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Data Article

An agro-physiological dataset on industrial tomatoes from nine years of field experiments conducted with alternative water-saving strategies in Mediterranean environments

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A R T I C L E   I N F O

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Dataset link: An agro-physiological dataset on industrial tomatoes from nine years of field experiments conducted with alternative water-saving strategies in Mediterranean environments (Original data)

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Deficit irrigation
Solanum lycopersicum L.
Crop yield
Quality
Crop water stress index
Brix

A B S T R A C T

The availability of field experimental data plays a pivotal role in advancing agricultural research, particularly in the Mediterranean, where farmers face significant challenges due to water scarcity and changing climatic conditions. We present a multi-year homogenized dataset of agro-physiological traits collected on industrial tomatoes and focused on the effect of deficit irrigation (DI). The dataset has been compiled over nine years and comprises 100 experimental plots, where 32 DI strategies have been tested. Visual observations on tomato phenology and qualitative and quantitative production data have been collected in field and laboratory surveys, complemented with detailed information on pedo-climatic conditions and irrigation scheduling (timing and volume). Researchers can find in this dataset a rich source for calibrating and evaluating agro-physiological models and a reference basis to study the relationships between DI strategies, weather variability, and the performance of tomato growing systems. Agronomists from the public and private sectors can gain domain knowledge to support local

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farmers with the best DI strategies to achieve high yields while optimizing water use. Moreover, this dataset serves as ground truth for digital decision support systems, which need real-world data to enhance their accuracy in guiding farmers on efficient water use. This data source is intended to become a crucial asset for researchers, agronomists, and decision-makers in the Mediterranean as it bridges the gap between research and practice in an area where farmers are already striving with water scarcity for industrial tomato cultivation.

Specifications Table

Subject	Agricultural Sciences
Specific subject area	Agronomy and Crop Science, Irrigation and water-saving techniques, Tomato yield and quality, Mediterranean environments.
Data format	Raw
Type of data	Table
Data collection	The data presented were collected in field experiments conducted on industrial tomato in Southern Italy, using the following instruments: soil water tension sensors (WATERMARK PN:200SS, Irrometer Company, Inc.); weather and soil moisture sensors (AgriSense^{TM}, Netsens); decision support system (Bluleaf^{TM}, Sysman Progetti e Servizi Srl,), Infrared thermometer (Scheduler Model 2, Delta-T Devices Ltd.), Steady-state diffusion porometer (SC-1, Decagon Devices); spectrophotometer (CM-700d, Minolta Camera Co. Ltd.), Hand-held refractometer (DBR35, XS INSTRUMENTS), pH-meter (GPL22, Crison Instruments S.A.).
Data source location	Institution: University of Foggia, Department of Agricultural Sciences, Food, Natural Resources and Engineering (DAFNE) Location: Foggia – 71122, Apulia region Zone: Capitanata area Country: Italy Coordinate: N 41° 32’ 37”; E 15° 30’ 13”
Data accessibility	Repository name: Mendeley Data Data identification number: doi 10.17632/h293p9hyxt.2 Direct URL to data: https://data.mendeley.com/datasets/h293p9hyxt/2

1. Value of the Data

- The dataset constitutes a reference basis to evaluate the effects of DI strategies on the yield and quality of industrial tomatoes grown in a Mediterranean area. Its peculiarity lies in the homogenous measurements of agro-physiological traits from nine years of field experiments, which have been complemented with physical soil properties, daily weather variables, and detailed irrigation scheduling.
- This dataset is useful to scientists who develop and use agro-physiological models reproducing the effects of pedo-climatic conditions and soil water availability on the growth and development of industrial tomatoes. They can be used either for model calibration and evaluation or as a reference background to develop new process-based simulation models.
- Agronomists and technicians from extension services in the area could benefit from this dataset where yield and major quality tomato traits are harmonized. They can use these data to gain knowledge and elaborate the best DI strategies to support farmers facing situations of water scarcity and high temperatures as a consequence of climatic changes.

Table 1
Name and content of the eight Microsoft Excel sheets composing the dataset.

