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Microclimate in a spruce and beech stand

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Abstract The study evaluates microclimate in a spruce and beech stand. Both stands are situated in the research area of Mendel University of Agriculture and Forestry (MUAF), Brno in the region of the Drahanská vrchovina Upland (altitude 625 m). Air temperature under tree crowns, soil temperature at a depth of 25 cm, soil water potential and xylem temperature were monitored in the stands in relation to particular phenological phases. Preliminary results indicated microclimatic differences between the stands during the growing season. Results obtained were compared with climatic factors in the open space near the studied stands.

Key words: *microclimate, Norway spruce, European beech, temperature, water potential, phenological phases, stem increment, forest stands*

Introduction

Plant communities, particularly forest ecosystems, show a potential to create, modify and protect their specific microclimate, which develops under the effect of a climageneticly homogeneous active surface (Intribus 1977, Matejka 2000, Litschman 2003). The thermal and moisture balance of the active surface (Tužinský 2003) is a main factor determining climatic properties of the ground layer of atmosphere and soil. The energy balance of forest is affected by the physiological regulation of matter and energy exchange between forest stands and the surrounding environment (Fitter, Hay, 1987).

Crowns of forest trees intercept solar radiation and high above the soil surface the crowns create active surface, which is important for the heat and moisture balance (Petrík et al. 1986). Microclimate represents the regime of meteorological events, which develop under the immediate effect of an active surface (Krečmer 1980).

The shape, dimensions and the geometrical structure of a plant play an important role in the creation of microclimate (Matejka, Huzulák 1987). The water regime of soils is dominantly affected by plant vegetation through water uptake utilizable for transpiration. Because plants withdraw water through their root system from the root zone of a soil profile during transpiration a decrease in the soil moisture occurs in the microclimatic sphere of soil. Air temperature also affects life functions of plants, particularly the uptake of nutrient, transpiration, photosynthesis, respiration etc. Functionality in the connection to the water balance in plants, soil and whole ecosystems is particularly unsubstitutable (Antal 2003). The aim of the paper was to evaluate microclimatic characteristics in a spruce and a beech stand in the area of the Drahanská vrchovina Upland in relation to phenological phases and diameter increment of wood. Preliminary results show differences in the microclimate of both sites in the course of the growing season. Results obtained are compared with data of climatic factors in the open space close to studied stands.

Material and methods

The stands occur in the research area of the Institute of Forest Ecology MUAF Brno in the region of the Drahanská vrchovina Upland at an altitude of 625 m. According to the geobiocoene type group it refers to *Fageta quercino-abietina* or, according to the Zurich-Montpellier School (Braun-Blanquet), to *Luzulo-Fagion* (composite authors 1992). According to the typological system of ÚHÚL (Institute for Forest Management Planning), the sites are ranked among the forest type group 5S, viz. oligo-mesotrophic Abieto/Fagetum and the forest type 5S1 - oligo-mesotrophic Abieto/Fagetum with *Oxallis acetosella* (PLÍVA, PRŮŠA 1969). From the point of view of climate, the region can be characterized as moderately warm and moderately humid with long-term mean annual temperatures 6.6 °C and mean annual precipitation 683 mm (composite authors 1992). In the period 1990 to 2006, mean annual temperature amounted to 6.96°C and total precipitation 734 mm. In studied stands, sensors for measuring air temperature were installed (Datalogger Minikin T), namely at the lower margin of crowns at a height of 4 m. In addition, other characteristics were also measured, namely soil temperature and water potential at a depth of 25 cm (Microlog SP) and xylem temperature (Datalogger Minikin TPX). In selected samples, the diameter increment dynamics was monitored by means of automatic (DR 22) and tape dendrometers. The automatic dendrometers are placed at a height of 4 m and tape dendrometers at a height of 1.3 m. These measurements of selected characteristics are carried out since 2005. It refers to measuring devices of EMS Brno Co. (Environmental Measuring System, Brno). Methodology and installation were described in detail in a paper of KUČERA, 2003, 2005.

Results and discussion

The microclimate of open coniferous stands differs from the open space microclimate only slightly. Slightly closed forest stands and initial developmental stages of forests affect particular climatic elements and climate as a whole only slightly. Well-closed coniferous stands show marked characteristics of the stand microclimate. The microclimate of broadleaved stands shows a striking difference between early spring and summer. Microclimatic conditions are most markedly affected by European beech (*Fagus sylvatica* L.). In summer, air temperature in beech stands is even 5°C lower as against the open space. In winter, however, these differences are very small and in spring months before foliage, air temperature can be even a little higher than outside the forest (PETRÍK et al.1986).

