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ПИХТА ДУГЛАСА – ХВОЙНОЕ ДЕРЕВО 22 ВЕКА? ОБЗОР ПОСЛЕДНИХ ЛИТЕРАТУРНЫХ ИСТОЧНИКОВ ЧЕХИИ

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В данной статье обобщены знания о выращивании пихты Дугласа (Pseudotsuga menziesii /Mirb./ Franco), её продуктивности, а также непроизводственных лесных функциях в условиях Чешской Республики / Средней Европы. В статье анализируются результаты исследований с точки зрения объема и стоимости производства по сравнению с отечественными породами деревьев, с точки зрения воздействия на почвы и разнообразие наземной растительности, а также с точки зрения стабильности и выращивания в последнее время. Основная цель - сравнение с елью обыкновенной, которая может быть успешно заменена вышеупомянутой породой с благоприятным воздействием на объем и стоимость производства древесины, на почвы и статус биоразнообразия наземной растительности. Ель обыкновенная сильно подвержена негативным воздействиям и находится под угрозой из-за приближающихся или предполагаемых климатических изменений. Также стабильность лесных насаждений может быть значительно поддержана заменой ели обыкновенной пихтой Дугласа. Эта порода может представлять подходящую альтернативу ели обыкновенной на возвышенностях и среднегорьях; это может способствовать высокой конкурентоспособности не только Чешского, но и Европейского лесного хозяйства в целом, повышая уровень стабильности и производства, уменьшая негативное воздействие изменения пород деревьев в прошлом.

Ключевые словаs: пихта Дугласа, производительность, влияние на почву, влияние на биоразнообразие, замена ели обыкновенной

DOUGLAS-FIR – SPRUCE FOR THE 22ND CENTURY? REVIEW OF THE RECENT CZECH LITERATURE

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Abstract

Presented paper summarizes the knowledge concerning the cultivation of Douglas-fir (*Pseudotsuga menziesii* /Mirb./ Franco), its production as well as its non-production forest functions in the condi-

tions of the Czech Republic/Middle Europe. It analyzes the research outcomes from the point of view of volume and value production in comparison with domestic tree species, from the point of view of the soil effects and effects on the ground vegetation diversity, and from point of view of stability and cultivation in the last period. Main aim is represented by the comparison with the Norway spruce, which can be with advantages replaced by this species, with favourable impact on amount and value of the timber production, on the soil and biodiversity status of the ground vegetation. The Norway spruce is heavily affected and endangered by the coming or supposed climatic changes. Also the stability of forest stands can be supported considerably replacing Norway spruce by Douglas-fir. This species can represent suitable alternative to the Norway spruce in lower and middle altitudes and it can contribute highly to the competitiveness not only of the Czech, but European forestry too, increasing stability and production, decreasing the negative effects of the tree species changes in the past.

Keywords: Douglas-fir, production, soil effects, biodiversity effects, Norway spruce substitution

Introduction

Douglas-fir (*Pseudotsuga menziesii* /Mirb./ Franco) represents an introduced tree species with the highest importance among those from the World temperate vegetation zone. In many countries, it was planted on large areas with high economic benefits (Britain, France, Germany), reaching hundreds of thousands of ha. In the Czech Republic, there are cca 5,800 ha of Douglas-fir plantations, increasing by some hundreds ha each year [10, 26]. On the other side, Norway spruce (*Picea abies* /L./ Karst.), as the most important native species, has many problems connected with climate extremes (climate change), manifesting as large-area spruce decline, especially in the border area: Czech Republic, Poland, Slovakia. Partial replacing of Norway spruce by Douglas-fir is so desirable in lower altitudes and on locations with lower precipitations [15, 18]. Relatively detailed research started in Europe reflecting importance of Douglas-fir in the future in many countries of the Western and Central Europe. Aim of the presented paper is completely document the production and environmental effects of this species basing especially on original studies in the conditions of the Czech Republic. Aims of the presented review is to actualize the knowledge concerning use of Douglas-fir in the Central-European conditions, especially in the Czech Republic, and promote and develop the formerly presented reviews [10, 15].