Sheet	Name	Content
1	Metadata	It contains detailed information to understand the other sheets. For each sheet, the variables are associated with a description, their type (i.e., integer, double, date, string), and unit of measurement; additional notes are provided.
2	Experiments	It describes the 32 field experiments in terms of transplanting and harvest date, tomato cultivar (Ulisse), and the irrigation regime.
3	Phenology	It contains the timing of occurrence of four main tomato phenological stages [3] from visual assessments: post-transplanting (S0), vegetative growth (S1), beginning of flowering (S2), and beginning fruit setting (S3).
4	Weather	It contains daily weather data (air maximum and minimum temperature, air maximum and minimum relative humidity, precipitation, global solar radiation, and wind speed) from weather stations placed near the experimental trials (Fig. 1).
5	Crop	It contains information regarding quantitative and qualitative parameters of industrial tomato, i.e., marketable (Fig. 2a), green, rotten, and total production, total soluble solids (°Brix, Fig. 2b), titratable acidity, pH, and colour parameters.
6	Soil	It contains information regarding main physical characteristics of the soil, such as clay, sand, and silt (% dry weight), field capacity ($m^3\ m^{-3}$) and wilting point ($m^3\ m^{-3}$).
7	Irrigation	It contains information regarding irrigation date and water volume of each irrigation events for each deficit irrigation treatment.
8	Physiology	It contains information regarding physiological parameters of the crop, such as stomatal conductance, crop and air temperature, crop water stress index.

- The dataset can be used to test and validate the performances of commercial or public digital decision support systems to optimize irrigation water use for growing industrial tomato, which is one of the most cultivated and water-demanding crops in Southern Italy.

2. Background

Italy is the largest tomato producer in Europe and a major tomato producing country worldwide, along with China, India, Turkey, and the United States. Most Italian tomato production occurs in the Capitanata plain in Southern Italy, where tomato cultivation is very intensive, especially regarding irrigation water requirements, which typically range from 400 to 600 mm. During the growing season (May–August), tomato plants face significant challenges due to low precipitation, leading to frequent water stress during critical growth phases. According to climatic projections in Mediterranean areas, groundwater availability will be restricted, requiring better rationalization of water use to sustain tomato yields and quality. Currently, tomato farming irrigation scheduling involves fixed intervals between irrigation supplies regardless of the crop water demand, which results in over-irrigation. Therefore, it is necessary to improve water use efficiency by adopting water-saving strategies, such as deficit irrigation.

3. Data Description

This dataset has been collected during multi-year field trials conducted to assess the effect of alternative DI strategies on industrial tomato. DI is a widely investigated farming strategy that reduces water applications below optimal crop requirements during the crop cycle without compromising production [1,2]. The dataset comprises 100 experimental plots carried out in nine years and entails 32 DI treatments. The treatments include nine controls (well-watered), 15 constant DI treatments (i.e., same irrigation regime during the crop cycle), and eight variable DI treatments. The dataset is released as a Microsoft Excel file (extension .xlsx) organized in eight sheets (Table 1) corresponding to the main typologies of data, i.e., irrigation wa-

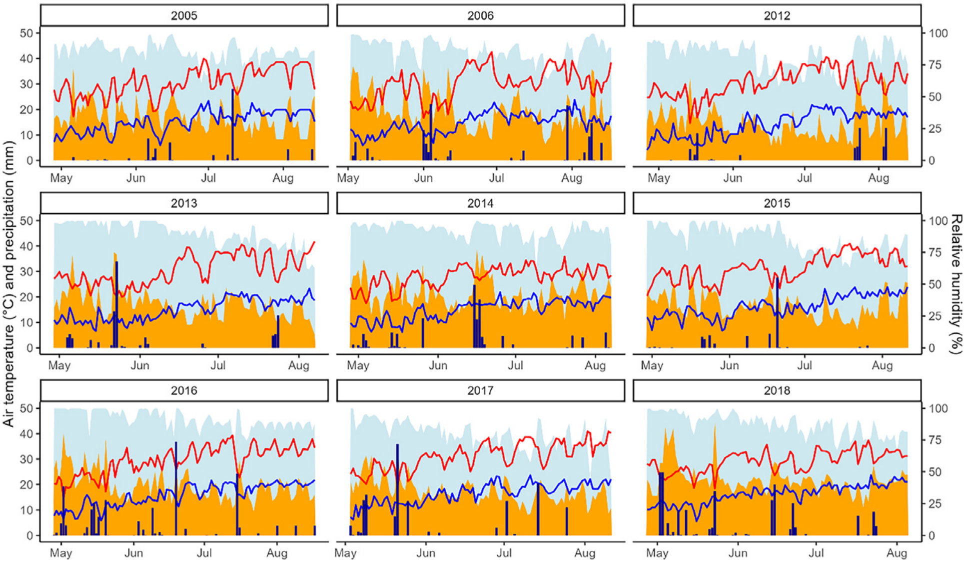

Fig. 1. Daily maximum (red line) and minimum (blue line) air temperature (°C, primary y-axis), precipitation (mm, blue bars, primary y axis) and maximum (cyan area) and minimum (orange area) relative humidity (%, secondary y-axis) during all experimental trials.

ter scheduling (volume and timing), physical soil characteristics, daily weather data, and agro-physiological variables (i.e., phenology, stomatal conductance, crop temperature, crop yield, and quality).