At present, the automatized measuring technology makes possible to obtain data sets the content of which is sufficiently large for the representative analysis of microclimatic conditions of the given forest stand (MATEJKA 2000).

Air temperature

In Tables 3 and 4, mean daily air temperatures are given in studied stands and in the open space during days when the start of particular phases was noted in Norway spruce and European beech. The values show different temperatures measured in the stands and in the open space. The highest temperature was noted in the beech stand, viz. on average from the beginning of the great growing season to the end of the photosynthetic activity in 2005 and 2006, namely 12.92°C and 13.35°C, respectively (see Tabs. 1 and 2).

Table 1: Mean daily air temperatures (°C) in studied stands and in the open space during days when the start of particular phases, mean daily air temperatures in growing season in the year 2005

Year 2005		**Mean daily air temperatures °C**		
Date	**Phenological phases**	**Beech stand**	**Spruce stand**	**Open space**
9/4/2005	*Start of measuring*	4.18	3.74	3.2
18/4/2005	*Budbreak of beech*	12.83	11.17	12.4
2/5/2005	*Onset of leaf development of beech*	20.48	18.23	18.92
24/5/2005	*Fully developed leaf surface of beech*	11.26	10.85	11.74
8/5/2005	*Budbreak of spruce*	5.13	4.58	4.84
18/5/2005	*Onset of leaf development of spruce*	6.61	6.28	6.59
20/6/2005	*Fully developed leaf surface of spruce*	16.99	16.87	17.14
24/3/28/10/	***Mean daily air temperatures in growing season***	**12.92**	**12.46**	**12.76**

Table 2: Mean daily air temperatures (°C) in studied stands and in the open space during days when the start of particular phases, mean daily air temperatures in growing season in the year 2006

Year 2005		**Mean daily air temperatures °C**		
Date	**Phenological phases**	**Beech stand**	**Spruce stand**	**Open space**
27/3/2006	*Start of air temperature above 5°C*	8.97	7.44	8.03
24/4/2006	*Budbreak of beech*	13.48	11.99	13.02
27/4/2006	*Onset of leaf development of beech*	13.55	12.27	14.08
19/5/2006	*Fully developed leaf surface of beech*	13.41	13.59	14.23
9/5/2006	*Budbreak of spruce*	13.68	12.96	13.81
11/5/2006	*Onset of leaf development of spruce*	11.88	11.46	12.06
20/6/2006	*Fully developed leaf surface of spruce*	20.99	20.92	21.54
27/3/29/10/	***Mean daily air temperatures in growing season***	**13.35**	**13.11**	**13.52**

The course of daily air temperatures in the stands and in the open space in the period April-May in 2005 and 2006 is depicted in Figs. 1 and 2. In both years, beech responded to air temperatures more markedly than spruce. Comparing air temperatures in both stands before unfolding leaves in the beech stand the spruce stand showed lower temperatures. The amplitude of temperatures in the spruce stand during a sunny day increased decreasing more slowly than in the beech stand. In an average radiation day before unfolding beech leaves (8/4/2006), maximum temperature during the day in the beech stand was 13.1°C, in the spruce stand only 9.8°C and in the open space 10.3 °C. In the open space, there is high dynamics of temperatures during the day, viz. in the course of the day, temperatures intensely increase and at night, temperatures rapidly fall whereas in stands, these changes are more gradual.

During night hours, differences in temperatures between the open space and the beech stand reached nearly 2 °C.

At the time, when the leaf area was fully unfolded both in beech and spruce, the highest temperature was noted in the open space (24.8°C), i.e. 2.7°C more than in the beech stand and 2°C more than in the spruce stand. The beech stand active surface is able to intercept and reflect solar radiation better and therefore, this stand preserves its microclimate and thus, air temperature in the stand is decreased and air humidity increased.

In the course of autumn stages of yellowing and fall of beech leaves, temperatures in the beech (13.3°C) and spruce (13.2°C) stands were almost balanced. In the open space, air temperature was 2°C higher than in the stands.

