Seasonal dynamics of the diameter increment of fir (*Abies alba* Mill.) and beech (*Fagus sylvatica* L.) in a mixed stand

R. KNOTT

Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry, Brno, Czech Republic

ABSTRACT: In the growing season 2001 changes were studied in the diameter increment of selected sample trees of silver fir and beech in a mixed stand using mechanical girth dendrometers. Within the selected set of trees individual differences were determined both in the dynamics of increment and in its total magnitude. The differences are evident not only between tree species but also within particular species in trees of the same diameter. On the basis of the results of a detailed study of diameter increment dynamics in the course of a year using a non-destructive method by means of mechanical dendrometers and measurements of particular components of microclimate individual growth responses of trees to selected external factors were determined.

Keywords: silver fir; European beech; diameter increment; dendrometer; climatic factors

At present, an issue is often discussed concerning expected climatic changes that could markedly affect the species composition of forest stands particularly in lower vegetation zones. In this context, a number of papers was published often with very different views on potential responses of tree species to the expected climatic change. According to CHALUPA (1992), an expected increase in temperature land changes in the amount and distribution of precipitation will exert considerable effects on the composition of forest ecosystems and on the distribution and composition of forest tree species in the region of the Czech Republic. MINĎÁŠ and ŠKVARENINA (1994) mentioned the following probable consequences of expected climatic changes for the species composition of forest ecosystems:

- the most available species threatened by climatic changes would probably be silver fir and Norway spruce primarily at the lower limit of their distribution and outside their natural range;
- under unimproved health conditions of montane and alpine spruce forests it is possible to expect a certain expansion of beech into these locations;
- even with respect to the expected shift of beech to higher locations beech will play an important role also in lower forest vegetation zones.

One of the possibilities of the study of growth responses of particular trees to external climatic changes is a detailed monitoring of changes in tree diameter in the course of the growing season. Based on the results it is possible to estimate the future potential growth response of trees to expected climatic changes. With respect to easy measurements, monitoring of the dynamics of diameter increment at breast height is used most frequently although at present projects are also under way where attention is paid to changes in diameter at various heights of the tree (VOGEL et al. 1996). The basic principle of measurements by means of special devices with a registration equipment was described e.g. by FRITTS (1976) or ŠMELKO et al. (1992). Dynamics of diameter increment in the course of a year and changes in tree diameter in the course of a day in relation to physiology in forest stands were recently dealt with by a number of authors (OFFENTHALER et al. 2001; DOWNES et al. 1999; JEŽÍK, VOŠKO 2002; ZWEIFEL et al. 2000; TATARINOV, ČERMÁK 1999). Studies dealing with changes in tree stem diameter under controlled climatic conditions (e.g. HÄBERLE et al. 1995) are also of great importance. At the present time, special devices, so called dendrometers are used for non-destructive monitoring of changes in tree diameter. There are two basic types of dendrometers, viz. point and girth ones (ĎURSKÝ, MOZOĽOVÁ 2001; NEUMANN 1996; KEELAND, SHARITZ 1997; PESONEN, MIELIKÄINEN 1995). On the basis of the analysis of the effect of external factors diameter increment is particularly influenced by the sociological

Supported by Grant Agency of the Czech Republic (Grant No. 526/00/D082) and by Research Plan MSM 434100005 of the Faculty of Forestry and Wood Technology Mendel University of Agriculture and Forestry Brno.

position of a tree, density, amount of throughfall, soil depth, moisture and physical properties (VOŠKO, JEŽÍK 1995). The magnitude of the diameter increment of trees during the growth is decisively affected by climatic factors the relationship being site-specific (ĎURSKÝ 1994).

Since 2001, a research project *Growth Response of Tree Species to Climatic Factors in a Beech/Fir Stand* has been solved on permanent thinning experimental plots of the Faculty of Forestry and Wood Technology in Mendel University of Agriculture and Forestry Brno under financial support of Grant Agency of the Czech Republic. Within the project, monitoring of diameter increment was carried out in a mixed stand of Forest District Olomučany, Training Forest Enterprise Křtiny in the growing seasons 2001 and 2002.

The objective of the paper is a preliminary evaluation of the diameter increment of two main species, viz. silver fir and beech primarily in relation to various diameters of selected sample trees with respect to the effect of main climatic factors in the growing season 2001.

MATERIAL AND METHODS

Research was carried out in Stand 123C_7 which originated by the natural regeneration of silver fir after 1920 within a short period of 5–10 years. In 1960, when the stand was aged 39 years, Department of Silviculture of the Faculty of Forestry in Mendel University of Agriculture and Forestry Brno established permanent thinning plots there according to a traditional layout. The total area of the stand is 10.84 ha. The stand is situated on a plateau slightly sloping towards NE at an altitude of 460 m (coordinates 49°19´25´´N and 16°40´11´´E). On the Brno effusive rock (granite), soils of illimerized podzol types were formed. From the viewpoint of forest typology, the stand was ranked among forest type 3S6, i.e. oak/beech communities of *Luzula* type with *Carex digitata.* In the present species composition, silver fir and beech show a dominant position, other species being European larch, Norway spruce, oak, interspersed species such as hornbeam, birch, goat willow, rowan and aspen. Remnants of the original stand remained in the stand as reserved trees (particularly Scots pine and European larch).

Prior to the beginning of the growing season 2001, mechanical dendrometers (EMS Brno) were installed on selected trees in the stand so that main diameter classes particularly in silver fir and beech would be uniformly represented. In addition to the main species dendrometers were also placed on selected reserved trees of spruce, larch and pine. The dendrometers were installed on 115 trees at a height of 1.3 m above the ground and on 6 sample trees in the close proximity of a measuring tower at other heights (5.3, 9.3, 13.3 and 17.3 m). The dendrometer belongs to the group of self-supporting instruments that eliminate drawbacks of some dendrometers referring to their attachment on trees by means of screws. Unfavourable responses of some trees to the attachment resulting in the formation of occlusions were described e.g. by ĎURSKÝ and MOZOĽOVÁ (2001). Values of the changing tree girth were read by ocular estimation to the nearest 0.1 mm. Reading the dendrometer data was carried out throughout the growing season in regular weekly intervals. In the paper, dynamics of silver fir (49 trees) and beech (42 trees) was evaluated only in 2001.

For the purpose of evaluation, all silver fir and beech trees with installed dendrometers were classified in 4-centimetre diameter classes. Average data on the course of diameter increment were calculated for the classes. From the whole set of studied trees three silver firs and beeches were always selected from diameter classes of 14, 30 and 50 cm for detailed evaluations. The classes were selected with respect to the distribution of sample tree frequency according to diameters and at the same time they characterize different social position of trees in the stand.

Weekly values of the girth increment of particular trees at breast height (b.h.) were determined as a difference in the girth of two successive readings and subsequently converted to diameter increment in cm. In assessment the values of current increment are always given for one week.

