ISSN 1821-1046
UDK 630

INSTITUTE OF FORESTRY
BELGRADE

INSTITUT ZA ŠUMARSTVO
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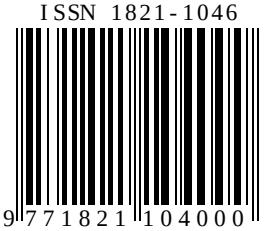
SUSTAINABLE FORESTRY ODRŽIVO ŠUMARSTVO

COLLECTION
TOM 63-64

ZBORNIK RADOVA
TOM 63-64

BELGRADE BEOGRAD
2011.

ISSN 1821-1046



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PROCEEDINGS

ZBORNIK RADOVA

Publisher
Institute of Forestry
Belgrade, Serbia

Izdavač
Institut za šumarstvo
Beograd, Srbija

For Publisher
Ljubinko Rakonjac, Ph.D.

Za izdavača
Dr Ljubinko Rakonjac

Printed in
150 copies

Tiraž
150 primeraka

Printed by
Klik tim DOO
Beograd

Štampa
Klik tim DOO
Beograd

Belgrade, 2011

Beograd, 2011

Cover Page: Author of the Photos Tatjana Ćirković-Mitrović, M.Sc.
Naslovna strana: Autor fotografije mr Tatjana Ćirković-Mitrović

CIP – Каталогизација у публикацији
Народна библиотека Србије, Београд

630

SUSTAINABLE Forestry : collection = Održivo šumarstvo = zbornik radova / chief editor = glavni i odgovorni urednik Snežana Rajković. - 2008, T. 57/58- . - Belgrade (Kneza Višeslava 3) : Institute of forestry, 2008- (Beograd : Klik tim). - 24 cm

Godišnje. - Je nastavak: Zbornik radova - Institut za šumarstvo = ISSN 0354-1894
ISSN 1821-1046 = Sustainable Forestry
COBISS.SR-ID 157148172

SADRŽAJ CONTENTS
TOM 63-64

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 63-64, 2011 ZBORNIK RADOVA 63-64, 2011

UDK 630*232.12=111
Original scientific paper

DEPENDENCE OF DOUGLAS-FIR MEAN DIAMETER ON GEOGRAPHIC ORIGIN OF CANADIAN PROVENANCES IN SEEDLING NURSERY CONDITIONS

Vladan POPOVIĆ[1], Vera LAVADINOVIĆ[1]

Abstract: *Seed and seedling tests, performed with the aim of acquiring knowledge of the genetic potential of selected provenances, are generally one of the first trials in a complex system of comparative examinations to be conducted upon introduction of alien tree species. This paper presents the results of the investigation of the dependence of the mean diameter of 14 Canadian origin Douglas-Fir provenances, originating from 49°10' to 51°35' latitude, 115°20 ' to 120°10' longitude and the altitude of 488 to 1,070m, on the geographic origin.*
Understanding the variability of a seedling mean diameter is of the major importance for acquiring knowledge of genetic potential of selected provenances, which is one of the key parameters for introduction of Douglas-fir into relevant forest sites in Serbia.

Key words: Douglas-fir, provenance, seedlings, mean diameter

ЗАВИСНОСТ СРЕДЊЕГ ПРЕЧНИКА ОД ГЕОГРАФСКОГ ПОРЕКЛА ДУГЛАЗИЈЕ КАНАДСКЕ ПРОВЕНИЈЕНЦИЈЕ

Извод: *Тестови са семеном и садницама, у којима се упознаје генетски потенцијал селекционисаних провенијенција, по правилу су међу првим огледима у сложеном систему компаративних испитивања која се спроводе при интродукцији страних врста дрвећа. У овом раду су приказани резултати испитивања зависности средњег пречника од географског порекла 14 провенијенције дуглазије пореклом из Канаде, које потичу: од 49°10` до 51°35` географске ширине , од 115°20` до 120°10` географске дужине и са надморске висине од 488 до 1070 м.*

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Translation: Dejan Arsenovski

Познавање променљивости испитиваних параметара средњег пречника саднице од значаја је за упознавање генетског потенцијала селекционисаних провенијенција, као једног од битних параметара за интродукцију дуглазије на одговарајућа станишта у Србији.

