GROWTH OF BLACK WALNUT (*Juglans nigra* L.) IN THE FLOODPLAIN FORESTS OF THE ŽIDLOCHOVICE FOREST ENTERPRISE

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Abstract

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The Židlochovice Forest Enterprise manages forests in South Moravia where an introduced North American tree species is grown. It is the black walnut (*Juglans nigra* L.). Although it has been grown there since the beginning of the 19[th] century, present oldest stands were planted about 120 years ago.

This paper presents a detailed vertical and horizontal growth ring analysis of black walnut sample trees from the Židlochovice Forest Enterprise (Forests of the Czech Republic, State Enterprise). Three sample trees coming from one of the oldest black walnut stands were analyzed. This paper provides a detailed analysis of the percentage of bark on individual trees and of the distribution of timber mass in relation to the height of the trees. It also deals with the height, diameter and volume growth of the sample trees. The paper observes that even at the age of 108 years a culmination of volume increment has not been detected, it notes that neither diameter increment nor ring area do not decrease up to the age of 108 years; it provides the morphology of the individual sample trees and compares the volume growth of black walnut with that of oak and ash. This paper observes that black walnut reaches higher yield than the aforementioned two tree species.

Key words: black walnut, *Juglans nigra* L., growth ring analysis, production capacity, forest yield science

Introduction

Black walnut (*Juglans nigra* L.) is an introduced North American tree species. Black walnut's relatively vast distribution range covers the eastern and central parts of Northern America. The Great Lakes and the provinces of Michigan and Ontario create its northern boundary, in the west it covers south Minnesota, North Dakota, north-east Nebraska, Kansas, Oklahoma and Texas, in the south the Mississippi delta, north-west Florida and Georgia, and in the east it reaches as far as west Vermont and Massachusetts.

The mean annual temperatures in this vast expanse range from 7 °C to 19 °C. The mean annual precipitation ranges from 640 mm in north Nebraska to 1780 mm in the Appalachian Mountains and in North Carolina. Black walnut's chief associated species include yellow poplar (*Liriodendron tulipifera* L.), white ash (*Fraxinus americana* L.), black cherry (*Prunus serotina* E h r h.), basswood (*Tilia americana* L.), beech (*Fagus grandifolia* E h r h.), sugar maple (*Acer saccharum* M a r s h.), oaks (*Quercus ssp.*) and hickories (*Carya ssp.*).

Its cultivation in Europe boasts more than a three-hundred-year-old tradition. In European forest management context black walnut was probably first exploited in the 19[th] century in Rheinland, where forest manager Rebmann launched its introduction into the forests. Black walnut stands in France can be found in the vicinity of the Rhein, near the town of Strassbourg. Black walnut stands in Germany were planted along the Rhein, near the town of Bensheim in Hessenland and the town of Bellheim in Rheinland-Pfalz.

Black walnut stands in the Slovak Republic were planted in the warmer parts of south and west Slovakia, mostly in lowlands and in the vicinity of the Váh, Hron and Nitra rivers. The most expansive areas of artificially cultivated black walnut can be found along the lower reach of the Hron river, about 43 ha in the vicinity of Želiezovce (Májovský, Krejča, 1965). In Slovak context, Tokár (1996, 1998) analysed the question of black walnut volume production. His work focuses on the development of volume production of tended mixed stands of oak (*Quercus rubra* L.) and black walnut (*Juglans nigra* L.) growing on permanent research plots, in relation to the tending within younger age classes.

Within the Czech Republic, we can trace individual trees or small groves of black walnuts mostly in parks or historical gardens. Forest stands in which black walnut is cultivated can be found only in South Moravia – in the Židlochovice management-plan area, Strážnice management-plan area and the Znojmo forest district. In these areas black walnut stands replaced the original *Ulmeto-Fraxineta* communities. Black walnut has been cultivated in South Moravian forests for more than 200 years. The stands are cultivated either as monocultures or mixed stands with the understorey of small-leaved linden (*Tilia cordata* L.). According to data from the forest management plan the total area of black walnut stands at the Židlochovice Forest Enterprise amounts to 258 ha of timber land (reduced area). The total area of black walnut stands managed by the Forests of the Czech Republic, State Enterprise, on the territory of the Czech Republic amounts to 526 ha of reduced area.

Only a limited number of detailed analyses on the growth of black walnut can be found and the data necessary for the study of the yield class of black walnut in the conditions of the Czech Republic are completely lacking. One possible method, which would help complement the information on the growth of black walnut, is destruction analysis of individual specimens. To be more precise, a vertical analysis of growth rings to study the tree's height development and a horizontal analysis to examine its diameter development. At present, growth ring analyses (i.e. the measuring and analyses of growth rings of individual tree species) belong to the standard range of procedures, which are implemented in growth models, in yield science, productivity measurements, forest management and many other disciplines which may not be exclusively connected with forestry. However, the application of certain methods within the growth ring analysis is a relatively new phenomenon. The rapid development of computer and monitoring technologies in the 1990s has spurred an extensive use of computer image analysis in many disciplines, including dendrochronology. The growth ring analyses of black walnut employed here used the image analysis computer system LUCIA G of Czech origin.

