

CONTRIBUTION TO THE IDENTIFICATION OF DOUGLAS FIR (*PSEUDOTSUGA MENZIESII* (MIRB.) FRANCO) PROVENANCES PROMISING FOR AFORESTATION PRACTICE

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Abstract

Rapid growth is one of the most valuable characteristics of Douglas fir. In order to make the best use of this feature of its, it is necessary to investigate the growth characteristics of this tree species at level population. The objective of this research is to contribute in identifying promising provenances of Douglas fir in the experimental plantation in Konyavska Mountain. In order to attain the above objective methodologies for establishment and assessment of provenance experiments, early tests and statistics were applied. The average values for height of the trees for a period of five consecutive years: 5, 6, 7, 8 and nine as well as the current height increment for four years for each provenance in the trial plantation established with provenances from the states of Oregon, Washington, Arizona and New Mexico in State Forest Service Kyustendil were estimated. Based on data about the sums of precipitation and air temperature, drought and semi-drought periods were determined for corresponding years. The provenances are determined as promising if they meet the following two conditions: to be at the top of classification according to reached height and current increment in height, and to be of current increment in height influenced by the duration of dry and semi-dry periods to the least extent.

Key words: provenance experiment, height growth, current increment, drought resistance.

Introduction

Rapid growth is one of the most valuable characteristics of Douglas fir. In order to make the best use of this feature of its, it is necessary to investigate the growth characteristics of this fir at level population.

Experiments for testing different Douglas fir provenances began in the native land of this species as early as in 1912

(Morris 1934), and these go on even today in all countries it has been introduced in (Kleinschmit and Bastien 1992).

This article reveals the investigated main quantitative growth characteristics of Douglas fir, namely: heights of 5-, 6-, 7-, 8- and nine-year-old seedlings and current increment in height of 6-, 7-, 8- and nine-year-old seedlings.

The two main objectives of this work are as follows:

1. Assessing the provenances in terms of their growth and current increment in height;

2. Determining the provenances whose current increment in height has been affected to the least extent by the duration of dry and semi-dry periods.

Materials and Methods

The trial provenance plantation established in Kyustendil State Forestry in the spring of 1990 is the object of the present investigation. The plantation contains provenances from 20 seed zones in the states of Oregon, Washington, Arizona and New Mexico. Detailed data on the latitudes, and longitudes of the provenances, as well as their altitudes, were published in 1990 (Popov 1990). The provenance trials were in accordance with the methods that Lines developed in 1967.

The plantation was established while using square spacing of 2-metre intervals between each two seedlings. The trial was in two replications. Each experiment plot had sizes of 16 to 16 meters. The height of each seedling was measured with precision of 2 cm for five consecutive years. Thirty-six seedlings were measured as an average for each replication. Methods of descriptive statistics and one-way analysis of variances were used for finding the seedling height and the current increment in height. The reliability of the group comparison methods by Fisher, Bonferroni, Scheffe, Duncan and Tukey (Dowdy and Wearden 1983) was checked in view of determining the significance of the differences between the average values of seedling heights and current

increment in heights. Rank correlation analysis was used for finding the stability of the seedling current growth in height. Graph analysis and rank correlation analysis were used for finding the relationships between the current increment in seedling height and the duration of the dry and semi-dry periods.

The mean monthly and annual temperatures of the air were taken from the reference book of Moralyiski (1986), and the monthly and annual sums of precipitation – from the book of Koleva and Peneva (1990) about the meteorological stations in Bulgaria; I have used the data about Kyustendil Meteorological Station, as it is the nearest to the trial plantation.

Walter's (1972) methods were used for determining the duration of the dry and semi-dry periods. I have used two curves expressing the rates of monthly precipitation sums. These sums are presented for Curve 1 on the right ordinate scale in such a way that 20 mm of precipitation correspond to 10°C on the left ordinate scale. For Curve 2, the monthly precipitation sums are presented in bold also on the right ordinate scale in such a way that 30 mm of precipitation correspond to 10°C on the left ordinate scale. The duration of dry periods, when there were such, is presented graphically in the diagrams, (Walter has called them 'ecological diagrams'.) Dry are the periods, presented on the abscise scale. For these periods, the curve that expresses the rates of the mean monthly temperatures passes above Curve 1. Semi-dry are the periods presented on the abscise scale, and the curve that expresses the rates of the mean monthly temperatures passes above Curve 2.