In the stand under investigation, automatic measurements of climatic parameters (air and soil temperature, soil water potential) have been carried out since 2001. On an open area at a distance of 200 m, air temperature and humidity, precipitation and global radiation are measured. The values of climatic measurements are automatically recorded as 10-minute means from 1-minute (or 5-minute) readings into a MiniCube model VV/VX (EMS Brno) logger. Temperatures and precipitation on the open area and soil water potential are evaluated in the paper. In the stand, two sensors of soil water potential were always placed at a depth of 10 and 30 cm under the soil surface, viz. in three segments under various species (silver fir, beech and open canopy).

In order to determine the existence of a relationship between the magnitude of increment and selected climatic factors in particular weeks of the 2001 growing season correlations were calculated between the current weekly diameter increment of all fir and beech trees at b.h. and precipitation totals and mean temperatures. Resultant Pearson's correlation coefficients which are defined as the covariance of two samples divided by the product of their standard deviations were depicted in diagrams in relation to the diameter of particular trees. The significance level was calculated on the basis of Student's *t*-distribution. Numbers of statistically significant correlations (at a significance level $\alpha = 0.05$) between increment and climatic factors are commented in the text.

RESULTS

The course of climatic factors in 2001

The course of mean daily temperatures and daily precipitation totals in 2001 is depicted in Fig. 1. In 2001, the total precipitation amounted to 644.1 mm at 162 pre-

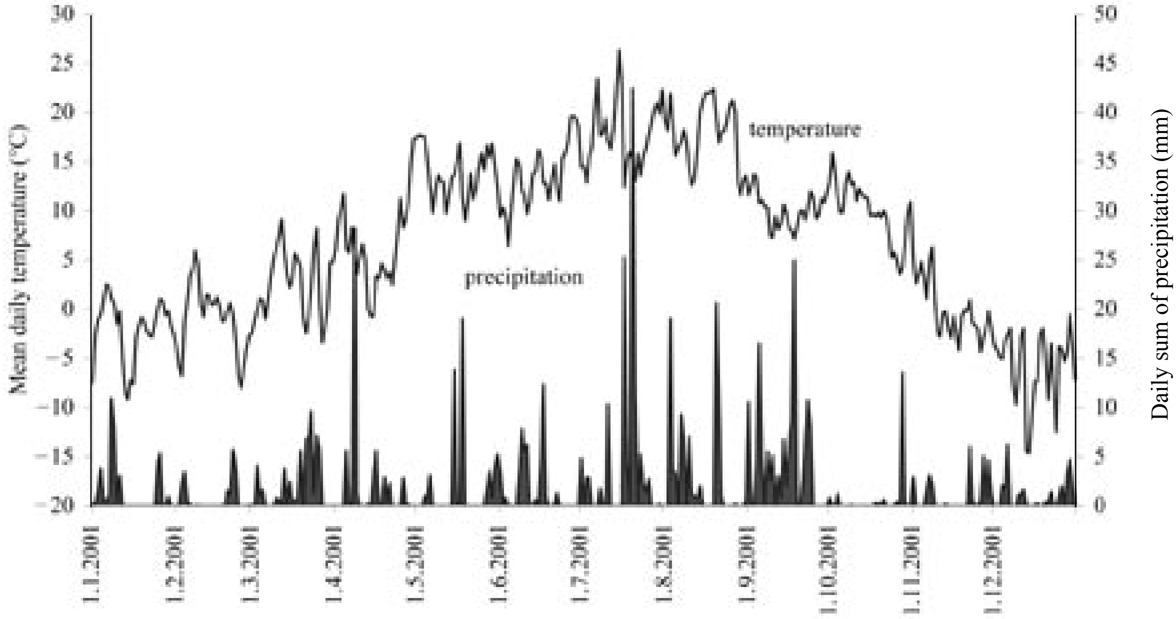

Fig. 1. Mean daily temperatures and daily precipitation totals in 2001

cipitation days. The distribution of precipitation in the course of the year was favourable. In addition to markedly below-average months of January, February, October, November and December also May with 10 precipitation days was a below-average month (47.8 mm). In other months, precipitation ranged about normal. Precipitation was markedly above-average at the turn of summer and autumn in July and September (as much as 131 mm) or also in August (86 mm). The value of Lang precipitation factor (92.6) is the second highest within the last ten years after 1997 whereas in other years the factor ranged mostly about the value of 55. Based on the Lang precipitation factor calculated for particular months of the growing season September (13.0) and July (6.7) were most favourable as for humidity.

Mean annual temperature in 2001 reached the value of 7.0°C (Fig. 1). Mean monthly temperatures in the course of the year were rather lower than in the period 1976 to 2000. Monthly temperatures in March, July and August were slightly below-average being markedly below-aver-

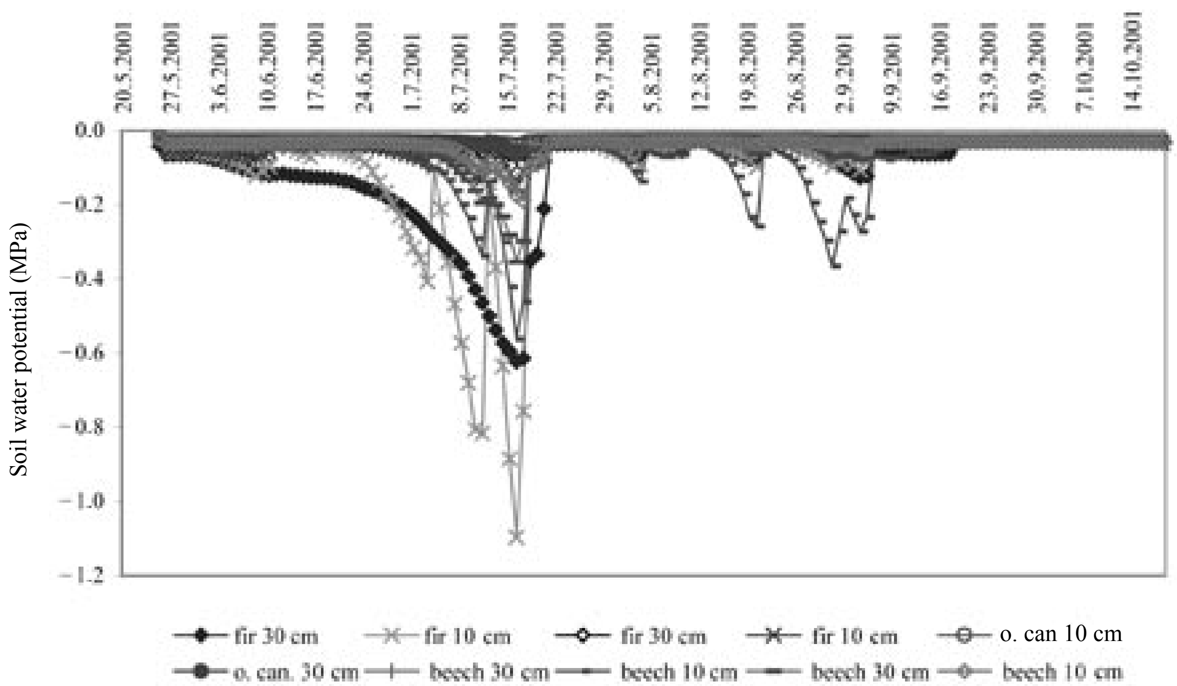

Fig. 2. The course of soil water potential below silver fir, beech and open canopy in 2001 (MPa)

age in April, June, September, November and December. July (17.7°C) and August (17.8°C) were the warmest months, the coolest month being December (–5.8°C). The highest temperature of 32.7°C was recorded on 15 July and the lowest one on 13 December (–17.5°C). The first value of an effective temperature (t > 10°C) calculated from daily data (Degree day – DD) was found to be 3.4 whereas the value calculated from hour data (Degree hours – DH) was already 11.3. The values of sums of effective temperatures (SET) in hour degrees (DH) were reached on the following days: SET 10°C 12 March, SET 50°C 1 April, SET 100°C 3 April, SET 1,000°C 2 May and SET 2,000°C 11 May.

