Düzce University Faculty of Forestry
Journal of Forestry
(DUJOF)

Journal of Forestry Volume 18, Number 1, pp. 69-76
Category: Research Article

https://dergipark.org.tr/tr/pub/duzceod
ISSN 2148-7855 (online), ISSN 2148-7871
Düzce University Faculty of Forestry

Long-Term Growth Comparisons Of Douglas-Fir (*Pseudotsuga menziesii*) With Some Of The Native Tree Species In The Western Black Sea Region Of Turkey

Türkiye'nin Batı Karadeniz Bölgesinde Yetişen Yerli Ağaç Türleri ile Douglas-Göknarının (*Pseudotsuga menziesii*) Uzun Vadede Büyüme Performasının Karşılaştırılması

Oktay YILDIZ[1*], Mehmet ŞAHİN[1]

Abstract

Douglas-fir (DF, Pseudotsuga menziesii (Mirb.) Franco is the first introduced and most promising exotic tree species for industrial wood production, and for this species, very detailed experiments were conducted. However, experiments with different origins of DF revealed unsuccessful results in a significant number of sites in the eastern and western Black Sea Region (BSR) of Turkey. The aim of this study is to compare the growth of DF trees as a fast-growing introduced tree species with those of some of the native tree species at the plantation age of year 17. The study area is located in the Melen Forest Management Chiefship of the Düzce Forest Management Directorate in the western BSR of Turkey. 17 years after planting, the soil pH on DF and the Scotch-pine (SP, *Pinus sylvestris* L.) sites were about 0.3 units lower than that on an eastern beech site (*Fagus orientalis* L). At the 17th year of stand establishment, beech trees accumulated 3.4 and 1.7 times more biomass than did Scotch pine (SP) and DF. In terms of plant nutrition, mean foliage nitrogen concentration in beech and hornbeam (*Carpinus betulus*) foliage was 57 and 117% higher than those in SP and DF foliage, respectively. Data implies that wood production can be increased by selecting superior genotypes and proper cultural treatments that will boost the production of native, fast-growing tree species. And this production can be higher that some of the well-known fast growing exotic species.

Keywords: Douglas-fir, plantation, biomass, fast-growing- species, Turkey

Özet

Duglas göknarı (DF, Pseudotsuga menziesii (Mirb.) Franco odun üretimi bakımından vaad eden bir tür olarak ilk olarak getirilip en çok denemesi yapılan türlerdendir. Fakat gerek doğu ve gerekse batı Karadeniz bölgesindeki birçok sahada farklı orijinlerle yapılan denemeler beklenen başarıyı gösterememiştir. Bu çalışmanın amacı hızlı büyüyen bir tür olarak duglas göknarının yerli türlerle büyüme performansını ağaçlandırmanın 17 yıllık verilerini kullanarak karşılaştırmaktır. Çalışma sahası Düzce Orman İşletme Müdürlüğü, Melen İşletme Şefliği içerisinde yer almaktadır. Ağaçlandırmadan 17 yıl sonra kayın ağaçlarının (*Fagus orientalis* L) biyokütlesinin sarıçam (*Pinus sylvestris* L.) ve duglas göknarınkinden sırasıyla 3.4 ve 1.7 kat daha fazla olduğu tespit edilmiştir. Beslenme açısından bakıldığında gürgen (*Carpinus betulus*) yapraklarının azot yoğunluğunun sarıçam ve duglas göknarınkinden sırasıyla % 57 ve % 117 daha fazla olduğu belirlenmiştir. Elde edilen veriler odun üretiminin yerli türlerde üstün genotiplerin seçilmesi ve kültürel işlemlerle de arttırılabileceği ve bu üretim artımının hızlı büyüyen olarak tanımlanan ekzotik türlerinkinden daha yüksek olabileceğine işaret etmektedir.

Anahtar Kelimeler: Duglas göknarı, ağaçlandırma, biyokütle, hızlı büyüyen türler, Türkiye

Received: 17.05.2022, Revised: 14.06.2022, Accepted: 29.06.2022
Address1: Duzce University, Forest Faculty, Duzce.
E-mail: oktayyildiz@duzce.edu.tr
* This study was produced from a master's thesis.