Soil temperature

Results of a phonological study (BEDNÁŘOVÁ, KUČERA 2002) showed that the beginning of budbreak was also affected by soil temperature. According to the paper, soil temperature affected more the beginning of budbreak in a young spruce stand than in a mature stand. Therefore, we carried out a detailed analysis of temperature conditions in particular stands and again, the effect of soil temperature on the start of studied phenophases was proved. Continuous increasing the air temperature in previous days was important for starting the phonological stages of unfolding beech leaves. Soil temperatures measured during evening hours (between 17:00 and 19:00) one day before the start of the stage were a crucial factor. The course of temperatures in the stands is given in Fig. 3 for 2005 and in Fig. 4 for 2006. Norway spruce began to bud as lately as soil temperature did not fall below 6°C setting at a temperature of 8°C. In 2006, spruce began to accrue as early as 29 April, i.e. at the time when soil temperature increased in the spruce stand.

Stem increment

Another factor serving to study the growth response of forest trees to microclimatic conditions of a site is monitoring the change of diameter increment of wood during the growing season. The diameter increment dynamics was carried out in selected sample trees of Norway spruce (*Picea abies* /L./ Karst.) and European beech (*Fagus sylvatica* L.). It has been found that beech shows the regular and gradual course of growth (Figs. 7 and 8). In Norway spruce, there was a marked boundary between its growth stages (Figs. 5 and 6). In July, its growth stagnated and at the beginning of August, it began again to accrue more markedly. It was found that the dynamics of the diameter increment of trees was considerably affected by the amount of precipitation during the growing season. The increment of particular species is described and illustrated as follows:

In Norway spruce, there was a noticeable diameter increment already from 29/4/2006 (Fig. 6.), i.e. before flushing. Maximum was noted at the end of July (26/7/2006). The second stage of growth of Norway spruce began 4/8/2006 with a maximum value on 9/8/2006. The growth of spruce was finished on 15/9/ 2006.

The beginning of the diameter increment of beech was noted on 10 May 2006 (Fig. 8), ie at the time when beech showed 100% foliage, however, leaf area was not fully developed. Maximum increment in beech was noted at the end of July (26/7/2006). The second stage of beech growth was noted at the beginning of August (2/8/2006) the growth being finished on 17/9/2006.

Fig. 1: The course of daily air temperatures in the stands and in the open space in the period April-May in 2005

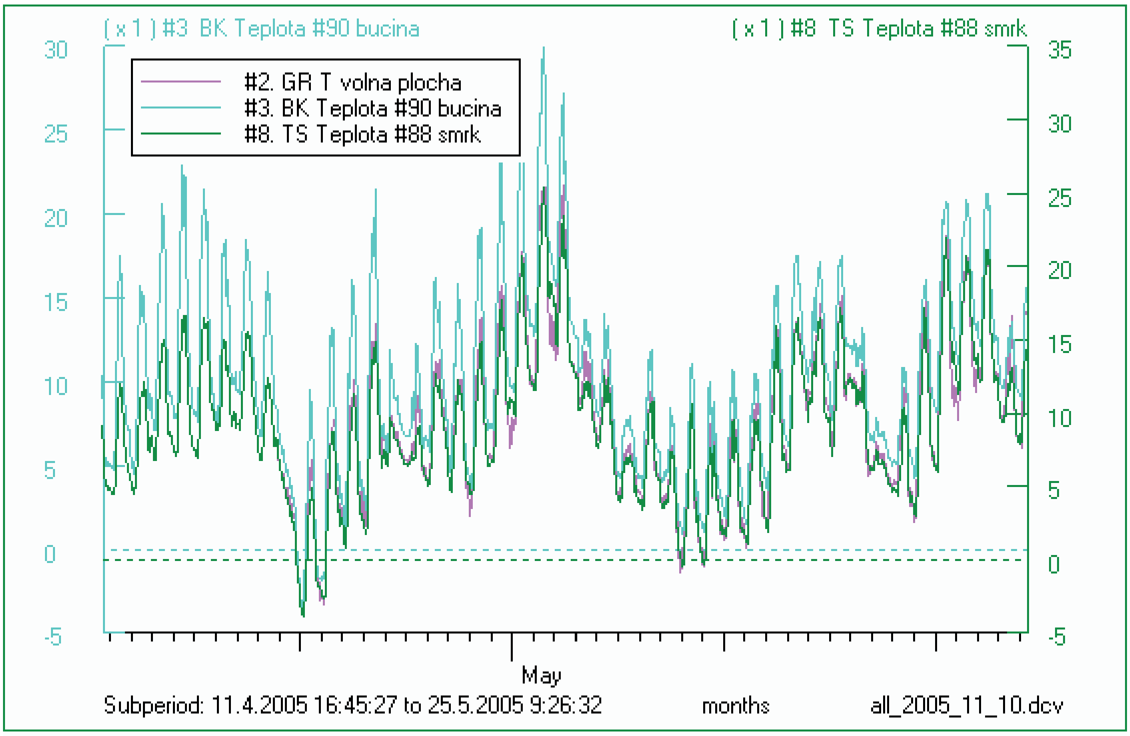


Fig. 2: The course of daily air temperatures in the stands and in the open space in the period April-May in 2006

