MANUSKRIPTE

GEOGRAPHICA AUGUSTANA

Peter Chifflard, Bernd Cyffka
Daniel Karthe, Karl-Friedrich Wetzel

Beiträge zum 44. Jahrestreffen des Arbeitskreises Hydrologie vom 15.-17. November 2012 in Lunz am See

Institut für Geographie UNIVERSITÄT AUGSBURG Band 13

GEOGRAPHICA AUGU

GEOGRAPHICA AUGUSTANA

Peter Chifflard, Bernd Cyffka,
Daniel Karthe, Karl-Friedrich Wetzel

Beiträge zum 44. Jahrestreffen des Arbeitskreises Hydrologie vom 15.-17.November 2012 in Lunz am See

Peter Chifflard, Bernd Cyffka, Daniel Karthe, Karl-Friedrich Wetzel

Beiträge zum 44. Jahrestreffen des Arbeitskreises Hydrologie vom 15.-17.November 2012 in Lunz am See

Augsburg 2013

ISBN 3-923273-89-4
ISSN 1862-8680

Umschlaggestaltung Jochen Bohn
Textverarbeitung Peter Chifflard
Druck Digitaldrucke Bayerlein GmbH Neusäß

Problems and possibilities in agricultural irrigation from a soil hydrological point of view

Sven Grashey-Jansen

Universität Augsburg, Institut für Geographie

1. Introduction

Approximately 70% of the global water withdrawal and 85% of the consumptive water use are for irrigation (Goodwin and O´Conell 2008). Unfortunately water use efficiency in the agricultural sector is very poor with more than 50% water losses (Hezarjaribi and Sourell 2007). In most cases the main goal in water management is to optimize irrigation water use efficiency (IWUE) not only to produce high quality, high yielding crops but also to ensure that runoff and leaching are minimized (Sadler et al. 2000). Mostly climatic and phenological factors are used to regulate irrigation. But irrigation efficiency is strongly influenced by soil properties.

2. Materials and Methods

Since 2003 soil tensiometric time-series data were measured in an hourly time resolution and recorded in irrigated orchards in South Tyrol (Northern Italy). Intervals of irrigation were registered by pressure sensors in the irrigations lines. The pedological field-research at soil pits was combined with analysis in the laboratory which provided quantitative information about the particle-size distributions at all measuring points.

The gained database (built by 131 seasonal time-series (April-November) of soil water tensions in different soil depths) made it possible to use statistical methods to describe the influence and efficiency of irrigation on different soils and in different soil depths (Grashey-Jansen 2008, 2010 and 2012). Furthermore, the derivation of pedotransferfunctions (Grashey-Jansen and Timpf 2010, Grashey-Jansen 2011) made simulative approaches concerning precision irrigation possible.

The statistical analyses and simulation approaches were performed using the proprietary software SPSS®, the free statistical software environment of R and the generic environment for modelling and experimenting SeSAm (**Sh**e**ll** for **S**imulated **A**gent Syste**m**s).

3. Results and Discussion

Figure 2 shows the time lags of the irrigation signals between 20cm and 40cm and 20cm and 60 cm soil depth of three different soil profiles each composed of equal soil textures (Sa, LoSa, SiLo). The time lags were calculated by cross correlations of 18 tensiometric time series captured at these locations.

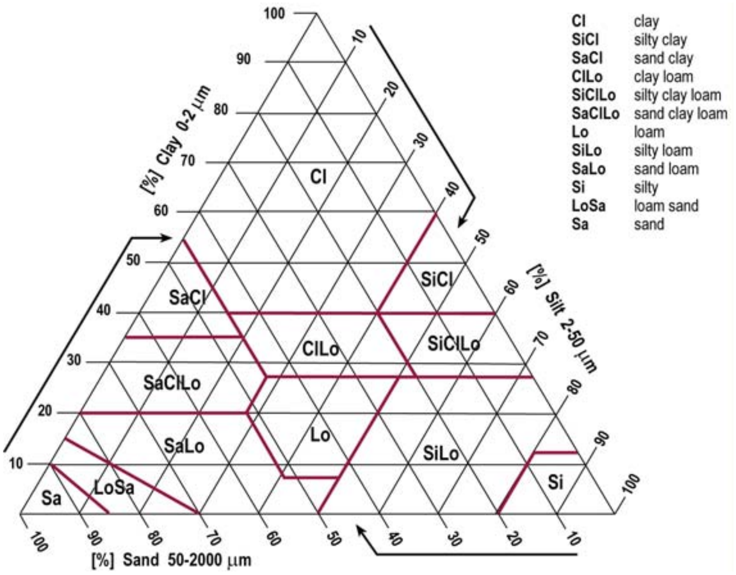

Fig. 1: Legend for Figure 2 and Figure 3.