The aim of the present work is to carry out a growth analysis of sample specimens of black walnut (*Juglans nigra* L.). The project used the data from a growth ring analysis of stem discs, which come from the oldest and best preserved black walnut stand at the Židlochovice Forest Enterprise.

Based on a detailed stem analysis of three black walnut sample trees the following partial analyses have been carried out:

- analysis of the percentage of bark on individual sample trees in different heights of the stem
- height growth analysis
- growth in thickness analysis
- volume increment analysis
- analysis of the stem morphology of sample trees
- comparison of selected characteristics with the growth of oak (*Quercus robur* L.) and ash (*Fraxinus excelsior* L.)

Material and methods

Analyzed material

The black walnut stand, from which the sample trees were taken, is situated in the Dyjskosvratecký valley basin (natural forest area 35 – "Jihomoravské úvaly"), approximately 30 km south of Brno, 48°58' northern latitude and 16°40' eastern longitude. It is situated on the right bank of the Svratka river, in the immediate vicinity of the river bed, within the cadastre of the village of Velké Němčice. These lands are the property of the state and constitute a part of the "Uherčický les" forest range in the Židlochovice Forest District, the Židlochovice Management-Plan Area (MPA).

The altitude is 177 m and according to the data from the Czech Institute of Hydrometeorology in Brno, meteorological station in Tuřany, the mean air temperature is 9 °C, the minimum occurring in January and maximum in July. The mean annual precipitation amounts to 490 mm, the minimum being in February and March and the maximum in July (based on data provided by the Czech Institute of Hydrometeorology in Brno, meteorological station Pohořelice).

The forest type is 1L2, i.e. *Ulmeto-Fraxinetum carpineum* floodplain on brown alluvial soil. In the lower horizons possible gleying. Humus is of mull form. The soil is neutral to mildly acid. Loamy, deep, freshly moist and loose soil prevails.

T a b l e 1. Mensurational characteristics of the oldest black walnut stand in the vicinity of Židlochovice, cadastre of the village of Velké Němčice, Židlochovice Forest District 126 C11

Validity of forest management plan (FMP)	Classification of the stand (in accordance with FMP)	Area of stand group [ha]	Stand density	Percentage of tree species [%]	Age (in accordance with FMP)	Height [m]	Diameter at breast height DBH [cm]	Standing volume per ha/ Total standing volume 1 ha/total (in accordance with FMP) [m^3 o.b.]
1927–1936	27g	1.21	8	100	36			212/255
1990–1999	126C10	1.76	10	100	97	30	42	482/848
2000–2009	126C11	1.41	9	100	107	33	53	517/730

In 1996 a detailed analysis was carried out with the intention of determining the standing volume of the forest stand. Mensurational characteristics are listed in the table below.

T a b l e 2. Basic characteristics of the stand - I

Tree species	Black walnut	Small-leaved linden
Number of trees in stand [pieces]	172	748
Number of trees per hectare [m^3 over bark]	154	785
Volume of average tree [m^3 o.b.]	4.9	0.2

T a b l e 3. Basic characteristics of the stand – II

Tree species	Black walnut Diameter at breast height DBH [cm]	Black walnut Height– H [m]	Small-leaved linden Diameter at breast height DBH [cm]	Small-leaved linden Height– H [m]
Weighted mean	56.3	35.9	16.8	15.8
Maximum population value	81.0	41.0	34.5	20.0
Minimum population value	37.5	30.0	7.5	8.0
Extent of the set [pieces]	172	49	748	31

T a b l e 4. Standing volume of individual tree species, based on the Forest Management Plan (FMP) of the Židlochovice MPA

Tree species	Black walnut	Small-leaved linden
Standing volume - Growing stock [m^3 o.b.]	837	141
Standing volume per ha - Growing stock per ha [m^3 o.b.]	718	148
Standing volume - Growing stock (FMP,1990)	848	not recorded

Stem discs from three sample trees of black walnut were analyzed . The following table presents major characteristics of the sample trees.

T a b l e 5. Characteristics of the analyzed sample trees

Characteristic	Sample tree		
	A	B	C
Age [years]	102	108	101
Height [m]	32	32	29
Breast height diameter [cm]	51	67	59
Setting of first strong branch	13.5 m	15 m	16
Social status	level	level	level
Number of stem disc samples	19	15	12
Number of measured directions	8	4	4

The stem discs were sanded on one side so that the growth rings could be scanned by computer for an image analysis. The following section discusses the measurement methods and the consequent processing of the acquired data.

System of computer image analysis employed

The basic concept of the implementation of computer image analysis and the succession in which individual equipment is used.