Planting material origin

The selection of a proper provenance is crucial for introduction of any tree species. Accordingly to the recent knowledge, the Douglas-fir provenances from the coastal zone of the North American Pacific region seem to be the best for European conditions, especially for W-European countries. For the Central Europe, more interior provenances are more suitable probably [9]. Also in other European countries, the populations originating from more continental climate could be suitable [2, 13, 19]. In many regions, the selected, well-adapted populations are available, because this species is planted for more than one century and the local conditions selected the most adapted genotypes, disposable both for natural as for artificial regeneration. The seed, or planting material source remains one of the most important topics for broader Douglas-fir use. The plantations of this

species can develop successfully not only in the most favorable conditions, but also in the areas with quite extreme, hot and dry, mezzo-climate and with low mortality.

Production of the Douglas-fir

The superiority was documented of the Douglas-fir to other species growing in comparable conditions in many studies and papers throughout the World. On specific sites, only Grand fir can compete this species [3]. In majority of other sites studied, Douglas-fir (DF) did show the highest growth and production potential [10]. On the other side, there are still many methodological problems and misundestandings. E.g. PETRÁŠ and MECKO [14] provided the production modelling of several main economic species basing of yield tables and site indexes. They document the results showing lower volume as well as value production of the Douglas-fir comparing to silver fir (*Abies alba*) and Norway spruce (*Picea abies*) by 26-35 % or even beech (*Fagus silvatica*) by 22 %. Reason for these results is considerable lower density of the Douglas-fir stands at the same stand heights comparing to other species, given by its ecological demands. But, on the contrary, this approach fails for the simple fact, that on the same site, the Douglas-fir reaches much higher height and diameter growth comparing to other species [5, 6, 7, 8, 22].

Studying individual tree growth and production, opposite extreme is observed. For example, KANTOR et al. [7, 8] documented in the stands of middle age (age 68 years, mixed stands – Scots pine, European larch, oak, beech, hornbeam, lime tree) a dominant production role of the Douglas-fir. The volume of individual Douglas-fir trees reached up to 2.9 m^3 at the given age, supposing even 6m^3 at the age of 100 years. Authors recommend Douglas-fir admixture at the level 10-30%.

Similarly, KANTOR [5] evaluated the Douglas-for production at more rich, i.e. mesotrophic sites of the Křtiny Training Forest Enterprise (MENDELU Brno) at the age of mature stands. There were 29 mixed stands surveyed assessed in total, with considerable occurrence of Douglas-fir at an age of 85 to 136 years. In each stand, 10 largest Douglas-firs with the 10 largest Norway spruces or European larches were compared as for height, DBH and standing volume. Significantly higher production potential of the Douglas-fir was found in all assessed stands. There were registered tree groups where the volume of Douglas-fir was 2 to 3 times higher than the volume of spruce or larch. For example, the mean volume for 10 tallest trees in one determined stand was recorded as 9.12 m^3 for Douglas-fir, 3.17 m^3 for spruce and 3.70 m^3 for larch. Annual ring analyses have shown that at present the volume increment of particular Douglas-fir trees ranges from 0.12 to 0.16 $m^3.yr^{-1}$ in these mature stands (i.e. roughly 1.5 m^3 during the last 10 years).

This team [6] continued also with the study of Douglas-fir production potential at acid sites of the Hůrky School Forest (Písek, South Bohemia), using the same methodology. In total, 17 mixed stands with the presence of Douglas-fir at the age of 88 to 121 years were assessed. Comparing 10 Douglas-fir trees with 10 Norway spruce, Scots pine or European larch trees of the largest volume, higher and generally significantly higher production potential of the introduced Douglas-fir was always found in all assessed stands again, in similar extend as in the previous case. In one of the measured stands, the mean volume of the 10 largest Douglas-fir trees was

6.30 m^3, comparing to only 1.93 m^3 for spruce and 2.25 m^3 for larch. The volume increment determined on the base of particular Douglas-fir tree ring analyses ranged between 0.06 to 0.10 $m^3.year^{-1}$.