An overview of the weather data collected in all experimental trials is presented in Fig. 1. Fig. 2 presents the main quantitative (marketable yield, Fig. 2a) and qualitative (Brix, Fig. 2b) agronomic traits in all experimental trials, and the main phenological traits along with irrigation scheduling (amount and timing, Fig. 2c).

4. Experimental Design, Materials and Methods

4.1. The field experimental design

All field trials were conducted on a farm located in the Capitanata area (N 41° 32’ 37”; E 15° 30’ 13”, Apulia, Southern Italy) in 2005–2006 and from 2012 to 2018, on industrial tomato (*Solanum lycopersicum* L.) cv. Ulisse F1 (S&G Syngenta Seeds S.p.A., Switzerland). Tomato plants have been transplanted in coupled rows spaced at 1.8 m, with a plant density of 2.8 plants m^{-2} (0.50 m between rows, 0.40 m on the row). A randomized block design was applied in all experiments, with three or four replications (blocks), and testing different deficit irrigation regimes. In the experimental years 2005–2006 and from 2012 to 2016, the tomato water consumption was calculated considering measurements of soil water tension at the effective rooting depth (soil layer depths: 0–20, 20–40, 40–50, and 50–60 cm), using WATERMARK sensors (PN:200SS, Irrometer Company, Inc.; Riverside, CA). These sensors were installed in each control plot before transplanting. In the experimental years 2017–2018, the cloud-based decision support system Bluleaf™ (Sysman Progetti e Servizi Srl, Rome, Italy), was used to estimate the tomato water consumption. This system is based on real-time acquisition of weather and soil moisture (0.3 m and 0.6 m depth) data collected by wireless sensors (AgriSense™, Netsens, Florence, Italy), which are used to compute daily crop evapotranspiration (ETc, mm d^{-1}). Daily reference evapotranspiration (ET0, mm d^{-1}) was calculated using the Penman-Monteith equation [4], using crop

