NORWAY SPRUCE TIMBER QUALITY AT DIFFERENT SILVICULTURAL MEASURES AND FOREST SITE TYPES*

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The paper deals with a comparison of production quality of individual assortments of Norway spruce growing on different types of forest sites of the training forest enterprise of the Czech University of Life Sciences Prague in Kostelec nad Černými lesy, Czech Republic. Two even-aged plots with different stand tending were compared: plot 1 – forest site type 4K (acidic-beechwood), plot 2 – forest site type 4P (acidic oak-firwood). The basic mensurational characteristics such as mean diameter, mean height, stand density, site index, mean tree volume, and stock volume were determined. The individual trees were divided into quality classes A, B, and C. From the statistical evaluation it is clear that the production potential is very similar on both plots. Lower stand density and higher light intensity affects differentiation of the diameter increment on both plots. The site type of plot 2 had a better effect on supply of ground water. The production of the individuals with high qualitative characteristics can be summarized into a few basic points for the maximum assortment yield.

assortment classes; timber grading; wood quality; forest site types

INTRODUCTION

In the past, one of much discussed issues was an appropriate evaluation of the wood production as well as the non-wood productive functions of forests. Search for a suitable detection of the standing volume and estimation of the potential financial return from timber yield requires finding the most appropriate method of the forest evaluation. Knowledge of the assortment composition of the stands is important for evaluation of the production (Tipmann, Stolariková, 2011).

A highly debated issue in the past and present has been the timber grading of standing stands. Many domestic and foreign authors attempted to find models for the purpose of the timber grading and to establish assortment tables. They applied the principle, primarily stereometric data acquisition, for constructing the assortment tables. In German-speaking countries, Flury (1916) is considered to be one of the founders who created the assortment tables for spruce, fir, and beech. Lang (1938) and Vogel (1939), who worked in Germany, established the graphical assortment tables following the Heliborn's timber grading (Pařez, Michalec, 1987).

Other authors dealing with timber grading on the basis of tables were Mitscherlich (1939) and Schilling (1960). Sloboda (1970) and Gaffrey (1996) were other authors dealing with the classification in Germany. They resolved creation of the assortment tables on the basis of mathematical modelling and the tables were focused on individual timber grading in local conditions. They similarly created assortment tables in Austria (Pařez, Michalec, 1987). Russian, Polish, Bulgarian, and Romanian authors were dealt with the creation of assortment tables in Eastern Europe, such as Anučin (1977) and Gorskij (1962) in Russia and in the years 1961–1975 Borzemski (1975) in Poland. Duchovnikov (1957) is among the Bulgarian authors who advanced the creation of the assortment tables. Like in the case of their German colleagues, their work was based on the principle of detecting the stereometric data. In the period of 1952–1962, assortment tables were elaborated by Korsuň (1963) for spruce, pine, beech, and oak growing in the conditions of the Czech Republic and Slovakia. Korsuň created tables for determining the percentage of assortments. Within 1973–1975 the problem of assortment tables was also resolved by Pařez who utilized the data from the measurements and information provided by Korsuň. Hubač (1973) created tables for spruce and subsequently Čermák, Hubač (1978) for beech. The two latter authors, which used stereometric principles, failed because such principles were not capable to describe adequately the internal quality of wood. Moreover, they overestimated the proportion of valuable assortment

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and underestimated the proportion of the lower quality assortments, too (P e t r á š , N o c i a r , 1991). In 1991, for the conditions of the Czech Republic and Slovakia, P e t r á š and N o c i a r created the latest assortment tables which categorize long logs of diameter class from 1 to 6 into I, II, IIIA, IIIB, V, VI quality grade and residues. These quality standards conform to the valid national standards CSN 480055 and CSN 480056. To create tables they used a new method of mathematical modelling on extensive empirical material. Recently, the assortment analysis has been elaborated by IFER – Institute of Forest Ecosystem Research, Ltd. in co-operation with other authors, mainly Č e r n ý , P a ř e z (2005). European countries based timber grading in most cases on European Standard EN 1 3 1 5 and EN 1 9 2 7 which sets out the criteria of timber grading for a large-diameter stand and the stacked timber in appropriate assortments. The International statistics leaves it to the discretion of individual countries, which assortments are used as representative. For this reason, there are some differences in the quality and dimensional characteristics of appropriate assortments (B l u ď o v s k ý , 1999).

