10.7251/AGSY1303945J

DYNAMICS OF THE WATER CONTENT IN THE SOIL DURING THE PERIODS WITHOUT PRECIPITATION IN THE BOCEGAJ SUBCATCHMENT IN 2009 AND 2010

Ľuboš JURÍK, Tatiana KALETOVÁ*

Department of Landscape Engineering, Slovak University of Agriculture in Nitra, Slovakia *(Corresponding author: tatiana.kaletova@uniag.sk)

Abstract

The decrease trend of volumetric soil water content was observed during the dry season of 30 days with the rainfall up to 3 mm in 2009 and 2010; 8.9.-8.10.2009 (30 days) and 23.6.-22.7.2010 (29 days) in Bocegaj subcatchment, Slovakia. The dynamics vary between the observation places and depth. The highest decrease was up to 300 mm depth, the lowest in depth 1000 mm. The differences were mainly up to 10 percent of volume (average 4.3 % vol.) in 2009 and over 15 percent of volume (average 13.3 % vol.) in 2010. Higher temperature, soil type and texture, and different crops influenced the recession of the soil moisture in 2010.

Key words: soil drought, volumetric soil water content, dynamics of soil water content

Introduction

The landscape structure is being changed, as well as the processes connected to the landscape. One of these processes is the water cycle. Knowledge of soil water content and its dynamic is significant, especially for farmers. They might be able to react in the time to avoid the water stress of plants by additional irrigation.

Soil moisture is an important component in the atmospheric water cycle, both on a small agricultural scale and in large-scale modeling of land - atmosphere interaction (WMO, 2008). Soil moisture should be measured at a location most representative of a watershed when climatic data or vegetative conditions indicate a likelihood of actual conditions (NRCS).

Rainfall and snowmelt are natural sources of soil water and are normally greatly reduced during drought. Slope shape, gradient, and soil surface roughness will affect soil water content since surface or subsurface run-on from adjacent upslope sites can add to the soil moisture, while surface runoff can remove water from a site. Evaporation, plant transpiration, and deep percolation beyond rooting depth are other factors that deplete soil moisture (NRCS).

Drought is a normal, recurrent feature of climate, although often erroneously considered an unexpected and extraordinary event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration within the natural variability and can be considered an insidious hazard of nature; it differs from aridity which is a long-term, average feature of climate (EUWI, 2007). It is often difficult to know when a drought begins. Likewise, it is also difficult to determine when a drought is over and according to what criteria this determination should be made. Intensity refers to the degree of the precipitation shortfall and/or the severity of impacts associated with the shortfall (WMO, 2006).

Droughts are commonly classified by type as meteorological, agricultural, hydrological and socioeconomic. *Meteorological drought* is usually defined by a precipitation deficiency threshold over a predetermined period of time. *Agricultural drought* is defined more commonly by the availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time. *Hydrological drought* is even further removed from the precipitation deficiency since it is normally defined by the departure of surface and subsurface water supplies from some average condition at various points in time. *Socio-economic* *drought* differs markedly from the other types of drought because it reflects the relationship between the supply and demand for some commodity or economic good, such as water, livestock forage or hydroelectric power that is dependent on precipitation (WMO, 2006; EUWI, 2007).