More relevant comparison is offered by the analysis of even-aged stands of particular tree species on comparable sites. One of published cases describe Podrázský, Remeš [16], comparing mixed broad-leaved stand (69 years, mixture of oak, hornbeam, lime tree) with Norway spruce (61 years) and Douglas-fir (45 years), growing on the same site (420 m a.s.l., 8.5 ºC, 550 – 650 mm annually, luvisol). Standing volume reached the values 266 m^3ha^{-1} (broad-leaves, 507 m^3ha^{-1} (Norway spruce) and 579 m^3ha^{-1} (Douglas-fir) respectively. The corresponding mean annual volume increment was 4.43, 8.45 and 13.87 $m^3ha^{-1}.a^{-1}$ respectively.

Another study documents production (and soil forming) function of particular tree species on afforested agricultural land [17]. The stands of the age 39 years were compared on the locality, established as even-aged plantations of Norway spruce, Scots pine, birch and Douglas-fir. The site is characterized by altitude 430 m a.s.l., mean annual temperature 7.5 ºC, mean annual precipitation 600 mm and soil type gleyed-luvisol to pseudogley (University Training Forest Kostelec nad Černými lesy). In these conditions, the values for mean stem reached 20.6 m of height and 19.5 cm of dbh for Scots pine, 20.1 m of height and 19.5 cm in dbh for Norway spruce, 24 m of height and 21.4 cm in dbh for birch and finally 21.6 m of height and 23.8 in dbh for Douglas-fir. Considering the stem number per ha (calculated) as much as 1408 (pine), 1157 (spruce), 440 (birch) and 928 pcs/ha (Douglas-fir), this represented 352.1, 349.4, 157.1 and finally 438.6 m^3/ha, showing Douglas-fir as the most productive species in given conditions.

Finally, PULKRAB et al. [20] modelled the economic effects of the Douglas-fir cultivation in the range of the whole Czech Republic. They used the possibilities, given by the Czech legislation and Forest Management Plans recommendations. They concluded, that there is potential for Douglas-fir cultivation on 149,616 ha to 163,713 ha (today 5,800 ha) at the national scale, representing 5.7 to 6.2 % of the stand area (today 0.22 %). The potential value increment ranged so between 25-28 mil. EUR per year for the whole Czech Republic. Replacing of the Norway spruce in lower altitudes by Douglas-fir seems to be very realistic and effective from the economical point of view. Very high value of the production potential was confirmed also by Podrázský et al. [18], documenting superior volume as well as value production both on local and national basis.

Silviculture of the Douglas-fir

Comprehensive summary of the silviculture approaches as well as of the newest research knowledge is given in the publication of SLODIČÁK, NOVÁK [23]. The problems of the forest stand establishing both by artificial, both by natural regeneration are well managed in the practice, the proper adaptation of the stand density is desirable. Douglas-fir reacts well on the thinning treatments and it has highly stabilizing effects in the forest stands. It is more demanding in relation to the water resources, but it is prospering better on the dryer sites on the contrary, comparing to the Norway spruce. There are described very well growing tree species mixtures with Douglas-fir, the most common with the Norway spruce again. The optimal admixture of Douglas-fir ranges between 20-40 % of the tree

individuals, in this case, there is a peak of the stand basal area as well as volume. Young individuals tolerate some shelter and there is option for shelter and border cut application [24], this species represent also very good alternative for the afforestation of abandoned and marginal agricultural lands [4]. The sources for further propagation need much better management [11].