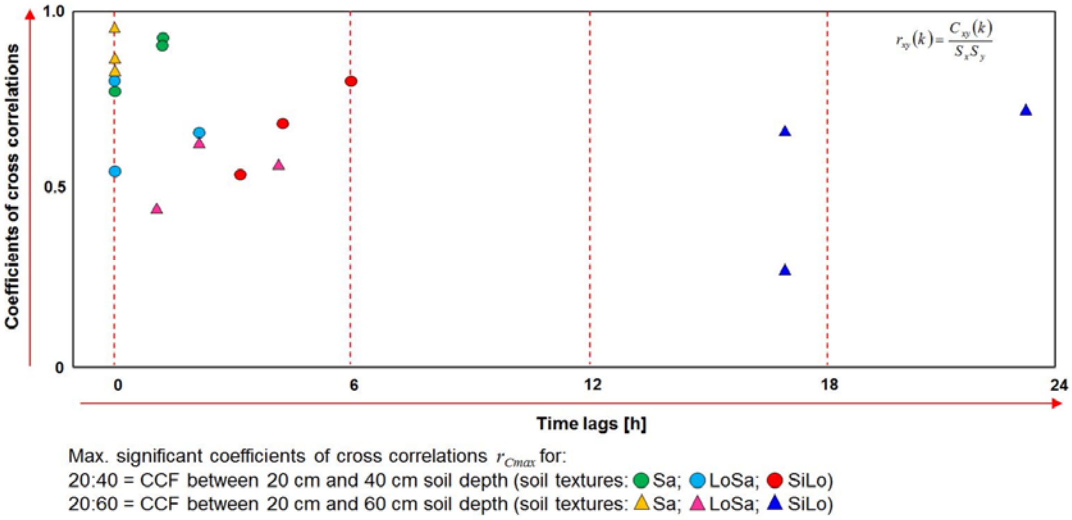

Fig. 2: Significant coefficients of cross-correlations in the 24-hour timeframe of three uniform soil profiles (significance level α = 0.01).

The shortest time lags can be detected for the sand profile (Sa). Irrigation signals need less than two hours to pass the soil depth of 60cm due to higher ratios of macro and medium pores. In the loam sand profile (LoSa) signals cause significantly longer time lags to reach the depth of 60cm. The silty loam texture with a higher ratio of micropores in the third profile causes signal delays up to 23 hours.

There are significant time differences in the soil hydrological response to the water-influx. The results of tensiometric time series analysis indicate that the pedological characteristics with their spatial variability decisively control the efficiency of irrigation (e.g. Grashey-Jansen 2008). As a consequence appropriate and precise irrigation must take soil conditions into account.

Grashey-Jansen and Timpf (2010) created an agent-based simulation of a soil dependent precision irrigation system. The model calculates an irrigation plan to ensure water application which is efficient and meets the demands (Figure 3). Thereby, the irrigation does not happen intermittently but in a continuous and dynamic way. This means that the amount of the water applied during the irrigation process is subject to controlled dynamic fluctuations. The irrigation plan shows these dynamics. The intensity of irrigation is variable during the whole period of irrigation because each soil depth (= area of virtual sensor nodes) contains the amount of water which corresponds to its maximal volume of water content at field capacity. This explains the varying values of the effective water amount. In addition to the intensity of irrigation the duration of irrigation is also controlled. Because of this dynamic way of irrigating the soil is given the needed water gradually, following the soil hydrological characteristics.

