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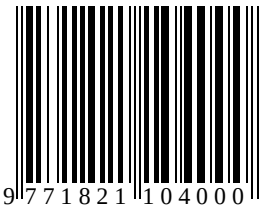

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Original scientific paper

TESTING OF CANADIAN DOUGLAS-FIR HEIGHT IN JUVENILE PHASE

Vera LAVADINOVIĆ[1], Vladan POPOVIĆ[1], Emil POPOV[2], Vukan LAVADINOVIĆ[3]

Abstract: *Introduction program of productive species were initiated in nearly all European countries but with different intensities. A common objective has been to create base material for seed procurement. Introduction objectives differ between countries, but most of them include adaptation and health, yield improvement, volume production and wood quality in some way.*

(Pseudotsuga menziessi Mirb/Franco) is one of the most important coniferous species in Europe both from an economic and ecological point of view. The provenance experiment of the North-West American conifer Douglas-fir were established in Serbia by the Institute of Forestry to test the genoecological characteristics of the species. Provenance experiment, contains the seed sources covering the central range of this species wich were collected from native area in Canada. The test included, fourteen seed provenances originating from Canada. Plants where produced in the nursery of the Institute, where they were measured. Early results from this provenances testing and growth information from the juvenile age in the nursery indicates that there are significant differences among Douglas -fir plants, what justifies the testing of introduced species by provenance experiment.

Keywords: Douglas-fir, provenance trials, mean height, introduction, seed transfer

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1. INTRODUCTION

Forest tree breeding has been ongoing for more than 70 years across Europe. It has successfully generated improved varieties for the major economical forest tree species. They are part of the present European forestry landscape and largely contribute to intensive wood production and other forest activities. Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) is native to the Pacific coast range and along the Rocky Mountains through Canada and USA. In the early 19th nineteenth century, it was introduced to Western Europe, where nowadays it covers almost 800,000 ha. Despite this considerable extent, the relatively recent introduction to Europe means this exotic species is still a minor forest species for several European countries. This status may be revised notably in the context of climate change, considering the high adaptability potential of the species. The original objective of most provenance tests was to identify the best seed sources for the test site area (Matyas, 1996).

Recent and projected changes in climate have increased interest in the potential growth responses of forest trees to climate change. Forest trees are adapted to their past environments, and their future growth and survival will depend on their ability to modify their phenotype in response to environmental change (Matyas, 1996).

The dominant height of a uniform stand, at a given age, is a good indicator of the potential productivity of that type of forest on that particular site (Cailliez, and Alder, 1980). This is based on Eichhorn's hypothesis (Eichhorn, 1904) that total production from a fully stocked stand, which is the volume currently standing plus anything removed in previous thinnings, is a function of its height (Savill et al. 1997).

The European forest almost dominated by introduced, non-native, tree species which occur on a wide range of site conditions. They have found a place in the classification in European Forest Types. The new European Forest Types are organized according to a hierarchical classification system structured into 14 Categories and 78 Types.

Introductions of forestry species were recorded for all regions, but the largest number of reports was for introductions to Africa (219 species). The dataset contained fewest records of forestry species introduced into Europe (95 species) and the Pacific (97 species) (EEA-2006).

Investigating the effect of transfer distances on the expression of genotype by environment interactions began with the innovative analyses of(Campbell, 1974), who regressed height growth of populations on geographic transfer distances. The use of transfer distances with the objective of understanding climate change effects on forest growth is more recent (Popov, 1990, Matyas, 1994, 1996, Schmidtling 1994, Carter, 1996, Rehfeldt et al. 1999, Wang et al. 2006, Thomson and Parker, 2008, Thomson et al. 2009).