Results and Discussion

Growth in height is one of the main quantitative characteristics that are used for finding the productivity and often viability of plants while testing various tree species, provenances and progenies. For the heights and current increments of seedlings of all the investigated provenances, the following values were found in cm: arithmetic mean (\bar{X}), standard deviation (σ), and standard error (α). The check of the precision of all mean values met the precision criterion of such investigations $p \leq 5\%$. The generalized results are presented in Figures 1 and 2. Analyses of variances were made for the reached heights and current increment in height of the trees.

Group comparisons in which Fisher test (after Dowdy and Wearden) was used made it possible to determine 14 good provenances as follows: No 4 Newhalem, No 31 Idanha, No 5 Newhalem, No 20 Parkdale, No 7 Darrington, No 8 Darrington, No 11 Bremerton, No 6 Darrington, No 9 Monroe, No 34 Toledo, No 29 Idanha, No 43 Oakridge, No 12 Moclips и No 10 Bremerton. These provenances were subdivided according to Fisher's test into four homogenous groups. The average height of each of these provenances exceeds by 10% the average for the whole trial plantation, i.e. $(\bar{X} + 10\% = 254.2 \text{ cm})$. Four of these 14 provenances have average heights each exceeding average height for the plantation by 20%, i.e. $(\bar{X} + 20\% = 277.3 \text{ cm})$. Ac-

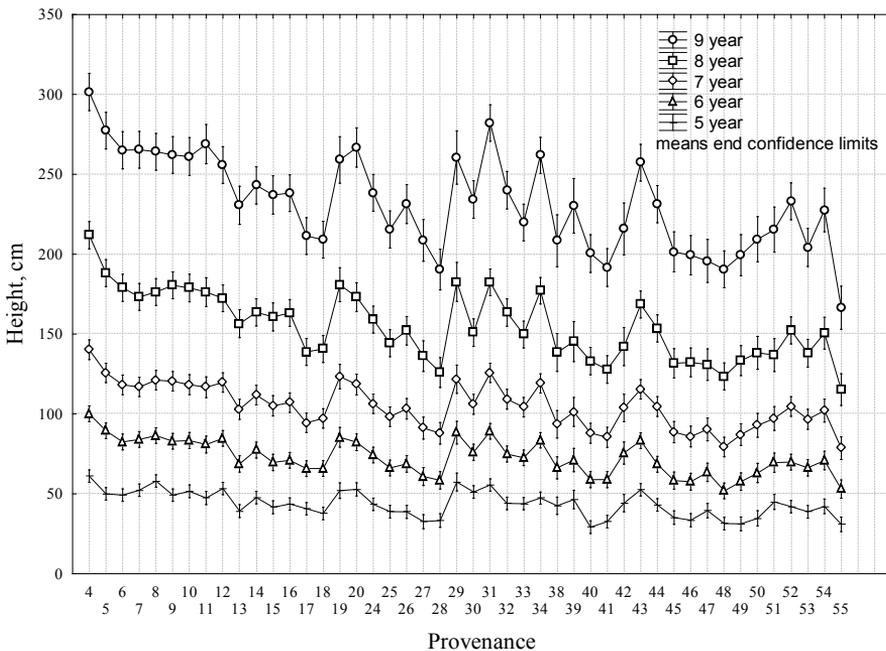


Fig. 1. Height growth of Douglas fir provenances in the age interval of 5 to 9 years.

