CLIMATE INFLUENCE ON NORWAY SPRUCE HEIGHT INCREMENT FROM MOLDOVITA RIVER BASIN

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Abstract

For a better understanding regarding the influence of climate on the trees biomass storage the analysis of height increment response of Norway spruce from the Moldovita River Basin to climate variation was done. In this study is presented the first study of the influence of climate to trees height increment in Romania, being a premiere to Romanian research in this field. Dendrochronological series of height increment were accomplished considering 82 measured trees from four sites. All individual height growth series were standardized using the negative exponential function. The reaction of trees height increment to climate variation was analyzed using the Pearson correlation indices. The height increment of Norway spruce from the Moldovita River Basin is positively influenced by precipitation from current July, whereas temperature from previous July, August and current June induce a decrease of height increment. Elaborating height increment series, quantifying with climatic factors and the analysis of their dendroecological and dendroclimatological potential represents a necessity for the researches in this field.

Key words: Norway spruce, Moldovita River Basin, height increment, climate, correlation

INTRODUCTION

The forests are a product of geographic environment and they significantly depend on the variation of climate factors. Understanding the connections between climate factors and forest ecosystems, respectively the impact of climate changes on forest vegetation are timely subjects that concern the scientific community (Andreassen K. et al., 2006).

Studies in the field of dendroclimatology, most of them, are based on the information given by tree-ring radial growth. The variables of annual ring of radial growth are mostly used thanks to fact that the study material is easy to obtain (Pensa M. et al., 2005).

Sampling and measuring annual tree-rings is relatively simpler, but total width of annual tree-ring, which is the most classical source of information in dendrochronology, has some advantages as an indicator source of the trees response to climate variation. Likewise, height increment reflects more precisely the growth potential of a tree by comparison with radial growth (Makinen H., 1998).

Knowing both the answer of height increment and diameter increment to climate variation allows a more profound knowledge and predictability concerning the influence of climate on the trees biomass storage. Although forest ecosystems from the Carpathian area have a major economical and ecological value, there are no studies in this direction.

Therefore, this study has as main purpose the knowledge and the analysis of height increment response of Norway spruce from the Moldovita River Basin to climate variation.

MATERIAL AND METHOD

The study site is represented by forest ecosystems of Norway spruce from the Moldovita River Basin (fig.1). In order to achieve the purpose of this study, there were identified and seen on the field Norway spruces stands younger than 60 years old, in which the tree whorls can be seen better. Four stands had been selected in which an experimental sample area has been located. The experimental areas that concern this study are presented in table 1 and figure 1.

Table 1

Geographical characteristics of experimental sample areas

No	Code series	u.a.	Forestry District	Species	Altitude (m)- Exposition	Latitude	Longitude
Height increment series							
1	mo1h	241c	Moldovița	Mo	1150-1250 - S	47°48'	25°28'
2	mo2h	243a	Moldovița	Mo	850-1150 - NV	47°47'	25°27'
3	mo3h	245b	Moldovița	Mo	810-970 - NV	47°46'	25°26'
4	mo4h	232a	Moldovița	Mo	880-1050 - S	47°48'	25°25'

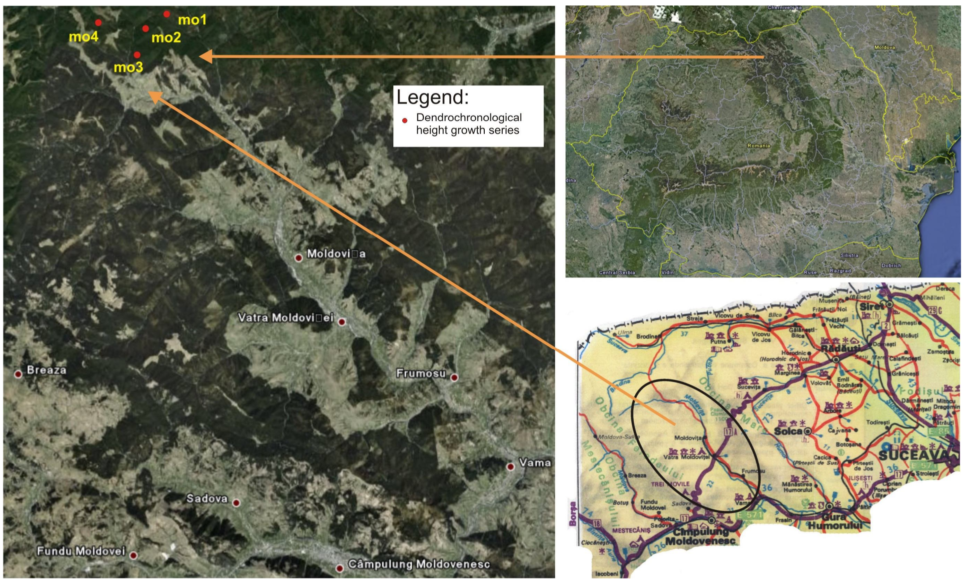

Fig. 1 Study sites

The method of elaborating series of height increment is, in general, similar to the one used to elaborate dendrochronological series in diameter, with some characteristics.