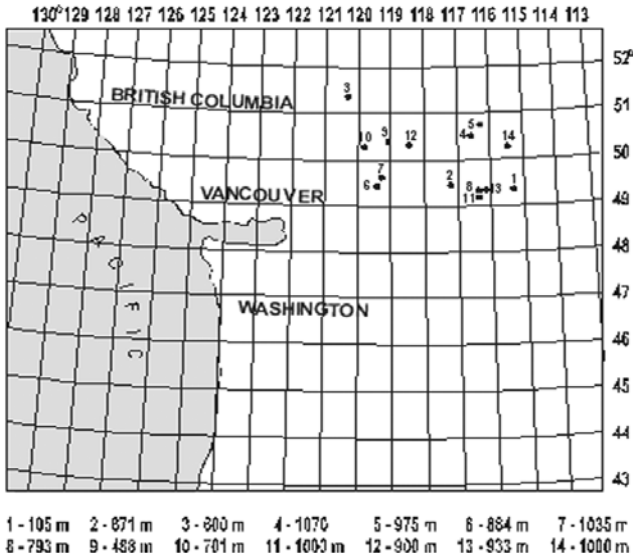
There is strong evidence that in woody plants, as in many other organisms, the transition from juvenility to sexual maturity is genetically controlled (Hackett, 1985, Greenwood and Hutchison, 1993, Greenwood, 1995). For this reason it is necessary to start with the control elements of growth in the juvenile stage of plant development.

2. MATERIAL AND WORK METHOD

As the material for this study, were used plants of fourteen Douglas-fir, which were produced in the Institute's nursery for forestry. Plant material was produced from the original seed of Douglas- fir, which comes from a part of Canada's natural range. Displaying origin provenance is given in Figure 1. Seeds were obtained through a forest seed centers 'Canadian Forest Service' from British Columbia. Table 1 presents the geographical characteristics of seed origin provenances of Douglas-fir and localities.

In the spring of 1999, the seeds were planted in containers. In April 2002, the seeds were transplanted in the nursery Sremčica, near Belgrade. The planting was conducted in rows, one provenance in one row. The distance between the rows was 2 m, while the distance between seedlings in a row was 1m.

In the end of vegetative season at 2003rd, the heights were measured of all plants in the experiment using a ruler, with an accuracy of 0.1 cm. The data were processed by a computer program STATGRAPHICS Plus. The statistical justification for the difference between the mean values of height was determined by LSD test with a probability of 95%. Influence of geographical origin provenances in height of seedlings was determined using Pearson's linear correlation coefficient



Picture 1. *Spatial layout chart of investigated provenances*

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

3. RESULTS AND DISCUSSION

Comparative analysis of medium height of fourteen Douglas-fir seedlings of different provenances from Canada, was conducted to determine the provenance variability and depending on the geographical characteristics of the seed origin.

The highest average height of 40.2 cm seedlings reached the provenances number five (30460), the provenances number three 38.9 cm (30667), and the lowest seedling the provenance number fourteen 25 cm (05092), the provenances number four 27.7 cm (05227), and the provenances number thirteen 28 cm (03 389), (Table 1).

Table 1. *Geographic characteristics of tested provenances*

Provenance		Location			Altitude (m)	Height (cm)
No.	Code		latitude	longitude		
1.	03333	Cranbrook	49°25'	115°20'	1050	28,4
2.	00848	Inonoaklin	49°50'	118°10'	671	37,8
3.	30667	Mann Creek	51°35'	120°10'	600	38,9
4.	05227	Gavia Lake	50°56'	116°35'	1070	27,7
5.	05226	Nine Bay	50°58'	115°32'	975	29,7
6.	03356	Trout Cr	49°40'	119°52'	884	30,5
7.	03360	Michell Cr	49°54'	119°37'	1035	29,1
8.	01198	Salmo	49°15'	117°30'	793	30,0
9.	30460	Mara Lk	50°48'	119°00'	488	40,2
10.	00278	Monte Crk	50°37'	119°52'	701	34,5
11.	03383	Sheep Creek	49°10'	117°15'	1000	35,3
12.	30461	Cooke Creek	50°38'	118°49'	900	32,2
13.	03389	Benton Creek	49°12'	117°25'	933	28,0
14.	05092	Sun Creek	50°08'	115°52'	1000	25,0

The statistical data indicates the existence of genetic variability in selected provenances of Douglas-fir from whose recognition depends heavily on the future success of the work on introduction.

