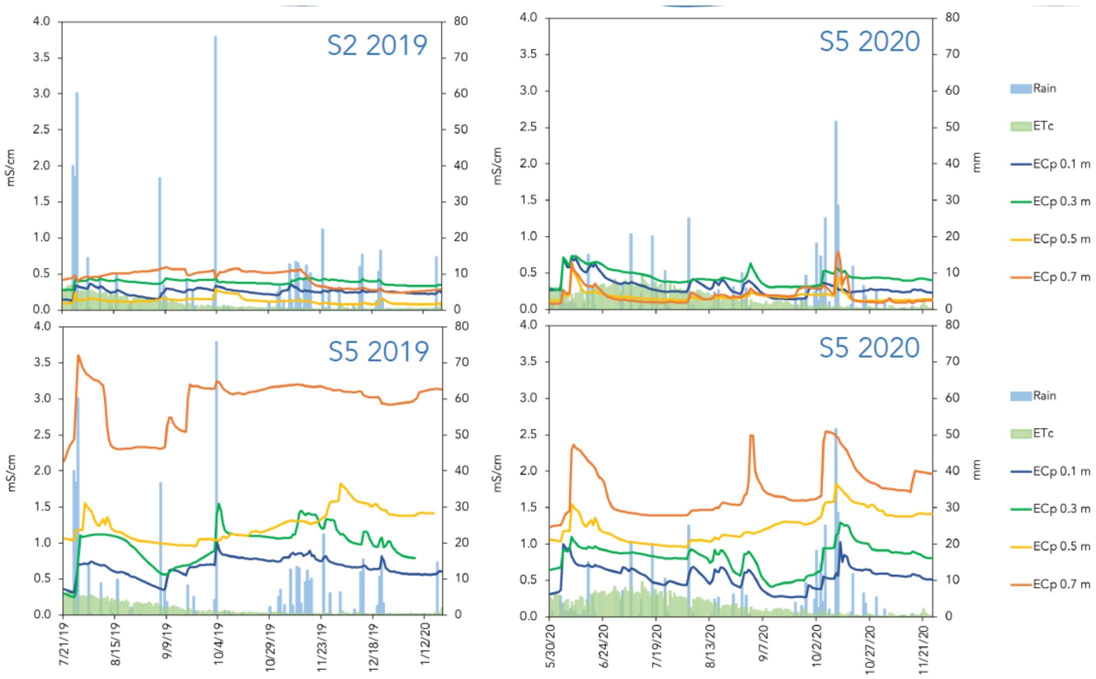

Fig. 13 – Rainfall, evapotranspiration and soil ECb at the monitoring stations established in the farmland.

Fig.14 shows the time behavior of the rainfall, evapotranspiration and soil electrical conductivity measured in the monitoring stations established in the farmland. Notice:

- Decrease in groundwater EC at S5 in 2020;
- EC increased during the winter period at S5 (2019);
- Similar groundwater EC at S2.