Similar to dendrochronological series in diameter, measuring height increment was completed in an ecological selected area, starting with a number of 15-25 trees (Fritts, 1976), that contains the maximum of microclimatic response. To elaborate dendrochronological series in height, healthy trees have been selected, from Kraft 1 class, predominant (the impact of competition is minimum), with straight and unharmed stem, avoiding trees with distorted, asymmetric crown.

Each selected tree was chopped down and height increment was measured between whorls from the stem, starting from top to bottom, in order to know the year since when the measuring of height increment begins. The measure was done with a measuring tape in centimeters. The values of measured height increment were written in an notebook, afterwards, at the office, being transferred into computer in order to be analyzed.

All individual height growth series were standardized to eliminate non-climatic influence and to obtain the maximum of climatic information from dendrochronological series. For that negative exponential function was used, because this one is maximizing the climatic response in the strongest way. It was used ARSTANwin software (Cook and Krusic, 2006). The residual dendrochronological series were used due to the fact that autocorrelation is cut out from the obtained index series.

In order to use an unitary set of climatic data for the entire study site, it appealed to climatic database with resolution of 0.5°x0.5° CRU T.S. 3.0. (Mitchell and Jones, 2005).

The reaction of trees to climate variation is analyzed through correlation indices of Pearson type. To this purpose, it was used DENDROCLIM 2002 software (Biondi and Waikul, 2004). The analysis was accomplished for years between 1967 and 2009, this period of time being dealt for all analyzed series. Concerning the meteorological data, for the studied site, the set of meteorological data (average monthly temperature and monthly precipitation) was taken from CRU T.S. 3.0. database, from 1967-2009.

The analysis of the correlation between dendrochronological series and meteorological parameters was accomplished from July of the previous year of annual growth development until July of the current year height increment development.

RESULTS AND DISSCUSIONS

Dendrochronological series of height increment were accomplished considering 20 measured trees from sites 1 and 3 and also considering 21 measured trees from sites 2 and 4 (table 3). The longest series with assured statistical coverage is the series from sample area number 3 (1951-2010), and the shortest is the one made considering the measuring in sample area number 2 (1967-2010) (fig. 2 and 3).

The average height growths range from 55,825 cm/year (site 1) to 63,938 cm/year (site 4). The trend of average height increment curve presents a negative exponential trend (figure 2).

Table 2

Statistic parameters of dendrochronological series of height increment

Statistic parameter	mo1h	mo2h	mo3h	mo4h
The length of series	1950-2010	1962-2010	1944-2010	1957-2010
The length of series with >10 trees	1963-2010	1967-2010	1951-2010	1961-2010
Number of trees	20	21	20	21
Average height increment (cm)	55,825	63,57	57,529	63,938
Standard deviation	0,176	0,161	0,19	0,152
Average sensibility	0,19	0,178	0,211	0,167
Autoccorelation of I degree	0,542	0,536	0,713	0,754
Average value of rbar	0,306	0,225	0,252	0,294
Correlation with average series	0,415	0,45	0,452	0,443