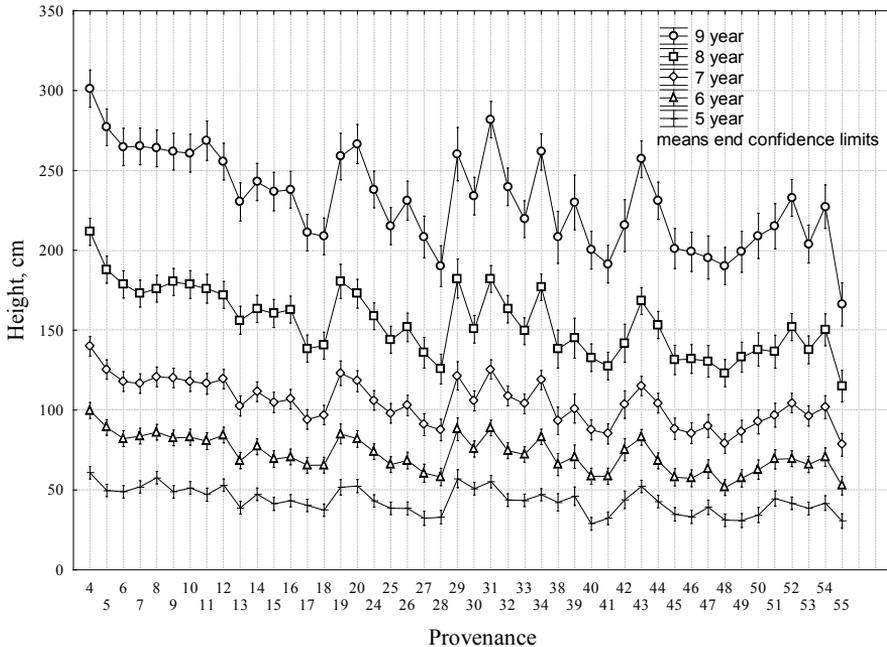


Fig. 2. Current height increment of Douglas fir provenances in the age interval of 6 to 9 years.

ording to the test these 4 provenances were subdivided into two homogenous groups.

The results obtained were compared with results pertaining to the set of provenance trials of IUFRO, which includes 182 provenances tested on the territories of 22 European countries (Kleinschmit and Bastien 1992).

These trials clearly show that provenances from the provinces in the Coastal Regions, the western part of the Cascade Mountains in the State of Washington, and the western part of the Cascade Mountains in the state of Oregon have good adaptiveness and growth in the most of the regions of testing. It must be pointed out here that these are regions of extremely great differences

in climate. Be speaking of the countries Denmark, Belgium, France, Italy, Great Britain, Turkey, the Canadian province of British Columbia and Germany.

The rank correlation analyses showed very great positive relationships between the average heights and increments. The results obtained show a distinct stability of the changes in the average heights and increments of the trees according to provenances. This makes it possible to carry out early testing and assess the growth in height of the provenances tested.

Plant organisms need particular environmental conditions for the normal occurrence of their growth and development. High temperatures and droughts are among the most unfavorable cli-