The quality of wood and the proportion of assortments depend on several factors. One of the factors that can affect the quality and quantity of valuable assortments is the method of the forest management. This is derived from the character of the stand development, depending on species, age, spatial and social arrangement of the woody plants (Š e b í k , P o l á k , 1990). P r k a , K r p a n (2010) stated that the application of appropriate tending increases the value of the timber assortments. Forest stands are also greatly influenced by soil conditions, which is a part of site investigation. The soil characteristics such as texture and nutrients content are important. The growth characteristics vary on extreme, acidic, fertile, enriched with humus or water, pseudogleyed, water logged or peat sites. Certain growth differences require research focusing on comparison of quality timber production of different sites (P l í v a , 1981). In this work, we compare the timber quality of Norway spruce at different silvicultural measures and different forest site types for the conditions of the Czech Republic.

MATERIAL AND METHODS

Timber quality of Norway spruce was investigated in the stands of the University Training Forest Enterprise in Kostelec nad Černými lesy, which is a part of the Czech University of Life Sciences Prague. To compare timber quality of Norway spruce, two forest site types were selected: acidic (K) as the most abundant forest site type in the Czech Republic and acidic gleyed (P) which belongs to pseudogleyed soils representing the largest part of the area (P o l e n o , V a c e k , 2007). The first sample plot (plot 1) is on the forest site type 4K – acidic-beechwood (coordinates 49°58′05.2″N, 14°51′05.6″E). The soils of the forest site type K are prevailingly medium deep with a varying soil skeleton composition. Mostly they are freshly moist to moderately moist. Production of tree species in this forest site type reaches average values (P o l e n o , V a c e k , 2007). The second sample plot (plot 2) occurs on the forest site type 4P – acidic oak-firwood (coordinates 49°56′4.3″N, 14°50′08.3″E). Forest site type P differs mainly in water content in the soil. While nutrient content is more or less the same, pseudogleyed soils are affected by fluctuating ground water causing alternation of oxidation and reduction processes in soil that are presented by a mosaic of rusty and grey soil colour (P l í v a , 1981). The yield of a tree species is average or slightly above average. Especially stands of spruce are labile and are threatened by wind and snow (P o l e n o , V a c e k , 2007).

Plot 1 was selected in the 115-year-old stand and plot 2 in the stand with the age of 120 years. The plots were chosen to represent the particular stand the best. The plots were equal in size covering an area of 0.2 ha each. Norway spruce was the only tree species occurring on both plots and all individuals growing there were measured (n = 55 on plot 1 and n = 45 on plot 2). Furthermore, the basic mensurational data were collected, such as diameter at the breast height (DBH), which was measured using a digital calliper with a precision of 0.1 cm. Tree height was measured with laser hypsometer with a precision of 0.1 m; stand density and site index (which was determined by the mean height and age) were assessed. The volume of the individual standing tree was calculated according to national volume tables. The health and quality status of individual trees was assessed by visual investigation. In addition, some wood defects such as damage of the basal part of the stem, irregularities of the stem form, number of knots, their size and their health condition were also found out and evaluated. For the standing trees, the method also required to perform ocular observation of the external characteristics to discover the potential damage of the stem or its part. The trees were then categorized into two classes –‘Z’(sound) and‘P’(damaged – e.g. size and number of knots, browsing, deer barking, frost cracks, or mechanical damage) (Table 1).

The individual trees were divided into quality classes A, B, and C. Class A includes stems of high quality, straight non-twisted growth without deformations. Knots less than 1 cm in diameter and one knot less than 3 cm per 1 m of length are tolerable for the spruce stem. Class B has a stem of reasonable quality with minor technical defects, solid knots without limited size, loose knots less than 4 cm are tolerable for broadleaved trees, while solid and loose knots less than 4 cm are permissible for spruce. Class C has a stem of low quality, with large technical defects, significantly branched with twisted growth less than 4%.

Table 1. Basic mensurational variables of plots 1 and 2

	Plot 1	Plot 2
Stand age (years)	115	120
Total number of trees	55	45
Number of sound trees	43	12
Number of damaged trees	35	10
Most frequent diameter classes	38	34
Mean quadratic diameter (cm)	36.3	33.3
Mean height (m)	30.6	30.3
Mean tree volume (m^3)	1.44	1.30
Stock volume on the sample plot (m^3)	86.03	58.59
Stock volume per ha (m^3 ha^{-1})	277	264
Stand density	0.7	0.9
Site index	30	28

Admissible are solid knots without limited size, loose knots for conifers less than 6 cm.

