

ELEMENTS OF WATER BALANCE IN AN OAK FOREST STAND ON CLAY SOIL

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Introduction

Considering that it has been shown in many studies that climate change has significant effect on soil water regime (Farkas et al., 2005) water can become the main limiting factor in food chain processes in many aspects. For example, (i) many input elements get into the food chain from precipitation, (ii) the speed of mineralization is greatly affected by precipitation circumstances and (iii) the uptake of elements from the soil is affected by soil moisture. However, there are many researches on water regime in forests but the details of water transport are not well known. Accordingly, site measurements on water balance elements and modelling of the water cycle in forests are very valuable achievements. The aims of this study are (a) to describe the soil of an oak forest stand (b) to determine the amount of precipitation reaching the ground in the stand, (c) to describe the soil water content dynamics and compare it with that in the grassland next to the forest stand with the aim of deepening the understanding of the water relations of food chain element transport in forest ecosystems.

Materials and methods

The study is carried on in the Mátra Mountains, Northern Hungary (N 47°50'37.6", E 19°43'16.5"). Elevation is 278 m a.s.l. The Mátra Mountain is made up of Paleogen and Neogene siliciclastic sequences and Miocene igneous rocks. It has a stratovolcanic structure; rhyolite tuff, pyroxene-andesite lava and tuff are characteristic. The studied soil is Haplic Vertisol according to WRB (Table 1), where depth of humus layer is 35 cm. The experimental forest stand is situated on nearly flat surface. It is dominated by Turkey oak (*Quercus cerris*) (50% cover). Small leaved lime (*Tilia cordata*) and field maple (*Acer campestre*) are present with 20-20% cover, while robinia (*Robinia pseudo-acacia*), northern red oak (*Quercus rubra*), scots pine (*Pinus sylvestris*) and wild pear (*Pyrus pyraster*) are considered as rare species. The canopy cover is 80-100 %. The cover of the shrub layer is 10-50%. Soil moisture and precipitation reaching the ground were measured continuously in the forest stand. Measurements have been continuing since 15 April 2005. ECH2O soil moisture probes were buried in three soil profiles, five pieces in each of them, between soil depths of 15 cm to 55 cm with 10 cm vertical distance between the sensors. The probes were placed parallel to the soil surface, orienting the flat side perpendicular to the surface of the soil. One of the sets has been set up later, in 26 June. Probes were established in one soil profile in the grassland next to the forest using the same method and orientation to have the ability to compare the water content dynamics of the forest and the grassland. The soil moisture probe was calibrated for the studied soil. Records of soil water content in each layer were taken in every 30 min. The grassland (Hagyó et al. 2005) has the same soil type as the forest. Three HOBO Data Logging Rain Gauges (Onset Computer Co., 2001) with a measurement resolution of 0.2 mm were set up below the forest canopy. Rain gauge 2 and 3 has choked during a hard rain event at the beginning of July so their data for 7-27 July cannot be used. We tried to choose the three measurement sites with different canopy cover to obtain representative results for the heterogeneous forest stand. We determined the canopy cover using photographs. At each rainfall measurement sites 24-mm photographs were taken with a digital camera (CANON EOS 300D). The camera was placed on the rain gauges with the lens facing straight up. Images were analysed with the software Adobe Photoshop 7.0 Trial (Adobe Systems Inc.,

USA) following a protocol described in Engelbrecht et al. (2001), changing the protocol when sky was too dark because of cloudiness, in this case setting brightness 0. Using this method, we obtained the percentage of black pixels that is considered to be the canopy cover.

Table 1. Profile description.

Genetic layer	Depth cm	Depth of sampling (cm)	Profile description:
Jele			
A ₀₀	0-3	-	Leaves.
A ₀	3-6	0-5	Moist not decomposed litter.
A ₁	6-10	5-10	Dark brown (10YR 3/3), moist, loose, clay. Medium granular structure, hard structural units when dry. Sticky and plastic. Moderately compacted many very fine and coarse roots. Clear boundary.
A ₂	10-20	10-20	Dark yellowish brown (10YR 3/4), moist, loose, clay. Strong fine angular blocky structure, hard structural units when dry. Sticky and plastic. Moderately compacted many very fine and coarse roots. Wavy boundary.
B	20-100	20-40	Dark brown (7.5YR 3/4), moist, friable, clay. Strong medium prismatic structure, hard structural units when dry. Sticky and plastic. Moderately compacted many very fine and coarse roots. The transition of the humus horizon is undulate. Wavy boundary.
C	100-		reworked andesitic tuff

Results and discussion

The total amount of precipitation measured by Rain gauge 1 between 14 April and 1 October was 281.4 mm. We compared the amount of measured rainfall before and after operation failures of rain gauge 2 and 3 (Table 2). Rain gauge 1 measured significantly smaller amount of precipitation than rain gauge 2 and 3 in the period 28 July – 10 October.

