V. FOREST BIOLOGY

VARIABILITY OF LEAVES PARAMETERS IN ORIENTAL PLANE TREE (*PLATANUS ORIENTALIS* L.)

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Abstract: This paper presents the results of leaves parameters measuring of Oriental plane tree (*Platanus orientalis* L.), a rare tree species of Bulgarian flora naturally occurring only along the river streams in the southern part of the country. Based on morphometric parameters, the variability of the leaves of the oriental plane tree in 8 natural habitats (Asenovgrad, Topolovo, Sandanski, Melnik, Petrich, Slavyanka, Gotse Delchev and Ivaylovgrad) of the species in Bulgaria has been investigated. A higher degree of variability was observed between half-sib offspring than between populations. Eight parameters of the leaves were measured, in most cases the population from Asenovgrad is superior to the other origins. The results show that the most differentiated features are the length of the leafstalk (LD) and the length of the middle lobe (L). The size and shape of the leaves are relatively homogeneous and this makes difficult to determine individual origins only by leaves.

Keywords: *Platanus orientalis*, leaf shapes, variability, oriental plane tree

INTRODUCTION

In Bulgaria *Platanus orientalis* L. reaches the northernmost limit of its natural distribution [3]. Its range covers the southern part of the Balkan Peninsula and all of temperate Asia to eastern India [5]. In Bulgaria, it is found only in the southern part of the country along the river basins and is the only naturally occurring representative of the Platanaceae family. Populations of this species in Bulgaria are located in three regions over four river basins. Their localities are separated by relatively high mountain ridges and some of the populations are also rather distant geographically. The analysis of the genetic variation and population structure of *Platanus orientalis* in Bulgaria made by showed a good level of genetic diversity, both within and among populations [3]. The main threats to genetic diversity of Oriental plane tree could be identified in three directions: habitat destruction and fragmentation, hybridization with the London Plane (*Platanus x acerifolia* (Aiton) Willd.), and overexploitation [2]. The adaptation of the species to these treats and generally to changing environmental factors involves both short-term physiological responses and long-term physiological, structural, and morphological modifications. These changes help plant minimize stress and maximize use of internal and ex-ternal resources [1]. On a longer time scale, there is the possibility that morphological modifications will occur through natural selection in response to environmental conditions, resulting in local adaptation and maintaining species persistence and integrity and then adaptive population divergence [4]. For this reason, it is of great importance, in parallel with genetic studies, to investigate the changes that occur in the basic morphological characteristics of a species that develops and propagates in natural conditions.

Comparison of the degree of morphological variability with the data on the population structure and the genetic diversity of the species will make it possible to evaluate its response to anthropogenic and natural factors of the environment, which may be manifested by shifting its range or by adapting [4]. This information is required when developing a gene conservation strategy for *Platanus orientalis*.

The aim of this study is to determine the endogenous, population and interpopulation variability of the leaves of the Oriental plane tree in the natural populations of the species in Bulgaria and their relationship with the particular origins.

MATERIALS AND METHODS

The object of this study are 8 natural populations of the Oriental plane tree in Bulgaria (Asenovgrad, Topolovo, Sandanski, Melnik, Petrich, Slavyanka, Gotse Delchev and Ivaylovgrad), located between 150 – 400 m above sea level. Collected material include 750 leaves from 250 randomly chosen trees from 50 half-sib offspring. From each tree, three leaves were taken.

Leaf variability was established on the basis of the following morphometric parameters (Fig. 1): leafstalk length (LD), leaf length (L), leaf width (D), median length (ML), width of the middle particle at its widest part (MLW), the width of the middle particle at the base (MLB), the length of the left axial partition (LNL), and the length of the right axial partition (LND), with each individual leaf was measured to the nearest 0.1 cm.

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The data were analyzed for variance using (ANOVA). Individual inheritance, additive genetic variation coefficient, as well as differentiation

between neutral genetic markers (F_{ST}) and quantitative traits (Q_{ST}) were also calculated.

Fig. 1. Investigated morphometric parameters to determine leaf variability in Oriental plane tree (*Platanus orientalis* L.) Legend: Leafstalk length (LD), leaf length (L), leaf width (D), median length (ML), width of the middle particle at its widest part (MLW), the width of the middle particle at the base (MLB), the length of the left axial partition (LNL)

RESULTS AND DISCUSSION

The measured 8 leaf parameters (Fig. 1) show higher variability between half-sib offspring than between populations. In most cases Asenovgrad is superior to other origins. This applies to all studied parameters. However, in some cases the superiority is not statistically significant. In terms of the LD parameter, Asenovgrad exceed statistically significant the other origins, which, in turn, are not statistically significant different from each other (Table 1). In terms of leaf length, Asenovgrad does not differ

statistically significant from most of the other origins, and the latter two origin do not differ statistically significant from each other. In terms of leaf width, the first three populations (Asenovgrad, Topolovo and Ivaylovgrad) are not statistically significant different, while the other populations have similar values, Sandanski shows the lowest value. The same tendency is observed for ML and MLW parameters, while Gotse Delchev has the lowest value for MLB. Similar are the results for the last two studied traits – LND and LNL (Table 1).