This investigation served for the establishment of the assortment model according to the principles made by Petráš, Nociar (1991). These assortment tables indicate the share of each assortments class that are long logs I – sliced veneer, musical instruments, special sporting, and technical goods, II – rotary-cut veneer, matches, sports equipment, IIIA – saw logs of a better quality, poles, special mine timber, building timber, and sleepers, V – pulpwood and agglomerated boards, VI – fuel wood and residues. The assortments criteria come from the above-mentioned technical conditions specified by the Czech national standards for conifer and broadleaved assortments of rough timber (CSN 48 0009, CSN 48 0055, CSN 1310) using the volume without bark.

Similarities or differences of the production potential (mean height and mean diameter) of the plots 1 and 2 were determined by the *t*-test for independent samples. The hypothesis sounds whether the measured and surveyed mensurational variables (the mean height and the mean diameter) and the assortment composition of the stems differ on both plots which was tested using chi-squared (χ^2) goodness-of-fit test.

RESULTS

The mensurational variables – the highest frequency of diameter classes, mean quadratic diameter, mean height, mean tree volume, stock volume on the sample plot, stock volume per ha, stand density, and site index were determined on both plots. Comparison of mensurational variables on both plots are presented in Table 1. The distribution of diameter frequencies was left-sided asymmetrical on both plots. The logarithmic function was used for height fitting on both plots. The regression equation determined the mean height with a value of 30.6 m and coefficient of determination R^2 which had a value of 0.7458 on plot 1 and the mean height with the value of 30.3 m with coefficient of determination R^2 which had a value of 0.6192 on plot 2 (Figs. 1 and 2).

The assortments class IIIA had the biggest representation of 49.0% in the volume of 42.17 m^3 on plot 1 and of 52.8% in the volume of 30.96 m^3 on plot 2 (Table 2).

According to the *t*-test there was a significant difference between mean diameters on both plots when the *P*-value was 0.043, which was less than significant (Table 3). On the contrary, *t*-test showed that there was no difference between mean heights of both plots. *P*-value was determined at 0.805 which exceeds the *P*-value level of 0.05 (Table 4). Shares of individual quality classes of Norway spruce growing on plots 1 and 2 were tested, too. Testing was performed by the chi-squared (χ^2) test on the 0.05 significance level. Based on the chi-squared test it has been found that the share of individual quality classes of Norway spruce growing on both plots do not differ ($P = (4.563 \geq 14.067 \times 0.05)$).

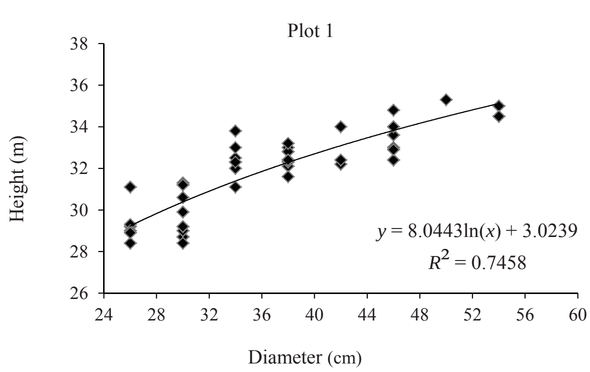

Fig. 1. Height fitting on the plot 1

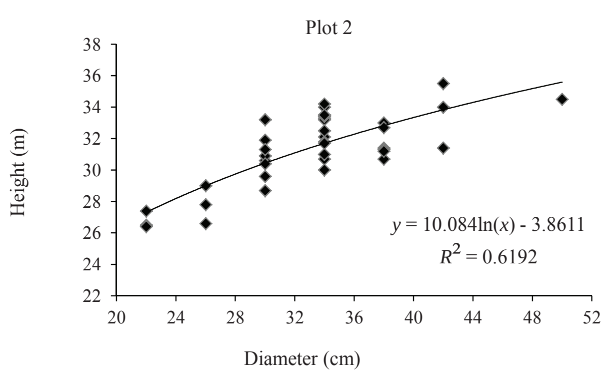

Fig. 2. Height fitting on the plot 2

DISCUSSION

Variability of both plots was statistically nonsignificant. On the basis of the measured values on both plots the production possibilities of both sites were evaluated. Furthermore, the growth characteristics on both forest site types were similar except diameter, one can state that acid soil and the structure of assortments display better results. The differences in favour of acid soil could also be interpreted by lower density which allows enhancement of the light increment. The site index was taken from the growth tables (models), which utilize just the mean height. The mean height is highly dependent on the vertical structure of stands and thus it is directly influenced by silviculture treatments.

