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SOIL RESPIRATION MEASUREMENT IN BEECH FOREST DURING TWO VEGETATION PERIODS AT STARA PLANINA

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Abstract: Stara planina presents one of the greatest mountains in Balkans spreading from Vrška Čuka to the Black sea where Western part of this mountain range is border between Serbia and Bulgaria. The research site was located at Vidlič in even-aged European beech coppice forest. In investigated stand, plot of 25x25 m area was established with 9 randomly selected where soil respiration was measured during climatically two different vegetation periods in 2013 and 2014. Measurements were performed with portable gas exchange measurement system ADC LCPro+. At the same time, evaporation, soil moisture content, soil temperature and air temperature were measured in order to correlate with soil respiration. Results showed significant impact of soil moisture content driven by climate conditions in two investigated years on soil respiration and evaporation.

Keywords: Stara planina, beech, soil respiration

DISANJE ZEMLJIŠTA U SASTOJINI BUKVE NA STAROJ PLANINI U TOKU DVE VEGETACIJE

Izvod: *Stara planina predstavlja jednu od najvećih planina na Balkanu koja se proteže od Vrške Čuke do Crnog mora. Na oglednom polju koje se nalazi u jednodobnoj izdanačkoj bukovoj sastojini na Vidliču je izvršeno merenje disanja zemljišta u toku vegetacionog perioda u toku 2013. i 2014. godine. Paralelno sa merenjem disanja je vršeno i merenje evaporacije, sadržaja vlage i temperature zemljišta, kao i temperature vazduha. Rezultati su pokazali začajan uticaj sadržaja vlage u zemljištu uslovljenih kimatskim prilikama na intenzitet disanja zemljišta i evaporaciju.*

Ključne reči: *Stara planina, bukva, disanje zemljišta*

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INTRODUCTION

Stara Planina (Old Balkan mountains) presents one of the greatest mountains in Balkans spreading from Vrška Čuka to the Black sea. On the western part, it presents border between Serbia and Bulgaria. According to some authors (Vidanović, 1960), western part of Stara Planina is divided to two geologically different mountains Stara Planina and Vidlič. Most common forest ecosystems are mountain beech forests, subalpine beech forests, beech-silver fir forests and spruce-silver fir forests (Horak, 2015).

The global atmospheric carbon concentration increased in previous decades due to the increase of use of fossil fuels for industrial development. Soils, containing twice as much carbon as the atmosphere, could strongly change the carbon dioxide concentration in the atmosphere due to altered carbon losses (Smith et al., 2008). Faster oxidation of soil organic matter due to global warming can therefore significantly increase atmospheric CO_2 concentration (Raich and Potter, 1995). Forests play significant role as sink for 80% of aboveground and 40% of belowground carbon (Dixon, 1994), therefore small disturbance of carbon sink in forest soils can significantly affect global carbon cycle (Ferrera et al, 2012).

Considering the fact of significance of impact of forest ecosystems on climate change and vice versa, and the importance of beech as main stand forming tree species, the aim of this research was to investigate effect of climatic conditions on soil respiration in beech stand.

MATERIAL AND METHODS

Study includes two forest stand from the network of forest ecoswystems included in the monitoring under the framework of the project entitled: „*Biosensing Technologies and Global System for Long-Term Research and Integrated Management of Ecosystems*“ (43002) financed by Ministry of Education and Science of republic of Serbia for the period 2011-2015. The stand is coppice beech forest (*Fagenion moesiace montanum*) situated at locality Vidlič at Stara planina at elevation between 990 and 1080 m_{asl}, on limestone steep terrain with N-NE exposition.

The 25x25m grid for measurement of soil respiration with 25 points was set in the selected stand in May 2011, where 10 randomly selected points were selected for measurement that were made during vegetation period (May-October) with portable gas exchange system (ADC LcPro+). The measurements were made instantaneously in the morning from 9 to 12 hours. Also, during the time of soil respiration measurement, moisture content at depth of 10cm, soil temperature (Tsoil), air temperature (Tair) and air temperature at 30 cm above the ground (T30) was measured. The measurements were performed during two different seasons: with severe drought (2013) and intensive precipitation (2014). All data were processed with Microsoft Excel and Statistica 12 software.

RESULTS AND DISCUSSION

Results of soil respiration Rs (Figure 1.) measurement showed effect of drought in 2013, where values ranged from 0,967 to 3,777 µmol$CO_2m^{-2}s^{-1}$. During 2013, the values of R_s had constant decrease from the beginning of the vegetation period until the end. The Rs values in 2014 were significantly higher in June, July and September when compared with 2013 and ranged from 1,675 to 4,610 µmol$CO_2m^{-2}s^{-1}$.