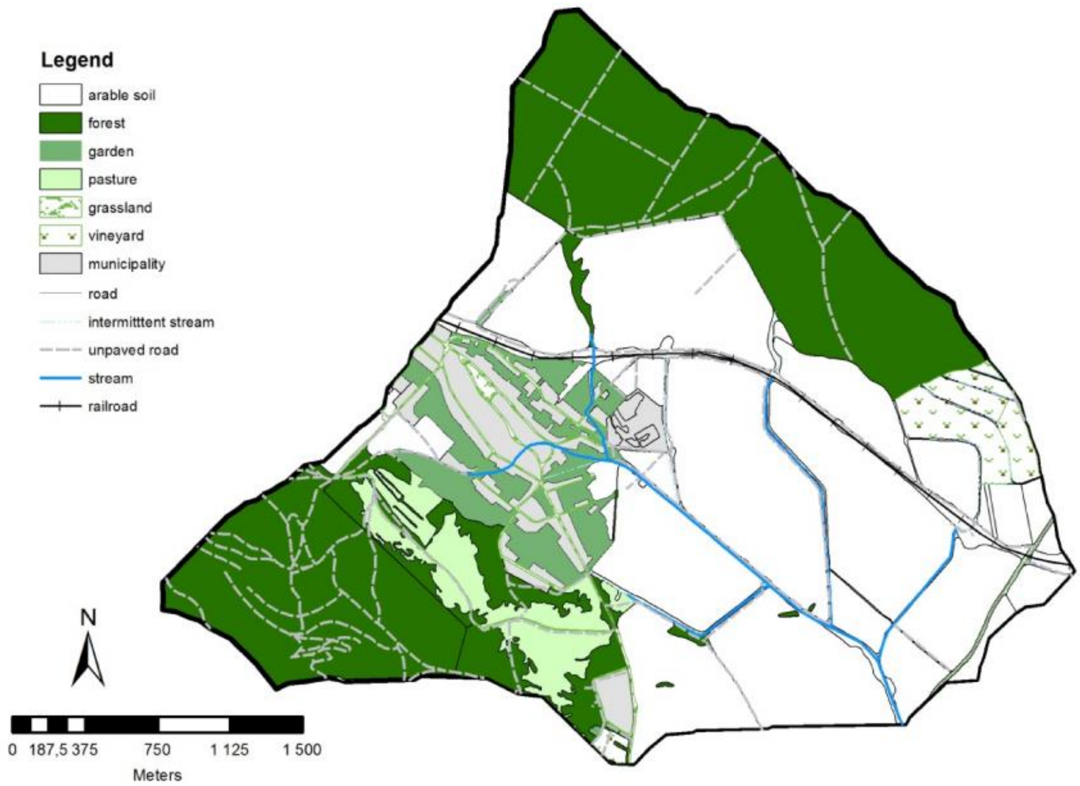
The aim of a paper is to show the dynamic of the soil moisture in an arable soil up to 1 m depth in the subcatchment Bocegaj during the period without precipitation in the years 2009 and 2010.

Materials and methods

The area of interest is a subcatchment of the Bocegaj stream with an area of 9.75 square kilometres. It is situated in Southeast Slovakia, approximately 10 kilometres northeast of Nitra. Daily average air temperature is 9.8 °C (mean value for years 1961-1990) in the Nitra region, and total yearly precipitation is 539 millimetres (mean value for years 1961-1990). Soil types are mainly represented by Haplic Luvisol (52 percent of arable soil), Cambisols (37.5 percent) and Fluvisols (10.5 percent). Soil texture groups are represented by loam top soil and clay loam subsoil (62.1 percent of arable soil), clay loam (15.3 percent), loam (7.5 percent), and sandy loam soils (15.1 percent). According to information from hydrogeologists, the relatively confined aquifer is quite variable under the terrain, at a range of approximately between 2 and 12 metres. The same situation exists with ground water level. The area of interest is detailed present in work Kaletova (2011).

The soil moisture by volume was monitored from the 8th September 2009 to the 24th November 2010 at a depth of 1 meter in the 5 observation places. The soil moisture was measured by the Profile Probe PR2/6 (Delta-T Device Ltd.) with connection to the Moisture Meter HH2 (Delta-T Device Ltd.). The Profile Probe PR2/6 uses frequency domain reflectometry to measure volumetric soil moisture. The observation places were constructed on the edge of the arable soil cross the area to be protected before the damage by farmers.

Two seasons with the total rainfall up to 3 mm were chosen; 8.9.-8.10.2009 (30 days) and 23.6.-22.7.2010 (29 days). We assumed that rainfalls up to 3 mm were intercepted on the vegetation. The measurements were done every fortnight.



