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PROPERTIES AND VARIABILITY OF DOUGLAS-FIR SEEDLINGS (*PSEUDOTSUGA MENZIESII* (MIRB.) FRANCO)

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Based on the comparative morphophysiological analysis of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seedlings, three half-sib lines from *Quercetum farneto-cerris s.l.* site, and three half-sib lines from *Saliceto-Populetum s.l.* site, the data on seedling characteristics and variability of this cultivated species are discussed. The paper also ascertains the variability of seedling properties that affect mother tree selection and production technology of plant material of desired characteristics for the application in forestry and landscape architecture and horticulture.

Key words: Douglas-fir, *Pseudotsuga menziesii*, variability, properties

INTRODUCTION

As it is can be claimed for all living beings, variability, as one of the essential life properties, characterises also all tree species. Variability is manifested as a phenomenon expressed in the progeny of parent plans, but also by itself, it is simultaneously the material for natural and planned selection. As the evolution theory suggests, in addition to inheritance and selection, variability is one of the three principal factors of natural and directed evolution of species. Depending on

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the properties of the factors which condition the occurrence of variability, there are two different groups of phenotype modifications: (1) modifications, i.e. changes conditioned primarily by the environmental factors and (2) genotype variations, modifications conditioned primarily by the genetic developments (TUCOVIĆ, 1990). The latter, genotype variations are manifested through genome mutations, mutations of the chromosome structure, gene mutations, extra-chromosome mutations and the combining variability, which is still, due to understandable circumstances, best studied.

The systematic study of variability of allochthonous tree species in the former Yugoslavia, and especially in Serbia, due to many objective reasons, is a recent activity. As for our Republic, it is not strange at all, because also there is not a long tradition of planned and organized cultivation of many, better to say of the majority of introduced tree species in the region of Serbia. It resulted in the fact that many introduced tree species have not been regularly, or not at all, monitored after the first inventory, therefore there are gaps in the study of their variability.

The above facts refer to many significant tree species, inter alia Douglas-fir. This extremely interesting species originating from North America has been cultivated in our country for more than half a century, being a valued conifer both in parks, urban coenoses and in forestry. Its excellent characteristics do not include only its morphological values, although it should be emphasised that this species attains the height of a hundred metres in its country of origin, which few other tree species can compete. In this context, it should not be forgotten that in Europe, in which it has been cultivated since 1827, thanks to the Scotsman David Douglas, who was sent two years before by the Royal Horticultural Society to study its properties, it does not attain half of the mentioned height, but in a geographically very wide area, just as in our country, it demonstrates additional properties, also worthy of our attention: fast growth, relatively high degree of adaptation, markedly good resistance to urban conditions, very good quality of wood and, indirectly, undeniably high aesthetical and ornamental values. Thanks to such characteristics, Douglas-fir has become one of the most willingly applied coniferous tree species in landscape architecture in Serbia, and its economic significance in Serbian forestry is also quite unquestionable.

Starting from the above facts, this paper presents the research of some of the significant properties of seedlings of this interesting allochthonous species at two sites in the wider region of Belgrade, and the results of the comparative analysis of the study characteristics.

MATERIAL AND METHOD

The seeds for the analysis of properties and variability of Douglas-fir seedlings were collected from six previously selected trees, from tree groups at the site of Hungarian oak and Turkey oak forest and at the site of willows and poplars, three trees at each site. Seed germination was carried out in the Faculty of Forestry laboratory, in Petri dishes immediately after seed collection, according to standard procedure and with a sufficient number of repetitions. During the seedling analysis,

Petri dishes were in the identical ecological conditions. Watering was every second day to the full water capacity. 28 days after the beginning of germination, on the sample of 25 seedlings, the following characters were analysed in each of the half-sib lines: hypocotyl length and diameter, number of cotyledons, cotyledon length and diameter, and length of root at the age of seedlings with opposite primary needles.

The study data were statistically processed, i.e. each character was assigned: mean value ($\bar{x}$), standard deviation (*S*), variation coefficient (*V*), error of mean value ($S\bar{x}$), error of standard deviation (*Ss*) and error of variation coefficient (*Vv*).

The variability was assessed at the level of trees and at the level of the introduced species as a whole. Both levels represent a complex of interactions of genetic, physiological, morphological and environmental factors.

RESULTS AND DISCUSSION

Douglas-fir seedlings germinate above ground. The hypocotyl is thin and greenish-white in colour. Cotyledons are linear, with integral margin. The primary needles are opposite. The following needles are similar to the primary needles. The internode above the cotyledons is undeveloped (STILINOVIĆ, 1985.).