Table 2. *Analysis of variance*

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6551,65	13	503,973	13,54	0,0000
Within Groups	11653,5	313	37,2317		
Total	18205,2	326			

Results of analysis of variance (Table 2) show a statistically significant difference at $p < 0.05$ between the mean height of seedlings, fourteen provenances of Douglas-fir.

Table 3. *LSD test*

Provenances	Mean	Homogeneous Groups
14	25,0	X
4	27,7	XX
13	28,0	XX
1	28,4	XX
7	29,1	XX
5	29,7	XX
8	30,0	XX
6	30,5	XX
12	32,2	XX
10	34,5	XX
11	35,3	XX
2	37,8	XX
3	38,9	X
9	40,2	X

LSD test were determined statistically significant differences between the mean height of seedlings of Douglas- fir provenances at confidence level $p < 0.05$. Provenances were grouped into six homogeneous groups which confirmed the high variability of the height of seedlings in fourteen provenances of Douglas-fir. In a homogenous group with the highest mean altitude of provenance are the provenances number: 9, 3 and 2, in the group with at least a high altitude provenances were the provenances number: 14, 4, 13 and 1 (table 3).

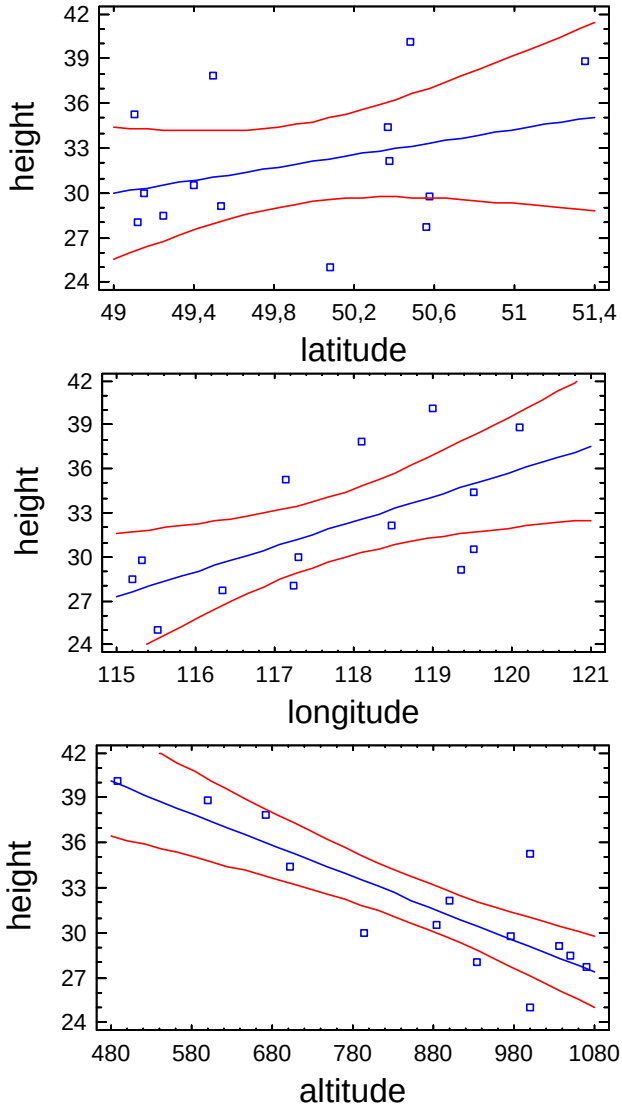
Influence of geographical origin provenance of Douglas-fir seedlings height was assessed by Pearson's linear correlation coefficient.

Table 4. *Geographic location and mean height correlation matrix of 14 Douglas-fir provenances, marked correlations are significant for $p<0.05$*

	Latitude	Longitude	Altitude	Mean Height
Latitude	1,00	0,2897	-0,3803	0,3271
Longitude		1,00	-0,6337*	0,6167*
Altitude			1,00	-0,8410**
Mean Height				1,00

On the basis of the Pierce coefficient values (table 4), it could be concluded that there is a positive correlation between latitude and mean height, but that correlation is not statistically significant.