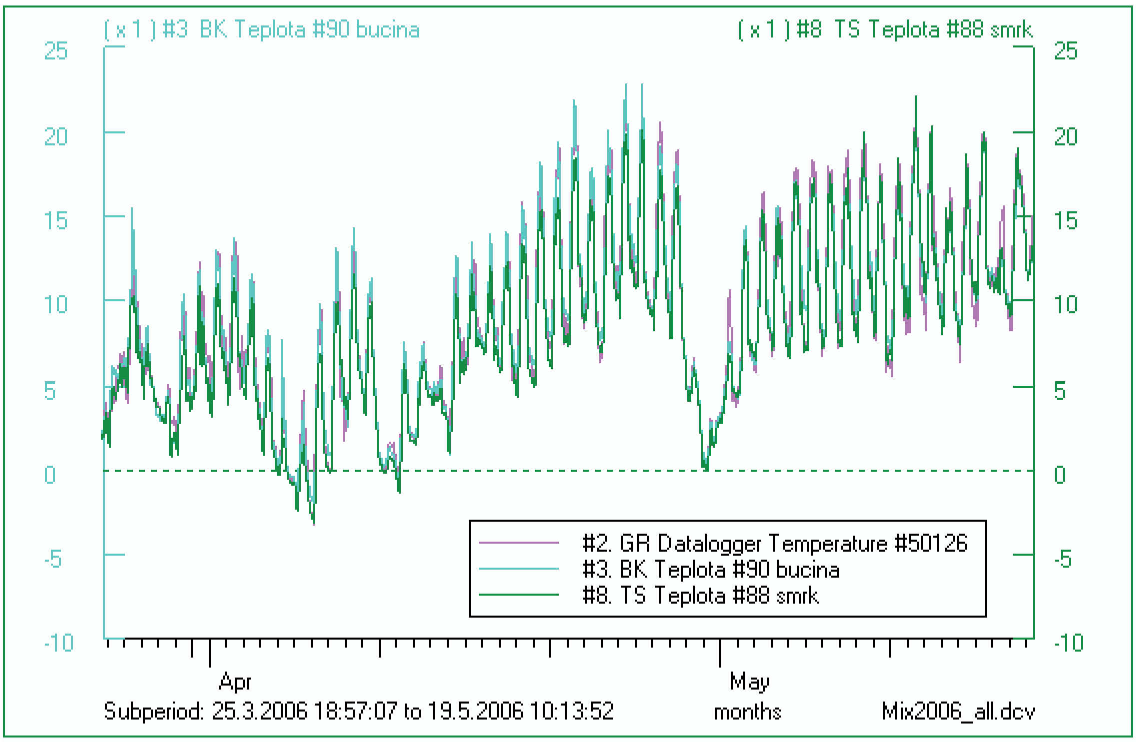


Fig. 3: The course of daily air and soil temperatures in the stands in the period April-June in 2005