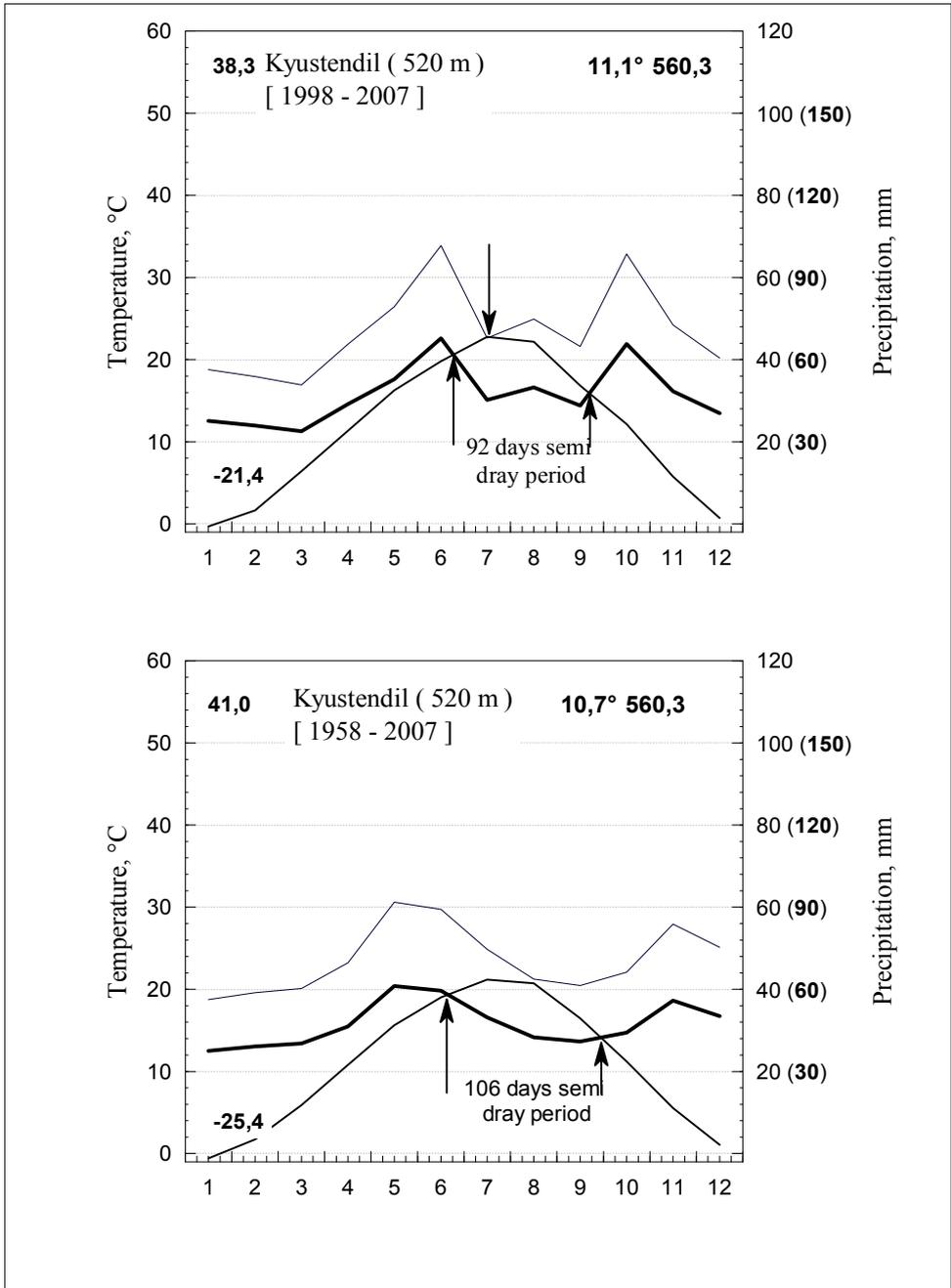


Fig. 3. Ecological diagrams 1.

matic conditions. In the Temperate Climatic Zone, the duration of hot and dry period affects negatively the current increment of trees.

Ecological climatograms have been made in accordance with Walter's methods. These are presented on Figures 3 and 4. The main climatic characteristics taken into consideration were the air temperature and precipitation sums for the last decade, the whole period that there is available information about, and the period when average values were found for the current increment in height of the trees of the provenances tested in the trial plantation in Kyustendil State Forestry. These climatograms provide particular visual information about the climatic conditions and their changes during the above mentioned periods of time.

The semi-dry periods determined for the years 1958–2007, 1998–2007 and 1991–1995 were respectively 106, 92 and 102 days. During the last interval of time the current increment of trees was determined, the availability was found of not only a semi-dry period but also of a dry one lasting 26 days.

This circumstance shows aggravation of the average values of temperature and precipitation during the growing season within the time interval that is of interest in connection with this investigation, and it provided the reason for more detailed analyses.

Climatograms have also been prepared for each particular year when current increment was found; based on these the availability and durations of the semi-dry and dry periods were determined with precision of 1 day. The values obtained are as follows: dry periods in 1995 – a total of 13 days, in

1994 – a total of 90 days, in 1993 – a total of 94 days, in 1992 – a total of 76 days and semi-dry period in 1995 – a total of 31 days, in 1994 – a total of 188 days, in 1993 – a total of 187 days, in 1992 – a total of 126 days.

The duration of the dry and semi-dry periods was compared with the current increment in height of the seedlings of all the provenances investigated. It was found out that the current increment diminished as dry period duration increased.

The correlation coefficients expressing the relationship between dry period duration and the current increment of the seedling in height, for all the provenances in trial had negative values as they varied from $R = -0.95$, for Provenance 42 Oakridge (OR) to $R = -0.70$ for Provenance 29 Idanha (OR). The low values of the correlation coefficients in this trial show lower dependence of current increment in height on the unfavorable conditions expressed as availability and duration of dry and semi-dry periods in each particular year.

