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Determination of threshold value of soil water content for field and vegetable plants with lysimeter measurements

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Both the potential water consumption of plants and their ability to withdraw soil water are necessary in order to estimate actual evapotranspiration and to predict irrigation timing and amount. In relating to root water uptake the threshold value at which plants reducing evapotranspiration is an important parameter. Since transpiration is linearly correlated to dry matter production, under the condition that the AET/PET-Quotient is smaller than 1.0 (de Wit 1958, Tanner & Sinclair 1983), the dry matter production begins to decline too. Plants respond to drought with biochemical, physiological and morphological modifications in order to avoid damages, for instance by increasing the root water uptake.

The objective of the study is to determine threshold values of soil water content and pressure head respectively for different field and vegetable plants with lysimeter measurements and to derive so called reduction functions.

Both parameter, potenzial water demand in several growth stages and threshold value of soil water content or pressure head can be determined with weighable field lysimeter. The threshold value is reached, when the evapotranspiration under natural rainfall condition (AET) drop clearly (0.8 PET) below the value under well watered condition (PET).

Basis for the presented results is the lysimeter plant Buttelstedt of the Thuringian State Institute of Agriculture. It consist of two lysimeter cellars, each with two weighable monolithic lysimeters. The lysimeter are 2.5 m deep with a surface area of 2 m2 to allow a non-restrictive root growth and to arrange a representative number of plants. The weighing accuracy amounts to 0.05 mm. The percolating water is collected by ceramic suction cups with suction up to 0.3 MPa at a depth of 2.3 m. The soil water content is measured by using neutron probe. One of the two lysimeter cellars represents the will irrigated, the other one the non irrigated and/or reduced irrigated part of field.

The soil is a Haplic Phaeozem with silt-loamy texture developed from loess (water content at wilting point amounts between 0.167 and 0.270 cm3/cm3 and at field capacity (0.03 MPa) between 0.286 and 0.342 cm3/cm3). The mean annual temperature is 8.2°C and the mean annual precipitation is 550 mm.

Results are as follows: Winter wheat begins to reduce evapotranspiration when the water content in the root zone to a depth of 2.0 m is smaller than 25 % of the available water holding capacity (AWC). That is equal to an amount of soil water of 171 mm. The threshold value of potatoes is 40 % of the AWC to a rooting depth of 0.6 m (49 mm soil water amount). The corresponding value for cabbage is 40 % of the AWC relating to a rooting depth of 1.2 m, for cauli flower 60 % of the AWC relating to a depth of 1.0 m and for onion 80 % of the AWC to a rooting depth of 0.3 m (90, 50 and 5 mm soil water amount). Nevertheless onion attain a maximum rooting depth of 0.9 m. The maximum rooting depths of winter wheat, potatoes, cabbage and cawli flower are 2.0, 1.0, 1.5 und 1.5 m. The date on which the threshold is reached is different, for winter wheat and cabbage just before harvest and for onion in a few days after 8-leaf-stage. However, it is assumed that these values are also the influence of weather reflect, particulary with regard to the transpiration demand of the atmosphere and the amount of rain fall during earlier growth stages which can prefer the development of adaptation mechanism. Although there are great differences between the plant species concerning root water uptake to avoid a decline of biomass production due to drought.