Aboutaleb Hezarjaribi, Heinz Sourell and Franz-Josef Bockisch, Brunswick

Site-specific Irrigation

Development of Application Maps and Dynamic Control of Center Pivot Irrigation Systems

"pre agro" presented its results at the end of February 2008. The successful collaborative project with 26 partners from industry and research did not deal with site-specific irrigation. Almost simultaneously a four year project on precision irrigation (PI) was carried out in Brunswick and became the topic of a dissertation. Not all problems could be solved, but it is possible to apply differentiated irrigation amounts with center pivot irrigation machines.

Dr. Aboutaleb Hezarjaribi made his doctoral thesis at the Institut für Betriebstechnik und Bauforschung der FAL in Braunschweig (Prof. Bockisch) in cooperation with the Institut für Pflanzenbau und Pflanzenzüchtung of the University Gießen.
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Keywords

Precision irrigation, precision mobile drip irrigation, center pivot irrigation machine, irrigation management zones

Literatur

[1] • *Hezarjaribi, A.*: Site-specific irrigation: Improvement of application map and a dynamic steering of modified centre pivot irrigation system. Dissertation, Universität Gießen, 2008

Spatial variation of total available water content (TAWC) as a primary factor causes spatial variation of irrigation depth and frequency within fields. While moving irrigation systems apply water at constant rates, some areas of the field may receive too much water and others not enough. In this regard, precision irrigation (PI) is capable of applying water in the right place in the right amount at the right time using the right irrigation system. Therefore the key objectives of the present study were

- Delineation of irrigation management zones (IMZs) using sensor-based soil electrical conductivity (ECa) measurement with the aid of EM38 and VERIS 3100,
- Developing and evaluating a precision mobile drip irrigation (PMDI) and
- Evaluating wireless EnviroSCAN sensors and AMBAV-models to measure the soil moisture content.

Materials and methods

EC25 data (ECa in 25 °C) were collected using EM38 and VERIS 3100 at field capacity on a 16.6 ha non-saline field in the FAL, Braunschweig, Germany. ECa data were obtained in s^{-1} intervals corresponding to a 2 to 3 m data spacing on transects spaced approximately 4 to 6 m apart. An ArcView (ESRI) software program was used to create the EC25 and TAWC maps after the readings were interpolated, using a spherical kriging model. 29 calibration points taken at a depth of 60 cm depth were located using DGPS to determine the best sensor-based method to monitor TAWC.

The second span of the centre pivot irrigation machine (CP) was modified to PMDI and controlled for variable-rate water application with a pulsing technique by installing solenoid valves (SV), programmable logic control (PLC) and using a Siplast drop tube instead of sprinklers. One quarter of the study field was controlled by the EnviroSCAN soil moisture sensor and another quarter was controlled by the AMBAV-model to determine irrigation depth.

Results and discussion

This study showed that, while qualitatively similar, EC25 data obtained with different commercial sensors were quantitatively different because of different depth-weighted response functions. The highest coefficients of determination (R^2) were generally found between EM38_h and EM38_v ($R^2 = 0.55$). In this study, a better value of R^2 between TAWC and the VERIS 3100 readings was found. The R^2 value from VERIS 3100-sh data for TAWC estimation was maximally (0.77) and matched the TAWC data quite

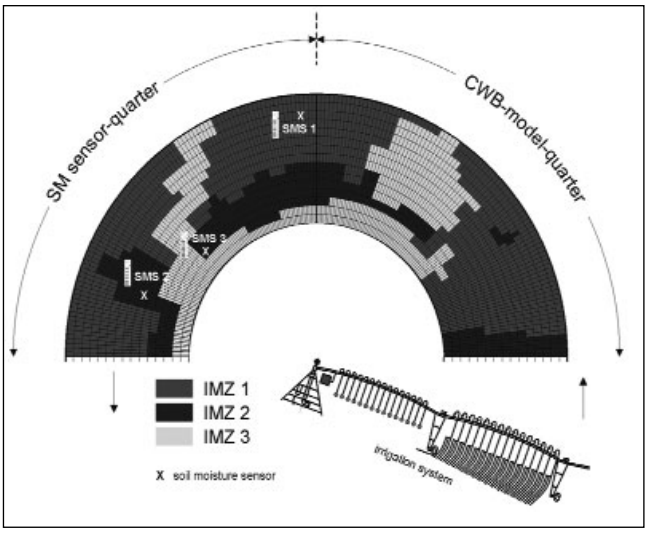

Fig. 1: Test layout with center pivot irrigation machine for precision irrigation and for determination of management zones. The area on left is managed by sensors, the area on right by a climatic water balance model