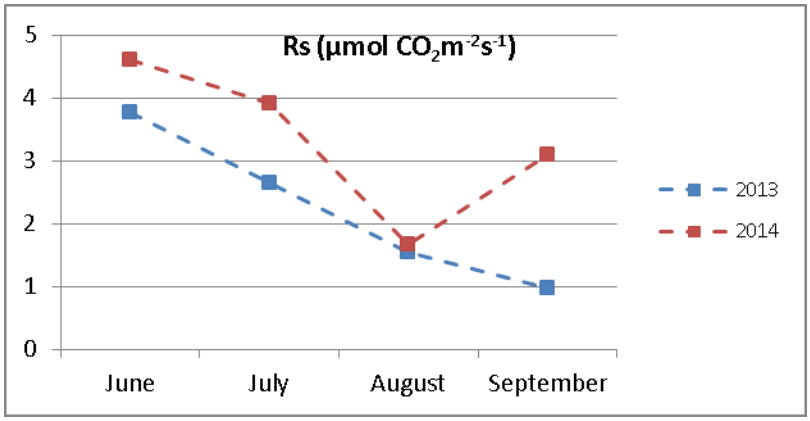

Figure 1. Soil respiration (R_s) in beech stand in vegetation seasons 2013-2014
Slika 1. *Disanje zemljišta (Rs) u bukovoj sastojini u vegetacionom period 2013-2014*

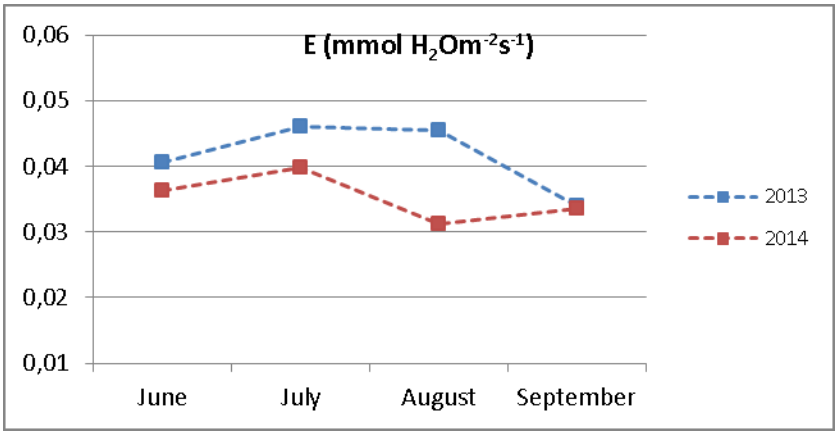

Figure 2. Evaporation (E) in beech stand in vegetation seasons 2013-2014
Slika 2. *Evaporacija (E) u bukovoj sastojini u vegetacionom period 2013-2014*

Results of soil evaporation (E) presented in figure 2. had higher values in 2013, when compared to 2014. The values in 2013 ranged from 0,033 to 0,046 $mmolH_2Om^{-2}s^{-1}$, while in 2014 the range was lower from 0,031 to 0,039. When compared dates of measurement, only measurements in September had similar values bot in 2013 and 2014, while all other had higher values in 2013.

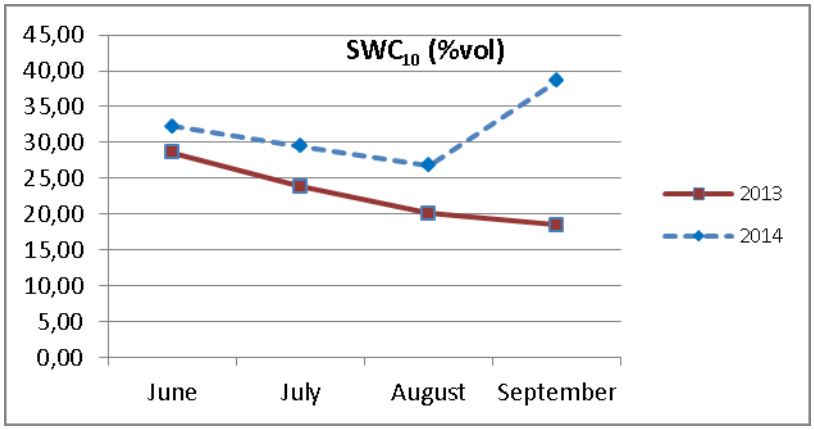

Figure 3. Soil moisture content (SWC_{10}) in top layer in beech stand in vegetation seasons 2013-2014

Slika 3. *Sadržaj vlage (SWC_{10}) u površinskom sloju zemljišta u bukovoj sastojini u vegetacionom period 2013-2014*