1. Introduction

Turkish forestry focuses mainly on timber production, and economically important trees have been harvested historically to maximize wood production without any considerations given to sustainability (Yildiz and Eşen, 2006). As a result, almost half of the Turkish forests are now considered degraded in terms of wood production (Kaya and Raynal, 2001). The gap between wood demand and supply has steadily been widening.

Due to recent wide-spread concerns about degraded conditions, forest managers tends to leave more and more forestlands for conservation purposes. As result, a significant amount of the natural forests are not and will not be available for timber production in coming years. Removing additional areas of natural forests through establishment of new protected areas and expanded logging bans will further reduce timber harvests (Maura-Costa and Aukland, 2001).

Plantations with fast-growing exotic species have been recommended to meet the wood demand (Şimşek, 1982). Forest plantations make up about 5% of global forest area (Dohrenbusch and Bolte, 2007). The gap between wood supply and demand can be partly narrowed with growing plantations of fast-growing tree species in ecologically sound conditions and using intensive cultural practices. In Turkey, potentially, the 1.5-million ha degraded forestland can be planted with fast-growing tree species (Şimşek, 1982). Although annual wood increment of the country's forests is very low (about 1.4 m^3 ha^{-1}), it can be increased to 10 m^3 ha^{-1} with fast-growing tree species (Şimşek, 1982).

Experiments with fast-growing tree species have been conducted since 1940's in Turkey. The Atlantic and Pacific coast of North America, Eastern Asia, and Mediterranean are the potential regions from which new tree species can be introduced to Turkey (Boydak et al., 1995). The most intensive studies in the country have been done with the US origin tree species including *Pinus radiata*, *Pseudotsuga menziesii, Pinus contorta*, *Pinus ponderosa, Pinus taeda, Pinus echinata, Pinus elliottii, Pinus muricata, Pinus virginiana, Pinus jeffreyi*, *Juniperus virginiana*, *Picea sitchensis, Sequoia sempervirens, Taxodium disticum, Cupressus arizonica*. However, only a few numbers of these species were represented with an enough number of origins from their natural distribution: *Pseudotsuga menziesii*, *Pinus contorta,* and *Pinus taeda* and experimental plantation with many species were failed except those represented with high number of origins (Boydak et al., 1995).

Douglas-fir (DF, Pseudotsuga menziesii (Mirb.) Franco is the first introduced and most successful tree species for industrial wood production and for this species, very detailed experiments were conducted (Şimşek, 1982). Data collected from these experiments indicated that the best origin of Douglas-fir with a height growth in the western and eastern Black Sea region (BSR) of Turkey is Washington Cascades origins (Boydak et al., 1995; Şimşek, 1982). The Marmara and western BSR of Turkey have similar growing conditions with the DF's natural distribution areas in the coast region of North America. Thus, Şimşek (1982) recommends that Douglas-fir can be planted in rhododendron-beech sites up to 1250 m elevations in eastern and western BSR of Turkey. However, experiments with different origins of DF revealed unsuccessful results in a significant number of sites in the eastern and western BSR. The growths of the trees in the plantations were differentiated due to site differences (Şimşek, 1982). One of the biggest DF plantation site (100 ha) was located in the Melen Forest Management Chiefship of the Düzce Forest Management Directorate in the western BSR.

The aim of this study is to compare the growth of Douglas-fir trees as a fast-growing introduced species with some of the native tree species that were planted in the same time and to evaluate changes in some of the soil and aboveground ecosystem properties among the different plantation sites.

2. Material and Method

2.1. Material

2.1.1. Study sites and establishment of plantation

This study was superimposed upon the foundation of a previous project where DF seedlings were planted in degraded beech- rhododendron forest in the BSR of Turkey. The study area is located in the Melen Forest Management Chiefship of the Düzce Forest Management Directorate in the western BSR. The experiment used a total of 200 ha site located on northern-northwestern aspects at 930 m elevation with a mean slope of less than 20 % in the Melen Chiefship (N 40° 46′ 03″ E 30° 53′ 31, 4″). The mean annual temperature of the site is 13 ºC, and it receives □800 mm mean annual precipitation. The growing season is about six months. Soil texture ranged from clay and clay loam to loamy clay. Soils in this region are classified as acid Brown Forest soils in Europe and the US (Tavernier and Smith, 1957).