The actual computer system used in image analysis consists of the following hardware:

A. Scanning device
- NAVITAR macroscope (enables scanning of objects ranging from 1mm to A3 size) equipped with three-chip Hitachi HV – C20 camera

B. Processing device
- PC (Pentium 90, 32 MB RAM, 1 GB HDD, CD ROM, 17" screen), software: LUCIA G 4.0 on Windows NT 4.0

C. Output format
- Export format MS Excel 2000

Procedure of growth rings measurement by computer image analysis

The method of growth ring analysis has, to a certain extent, been standardised (Fritts, 1976). However, there is still one "critical point" to solve, namely the measurement of width and other features of growth rings (from the point of view of precision and speed of measurement as well as reliability of distinction of individual growth rings). Given the fact that growth rings measurement is a routine and highly demanding process (especially where there is a need to process a high number – hundreds or thousands of growth rings) and its precision depends exclusively on the measurer's experience, abilities and accuracy, the work submitted here made use of an already elaborated macroprogramme (Drápela, Mazal, 1999), which has been partly adjusted for the purposes of black walnut (*Juglans nigra* L.) measurement. The macroprogramme allows us to make full use of computer image analysis, enabling the automation of the procedure.

Using the material collected for the purposes of growth ring analysis, we can chose between the following sample types:

- Stem disc – a thin disc of wood cut vertically to a longitudinal axis of the stem covering the whole area of transversal cut at a certain height of the stem.
- Bore - a thin little cylinder (usually up to 5 mm wide in diameter) sampled from the tree vertically to the longitudinal stem axis reaching up the heartwood (the length of the bore may fluctuate depending on its purpose).

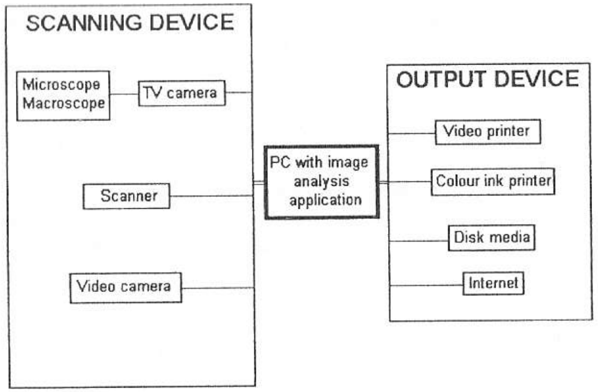


Fig. 1. Diagram of the computer system used for image analysis.

There are advantages as well as disadvantages to both stem disc and bore methods from the point of view of technical processing and the value of the information provided. As the stem discs method gives a better perspective and provides information that is easier to work with, it has been the one adopted here.

Coloured scans served as the basic source of information. The scans were created by directly reading the stem disc of the analysed sample tree.

A coloured 3 CCD TV camera recorded the stem disc and a LUCIA G. programme digitalised the image. The programme itself marked the parameters of a given segmentation, i.e. it always stated upper and lower threshold value for each of the components (R-red, G-green, B-blue) of the scan. By using a so-called threshold method, or specification of the upper and lower limit of the colour spectrum of a particular part of the digital picture (in this case summer wood), a binary picture originates. This picture contains only two colours, black for summerwood and white for residual area. On such a picture, the spacing between the individual boundaries of spring and summerwood is measured automatically and the values registered in a table. It is possible to check the outcome visually and, in case of imprecision, correct them by further manual work.

Method of data processing

The output of LUCIA G system is subsequently fed to and further processed by the Microsoft Excel programme.

The methodology of data processing is further described under the appropriate heading.

Stating proportion of bark, sap wood and hardwood stem part in individual sample trees

Bark proportion in sample trees has been calculated for individual sections (parts of the stem between drilled stem discs). On both sides of the section (upper and lower) surface area of bark (cm^2) was stated by stereometrical formulas. The mean has been calculated and the outcoming value multiplied by the length of a relevant stem section. Furthermore, percentage share of bark has been calculated for each section. The proportion of sap wood and hardwood parts has also been stated for individual sections. Data concerning the boundary between sap wood and hardwood part were recorded manually.

Height growth analyses

Based on a combination of the age value of a particular stem disc and the height from the foot of the tree we are able to reconstruct the height growth of a tree. Thus a chronosequence of height of the tree in relation to age was assigned for each of the three sample trees. The chronosequence of values established by experiment has been balanced for our purposes by a convenient Michailov's growth function, which is, according to Zach (1994) suitable to describe the growth process of wood trees. The final growth curve for each of the three sample trees shows height growth of trees.

Diameter growth analyses

Radial growth has been measured for individual stem discs and can be used in reconstructing a large part of the height spectrum of the individual sample trees. An empirical value curve of accretion as a chronosequence of thickness of growth rings ranging from the youngest up to the oldest, has been put together for all discs. For a stem disc of breast height (1.3 m from the heel of the tree) an analytical accretion and growth curve have also been elaborated by fitting an experimental point field in the Michailov's function.