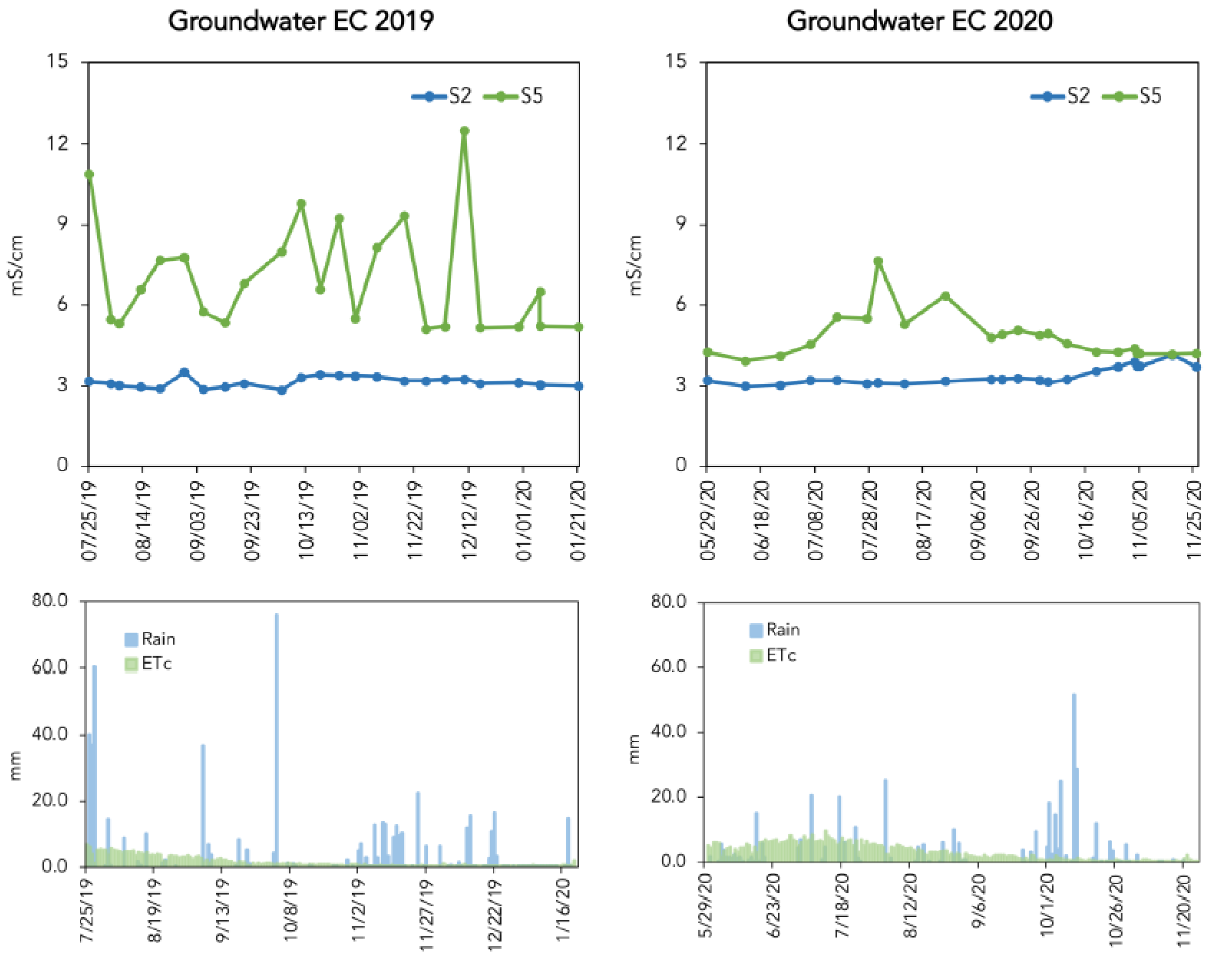

Fig. 14 – Rainfall, evapotranspiration and groundwater EC at the monitoring stations established in the farmland.

3.2 Crop traits

Collection of four or five biomass samples at each monitoring station (S) location. Each one consisted of gathering 2 m2 of biomass. Each plant of the collected sample was measured for height and the sample was weighted in the field. Then, a sub-sample is dried at 65 °C and analyzed for total nitrogen (TKN) and residual humidity (Fig. 15). In addition, the samples collected before harvesting were also analysed for grain quality (proteins, fat, and starch %). The outcomes are presented in Fig. 16. The N % decreased during the 2020 growing seasons according to maize phenological stages. The comparison between the grain analyses performed in 2019, 2020, and 2021 shows a strong difference between N % of S3 and S5. The protein content was always lower at S1 and S4 while the highest values were found at S3. A decrease in the starch % was observed from 2019 to 2021 at all stations, with the exception of S5 where the trend was the opposite. The fat % increased at all stations during the 2021 growing seasons with the highest values found at S2 and S4.