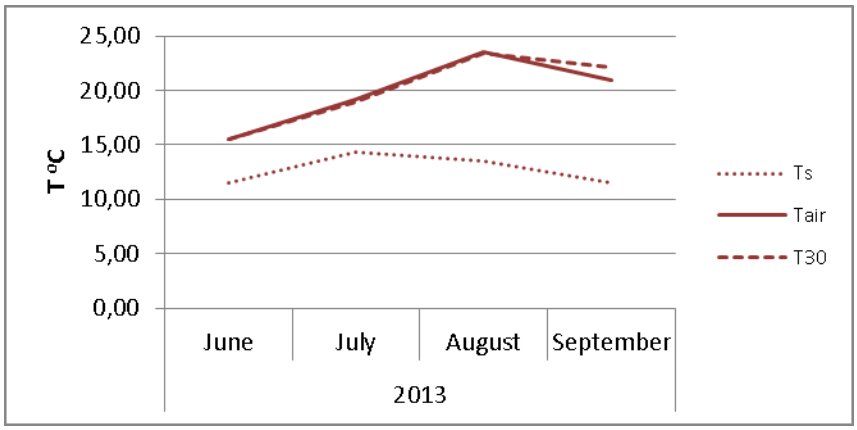

Figure 4. Soil temperature (T_s), atir temperature (T) and air temperature above soil surface (T_{30}) in beech stand in vegetation season 2013

Slika 4. *Temperature zemljišta (Ts), vazduha (T) i vazduha iznad površine zemljišta (T_{30}) u bukovoj sastojini u vegetacionom period u 2013*

The soil moisture content SWC_{10} (figure 3.) in top soli layer was significantly higher in 2014 during all four measured dates. The values ranged from 26,77%vol in August to 38,59% vol in September. The trend was decrease from June to August, and then increase in September. The soil moisture content in 2013 recorded decrease during whole vegetation period from June (28,56%vol) to September (18,48% vol).
Soil temperature T_s values in 2013 (figure 4.) ranged from 11,4°C to 14,7°C, while in 2014 (figure 5.) the range was higher from 9,9 °C to 16,4°C. As previously mentioned, the variability of soil temperature was significantly greater in 2014, when compared to 2013 what is similar to air temperature (figs. 4 and 5), where variations in 2014 caused fluctuation, while the air temperature in 2013 increased during the vegetation period and had highest value of 23,6°C in August.

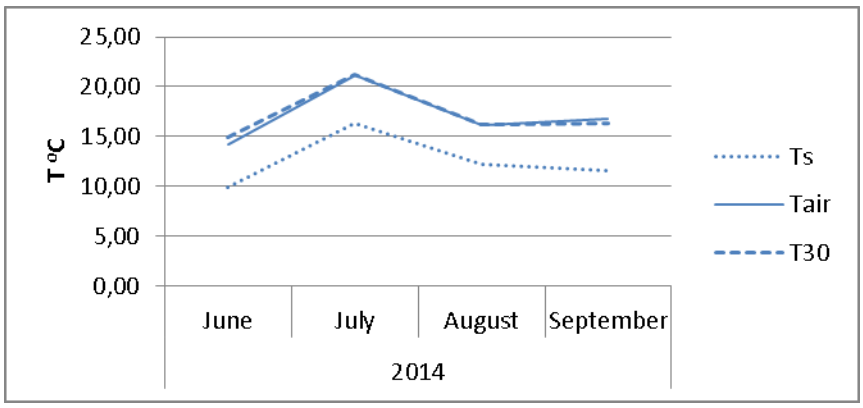

Figure 5. Soil temperature (T_s), atir temperature (T) and air temperature above soil surface (T_{30}) in beech stand in vegetation season 2014
Slika 5. *Temperature zemljišta (Ts), vazduha (T) i vazduha iznad površine zemljišta (T_{30}) u bukovoj sastojini u vegetacionom period u 2014*

Table 1 Correlation coefficients amongst investigated parameteras
Tabela 1. *Koeficijenti korelacije između ispitivanih parametara*

	T_s	E	SWC_{10}	T_{air}	T_{30}
R_s	0,0655	0,0944	0,7094*	0,5544	0,5768
T_{soil}		0,3522*	0,2298	0,6645	0,5945
E			0,3698	0,4848	0,4250
SWC_{10}				0,6548	0,7087*
T_{air}					0,9891*

*values were significant for $p<0,05$ / vrednosti su bile signifikantne za $p<0,05$

Statistical analysis of correlations showed significant dependence of soil respiration (R_s) on soil water content (SWC_{10}) with R^2=0,7094, while R_s was not dependant on soil temperature. On the other hand, evaporation (E) had significant weak correlation

with Ts (0,3533). As expected, SWC_{10} depended on air temperature above the soil surface (0,7087), while T and T_{30} were sigbificantly correlated (0,9891), as expected.

