MORPHOMETRIC AND PHYSIOLOGICAL ANALYSIS OF FAGUS SYLVATICA AND CARPINUS BETULUS LEAVES

A.G. KOLOZSVARI[1], Adina-Daniela DATCU[1,2], F. SALA[1]

[1]Banat's University of Agricultural Sciences and Veterinary Medicine „King Michael I of Romania" from Timișoara, Soil Science and Plant Nutrition
[2]West University of Timișoara, Faculty of Chemistry, Biology, Geography, Biology-Chemistry Department
[*]Corresponding author: andrei.kolozsvari@live.com

Abstract. *This study purpose was to assess some morphometric and physiological indices at two woody plant species, European beech (Fagus sylvatica L.) and common hornbeam (Carpinus betulus L.), to describe plant behavior in different forest zones, at different altitudes and light intensities. The samples were collected from a beech forest located in western part of Romania, at an average altitude of 230 a.s.l., in October 2020. Leaves that were intact and healthy were selected. These were scanned and then taken into plant physiology lab for dry weight determination. The analyzed indices were leaves lengths, perimeters and areas with a specific software. Dry weight of each sample was determined using an analytical balance, after the completion of drying process in an oven, at 100 ˚C. After this, specific leaf weight (SLW) was obtained. Regarding the results, in general, beech leaves were longer and with a higher perimeter than common hornbeam ones. The highest values of this indices were obtained for beech samples collected from the forest. Leaf area was higher for beech leaves, when compared with hornbeam leaves. Between gravimetric indices tested in this study, dry weight behavior was similarly with leaf areas one. Leaf area and dry weight of a sample are related with photosynthetic efficiency and plant investments can be noticed through leaves analysis. Also, variations in specific leaf weight values were observed. This index had the lowest mean values for the samples taken from trees located inside the forest. This can be due to a lower light level in that site. Higher values were obtained for the rest of the samples. In general, hornbeam leaves presented a higher specific leaf weight when compared with beech leaves, and the highest value was obtained for the samples taken from trees that grow at the forest edge where light intensity is higher than inside the forest.*

Keywords: *morphometric indices, leaf behavior, leaf area, specific leaf weight, beech forest*

INTRODUCTION

The European beech (*Fagus sylvatica* L.) is a deciduous tree that reaches 30-40 m and it can attain heights up to 50 m in some places (PACKHAM et al., 2012). Beech is widely distributed in Central and Western Europe. In the northern part of its range beech grows at low elevations while in the southern part it is found at altitudes above 1000 m a.s.l. (FANG AND LECHOWICZ, 2006; VON WUEHLISCH, 2008; BAKER et al., 2011).

It is the main forest species in Romania, occupying 30% of the forest vegetation area (IFN, 2020), with a high economic value (TANASE et al., 2019) and contains some bioactive compounds, including phenolic compounds like catchin, vanillic acid, yringin and taxifolin (TANASE et al., 2018).

European beech leaves are elliptical. They have wavy margins and short teeth at the end of the parallel veins on each side, and they do not have any lobes or peaks, but a short stalk. Their color is dark and shiny green (JOHNSON AND MORE, 2006; SIKKEMA et al., 2016).

The common hornbeam (*Carpinus betulus* L.) is a small to medium sized deciduous tree, normally reaching heights of 20-25 meters (SIKKEMA et al., 2016). The hornbeam has a large range of distribution and covers Central Europe, up to southern England, southern Europe (excluding the Iberian Peninsula), and the south part of Sweden. Eastwards it can be found

across the Black Sea reaching the Caucasus and northern Iran (SIKKEMA et al., 2016). Its altitudinal distribution ranges from sea level to 700 m in Central Europe, 1 000 m in the Western Alps and 1800 m in Iran (PARIDARI et al., 2013; SIKKEMA et al., 2016).

The leaves are alternate, obovate, simple, 8-10 cm long, with serrated margins, opaque with prominent parallel veins (JOHNSON AND MORE, 2006). They are similar to those of beech (*Fagus sylvatica*) but less shiny (SIKKEMA et al., 2016).

