DENDROCHRONOLOGY OF OAK SPECIES IN VASLUI REGION, TREE-RING GROWTH RESPONSES TO CLIMATE

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Abstract

In this research we've investigated the response of radial growth of Quercus robur L. and Quercus petraea (Matt.) Liebl to climate. For oak and sessile oak we have measured the early wood and the late wood, knowing that the early wood of oak is formatted as a result of the condition during the previous autumn and the late wood is formed, based on the current year resources for the growing ring. The Q. robur and Q. petraea respond positive to the precipitations from the current vegetation season (May – June). The analysis of the negative characteristic years related to the dryness index represents a way to observe the trees´ reaction. The connection in time between climate and radial growth was not constant, which means another factor it replaced the stress factor.

Key words: oak, sessile oak, early wood, late wood

INTRODUCTION

A major objective in dendroclimatology is to obtain information about variation of climate. The response of tree ring growth to climate can be significant at the limit of the natural area of species studied and very important is the sensitivity of species. Tree rings contain plenty of information about the climatic condition which affects trees growth (Fritts, 1976).

The response of tree ring growth to climate is constant in time, during the life span of tree (Fritts, 1976). This theory is relative, because it is possible in time to change the limiting factor named climate with another environmental stress factor, for example ages and natural tree competition (Rozas, 2004).

Quercus species, especially Qercus robur L. is very important for dendrochronologycal studies in Europe. Many research was made in ecology, archaeology, climatology, for this species the responses to climate variation having been widely studied (Rozas, 2004, Lebourgrgeois, 2000, Drobyshev, 2008, Cufar, 2008a). In Romania are same studies made by Tissescu (1991), Borlea (1998), Popa (2002), and Neagu (2010).

MATERIAL AND METHOD

The study area is represented by a forestry ecosystem located near Barlad (46º25′N, 27º25′E), at 285 m altitude. The data set was collected according to the dendrochronological principles (Fritts, 1976; Cook & Kairiukstis, 1990; Popa, 2002; Grissino – Mayer, 2003). A number of 33 samples from trees of sessile oak and 32 samples of oak trees were collected in an area chosen so as to minimize the effects of the disturbance inside and outside the ecosystem (Popa, 2003).

The measurements of the cores were made with the digital positionmeter LINTAAB and a TSAP program (Rinn, 1996). The time series where thus visually and statistically cross-dated using the TSAP and COFECHA programs. We standardized the series of tree rings measurements and we have removed the signal induced by the age factor.

The ARSTAN win program (Cook, 1985) was used in order to obtain the standardized growing indexes by, applying a cubic spleen function with a periodicity equal to 20% from the length of the series (Cook and Kairiukstis, 1990). In the dendroclimate analysis we have used a dendrochronological series of residual type (RES), resulted from the elimination of the remaining autoregressive correlation further the standardization.

The climatic data come from the CRUTS 3 (Jones and Haris, 2008), for the period 1901 – 2006. This data is characterized by a multi-annual average temperature of 9,3°C, and an annual level of precipitations of 530 mm.

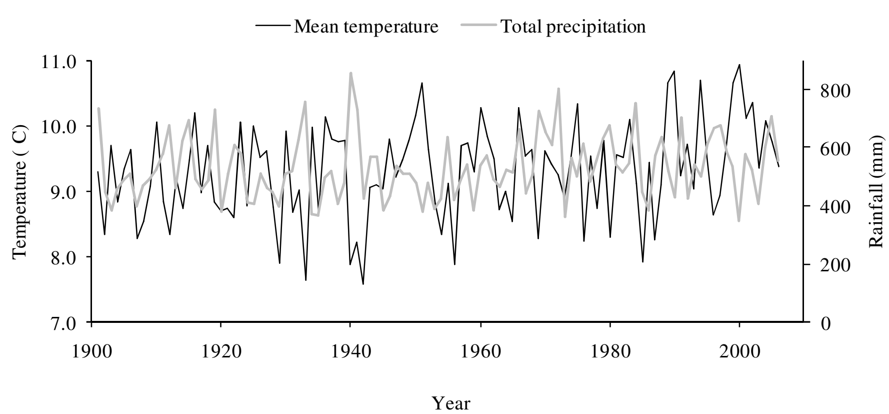

Fig. 1 The variation of total annual precipitation and mean annual temperature.