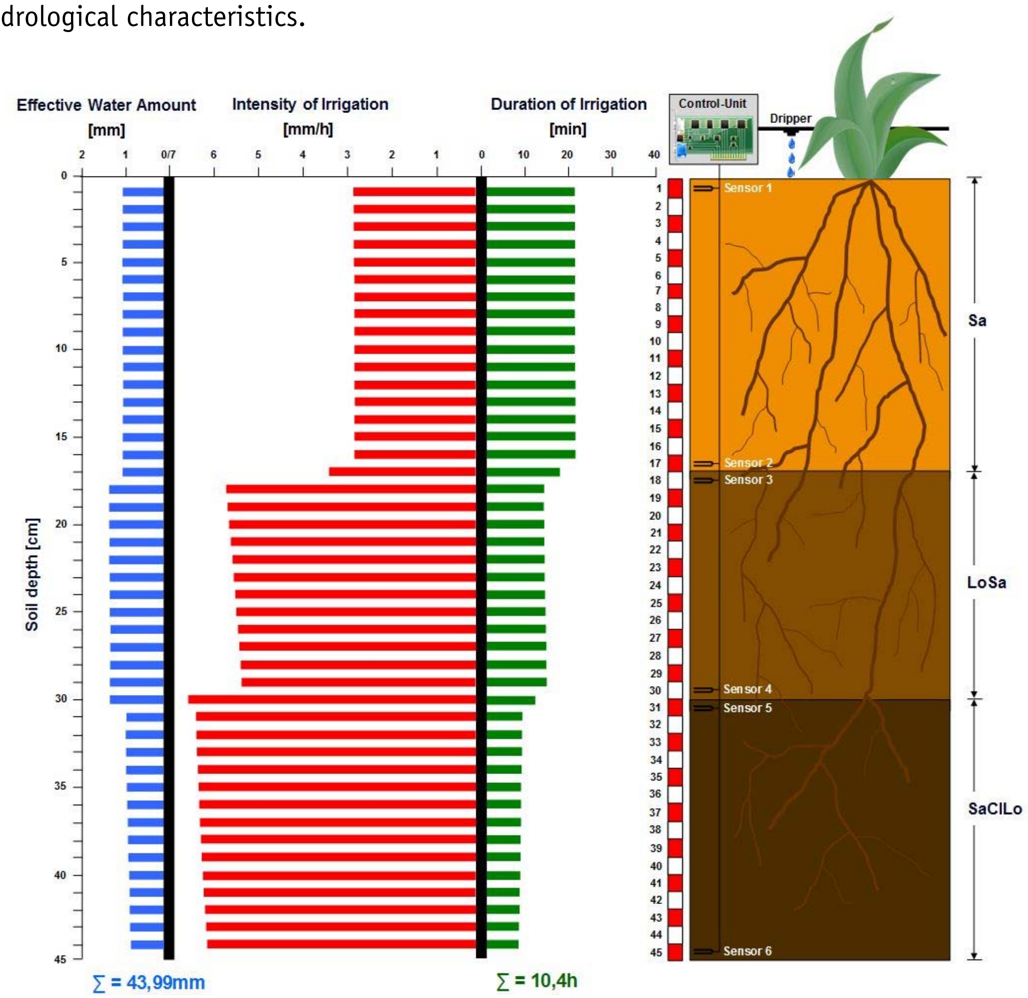

Fig. 3: Output of a simulated irrigation schedule with the corresponding soil profile.

4. Conclusions

To optimize irrigation practice economically and ecologically it is essential to provide an objective basis for the irrigation process. However, atmospheric parameters as well as groundwater proximity must not be overrated: close attention to the pedological conditions should be a primary consideration. Soil physical properties can change enormously over small distances but the composition and properties of the cultivated soils are rarely taken into consideration. An approach of precision irrigation requires precise knowledge of soil properties. The presented irrigation plan adapts to measured soil water dynamics, differentiating between different soil strata and soil depths.

Literature

Goodwin, I. and O'Connell, M.G. (2008): The future of irrigated production horticulture – world and Australian perspective. *Acta Horticulturae* **792**:449–458.

Grashey-Jansen, S. (2008): Raum-zeitliche Differenzierung der Bodenwasserdynamik auf obstbaulich genutzten Standorten in Südtirol unter Bewässerungseinfluss. *Geographica Augustana* **3**. Augsburg.

Grashey-Jansen, S. (2010): Pedohydrological case study of two apple-growing locations in South Tyrol (Italy). *Agricultural Water Management* **98**:234-240.

Grashey-Jansen, S. and Timpf, S. (2010): Soil hydrology of irrigated orchards and agent-based simulation of a soil dependent precision irrigation system. *Advanced Science Letters* **3/3**:259-272.

Grashey-Jansen, S. (2011): Simulation einer sensorgestützten Präzisionsbewässerung von Standorten im Südtiroler Obstanbau. In: *Hallesches Jahrbuch für Geowissenschaften* **32/33**:49-56.

Grashey-Jansen, S. (2012): The influence of physical soil properties on the water supply of irrigated orchards – some examples from Val Venosta (South Tyrol/Northern Italy). *Journal of Environmental Biology (Special Issue: Environment and Geography in Mediterranean)* **33**:417-424.

Hezarjaribi, A. and Sourell, H. (2007): Feasibility study of monitoring the total available water content using non-invasive electromagnetic induction-based and electrode-based soil electrical conductivity measurement. *Irrigation and Drainage* **56**:53-65.

Sadler, E. J., Evans, R., Buchleiter, G., King, B. and Camp, C. (2000): Venturing into precision agriculture. *Irrigation Journal* **50 (3)**:15–17.

Anschrift des Verfassers:

Sven Grashey-Jansen

Geographisches Institut , Universität Augsburg

Universitätsstr. 10, D-86159 Augsburg

Email: sven.jansen@geo.uni-augsburg.de