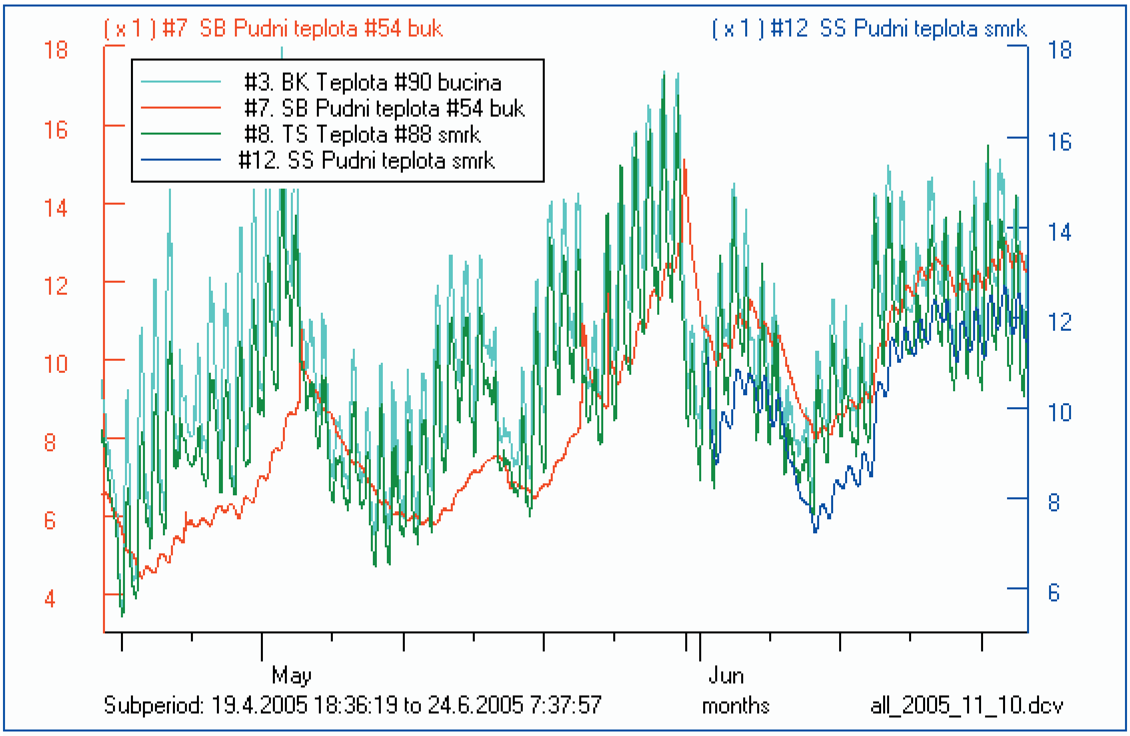


Fig. 4: The course of daily air and soil temperatures in the stands in the period April-May in 2006

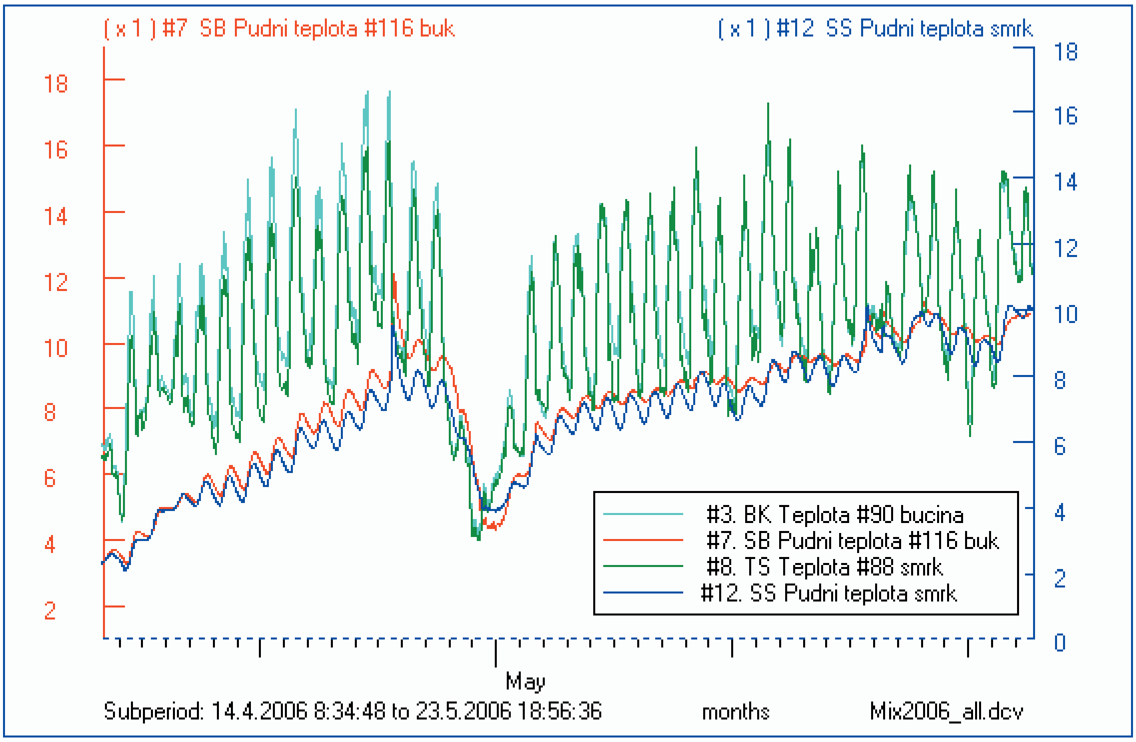


Fig. 5: Stem increment of the spruce in the relation water potential and the course of air and stem temperature in 2005