Soil effects of Douglas-fir

Our original as well as other studies confirmed soil improvement (or neutral) effects of the Douglas-fir in broader European conditions, always positive in comparison with the Norway spruce [1, 10]. In the more detailed case studies ULBRICHOVÁ et al. [25] evaluated the effects of Douglas-fir and Norway spruce on the soil characteristics and humus accumulation in the middle altitudes (410 m) and middle aged (cca 50 years as well as mature stands (99 years) in the Kostelec nad Černými lesy area. For both species, soil characteristics describing acidity, sorption complex characteristics, quantitative characteristics of humus profile and amount of total and accessible nutrients were compared. The holorganic horizons acidity was significantly lower by (-0.75 pH) as well as exchangeable H^+ and Al^{3+} ions content (two times lower) in Douglas-fir stand compared with the Norway spruce stands. More favorable conditions of qualitative soil sorption complex characteristics were also confirmed in Douglas-fir stand, with significantly higher base saturation and total base content (both two times higher values). Accessible nutrients content in the upper organic horizon differed significantly for calcium and magnesium (in all organic horizons), and also for potassium and phosphorus in the upper organic horizons, with higher content in Douglas-fir stands again. Total nutrients content differed only in the case of calcium with higher values in Douglas-fir stand. In the study area, positive effect of Douglas-fir on the soil characteristics compared with Norway spruce was fully confirmed. Comparing to another domestic coniferous tree species, Douglas-fir acidifies less the upper soil layers and contributes to origin of better humus forms. It recycles nutrients more effectively and produces litter which is easily decomposed and transformed. It could be considered as an appropriate partial substitution for Norway spruce in corresponding site conditions. Very similar results were obtained by MENŠÍK et al. [12].

Effects of Douglas-fir on the biodiversity - plant communities

The biodiversity aspect is also vitally important -.to this moment, only the Douglas-fir effects on the ground vegetation were studied in larger extent. The most recent study is represented by PODRÁZSKÝ et al. [18]. In total, 67 parallel plots were chosen from the database of 153 phytosociological relevés made in the Douglas-fir and parallel Norway spruce, European Beech and oaks dominated stands to find influences of this introduced tree on the understory layer in totally 12 localities on the whole Czech Republic territory. Douglas-fir stands influence their habitats, which was indicated by species composition changes in the ground vegetation, as well as by abundance and dominance of particular species. Douglas-fir cultivation increases species diversity of the stands, but decrease their abundance. Described differences in understory are not so noticeable, when European beech and Sessile oak stands are substituted by Douglas-fir once. But even the significant phenomenon of striking nitrophilous species occurrence as *Geranium robertianum*, *Urtica dioica* and *Galium aparine* manifests here. This indi-

cates conspicuous content of available nitrates in the humus and top of the soil horizon. This research demands more data to be obtained in the future, as well analyses of this species on other biota compartments are desirable.

Conclusions

The comprehensive research oriented on the Douglas-fir confirmed its position as a very promising tree species. There are documented relatively high production effects, the timber of this species being of good quality, comparable to Norway spruce or European larch [21]. Its share in the stand structure should represent cca 20-40 % of the individuals, regularly distributed. In this case, the production potential of the forest stands should increase considerably, with visible effects related to higher stability of the stands, improved humus as well as soil status, comparing to other coniferous species. Also the biodiversity of the ground vegetation will be affected less negatively, comparing to more common conifers such as Norway spruce, Scots pine or European larch. There is clear and positive potential of this species, to partly replace the Norway spruce in lower altitudes, where this species suffers because of climate change and/or extremes.

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ОЦЕНОЧНЫЕ КРИТЕРИИ КАЧЕСТВА ПЛОДОВ ОРЕХА ГРЕЦКОГО В ЦЕНТРАЛЬНОМ ЧЕРНОЗЕМЬЕ

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Для полноценного воспроизводства устойчивых и продуктивных лесных и садово-парковых насаждений необходимо проведение акклиматизации перспективных видов древесных растений в современных условиях климатических изменений и антропогенного процесса. Улучшение состоя-