# The comparison of soil moisture content changes in the moorsh layer under shrubs and grass vegetation

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**Abstract.** The objective of the research was to compare the soil moisture content changes in the top moorsh layer (0–25 cm) covered by shrubs and grass vegetation under the same groundwater level and climatic conditions. The measurements of soil moisture content values for both sites under different vegetation were performed using the TDR method. The values of soil moisture content for shrubs ranged from 49.7% vol. to 14.4% vol. For grassland the values of moisture content ranged from 58.9% vol. to 24.9% vol. The analysis of soil moisture content values showed that it was lower by about 10% vol. under shrubs in comparison with grass vegetation under the same climatic and water table conditions.

**Key words**: shrubs, birch, grass, TDR method, soil moisture content

## INTRODUCTION

The relinquishment of grass cutting on peatlands meadows results in plant succession. The first stage of change is characterised by the occurrence of the typical plants for the extensively used meadows. During the next stage the shrubs and wood plants start to appear on the abandoned area. The last stage is the development of forest ecosystems. The succession reduces biodiversity, increases plants' water consumption and strongly influences physical and chemical properties of the soils. The increase of plant water requirements results in a decrease of soil moisture content that is not favourable for peat soils, because water is the most important environmental factor in protection and maintenance of these soils (Okruszko, 1993; Oleszczuk et al., 1999; Brandyk et al., 2001; Brandyk & Szatyłowicz, 2002; Brandyk et al., 2006).

The limitation of meadows harvesting for the Biebrza river valley, which is one of the biggest fen peat soils complexes located in North-East Poland, has been observed since the 1970's. The main consequence of this process was plant succession from grass communities into reeds, willows and birch forests (Wołejko, 2002; van Diggelen et al., 2006). Bartoszuk et al. (2004) reported that shrubs and forests presently occupy almost 25% of the total area of the Biebrza river valley. The birch forests growing on drained organic soils caused the increase of plant water requirements due to higher evapotranspiration of trees in comparison with grasses, which resulted in higher precipitation deficits (Brandyk et al., 1996; Brandyk & Szatyłowicz, 2002). The analysis of the soil water regime of peat soils under different vegetation (grassland, arable land and forest) showed that the most intensive drying of the top layers of fen peat soil occurred under forest ecosystems (Gotkiewicz & Szuniewicz, 1987; Gotkiewicz et al., 1994). The research on water conditions of peat-moorsh soils under both the forest and the meadow performed by Chrzanowski (2001) showed that the water table levels and the values of moisture content were much lower under birch forest than under grassland vegetation. The drying of the top layers of organic soils can accelerate their mineralization, decomposition and subsidence (Okruszko, 1993; Gotkiewicz et al., 1994). The changes of the basic physical (bulk and particle density, porosity) and hydraulic properties of the upper organic soil layer under forest vegetation were also observed. Reduction of soil water retention abilities, increase of hydraulic conductivity values as well as a remarkable loosening of soil structure under forest vegetation was much higher in comparison to areas covered by grasslands (Silnis & Rothwell, 1998; Brandyk & Szatyłowicz 2002; Chrzanowski, 2002; Mueller et al., 2007). The review of the literature data showed that the previous researches dealt mainly with the consequences of plant succession and soil drainage for forest ecosystems only on peat soils. There are limited research results on the hydrological impacts of young trees and shrubs on peat soils conditions. The estimation of water requirements of young willow trees (Cienciala & Lindroth, 1995; Lindroth et al., 1995; Nagler et al., 2003) as well as birch trees growing on peat soils were also presented (Oleszczuk et al., 2005). However, there is a lack of information in the literature on soil water conditions of the upper layers located under the abandoned peat grasslands, especially during the invasion period of shrubs and woody vegetation.

The aim of this study is to compare the soil moisture content changes of the moorsh layer covered by shrubs and grasses vegetation under the same climatic conditions and the same groundwater regimes.