The most humid month is June 74 mm and the hottest is July with a temperature of 20.8 °C.

The analysis of the climate-radial growth relation was done trough the correlation coefficient. The temporal stability of correlative relation was calculated using the Dendroclim 2002 program (Biondi and Waikul, 2004). The period analyzed is comprised between the September previous year and September current vegetation season.

RESULTS

The dendrochronological series are characterized by a descriptive statistics in all chronologies witch show a relatively low mean standard deviation and sensitivity, respectively 0.200, and 0.240 at oak ring width residual series, and 0.230 and 0.249, at the sessile oak series.

The common variance in the first eigenvector for EW vas lower, comparing with ring-width and LW, and between species was higher for sessile oak chronologies. The first order autocorrelation was normal for all series higher at oak ring-width series 0.091 and lower at LW oak series (-0.030). The mean correlation between trees relives a high correlation at the ring-with series: 0.455 at oak series respectively 0.527 at sessile oak chronology, and considerably low in EW chronology (0.190 and 0.203).

Table 1

General parameter characterizing oak and sessile oak chronology for entire ring, early wood ring and late wood ring

Parameter	**Oak residual chronology**			**Sessile oak residual chronology**		
	Ring with	EW	LW	Ring with	EW	LW
Time span	195	-	-	186	-	-
Number of cores	32	-	-	31	-	-
Number of rings	5174	-	-	5202	-	-
Age range of trees	128-195	-	-	87-186	-	-
Mean corr. among all radii	0.455	0.189	0.422	0.527	0.204	0.518
Mean corr. between trees	0.455	0.190	0.421	0.527	0.203	0.518
Mean corr. radii vs. mean	0.686	0.459	0.661	0.736	0.476	0.730
Mean sensitivity	0.240	0.129	0.365	0.249	0.109	0.356
Standard deviation	0.200	0.092	0.299	0.230	0.114	0.307
First autocorrelation order	0.091	-0.020	-0.030	-0.146	0.069	-0.120
Signal to noise ratio	25.027	6.315	21.85	27.84	6.35	27.95
Expressed population signal	0.947	0.819	0.947	0.968	0.869	0.968
Variance in first eigenvector	49.80%	23.02%	46.30%	55.34%	24.27%	54.46%

The mean correlation between radii and mean is higher for sessile oak 0.736, compared to that of oak which has a value equal of 0.686. Mean sensitivity display a raise value in LW series 0.365 and 0.356, and weak level in EW.

49.80% and 55.34% of the variance in the residual chronology of oak and sessile oak was explained by bootstrapped response function calculated for the period 1814 – 2008 for oak series, and 1823 – 2008, for sessile oak chronology.