In the growing season 2001, a typical course (Fig. 2) of the soil water potential (Ψ_{soil}) was found at studied depths (10 and 30 cm) in all variants (silver fir, beech and open canopy). From the initial condition of the sufficient soil water supply under full field moisture capacity the value of soil water potential was kept on a favourable level thanks to frequent precipitation. If the supply of water into soil through precipitation was lower, the value of Ψ_{soil} gradually exponentially increased due to the effect of evaporation and water consumption by plants (or runoff). If the period without precipitation was longer in some cases (depth or variant of position), Ψ_{soil} values > 1.3 MPa were reached which resulted in the total inaccessibility of water from soil in the place of measurement. The increasing trend of soil water potential or the continuing period of a wilting point were stopped (Ψ_{soil} value rapidly decreased) if precipitation in the open area also got under the stand in sufficient amounts supplying thus water reserves in the soil.

In the segment with open canopy, the values of soil water potential (Ψ_{soil}) were in limits of full field moisture capacity in the course of the whole growing season 2001. The highest values of the potential were reached in mid-July (17. 7.). At a depth of 30 cm below the soil surface, the value of –0.07 MPa was reached. It is possible to conclude that within this segment soil water was easily accessible for trees.

From the beginning of July, the availability of water decreased gradually to the value of –1.3 MPa in the segment below silver fir expressed by soil water potential in the area of one of the sensors placed at a depth of 10 cm. The value expressing nearly the total inaccessibility of water to plants could be caused by placing the

Table 1. Mean monthly values (in %) of total annual increment according to diameter classes

Species	Diameter class	Month					
		April	May	June	July	August	September
Beech	10	0.0	15.3	26.2	36.1	19.1	3.3
	14	0.2	19.8	33.0	29.4	16.0	1.7
	18	0.0	20.8	30.0	28.6	17.0	3.5
	22	0.5	17.1	29.4	30.3	18.2	4.6
	26	0.0	17.8	27.9	27.2	21.5	5.7
	30	0.0	17.1	28.5	29.2	19.6	5.7
	34	0.0	20.5	24.9	30.1	19.9	4.6
	38	0.1	16.0	27.4	30.3	21.6	4.6
	42	–2.2	16.4	27.6	37.8	17.3	3.1
	46	0.8	15.6	23.8	30.9	21.9	7.0
	50	–0.4	18.8	23.2	30.8	21.7	5.8
	54	0.6	26.4	23.3	30.7	14.7	4.3
	58	–0.8	31.5	31.5	24.2	9.7	4.0
	Average	–0.1	19.5	27.4	30.4	18.3	4.5
Fir	14	12.1	36.9	22.7	15.6	7.1	5.7
	18	2.4	36.6	13.4	21.3	14.6	11.6
	22	6.9	38.1	14.6	13.8	14.6	11.9
	26	3.9	37.1	20.2	17.0	11.7	10.2
	30	3.6	38.6	21.6	10.7	14.4	11.0
	34	1.6	35.0	23.9	15.5	13.9	10.0
	38	2.0	42.2	20.3	12.2	11.0	12.2
	42	1.5	38.1	23.5	15.7	11.0	10.2
	46	0.8	31.7	18.9	15.1	20.1	13.5
	50	2.5	35.7	24.5	16.3	11.9	9.1
	Average	3.7	37.0	20.4	15.3	13.0	10.5

sensor under the crown of a silver fir, which could result in minimum throughfall. The potential found at the same depth in the second sensor exhibited more favourable values (about –0.18 MPa). The increasing trend of aggravated availability of soil water (caused both by evaporation and increased consumption of trees in the period of growth) was already noticed at the end of June being always interrupted by fallen precipitation. In the period 24 June to 17 July, 16 days were without precipitation. In total, the precipitation amounted to 22.7 mm. On 17 July, 25.3 mm precipitation fell which was sufficient for the replenishment of soil water. From mid-July, Ψ_{soil} values did not exceed a limit of 0.15 MPa.

The course of soil water potential values in the segment below beech trees was more balanced against silver fir (Fig. 2) in the period on the turn of June and July. Increase in Ψ_{soil} occurred more slowly than below silver fir, the highest value of Ψ_{soil} 0.69 MPa being recorded on 17 July at a depth of 10 cm below the soil surface. At the same time, about 1.5 hour delay is evident in the decrease of soil water potential from a maximum to a minimum value (e.g. on 17 July). The differences in the course of Ψ_{soil} can be explained by the different position of beech branches. Water intercepted by the crown and led by oblique branches flows along the stem to the tree foot into the soil. Thus, higher amounts of water can reach the soil under beech as compared with silver fir (of course in dependence on the intensity and duration of precipitation). Although 3 sensors signalized good availability of soil water in August and September, the values in one sensor at a depth of 10 cm were found to indicate the worsened availability of soil water from mid-August (Ψ_{soil} value, however, did not exceed the level of 0.4 MPa).

Increment of silver fir

Radial increment of silver fir at b.h. (Fig. 3) began nearly in all diameter classes in the first week of May. The total duration of growth in all diameter classes was 19 to 20 weeks. All silver fir trees completed their increment by the end of September. In the lowest diameter classes, the majority of annual increment was created by the end of July (70–90%). In August and September, trees in the class grew up minimally with respect to the total increment per year. The highest increment (as much as 42% of the total annual increment) was noticed in all diameter classes of silver fir in May (Table 1). The absolute magnitude of the average increment in diameter classes is markedly dependent on the diameter of studied trees. For example, fir trees in a diameter class of 22 cm grew up only by 0.13 cm on average over the whole growing season 2001, trees in diameter classes 10 and 14 cm even less (Fig. 3b). The largest trees (classes 46 and 50 cm) increased gradually their diameter by as much as 0.82 cm per year. The percentage expression of the values of dynamics of increment in relation to the total amount of increment (Fig. 3c) indicates synchronization among trees in all diameter classes in particular weeks of the growing season. Differences in the average curves of silver fir range between diameter classes in an interval of max. 20% in the same week. Between particular trees, much greater differences were found. Observations from a week until 30 May can serve as an example. Some trees created about 50% of their total annual increment while other trees only 20%.