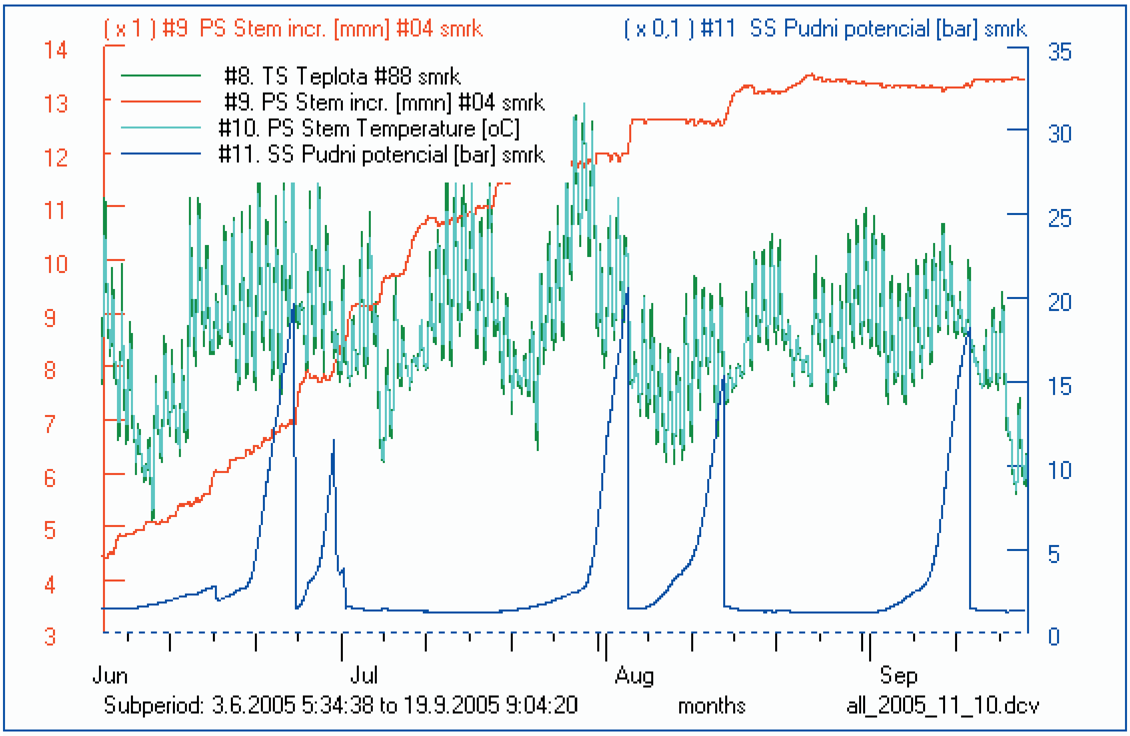


Fig. 6: Stem increment of the spruce in the relation water potential and the course of air and stem temperature in 2006