Volume growth analyses

Using stereometric functions we calculated the volumes of individual growth rings for individual stem sections. A table containing time identification of the growth ring and its volume has been worked out for each section. Subsequently all data of individual sections were produced in a single table and growth ring volumes with the same time identificator were added resulting in a chronosequence of volume growth. As a cumulative function to the chronosequence later on, a chronosequence of volume growth of individual sample trees has been worked out.

Stem morphology

Establishing the thickness of a sample tree according to the height of analysed stem disc, we were able to elaborate graphs of the morphological profile of individual sample trees.

Comparing black walnut growth with selected tree species

The volume growth of individual sample trees was compared with the growth of two major broadleaved trees in the Czech Republic, i.e. the growth of oak and beech. The comparison was made between the growth of all three sample trees of black walnut and an oak and ash model growth, simulated by SILVISIM programme. As the analysed sample trees come from very productive stand sites, we used the best site quality out of the range of qualities in the Czech Republic for comparison of both trees (ash and oak).

Results

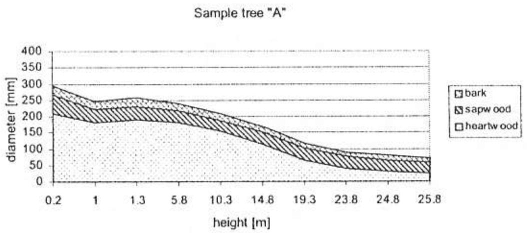
Bark, sap wood and hardwood stem proportion in individual sample trees

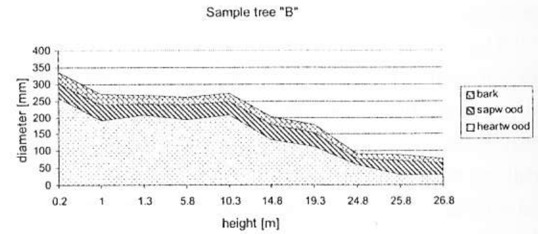
Table 6 documents bark proportion in individual sample trees at various stem heights. A very balanced distribution of bark in all three sample trees along the whole stem length as well as in absolute quantity can be noted. It reaches from 20 % (sample tree B) up to 21.7 % (sample tree C). Percentage of bark is the lowest in the basal part of the tree ranging from 16.4 % (sample C) up to 19.3 % (sample B) at the lowest levels. The percentage of bark increases with increasing height of measurement. In upper parts of the stem it reaches up to 33.5 %.

As the preceding charts reveal, the proportion of sapwood is relatively constant throughout the entire height of the trees, whereas the proportion of heartwood decreases with height. A comparison of individual stems shows that the distribution of sapwood is very uniform, depending only on the extent of branching of a given stem, as in places where branching occurs the sapwood part is wider (see sample tree C: height 22.3 m, sample tree B: height 27.8 m). Sapwood takes up about 25 % of a tree's volume in the basal part of the stem and up to 60-70 % in the top part (see sample tree B where sapwood took up 90 % at the height of 31 m). The logical conclusion is that the production of heartwood within a stem is triggered by a certain age of the growth rings, and is related to the water-conducting capability of tissues, which decreases with age. It would seem that the percentage of sapwood is related to the number of active water-conducting growth rings. For example, the average width of sapwood in sample tree was 31 growth rings, the variation in span being 20–45 growth rings in the top part.

T a b l e 6. The proportion of bark in sample trees

Sample tree "A"		Sample tree "B"		Sample tree "C"	
Section [m^3]	Bark proportion [%]	Section [m^3]	Bark proportion [%]	Section [m^3]	Bark proportion [%]
0.2-1	17.8	0.2-1	19.3	0.27-1	16.4
1-1.3	19.4	1-1.3	19.4	1-1.3	16.0
1.3-5.8	19.5	1.3-5.8	17.7	1.3-5.8	19.7
5.8-10.3	19.6	5.8-10.3	17.9	5.8-10.3	22.0
10.3-14.8	19.9	10.3-14.8	19.9	10.3-14.8	23.8
14.8-19.3	22.5	14.8-19.3	23.6	14.8-19.3	25.8
19.3-23.8	27.8	19.3-24.8	25.0	19.3-21.3	27.8
23.8-24.8	29.6	24.8-25.8	32.0	21.3-22.3	30.1
24.8-25.8	30.9	25.8-26.8	32.2	22.3-23.3	31.9
25.8-26.8	31.9	26.8-27.8	27.1	23.3-24.3	31.3
26.8-27.8	32.2	27.8-29.8	26.1	24.3-25.3	33.5
27.8-28.8	33.2	29.8-30.8	25.3		
		30.8-31.8	29.7		
Total	20.6	Total	20.0	Total	21.7





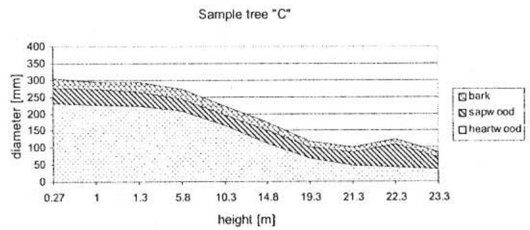


Fig. 2-4. Percentage of bark, heartwood and sapwood in the stems of the sample trees.

