SOIL MOISTURE DYNAMICS IN MOUNTAIN AREAS DURING DRY PERIODS OF HYDROLOGICAL YEAR

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Abstract

The main subject of this paper is the problem of drought and its influence upon the water regime in mountain forests. During the growing season, especially during its dry periods and summer, drying off of the soil physiological profile can be observed. In the upper layers of the soil, where the majority of spruce active roots grow, the amount of available water decreases to the area with low or even very low supply. Water availability thus decreases. During extremely dry periods even total drain of water can be observed.

Keywords: chronoizoplets, soil moisture, hydrolimits, physiologically available water

INTRODUCTION

Forest belongs to biological system that influences the water circulation more significantly than any other plant association. Forest ecosystems significantly influence each compound of the water balance.

Forest tree species perform also a various relationship to the water regime. Generally it can be stated that the more active the organisms are the higher demands they show towards hydrothermic regime of the environment. Each tree has its biorhythm that differs according to the soils type, intensity of solar radiation, the level of available nutriment and especially the supply of water in the soil. If there is not sufficient water available for trees, no matter what species it is and what is the demand for water, the contact between active (sucking) roots of the tree and water is interrupted. Subsequently the physiological weakening takes place.

Existence and the growth of forest ecosystems are limited by moisture conditions in the soil, especially in lower altitudes. On the other hand high productivity of forest ecosystems in mountains is explained by favorable influence of sufficient supply of available water. In spite of this the sanitary condition of mountain forests is worsening and these forests gradually die away faster compared to forests in lowlands. The most frequent hypothesis to be mentioned is the influence of emissions attacking forest ecosystems as dry or wet deposition. This results in soil acidification and accumulation of toxic elements in the humus layer, especially H ions, sulfur, aluminum compounds
and various microelements. Contaminant concentrations negatively influence also the water regime in the forest soils, namely causing increase of the osmotic pressure of the soil solutions. This can result in increase the limit of available water for forest tree species.

In recent time forest stands are threatened by climatic changes characterized by extremely high or low air temperatures and precipitation what can be proved by presence of heavy rains or extreme droughts. As for the first case the forest soil owing to its retartation and retention ability is able to buffer the floods and culmination flows. As for the occurrence of hydropedological cycles with insufficient available water supply the forest often is not able to respond adequately. Over longer lasting dry periods mountain forests can reach the state of a total exhaustion when their resistance decreases and protection reaction of trees fail.

CHARACTERISTICS OF THE AREA AND METHODS

The research was carried out on the research plot Oravská Polhora – Borsucie, in the area of Orava region and it was established in 1984. Characteristics of the research plot are presented in Table 1.

Actual soil moisture was determined from soil samples gathered in week intervals, taken from each 10 cm layer of the soil profile to the depth of 80 cm. Gravimetric method was used using soil bore. The soil moisture conditions were determined through the relation to hydrophysical characteristics of the soil, maximum capillary capacity MCC, point of diminished availability PDA, and the wilting point WP (Tuzinsky, 1990).

Ecological classification of the water regime was determined according to Kutílek (1971).

RESULTS

The climate character forms the soil moisture dynamics, especially through the precipitation intensity and its spatial and time distribution, furthermore through evapotranspiration, surface and belowground run-off and stratigraphic composition of the soil profile.

At the beginning of the hydrological year (November) soils below the forest stand are supplied by water in the range of the hydrolimits of MCC and PDA. Under favorable atmospheric condition (sufficient precipitation) the water supply in the soil is in the upper third of this variation range and in the case of precipitation deficit in the lower third. The most favorable moisture conditions were recorded at the turn of winter and spring. At this time as snow melts water supply in the soil shows even surplus of the gravitational water. According to a relatively small water holding capacity of the forest soil (> 40 % of the skeleton) there is usually easily available water, medially movable, ranging from the hydrolimit of the full water capacity (FWC) to MCC. Such moisture condition represents very favorable start of the growing season as for the water availability for trees.

During the growing season (Fig. 1) the soil moisture dynamics is very variable. The biggest differences can be observed especially in the upper layers of the soil profile (0 – 20 cm). Optimal amount of the soil water (around 60 to 80 % of the MCC) lasts approximately until June or even longer in periods with sufficient precipitation. An intensive decrease in the soil moisture can be observed in summer when drying period culminates. In the upper 0 – 30 cm layer of the soil the increased consumption of water is recorded. This layer also shows the biggest presence of active (sucking) roots. Water desuction by roots of forest trees and undergrowth vegetation is apparent from values of evapotranspiration that represent 4 mm.day⁻¹.

