Measurement of European beech transpiration rate under drought stress

Dana Kovalčíková[1], Katarína Střelcová[1], Ľubica Ditmarová[2]

[1]Faculty of Forestry, Technical University in Zvolen, Masarykova 24, 960 53 Zvolen, Slovak Republic,
e-mail: kovalcikova@vsld.tuzvo.sk
[2]Institute of Forest Ecology of the Slovak Academy of Sciences, Štúrova 2, 960 53 Zvolen, Slovak Republic

Abstract

Kovalčíková, D., Střelcová, K., Ditmarová, Ľ. 2012. Measurement of European beech transpiration rate under drought stress. *Folia oecol.*, 39: 36–44.

The paper presents results of a pilot measurement of transpiration rate in European beech plants under drought stress. The measurement was carried out with "Baby EMS 62 modular sap flow systems for small stems or branches". The plants used for measuring the transpiration rate were 4-year-old, the measurements was carried out in the summer 2010. The trees were divided into two groups: a drought-stressed group and a regularly irrigated (control) group. The simulation of drought started on July 9 2010, the measurement of sap flow on August 20 2010. In order to find out the possibility for the transpiration recovery, irrigation was applied after a severe drought exposure on the drought-stressed plants on August 24 2010. Despite expectations, the irrigation did not influence transpiration of the drought-stressed plants, although the absolute value of the soil water potential dropped to a minimum. The drought-stressed individuals achieved substantially lower values of transpiration rate, both before and after irrigation, in comparison with the control group. Further, dependence between transpiration and meteorological factors was investigated. The meteorological factors in concern are continually recorded at the mesoclimatic station situated in the "Borová hora" Arboretum. The values of transpiration rate for the drought-stressed individuals were less dependent on meteorological factors (relation fitted with a polynomial regression function of the second order) than for the control plants.

Key words

drought, *Fagus sylvatica* L., heat balance method, transpiration

Introduction

In relation to the discussion about the climatic changes, attention is paid to drought problems and their impact on forest ecosystems. Shortage of available water in growing season and presence of harmful meteorological events – including long drought periods, are only some of supposed impacts of climatic changes (Hanson and Weltzin, 2000; Liesebach, 2002; Šútor et al., 2004; Houghton, 2005; Lapin and Szemesová, 2009).

In general, drought is defined as condition or time period with water deficit (Novák, 2009) in soil, in plants or in atmosphere (Sobíšek et al., 1993). If this condition or time period exceeds limits of the plant's tolerance, the plant is exposed to stress. The stress inhibits normal functions of plants, which results in reduction of growth and reproduction (Slováková and Mistrík, 2007). The occurrence of drought is possible to consider not only from the meteorological and hydrological point of view, but also in relation to tree physiology – which means the direct detection of the water status in plant. That approach is the most reliable way how to define the presence of stress influencing the plant.

Transpiration is one of the physiological processes suitable for serving as tools in detecting drought stress. It serves an important role in the plant cooling, removal of excessive turgor and increase in uptake and transport of mineral nutrients (Kmeť, 1998). There have been developed numerous methods for measuring sap flow in tree trunks. Much attention is paid to the "trunk heat balance method" (Čermák et al., 1973). A modification of this method is baby sensors (Čermák et al., 2004), suitable for measuring sap-flow in branches and trunks with small diameters (6–20 mm), produced by EMS Brno (Fig. 1), described by Čermák et al. (1984), and lately by Lindroth et al. (1995).

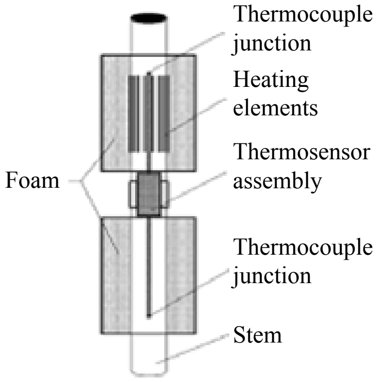

Fig. 1. Scheme of an EMS „baby sensor" designed for branches or trunks with a small diameter (Čermák et al., 2004).

It is also possible to determine transpiration of plants grown in containers – by means of the gravimetric method. In this way, transpiration has been considered to be the only source of water output, because of the elimination of soil evaporation (Kovalčíková et al., 2010). The gravimetrical method is precise, but demanding on time and work. These drawbacks can be eliminated by using scales providing a continual record of weight changes.

The above mentioned baby sensors show many advantages, such as easy application, low time consumption and continual record. Another positive feature is no need for plastic bags used for elimination of soil evaporation (unlike in gravimetric method where only packing the lower parts of plants into plastic bags could exert stress on them).