Height growth analysis

The following figures document the height development of individual sample trees in relation to their age. These growth curves incorporate data from the stem discs and provide a reliable information on the growth of the analyzed trees. Broken line always denotes the part of the curve which has been projected.

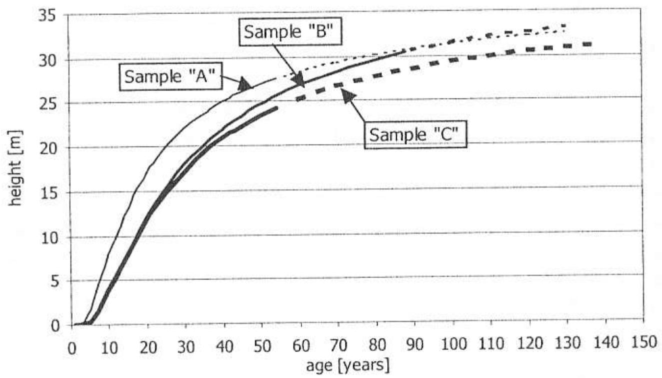


Fig. 5. Height development of black walnut (sample trees A, B and C).

The height development of sample tree A differs from the development of sample trees B and C. Its growth at young age was faster and its increment was higher. However, in later years its growth slowed down and at the age of 130 years it exhibits the same characteristics as sample tree B. We can assume that owing to its branching, the sample tree A was most probably a dominant specimen which claimed competitive advantage over its surroundings.

The height growth of all three sample trees nears the asymptote of 35 meters. Information revealed by the growth curves is confirmed by the increment curves from the following graphs. In these, the blue curve denotes the current increment while the red curve denotes the mean increment. The graph of growth increment helps determine the optimum period during which black walnut is most susceptible to tending. This period can be characterized as a time cycle, in whose course the current height increment culminates, since the height increment is a tree's means of compensating the pressure of the surrounding competition. In the culmination period a tree is susceptible to thinning and cleaning, it is capable of filling gaps and making use of the open space to intensively increase its biomass.

The height increment of all three sample trees culminated after their tenth year, sample tree A culminating earlier than B and C, i.e. around the age of 12–13 years. We can assume that from then up to the age of 30–40 years the trees are highly susceptible to thinning and thus the tending of black walnut stands should be concentrated mainly in this period. Around the age of 40–50 years the decrease of increment gradually stops and its curve flattens.

The following figures show the parameters of increment functions derived from the aforementioned growth functions.

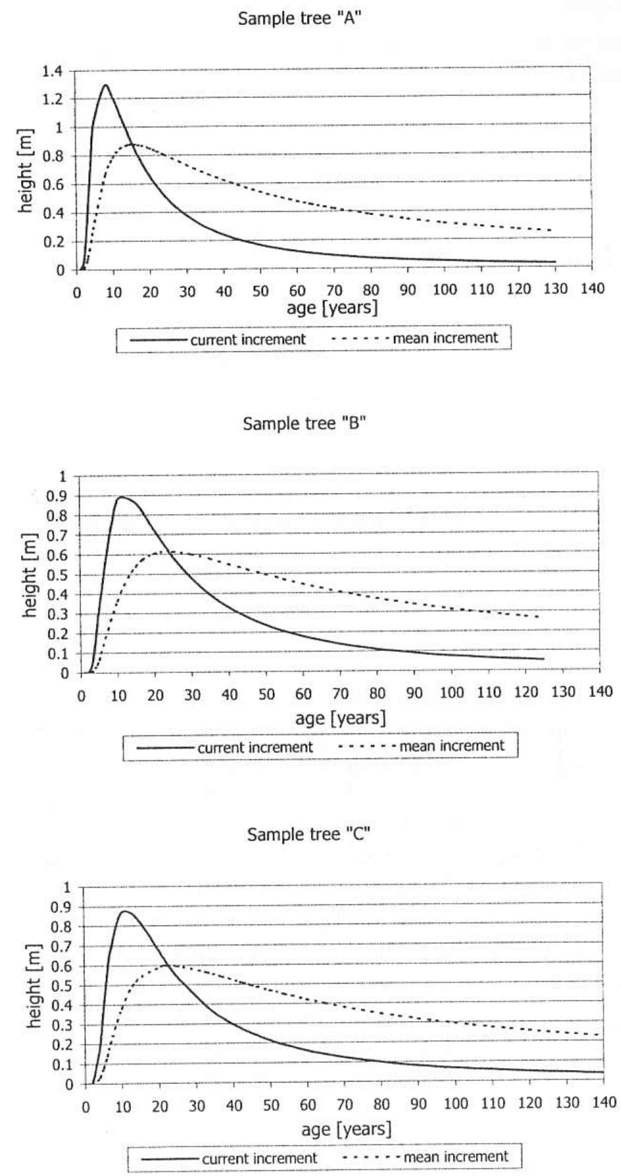


Fig. 6–8. Current and mean height increments of black walnut sample trees.