Available water supply evaluation in the layer of 0 – 20 cm of the soil profile shows that it varies from good supply (> 40 mm) in winter and spring, through sufficient supply (20 – 40 mm) majorly of the growing season to area of insufficient supply (< 20 mm) in periods after a longer lasting dry and warm weather.

In the whole physiological soil profile (0 – 100 cm) during the winter accumulation period (XII. – III.) we recorded sufficient (90 – 130 mm) and even very good (> 160 mm) supply of available water in dependence upon previous year. The majority of the growing season was characterized by sufficient supply of available water, in summer this supply decreased to the low supply (90 – 60 mm) as a result to insufficient precipitation.

Increased consumption of the soil water is severe especially in areas suffering from precipitation deficit during dry periods that occur more frequently even in higher altitudes. Increased evapotranspiration activity connected with low supply of water in the soil result in decrease of the biological activity of the soil. Data on the soil moisture regime, available water supply, moisture intervals, and ecological classification of the water regime (Table 2) show that moisture changes in the soil during dry periods of the hydrological year are very intensive and particularly dangerous for the forest ecosystems. This applies especially for spruce which root system of is concentrated in the upper layers of the soil profile. Trees are not able to consume required amount of water as decrease of water amount to low or insufficient supply (< 90 mm) creates such soil profile that restrains active roots from contact with available water.
Fig. 1. Chronozopicls of the soil moisture during the growing season

Fig. 2. Available water supply in the upper 0 – 20 cm layer of the soil

Table 2
Soil water supply and ecological classification of the water regime during dry periods of the hydrological year

<table>
<thead>
<tr>
<th>Dry period</th>
<th>Number of precipitation days [mm]</th>
<th>Water supply [mm] (0 – 100 cm)</th>
<th>Hydrolimits</th>
<th>Soil moisture intervals</th>
<th>Available water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>4</td>
<td>220.5 – 160.5</td>
<td>PDA – WP</td>
<td>G</td>
<td>L – VI</td>
</tr>
<tr>
<td>1993</td>
<td>3</td>
<td>350.7 – 280.5</td>
<td>MCC – PDA</td>
<td>SU</td>
<td>G</td>
</tr>
<tr>
<td>1994</td>
<td>2</td>
<td>256.5 – 205.8</td>
<td>PDA – WP</td>
<td>SA</td>
<td>L</td>
</tr>
<tr>
<td>1995</td>
<td>3</td>
<td>195.8 – 125.8</td>
<td>MCC – PDA</td>
<td>SU</td>
<td>G – L</td>
</tr>
<tr>
<td>1996</td>
<td>7</td>
<td>200.7 – 130.5</td>
<td>MCC – WP</td>
<td>SA – SA</td>
<td>G</td>
</tr>
<tr>
<td>1997</td>
<td>10</td>
<td>225.6 – 155.7</td>
<td>PDA – WP</td>
<td>SA</td>
<td>L</td>
</tr>
<tr>
<td>1998</td>
<td>1</td>
<td>320.7 – 250.5</td>
<td>MCC – PDA</td>
<td>SU – SA</td>
<td>G – L</td>
</tr>
<tr>
<td>1999</td>
<td>4</td>
<td>230.4 – 160.5</td>
<td>PDA – WP</td>
<td>SA</td>
<td>L</td>
</tr>
<tr>
<td>2000</td>
<td>2</td>
<td>260.5 – 195.4</td>
<td>PDA – WP</td>
<td>SA</td>
<td>L – VI</td>
</tr>
<tr>
<td>2001</td>
<td>8</td>
<td>340.5 – 270.5</td>
<td>MCC – PDA</td>
<td>SA</td>
<td>G</td>
</tr>
</tbody>
</table>

MCC = maximal capillary capacity
PDA = point of diminished availability
WDP = wilting point
SU = semiulvic interval (MCC – PDA)
SA = semiarid interval (PDA – WP)
G = good available water supply
L = low available water supply
VI = very low available water supply
CONCLUSION

Mountain forests, especially spruce forest stands, suffer from worsening of their sanitary conditions due to dry periods resulting from changes in air temperature and precipitation. Forest ecosystems are threatened by occurrence of pedohydrological cycles with low or even insufficient supply of available water in the soil. This negatively influences physiological processes of forest stands. Longer lasting and frequent dry periods result in decrease of the ecological stability and gradual loss of defense mechanism towards damaging factors.

Acknowledgement: The research was supported by finance of the project VEGA 1/9264/02, VEGA 1/9207/02, and VEGA 1/9265/02.

REFERENCES


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Received: 01.08.2003