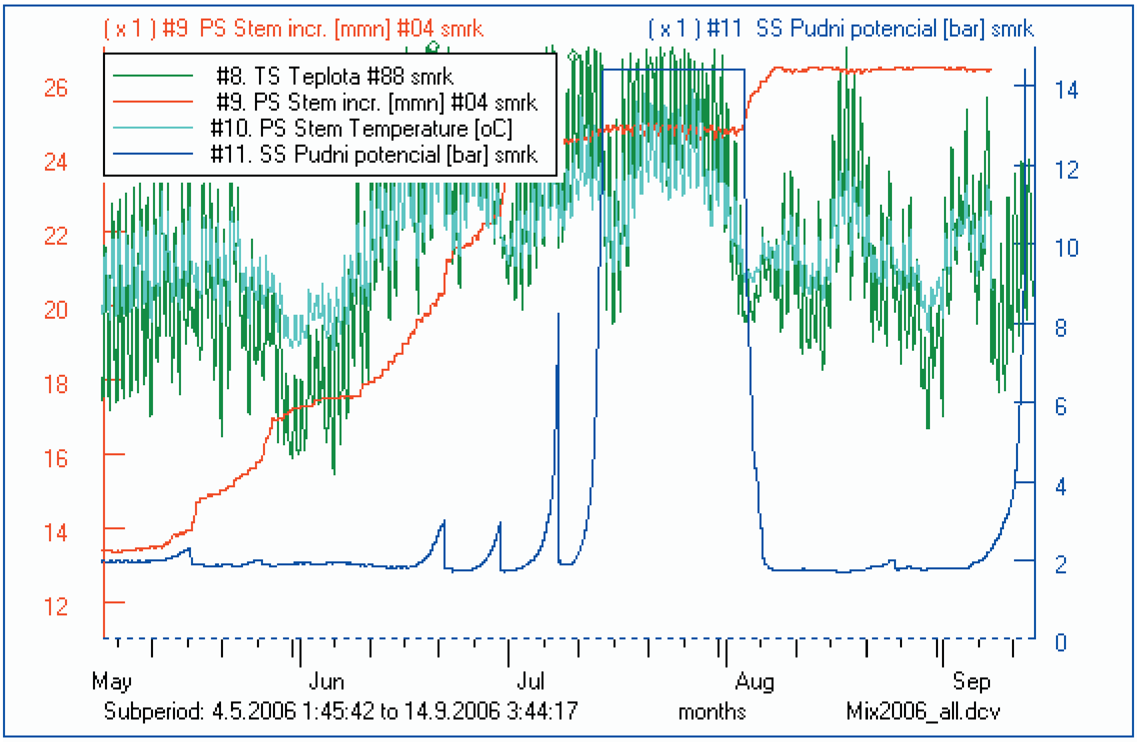


Fig. 7: Stem increment of the beech in the relation water potential and the course of air and stem temperature in 2005