The development of actual sample trees of silver fir from selected diameter classes is depicted in Fig. 4. The smallest fir trees grew up mainly at the beginning of the growing season in May. Fir in diameter classes 30 and 50 cm created about 80% increment by the end of July. In August and September, even 20–25% of the total seasonal increment were recorded. Fir trees reached maximum of their increment in all three selected diameter classes in May (as much as 50% of the total annual increment). At first, growth curves of silver fir rapidly increased, however, from June the growth was gradually retarded. The most rapid beginning of growth was observed in sample tree No. 36 in a diameter class of 30 cm, which grew up by 0.08 cm in the second week of May thus creating 20% of its total annual increment. In a diameter class of 30 cm which includes also this tree it is possible to observe even the second period of an increased increment from mid-August to mid-September. In a diameter class of 50 cm, growth curves of both sample trees showed the same course by the end of May. From the beginning of June, however, increment of the two trees began to differentiate. While sample tree No. 126 increased gradually its diameter (by the end of the year by about 0.5 cm), silver fir No. 133 with the decreasing magnitude of current increment increased its diameter only by 0.1 cm by the end of the growing season. Retardation of the increment of fir No. 133 can be explained by its position in the closed part of the stand and thus also by higher competition of neighbouring trees while tree No. 126 is in an open position without marked competitors. Trends of current increments (increase – decrease) of sample trees of fir are nearly identical in particular weeks. In the course of the growing season, diameter increment was completely stopped three times in the majority of selected firs in the middle of summer (weeks till 27/6, 11/7 and 1/8) obviously owing to decreased availability of soil water. Then, all fir trees always restored their growth.

The cessation of fir tree increment is also evident from Fig. 5, which depicts the relationship between the current increment of all trees and stem diameter in the selected weeks of the growing season 2001. In the last week of June (a week till 27/6), an increment was recorded only in trees of d.b.h. > 30 cm. Trees < 30 cm did not grow up at all in this week with the exception of fir No. 53, which increased its diameter by 0.02 cm in this week. Decrease in the magnitude of the increment was also recorded in beech in this week but the absolute cessation of growth occurred in two trees only (d.b.h. 32.6 and 49.8 cm). In the course of the whole growing season 2001, higher increment in beech than in silver fir was found in the majority of sample trees of comparable diameters. At the beginning of the season

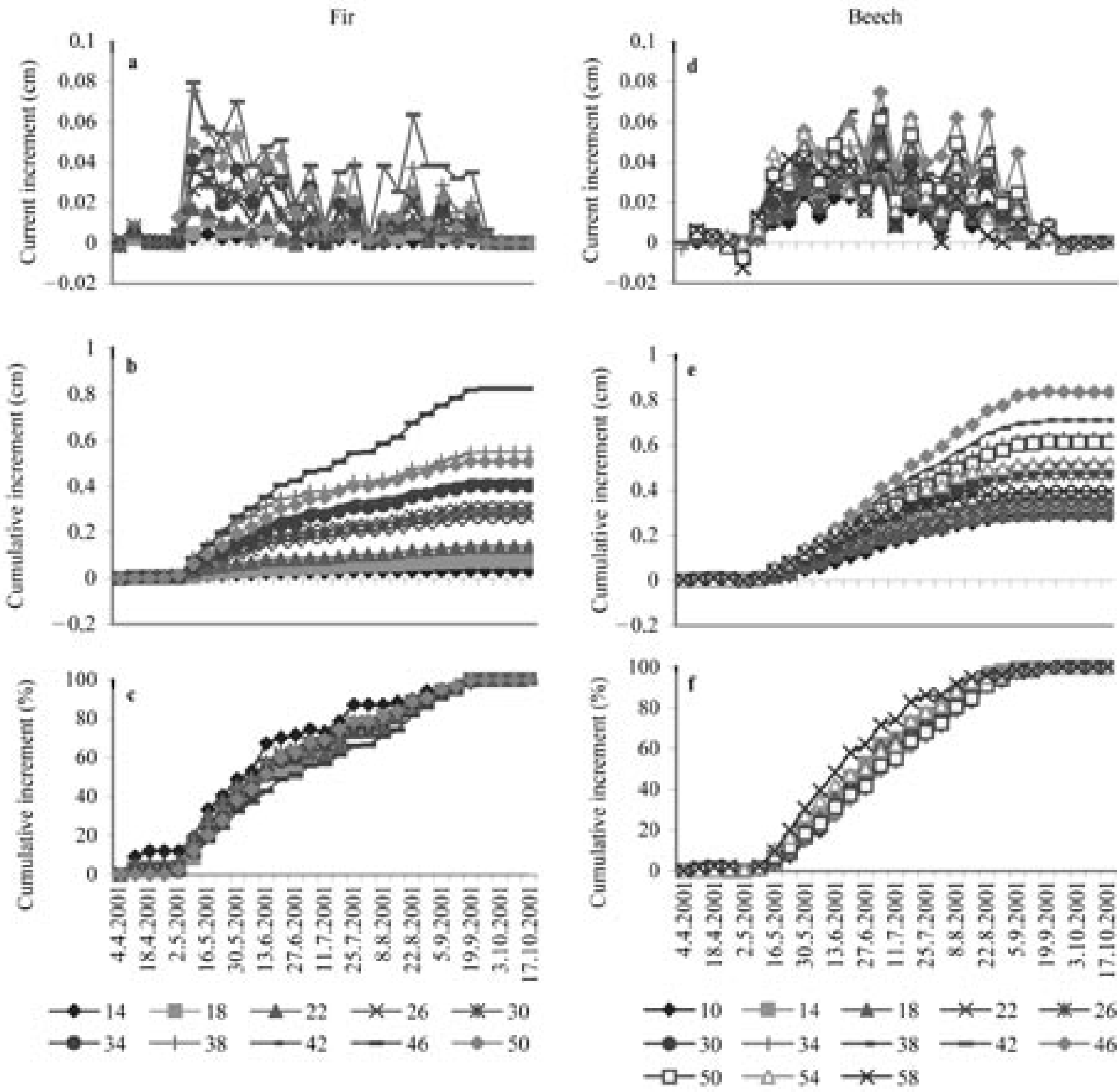

Fig. 3. Mean current (a, d) and cumulative (b, e) diameter increment of silver fir and beech in particular diameter classes and its relative expression in % (c, f) of the total annual increment

(Fig. 5 – 16. 5.), large-diameter fir trees grew up more than beech trees of the same diameter. The last marked increment was noticed in a week till 5/9 being comparable in both species of all diameter classes.

A relationship between the magnitude of the total annual increment and diameter of all studied fir and beech trees is depicted in Fig. 6. The total magnitude of diameter increment is markedly dependent on the diameter of trees in both species and thus also on the social position of particular trees in the stand.