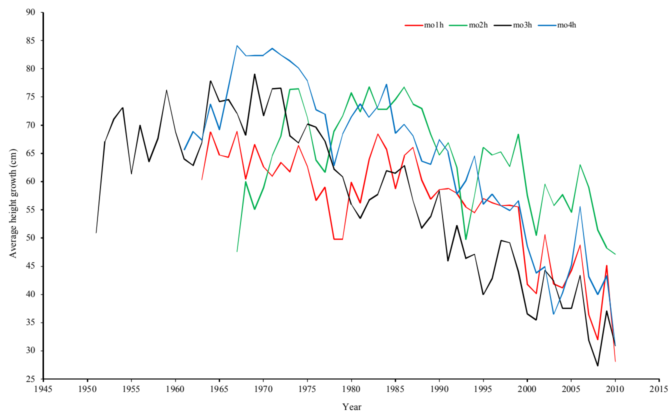

Fig. 2 Average height growth series

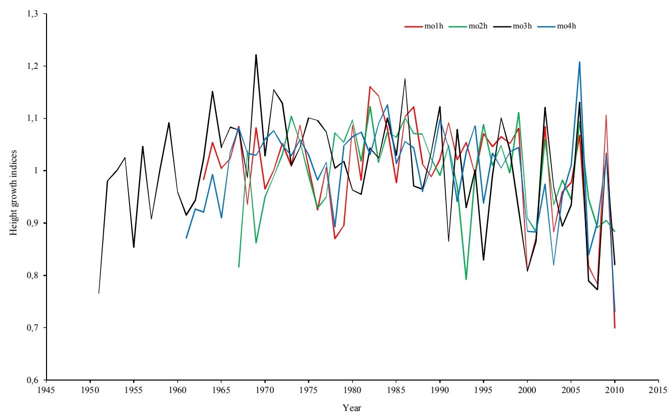

Fig. 3 Height growth indices series

Norway spruce dendroclimatological response analysis in relationship with height is presented in figure 4 and table 3.

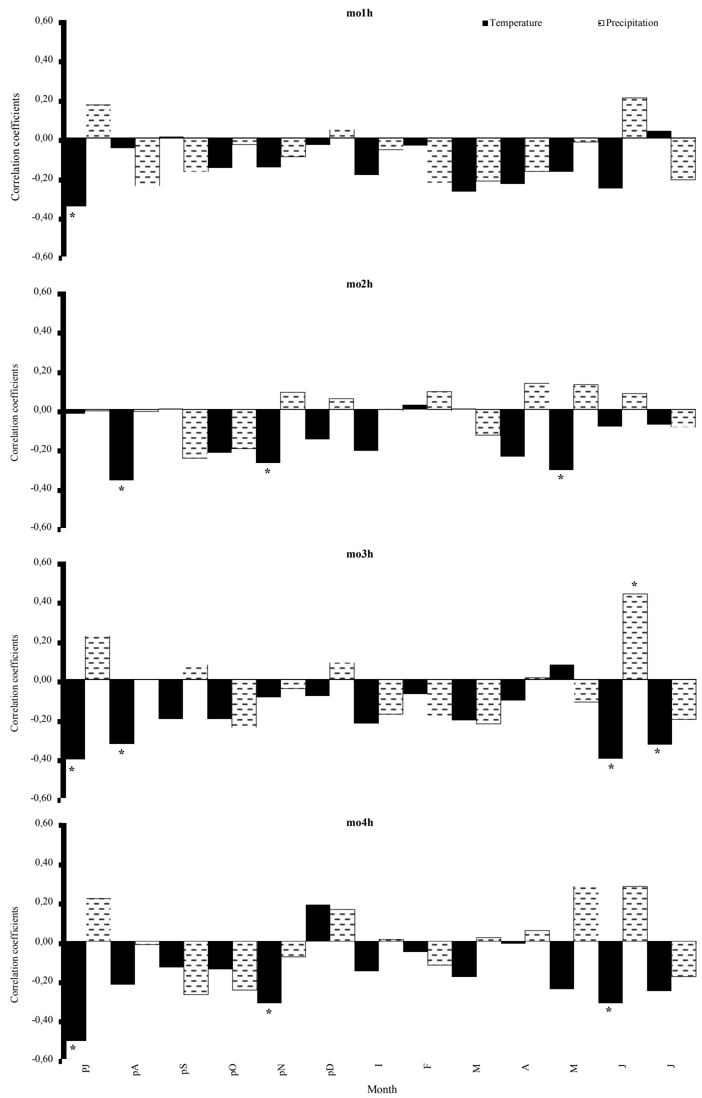

Fig. 4 Relationship between series of height increment indices and climatic parameters (the star represents the months with significant influence on growth)

Table 3

Pearson correlation between responses to climate of height increment indices series

Variable	mo1h	mo2h	mo3h	mo4h
mo1h	1	0,425	0,550	0,607
mo2h	0,425	1	0,442	0,485
mo3h	0,550	0,442	1	0,645
mo4h	0,607	0,485	0,645	1

In the first sample area, most of climatic variables have a negative influence on height increment of Norway spruce, the temperature from the previous July being significant. In the second sample area, there isn`t any climatic variable with significant positive influence on height increment. The precipitation during the current summer of growth development have a positive influence, but they don`t have a statistical assured meaning. A reduced height growth is mainly significantly determined by temperature from previous August and November and by those from current May. In the case of the third sample area, the precipitation from current July have a positive determinant influence on height increment, and a negative influence has the temperature from previous July and August, current June-July. The trees height growth from the fourth sample area is positively influenced by precipitation from May and June, being though statistically insignificant. A reduced height growth is mainly induced by temperature from previous July and November, current July.

