15th World Processing Tomato Congress & 17th ISHS Symposium on Processing Tomato
2024 Budapest

Use of precision irrigation for water efficient management in a processing tomato farm

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Introduction

The objective of precision irrigation is to apply water in a certain place at the required time and with the required volume in order to achieve the highest crop production. Optimal and efficient production is achieved through systematically collecting data on what happens in the crop, the climate and the field, the use of modelling technologies on the soil-water-plant-climate system, and automatic control techniques (Fuentes et all, 2020). The use of precision irrigation in agriculture will mitigate the effects of climate change while improving the profitability of farms using irrigation systems that adjust the real water needs of crops. IrriDesk is a digitalisation tool that allows us to carry out automatic precision irrigation by combining different technologies based on crop monitoring and simulation to optimise the use of water in agriculture, mainly for farmers with limited irrigation water allocations per season. IrriDesk produces a daily closed loop to control irrigation using an algorithm that combines meteorological data, soil sensors, satellite remote sensing and simulations (Casadesús et al.,2012).

OBJECTIVE: To validate in field conditions the IrriDesk tool. We aim to implement an automated drip irrigation system in an industrial tomato plot in "Vegas Bajas del Guadiana" and evaluate how IrriDesk achieves profitable productions with a water consumption limit lower than 5000 m³/ha. This research is crucial for the future of tomato cultivation, and we believe it will significantly contribute to the industry's efforts in water conservation.

Material and Methods

Experimental field

The work was carried out within the DIGISPAC project, in collaboration with the companies UNILEVER and GRUPO CONESA through their company AGRAZ in a commercial plot of industrial tomato of 15 hectares belonging to the company Explotaciones Aldea del Conde, S. L. (Alconsa S.L.), located on the Aldea del Conde farm in the municipality of Talavera la Real, Badajoz, Spain (latitude 38°84'65.64 "N, longitude 6°72'59.18 "W, datum WGS84).

The crop chosen for this project was the processing tomato (Lycopersicum esculentum Mill) variety UG16112, meticulously transplanted from 3-10 April 2023. The planting density was precisely set at 29,000 (plants / ha) in a double row, with plants placed in three rows of 46 cm between continuous plants.

The plot was divided into two zones with differential irrigation management and drip irrigation system, following the following criteria(Fig.1a): Zone1 (IrriDesK) with a surface of 5.12 ha: automatic irrigation management following the information provided by the IrriDesK web platform. This tool allows controlled deficit irrigation (CDI) strategies that impose water deficits in the phenological stages that are less sensitive to water stress to reduce vegetative growth while minimally affecting yield and fruit quality. For this study, RDC was applied at the ripening stage. Zone 2 (Farmer) with a surface of 4.34 ha: The farmer traditionally manages irrigation.

Before transplanting the crop, the plot was spatially characterised using historical maps of the Normalised Vegetation Index (NDVI) and massive measurements of the apparent soil conductivity (ECa) with the Dualem-1S sensor made by the GREENFIELD company. This is necessary to identify the most suitable points where the sensors are to be installed.

Figure 1: Test plot: a) Normalised Vegetation Index Map, b) Soil apparent electrical conductivity map, c) Zones with different irrigation management.

Control points and irrigation strategy

In zone 1 (IrriDesK) three control points and Two in Zone 2 were selected. In these points soil water content was monitored with Teros 10 capacitance probes (Decagon Devices, Inc., Pullman, USA). To characterise the wet bulb in the dripper's influence environment, nine sensors were placed 20 cm deep and 10 cm apart from the dripper horizontally towards the bed. The moisture sensors allow irrigation to be adjusted to the real water needs of the crop at each phenological stage, enabling the model to make changes in the established irrigation doses according to the availability of water in the soil. Irrigation volumes were recorded daily using digital water meters (MTKD-M, Zenner, Villaviciosa de Odón, Madrid) installed in each irrigation zone. In addition, an Apogee SI411 thermal sensor (Decagon Devices, Inc., Pullman, USA) was installed at each control point. At the same time, three monitoring points were selected where punctual measurements of crop water status (leaf water potential) were taken with a PUMP-UP (PMS instruments) portable pressure camera. All the control and monitoring points were used to obtain the commercial production, selecting a surface of 9m² in each of the points.