Rose et al. (2009) studied the physiological response of beech plants of different provenances to drought stress from the viewpoint of their adaptation to drought. Ditmarová et al. (2010) studied influence of the advance drought on the physiological characteristics of spruce plants. Rose et al. (2009), similarly as Ditmarová et al. (2010), carried out experiment in conditions of containers. Schraml and Rennenberg (2002) concerned with response of different beech ecotypes to drought stress, by observation of their physiological characteristics. Many authors observed drought effects on transpiration rate and on physiological parameters (Sala and Tenhunen, 1996; Cienciala et al., 1997; Cochard et al., 2002; Aslam and Tahir, 2003).

The attempts for quantitative estimations of the water use in adult trees, with using data achieved from plants in containers, were not successful (Wullschleger et al., 1998). In thickets and in small trees, the water flow across the main trunk is equivalent to the crown transpiration. In larger trees, it is possible to observe a significant delay between the variation in transpiration and the variation in the water flow measured near the trunk base (Schulze et al., 1985). The delay can take from a few minutes to several hours and, according to available information, it is caused by the water exchange between the sap flow and the store volume of the trunk above the point in which the water flow is measured (Wullschleger et al., 1998). The trees with higher store capacity keep their maximal transpiration rate for a substantially longer part of day than the trees with lower store capacity (Goldstein et al., 1998).

Our research aims have been set as follows:

- Quantification of transpiration rate reduction [g; g m^{-2}] in drought-stressed beech plants in comparison with potential transpiration in regularly irrigated plants
- Confirmation of dependence of transpiration on meteorological variables represented by vapour pressure deficit
- Evaluation of the results of the pilot measurement with sap flow carried out on beech plants with using the "baby EMS 62 standard system for measuring branch transpiration or transpiration of trunks with small diameters".

Material and methods

The object of our research was a group of ten four-year-old European beech (*Fagus sylvatica* L.) plants, from the forest enterprise Beňuš, provenance of the seed area Podtatranská (6. vegetation zone). The plants were transferred into the Arboretum "Borová hora" and covered with a roof for eliminating precipitation. The sap flow in trunks was measured using a "baby" EMS 62 standard system (Fig. 2, Fig. 3). The transpiration rate (kg h^{-1} cm^{-1}) was recorded at intervals of 10 minutes. The transpiration rate was calculated based on the tree circumference [cm], so the values of transpiration rate were expressed in kg h^{-1}.

Fig. 2. "Baby EMS 62 modular sap flow system for small stems or branches".

Fig. 3. Container experiment with beech plants.

The measurements were carried out during the summer of 2010. The plants were divided in 2 groups: drought-stressed plants and regularly irrigated (control) plants. The simulation of drought started on July 9 2010, the measurement of sap flow on August 20 2010. To test the ability to recovery, the drought-stressed plants were exposed to irrigation on August 24 2010.

Meteorological data, continually recorded by a mesoclimatic station situated in area of the Arboretum, were used for evaluation of the effects of environmental variables on transpiration rate. The concerned meteorological data are available on the Website of the Technical University in Zvolen (www.tuzvo.sk). The soil water potential was recorded simultaneously, with the aid of gypsum blocks Datalogger MicroLog SP3 (EMS Brno). The measured meteorological characteristics were visualised and processed, with using a MINI 32 software (EMS Brno). The vapour pressure deficit was calculated according to the Magnusson's formula, providing with the recorded meteorological data (Sobíšek et al., 1993). For fitting the relation between transpiration rate and vapour pressure deficit, we used the polynomial regression analysis of the second order in the MINI 32 software.

For each examined beech plant, we calculated the area of its assimilatory apparatus, with using the Cernota (Kalina and Slovák, 2004) computer programme. Then the obtained data were used for calculation of the transpiration rate per a unit assimilatory area (g m^{-2}). Statistical analysis was carried out in the program package Statistica 7 (Duncan test).

Results and discussion

Water usage in plants is defined also as the amount of water used for transpiration, because the most of the water in plants is used in this process (Penka, 1985). At presence of sufficient soil moisture, the transpiration is generally controlled by atmospheric conditions: primarily air temperature and air humidity. Global radiation also influences the transpiration rate in a positive way (Kincl and Krpeš, 2000).

The values of the total mean daily transpiration rate in drought-stressed plants over a 26-day period (20.8.–14. 9. 2010) reached only 84.58 g of water – representing but 10.87% of 778.38 g transpirated by regularly irrigated plants. If we declare values of irrigated plants as potential values, then the transpiration loss makes 89.13%.

After estimation of the assimilatory area in plants done with the program Cernota, we found out that the assimilatory apparatus of the regularly irrigated plants was 1.5-times larger (on average) in comparison to the drought-stressed plants. According to the Duncan test, the differences in assimilatory apparatus between the drought-stressed and control plants were statistically significant (Fig. 4). Another statistically significant difference between variants was also revealed in the trunk circumference (Fig. 5). The trunk circumference in regularly irrigated plants was 1.2-times, on average, the circumference in the drought-stressed plants.