## MATERIALS AND METHODS

The measurements of organic soils water conditions under different plant covers were performed at the experimental plot located in Kuwasy drainage-subirrigation system (the Middle Biebrza Basin, Poland). This plot is situated at the distance of 200 m from the Kuwasy main drainage-irrigation channel. The measurements of soil water content under different types of vegetation covers were conducted in the moorsh layer (0-25 cm) developed from the willow peat. The field measurements of soil water regime were taken for 2 separate sites located 10 m apart. The first was covered by young birch forest vegetation (10-year old trees) and the second was used as extensive grasslands (mown twice a year). The measurements of soil moisture contents of each site were performed in three replications from 2 June-30 September 2006. The soil moisture contents were measured in the 25 cm deep upper soil layer with the use of the time domain reflectometry (TDR) method. The TDR probe consisted of two parallel 25 cm long wave-guides, 5 mm in diameter, pressed vertically into the moorsh layer 25 mm apart. The measurements of the dielectric constant values were taken with the use of the Tektronix 1502B cable tester. The values of the volumetric moisture content were calculated with the use of the calibration equation developed for the moorsh layer by Oleszczuk et al. (2007). The groundwater levels were measured in an observation well installed midway between the two sites; measurements were usually taken every 3 days..

The daily values of precipitation and air temperature were recorded automatically at the Skye Company, a meteorological station located near the experimental sites. The monthly average meteorological data measured at the Biebrza Meteorological Station (Chrzanowski, 2006) for the periods (IV-IX) from 1962–2000 were used to characterise meteorological conditions.

The basic soil properties for top layers in the soil profiles such as bulk density, porosity and ash content were determined in 6 replications on samples collected during the measurement period in 2006. The values of bulk density were determined using the gravimetric method. Ash content was measured by igniting dry moorsh in a muffle furnace at a temperature of 550°C up to the constant weight (Maciak & Liwski, 1996). The total porosity was calculated using the values of bulk density and particle density.

## RESULTS AND DISCUSSION

The determined average values of the physical soil properties with values of standard deviations are presented in Table 1. The analysis of the data indicates that the soil profiles covered by different types of plants exhibit similar values of bulk density, porosity and ash content.

**Table 1**. Physical properties of the investigated soil layers under shrubs and grass vegetation.

| Depth (cm) | Bulk density (g cm$^{-3}$) | | Porosity (%) | | Ash content (% a.d.m.) | |
|---|---|---|---|---|---|---|
| | Average | Standard deviation | Average | Standard deviation | Average | Standard deviation |
| Shrubs | | | | | | |
| 5–10 | 0.23 | 0.015 | 85.80 | 0.83 | 13.52 | 0.99 |
| 15–20 | 0.25 | 0.019 | 84.75 | 1.20 | 13.92 | 0.93 |
| 25–30 | 0.22 | 0.021 | 86.47 | 1.18 | 13.28 | 1.50 |
| Grass | | | | | | |
| 5–10 | 0.24 | 0.010 | 85.40 | 0.63 | 13.60 | 1.22 |
| 15–20 | 0.25 | 0.016 | 84.47 | 1.01 | 13.79 | 1.54 |
| 25–30 | 0.22 | 0.032 | 86.05 | 1.67 | 13.18 | 1.46 |

The monthly values of air temperature and precipitation recorded at the automatic meteorological station for April-September 2006 were compared with long term average values of precipitation and air temperature recorded at the Biebrza Meteorological Station for the years 1962–2000 (Table 2). The monthly average values of air temperature in April, May and June 2006 were very close to the long-term average values for the respective months. The average values of air temperature in July, August and September 2006 were higher in comparison with the long-term (1962–2000) average values for these months. The considerable variability of monthly precipitation sums during the vegetation period in 2006 was observed. Precipitation in April and June 2006 was about 50% lower in comparison with long-term data. The values of monthly sums of precipitation recorded in May and September 2006 were very close to the average values of the long-term precipitation sums. The biggest differences between monthly sums of precipitation measured in 2006 in comparison with long-term monthly averages were observed in July and August 2006. From the analysis of the data presented in Table 2 it can be seen that July 2006 was a relatively dry month: the sum of precipitation was about 3 times lower than the long-term monthly average value. August 2006 was relatively very wet: the recorded value of the precipitation sum was about 3.5 times higher than the long-term monthly average value. The average value of air temperature for the whole vegetation period in 2006 (IV-IX) was slightly higher than long-term average values (Table 2); precipitation for the same period was about 20% higher in comparison with the long-term (1962–2000) average value for the same considered period.