Fir trees in the diameter class of 14 cm reached the lowest nearly negligible values, viz. 0.08 cm only while some trees did not grow up at all. An increase in basal area of the trees was logically also inexpressive (max. 1.84 cm^2). The highest increment in stand b.a. was reached in silver fir of a diameter class of 46 cm (60.53 cm^2) at a increment of 0.82 cm.

Increment of European beech

The beginning of diameter increment in beech (Fig. 3d) was noticed in the second week of May, i.e. roughly one week later than in silver fir. The growth continued 19 weeks being finished in mid-September. The increment maximum of beech sample trees was concentrated on June and July while in large-diameter trees, there was an evident shift of maximum values to July (Table 1). Growth curves of beech (Fig. 3e) in all diameter classes are less steep at first as compared with those in silver fir, however, from June its growth gradually accelerated. In small-diameter classes, a more intensive start of increment was noticed and, at the same time, also earlier cessation of growth than in trees of larger diameters.

Based on the percentage expression of values of beech increment in relation to the total magnitude of the incre-

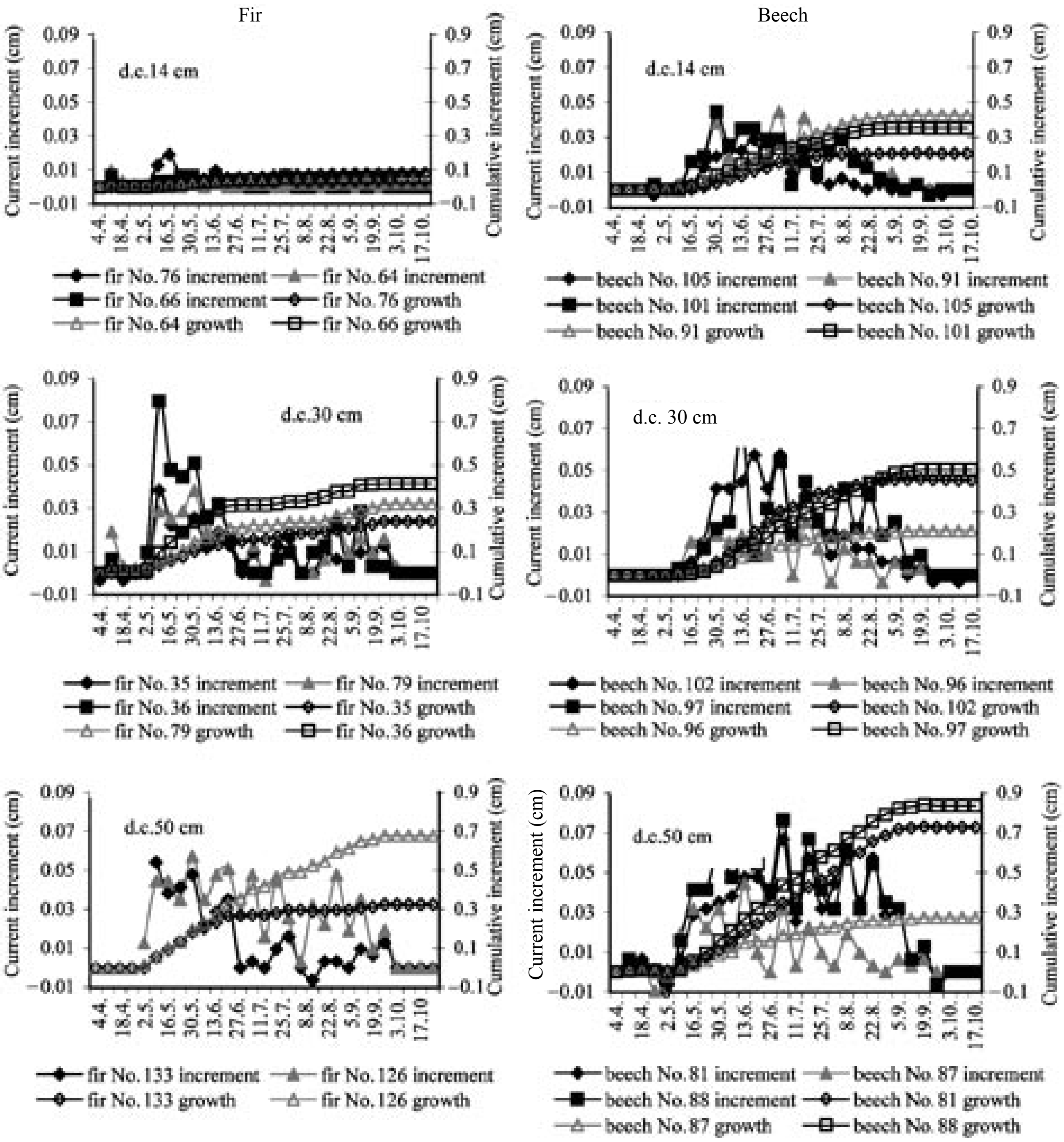

Fig. 4. Growth and increment curves of selected sample trees of silver fir and beech in diameter classes (d.c.) of 14, 30 and 50 cm

ment in particular weeks (Fig. 3f) it is evident that there is a better synchronization of growth dynamics of all diameter classes as compared with silver fir. Among particular trees, similarly like in silver fir, there are individual differences even in this per cent expression of increment dynamics in relation to the total magnitude of the increment. As an example of the difference, an increment in the last week of May can be given. By the end of May, 10 to 30% of the total annual increment were created in the majority of particular beech trees. For example, beech No. 111 is an exception (diameter class 34 cm) because already 42% of the annual increment were created in the tree within the period. Another extreme was recorded in beech No. 40, diameter class 42 cm, which created only 4% of its total annual increment in the same period.

As for selected trees in a diameter class of 14 cm (Fig. 4), beech trees No. 105 and 101 grew up most in June 43 and 35% of annual increment, respectively), beech No. 91 in July (35%). In September, increments from the aspect of total increment were already insignificant in the diameter class. The largest beech trees (diameter class 50 cm) show their growth curve more flatter thanks to the shift in increment culmination to July. As for this diameter class, the most intensive start in growth was shown