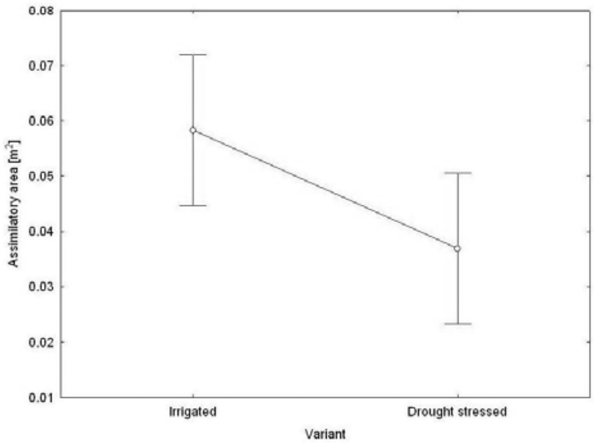

Fig. 4. Difference in assimilatory area between irrigated and drought-stressed beech seedlings. Assimilatory area was determined with a program Cernota (Kalina and Slovák 2004); variant; LS; means current effect: $F(1, 8) = 6.5059$, $p = 0.03414$; effective hypothesis decomposition; vertical bars denote 0.95 confidence intervals.

We assume that the drought stress, influencing plants for more than 2 months, could have been the reason for the significant reduction of the assimilatory apparatus and, similarly, the reduction of trunk circumferences in the drought-stressed plants. The lack of water in their tissues probably caused the trunks to shrink and to reduce their overall size.

In case of transpiration rate per unit of area [g m^{-2}], the calculated difference between the drought-stressed and regularly irrigated plants was somewhat lower. The value of transpiration rate of the drought-stressed plants achieved 2,524.63 g m^{-2}, making 17.74% of the potential value of transpiration rate represented by the regularly irrigated plants: 14,233.64 g m^{-2} in course of the experiment. The transpiration [g m^{-2}] values in the period 20. 8.–14. 9. 2010 are summarised in Fig. 6. On August 23 2010, the device broke down – causing that the transpiration of the regularly irrigated plants dropped to zero.

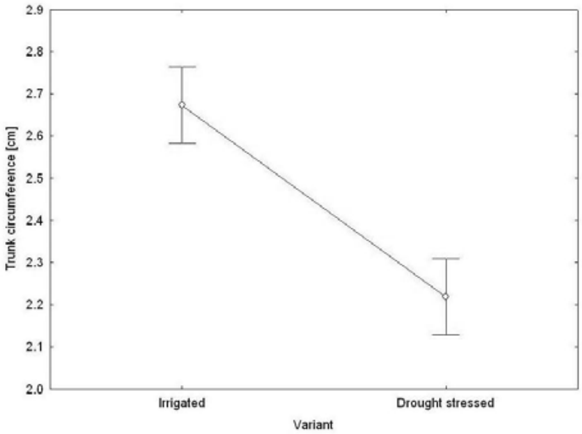

Fig. 5. Difference in trunk circumference between irrigated and drought-stressed beech seedlings; variant; LS; means current effect: $F (1, 8) = 67.030$, $p = 0.00004$; effective hypothesis decomposition; vertical bars denote 0.95 confidence intervals.

In trees sufficiently supplied with soil water, transpiration is influenced primarily by evaporative demands of the atmosphere (Masarovičová et al., 1989; Matejka et al., 2009). Masarovičová (1989) discovered a linear dependence of water uptake on mean daily temperature, and water uptake on vapour pressure deficit. Masarovičová et al. (1989) found out that in trees sufficiently supplied with water, their internal water deficit was not influenced by soil water deficit, but primarily by evaporative demands of the atmosphere. This fact has also been confirmed by Matejka et al. (2009), who observed transpiration accelerated due to high vapour pressure deficit – mostly in the seasons, when forest was sufficiently supplied with soil water. During seasons with dry soil, the differences between the transpiration influenced by mean vapour pressure deficit and high vapour pressure deficit are negligible.

The mean daily transpiration rate correlated with the daily mean vapour pressure deficit better in the regularly irrigated plants than in the drought-stressed plants – as it is shown in Table 1 and Table 2 summarising the results of our correlation analysis. According to the mean coefficients of determination, the influence of vapour pressure deficit explains about 36.19% (R^2) in irrigated plants and only 10.39% (R^2) in drought-stressed plants. The values of daily transpiration total [g m^{-2}] and daily average of vapour pressure deficit are illustrated in Fig. 7.