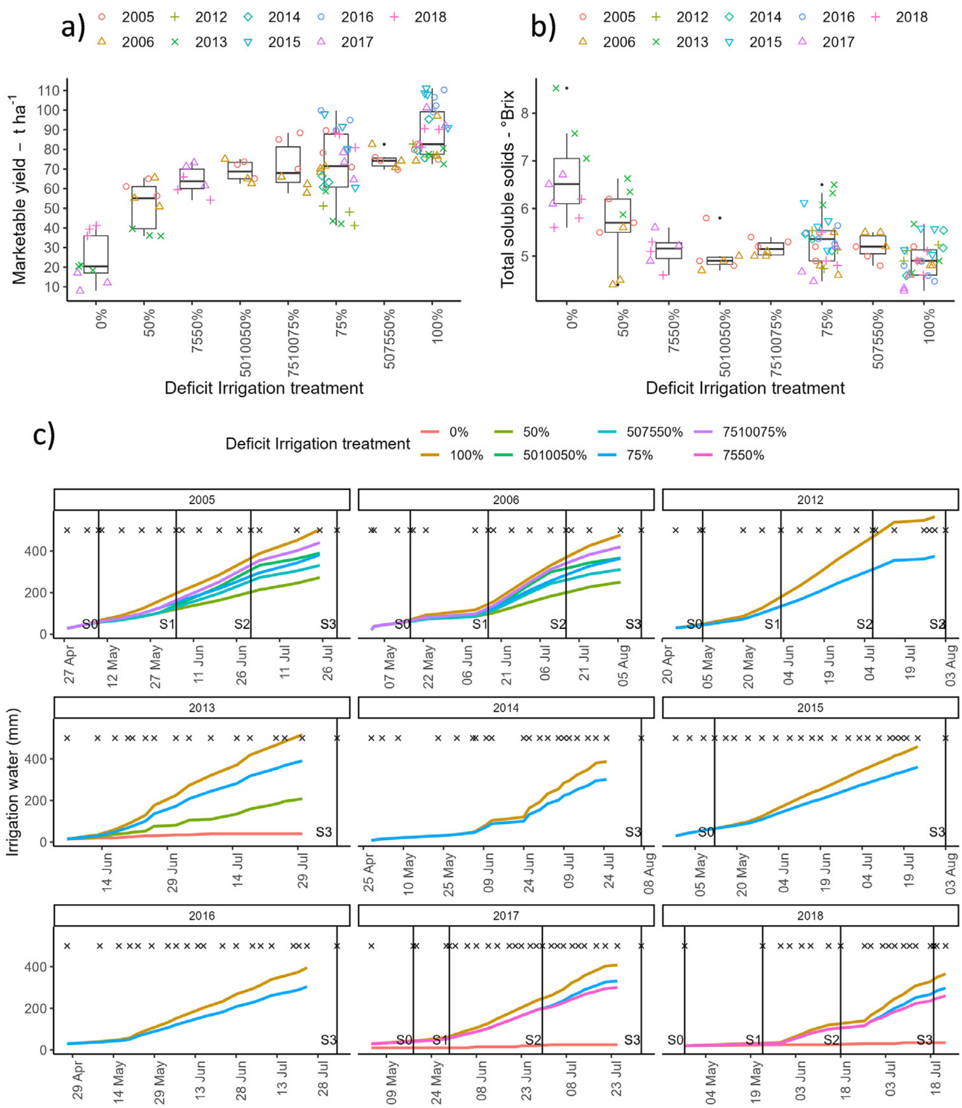

Fig. 2. Boxplots (25th to 75th percentiles) of marketable yield (t ha^{-1}, a) and °Brix (b) in all deficit irrigation treatments and years (colored points). Fig. 2c reports the irrigation events (crosses) and cumulated irrigation water (colored lines), in all experimental years, whereas vertical lines mark the phenological stages (S0, S1, S2, S3, see text for details).

coefficient (Kc) values specific to Mediterranean environments. ETc was estimated as ET0 × Kc, following the FAO two-step procedure [4]. In all experimental years, the irrigation was triggered when soil humidity fell below 40 % of the available water depletion until soil water content was set to field capacity. A drip irrigation system was used, as a single plastic pipe arranged in the middle of each paired row, with drippers of 2 L h^{-1} flow rate spaced every 0.4 m. Additionally, volumetric flow meters were used to monitor the distributed water volumes for each irrigation regime. The fertilisation practices and the pest and weed control replicated farmers' typical management in the area, aiming at growing the crop without any abiotic and biotic stress. A detailed description of the field experimental trials follows.

4.2. Experimental years 2005–2006

Tomato plants were hand-transplanted on April 28 (2005) and on May 2nd (2006). The field trials comprised five deficit irrigation regimes plus a control where 100 % of the tomato water consumption was restored (named 100 %). Two constant DI treatments were applied, restoring 50 % and 75 % of the tomato water consumption. Three additional variable DI treatments were tested, where 50 %, 75 % and 50 % (named 507550 %), 75%, 100%, and 75% (named 7510075 %), and of 50 %, 100 %, and 50 % (named 5010050 %) of the crop water consumption has been restored. These treatments have been differentiated in the three main crop phenological stages: from the end of transplanting shock to flowering of the first truss (S1); from the flowering of the first truss to fruit breaking colours of the first truss (S2); and from fruit breaking colours of the first truss to harvest (S3), respectively. The fresh fruits were hand-harvested on July 31 (2005) and on August 14 (2006).

4.3. Experimental years 2012, and 2014–2016

Tomato plants were hand-planted on April 25 (2012), April 28 (2014), April 29 (2015) and April 27 (2016). The field trials comprised the 100 % control treatment and a constant DI treatment where 75 % of the crop water consumption was restored during the crop cycle (named 75 %). The fresh fruits were hand-harvested on August 3 (2012), August 7 (2014), August 3 (2015), and on August 4 (2016).

4.4. Experimental year 2013

Tomato plants were hand-transplanted on April 29 (2013). This field trial comprised three DI treatments, plus the 100 % control treatment. The constant DI treatments were 0 %, irrigated only at transplanting and during fertigation, and 50 % and 75 %, which were characterized by restoring 50 % and 75 % of the tomato water consumption, respectively. The fresh fruits were hand-harvested on July 31 (2005) and on August 14 (2006).