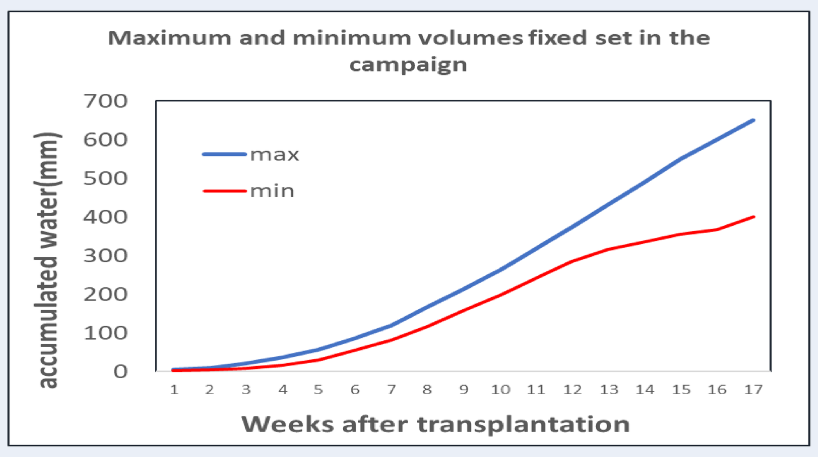

Figure2. Maximum (max) and minimum (min) accumulated water values initially set initially established.

One of the most critical information to be introduced into the system is the irrigation strategy. This information is included in the campaign plan, establishing water distribution during the campaign. In this case, the values entered in IrriDesK were imposed by the farmer, who indicated that 550 mm were to be applied during the whole irrigation campaign. So, a maximum limit of 650 mm and a lower limit of 400 mm were entered in IrriDesK (Figure.2).

Results

Evolution of accumulated water applied in the treatments

In processing tomato cultivation there are the following crop phases: transplanting phase (Phase I), rapid growth phase (Phase II), fruit growth phase (Phase III) and ripening phase (Phase IV). It is observed that after transplanting (Phase I), IrriDesK applies less water than that imposed in the seasonal plan. At the time of transplanting, the soil profile is filled with water up to the maximum depth that reaches the roots, so that IrriDesK adjusts to the specific conditions of the plot and reduces the water applied in this phase. In the rapid growth phase (phase II) RDC cannot be applied as a water deficit in this period can lead to a high number of flower abortion. So, here the system follows the previously imposed seasonal plan. Then, in the fruit growth phase (phase III), RDC strategies cannot be applied either, as fruit fattening must be encouraged. IrriDesK is modulated and adjusted to the seasonal plan initially foreseen in the campaign so that the crop does not suffer water stress. In the ripening phase of the crop (IV), the green fruits start to turn red, and this is a favourable period to apply RDC strategies (figure 3a). IrriDesK adjusts at this stage of the crop by reducing the amount of water applied to the crop. The adjustments made by the Irridesk model during the crop cycle, based on the campaign programming and the measurements of water content in the soil and crop water status made at the different control points, made it possible to reduce the volumes of water applied in relation to the traditional irrigation carried out by the farmer, while remaining within the maximum limits of 500 mm established for the irrigation campaign. In figure 3b shows the amount of water applied in each of the management zones during the 2023 irrigation season, Farmer(559mm) and IrriDesk(413mm).