The plantation originally was established in 1988. The site originally had a degraded beech-fir (*F. orientalis* Lipsky) stand with rhododendron (*Rhododendron ponticum* L.) in the understory. The site was cleared of unwanted vegetation with a bulldozer (21 metric tons, Caterpillar DZG™). The bulldozer was equipped with a brush rake uprooted the vegetation cover and piled the debris offsite into windrows. Then the soil was prepared for planting using an Mb-track tractor. 2+0 DF seedlings, originated from Washington USA, were obtained from the Istanbul Alemdağ Forest Nursery in 1990 and 1991. The DF seedlings were planted with 1.5 X 2 m spacing. 2+0 Scotch pine seedlings, obtained from Bolu Forest Nursery, were planted with 1.25 X 2.5 m spacing in 1989. The same year a beech stand with a mixture of hornbeam was naturally regenerated in an adjacent area.

2.1.2. Collection and analysis of samples

To estimate tree biomass and foliage nutrient concentrations, sample-trees were cut with a chainsaw from five randomly selected quadrants (5 x 5 m) on each site (4 X 5 =20 sampling units). The stems, branches and leaves of sample trees were separated, and fresh weight of each sample was recorded in the field. The sample from each tree component was sub-sampled for each plot to determine its moisture and nutrient content. Total tree biomass (kg ha^{-1}) was estimated after adjusting for moisture content. Moisture content was calculated from the sub-samples that were weighed fresh and oven-dried at 65 °C in the lab for two days. After calculating the biomass of individual components for each treatment, values were summed to estimate total aboveground biomass.

Foliage nutrient concentrations were determined from sub-samples collected during destructive biomass sampling. Sub-samples collected from experimental units were air-dried, then ground using a conventional coffee-grinder. Nitrogen concentrations were determined from micro-Kjeldahl digests (Kjeltec Auto 1030 Model) (Bremner, 1996). For the remaining nutrient analyses (P, K, Ca, Mg and S), plant tissue samples were digested with a mixture of nitric and perchloric acids (Jones and Case, 1990). Phosphorus and S concentrations were determined using a Spectronic 20D Colorimeter. Calcium and Mg were measured with a Perkin-Elmer 3110 Atomic Absorption Spectrometer, while K was determined using a Jenway Flame Photometer.

To determine the acidity, soil samples were taken from 0-10 cm and 10-20 cm depths at five randomly selected locations on each experimental unit. Then soil pH was determined using a pH meter for air-dried samples placed in deionized H_2O (Thomas, 1996).

2.1.3. Statistical Analysis

The tree biomass and foliage nutrient concentrations and soil pH were evaluated using an analysis of variance procedure for a randomized design. Tukey's HSD test with a = 0.05

was performed to permit separation of means. SAS was used for all statistical analyses (SAS, 1996). Results were considered significant at $P < 0.05$.

3. Results and Discussion

17 years after plantations, the soil pH for the 0-20 cm soil depth was significantly different among sites ($P = 0.01$). The soil pH on the DF and Scotch pine (SP) sites were about 0.3 degree lower than that on the beech site (Figure 1). It can be concluded that comparing to the broadleaves, conifer needles might have acidified the soil on these sites.