During the measurement period, there were registered 6 rainy days (a rainy day was defined by a daily precipitation total exceeding 1 mm) and 6 days with the daily precipitation total lower than 1 mm. The lower transpiration rate in rainy days is caused not only by the rain itself, but mainly by the lower daily global radiation at presence of cloudiness and higher air humi-dity. The transpiration values observed on the cloudy days are shown in Fig. 8. The transpiration rate in plants manifested lower values during the rainy days in comparison with the days without precipitation and days with precipitation less than 1 mm. Fabrika et al. (2009) suggests the 1 mm daily precipitation total as the threshold for statistically significant differences in rate of tree transpiration. Herzog et al. (1998) declared that precipitation retained by tree canopies provides moisture to the layer adjacent to the leaves. This moisture is depleted earlier than the water

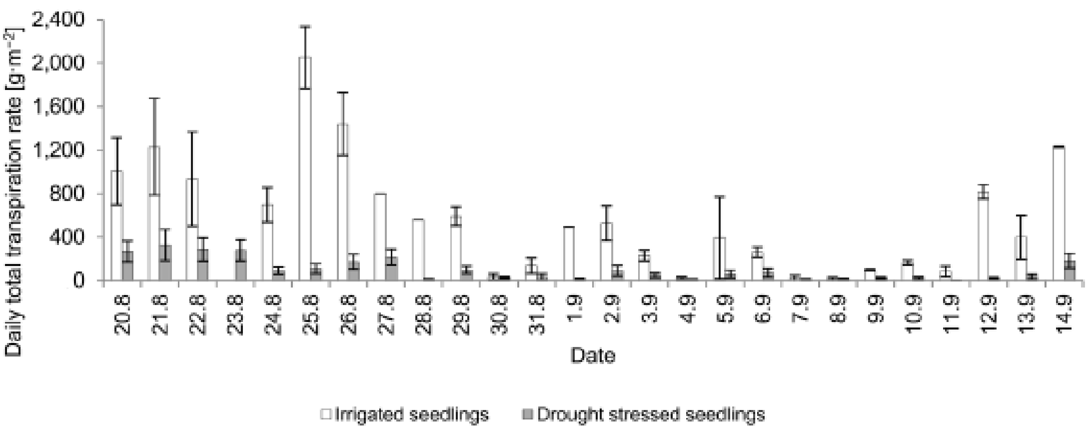

Fig. 6. Dynamics of daily transpiration total in course of 26 days, measured in the "Borová hora" Arboretum, measured by using "baby sensors" – heat balance method. Error bars express the average mean error.

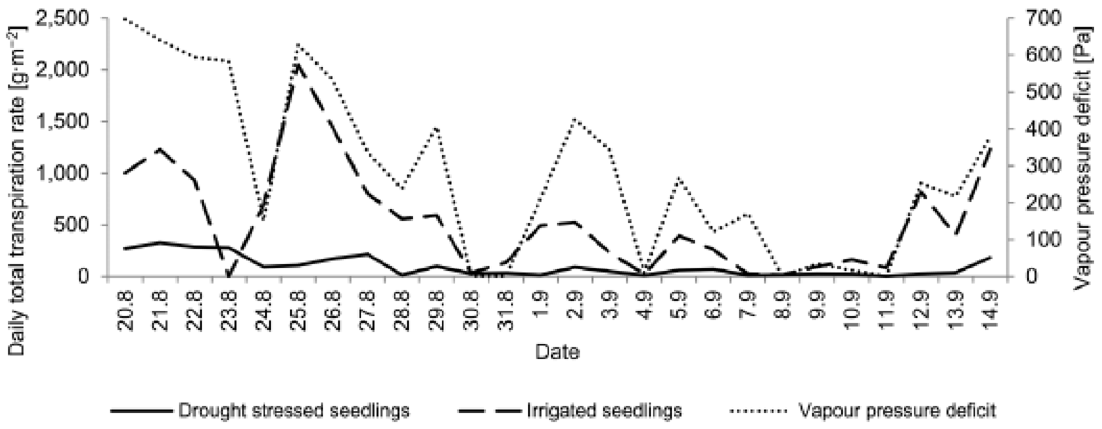

Fig. 7. Course of the mean daily totals of transpiration rate during the 26 days, measured in the "Borová hora" Arboretum, by using "baby sensors" – heat balance method. The graph is supplemented by a curve for vapour pressure deficit, calculated according to the Magnuson´s formula from meteorological characteristics (air temperature and humidity) recorded continually by the mesoclimatic station in the Arboretum.