The study results of seedling characters and the variability of six Douglas-fir half-sib lines are presented in Tables 1 - 3. Average hypocotyl height at the level of the species at the age of opposite primary leaflets ranges from 19.76 mm to 39.44 mm, mean diameter of hypocotyl ranges from 0.51 mm to 1.08 mm. Half-sib line seedlings from willow and poplar sites attained larger sizes.

Table 1. Statistical parameters of hypocotyl length and diameter of 6 Douglas-fir half-sib lines at two sites

Statistical parameter / Tree	Property	$\bar{x} \pm S_{\bar{x}}$	$S \pm S_S$	$S \pm S_V$
		Site of willows and poplars		
1	length (mm)	31.12 ± 6.22	3.30 ± 0.43	10.63 ± 1.48
	diameter (mm)	1.00 ± 0.21	0.06 ± 0.00	0.35 ± 0.08
2	length (mm)	39.44 ± 7.88	2.55 ± 0.50	6.47 ± 0.90
	diameter (mm)	1.08 ± 0.21	0.16 ± 0.04	12.11 ± 1.70
3	length (mm)	34.68 ± 6.93	2.03 ± 0.04	5.87 ± 0.82
	diameter (mm)	1.06 ± 0.02	0.10 ± 0.01	9.88 ± 1.38
		Site of Hungarian oak and Turkey oak		
4	length (mm)	21.70 ± 4.24	1.14 ± 0.09	5.27 ± 0.74
	diameter (mm)	0.58 ± 0.06	0.09 ± 0.00	17.22 ± 2.41
5	length (mm)	24.40 ± 4.88	1.00 ± 3.41	4.09 ± 0.57
	diameter (mm)	0.77 ± 0.01	0.09 ± 0.00	12.69 ± 1.77
6	length (mm)	19.76 ± 3.92	0.96 ± 0.02	4.90 ± 0.68
	diameter (mm)	0.51 ± 0.10	0.07 ± 0.00	14.17 ± 1.98

According to the literature data, Douglas-fir seedlings have 6 – 7 cotyledons. However, all seedlings from Hungarian oak and Turkey oak sites had a lower number of cotyledons, altogether 4 or 5 cotyledons, while on the other hand, the seedlings from willow and poplar sites are characterised by a higher number of cotyledons of all seedlings, altogether 8 or 9. The average length of cotyledons at the level of the species ranged from 12.48 mm to 27.12 mm, diameter from 0.31 mm to 0.82 mm. Mother trees from the alluvial site excel in cotyledon length and diameter,. Average length of the taproot at the level of the species ranged from 27.32 mm to 75.92 mm.

Table 2. Statistical parameters of cotyledon length and diameter of 6 Douglas-fir half-sib lines at two sites

Statistical parameter / Tree	Property	$\bar{x} \pm S_{\bar{x}}$	$S \pm S_S$	$S \pm S_V$
		Site of willows and poplars		
1	length (mm)	21.04 ± 4.20	1.62 ± 0.20	7.69 ± 1.07
	diameter (mm)	0.55 ± 0.10	0.11 ± 0.01	21.15 ± 2.95
2	length (mm)	23.16 ± 4.63	1.37 ± 0.03	5.93 ± 0.83
	diameter (mm)	0.82 ± 0.16	0.08 ± 0.00	9.88 ± 1.38
3	length (mm)	23.36 ± 4.67	1.25 ± 0.30	5.36 ± 0.75
	diameter (mm)	0.80 ± 0.16	0.09 ± 0.00	12.19 ± 1.70
		Site of Hungarian oak and Turkey oak		
4	length (mm)	12.48 ± 2.49	0.91 ± 0.17	7.36 ± 1.21
	diameter (mm)	0.31 ± 0.06	0.07 ± 0.00	25.03 ± 3.50
5	length (mm)	15.08 ± 3.01	0.76 ± 0.11	5.03 ± 0.70
	diameter (mm)	0.47 ± 0.04	0.11 ± 0.00	24.45 ± 3.42
6	length (mm)	27.12 ± 5.42	37.81 ± 3.16	12.90 ± 1.50
	diameter (mm)	0.81 ± 0.16	0.06 ± 0.00	9.68 ± 1.35

Table 3. Statistical parameters of root length of 6 Douglas-fir half-sib lines at two sites