For this common deciduous species, physiological studies are of interest, due to the fact that they can be used as bioindicators of air quality. Specific leaf weight (the ratio of leaf dry mass to leaf area) (JUMRAN AND BHATIA, 2020; DATCU et al., 2020) and specific leaf area (the ratio of leaf area to leaf dry mass) (IANOVICI et al., 2015) are some physiological indices largely utilized in leaf behavior researches. The leaf area index (LAI), plant height, biomass, the fraction of absorbed photosynthetically active radiation (FPAR), the fraction of vegetation cover are also parameters of interest in plant behavior and photosynthesis researches (SHARIFI, 2018; APOLO-APOLO et al., 2020). Methods for LAI determination are grouped in direct and indirect methods, and have been widely assessed and reviewed in the literature (JONCKHEERE et al., 2004; DOS SANTOS et al., 2016). Leaf N and LPC are total the total amounts of N and P respectively, per unit of dry leaf mass, expressed in mg g^{-1} (JUMRAN AND BHATIA, 2020). Leaf nitrogen (LN) concentration and Leaf mass per area (SLA; LMA) are important traits for the growth and development of plants due to the fact that they provide information upon main attributes such as relative growth rate and leaf gas exchange (GARNIER et al., 1997). Specific leaf area represents the light capture area deployed per unit leaf mass (WRIGHT AND WESTOBY, 2001) and its values increase as leaf thickness decreases (MEZIANE AND SHIPLEY, 2001).

The aim of this study was to assess the morphometric and photosynthetic indices at two woody plant species, beech and common hornbeam, to describe plant behavior in different forest zones, at different altitudes and light intensity.

MATERIAL AND METHODS

The analyzed species were European beech, *Fagus sylvatica* (Fagaceae) and common hornbeam - *Carpinus betulus* (Betulaceae). The leaves were harvested from a beech forest, from a medium altitude of 230 m.

Beech and common hornbeam leaves were collected in October 2020. All the samples were intact, with some senescence features.

Sample 1, conventionally noted BLF (beech leaves - forest) consisted of beech leaves, collected from the forest (240 m altitude).

Sample 2 consisted of hornbeam leaves (HLNR – hornbeam leaves near road), collected from a clear cut forest patch near forest road (239 m altitude).

Sample 3 consisted of beech leaves (BLNR – beech leaves near road), collected from a clear cut forest patch near forest road (239 m altitude).

Sample 4 consisted of hornbeam leaves (HLFE – hornbeam leaves from forest edge) collected from a forest edge (218 m altitude).

The samples were analyzed with Digimizer software, length (LL – leaf length), perimeter (LP – leaf perimeter) and area (LA – leaf area) being obtained. After this, the samples were placed in an oven (Sauter model) for 6 hours, at 100 ˚C, dry weight (DW) being obtained. Specific leaf weight (SLW) (g m^{-2}) was calculated by dividing dry weight values to leaf area.

Statistical analysis was performed using PAST software v3 (HAMMER et al., 2001). Correlations between indices were performed.

RESULTS AND DISCUSSION

In Table 1 minimum, maximum and mean values of leaves lengths and perimeters from all data sets analyzed can be observed.

In general, beech leaves were longer that hornbeam ones. Between the beech leaves, those from forest were a little longer than the ones harvested from a tree near the road. Hornbeam leaves were longer for the samples from a tree situated near the road, when compared to forest edge. Same tendencies were observed when the leaf perimeter was analyzed. Strong positive correlation was obtained between leaf lengths and perimeters of beech sample ($r = 0.947$ in the case of the near the road beech and $r = 0.909$ in the case of inside the forest samples).

Also, a high positive correlation was also obtained for Carpinus lengths and perimeters of leaves from the forest edge ($r = 0.930$).

Table 1

LL and LP min, max and mean values for all studied samples

Sample		LL (cm)	LP (cm)	Correlation coefficient
BLF	Min	8.8020	23.6550	0.909
	Max	11.4570	37.2710	
	Mean	10.2279	28.9129	
HLNR	Min	6.3400	19.8090	0.651
	Max	8.2690	27.6160	
	Mean	7.3839	23.5391	
BLNR	Min	8.5430	23.8110	0.947
	Max	11.0230	31.6910	
	Mean	10.1011	28.2657	
HLFE	Min	6.3950	19.2700	0.930
	Max	10.0200	32.1750	
	Mean	7.9230	25.3778	

In addition, leaf area was also determined. In Figure 1, the mean values of LA for the four data sets can be observed.