There is a positive correlation between longitude and mean height and this correations is statistically significant. There is a negative correlation between altitude and mean height, and that correlation is statistically significant. A similar correlation was also established in the tests involving seeds of the same provenances (Lavadinović et al. 2004.), the same as in the tests with the average diameter (Popović and Lavadinović, 2011.).



Graph 1. *Latitude, longitude and altitude impact to a height of seedlings*

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

4. CONCLUSION

Maturing trees is characterized by elements of growth: height and diameter, so monitoring is in order to control genetic variation of seed transfer and environmental influences. Clearly, the potential for height growth is under strong genetic control, and the genetic potential is strongly moderated by the availability of resources in nursery conditions.

Developmental in height growth does not exhibit the environmental sensitivity or variability that is evident in absolute height growth or maximum height.

Variation in growth is associated with the geographic characteristic of the provenance.

This association suggests we can transfer seed sources a considerable distance without significant risk of maladaptation

Based on the obtained results it can be concluded that bares seedling height increased going from Eastern to Western provenances and from the southern to the northern provenances. With the rise of sea level height sizes are smaller and this effect is the most expresive.

Earlier genecological work showing Douglas-fir to be locally adapted and therefore seed transfer should be limited in new environment. For that reason the selection of best adapted provenaces is possible by testing the introduction species by provanance test.

Acknowledgement

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TESTING OF CANADIAN DOUGLAS-FIR HEIGHT IN JUVENILE PHASE

Vera LAVADINOVIĆ, Vladan POPOVIĆ, Emil POPOV, Vukan LAVADINOVIĆ

Summary

The European forest almost dominated by introduced, non-native, tree species which occur on a wide range of site conditions. They have found a place in the classification in European Forest Types. The new European Forest Types (EFTs-2006) are organized according to a hierarchical classification system structured into 14 Categories and 78 Types.

Introductions of forestry species were recorded for all regions, but the largest number of reports was for introductions to Africa (219 species). The dataset contained fewest records of forestry species introduced into Europe (95 species) and the Pacific (97 species).

The majority of forestry species for introduction, are with the purpose to improve the economical, production and marketing value of the forestry sector.

General observation is that the introduced species Douglas-fir is the most promoted in most countries of Europe

In Serbia, the program introduction, Douglas fir was initiated by placing provenijeničnog test with the original seed originating from North America. Continued with the establishment of a test douglas fir provenijeničnog originating in Canada.

This paper presents the results of the test height of Douglas- fir seedlings of different provenances of the original native seeds from Canada. Significant differences between provenances confirmed the validity testing of introduced species through provenance test.

TESTIRANJE VISINA KANADSKE DUGLAZIJE U JUVENILNOJ FAZI

Vera LAVADINOVIĆ, Vladan POPOVIĆ, Emil POPOV, Vukan LAVADINOVIĆ

Rezime

Evropskim šumama gotovo da dominiraju introdukovane vrsta drveća koje se javljaju na širokom spektru uslova staništa. Oni su našli svoje mesto u klasifikaciji evropskih tipova šuma. Novi evropski tipovi šuma (EFTs-2006) su organizovani prema hijerarhijskom sistemu klasifikacije koja su struktuirana u 14 kategorija i 78 vrsta.

Introdukcija šumarski vrsta zabeležena za sve regione, a najveći broj je u Africi (219 vrsta) a najmanji u evidenciji šumskih vrsta: u Evropi (95 vrsta) i Pacifiku (97 vrsta).

Većina šumskih vrsta za introdukciju, su sa ciljem da se unapredi ekonomska, proizvodna i tržišna vrednost šumskog privrednog fonda.

Opšte zapažanje je da je od introdukovanih vrsta Duglazija je njazastupljenija u većini zemalja Evrope.

U Srbiji program introdukcije duglazije započet je postavljanjem provenijeničnog testa sa originalnim poreklom semena iz Severne Amerike. Nastavljeno je sa osnivanjem provenijeničnog testa duglazije poreklom iz Kanade.

U radu su prikazani rezultati testiranja visina sadnica duglazije, različitih provenijencija sa originalnim poreklom semena iz Kanade.

Značajne razlike izmedju prvenijencija su potvrdile opravdanost testiranja introdukovanih vrsta putem provenijeničnog testa.