4.5. Experimental years 2017–2018

Tomato plants were hand-transplanted on May 3 (2017) and April 27 (2018). The field trials tested three DI treatments plus the 100 % control treatment. Two constant deficit irrigation regimes were applied: 0 %, irrigated only at transplanting and during fertigation, and restoring 75% of the tomato water consumption. An additional variable irrigation regime was applied: 7550 %, restoring 75 % (S1–S2) and 50 % (S2–S3), of the tomato water consumption. The fresh fruits were hand-harvested on July 31 (2005) and on August 14 (2006).

4.6. Data collection

Soil physical characteristics were evaluated by taking samples at 0–0.4 m depth before transplanting. Soil analyses were performed following the standard procedure from Italian Ministerial Decree, 1999 [5]. Daily values of maximum and minimum air temperature (°C), rainfall (mm), global solar radiation (MJ m^{-2} d^{-1}), maximum and minimum relative air humidity (%), and average wind speed (m s^{-1}) were recorded from May to August (Fig. 1) by a weather station placed close to the experimental trials. The phenological stages of post-transplanting (S0), vegetative growth (S1), beginning of flowering (S2), and fruit setting (S3) have been recorded by weekly visual inspections, and set when 50 % of the plants reached a given phenological stage. During

S2, canopy temperature has been measured between 12:00 a.m. and 01:00 p.m. (i.e., at maximum sunlight intensity) on June 13 (2005), June 26 (2006), June 18 and July 2nd (2012), July 1st (2013), June 30 and July 3rd and 14 (2014), June 25, July 2nd, 6, 8, 13, and 15 (2015), and June 24 and 27, and July 4, 6, 11 and 13 (2016). Canopy and air temperatures were recorded using an infrared thermometer with a spectral response of 8 mm to 14 mm (Scheduler Model 2; Delta-T Devices Ltd.); these values were used to calculate the crop water stress index (CWSI) [6]. In the Experimental year 2012, stomatal conductance (mol m^{-2} s^{-1}) was measured during S2 stage (June 18th and July 2nd). Measures were taken underside the first fully expanded leaf [7] using a steady-state diffusion porometer (Model SC-1; Decagon Devices, Pullman, WA, USA) and randomly selecting ten leaves per replicate. Tomatoes were hand-harvest when the rate of ripe fruits reached approximately 95 %; the following morpho-physiological traits were measured on six plants per plot: the weight of ripe (marketable production), unripe (green production), and rotten fruits (rotten production), the total production as the sum of marketable, green and rotten production, and the mean fruit weight. Ten ripe fruits per replication were randomly chosen for the quality measurements. The colour parameters were measured using a CM-700d spectrophotometer (Minolta Camera Co. Ltd., Osaka, Japan), as the CIELAB coordinates (i.e., a*, b*) on two opposite sides of the middle part of the fruit surface. Total soluble solids (°Brix) were measured with a hand-held refractometer with automatic temperature compensation (mod. DBR35, XS INSTRUMENTS, Carpi, Italy). Titratable acidity (g citric acid 100 ml^{-1} fresh juice) and pH were measured according to AOAC Official method 942.15 and 981.21, respectively [8].

Limitations

One limitation of this dataset is the absence of multiple leaf area index and fruit biomass samples throughout the growing season. This constraint hampers the ability to calibrate the daily dynamic progress of tomato growth precisely. However, the dataset compensates for this limitation by offering harvested yield data across various conditions. This enables crop modelers to obtain reliable insights into the impact of alternative deficit irrigation regimes under diverse tomato growing conditions.

Ethics Statement

Authors have read and follow the ethical requirements for publication in Data in Brief and confirming that the current work does not involve human subjects, animal experiments, or any data collected from social media platforms.

Data Availability

An agro-physiological dataset on industrial tomatoes from nine years of field experiments conducted with alternative water-saving strategies in Mediterranean environments (Original data) (Mendeley Data).

CRediT Author Statement

Federica Carucci: Conceptualization, Methodology, Investigation, Writing – original draft; **Simone Bregaglio:** Writing – review & editing, Validation, Visualization; **Delia Pia Caldarola:** Data curation; **Giuseppe Gatta:** Writing – review & editing; **Marcella Michela Giuliani:** Supervision, Writing – review & editing.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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