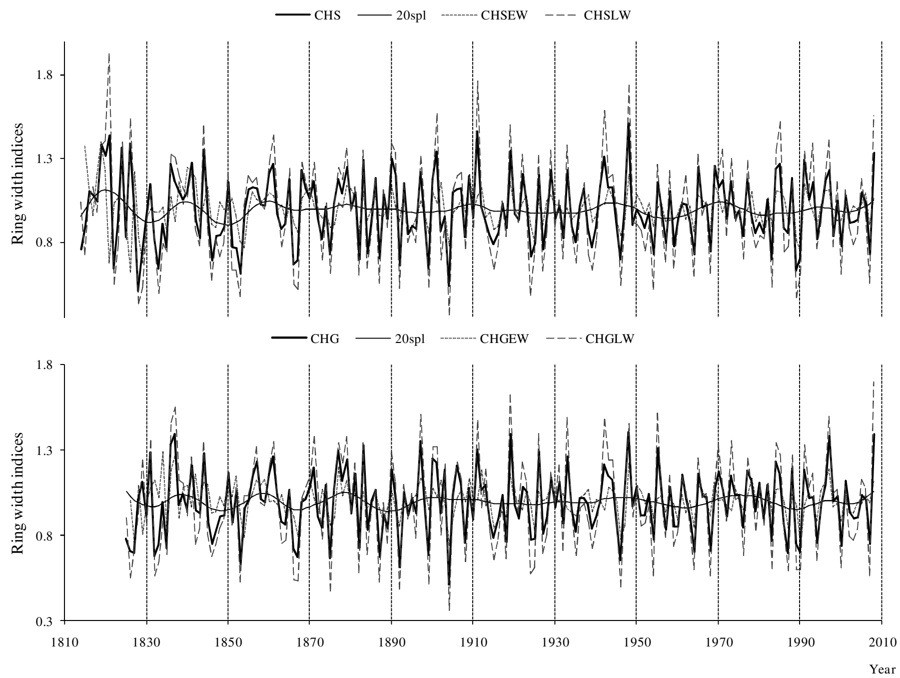

Fig. 2 The series of ring width indices for oak (CHS) and sessile oak (CHG), distinctively on total ring width, early wood and late wood

The ring width and late wood series shared a common positive relationship with April, May, June and July precipitation of current year of growing, early wood showed an insignificant correlation with previous year of ring formation. The correlation value between total ring and late wood are almost the same.

The temperature influence on increasing is negative and high in April, June and July. The oak's reaction to temperature from May is stronger than sessile oak's reaction in the same period. The correlation between May until September of current year and formation of early wood are pure statistical, also the precipitation on December until March.

Various from oak at sessile oak correlation between precipitation and growing are more pronounced March, April, May and July, for the ring width and late wood series. If the reaction of trees at precipitation is almost positive the correlation with temperature is prevalently negative, having a maximum influence in June -0.29 for oak and -0.30 for sessile oak ring width. Analyzing this month correlation with late wood we can observe that this part of ring formation is more sensitive (-0.31 for oak and -0.33 for sessile oak).

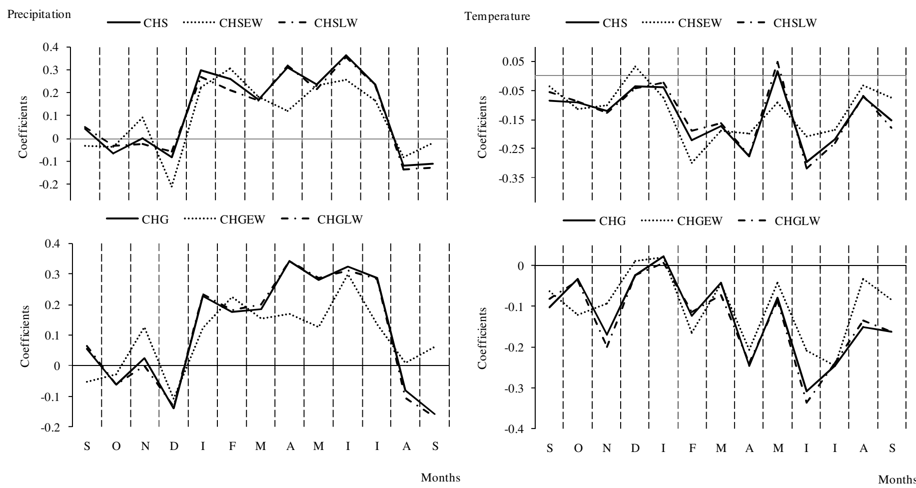

Fig. 3 Correlation between residual tree ring chronology for oak (CHS) and sessile oak (CHG), distinctively on total ring width, early wood and late wood and precipitation and temperature