Volume growth analysis

The culmination point of volume increment was not found. Up to the time of felling, all three sample trees showed a continuous increase of both the current and mean increments.

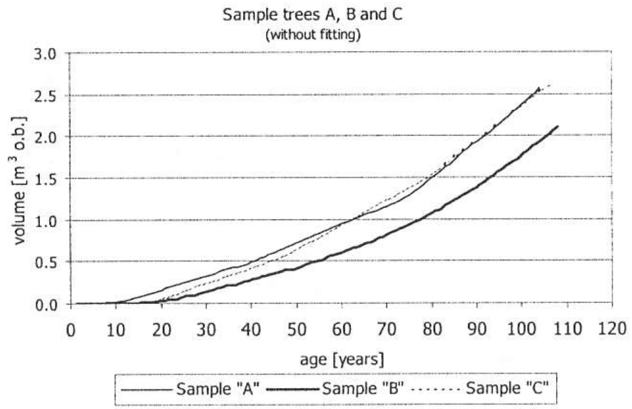


Fig. 9. Volume growth of black walnut sample trees.

The following reasons might be accounted for:

a) the analyzed samples had grown in soil with an exceptionally high production potential, which provided for an unlimited supply of nutrients

b) black walnut is a tree species with a highly flexible secondary growth and as such responds positively to favourable growth conditions

c) the development of the chosen sample trees is not necessarily characteristic of all the specimens of this tree species, particularly if the trees' parameters were not chosen with the aim of representing their respective stands

Should b) be the case, it would mean that it is not economically sensible to fell black walnut stands at the age of 100 years since even at this age the trees show a growing increment and felling would result in production loss. The optimum felling age needs to be determined differently, the proposed procedure being a thorough long-term recording of both the assortment structure of the felled trees and the assortment structure of the secondary crop.

Stem morphology

These graphs have been included in the analysis with the intention of giving a comprehensive view of the problem. It is apparent that, as with every broadleaved tree species, the stems greatly vary in shape and the forming and final shape of a tree are subject to many factors.

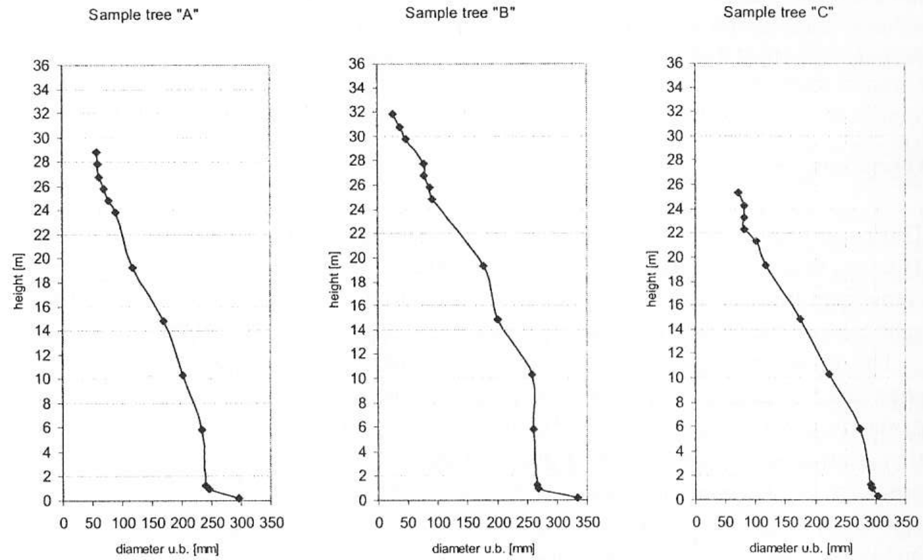


Fig. 10–12. Stem morphology of the black walnut sample trees.

