THÜNEN

Project *brief*

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Sensor based irrigation management for potatoes

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- **The canopy temperature of potato plants can be measured contact-free using stationary mounted infrared thermometers.**
- **Drought stress of potato plants can be assessed from the canopy temperature and current weather data.**
- **Canopy temperature can only be used as a supplementary parameter for irrigation management, because it can only serve as drought stress indicator, as long as the potato canopy is fully closed and with prevailing unclouded weather conditions.**

Background and aims

About 50 % of German potato production is located in the state of Lower Saxony, and 50 % thereof in the northeast region of Lower Saxony. The predominant light soils in that region are particularly well suited for potato production, but field irrigation is essential to produce adequate yield and the required quality.

Groundwater abstraction for field irrigation is legally restricted in Lower Saxony and costly. Therefore, the Chamber of Agriculture in Lower Saxony carries out long time irrigation experiments in Hamerstorf near Uelzen. The results are an integrated part of consultancy for potato producers.

Irrigation management is an important instrument for efficient water use in field irrigation. The demand for irrigation water can be determined by various methods. Some of them are irrigation consultancy from local authorities or organizations, water balance calculation, visual or manual soil moisture estimation on field, or soil moisture sensors.

The project "Sensor based irrigation management for potatoes" (Sensorgestützte Beregnungssteuerung in Kartoffeln, SeBeK) was funded by the state of Lower Saxony and the EU from 2016 to 2020. In this project, we investigated an innovative method, how the irrigation demand of potatoes can be determined by canopy temperature measurement and calculation of the Crop Water Stress Index (CWSI).

The project aim was to judge whether the CWSI can be determined reliably under north German site conditions, and whether the CWSI is suited as a useful parameter for potato irrigation management in that region.

Methodological approach

The project was based on its own irrigation experiments at the experimental station in Hamerstorf near Uelzen, and on sensor measurement at some potato fields of a farmer near Uelzen. The experiments were carried out in the years 2017 to 2019.

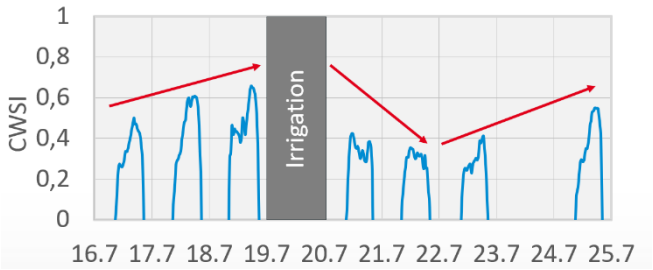
Fig. 1: Infrared temperature sensors and weather measurement equipment on a potato field, year 2018.

Source: Thünen Institute / Martin Kraft (2018).

Different numbers of infrared thermometers were mounted at all experimental sites, 2 m above ground, pointing downwards obliquely and at right angle to the potato ridges, in order to present a closed canopy to the sensors as early as possible (Fig. 1). In addition, extensive weather measurement equipment had to be installed. Only by simultaneous measurement of canopy temperature and several weather and radiation parameters, the CWSI values can be calculated such that they can be interpreted as a quantitative estimator for the plant drought stress. All sensors were operated from potato emergence to medium withering. The sensor data were registered, transferred and presented online to all project partners continuously.

On the experimental station, irrigation was managed by weekly soil sampling and soil moisture measurement. The farmer managed the irrigation by visual monitoring of the potato leaves and topsoil moisture.

Fig. 2: Irrigation management of potatoes on the basis of the Crop Water Stress Index CWSI: The daily maximum of the CWSI course rises due to evapotranspiration until it exceeds a predefined threshold, triggering an irrigation event. During about two days after irrigation, the CWSI decreases, and then the rise starts again.



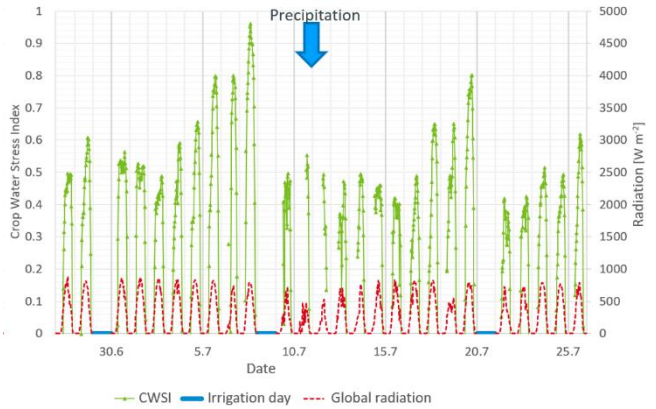
Source: Thünen Institute / Johanna Schröder (2019).

Results

The CWSI of potatoes can be measured under north German conditions and can be taken into account as a suitable criterion for the optimum irrigation date (Figures 2 and 3). In this project, the infrared temperature sensors and the weather measurement equipment were installed in the potato field. Alternatively, the equipment can be installed at the field border, so that the field work, mainly the plant protection doesn't get hampered.

The measurement can take place continuously by stationary sensor equipment. The CWSI value at early afternoon is the representative value for the whole day, since the temperature signal of stressed plants is at its maximum in this daytime, as is the temperature difference between stressed and non-stressed plants. The measured values can continuously be provided and presented online, so that the farm operators can schedule the irrigation already two days ahead without the necessity to visit the field physically.

Fig. 3: In the really dry summer Sommer 2018, the CWSI remained for the first few days after irrigation or precipitation around 0.5, and then started its rise again. CWSI values from 0.7 indicate a considerable drought stress of the potato plants.



Source: Thünen Institute / Johanna Schröder (2018).

Two restrictions must be considered, when it comes to CWSI based irrigation management. Due to these restrictions, canopy temperature and CWSI are not sufficient as stand-alone instrument for irrigation management:

- The CWSI can only be measured by infrared thermometers at full canopy closure. Otherwise, the surface temperature of the soil distorts the measurement result. In this project, the irrigation season lasted 68 days (average of food and starch potatoes), while the canopy was fully closed only for 29 days. Eventually, additional thermal cameras can prolongate the measurement period.
- The CWSI can only be determined reliably at clear sky or very light clouded sky. Thus, the CWSI is not consistently available on all days in northern Germany and central Europe.

In summer 2018, it became apparent that sensor-based irrigation management gives limited benefit during long lasting dry periods, because irrigation is then applied at its maximum technical capacity in a real farming situation. The current irrigation infrastructure, based on mobile irrigation machines, doesn't allow changes in the irrigation schedule on short notice. To tap the full potential of the CWSI, the irrigation infrastructure needs to be changed to different irrigation systems such as drip irrigation or center pivot irrigation systems.

The project results are relevant also for the approach of deriving irrigation recommendation from drone- or satellite-based thermal imaging.

Further Information

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Publications

Meinardi D et al. (2021): Sensorgestützte Beregnung von Kartoffeln: Entwicklung des Crop Water Stress Index für Nordostniedersachsen. Thünen Working Paper 179, Braunschweig, 120p.

Ekinzog EK et al. (2022): Revisiting crop water stress index based on potato field experiments in Northern Germany, Agricultural Water Management 269, 107664.

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