OPINION

on the thesis for the degree of Doctor of Science in area of higher education 6. **Agricultural sciences and veterinary medicine,** professional field 6.5. ***Forestry***, scientific speciality ***Forest plantations, breeding and seed production***

Author of the thesis: Krasimira Nikolova Petkova-Tzolova, assoc. prof., PhD, Faculty of Forestry, University of Forestry, Sofia

Subject of the dissertation thesis: „A potential for adaptation of Douglas fir and Common Beech to climate change"

Member of the scientific jury: Veselka Atanasova Gyuleva-Pantova, assoc. prof., PhD, Forest Research Institute – BAS, area of higher education 6. Agricultural sciences and veterinary medicine, professional field 6.5. *Forestry*, scientific speciality *Forest plantations, breeding and seed production,* appointed as a member of the scientific jury with the Order No ЗПС-636./28.11.2019 of the Rector of the University of Forestry.

1. Short biography of the applicant. After completing her secondary education in 1976, Dr. Krasimira Petkova also completed the full five-year higher education course in forestry (University of Forestry, Sofia) in 1981. In 1990 she acquired the educational and scientific degree "doctor" with her PhD thesis "On the breeding of Douglas fir (*Pseudotsuga menziesii* Mirb.(Franco)) in some regions of the Balkan Range". From 1988 until now Dr. Krasimira Petkova works at the University of Forestry, Sofia and has consecutively achieved the academic positions "assistant professor", "chief assistant professor" and "associate professor". She is a lecturer in the subject "forest plantations". In the light of improving and enhancing her teaching and research capacity, I find out her participation and successfully defended courses and training programmes over the last ten years, as well as her participation in various national and international scientific projects very useful. She is fluent in Russian, German and English languages.

2. Actuality of the thesis. The present dissertation, developed on 199 pages, is a result of the long-term studies on the survival rate, growth performance and bioproductivity of seed-originated Douglas fir (*Pseudotsuga menziesii* Mirb. (Franco)) populations from different regions of the USA, Germany and Bulgaria , as well as common beech (*Fagus sylvatica* L.) geographic provenances from different German and Bulgarian geographical regions and tested on different locations in Bulgaria (so called provenance trials). The correlation between plant height as a quantitative trait and some climatic components of the various seed-originated populations and the newly established geographical plantations have been analysed, synthesized and summarized. Geographical seed-originated populations with potential for successful adaptation to further climate change are identified, as well as seed-originated populations suitable for further breeding are suggested. The obtained results are a basis for further optimization of the concordance between the corresponding soil-climatic conditions and the selected populations of the tree species, as well as for the development of the further programs for assisted migration of Douglass fir and Common Beech. All this makes the dissertation work favourable and meaningful in the near future.

3. Degree of knowledge of the problem state and creative interpretation of the literature review. The literature review is very well structured on 43 pages, introducing the reader to the issues of climate change and the role of tree species. In particular, the possibilities of the provenance testing, including plantations of different seed-originated populations of Douglas fir and common beech, have been analysed as an important indicator of the compliance between the climatic indices and habitat conditions as a result of the transfer from long-range reproductive materials. The methods for analysing of the growth response to climate change and assisted migration are also reviewed. It is obvious that Dr. Krasimira Petkova is well-informed and she is extremely skilful in analysing and synthesizing what she has achieved so far in the topics she has developed.

4. Main purpose, tasks, hypotheses and methods of the research. Relevance of the chosen research methodology with the stated purpose and tasks of the dissertation. The main purpose of the thesis is realistic and clearly stated. It focuses on the evaluation of the potential of different provenances of Douglas fir and common beech seed-originated populations to response to climate change. Seven major scientific tasks have been formulated to assess the transfer from place of origin to the place of growth, the latter reflecting differences in climatic conditions. In general, various methods, both specific to phenological, morphological and taxation studies, as well as the well-known statistical techniques and approaches by using the capacity of R-statistics, have been mastered and applied by the applicant for the accomplishment of the assigned scientific tasks.

5. Visualization and presentation of obtained results. The presented scientific results are illustrated through 55 figures, 32 tables and 10 annexes. The figures and tables are precisely designed. The obtained results are presented in several major areas and they are subordinated to the overall purpose and objectives of the study.

Based on an analysis of basic phenological and morphological features, it has been found out that the continental origin of Douglas fir has an earlier onset of vegetation and a higher survival rate comparing to the seed-originated Douglas fir plants acquired from the coast. The classification distribution through the ABC analysis of the average height clearly distinguishes the 24 provenances belonging to class A (the fastest growth). Other 13 provenances belonging to class C and classified as the slowest-growing plants of Douglas fir, retained this position for the entire studied period.