Кључне речи: дуглазија, провенијенција, саднице, средња висина

1. INTRODUCTION

The primary reason for establishment of provenance test is to determine the economic justification for introduction and to assess the risk arising from a transfer of seeds from their natural, autochthonous zones of origin. Introduction must involve only those species that attain maximum production qualities and economic effectiveness in their natural areal. Upon the transfer of seeds into forest sites with new ecological conditions, the genetic potential of species is tested by means of provenance trials. Another important reason for establishment of provenance trials is avoiding risk and damage from introduction of non-productive and non-adaptive provenances. Several years-long trials of introduced seed, begin by a laboratory analysis of germination, measurement of tray plants, survival percentage of seedling nursery plants, establishment of a field trial and a years-long measurement of plant taxation elements until fruit bearing and collection of F2 generation seeds.

Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco) has a broad areal in North America, from west Oregon, across the Washington state, to British Columbia. Autochthonous forests of this type are one of the most productive forests in the world, which is a reason for a considerable interest that exist for establishment of this culture beyond the limits of its natural areal. (J. Bradley, St. Clair i R. Sniezko, 1999). Owing to its extensive adaptability, ecological variability and a potential value, Douglas- fir is one of the most investigated and, at the same time, most important allochthonous conifer species in Europe (John, 1988; Linhart, 1990; Kleinshmit, Bestien, 1992; Schober, 1963). According to the available data, cultures of this species have been established in 26 European countries, on the surface area of 200,000ha (Schober R.). The process of Douglas-fir introduction to Europe was initiated in 1850, when first cultures were established. The success and productivity of the first established cultures differed, largely due to the unknown origin of the seeds used for production of seedlings for their establishment. Based on the studies conducted in North America, as well as potential tests of this species in Europe, a detailed knowledge of the genetic potential of Douglas-fir provenances was acquired. The obtained results from the comparative tests had an impact on regionalisation and more proper selection of the seed sources in North America, which contributed to stability and overall quality of Douglas-fir cultures in forest sites outside its natural areal. The introduction of Douglas-fir in the region of South East Balkans began towards the end of 19th and at the beginning of 20th century. Initially, it was planted as a park-decorative species, and later as a species in forest cultures. (Vrcelj- Kitić, D., 1982). Two Douglas-fir provenance trials were established in Serbia in 1982, with the seed from the known North America seed sources, ranging from New Mexico to British Columbia. Trial facilities were

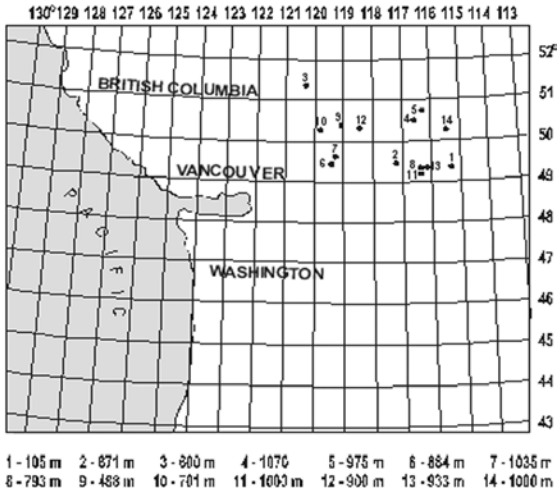
created in Juhor near Jagodina and Tanda near Bor from the seedlings produced in the seedling nursery of the Institute of Forestry in Belgrade.

The results of the research conducted in the experimental facilities in Serbia, (Lavadinović, V., et al. 1995, 1996a, 1996b, 1996c,1997, 1999, 2001) proved that provenances from the higher latitudes of North America are characterised by genetic potential that makes them suitable for establishing their cultures in Serbia. The above-stated results directed the further research towards Douglas-fir provenances from Canada, of the latitude ranging from 49°10' to 51°35', longitude from 115°20' to 120°10' and altitude from 488 to 1070 m.

2. MATERIAL AND WORK METHOD

The paper presents the results of the seedling mean diameter measurement and their discrepancies, depending on geographic characteristics of the seed origin, in a plant juvenile development phase at the seedling nursery in Sremčica. The seed of 14 Douglas-fir provenances, originating from its natural areal in Canada and obtained through a forest seed centre 'Canadian Forest Service' from British Columbia, was used for production of seedlings for establishment of the trial. The sowing of seed was conducted in May 1999, while the trial was established in April 2002, at the seedling nursery in Sremčica. The planting was conducted in rows, one provenance in one row. The distance between the rows was 2m, while the distance between seedlings in a row was 1m. Picture 1 presents the spatial layout of provenance origins, while their geographic characteristics and original codes are presented in table 1.

