Geophysical Research Abstracts
Vol. 16, EGU2014-6253, 2014
EGU General Assembly 2014

How do current irrigation practices perform? Evaluation of different irrigation scheduling approaches based on experiements and crop model simulations

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The increasing worldwide water scarcity, costs and negative off-site effects of irrigation are leading to the necessity of developing methods of irrigation that increase water productivity. Various approaches are available for irrigation scheduling. Traditionally schedules are calculated based on soil water balance (SWB) calculations using some measure of reference evaporation and empirical crop coeffcients. These crop-specific coefficients are provided by the FAO but are also available for different regions (e.g. Germany). The approach is simple but there are several inaccuracies due to simplifications and limitations such as poor transferability. Crop growth models - which simulate the main physiological plant processes through a set of assumptions and calibration parameter - are widely used to support decision making, but also for yield gap or scenario analyses. One major advantage of mechanistic models compared to empirical approaches is their spatial and temporal transferability. Irrigation scheduling can also be based on measurements of soil water tension which is closely related to plant stress. Advantages of precise and easy measurements are able to be automated but face difficulties of finding the place where to probe especially in heterogenous soils.

In this study, a two-year field experiment was used to extensively evaluate the three mentioned irrigation scheduling approaches regarding their efficiency on irrigation water application with the aim to promote better agronomic practices in irrigated horticulture. To evaluate the tested irrigation scheduling approaches, an extensive plant and soil water data collection was used to precisely calibrate the mechanistic crop model Daisy.

The experiment was conducted with white cabbage (Brassica oleracea L.) on a sandy loamy field in 2012/13 near Dresden, Germany. Hereby, three irrigation scheduling approaches were tested: (i) two schedules were estimated based on SWB calculations using different crop coefficients, and (ii) one treatment was automatically drip irrigated using tensiometers (irrigation of 15 mm at a soil tension of -250 hPa at 30 cm soil depth). In treatment (iii), the irrigation schedule was estimated (using the same critera as in the tension-based treatment) applying the model Daisy partially calibrated against data of 2012. Moreover, one control treatment was minimally irrigated. Measured yield was highest for the tension-based treatment with a low irrigation water input (8.5 DM t/ha, 120 mm). Both SWB treatments showed lower yields and higher irrigation water input (both 8.3 DM t/ha, 306 and 410 mm). The simulation model based treatment yielded lower (7.5 DM t/ha, 106 mm) mainly due to drought stress caused by inaccurate simulation of the soil water dynamics and thus an overestimation of the soil moisture. The evaluation using the calibrated model estimated heavy deep percolation under both SWB treatments.

Targeting the challenge to increase water productivity, soil water tension-based irrigation should be favoured. Irrigation scheduling based on SWB calculation requires accurate estimates of crop coefficients. A robust calibration of mechanistic crop models implies a high effort and can be recommended to farmers only to some extent but enables comprehensive crop growth and site analyses.