The correlation between the difference in the average minimum temperatures of the place of origin and that of the place established in Bulgaria and the difference between the average heights of each origin and the average height of the local origin is statistically analysed. Regression models have been found out, which prove that negative differences in the temperatures and the positive values of the relative heights are strong indicators of reaching higher values of the heights of the non-native origins compared to the local origins. In doing so, these better origins have been identified. On the basis of the transfer distance, it has been shown that the origins transferred to a colder winter have a higher height growth than the native origin compared to those displaced to a warmer winter.

Based on the relationship between the relative heights and the difference in the continental index, it has been shown that as the difference in the continental index increases, the relative height increases, too. In other words, a part of the non-native origins has higher heights than the local originated plants. A regression model has shown that all continental seed-originated populations have been transferred to wetter conditions, while the coastal and western Cascade Mountains seed-originated populations have been transferred to significantly drier conditions. Most continental seed-originated populations have lower heights than native seed-originated populations. Seed-originated populations growing at an average annual temperature of 9.4^{0}C

have been found out to have optimal growth. Half of the seed-originated populations transferred from the cooler summer by 5.6^{0}C compared to the geographical one show better growth than the local seed-originated populations, based on diameter growth, mechanical stability and stem volume and productivity.

For the investigated seed-originated populations of common beech it is proved that the Bulgarian seed-originated populations differ in earlier full-leaf appearance than the German ones. A statistically significant correlation between the average date of dispersal and the longitude of the seed-originated population has been demonstrated. This dependence has also been found out for the autumn coloration of leaves. The seed-originated populations of common beech with the highest survival and height growth rates have also been identified. Bulgarian seed-originated population Petrohan retains its leading position. It has been proven by the Elenberg coefficient and the eco-distance that the transfer of Bulgarian and German seed-originated populations is towards drier and warmer conditions in Varbitsa and Vidin, and in Kipilovo - towards cooler and wetter conditions. The effect of habitat conditions on the plant height is strongly statistically proven. Growth rates in height have been found to slow down, both in wetter and drier conditions, based on environmental distance analysis. The location of the seed-originated population has been shown to be similar. It is proved that under extreme conditions of the environment with the best growth preservers are Bulgarian seed-originated populations from altitude up to 900 m a.s.l. German and Bulgarian seed-originated populations in warmer climates have been shown to have similar growth rates in height.

6. Discussion of results and literature used. In order to write this thesis, the author has used 355 titles, 56 of which are in Cyrillic and 299 in Latin. The information obtained from them is cleverly and adequately used to analyse and summarize the results obtained in this work.

7. Contributions to the thesis. I accept the Thesis Contribution Report developed and presented by the Applicant in this way.

8 Assessment of the degree of the dissertation's personal participation in the contributions. I take the author's achievements in this dissertation as a personal matter.

9. Critical notes and questions. I have no critical remarks.

However, I have a question to the author. If in the statistical analyses the diameter of the plant is used as a variable instead of its height, would the results presented by the ABC analysis be confirmed?

10. Published articles and citation. In the topic of this dissertation, 13 publications were published, 4 of which were published by the author, 6 are published by Krasimira Petkova as first author and 3 - as second author. Their cumulative impact factor is 1.603. The total number of citations was 38, including in specialized publications with a high impact factor.

11. Assessment of dissertation publications: number, nature of publications in which they are printed. Reflections in Science - Used and Cited by Other Authors. More than half of the articles have been published in specialized scientific journals, referenced and indexed in a worldwide database of scientific information. A sufficiently large number of citations in international publications with high impact factor have been noted. The number and characteristic of the publications meet the national minimum requirements of the Development of the Academic staff act in the Republic of Bulgaria and the Regulations for its implementation

at the University of Forestry.

The submitted abstract reflects objectively the structure and content of the dissertation.

CONCLUSION:

On the basis of the various methods of research, correctly performed experiments, drawn conclusions, I believe that the presented thesis meets the requirements of the Development of the Academic staff act in the Republic of Bulgaria and the Regulations for its implementation at the University of Forestry.

I PROPOSE ASSOC. PROF. Krasimira Nikolova Petkova-Tzolova to obtain the scientific degree **"Doctor of science"** in the area of higher education 6. ***Agricultural sciences and veterinary medicine***, Professional field 6.5. ***Forestry***, scientific speciality ***Forest plantations, breeding and seed production.***

Date: 10.02.2020
Sofia

Signature: .....
(Assoc. Prof. Veselka Gyuleva, PhD)