The analysis of correlation values between responses to climate of height increment indices series reveals an homogeneity with a statistical assured meaning of Norway spruce height increment dendroclimatological response.

Concerning the regional series, the height increment of Norway spruce from the Moldovita River Basin is positively influenced by precipitation from current July, whereas temperature from previous July, August and current June induce a decrease of height increment (figure 5).

Climatic parameters from the previous year of current height increment growth development have influence on terminal bud development causing storage of reserve substances while climatic parameters from the current year of current height increment growth development influence the speed and the size extension of twigs (Lanner, 1976).

Negative correlation with average temperature from current June were pointed out for height increment of Norway spruce from north-east part of Slovenia, situated at about 350 altitude (Levanic and others, 2009).

A negative response of height increment to climatic parameters from July of the previous year height increment growth was relieved as well in other studies for another species.

At the northern timberline forest, where temperature during the summer represents the main limitative factor of growth, the height growth of Pinus sylvestris is mainly determined by the average temperature of July from the previous year of growth (Juntila and Heide, 1981; Jalkanen and Tuovinen, 2001; McCarroll and others, 2003; Salminem and Jalkanen, 2004; Lindholm and others, 2009).

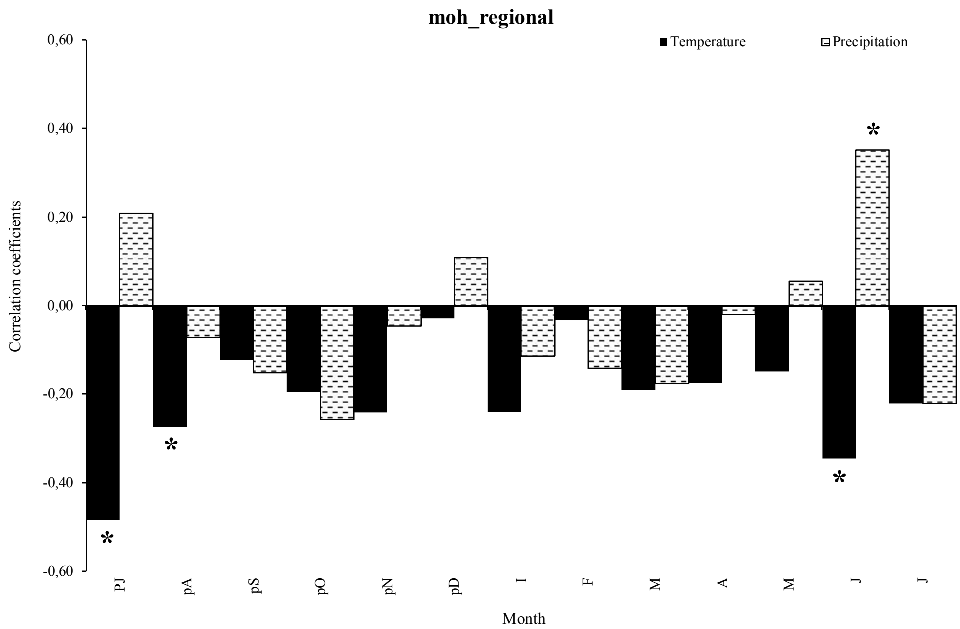

Fig. 5 Relationship between series of regional height increment and climatic parameters (the star represents the months with significant influence on growth)

The same thing was demonstrated in the case of height increment of Pinus sylvestris from the south part of Finland (Makinen, 1998). The correlation between height increment and the average temperature of previous July was positive in all the cases. Also, the strong positive correlation between height increment of Pinus sylvestris and the temperature during the current summer of growth development was highlighted (Jalkanen and Tuovinen, 2001; McCarroll and others, 2003).

CONCLUSIONS

For a deeper understanding of the relationship between forest vegetation and complex actions of climate, it is necessary to understand the relationship between climate and growth trees, both concerning diameter and height increment. Therefore, elaborating height increment series, quantifying with climatic factors and the analysis of their dendroecological and dendroclimatological potential represents a necessity, being a premiere to Romanian research in this field. Knowing both height and diameter increment response to climate variation allows deeper knowledge and predictability concerning the influence of climate on the trees biomass storage.

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