In summer 2010, breast diameters of all trial trees were measured by a caliper, with the accuracy of 0.1mm. The obtained data were processed by a computer programme STATGRAPHICS Plus. Statistical justification of differences between breast diameter arithmetic means was established by the LSD test, with the probability of 95%. The impact of provenances' geographic origin on seedling breast diameter is determined by the Pierce linear correlation coefficient.



Picture 1. *Spatial layout chart of investigated provenances*

Table 1. *Geographic characteristics of tested provenances*

Provenance		Location			Altitude
No.	Code		latitude	longitude	(m)
1.	03333	Cranbrook	49°25'	115°20'	1050
2.	00848	Inonoaklin	49°50'	118°10'	671
3.	30667	Mann Creek	51°35'	120°10'	600
4.	05227	Gavia Lake	50°56'	116°35'	1070
5.	05226	Nine Bay	50°58'	115°32'	975
6.	03356	Trout Cr	49°40'	119°52'	884
7.	03360	Michell Cr	49°54'	119°37'	1035
8.	01198	Salmo	49°15'	117°30'	793
9.	30460	Mara Lk	50°48'	119°00'	488
10.	00278	Monte Crk	50°37'	119°52'	701
11.	03383	Sheep Creek	49°10'	117°15'	1000
12.	30461	Cooke Creek	50°38'	118°49'	900
13.	03389	Benton Creek	49°12'	117°25'	933
14.	05092	Sun Creek	50°08'	115°52'	1000

3. RESULTS AND DISCUSSION

A comparative analysis of the attained mean diameters of Douglas-fir seedlings from 14 Canadian provenances was published for the purpose of establishing inter-provenance variability and its dependence on geographic characteristics of the seed origin.

Table 2. *Breast diameter of tested Douglas-fir provenances*

Provenance		Diameter
No.	Code	(mm)
1.	03333	13
2.	00848	28
3.	30667	20
4.	05227	10
5.	05226	7
6.	03356	6
7.	03360	8
8.	01198	7
9.	30460	22
10.	00278	11
11.	03383	15
12.	30461	14
13.	03389	21
14.	05092	10

The largest breast diameter of 28 mm was attained by the trees of the second provenance (00848), followed by the ninth 22 mm (30460), the thirteenth 21mm (03389), while the smallest diameter of 6 mm was attained by the trees of the sixth provenance (03356), the fifth 7mm (05226) and the eighth, also 7 mm (0119), as can be seen in table 2.

The obtained statistical data point out to the existence of genetic variability in selected Douglas-fir provenances, understanding of which is essential for the further success of introduction work.

Table 3. *Summary statistics*

Provenance	Average	Standard deviation	Coeff. of variation	Range
1	13,0	9,46044	72,7726%	31,0
2	28,4688	12,59	44,2238%	56,0
3	20,0641	9,41585	46,9288%	41,0
4	10,3793	5,12984	49,4237%	25,0
5	6,66667	4,19921	62,9881%	15,0
6	6,0	3,09121	51,5201%	9,0
7	7,82353	3,63043	46,404%	14,0
8	7,31818	4,04011	55,2065%	14,0
9	21,7015	10,8698	50,0877%	45,0
10	10,6667	7,42582	69,6171%	37,0
11	14,5952	7,47372	51,2066%	37,0
12	13,8298	6,83126	49,3952%	25,0
13	20,5082	10,366	50,5457%	46,0
14	10,4588	5,73534	54,8373%	31,0
Total	15,8236	10,6947	67,5866%	61,0

Table 4. *Variance analysis*

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	27268,8	13	2097,6	29,26	0,0000
Within groups	43301,0	604	71,6903		
Total (Corr.)	70569,8	617			

The results of the variance analysis (table 4) indicate the existence of statistically significant discrepancies at the level $p<0.05$, between breast diameters of 14 Douglas-fir provenance trees.

Table 5. *LSD test*

Provenances	Mean	Homogeneous Groups
6	6,0	X
5	6,66667	XX
8	7,31818	XXX
7	7,82353	XXX
4	10,3793	XXXX
14	10,4588	XX
10	10,6667	XXXX
1	13,0	XXX
12	13,8298	XX
11	14,5952	X
3	20,0641	X
13	20,5082	X
9	21,7015	X
2	28,4688	X

By means of the LSD test, statistically significant differences between mean breast diameters of Douglas-fir provenances were determined at the reliability level $p<0.05$. The provenances were grouped in 4 homogenous groups, which confirmed the variability of mean breast diameters of 14 Douglas-fir provenances. The provenances 2, 9, 13 and 3 belong to a homogenous group with the largest breast diameter, whereas the provenances 6, 5, 8 and 7 belong to a group with the smallest breast diameters.