Results and discussion

The values of the volumetric soil water content in % of volume is shown on the figure 2 in depths 100, 200, 300, 400, 600 and 1000 mm. The figure shows only the period without precipitations up to 3 mm. The figure 3 shows differences in % of volume between minimal and maximal value of volumetric soil water content during the period.

There is visible decrease trend of the soil moisture during the period without rainfall up to 3 mm in both years. Higher decreases were in the 2010. The main point is that on the first day of the observation the soil water content was almost equal to field capacity. There was enough soil water to evaporate, and crops were in the growth (tab. 1). Also, the higher temperature, soil type and texture, and different crops influenced the recession of the soil moisture in 2010.

Table 1 Crops grown around the observation places

Place	2009	2010
1	after the tillage; *Brassica napus* was seeded	*Brassica napus*
2	after the tillage; *Brassica napus* was seeded	*Brassica napus*
3	after the tillage; *Triticum aestivum* was seeded	*Triticum aestivum*
4	*Medicago sativa*	*Medicago sativa*
5	after the tillage	*Cucurbita pepo*

The dynamics vary between the observation places and depth (fig. 2). The highest decrease was up to 300 mm depth, the lowest in depth 1000 mm. In the literature (e.g. Dub, 1963) it is written that by the influence of evapotranspiration, arable soil during the dry season is dried up only in the upper layer up to a depth of 150 mm and slightly less in the layer from 150 to 250 mm, the deeper layers dry up very little. The differences were mainly up to 10 percent of volume (average 4.3 % vol.) in 2009. In 2010 the differences were over 15 percent of volume (average 13.3 % vol.) (fig. 3).

The volumetric soil water content descended below the wilting point at the end of observed period in the soil depth of 100 mm in all places. Mainly in 2009 the soil moisture was lower than the wilting point. The wilting point was defined according to soil type and texture (range 17 – 23 %).

The decrease of volumetric soil water content in lower depths of the profiles was made by the capillary raise of water into upper soil layers, water consumed by plants, and percolation of the soil water into deeper layers. The ground water level was not observed at a depth of 2 m, therefore the influence on soil moisture by capillary raised ground water is not assumed in these observation places.