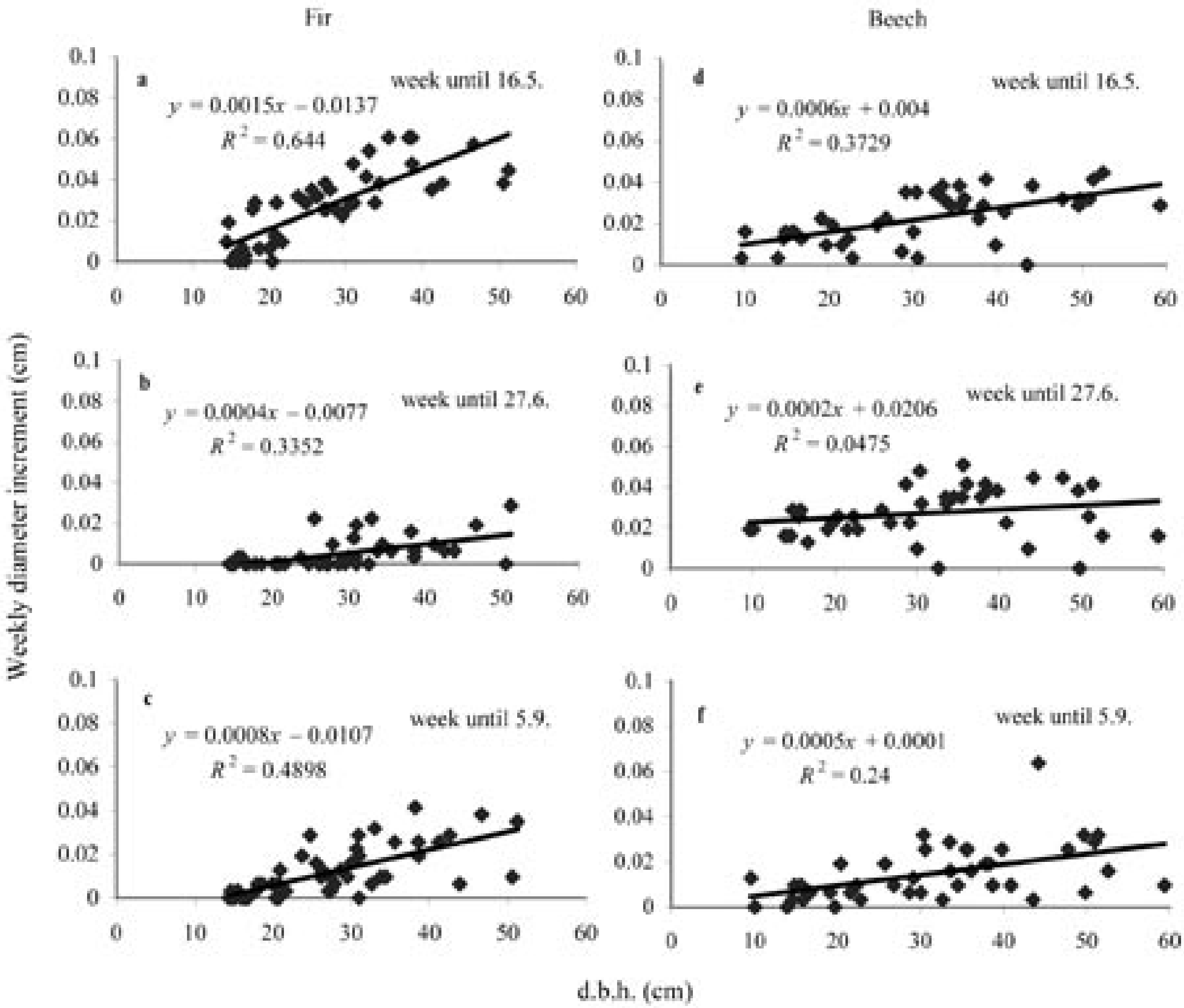

Fig. 5. Relationships between the diameter increment of silver and beech and diameter of trees in weeks until 16. 5. (a, d), 27. 6. (b, e) and 5. 9. 2001 (c, f)

by tree No. 87, which created nearly 20% of its annual increment in the first two weeks of growth. In spite of the rapid start of growth, the tree reached only 1/3 of the absolute increment (0.29 cm only) of other beech trees in the same diameter class (as much as 0.85 cm). According to the magnitude of the total annual increment the large-diameter beech can be ranked among trees of the smallest diameter class (14 cm) that grew up by 0.21 to 0.43 cm at b.h. in the growing season 2001. Based on the b.a. increment (22.73 cm^2), the tree can be ranked among trees of a diameter class of 30 cm which grew up from 10.24 to 24.50 cm^2. Current weekly increments of beech showed the same trend in the majority of cases although exceptions occurred when some trees responded by decreased increment whereas other beech trees increased their increment. Within the growing season 2001, a marked decrease in current weekly increment was noticed in beech and in some sample trees, the diameter increment was quite stopped in some weeks. The increment decrease is most marked in beech in all diameter classes in a week between 4. 7. and 11. 7. Decrease in beech diameter is of interest in a diameter class of 50 cm at the beginning of leaf unfolding.

The absolutely highest increment of beech (0.86 cm) was recorded in a tree of a diameter class of 46 cm (Fig. 6). The tree increased its b.a. by 60.45 cm^2 over the growing season. The highest increase in b.a. (69.19 cm^2) was found in a beech tree of 51.4 cm d.b.h. (diameter class 50 cm) at a diameter increment of 0.85 cm. From the total set of the studied beech trees some large-diameter trees (e.g. sample tree No. 87 of d.b.h. 49.8 cm) grew up in diameter per year as much smaller trees (roughly by 0.29 cm). Their b.a. increment (22 cm^2) was, however, up to 4-times higher than that in trees of small-diameter classes thanks to their diameter.

Correlation between the diameter increment of fir and beech and climatic factors

To determine the rate of dependence between the magnitude of the increment and climatic factors in particular weeks of the growing season 2001 their correlation was carried out. The results of correlation analysis of current weekly diameter increments of all trees and climatic factors (precipitation total and mean temperatures) of the

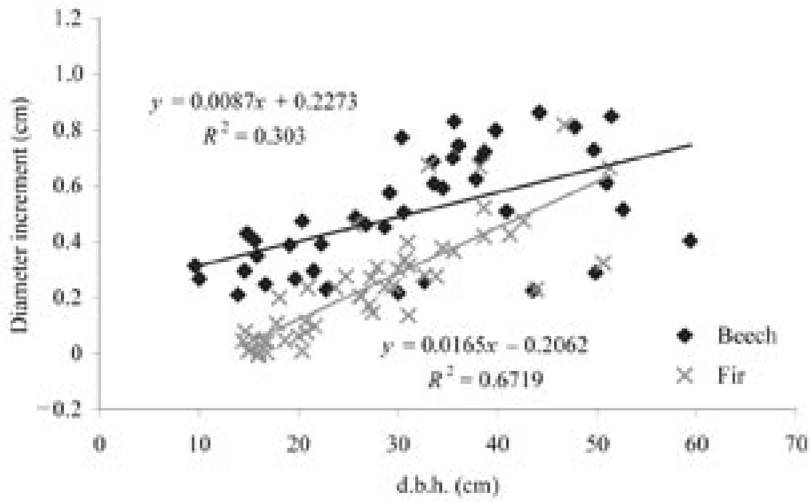

Fig. 6. Relationship between the total annual diameter increment of silver fir and beech and tree diameter in 2001

given week are depicted in Fig. 7. In the diagrams, relationships are expressed between the magnitude of correlation coefficients of particular trees and their diameter.