Comparison of the growth of black walnut and some other tree species

The graph presented here reveals that the production capacity of black walnut is higher than that of oak. It also clearly shows that the volume growth of black walnut culminates earlier

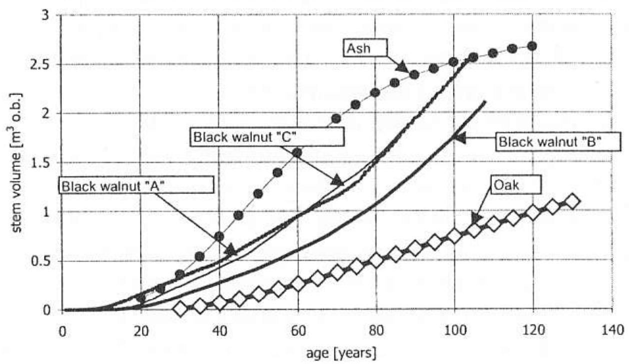


Fig. 13. Comparison of volume growth of black walnut and selected tree species.

than that of oak. A comparison of black walnut and ash reveals that the production cycle of ash can be viewed as shorter and its production higher than that of black walnut. Differences can be spotted also among the individual black walnut sample trees. The growth of sample trees A and C differs from that of B. At the age of 100 years, the latter shows stem volume lower by 1.1 m^3. However, even in this case the volume of 1.8 m^3 reached in 100 years is more than 1 m^3 higher than that of oak (0.8 m^3).

Discussion

This paper presents an analysis of the growth of black walnut as an introduced tree species. The vast majority of papers focusing on the growth and management of this tree species come from the USA, the country of its origin, and the paper's conclusions can hardly be applicable in the growth conditions and forest management system of the Czech Republic.

The development of computer technologies enables us to a certain extent to reduce the costs and difficulty of procedures which until recently had been extremely cumbersome and demanding in terms of evaluation. By implementing computer image analysis and destruction analysis of the sample tree's growth rings we tried to reveal the regularities in the growth of black walnut in the conditions of South Moravian floodplain forests. Needless to say, however, the destruction analysis remains a demanding and expensive method. This is increased by the fact that valuable wood is damaged and the resulting loss must be included in the costs of the method. The chosen number of three sample trees thus represents a compromise between the required informative value of our analysis and the costs.

The "Results" section of this paper notes a relatively high percentage of bark on the sample trees. However, this amount (almost 22 % of the total stem part of a tree) is not unusual and has been observed to a comparable extent in other tree species, such as pine, larch and oak. The aforementioned information has proved valuable for the sales department, as it enables us to make provision for possible discounts. Height growth analysis revealed that with increasing age the height of all three sample trees was nearing 36 m. The height growth of a tree species is genetically determined, a lesser part in the tree's development is played by the respective site's conditions and the pressure of competition. Seen from this perspective, the height of 36 m does not rank among the maximum recorded data (Hrib, 2001).

The course and character of growth curves of the sample trees attests to the fact that black walnut is a fast-growing tree species, its height increment culminating at a relatively young age (10–20 years). Thus we can adopt general conclusions relevant to tree species with a similar growth strategy, i.e. lesser tolerance to shade, physical maturity reached at a young age (reproductive potential) and shorter growth cycle. In terms of silvicultural measures, we expect that the trees show highest susceptibility to tending at a relatively young age of 30–40 years. Diameter analysis results reveal an uneven, in some cases even increasing diameter increment in older age. We have reasons to believe that the effect of an open stand increment induced by a high-forest-with-reserves management would be justified. It is interesting to note that the volume growth of black walnut at the analyzed age (110 years) does not reach the inflexion point and as such does not show a slowing of the volume increment. This should justify an increase of the felling age beyond 110 years. However, we must bear in mind that we speak of the culmination of volume, not the culmination of value which would be reflected in sales. Secondly, we did not take into account the fact that fungal diseases spread more significantly in higher ages. Seen from this perspective, the conclusions drawn about volume growth should be considered only as a point of reference. An evaluation of felling maturity must proceed from information on entire forest stands, it must optimize data from forest management records and take into account the grading of felled timber, both in principal and secondary (thinning) stands. We can draw a parallel with the recommended rotation period for black walnut stands, issued as a part of general guidelines of forest management at the Židlochovice MPA. These guidelines propose a rotation period of 140 years with a regeneration period of 30 years, provided that a forest manager determines the actual felling age of a given forest stand after considering a number of other criteria (e.g. the current supply and demand, health condition of the stand).

A comparison of the growth of black walnut and our most frequently grown tree species, oak and ash, revealed that the analyzed tree species reaches a higher yield than oak and lower yield than ash at a specific age. This fact might lead to an increased planting of black walnut on productive forest land. Needless to say, however, that black walnut is an introduced tree species and its influence on the native tree, plant and animal communities in our conditions has not been analyzed yet. Journals mention a relatively high allelopathic effect of black walnut on the undergrowth and the surrounding trees (Jose, Gillespie, 1998). The possible negative impact of introduced tree species on the original ecosystems has led to the recommendation that no more than 10% of timber land at the Židlochovice MPA should be covered by introduced tree species.