Statistical parameter / Tree	$\bar{x} \pm S_{\bar{x}}$	$S \pm S_S$	$S \pm S_V$
	Site of willows and poplars		
1	27,76 ± 5,52	1,26 ± 0,18	4,60 ± 0,44
2	59,00 ± 11,08	6,25 ± 0,08	11,06 ± 1,54
3	75,92 ± 15,18	4,04 ± 0,10	5,32 ± 0,74
	Site of Hungarian oak and Turkey oak		
4	24,60 ± 4,92	1,41 ± 0,14	5,75 ± 0,80
5	27,32 ± 4,67	4,07 ± 0,37	14,93 ± 2,08
6	34,24 ± 6,84	2,14 ± 0,18	6,27 ± 0,87

The most vital seedlings, based on all analysed parameters, were those from the tree No. 2, selected at the site of willow and poplar. The justification of statistical differences of mean values of tree No. 2 seedlings compared to other trees, confirms the inheritance base of the analysed characters, i.e. it emphasizes

their significance as the markers for early selection. In addition, taking into account that Douglas-fir originates from the Pacific Ocean region, it is evident that there is a positive effect of ecological conditions at the alluvial site of Belgrade, similar to those in which initial populations grow in North America.

The presented analysis of seedling characters of different half-sib lines from two sites was performed in the aim of the assessment of genetic, morphological and physiological variability of Douglas-fir in our country. It should be taken into account that the majority of analysed characters are quantitative and that they were controlled by polymer genes whose effects are added. Similarly, the variability of quantitative characters is very significant and it has a continuing character. In general, natural selection at the genetic plan enables permanent modifications in the genetic structure of the new populations (TUCOVIĆ and ISAJEV, 1985), while the selection is possible and successful only if there is free genetic variability, which should be detected and classified.

Based on the above facts, the research of apparently less significant morphological and physiological properties of Douglas-fir seedlings in the earliest period is becoming increasingly significant. The knowledge of the spontaneous variability of species immediately after the development of cotyledons enables the detection of deviations, especially under the occurrence of haploids, polysomics, polyploids, etc., which enable intermittent speciation (TUCOVIĆ, 1990). Consequently, the data presented in the Tables can be significant for further investigations and professional activities in the future more efficient selection or in the better use of the potential of the initial seed trees.

CONCLUSIONS

The study data referring to the characters and variability of Douglas-fir seedlings are based on the total and comparative analysis of the seedlings of six half-sib lines, originating from the selected trees of the populations at different sites in Belgrade. In addition to the determination of quantitative parameters, the occurrence of abnormal properties of seedlings was also recorded. The following properties were also recorded during the study: accreted cotyledons, reduced number of cotyledons, higher number of cotyledons and retarded growth with reduced vitality of roots.

The study shows that Douglas-fir seedlings are characterised by a well developed root system, which, together with the subsequent fast height and diameter increment of trees, explains the occurrence of the individuals with the maximal dimensions, especially at the site of willow and poplar.

The identified specialties and the observed variability of Douglas-fir seedling properties are significant for the technology of seed and nursery production. The study results are the base of the proposal that the standard control of seed properties should also include the identification of the limits of seedling variability, based on which further treatment of seed collection and seed utilization from the selected trees should be determined. This activity is very significant in the practice of landscape architecture, especially because many trees in the green spaces and

recreation areas showed to be high-quality individuals of extraordinary aesthetic characteristics and functions. Not less important is the significance of Douglas-fir today or in future in forestry practice in Serbia.

Finally, the significance of this study is also supported by the theory, which starts from the idea that the stabilising, disruptive and directed selection of seedlings is a very important process, because only the selection can explain the additive and highly organized nature of adult trees (TUCOVIĆ, 1990) of the cultivated species *Pseudotsuga menziesii* ((Mirbb.) Franco), of which out of several tens of thousands of potential seedlings often only several trees grow up.

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OSOBINE I VARIJABILNOST KLIJAVACA ZELENE DUGLAZIJE (*PSEUDOTSUGA MENZIESII* (MIRB.) FRANCO)

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Izvod

Na osnovu komparativne morfofiziološke analize klijavaca *Pseudotsuga menziesii* (Mirb.) Franco, i to tri linije polusrodnika sa staništa šume sladuna i cera i tri linije polusrodnika sa staništa vrba i topola, iznose se podaci o osobinama i promenljivosti klijavaca ove gajene vrste. U radu se takođe konstatuje promenljivost svojstava klijavaca koja utiču na selekciju materinskih stabala i tehnologiju proizvodnje sadnog materijala sa željenim osobinama, za primenu u šumarstvu i pejzažnoj arhitekturi i hortikulturi.

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