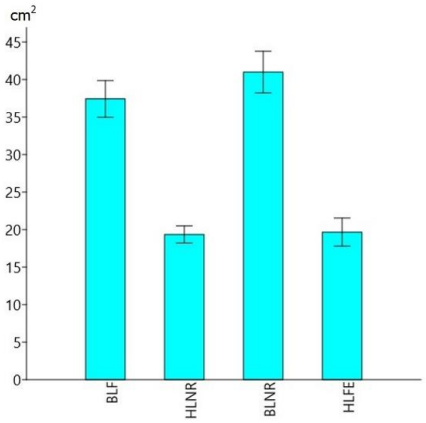

Figure 1. Mean values of LA for the analyzed samples

In general, this index was higher for beech leaves, when compared with hornbeam leaves. The leaves data set 3 (BLNR) had the highest LA mean values and the second data set (HLNR) had the lowest mean values of LA.

In Figure 2, the mean values of leaf dry weight can be observed. This index was determined after the samples were dried in an oven. Dry weight varied similarly with LA values.

When SLW (Figure 3) was determined (g m^{-2}), other variations were observed. This index had the lowest mean values for the BLF samples. This fact can be related with a low light level inside the forest. Higher values were obtained for the rest of the samples. In general, hornbeam leaves presented a higher SLW when compared with beech leaves, and the highest value for the HLFE samples, when light intensity is big. SLW of both beech and hornbeam trees that grow at the forest edge was higher than the one of trees from inside the forest.

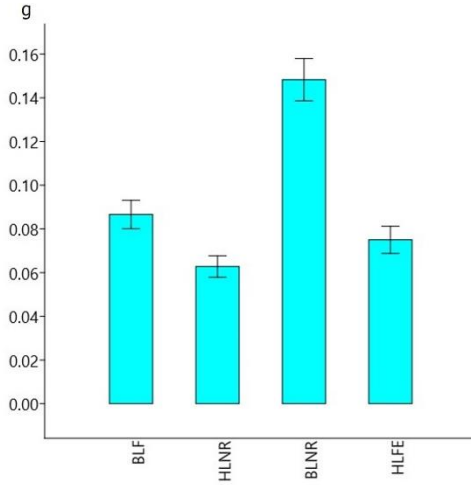

Figure 2. Mean values of DW for the analyzed samples

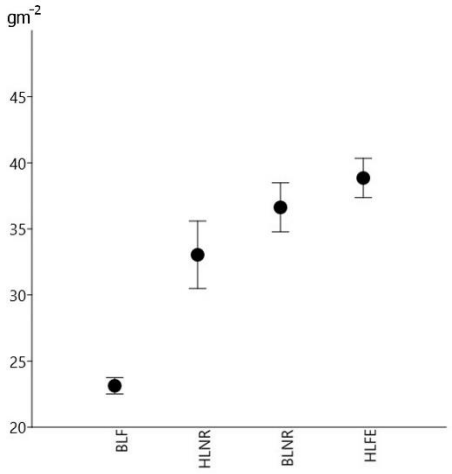

Figure 3. Mean values of SLW (g m^{-2}) for the analyzed samples

CONCLUSIONS

This study aimed to assess the morphometric and photosynthetic indices at two woody plant species, European beech and common hornbeam, and to describe plant behavior in different forest zones, at different altitudes and light intensity. The analyzed indices were leaves lengths, perimeters, areas, dry weight and specific leaf weights. High positive correlations were obtained between the first two indices. Generally, the first four indices had bigger values at beech samples. SLW presented variations between the samples, the samples from sunny areas having the highest values. Further researches will be on the interdependence between morphometric and other gravimetric or physiological indices, because light or shade, different altitudes and sites modify numerous traits in leaves, and in trees.

ACKNOWLEDGEMENTS

The authors wish to thank West University of Timisoara for providing the equipment and tools.

BIBLIOGRAPHY

APOLO-APOLO O.E., PEREZ-RUIZ M., MARTINEZ-GUANTER J., EGEA G. 2020. A Mixed Data-Based Deep Neural Network to Estimate Leaf Area Index in Wheat Breeding Trials. Agronomy 10: 175.

BAKER R., CANDRESSE T., SIMON E.D., GILIOLI G., GRÉGOIRE C., JEGER M.J., KARADOJA O.E., LÖVEI G., MAKOWSKI D., MANCEAU M., NAVAJAS M., PUGLIA A.P., RAFOSS T., ROSSI V., SCHANS J., SCHRADER G., UREK G., VAN LENTEREN J.C., VLOUTIGLOU I., WINTER S., ZLOTINA M. 2011. Scientific Opinion on the Pest Risk Analysis on *Phytophthora ramorum* prepared by the FP6 project RAPRA. EFSA Journal 9 (6): 2186.