Table 1. Results of regression analysis with the MINI 32 program, showing dependence of transpiration rate [kg h^{-1}] in regularly irrigated beech plants on vapour pressure deficit

Plant No.	CP	DV	n	Regression coefficients for $y = ax^2 + bx + c$			R^2
				a	b	c	
1	VPD	ITR	3,744	9.04204E-9	–3.78421E-6	0.000500118	0.534665
2	VPD	ITR	3,744	1.30384E-9	1.18287E-6	0.000714083	0.148871
3	VPD	ITR	3,744	2.33054E-9	1.81571E-6	0.000203131	0.506251
4	VPD	ITR	3,744	1.18158E-9	5.84139E-6	0.000310635	0.480084
5	VPD	ITR	3,744	–519.10900E-12	3.027700E-6	14.06116E-6	0.139747

CP, categorical predictor; DV, dependent value; VPD, vapour pressure deficit; ITR, transpiration intensity [kg h^{-1}]; n, number of measurements.

Table 2. Results of regression analysis with the MINI 32 program, showing dependence of transpiration intensity [kg h^{-1}] in drought-stressed beech plants on vapour pressure deficit

Plant No.	CP	DV	n	Regression coefficients for $y = ax^2 + bx + c$			R^2
				A	b	c	
1	VPD	ITR	3,744	18.337E-12	–13.3796E-9	5.01318E-6	0.003177
2	VPD	ITR	3,744	1.05035E-9	–121.921E-9	0.000115561	0.247219
3	VPD	ITR	3,744	1.44459E-9	–924.882E-9	96.4591E-6	0.249679
4	VPD	ITR	3,744	–3.0182E-12	–59.023E-9	94.4895E-6	0.012474
5	VPD	ITR	3,744	51.9111E-12	–11.2442E-9	32.1239E-6	0.006867

CP, categorical predictor; DV, dependent value; VPD, vapour pressure deficit; ITR, transpiration intensity [kg h^{-1}]; n, number of measurements.

contained in plants, so the transpiration is limited, and the demand on evaporation is reduced. However, in our case, this interception was eliminated by sheltering the plants with a roof.

To test the potential for recovery of the transpiration in the studied plants, the drought-stressed plants were irrigated on August 24. Despite the expectations, the irrigation was not responded by transpiration, although the absolute value of soil water potential dropped in some cases as much as 11 bars to a minimum close to zero. In contrast to the drought-stressed plants, decreasing transpiration values were observed in

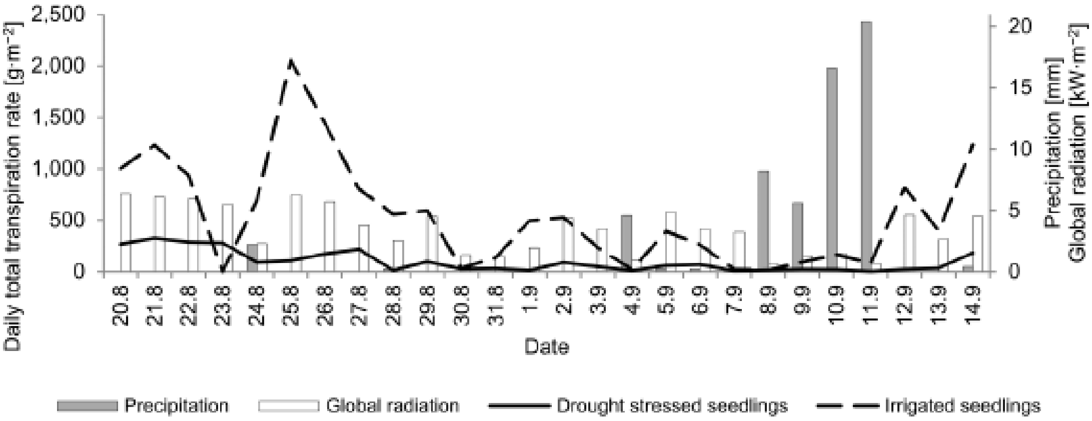

Fig. 8. Course of mean daily totals of transpiration [g m^{-2}] during 26 days, measured in the "Borová hora" Arboretum by using "baby sensors" – heat balance method. The graph is supplemented by the daily totals of precipitation and global radiation intensity, recorded continually by the mesoclimatic station in the Arboretum.

regularly irrigated plants on the day following the irrigation (August 25 2010) (Fig. 7, Fig. 8).

It is useful to compare the transpiration rate in plants between our two most frequent tree species – beech and spruce. The maximum value of mean daily transpiration in irrigated 4-year-old beech plants represented 2,052 g m^{-2} – compared to 544 g m^{-2} measured in 4-year-old regularly irrigated spruce plants. Comparing between these two species requires also comparing between their assimilatory areas: 0.0583 m^2 in beech plants and 0.4055 m^2 in spruce plants (Kovalčíková et al., 2011). Petráš et al. (1985) found that the leaf biomass in spruce is more abundant than in beech or pine. The authors also observed that the difference was more pronounced with increasing tree diameter. It could be one of the reasons why spruce is seriously endangered by drought. The larger area of assimilatory organs, together with a lower surface resistance (Roberts, 1983) in relation to evaporation, would be the cause underlying the lower resistance of spruce to drought stress.