Table 1. Mean values of leaf parameters

Population	Parameters							
	LD	L	D	ML	MLW	MLB	LND	LNL
Sandanski	10.59 b	85.88 c	79.43 d	44.86 c	28.33 d	20.19 cd	60.58b	59.78 d
Slavyanka	10.12 b	96.11 ab	91.65 bc	55.95 ab	32.68 bc	22.10 bcd	73.55ab	67.84 bc
Petrich	10.69 b	99.12 ab	91.01 bc	58.96 ab	31.99 bcd	20.67 cd	69.24ab	69.01 bc
Melnik	8.98 b	98.75 ab	86.77 cd	54.73 ab	33.11 bc	22.64bc	68.05ab	68.16 bc
Gotse Delchev	9.96 b	91.55 bc	84.62 cd	51.81 bc	29.51 cd	19.88 d	64.94ab	65.16 cd
Asenovgrad	13.80 a	102.28 a	105.98 a	60.72 a	37.58 a	25.18 a	77.74a	77.58 a
Topolovo	9.22 b	96.89 ab	98.17 ab	59.37 ab	35.28 ab	23.48 ab	71.19ab	70.83 abc
Ivaylovgrad	10.16 b	98.81 ab	101.20 ab	58.40 ab	34.43 ab	24.27 ab	73.75ab	73.05 ab

Note: Mean values denoted by identical letters do not differ statistically significantly at $p \leq 0.05$

The traits differed significantly between the half-sib offspring (Table 2). Analysis of variance showed that the family effect was always statistically significant ($p \leq 0.05$), whereas the block x offspring interaction was only significant for the MLB and LND traits (Table 2). The differences between the offspring were also confirmed by the dispersion

components (Table 3). The family component of the dispersion varies from 8% (L) to 24% (MLB). Therefore, inheritances (based on individual measurements) are high and range from 0.26 to 0.72. Practically, the average of the inheritance coefficients of leaf traits (0.51) is close to that of height growth (0.43) found by Grueva, Zhelev (2010).

Table 2. Statistical significance (*p-value*) of the influence of block factors, offspring and the interaction between them on leaf parameters

Source of variation	Freedom degree	Parameters							
		LD	L	D	ML	MLW	MLB	LND	LNL
Block	2	0.429	0.191	0.108	0.065	0.078	0.026	0.030	0.051
Offspring	48	0.003	0.039	<0.001	0.001	0.001	<0.001	0.015	0.002
Block x offspring	96	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 3. Dispersion components and inheritance coefficients of leaf parameters

Dispersion components	Variables											
	LD		L		D		ML		MLW		MLB	
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
Offspring	0.025	15.72	0.0045	8.74	0.013	19.40	0.013	16.88	0.013	17.81	0.012	24.19
Block x offspring	0.037	23.27	0.018	34.95	0.018	26.87	0.023	29.87	0.020	27.40	0.0076	15.32
Error	0.097	61.01	0.029	56.31	0.036	53.73	0.041	53.25	0.040	54.79	0.030	60.48
h^2	0.47		0.26		0.58		0.51		0.53		0.72	

As is logical to expect, leaf traits are interrelated, as leaf sizes are generally dependent on environmental conditions and if these conditions have a beneficial effect on a particular trait, they are also expected to have a beneficial effect on other features. The results

show (Table 4) that all correlation coefficients are statistically significant different from 0, that mean, there is a significant positive dependence between the studied traits. Correlation coefficients range from 0.315 (LD-MLB) to 0.942 (LD-LNL).

Table 4. Correlation coefficients between leaf traits.
All correlation coefficients are significantly different from 0 at $p \leq 0.05$

	L	D	ML	MLW	MLB	LND	LNL
LD	0.449	0.587	0.546	0.486	0.315	0.547	0.583
L	1	0.796	0.803	0.75	0.664	0.776	0.839
D		1	0.914	0.889	0.760	0.870	0.942
ML			1	0.86	0.639	0.844	0.917
MLW				1	0.803	0.789	0.863
MLB					1	0.675	0.744
LND						1	0.892

The results of the discriminant analysis (Fig. 2) show that there is no clear distinction between the different origins based on leaf characteristics. This largely confirms the findings of a study by Delkov (1977), which found some difference between the leaves of the fruiting twigs and those of the

vegetative ones, which are always slightly larger, and the first leaves in spring are most often tripartite. However, some of the origins can be more clearly distinguished, such as Asenovgrad (No 1), Sandanski (No 6), Ivaylovgrad (No 3). The other origins overlap to a considerable extent.

Fig. 2. Diagram of discriminant analysis based on leaf parameters; 1 – Asenovgrad, 2 – Gotse Delchev, 3 – Ivaylovgrad, 4 – Melnik, 5 – Petrich, 6 – Sandanski, 7 – Slavyanka, 8 – Topolovo.

The Jentys-Szaferowa diagram (Fig. 3) again highlights Asenovgrad as different from the rest. It can also be seen that the most differentiating

features are the length of the leafstalk and the length of the middle lobe.

Fig. 3. Jentys-Szaferowa diagram of leaf variability: A – Asenovgrad, GD – Gotse Delchev, IV – Ivaylovgrad, M – Melnik, P – Petrich, S – Sandanski, SL – Slavyanka, T – Topolovo

CONCLUSIONS

The results show that the most differentiated population is from Asenovgrad. The most differentiated features are the length of the leafstalk and the length of the middle lobe. The degree of variability is higher among half-sib offspring than among populations. The correlation coefficients between the individual traits are high as well. It is not possible to determine the individual origins on the leaves. The findings from previous studies confirm that the size and shape of the leaves of the oriental plane tree are homogeneous in Bulgaria. It must always pay attention that leaf parameters are more environmentally unstable and are significantly influenced by environmental conditions, especially humidity. The analysis shows that even such traits, can have a serious genetic component in their inheritance. That is confirmed by high individual inheritances. The established relationships between the studied leaf parameters can be used to develop a system of features related to an economic valuable trait that is the subject of future research.

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