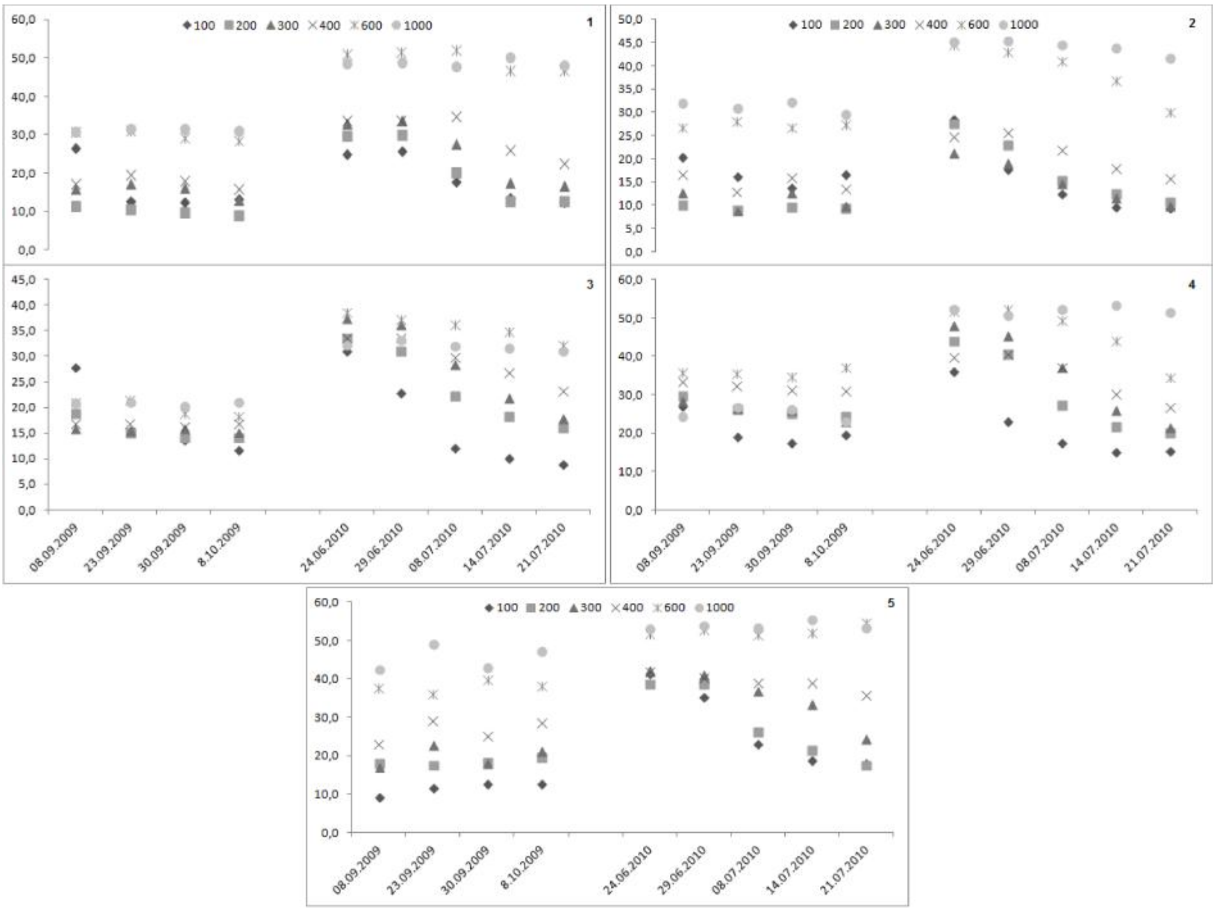


Figure 2 Dynamics of volumetric soil water content (in % vol.) in different depth during the periods without the precipitation