Hanson and Weltzin (2000) observed that the younger growth stages were more sensitive to the water deficit caused by strong or long-lasting drought then the adult trees. Adult trees show lower sensibility for water deficit due to their deep root system and significant reserves of carbohydrates and nutrients. However, drought can make trees more prone to attacks by insects and diseases. The significance of influence of the interaction between the genotype and environment is also decreasing with increasing age (Krajmerová, 2007).

Conclusions

The low transpiration rate observed in the drought-stressed plants is no surprise. The timing of irrigation of the drought-stressed plants was too late, so the irrigation was not responded by an increase in transpiration rate in the drought-stressed plants.

There were observed significant differences in values of biometrical characteristics (assimilatory area, trunk circumference) between the drought-stressed plants and the regularly irrigated plants. We may conclude that it was caused by the negative effect of long-lasting drought stress.

Comparing the results of the pilot measurement of sap flow in beech plants with using "baby EMS standard systems for small stems or branches" with the results obtained by applying the gravimetric method, we found the two in a good accordance. However, it is necessary to notice that the first show many profits compared to the gravimetric method, such as low demands on time and continuity. Moreover, the installation of baby sensors is simple. However, the recording failure on August 23 2010, in the case of regularly irrigated plants, shows that certain risk is not possible to exclude with using technical equipments.

Acknowledgement

This publication is the result of the project implementation: Extension of the Centre of Excellence "Adaptive Forest Ecosystems", ITMS: 26220120049, supported by the Research & Development Operational Programme funded by the ERDF (50%) and of the project supported grant agency VEGA 2/0006/11 (50%).

References

Aslam, M., Tahir, M.H.N., 2003. Morpho-physiological response of maize inbred lines under drought environment. *Asian J. Pl. Sci.,* 2 (13): 952–954.

Čermák, J., Deml, M., Penka, M. 1973. A new method of sap flow rate determination in trees. *Biol. Plant.*, 15: 171–178.

Čermák, J., Kučera, J., Nadezhdina, N. 2004. Sap flow measurements with some thermodynamic methods, flow integration within trees and scaling up from sample trees to entire forest stands. *Trees*, 18: 529–546.

Čermák, J., Jeník, J., Kučera, J., Židek, V. 1984. Xylem water flow in a crack willow tree (Salix fragilis L.) in relation to diurnal changes of environment. *Oecologia*, 64: 145–151.

Cienciala, E., Kučera, J., Lindroth, A., Čermák, J., Grelle, A., Halldin, S. 1997. Canopy transpiration from a boreal forest in Sweden during a dry year. *Agric. Forest Meteorol.*, 86: 157–167.

Cochard, H., Coll, L., Le Roux, X., Améglio, T. 2002. Unraveling the effects of plant hydraulics on stomatal closure during water stress in walnut. *Pl. Physiol.*, 128: 282–290.

Ditmarová, Ľ., Kurjak, D., Palmroth, S., Kmeť, J., Střelcová, K. 2010. Physiological responses of Norway spruce (Picea abies) seedlings to drought stress. *Tree Physiol.*, 30: 205–213.

Fabrika, M., Střelcová, K., Magová, D. 2009. Empirický model transpirácie buka v rastovom simulátore SIBYLA [Empirical model for transpiration of beech in tree growth simulator]. *Acta Fac. for. Zvolen*, 51 (3): 99–112.

Goldstein, G., Andrade, J.L., Meinzer, F.C., Holbrok, N.M., Cavalier, J., Jackson, P., Celis, A., 1998. Stem water storage and diurnal patterns of water use in tropical forest canopy trees. *Plant, Cell Envir.*, 21: 397–406.

Hanson, P.J., Weltzin, J.F. 2000. Drought disturbance from climate change: response of United States forests. *Sci. total Environ.*, 262: 205–220.

Herzog, K.M., Thum, R., Kronfub, G., Heldstab, H.J., Hásler, R. 1998. Patterns and mechanisms of transpiration in a large subalpine Norway spruce (Picea abies (L.) Karst.). *Ecol. Res.*, 13: 105–116.

Houghton, J. 2005. Global warming. *Rep. Prog. Phys.*, 68: 1343–1403.

Kalina, J., Slovák, V. 2004. The inexpensive tool for the determination of projected leaf area. *Ekológia (Bratislava),* 23, Suppl. 2: 163–167.

Kincl, M., Krpeš, V. 2000. *Základy fyziologie rostlin* [Basic concepts in plant physiology]. Ostrava: Montanex. 221 p.

Kmeť, J. 1998. *Fyziológia rastlín* [Plant physiology]. Zvolen: Technická univerzita vo Zvolene. 164 p.