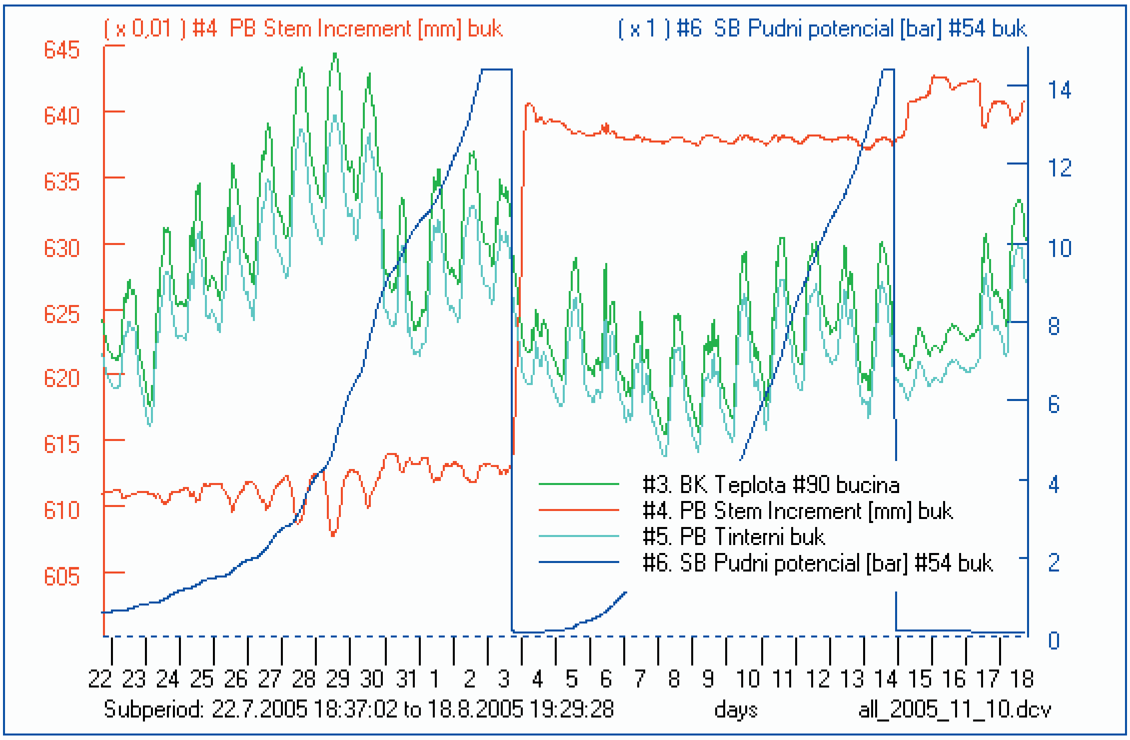
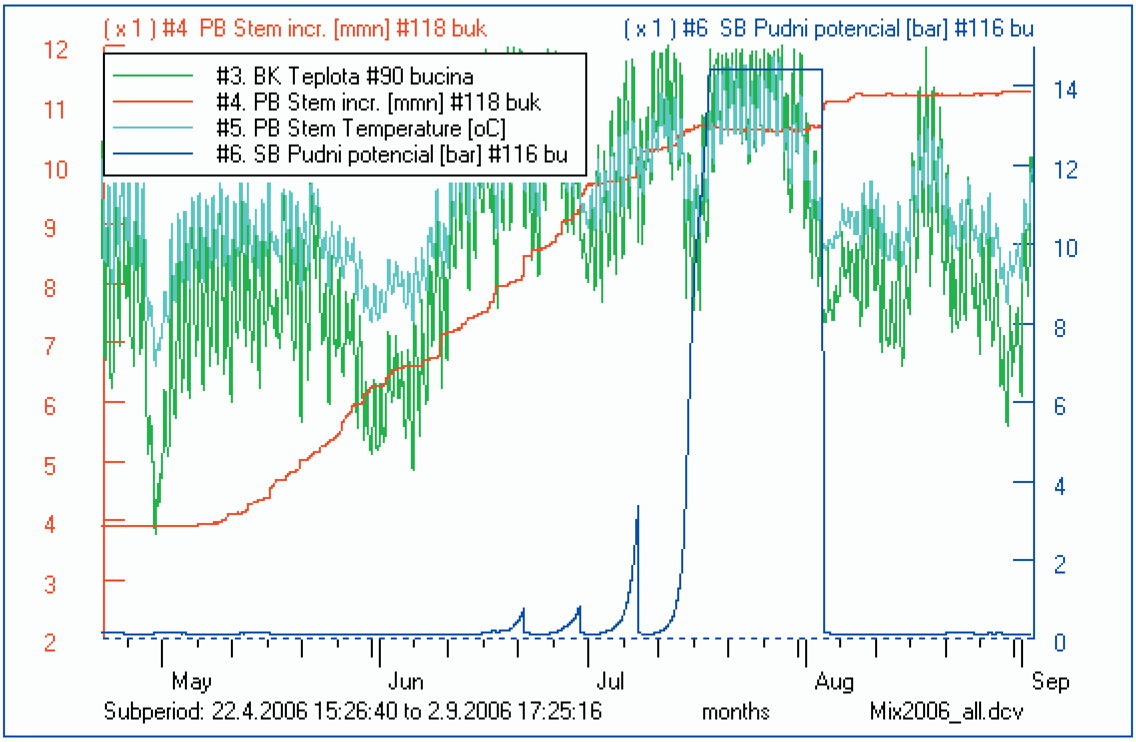


Fig. 8: Stem increment of the beech in the relation water potential and the course of air and stem temperature in 2006



Conclusion

In the course of the paper preparation information was obtained and evaluated on the relationship between the growth and developmental processes of forest trees and microclimatic conditions of the environment. Air temperature measured right in the stands ranked among most fundamental. Beech stand affected microclimatic conditions most markedly. Before the full foliage of beech in stands, air temperature in the beech stand was higher than in the open space and in the spruce stand. The lowest temperature was measured in the spruce stand. The temperature amplitude in the spruce stand during a sunny day increased and decreased more gradually. At the time, when the assimilatory area of beech and spruce was fully developed, the highest temperature was noted in the open space, i.e. 2.7°C more than in the beech stand and 2°C more than in the spruce stand.

To start the phenological stage of leaf unfolding in beech and budbreak in Norway spruce continual increase in air temperature in previous days was important, however, increasing soil temperature above 6°C was a decisive factor for the start of the stages. After starting the phenological stage of leaf unfolding in beech and budding in Norway spruce, permanent increase in air temperature in previous days was important. Nevertheless, increasing the soil temperature above 6°C was a decisive factor for the start of these stages. Diameter increment of Norway spruce was already apparent before budding and in beech, diameter increment started at the time when the species was 100% foliaged, however, its leaf area was not fully developed.

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