**Table 2**. The monthly average air temperatures and precipitation sums for investigated period in 2006 together with long-term monthly averages of air temperature and precipitation sums for the period 1962–2000.

| Year | Months | | | | | | |
|---|---|---|---|---|---|---|---|
| | IV | V | VI | VII | VIII | IX | IV-IX |
| | | | Temperature (°C) | | | | |
| 2006 | 6.1 | 12.2 | 15.7 | 20.4 | 16.8 | 13.6 | 14.2 |
| 1962–2000 | 6.4 | 12.4 | 15.7 | 17.0 | 16.1 | 11.6 | 13.2 |
| | | | Precipitation (mm) | | | | |
| 2006 | 18.7 | 55.0 | 36.2 | 23.2 | 215.5 | 46.8 | 395.5 |
| 1962–2000 | 36.4 | 53.6 | 68.6 | 71.4 | 61.1 | 52.3 | 343.4 |

The results of the field measurements of precipitation, air temperature, soil moisture contents (under grass and shrubs vegetation) and ground water levels are presented in Fig. 1. The analysis of the soil moisture data showed that at the beginning of the measurements (2.06.2006) the value of volumetric moisture content was at the level of about 50% vol. for the grass cover and about 10% vol. lower for shrub cover, respectively (Fig. 1b). During the next month, July 2006, the relatively high air temperatures and relatively low sum of precipitation caused the decrease of soil moisture content for both vegetation covers. The lowest values of the soil moisture content were measured at the end of July. The soil moisture content value for grassland cover was close to 25% vol. and for shrubs about 15% vol., respectively. The occurrence of the very high precipitation at the beginning of August caused the significant increase of the soil moisture content at two considered experimental sites. The highest daily rainfall - 47 mm - was recorded on 30 August 2006 and caused an increase of soil moisture content up to 60% vol. for grassland cover and up to 45% vol. for shrub cover. In September 2006, a significant drop of soil moisture content to 50% vol. for grassland cover and to 36% vol. for shrub cover was observed due to a gradually decreasing groundwater level from about 30 cm to about 80 cm below the soil surface.

The analysis of the depth of ground water level position changes as presented in Fig. 1c showed for the month of June only very minor changes in range 40–50 cm below the soil surface. In the first decade of July 2006 the groundwater table decreased to 75 cm due to water uptake by plants, very high air temperatures and low precipitation. By the end of July, the groundwater level had risen about 20 cm, possibly due to subirrigation caused by the rise of the open water level in the Kuwasy channel.

The very high precipitation sum recorded in August 2006 (215.5 mm) resulted in the rise of ground water level to 20 cm below the soil surface. In late August and in September the gradual decrease of groundwater position was observed down to 80 cm below the soil surface as the result of open ditch drainage by Kuwasy channel.