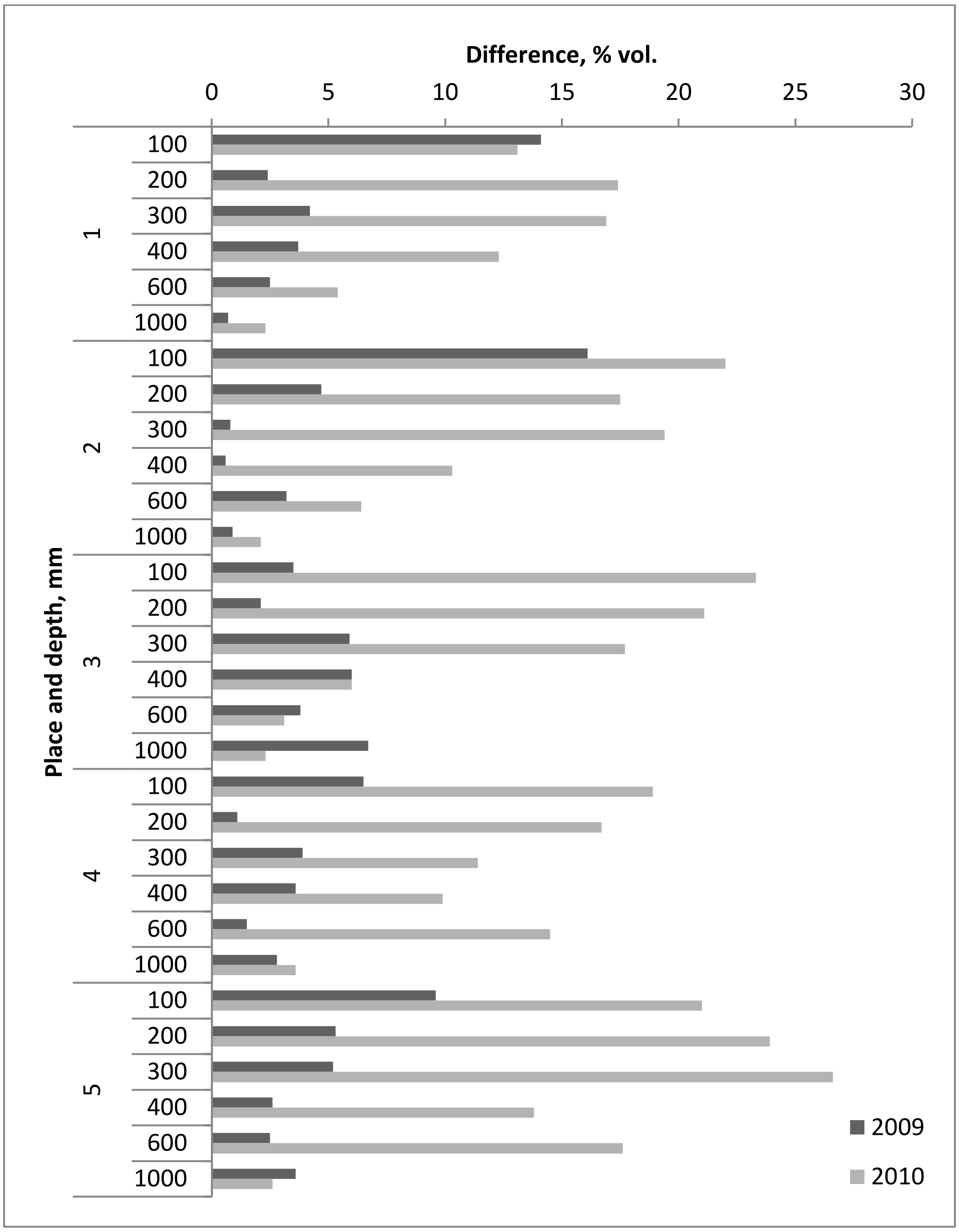


Figure 3 Differences of the soil moisture in different depth and place in the 2009 and 2010

Conclusion

The decrease trend of volumetric soil water content was observed during the dry season of 30 days with the rainfall up to 3 mm in 2009 and 2010. The main influence on the decrease had the high air temperature, crops and soil type and texture. The higher decrease was in 2010 because of the crops in the soil and higher air temperature. There is evidently visible decrease of the soil moisture in the season without rainfall (approximately 2 volume percent per week in 2009).

Knowing the amount and dynamics of soil water content we may predict and react in time to the current, especially climatic, conditions of the environment. Farmers may determine the date and amount of additional irrigation, or apply other agrotechnical arrangements; water managers may forecast floods and so on.

The landscape, its structure, and its cover are dramatically changed in the agricultural used part during the year and mainly due to the impact of water cycle on evapotranspiration. Repudiation of the landscape like the part of cycle is a mistake of majority of models, and so results on the differences between simulated and measured values.

Acknowlegdement

This work was supported by grants No. VEGA 1/0949/11, VEGA 1/0027/12 of the Scientific Grant Agency.

References

DUB, O. 1963. *Hydrologia, hydrografia, hydrometria* (Hydrology, hydrography, hydrometry). Vydavatelstvo technickej literatury, Bratislava.

EUWI, 2007. Mediterranean Water Scarcity and Drought Report. Technical report 009-2007. <http://www.emwis.net/topics/WaterScarcity/PDF/MedWSD_FINAL_Edition> Accessed on 29/10/2008.

KALETOVA, T. 2011. Retencia a spotreba vody v poľnohospodársky využívanej krajine (Water retention and water consumption in agricultural landscape). PhD. thesis. Nitra. (In Slovak with English abstract)

NRCS. Technical soil services handbook. Part 630: Special Projects, Studies, and Inventories. <http://soils.usda.gov/technical/tssh/contents/part630.html> Accessed on 25/10/2009.

WMO, 2006. Drought monitoring and early warning: concepts, progress and future challenges. <http://www.wamis.org/agm/pubs/brochures/WMO1006e.pdf>. Accessed on 25/10/2009.

WMO, 2008. Guide to Meteorological Instruments and Methods of Observation - No. 8. Seventh edition, 2008.