Table 2. Data on rainfall of the three rain gauges.

	14 April - 5 July	28 July - 10 Oct
Rain gauge 1	159.4	83.2
Rain gauge 2	157.8	157.2
Rain gauge 3	164.2	170.0

The full-developed canopy cover was 80-90 % above the rain gauges (Table 3). It was similar above rain gauge 2 and 3 and lower above Rain gauge 1. The daily rainfall measured by Rain gauge 2 and Rain gauge 3 were similar for the whole period; data of Rain gauge 1 differed, it measured 28 times more, 36 times less amount of rainfall than Rain gauge 2 (on days with

non zero data). The delayed records show that this is resulted by water dropping from the leaves.

Table 3. Canopy cover (% of black pixels) above the three rain gauges at different times.

	04.19.2005.	05.27.2005.	10.11.2005.
Rain Gauge 1	50.27	81.61	80.95
Rain Gauge 2	53.86	88.12	85.35
Rain Gauge 3	80.71	92.46	90.14

The measured soil water content values are presented in Fig.1. Soil water content dynamics was similar in the three soil profiles in the forest. Soil water content (SWC) was smaller in the 10-20 cm layer than in the deeper layers in all of the soil profiles in spring, also in the grassland. Later on, SWC decreased at different rates in the profiles. SWC started to decline intensively at the beginning of June and reached zero in soil profile 1, while the reduction was smaller in soil profile 2. The deeper layers (20-30 cm, 30-40 cm and 40-50 cm) dried more intensively in this profile in summer. There was an intensive decrease in the 10-20 cm and 20-30 cm layers in the grassland, but soil water content didn't reached zero, the local minimum was 10.74 v/v% (9 June). The layers below 20 cm were wetter in the grassland than in the forest, probably due to the smaller water uptake by the plants from this layer in the grassland as the main root mass is in the layer of 0-20 cm depth in the grassland versus the whole soil profile is moderately compacted many roots (Table 1) in the forest.

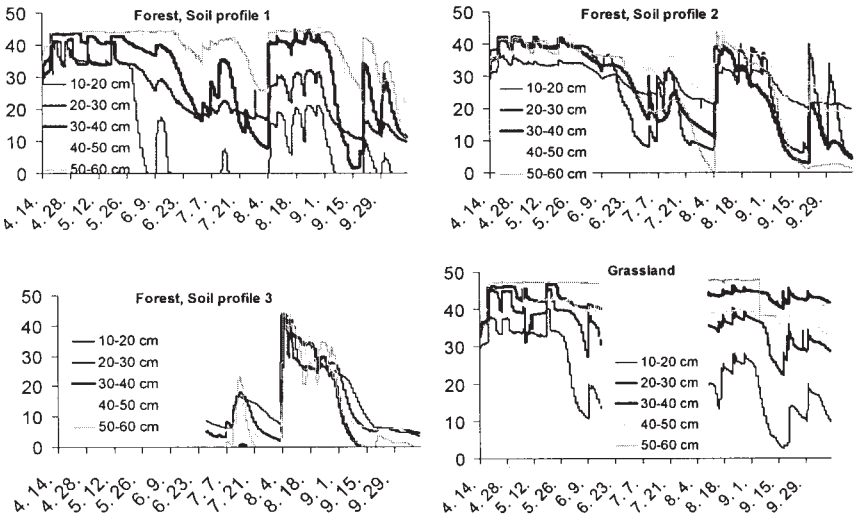


Figure 1. Soil water content in two soil profiles in the forest (a., b., c.) and in the grassland (d.).

Conclusions

The relationship between canopy cover and measured rainfall below the canopy was poor, probably because not all of the intercepted water evaporated and water dropped down from the leaves, with time delay.

Soil water content sometimes decreased very intensively, even to zero. It occurred in the 10-20 cm layer in soil profile 1 and in the 30-40 cm and 50-60 cm layers in soil profile 3 in the forest. We assume that this result arose from the decrease of bulk density and crack formation. Therefore, the differences between the soil water dynamics of the soil profiles in the forest seem to be attributable to the spatial heterogeneity of soil volume changing, shrinking and swelling. These are important processes in the studied heavy clay soil because cracking has an effect on rapid water and nutrient transport. According to our work these processes can be studied by soil moisture measurements.

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