DATCU A.D., IANOVICI N., SALA F. 2020. A method for estimating nitrogen supply index in crop plants: case study on wheat. Journal of Central European Agriculture 21 (3): 569-576.

DOS SANTOS J.C.C., COSTA R.N., SILVA D.M.R., DE SOUZA AA., DE BARROS PRADO MOURA F., DA SILVA JUNIOR J.M., SILVA J.V. 2016. Use of allometric models to estimate leaf area in Hymenaea courbaril L. Theoretical and Experimental Plant Physiology 28: 357–369

FANG J., LECHOWICZ M.J. 2006. Climatic limits for the present distribution of beech (*Fagus L.*) species in the world. Journal of Biogeography 33: 1804.

GARNIER E., CORDONNIER P. GUILLERM J.L., SONIE,L. 1997. Specific leaf area and leaf nitrogen

concentration in annual and perennial grass species growing in Mediterranean old fields. Oecologia 111: 490–498.

HAMMER Ø., HARPER D.A.T., RYAN P.D. 2001. PAST: Paleontological Satistics software package for education and data analysis. Paleontologica Electronica 4 (1): 1-9.

IANOVICI N., VEREȘ M., CATRINA R.G., PÎRVULESCU A.-M., TĂNASE R.M., DATCU A.D. 2015. Methods of biomonitoring in urban environment: leaf area and fractal dimension. Annals of West University of Timișoara, ser. Biology, 18 (2): 169-178.

IFN. 2020. www.roifn.ro (accessed 2020).

JOHNSON O., MORE D. 2006. Collins tree guide. HarperCollins Publishers; UK ed. 464 p.

JONCKHEERE I., FLECK S., NACKAERTS K., MUYS B., COPPIN, P., WEISS M., BARET F. 2004. Review of methods for in situ leaf area index determination Part I. Theories, sensors and hemispherical photography. Agricultural and Forest Meteorology 2004, 121: 19–35.

JUMRAN K., BHATIA V.S. 2020. Influence of different light intensities on specific leaf weight, stomatal density photosynthesis and seed yield in soybean. Plant Physiological Reports 25(2): 277–283.

MEZIANE D., SHIPLEY B. 2001. Direct and indirect relationships between specific leaf area, leaf nitrogen, and leaf gas exchange: Effects of irradiance and nutrient supply. Annals of Botany 88: 915–927.

PACKHAM J.R., THOMAS P.A., ATKINSON M.D., DEGEN T. 2012. *Fagus sylvatica* in Europe: distribution, habitat, usage and threats. Journal of Ecology 100: 1557.

PARIDARI I.C., JALALI S.G., SONBOLI A., ZARAFSHAR M., BRUSCHI P. 2013. Leaf macro- and micro-morphological altitudinal variability of *Carpinus betulus* in the Hyrcanian forest (Iran). Journal of Forestry Research 24: 301.

SHARIFI A. 2018. Estimation of biophysical parameters in wheat crops in Golestan province using ultra-high resolution images. Remote Sensing Letter. 9: 559–568

SIKKEMA R., CAUDULLO G., DE RIGO D. 2016. Carpinus betulus in Europe: distribution, habitat, usage and threats. In: SAN-MIGUEL-AYANZ, J., DE RIGO, D., CAUDULLO, G., HOUSTON DURRANT, T., MAURI, A. (Eds.), European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg, p. 2.

TANASE C., COSARCA S., TOMA F., MARE A., MAN A., MIKLOS A., IMRE S., BOZ I. 2018. Antibacterial activities of beech bark (*Fagus sylvatica* L.) polyphenolic extract. Environmental Engineering and Management Journal 17(4): 877-884.

TANASE C., MOCAN A., COSARCA C., GAVAN A., NICULESCU A, GHELDIU A.M., VODNAR D.C., MUNTEAN D.L., CRISAN O. 2019. Biological and chemical insights of beech (*Fagus sylvatica* L.) bark: a source of bioactive compounds with functional properties. Antioxidants 8: 417.

VON WUEHLISCH G. 2008. EUFORGEN Technical Guidelines for genetic conservation and use for European beech (*Fagus sylvatica*). Bioversity International, Rome, Italy. 6.

WRIGHT I.J., WESTOBY M. 2001. Understanding seedling growth relationships through specific leaf area and leaf nitrogen concentration: Generalisations across growth forms and growth irradiance. Oecologia 127: 21–29.