Conclusion

With regard to the data acquired by the growth ring analysis we can state the following:

- the percentage of bark is the lowest in the basal part of the trees, ranging from 16.4 % (sample C) up to 19.3 % (sample B) at the lowest levels. In upper parts of the stem it reaches up to 33.5 %
- the proportion of sapwood is relatively constant throughout the entire height of the trees, whereas the proportion of heartwood decreases with height. Sapwood takes up about 25 % of the tree's volume in the basal part of the stem and this proportion can increase up to 60–70 % in the top part (see sample tree B where sapwood took up 90 % at the height of 31m)
- the height increment of all three sample trees culminated after their tenth year, sample tree A culminating earlier than B and C, i.e. around the age of 12–13 years. We can assume that from then up to the age of 30–40 years the trees are highly susceptible to thinning and thus the tending of black walnut stands should be done mainly in this period. Around the age of 40–50 years the decrease of increment gradually stops and its curve flattens
- secondary, or diameter increment of black walnut is more stable in higher parts of the trees and almost constant in the crown, in contrast to the uneven and erratic increment at the tree foot
- the production capacity of black walnut is higher than that of oak. It is also apparent that the volume growth of black walnut culminates earlier than that of oak. A comparison of

black walnut and ash reveals that the production cycle of ash can be viewed as shorter and its production higher than that of black walnut.

Our experience with black walnut cultivation hitherto confirms a satisfactory growth of this tree species in the conditions of South Moravian river valleys. Judging by the health condition of the stands and the current situation in the timber market, we can say that the ideal rotation period in our conditions is 130–140 years.

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Hrib M., Kneifl M., Kadavý J.: **Růst ořešáku černého** *(Juglans nigra L.)* **v podmínkách lužních lesů LZ Židlochovice.**

V lesích jižní Moravy je v porostech pěstován druh introdukované severoamerické dřeviny – ořešák černý (*Juglans nigra* L.). I když se ořešák černý na jižní Moravě pěstuje od počátku 19. století, jeho současné nejstarší porosty byly založeny umělými výsadbami přibližně před 120 lety.

Práce se zabývá detailní vertikální a horizontální letokruhovou analýzou vybraných vzorníků ořešáku černého (*Juglans nigra* L.) na LZ Židlochovice (Lesy české republiky s.p.). Byly analyzovány tři vzorníky z jednoho z nestarších porostů ořešáku černého. Práce detailně analyzuje podíl kůry u jednotlivých stromů a distribuci její hmoty v závislosti na výšce stromu, zabývá se výškovým, tloušťkovým a objemovým růstem vzorníků. Konstatuje, že ani ve věku 108 let nebyla nalezena kulminace objemového přírůstu, neklesající přírůst tloušťky, a tím i kruhové plochy do věku 108 let, popisuje morfologii jednotlivých vzorníků a následně srovnává objemový růst ořešáku černého s dřevinami dubem a jasanem. Konstatuje, že ořešák černý dosahuje vyšší produkce, než zmíněné dvě dřeviny.

BIOENERGY PRODUCTION OF AGRICULTURAL SOILS COVER

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Abstract

Vilček J.: Bioenergy production of agricultural soils cover. Ekológia (Bratislava), Vol. 22, No. 2, 177–182, 2003.

Soil energetic effectivity knowledge through biomas produced by plant can be one of the decisive parameters of their production capability assessment as well as categorization for their potential use. Based on the crops production soil parameters were selected and potential of bioenergy production of Slovak soils was derived. Energetically most productive are the soil types like Chernozems (88.6 GJ.ha^{-1}) and Mollic Fluvisols (76.14 GJ.ha^{-1}). The least energy amount generate Gleys, Organosols, Solonetzes and Lithosols (31.63 GJ.ha^{-1}). The highest assumption for energy production (79.11 GJ.ha^{-1}) is upon the soils located in the climatic region very warm, very dry, lowland. According textural composition most energy (56.98 GJ.ha^{-1}) was produced by loamy soils, do not threaten by wate erosion (73.25 GJ.ha^{-1}), by sloping to 3° (66.61 GJ.ha^{-1}) and skeletonless soils (68.57 GJ.ha^{-1}). According tu selected scale of plant biomass production assessment on farm land, the soils high and very high productive (above 212 GJ.ha^{-1}) are located mostly in plains. Energy accumulated in farmland exploitability by plants cropped is variable depending from soil representative and its properties. The lowest exploitability was found at Cambisol (0.7–1.8%), the highest at Regosols (3.1–7.0%).

Key words: soil energy parameters, energy production, soil production potential

Introduction

Soil is one of the ecosystem compounds, essential and inseparable part of biosphere and therefore its energetic characteristics should be based on biological and soil forming processes complexity. Through plants microorganisms and humus considerable amount of transformed solar energy is accumulated in soil, this energy is being consumed for continous development of soils and their productivity. Biogeocoenoses as selfregulated systems represent energetic unity of mutual reactions among the lowest atmosphere layer, plant, soil, microorganisms and animals. I.e. if we want to regulate useful biomass synthesis (food, fodder, etc.), we must know basic rules of energy flow and transformation in particular