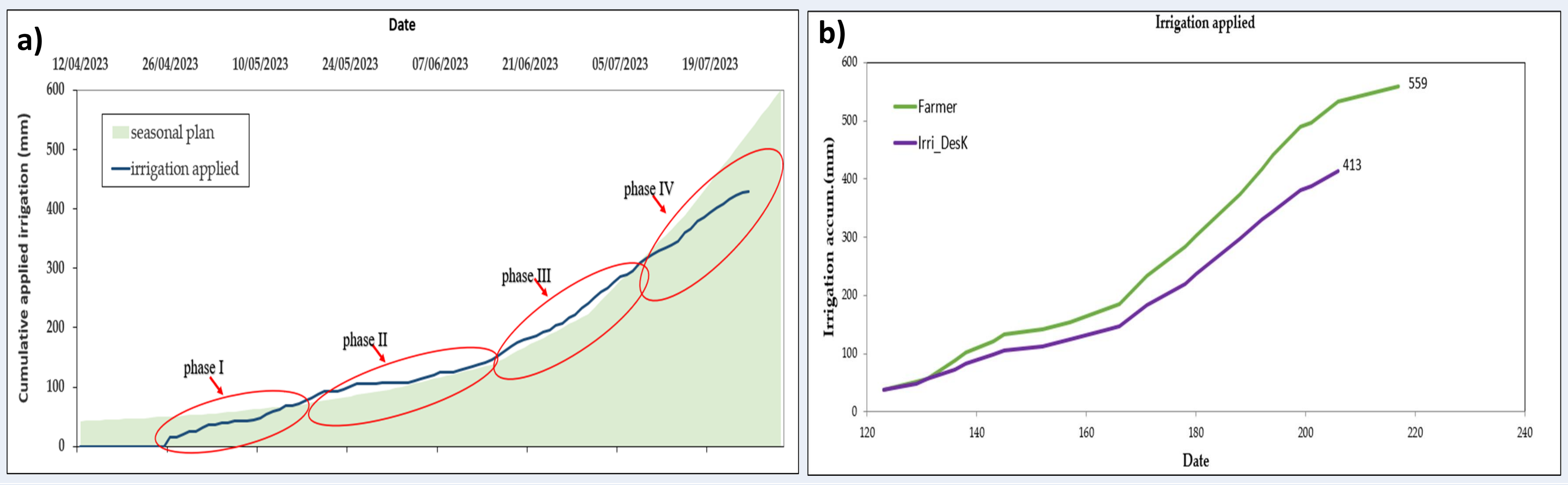

Figure 3. a) Adjusting IrriDesk to the seasonal plan. b) Amount of water applied in each of the management zones during the 2023 irrigation season, Farmer (559mm) and IrriDesk (413mm).

Yield and Quality

The amount of water applied in the farmer's zone was higher than that in the IrriDesK zone, which applied 26% less water than the farmer. The water applied was lower than the maximum water limit set at the beginning of the campaign (500 mm). In relation to production, it is observed that there are no differences in the production obtained in the two zones (table 1). About the quality parameter °Brix, which is very important for the industry and to be considered when establishing the economic yields of the crop, it was observed that the highest values of °Brix were obtained in the IrriDesk area.

Table 1. Water applied, rainfall, total water applied, total tomato yield and quality parameter (ºBrix)

Zones	Applied water (mm)	Rainfall (mm)	Total (mm)	Yield (t/ha)	º Brix
Farmer	559	54	613	148,59	5,15
IrriDesK	413	54	467	140,06	5,42 *

The asterisk indicates differences between treatments p<0.05 according to the Tukey test.

Conclusions

- IrriDesk helps the farmer to adapt controlled deficit irrigation strategies in tomato cultivation in situations of low water availability and to improve crop quality.
- With IrriDesK, the farmer takes the reins of irrigation management. This technology enables automatic irrigation based on the agronomic management selected by the farmer, adjusting the water doses according to the soil moisture conditions.
- IrriDesk is a water-saving champion, using a significantly lower volume of water than the farmer (around 26% on average). It does this by adapting to the information provided by the sensors in each area.
- IrriDesk makes it possible to maintain good production with a water limit set as an initial target.
- IrriDesK can adjust irrigation scheduling according to the water content of the soil and improve water use efficiency.
- IrriDesK can improve the quality of processing tomatoes and, consequently, the profitability of the crop.

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Acknowledgements

To the company Explotaciones Aldea del Conde, S.L. (Alconsa S.L.) for their help and to their technician Antonio Tienza, to Unilever and Agraz, a company of the Conesa group, for their commitment to a more sustainable and environmentally friendly agriculture and for their technical support in the development of this trial. This research is part of the DIGISPAC project (TED2021-131237B-C22) which has received a financial contribution from the programme Convocatoria 2021 - "Proyectos de Transición Ecológica y Transición Digital".

DigiSPAC project *TED2021-131237B-C22*