Kovalčíková, D., Kurjak, D., Střelcová, K., Ditmarová, L. 2010. *Charakteristiky vodného režimu sadeníc smreka v podmienkach stresu suchom* [Characteristics of water regime in spruce seedlings in conditions of a container experiment]. *Acta Fac. for. Zvolen,* 52, Suppl. 1: 57–70.

Kovalčíková, D., Střelcová, K., Kurjak, D., Ditmarová, Ľ., Baláž, P., Frič, M. 2011. Fyziologická reakcia sadeníc smreka na simulované sucho [Physiological response of spruce seedlings to simulated drought stress]. In Střelcová, K., Sitková, Z., Kurjak, D., Kmeť, J. (eds). *Stres suchom a lesné porasty: aktuálny stav a výsledky výskumu.* Zvolen: Technická univerzita. 266 p.

Krajmerová, D. 2007. *Vyhodnotenie niektorých rastových a adaptačných charakteristík poľských a slovenských proveniencií smreka obyčajného* [Evaluation of some growth and adaptation characteristics of Polish and Slovak provenieces of Norway spruce]. PhD thesis. Zvolen: Technical University in Zvolen, Faculty of Forestry. 168 p.

Lapin, M., Szemesová, J. 2009. Review of climate change and GHGs inventory in Slovakia. *Meteorol. Čas.*, 12: 151–155.

Liesebach, M. 2002. On the adaptability of Norway spruce (Picea abies (L.) Karst.) to the projected change of climate in Germany. *Forstwiss. Cbl.*, 121, Suppl. 1: 130–144.

Lindroth, A., Čermák, J., Kučera, J., Cienciala, E., Eckersten, H. 1995. Sap flow by heat balance method applied to small size Salix-trees in a short-rotation forest. *Biomass Bioenerg.,* 8: 7–15.

Masarovičová, E., 1989. Water uptake, carbon dioxide assimilation and growth of the common oak saplings (Quercus robur L.). *Biológia (Bratislava)*, 44: 827–836.

Masarovičová, E., Navara, J., Požgaj, J. 1989. Využitie kompenzačných lyzimetrov na stanovenie príjmu vody mladými stromami duba (Quercus cerris L.) [Use of compensation lysimeters in evaluating water uptake by young turkey oak (Quercus cerris L.) trees]. *Lesnictví*, 35 (5): 405–414.

Matejka, F., Střelcová, K., Hurtalová, T., Gömöryová, E., Ditmarová, Ľ. 2009. Seasonal changes in transpiration and soil water content in a spruce primeval forest during a dry period. In Střelcová, K., Matyas, C., Kleidon, A., Lapin, M., Matejka, F., Blaženec, M., Škvarenina, J., Holécy, J. (eds). *Bioclimatology and natural hazards*. Dordrecht: Springer. 298 p.

Novák, V. 2009. Physiological drought – how to quantify it? In Střelcová, K., Matyas, C., Kleidon, A., Lapin, M., Matejka, F., Blaženec, M., Škvarenina, J., Holécy, J. (eds). *Bioclimatology and natural hazards*. Dordrecht: Springer. 298 p.

Penka, M. 1985. *Transpirace a spotřeba vody rostlinami* [Transpiration and water use in plants]. Praha: Academia. 256 p.

Petráš, R., Košút, M., Oszlanyi, J. 1985. Listová biomasa stromov smreka, borovice a buka [Leaf biomass of spruce, pine and beech trees]. *Lesn. Čas.*, 31: 121–136.

Roberts, J. 1983. Forest transpiration: a conservative hydrological process? *J. Hydrol.*, 66: 133–141.

Rose, L., Leuschner, Ch., Köckemann, B., Buschmann, H. 2009. Are marginal beech (Fagus sylvatica L.) provenances a source for drought tolerant ecotypes? *Eur. J. Forest Res.*, 128: 335–343.

Sala, A., Tenhunen, J. D. 1996. Simulations of canopy net photosynthesis and transpiration in Quercus ilex L. under the influence of seasonal drought. *Agric. Forest Meteorol.*, 78: 203–222.

Schraml, C., Rennenberg, H. 2002. Ökotypen der Rotbuche (Fagus sylvatica L.) zeigen unterschiedliche Reaktionen auf Trockenstress. *Forstwiss. Cbl.*, 121 (2): 59–72.

Schulze, E.D., Čermák, J., Matyssek, R., Penka, M., Zimmermann, R., Vasícek, F., Gries, W., Kučera, J. 1985. Canopy transpiration and water fluxes in the xylem of the trunk of Larix and Picea trees – a comparison of xylem flow, porometer and cuvette measurements. *Oecologia*, 66: 475–483.

Slováková, Ľ., Mistrík, I. 2007. *Fyziologické procesy rastlín v podmienkach stresu* [Physiological plant processes in stress conditions]. Bratislava: Univerzita Komenského. 240 p.