The investigation was conducted for two different forest site types, but it seems that both of them are very similar concerning the actual wood production. Different forest site types did not affect timber quality of Norway spruce. Our finding corresponds with findings from literature sources. Danilovic (2006) mentioned that timber quality was considerably affected by the presence of knots and that the presence and size/extent of wood defects like knots, curvature, cancer, splits, rots, and burrs were highly influenced by stand tending, especially in younger stages of stands. Jäppinen, Nylinder (1997) stated that the proportion of A-grade logs varied with unevenness and taper. At a low unevenness, the proportion of A-grade logs goes up and similar findings are shown in our results. From the comparison of coefficients of variation it is found out that the first sample plot, which includes a higher amount of quality timber, has lower unevenness. While Pařez, Michalec (1987) divided timber just into 3 categories (sawn timber, pulpwood, and firewood), our sorting used the tables of Petráš, Nociar (1991) that count also on timber for veneer. Therefore, our findings are better applicable for end users. The positive effect of thinning on the diameter growth of Norway spruce is valid under the condition that the crowns are released early enough and in a sufficient extent. The enhancement of the increment may be taken as a generally known fact which was stressed in the previous studies (Korpeľ, 1991). Tending of young stands in the open canopy regime increases their resistance against wind and snow fractures because of the augmented diameter increment. On the contrary, the size of the crowns decreases the resistance against windfall (Chroust, 1997).

Table 2. Total representation of assortments in individual assortment classes on plots 1 and 2

Assortment classes	Representation of plot 1 (%)	Representation of plot 2 (%)
I	3.7	1.4
II	25.9	23.1
IIIA	49.0	52.8
IIIB	14.2	14.3
V	7.2	8.4
VI	0.0	0.0
Residues	0.0	0.0

CONCLUSION

From the statistical evaluation it is clear that the production potential is very similar on both plots. Lower stand density and higher light intensity affect differentiation of the diameter increment on both plots. The site type of plot 2 had a better effect on supply of ground water.

The whole production quality also depends on the structure of the timber assortments. In addition, the production is derived from intensive management during the stand development that should be carried out in time and carefully. Naturally, different forest site types require different management. However on the majority of sites the target should be maximal quality production covering all expenses during the stands development.

Our work was carried out on mature stands; therefore the present status cannot be influenced by any interventions now. The requirements for suitable tending are only theoretical and will serve for regenerated stands on the area. In any case, the reasonable and careful management of stands is crucial for the highest quality production. The paper is only a small

Table 3. T - test there was a significant difference between the mean diameters on both plots

Mean diameter plot 1 (cm)	Mean diameter plot 2 (cm)	CV plot 1*	CV plot 2*	p**	SD plot 1***	SD plot 2***	P-value
36.3	33.3	0.188	0.183	0.025	6.846	6.101	0.043

*coefficient of variation, ** probability, *** standard deviation

Table 4. T - test there was a significant difference between the mean heights on both plots

Mean height plot 1 (m)	Mean height plot 2 (m)	CV plot 1*	CV plot 2*	p**	SD plot 1***	SD plot 2***	P-value
30.6	30.3	0.086	0.083	0.741	2.639	2.543	0.805

*coefficient of variation, ** probability, *** standard deviation contribution to highly-debated issues about benefits taken from the forests.