In the growing season 2001, precipitation and temperatures showed mainly positive effects on diameter increment. The dependence of the increment of particular fir trees (49) and beech trees (42) on the selected climatic factors expressed by pair correlation coefficients ranges from –0.4 to + 0.75. The determined generally low values of correlation coefficients can be caused by intercorrelations of independent variables. Nevertheless, in Fig. 7a–d it is possible to see an increasing positive dependence of the magnitude of the weekly increment of fir and beech on air temperature with an increasing tree diameter. In beech (Fig. 7d), higher dependence of increment on temperature was found compared to silver fir (Fig. 7b), which is also documented by the number of statistically significant correlations (31 in beech against 5 in fir). In 7 fir trees < 22 cm d.b.h. and in 1 fir of 51 cm d.b.h., a negative effect of temperature on increment was found. The effect of precipitation totals on the weekly diameter increment of fir trees decreased with the increasing diameter of sample trees (Fig. 7a) while the level of the dependence of beech increment (Fig. 7c) did not nearly change with the increasing diameter of sample trees (correlation coefficients ranged about 0.2). Within the selected set of trees a lower level of increment dependence on precipitation was determined, which is also documented by the number of statistically signification correlations (9 in fir as against 1 in beech). Statistically significant effect of precipitation totals on diameter increment was found in fir trees < 25 cm d.b.h.

Generally, it is possible to conclude that the increment of large-diameter beech trees (i.e. dominant trees) correlated with precipitation and temperatures to a greater extent than the increment of small-diameter trees (subdominant trees). Large-diameter fir trees correlated more with temperatures and less with precipitation as compared

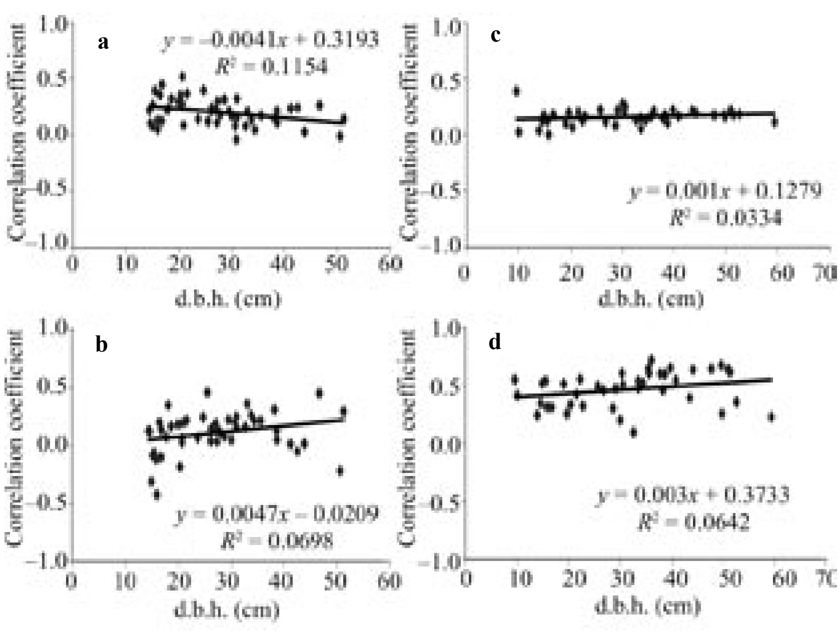

Fig. 7. Correlation between the magnitude of the current increment of all trees in particular weeks and weekly climatic data (a, c – precipitation, b, d – temperature)

with trees of a smaller diameter. At the same time, it is necessary to emphasize that a different level of correlation of diameter increment with weekly values of precipitation and temperatures was found in trees of nearly the same diameter. Main causes of the differences in the response of tree increment to climatic factors can be considered to be intercompetition, health conditions, social position, dimensions of assimilatory apparatus and genetic preconditions of particular trees.

CONCLUSIONS

In the course of the growing season 2001, monitoring of diameter increments of selected sample trees of silver fir and beech was carried out in a mixed stand by means of mechanical girth dendrometers EMS. Within the selected set of trees, it is possible to see individual differences both in the dynamics of increment and in its total magnitude. The differences are evident not only between the species but also within a species in the same diameter class. In silver fir and beech there are trees that can be ranked into quite different diameter classes on the basis of the course of their growth and total increment.

Fir trees reached a maximum of increment in all diameter classes in May (as much as 50% of the total annual increment). The culmination of beech increment is shifted to June and July while the shift is more marked with the increasing diameter of sample trees. In a majority of the studied trees (fir and beech), current weekly increments showed the same trend although periods occurred when some trees responded by decreasing their increment even within a diameter class whereas other trees increased their increment within the same period. The effect of diameter on the tree growth is obviously overlaid in some cases by more intensive competition or by other effects of the environment. Different genetic conditions of particular trees and their health state probably play an important role.

Individual increment response of trees in particular weeks was also demonstrated by correlations between the magnitude of increment and precipitation and temperatures. The higher level of increment dependence on temperature with the increasing diameter of sample trees was found in silver fir and beech. The increment of large-diameter fir trees correlated with precipitation less than the increment of small-diameter firs whereas the level of the dependence of the increment of beech trees did not almost change with diameter.

It is not possible to deduce final conclusions on the growth response of selected trees on the basis of the observations of radial increment in the course of the growing season. However, even these preliminary results can contribute to elucidate individual responses of forest trees to external factors. On the ground of better prediction ability it is necessary to monitor the growth dynamics of diameter increment in more successive growing seasons. Only then will it be possible to deduce the proportion of main external (socioecological position, density, throughfall, soil moisture) and internal factors in the formation of annual rings in particular years.

The study of diameter increment by a non-destructive method through mechanical dendrometers makes it possible to record changes in growth in weekly intervals. Shorter intervals of reading in the procedure in the case of a higher number of installed dendrometers are considerably time-consuming. Another possibility of detailed monitoring of the increment dynamics is the use of electronic devices with the automatic registration of diameter changes. The results of detailed measurements can be used for the study of changes in tree diameter in connection with external climatic factors even within the time horizon of particular days.

References

CHALUPA V., 1992. Měnící se složení zemské atmosféry, předpokládané klimatické změny a jejich vlivy na lesní porosty. Lesnictví-Forestry, *38*: 973–986.

DOWNES G., BEADLE CH., WORLEDGE D., 1999. Daily stem growth patterns in irrigated *Eucalyptus globulus* and *E. nitensin* relation to climate. Trees, *14*: 102–111.

ĎURSKÝ J., MOZOĽOVÁ Z., 2001. Dynamika hrúbkového rastu stromov horského lesa počas vegetačného obdobia. In: Stav a perspektívy ekologického výskumu horských lesných ekosystémov. Zbor. ref. a posterov z medzinár. ved. konf. (CD-ROM), Poľana 22.–25. 10. 2001: 9.

ĎURSKÝ J., 1994. Použitie dendroklimatických modelov na kvantifikáciu zmien prírastku stromov vplyvom imisií. Lesn. Čas., *40* (2): 147–152.

FRITTS H.C., 1976. Tree rings and climate. London, New York, San Francisco, Academic Press: 567.

HÄBERLE K.H., SCHMOLKE W., LORIS K., PAYER H.D., 1995. Use of dendrometers on young spruce under controlled climatic conditions. Forstliche Forschungsberichte München, No. 153: 45–58.