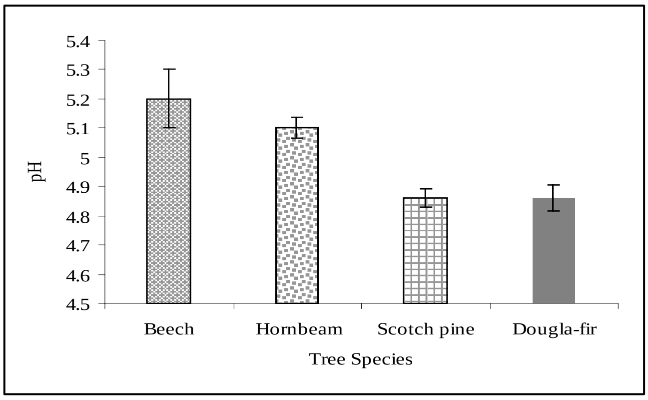

Figure 1. Means and SE of soil pH for the sites with different tree species

There was a significant difference in the amount of tree biomass between the sites ($P = 0.0001$). At the 17th year of stand establishment, beech trees accumulated 3.4 and 1.7 times more biomass than did DF and SP (Figure 2). Genetically, DF might have a high growing potential. However, soil and climatic conditions might also have a significant influence on the growth. The main goal in plantations is to secure the highest economical return from the site. Data indicate that native broadleaved species can accumulate more biomass than fast-growing DF in these regions.

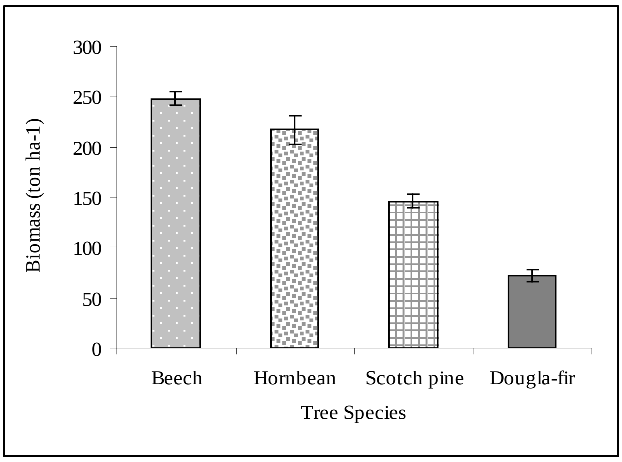

Figure 2. Means and SE of biomass for different tree species.

Foliage nutrient concentrations were significantly different among the tree species for N (P= 0.0001), P (P=0.0005) and K (P=0.0009). Mean nitrogen concentration in beech and hornbeam foliage was 117% and 58% higher than the mean of DF and SP foliage, respectively (Table 1). Mean phosphorus concentration of beech foliage was 78% higher than mean of DF, hornbeam, and SP foliage. Potassium concentration of beech foliage was also almost 50% higher that mean of DF and SP foliage (Table 1).

Table 1. Means and SE of foliage nutrient concentrations for different tree species

Species	N	P	Ca	K	Mg
	‹---------------------------------------mg g^{-1}	---------------------------------------›			
Beech	3.24 ± 0.15a	0.250 ± 0.025a	1.96 ± 0.1a	0.65 ± 0.03a	0.30 ± 0.01a
Hornbeam	2.36 ± 0.1b	0.135 ± 0.003b	2.70 ± 0.4a	0.54 ± 0.02ab	0.25 ± 0.01a
Scotch pine	1.42 ± 0.03c	0.15 ± 0.015b	1.60 ± 0.06a	0.44 ± 0.025b	0.20 ± 0.01a
Douglas-fir	1.57 ± 0.07c	0.135 ± 0.003b	1.77 ± 0.4a	0.43 ± 0.01b	0.26 ± 0.03a

Forest productivity is regulated by the availability of essential tree growth resources. Forest vegetation manipulation may result in the modification of nutrient cycling and forest productivity (Fox, 2000). It is apparent that native broadleaved species have more nutrient rich foliage. Thus, soils in these sites may be richer comparing to the sites with conifers.

Plantations will play an increasingly significant role in future timber supply, and fast-growing plantations will result in a new production capacity in Turkey. However, conversion of native broadleaves to fast-growing conifer plantations may cause changes in stand structure and composition. Plantations in Turkey can contribute towards offsetting but not replacing reductions in harvest from natural forests (Boydak et al., 1995; Şimşek, 1987). Most of the beech forests still retain a substantial degree of naturalness. Production of highest quality beech timber is an issue of high priority. Economic investments and capital flows from fast-growing plantations are not guarantee. Some poplar plantations in Turkey, for example, phased out as they matured due to a lack of adequate demand and profitability. In addition, efficient growing of plantation timber does not also assure advantage in domestic processing of that material.

