Water Dynamics in Plant Production, 2nd Edition

Questions and Discussion Points

Chapter 9 – Water Use by Crops

Section 9.1
1. Please define leaf area index (LAI) and outline the significance of leaf:root ratio for the water use of crops.
2. Total root length is greater for cereals (oat) than for grain legumes (faba bean) as illustrated in Fig. 9.2. Calculate the total root surface area of the root system of the two crops at the end of June. The average root diameter is assumed to be 200 µm (cereals) and 600 µm (grain legumes).

Section 9.2
1. Under conditions of non-limiting soil water supply and a given potential evapotranspiration, the actual transpiration of a crop stand is governed by the leaf area index (LAI). Please give reasons why the transpiration rate will increase with increasing LAI, but will finally approximate a maximum rate.
2. Define 'relative transpiration'. Why is it used?
3. In a temperate climate in spring (April) water consumption is usually larger for winter cereals than spring cereals (Fig. 9.5). Explain why this is.

Section 9.3
1. The water uptake rate per unit volume of soil (WU) depends on soil matric potential or water tension (Fig. 9.7). The response curve attains a maximum at medium moisture and declines again on both the wet and the dry sides. Give reasons for this optimum response.
2. WU depends on root length density (L_v), as shown for oat in Fig. 9.8. This result came from a regression analysis of field data collected over a growing season. Describe and explain the relation between L_v and WU.
3. Give reasons for successive or phased water withdrawal by a root system (Fig. 9.9) from one soil layer after another in the profile.
4. Please consider and explain the idea of a maximum water uptake rate (WU_{max}) in a soil layer (LWU_{max}), which is achieved only once within the season.
5. Please discuss the influence of (a) root length density (L_v) and (b) rooting depth (z_r) on the water uptake rate in a soil layer under optimum conditions (Eqn 9.3). Describe the consequences for water uptake within the season as related to rooting depth of a crop.
6. Water extraction by roots is usually more intense in shallow soil layers than in deeper soil layers. Outline the reason for this behavior taking into consideration the water potential distribution in the plant (Section 7.6). Identify an ecological consequence.
7. Explain the rule 'soil evaporation is reduced by root water extraction'.

Section 9.4
1. Describe the two terms 'available soil water' and 'extractable soil water'.
2. Please explain the term 'effective rooting depth'.
3. Calculate the amount of extractable water (W_{extr}) for sugarbeet, growing on a sandy loam with an available field capacity (FC_{av}) of 0.18 $cm^3\ cm^{-3}$. The effective rooting depth ($z_{r\ eff}$) is 0.95 cm.

Section 9.5
1. Describe and discuss the daily course of leaf water potential for oat and faba bean (Fig. 9.14). Explain the differential course shown for the two crops by observing stomatal conductance.
2. Explain why oat has the features of a water spender but faba bean those of a water saver.

Section 9.6
1. What is an important pre-condition for the concept of extractable soil water?
2. Outline the relation between crop water use and leaf area duration (LAD).
3. Discuss the data on evapotranspiration (ET), soil evaporation (E), crop transpiration (T) and subsoil drainage (D) presented in Table 9.3.

Section 9.7
1. In a hypothetical soil profile drainage or capillary rise are assumed to be small and will therefore be disregarded. Explain the necessary measurements to evaluate cumulative ET from the start to the end of the cropping season.
2. For the estimation of soil evaporation (E) under the canopy of a crop, the potential soil evaporation under the crop (E_p*) has to be determined first. Which parameters have to be measured for estimation of E_p* by applying the Ritchie (1972) equation?
3. Why does Ep* have to be reduced to obtain the actual soil evaporation under the crop?
4. In a soil profile planted with crops, the water content in a rooted soil layer will change from day to day. What are the two fluxes that cause the change in soil water content? Which flux provides the basis for calculating the daily water uptake rate of the roots within that soil layer?

Section 9.8
1. Explain the term ‘numerical simulation’ as a tool to study water dynamics of cropped soils.

Box 9.1
1. Please present a description of a lysimeter. Include the purpose for the use, essential features and kinds of measurements.

Box 9.2
1. Explain the essential difference between lysimeter studies and investigations by use of the sap flow technique.