Conclusion

Provenances 4 Newhalem, No 29 Idanha and No 10 Bremerton have been determined as promising. They meet the following requirements: to be at the top of classification according to reached height and current increment in height, and to be of current increment in height influenced by the duration of dry and semi-dry periods to the least extent. We consider the methodological approach used genuine and therefore, deserving greater attention while assessing tree species and provenances in trial plantations.

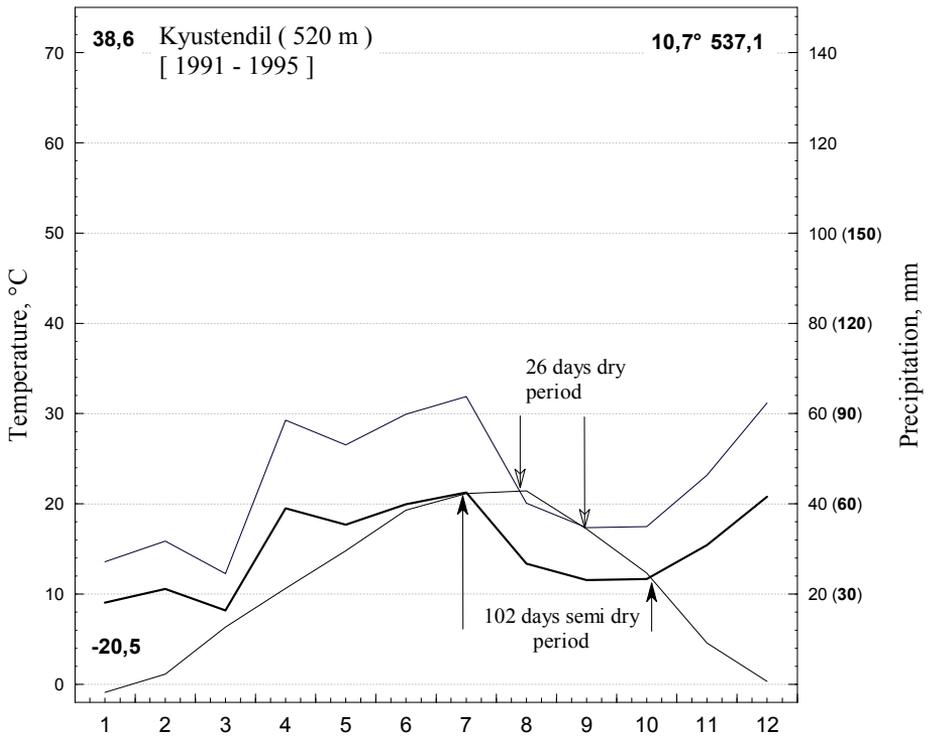


Fig. 4. Ecological diagrams 2.

References

- Dowdy S.**, Wearden S. 1983. Statistics for Research, Wiley Series in Probability and Mathematical statistics, Applied Probability and Statistic Section, John Wiley and Sons, New York, 537 p.
- Kleinschmit J.**, Bastien J.C. 1992. IUFRO's role in Douglas-Fir (*Pseudotsuga menziesii* (Mirb. Franco) tree improvement. – *Silvae genetica*, vol. 41 (3): 161–173.
- Koleva E.**, Peneva R. 1990. Climatic Reference book, Precipitation in Bulgaria, Publishing House of BAS, Sofia. (In Bulgarian)
- Lines R.** 1967. Standardization of Methods for Provenance Research and Testing XIV IUFRO – Congress, Munchen, vol. III: 672–718.
- Moralyiski E.** 1986. Climatic Reference book for PRB, Air temperature in Bulgaria, Science and Art, Sofia. (In Bulgarian)
- Morris W.G.** 1934. Hereditary Test of Douglas Fir Seeds and their Application to Forest Management. *Journal of Forestry*, 1934, vol. 32: 11–17.
- Popov E.** 1990. The influence of Douglas-Fir (*Pseudotsuga menziesii* (Mirb.) Franco) seed provenances on the growth in the height, terminal but formation and the frost resistance of one year old seedlings. – *Nauka za gorata* (Forest science), 3: 3–17. (In Bulgarian)
- Walter H.** 1972. Vegetation of the Earth and Ecological System of the Geo-biosphere. Verlag Eugen Ulmer, Stuttgart: 25–27.