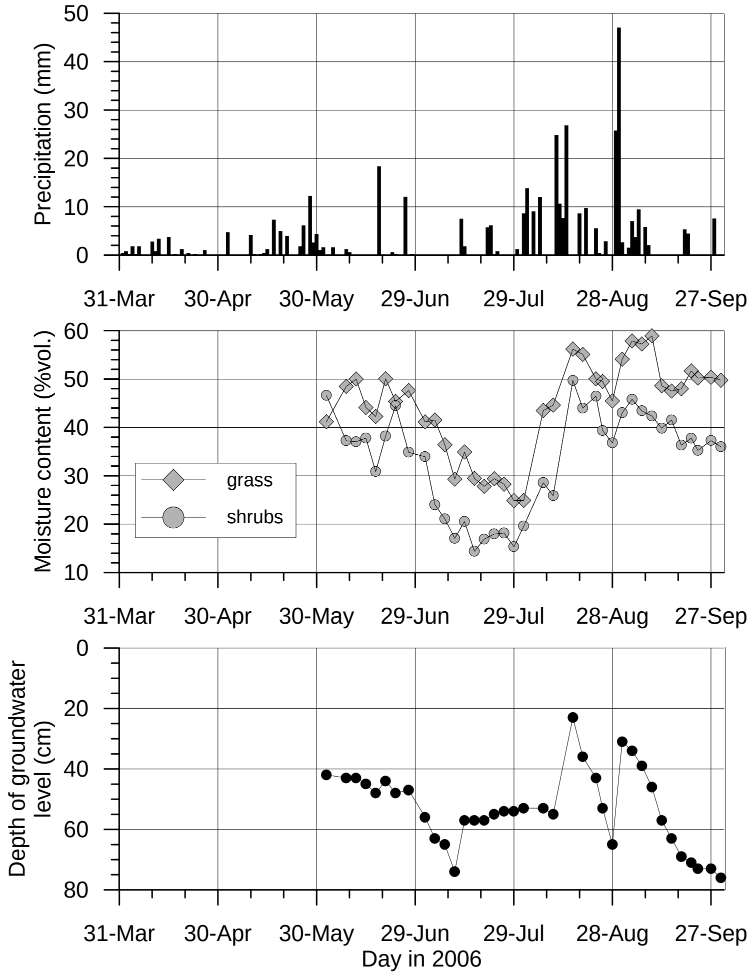


**Fig. 1**. Results of field measurements in vegetation season in 2006:
(a) precipitation and air temperature, (b) soil moisture contents under shrubs and grass, (c) groundwater levels.

The comparison between soil moisture content values in the top moorsh layer (0–25 cm) under shrubs and grass vegetation is plotted in Fig. 2. The data indicates that the measured soil moisture values under shrubs vegetation were generally lower by about 10% vol. in comparison with moisture content values recorded under grass vegetation. In the wetter range (moisture content above 40% vol.) the observed differences between moisture content values under the two considered vegetation types were smaller. The presented data in Fig. 2 were fitted with linear regression equation.

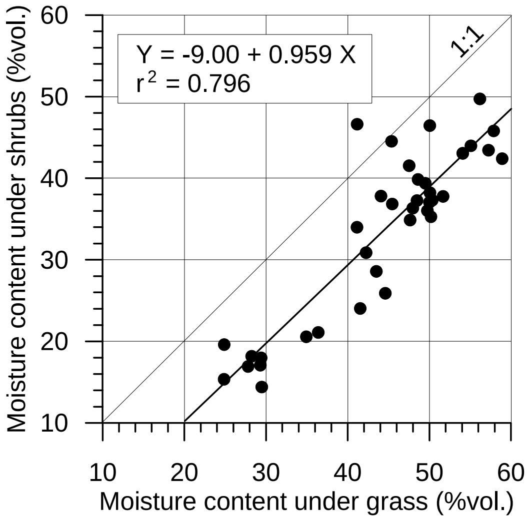


**Fig. 2**. The comparison of soil moisture contents in the top moorsh layer under shrubs and grass vegetation.

The fitting results are also presented in Fig. 2; the obtained linear relationships showed strong correlation between the soil moisture contents values at both sites (determination coefficient 79.6%).

## CONCLUSIONS

The performed analysis of soil moisture content changes in the top moorsh soil layer showed their high variability for both types of vegetation for the considered period, June-September 2006. The measurements of soil moisture content values for both sites under different vegetation were performed using the TDR method. The values of soil moisture content for shrubs were in a range from 49.7% vol. to 14.4% vol. For grassland the values of moisture content ranged from 58.9% vol. to 24.9% vol. From the data presented in this study it can be seen that the measured soil moisture values under shrubs vegetation were generally lower by about 10% vol. in comparison with moisture content values recorded under grass vegetation.

The influences of physical properties of the moorsh layers on the moisture regime for both sites were not observed. The differences in water content can be explained as a result of different water consumption by shrubs and grass vegetation.

The protection of organic soils against mineralization and the rational agricultural use of these soils can be fulfilled by their use as permanent grasslands.

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