Fig. 15 - Sub-sample of maize grain and leaves collected few days before harvesting.

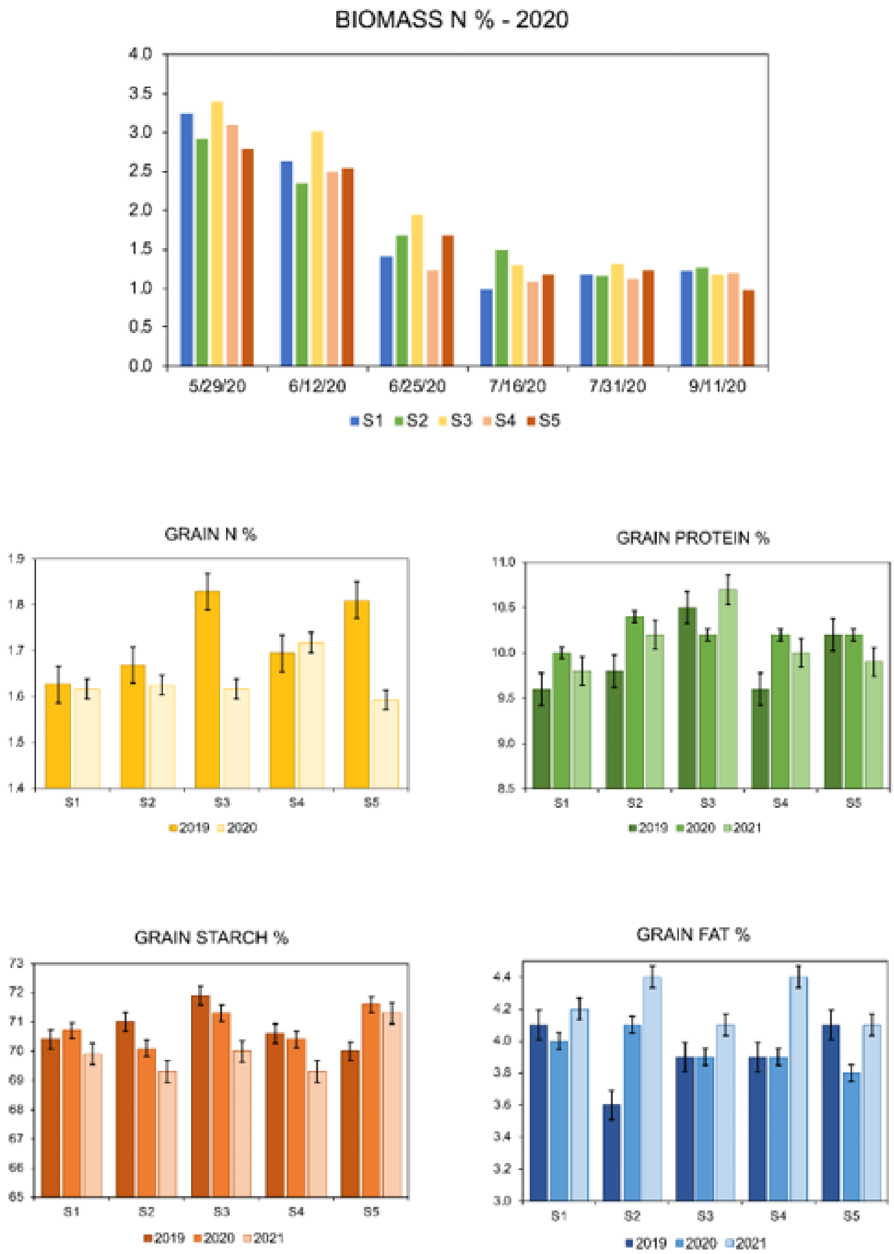

Fig. 16 - Biomass samples, nitrogen, protein, starch, and fat % of maize grain at the end of the growing seasons in 2019, 2020, and 2021.