REFERENCES

Anučin NP 1977: Forest inventory. Goslesbumizdat, Moskva – Leningrad, 520 p. (in Russian)

Bluďovský Z (1999): Tendency of price development of raw timber in Czech Republic. Zprávy lesnického výzkumu, 12, 24–28. (in Czech)

Borzemski E (1975): Methodology processing of assortment tables for pine. Roczniki Nauk Lesnych, I: 18, 157–185. (in Polish)

Čermák V, Hubač K (1978): The assortment tables for the broadleaves. Príroda, Bratislava, 205 p. (in Slovak)

Černý M, Pařez J (2005): Determination of volume and sorting of standing trees using the model of stem form. Lesnická práce, 84, 658–660. (in Czech)

Chroust L (1997): The ecology of forest tending. VÚLHM, Výzkumná stanice Opočno. (in Czech)

CSN 48 0009 (1977): Volume tables of round timber without bark according to mean diameter measured in bark. Czechoslovak State Standard. (in Czech)

CSN 48 0055 (1985): Coniferous assortments of green wood. Technical requirements. Czechoslovak State Standard. (in Czech)

CSN 1310 (2000): Round and sawn timber – Method of measurement of features. Czechoslovak State Standard. (in Czech)

Danilovic M (2006): Effect of quality factors especially of sweep of poplar trees on assortment structure. Glasnik Sumarskog Fakulteta, Univerzitet u Beogradu, 94, 135–150.

Duchovnikov J (1957): The assortment tables of pine. Naučne Trudowe, Sofia, 67–82. (in Bulgarian)

EN 1927 (2008): Qualitative classification of softwood round timber. European Standard. (in Czech)

EN 1315 (2010): Dimensional classification of round timber. European Standard. (in Czech)

Flury PH (1916): Studies on the range conditions for the spruce, pine and beech. Releases of the Swiss Central Office for the Forest Research, Switzerland. (in German)

Gaffrey D (1996): Variety-oriented portfolio growth - Simulation model intraspecific on the base, competitors related individual tree growth - particularly in terms of the diameter - the example of Douglas fir. Berichte des Forschungszentrums Waldökologie, Göttingen, Reihe A, 133, 413 p. (in German)

Gorkij NP (1962): Manual to compile tables. Goslezbumizdat, Moscow, 365 p. (in Russian)

Hubač K (1973): The assortment tables for the conifer trees. Príroda, Bratislava, 325 p. (in Slovak)

Jäppinen A, Nylinder M (1997): Automatic sorting of spruce (*Picea abies* (L.) Karst) sawlogs by grade. Holz als Roh- und Werkstoff, 55, 301–305.

Korpeľ V (1991): Silviculture. Príroda, Bratislava, 465 p. (in Slovak)

Korsuň F (1963): Tables of stem profiles and assortment tables for pine. Práce Výzkumných ústavů lesnických, 27. (in Slovak)

Lang A (1938): Table of spruce in the Württemberg Forest Management Institute. General Forestry and Hunting Newspaper, 114, 161–167. (in German)

Mitscherlich G (1939): Assortment tables for spruce, pine, beech and oak. Mitteilungen aus Forstwirtschaft und Forstwissenschaft, 10, 569 – 583. (in German)

Pařez J, Michalec M (1987): The percentage assortment tables for the main tree species in Czechoslovakia. VÚLHM Jíloviště-Strnady. (in Czech)

Petráš R, Nociar V (1991): Assortment tables of main tree species. Veda, Slovenská akademie věd, Bratislava, 308 p (in Slovak)

Plíva K (1981): Differentiated methods of forest management in Czechoslovakia. Ministerstvo lesního a vodního hospodářství ČSR, Státní zemědělské nakladatelství, Prague, 213 p. (in Czech)

Poleno Z, Vacek S (2007): Silviculture II. Theoretical Foundations of Silviculture. Lesnická práce s.r.o., Kostelec nad Černými Lesy, 313 p. (in Czech)

Prka M, Krpan APB (2010): Impact of tending measures on assortment structure of fellings in central Croatian beech stands. Acta Silvatica & Lignaria Hungarica, 6, 171–182.

Schilling O (1960): Table of spruce for the taper for k = 0.550. General Forestry and Hunting Newspaper, 131, 207–213. (in German)

Sloboda B (1970): Der QF-Rechner. Mitt. Der Baden-Württemb. FVFA, Nr. 3, 1-24. (in German)

Šebík L, Polák L (1990): Science of wood production. Príroda, Bratislava, 322 p. (in Slovak)

Tipmann L, Stolariková R (2011): Methods of data collection todd determine sorting of standing spruce and beech stands. In: Detection of standing timber in forensic practice. Ústav pro hospodářskou úpravu lesů Brandýs nad Labem – pobočka Plzeň, ISBN 978-80-260-1216-0, 18-23. (in Czech)

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