The R_s values differed between vegetation seasons with higher levels in 2014, what is influenced by drought in 2013. Soil respiration values range was between 0,967 and 4,610 $\mu molCO_2m^{-2}s^{-1}$ what is less than soil respiration of boreal forest (0,4-6,9 $\mu molCO_2m^{-2}s^{-1}$) measured by Khomik et al., (2006). The decrease in August 2014 can be explained by the lowered temperatures (T_s, T and T_{30}) on the measurement date in August. The temperature effect of the soil temperature on the soil respiration shows linearity (Lloyd and Taylor, 1994) or exponetial dependence (Qi et al., 2002) in well humid soils, what explains decrease of R_s for above mentioned measuring date.

The evaporation of soils was higher in 2013 probably caused by lowered air humidity during dry seasons compared to higher air humidity in moist seasons. The soil humidity expressed through SWC_{10} was lower in 2013 with evident decreasing trend. This decrease affected soil respiration which decreased from the beginning of the vegetation period. These results are in accordance with Fenn et al. (2010) who showed that annual variation of SWC has less effect on R_s while seasonal effect of SWC is more evident during period July-September when it induces decrease of soil respiration.

The correlation between R_s and SWC_{10} was significant (0,7094), although the effect of soil temperature on soil respiration was not recorded both in correlation and multiple regressions calculations. However, the correlation between Ts and SWC10 was weak but significant (0,3522). The results of Pilipović et al., (2014) showed that soil respiration in Douglas fir-spruce plantation at nearby location did also not showed influence of soil temperature on soil respiration but only soil humidity. On the other hand, results of Vincentt et al., (2006), showed clear seasonal trend of the effect of T_s and SWC on soil respiration, especially during summer droughts.

CONCLUSIONS

Obtained results showed significant influence of drought on respiration of soil in mountain beech forest on Stara Planina. Although many researches showed influence of soil temperature on respiration of soil, the soil moisture content was most important driver of respiration processes on investigated site. In order to make more certain conclusions, the frequency of measurements should be increased during vegetation. On the other hand, the methodology selected for this investigation indicates its functionality as tool for monitoring of climate change on forest ecosystems and carbon cycle

Acknowledgements

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Sažetak

DISANJE ZEMLJIŠTA U SASTOJINI BUKVE NA STAROJ PLANINI U TOKU DVE VEGETACIJE

by

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Stara planina predstavlja jednu od najvećih planina na Balkanu koja se prostire od Vrške Čuke do Crnog mora, čiji zapadni dio ovog planinskog venca predstavlja granicu između Srbije i Bugarske. Najvažnije vrste drveća koje obrazuju sastojine na Staroj planini predstavljaju Fagus silvatica i Fagus orientalis, gde evropska bukve pokriva zapadni deo ovog planinskog lanca. Ovo istraživanje je obuhvatilo lokalitet Vidlič sa dozrevajućom izdanačkom šumom evropske bukve. Na odabranom lokalitetu je postavljena ogledna površina dimenzija 25x25 metara prostora sa 9 slučajno izabranih tačaka na kojima je izvršeno merenje disanja zemljišta u klimatski dva različita vegetaciona perioda u 2013. i 2014. Merenja su izvršena prenosnim uređajem ADC LCPro +. Istovremeno, evaporacija, sadržaj vlage zemljišta, temperatura zemljišta i temperatura vazduha su mereni u cilju određivanja korelacije sa disanjem zemljišta. Rezultati su pokazali razliku između sezona, gde je u 2014.disanje zemljišta bilo jačeg intenziteta i kretalo se od 1.66 do 4.68 $\mu molCO_2m^{-2}s^{-1}$, dok su se u 2013. vrednosti kretale od 0.97 do 3.78 $\mu molCO_2m^{-2}s^{-1}$. Takođe u pogledu sezonskih varijacija, u 2013. godini je pad bio konstantan od početka do kraja vegetacije, dok je u 2014. zabeležen rast disanja zemljišta u septembru 2014. godine. Sadržaj vlage u zemljišta se kretao od 18.48%$_{vol}$ u septembru 2013. godine u 38.59%$_{vol}$ u septembru 2014. godine sa dinamikom kretanja vlage sličnom dinamici disanju zemljišta. Rezultati regresione

analize ukazuju na značajnu korelaciju disanja zemljišta i sadržaja vlage u zemljištu (0,7094), kao i na korelaciju evaporacije i temperature zemljišta (0,3522). Dobijeni rezultati ukazuju na zavisnost disanja šumskih ekosistema bukve od sadržaja vlage u zemljištu uslovljene klimatskim prilikama, što nam daje dobar polazni osnov za daljnji razvoj metodologije monitoring uticaja klimatskih promena na disanje zemljišta šumskih ekosistema.