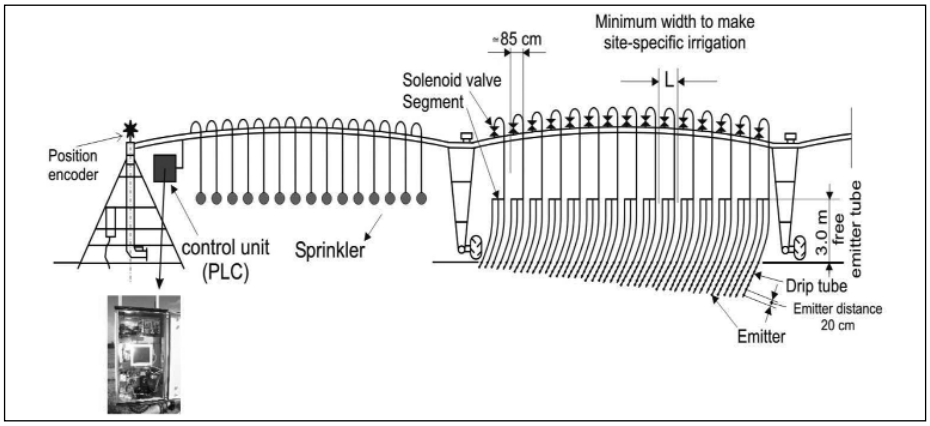

Fig. 2: Modified center pivot irrigation machine, 2nd span for precision irrigation

well. The R^2 values to EM38-h and EM38-v data were low and apparently could not adequately reflect the spatial variability of the TAWC due to the higher influence of the EM38 on deeper layers.

The developed concept of pulse irrigation was a feasible and a viable technique. Water application was directly proportional to the fraction of time the valve was opened as the system was capable of controlling fifteen banks of fifteen nozzles. There were no apparent problems with the pulsing water delivery system, where the field tests were conducted. Uniformity coefficients were reduced by decreasing the pulsing level and increasing CP speed.

The control unit was able to monitor wireless soil moisture sensors via radio telemetry and communication from the EnviroSCAN sensors to the central ISM modem, which worked as expected. Although the EnviroSCAN soil moisture sensor was found to be delicate and intricate to use and calibrate, but soil moisture data were easily sent from the control unit and received by the mobile phone (*Fig. 2*) and then transferred to an Excel spread sheet on a computer using easy and suitable "Kurznachricht Pro 2.2" software ("short message") to calculate irrigation depth. The results suggest that EnviroSCAN sensors are able to follow the general trends successfully as soil water content measured by sampling changed during the growing season. Meanwhile, an AMBAV model as a cheap and reliable alternative instead of the expensive EnviroSCAN sensor was capable of determining and simulating soil moisture in the root zone of grass crops.

Drip irrigation design should be based on reliable data sets, but not on data supplied by the manufacturer. Based on the laboratory experiments, it was found that the in-line Siplast emitter has high emission uniformity and a low coefficient of variation.

The economic analysis of this study showed that although capital requirement per hectare under PMDI is about € 338 and € 250 more than for drip irrigation in Germany and Iran, respectively, it causes perceptibly less annual fixed cost than drip irrigation (111 and 128 €/ha year) cheaper than drip irrigation in Germany and Iran, respectively. Although PMDI causes more annual fixed expenses than CP irrigation, it has less labour, water and energy cost than drip irrigation and has the potential benefit to increase yield quantity, quality and farming benefit. The results showed as an important policy implication that PMDI was able for reduction of energy and water consumption of 70 % and 25 %, respectively in comparison with the CP.

Conclusion

Sensor-based ECa measurement at F.C. in non-saline soil can be used as a cheap, rapid and non-destructive alternative to delineate IMZ instead of using soil sampling and aerial photography methods. Field studies using larger irrigation systems and fields with different soil types, topographic or crop characteristics are recommended to validate the precision irrigation concept and to realize and ensure a positive net economic return to the producer.

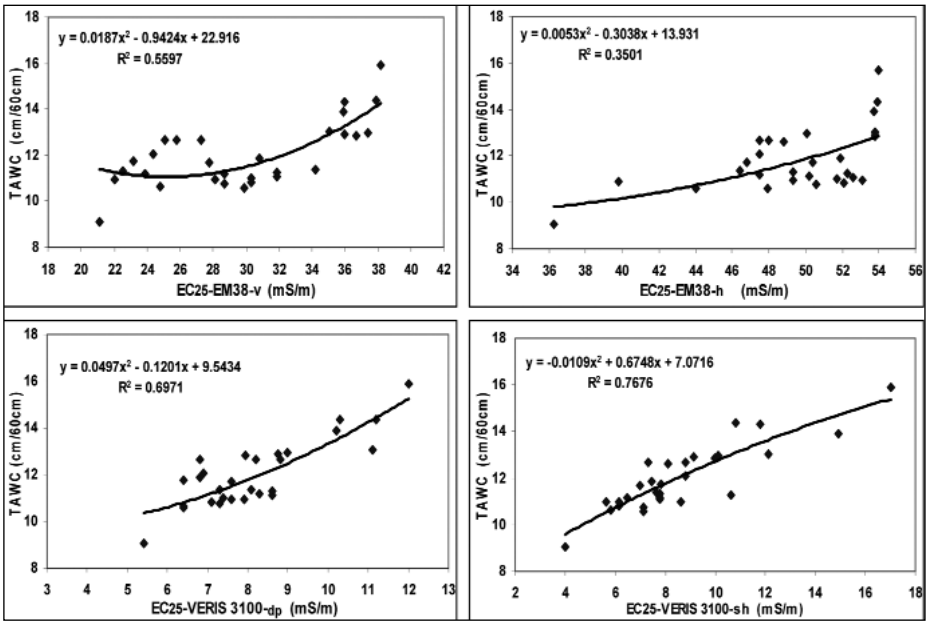

Fig. 3: TAWC calibration from different ECa readings standardized to 25 °C (EC 25) obtained with EM 38 (both horizontal 75 cm and vertical 150 cm orientations) and VERIS 3100 (both shallow 30 cm and deep 90 cm readings)