Traditionally forest were preserved for wood resources however, lately non-timber aspects has (wildlife, water biodiversity, recreation etc.) becoming increasingly important. If the strategic goal is maximum timber production and financial return, production forests can be made more natural by using native trees on stand composition, and natural regeneration can be used instead of planting. Natural regeneration or regeneration based on native species enables in situ conservation and integrity of local genetic material. These can enhance the overall value of the region's forest resources. Therefore, plantations with fast-growing-species should be established where it be technically, economically and socially feasible as well as environmentally friendly.

References

Boydak, M., Oliver, C. D. and Dirik, H. (1995). Introduction possibilities of some native fast-growing coniferous forest tree species of the USA to Turkey. *Poplar and fast-growing Forest Trees research Institute*.

Bremner, J. M. (1996). Nitrogen – Total. In: Sparks, D.L. (Eds.) Methods of Soil Analysis – Part 3 - Chemical Methods. Soil Science Society of America, American Society of Agronomy, Madison, Wisconsin, 1085-1121.

Dohrenbusch, A. and Bolte, A. (2007). Forest Plantations. In Wood Production, Wood Technology, and Biotechnological Impacts, 73-83.

Fox, R.T. (2000). Sustained productivity in intensively managed forest plantations. *Forest Ecololgy and Management*, *138*, 187-202.

Jones, J.B. Jr., Case, V.W. (1990). Sampling, handling, and analyzing plant tissue samples. In: Westerman, R.L. et al. (Ed.), Soil Testing and Plant Analysis- 3rd Ed., Soil Science Society of America, Madison, Wisconsin, USA, 389-427.

Kaya, Z., Raynal, D.J. (2001). Biodiversity and conservation of Turkish forests. *Biological Conservation*, *97*, 131-141.

Maura-Costa, P. and Aukland, L. (2001). Plantations and greenhouse gas mitigation: A short review. Forest plantations Thematic papers. Forestry department. Food and agriculture organization of the United nations. Edited by D.J. Mead. Working paper FP/12, FAO, Rome (Italy).

SAS Institute, Inc. (1996). SAS/STAT Users Guide, Version 6.12. SAS Institute, Cary, North Carolina.

Şimşek, Y. (1987). Karadeniz Bölgesi'nde yapılacak Douglas (Pseudotsuga menziesii (mirb. Franca) ağaçlandırmaları için orijin seçimi. *Ormancılık Araştıma Ensrtitüsü Yayınları*, *190*. Ankara, Turkey.

Şimşek, Y. (1982). Hızlı gelişen ekzotik tür denemelerinin ortaya koyduğu teknik ve Ekonomik bulgular, Pilot ağaçlandırma ve geniş geniş uygulamalara geçebilme olanakları. Türkiye'de Hızlı gelişen türlerle endüstriyel ağaçlandırmalar sempozyumu. 21-26 Eylül. 1981. Kefken (İzmit) -Korudağı-Dardanos (Çanakkale), Ankara.

Tavernier, R., Smith, G.D. (1957). The concept of Braunerde (Brown Forest soils) in Europe and the United States. *Advances in Agronomy*, *9*, 217-289.

Thomas, G.W. (1996). Soil pH and soil acidity. In: Sparks, D.L. et al. (Eds.), Methods of Soil Analysis – Part 3 – Chemical Methods, Soil Science Society of America and American Society of Agronomy, Madison, Wisconsin, USA, 475-490.

Waggener, T. (2001). Role of plantations as substitutes for natural forests in wood supply-lessons learned from the Asia-Pacific region. Forst plantations Thematic papers. Forestry department. Food and agriculture organization of the United nations. Edited by D.J. Mead. Working paper FP/7, FAO, Rome (Italy).

Yildiz, O., Eşen, D. (2006). Effects of different Rhododendron control methods in eastern beech (Fagus orientalis Lipsky) ecosystems in the western Black Sea Region of Turkey. *Annals of Applied Biology*, *149*, 235-242.