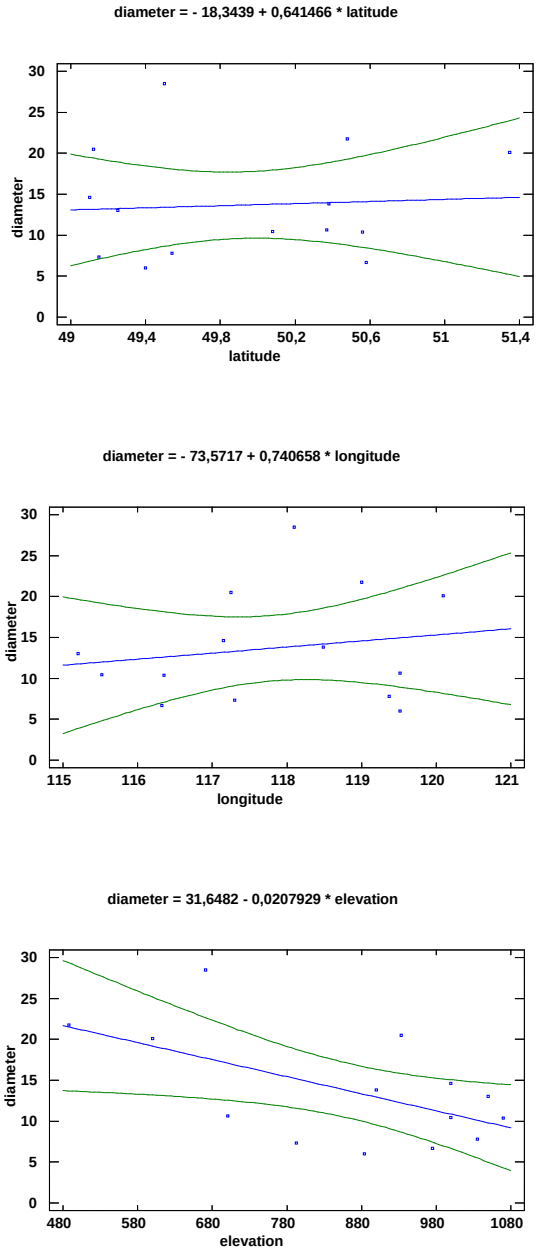
The impact of provenances' geographic origin on a Douglas-fir seedling diameter was examined by means of the Pierce linear correlation coefficient.

Table 6. *Geographic location and breast diameter correlation matrix of 14 Douglas-fir provenances, marked correlations are significant for p<0.05*

	Latitude	Longitude	Altitude	Breast diameter
Latitude	1,00	0,2897	-0,3803	0,0681
Longitude		1,00	-0,6337*	0,1756
Altitude			1,00	-0,5715*
Breast diameter				1,00

On the basis of the Pierce coefficient values (table 6), it could be concluded that there is a positive correlation between longitude and diameter, but that correlation is not statistically significant. There is a negative correlation between altitude and diameter, and that correlation is statistically significant. A similar correlation was also established in the tests involving seeds of the same provenances (Lavadinović, V., et al. 2004.)

Based on the obtained results, it can be concluded that the diameter size is increasing from east provenances to the west. The diameter size is decreasing with the increase of altitude and that is the most pronounced impact (graph 1).



Graph 1. *Latitude, longitude and altitude impact on breast diameter*

4. CONCLUSION

In the juvenile development phase in seedling nursery conditions, the plants exhibit variability of growth characteristics. In order to draw more certain

conclusions with respect to which provenance exhibits better adaptability, it is necessary to monitor the development of older trees.

In this phase of juvenile plant development, the provenances 2, 9, 13 and 3 stood out as the best according to the attained mean breast diameters, while the provenances 6, 5, 8 and 7 were ranked the worst. However, it is too early to propose those data as the underlying basis for the establishment of Douglas-fir cultures. The conducted research presents the basis for selection of a relevant Douglas-fir Canadian provenance for establishment of plantations in Serbia. In order to conduct a more proper selection of provenances, it is necessary to continue to monitor the plant development and then, by consolidating several research results, recommend provenances that are most suitable for establishment of Douglas-fir cultures in Serbia.

Acknowledgement

This paper was produced in the framework of the project 'Study of climatic change environment impact: monitoring impact, adaptation and mitigation' (43007), financed by the Republic of Serbia Ministry of Education and Science, in the framework of Integrated and Inter-disciplinary research programme for the period 2011-2014.

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Reviewer: Ph.D. Branko Stajić