Sobíšek, B., Bednář, J., Černava, S., Flux, J., Frühbauer, J., Gottwald, A., Hodan, L., Jurčovič, P., Kakos, V., Kalvová, J., Koldovský, M., Kopáček, J., Krejčí, J., Krška, K., Munzar, J., Nedelka, M., Otruba, A., Panenka, I., Papežsen, A., Pícha, J., Podhorský, D., Popolanský, F., Pretel, J., Pribiš, J., Rein, F., Setvák, M., Schoberová, E., Slabá, N., Sládek, I., Strachota, J., Štekl, J., Táborský, Z., Trefná, E., Trhlík, M., Vesecký, A., Zeman, M., Zikmunda, O. 1993. *Meteorologický slovník výkladový a terminologický* [Meteorological dictionary terminological and explanatory]. Praha: Academia, Ministerstvo životního prostředí. 594 p.

Šútor, J., Gomboš, M., Ivančo, J. 2004. *Impakt extrémnych meteorologických javov na vodný režim v prírodných podmienkach Východoslovenskej nížiny* [Impact of extreme meterological events to water regimen in natural conditions of the Východoslovenská nížina lowland] [cit. 2011-07-09]. http://fzki.uniag.sk/web/bpd2004/content/07Sekcia_agrohydrologie_a_ochrany_pody /Sutor.pdf

Wullschleger, S.D., Meinzer, F.C., Vertessy, R.A. 1998. A review of whole-plant water use studies in trees. *Tree Physiol.*, 18: 499–512.

Meranie transpiračného prúdu sadeníc buka v podmienkach stresu suchom

Súhrn

V príspevku sú predložené výsledky z pilotného merania transpiračného prúdu na sadeniciach buka prostredníctvom „baby“ EMS 62 štandardného systému na meranie transpirácie vetiev alebo kmeňov s malými priemermi. Meranie prebiehalo v letnom období 2010 na 10 jedincoch buka vo veku 4 rokov. Jedince sme rozdelili na 2 skupiny: suchom stresované a pravidelne zavlažované (kontrolné). Súčasne bol zaznamenávaný vodný potenciál pôdy. Simulácia sucha začala 9. júla 2010, meranie transpiračného prúdu 20. augusta 2010. Nižšia transpirácia suchom stresovaných sadeníc bola samozrejme očakávaná. Za účelom zistenia schopnosti obnovy transpirácie bola 24. augusta na suchom stresované jedince aplikovaná zálievka. Na transpirácii stresovaných sadeníc sa však neprejavila, aj keď absolútna hodnota vodného potenciálu pôdy klesla na minimum. Fyziologické procesy rastlín neboli vzhľadom na dlhodobé negatívne pôsobenie sucha schopné obnovy a návratu k pôvodnej funkcii. Jednotková transpirácia suchom stresovaných sadeníc dosiahla za obdobie 26 dní 17,74 % z potenciálnej jednotkovej transpirácie, reprezentovanej jedincami pravidelne zavlažovanými. Zálievka suchom stresovaných sadeníc po viac ako 2 mesiacoch bez zalievania bola aplikovaná príliš neskoro a preto nespôsobila zvýšenie transpirácie suchom stresovaných sadeníc. Na suchom stresovaných sadeniciach sa prejavili v porovnaní s pravidelne zavlažovanými sadenicami pomerne veľké rozdiely v hodnotách biometrických veličín (plocha asimilačných orgánov, obvod kmienkov), ktoré pripisujeme dlhodobému negatívnemu vplyvu sucha. Zisťovali sme tiež závislosť transpirácie od meteorologických činiteľov, kontinuálne zaznamenávaných na mezoklimatickej stanici v Arboréte Borová hora. Rýchlosť transpirácie suchom stresovaných jedincov vykazovala v porovnaní s transpiráciou kontrolných jedincov nižšiu závislosť od meteorologických prvkov, vyjadrenú polynomickou regresnou funkciou druhého radu. Podľa priemerných koeficientov determinácie bolo možné prisúdiť vplyvu sýtostného doplnku u zavlažovaných sadeníc 36,19 %, ale v prípade suchom stresovaných sadeníc iba 10,39 %. Na základe zhodnotenia výsledkov z pilotného merania transpiračného prúdu na sadeniciach buka prostredníctvom „baby“ EMS 62 štandardného systému na

meranie transpirácie vetiev alebo kmeňov s malými priemermi možno skonštatovať, že namerané hodnoty sú v porovnaní s gravimetrickým meraním reálne, oproti gravimetrickému meraniu poskytujú však množstvo výhod, a to najmä nepretržitosť, časovú nenáročnosť merania a jednoduchosť inštalácie „baby senzorov".

Received August 1, 2011
Accepted September 9, 2011