JEŽÍK M., VOŠKO M., 2002. Diameter increment and its dynamics in the course of vegetation period in submountain beech forest. Ekológia (Bratislava), *21* (1): 50–60.

KEELAND B.D., SHARITZ R.R., 1997. The effects of water-level fluctuations on weekly tree growth in a southeastern USA swamp. Amer. J. Bot., *84* (1): 131–139.

MINĎÁŠ J., ŠKVARENINA J., 1994. Predpokladané dôsledky klimatických zmien na lesné ekosystémy. Národný klimatický program SR, Zväzok 1. Bratislava: 57–82.

NEUMANN U., 1996. Model for the radial increment within a year. Deutscher Verband forstlicher Forschungsanstalten, Sektion Forstliche Biometrie und Informatik: 8. Tagung, Tharandt/Grillenburg, 25.–28. September 1995: 6–17.

OFFENTHALER I., HIETZ P., RICHTER H., 2001. Wood diameter indicates diurnal and long-term patterns of xylem water potential in Norway spruce. Trees, *15*: 215–221.

PESONEN E., MIELIKÄINEN K., 1995. Measuring band for automatic monitoring of increment. Forstliche Forschungsberichte München, No. 153: 59–63.

ŠMELKO Š., WENK G., ANTANAITIS V., 1992. Rast, štruktúra a produkcia lesa. Bratislava, Príroda: 342.
TATARINOV F., ČERMÁK J., 1999. Daily and seasonal variation of stem radius in oak. Ann. For. Sci., *56*: 579–590.
VOGEL M., PESCHKE G., RÜLICKE A., 1996. Calculation and interpretation of changes in stem water storage of a 100-year-old spruce tree. Allg. Forst- Jagdztg, *167* (8): 162–167.
VOŠKO M., JEŽÍK M., 1995. Účinok faktorov klimatopu na dynamiku hrúbkového prírastku stromov In: Lesné ekosystémy a globálne klimatické zmeny. Zvolen, Lesnícky výskumný ústav: 144–149.
ZWEIFEL R., ITEM H., HÄSLER R., 2000. Stem radius changes and their relation to stored water in stems of young Norway spruce trees. Trees, *15*: 50–57.

Received for publication September 4, 2003
Accepted after corrections December 30, 2003

Sezonní dynamika tloušťkového přírůstu jedle (*Abies alba* Mill.) a buku (*Fagus sylvatica* L.) ve smíšeném porostu

R. Knott

Lesnická a dřevařská fakulta, Mendelova zemědělská a lesnická univerzita, Brno, Česká republika

ABSTRAKT: V průběhu vegetační sezony roku 2001 probíhalo sledování tloušťkového přírůstu vybraných vzorníků jedle a buku ve smíšeném porostu pomocí mechanických obvodových dendrometrů. V rámci vybraného souboru stromů byly zjištěny individuální rozdíly jak v dynamice přírůstu, tak i v jeho celkové velikosti. Tyto rozdíly jsou patrné nejen mezi dřevinami, ale i v rámci druhu u stromů shodných tlouštěk. Na základě výsledků detailního sledování dynamiky tloušťkového přírůstu v průběhu roku nedestruktivní cestou prostřednictvím mechanických dendrometrů a měření složek mikroklimatu byla zjištěna individuální růstová odezva stromů na vybrané vnější faktory.

Klíčová slova: jedle bělokorá; buk lesní; tloušťkový přírůst; dendrometr; klimatické faktory

V průběhu vegetační sezony roku 2001 probíhalo sledování tloušťkového přírůstu vybraných vzorníků jedle a buku ve smíšeném porostu pomocí mechanických obvodových dendrometrů EMS. V rámci vybraného souboru stromů lze pozorovat individuální rozdíly jak v dynamice přírůstu, tak i v jeho celkové velikosti. Tyto rozdíly jsou patrné nejen mezi dřevinami, ale i v rámci druhu ve stejné tloušťkové třídě. U jedle i buku se vyskytují stromy, které lze na základě průběhu jejich růstu i celkového přírůstu zařadit do zcela jiných tloušťkových tříd, než do kterých náležejí podle své tloušťky.

Jedle dosáhly maxima přírůstu ve všech tloušťkových stupních v měsíci květnu (až 50 % celkového ročního přírůstu). Kulminace přírůstu buků je posunuta do června a července, přičemž tento posun je zřetelnější se zvětšující se tloušťkou vzorníků. U převážné části sledovaných stromů (jedlí i buků) měly běžné týdenní přírůsty shodný trend, i když se vyskytla i období, ve kterých některé stromy i v rámci jedné tloušťkové třídy reagovaly snížením přírůstu, zatímco ostatní svůj přírůst ve stejné době zvyšovaly. Vliv tloušťky na růst stromů je tak zřejmě v některých případech překryt silnějším působením konkurence nebo jinými dalšími vlivy prostředí. Nezanedbatelnou úlohu mají pravděpodobně i rozdílné dědičné předpoklady jednotlivých stromů a jejich zdravotní stav.

Individuální přírůstová reakce stromů v jednotlivých týdnech byla potvrzena i korelacemi mezi velikostí přírůstu, srážkami a teplotami. Vyšší míra závislosti přírůstu na teplotě se zvyšující se tloušťkou vzorníků byla zjištěna u jedle i buku. Přírůst silnějších jedlí koreloval se srážkami méně než přírůst slabších jedlí, zatímco velikost závislosti přírůstu buků se v souvislosti s tloušťkou téměř neměnila.

Na základě pozorování radiálního přírůstu v průběhu jedné vegetační sezony nelze vyvodit konečné závěry o růstové odezvě vybraných konkrétních stromů, ale i tyto předběžné výsledky mohou přispět k objasnění individuálních reakcí lesních dřevin na vnější faktory. Z důvodu lepší vypovídací schopnosti je proto nezbytně nutné sledovat růstovou dynamiku tloušťkového přírůstu ve více po sobě následujících vegetačních sezonách. Teprve potom bude možné odvodit podíl hlavních vnějších (socioekologické postavení, hustota, úhrn podkorunových srážek, vlhkost půdy) i vnitřních faktorů na utváření letokruhů v jednotlivých letech.

Sledování tloušťkového přírůstu nedestruktivní cestou prostřednictvím mechanických dendrometrů umožňuje podchycení změn růstu v řádově týdenních intervalech. Kratší interval odečítání je při tomto postupu v případě vyššího počtu instalovaných dendrometrů časově značně náročný. Další možností detailního pozorování dynamiky přírůstu je použití elektronických přístrojů s automatickým záznamem změn tloušťky. Výsledky takto podrobných měření mohou pak být využity k detailnímu studiu změn tloušťky stromů v souvislosti s vnějšími klimatickými faktory i v časovém horizontu jednotlivých dní.

Corresponding author:

Ing. ROBERT KNOTT, Ph.D., Mendelova zemědělská a lesnická univerzita, Lesnická a dřevařská fakulta, Lesnická 37, 613 00 Brno, Česká republika
tel.: + 420 545 134 124, fax: + 420 545 211 422, e-mail: knott@mendelu.cz