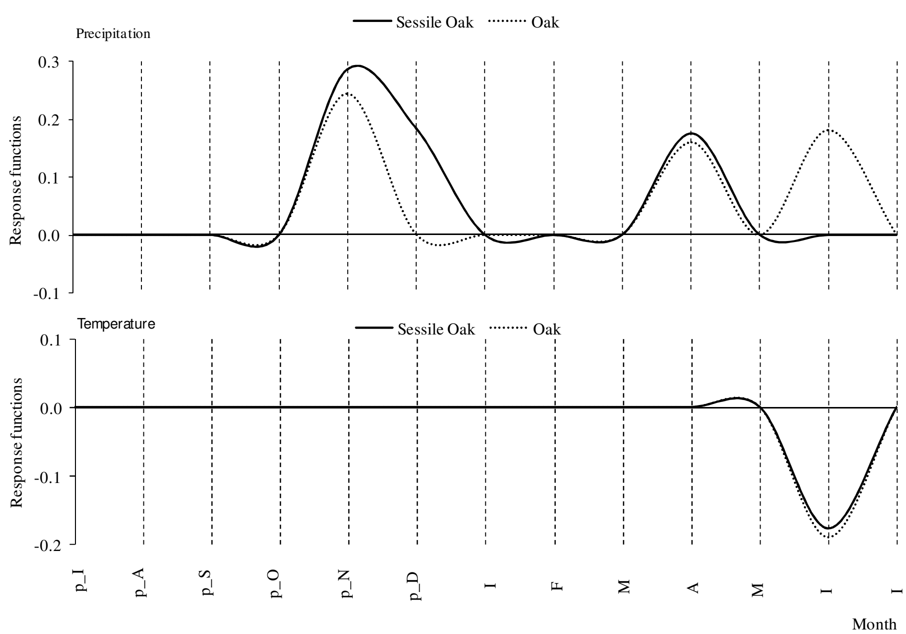

Fig. 4 Significant response functions values for oak and sessile oak

Analyzing significant response functions we can observe a difference be twin oak and sessile oak, for the precipitation parameter. Thus sessile oak reveal a higher value for the November and December previous year and also a bigger value for April current year of ring formation. For June value is worthless in compensation the oak show a value strongly significant.

The response function values for precipitation are approximately identical for both species bigger negative significant value are for the oak.

DISCUSION

All descriptive statistics in all chronology reveal that the oak and sessile oak chronologies are comparable with chronology from other location from Western Plain of Romania and Europe.

The mean standard deviation as well as the mean sensitivity have low values for the ring characteristic width and EW, between 0,092 and 0,249, whereas for the LW characteristic –much higher values, reaching 0,365. The average correlation between radius, trees and radius versus shows us a strong correlative connection to LW and RW characteristics, whereas for the early wood, the correlations are minimum and insignificant.

The correlation between these characteristics also shows us a greater homogeneity of sessile oak, comparing to that of oak. The explanation of this phenomenon can be made by the non-dependence of the early wood on the characteristics of the species being purely individual, with a strong biological basis. Every growth ring done the necessary stand for the transport of sap to the canopy, and the EW ring size is most of the time given by the leading vessels' size and not by their number.

Even the growth series analysis reveals a greater homogeneity when it comes to sessile oak species - 0,729 compared to that of oak - 0,662, but a greater sensitivity average in oak -0,292 rather that of the durmast, which is 0,279. From this, we can conclude, on the basis of the stationary analysis, that the oak is situated at the limit of the superior habitat, while sessile oak is situated at the inferior limit.

The statistic dendrochronological series trust, expressed through the common population signal parameter, shows very high values of the RW and LW characteristics, both types with an identical value. The value obtained for the EW characteristic being much lower, is something which indicates the fact that series statistical insurance is given only by the LW characteristic.

The statistical size of the common variance between the trees, given by the signal to noise ratio (SNR), show maximum values for both species in the total ring. The version explained by the first main component, the climate respectively, varies between 55, 34% in sessile oak and 49, 8% in oak, minimum values being at the component EW 23, 02% in oak and 24, 27% in sessile oak trees. The explanation of the value differences between both species which have been studied at the same site is that the impact of the climate on the growth was different.

The correlation analysis between radial growth and climate indicates climatic response differences between the two species. The oak's reaction to Month May's temperature is stronger than sessile oak's. Precipitations have a much stronger influence on the ring formation in sessile oak between March-July.

Early wood responds to both the previous year and the current year variation of temperature, especially in April and May. Latewood responds positively to the precipitations in the vegetation season and negatively to temperature. From the correlation analysis of the two analyzed species and the climate the result is that oak is much strongly positively influenced by temperature, whereas the sessile oak is influenced by the precipitations at the beginning of the vegetation season.

CONCLUSION

The analysis of relation between climate and radial growth was strongly studied, its knowledge being a challenge. In this study, the analyses of dendrochronologic series show the fact that both oak and sessile oak are species sensitive to climate, which sometimes react differently.

The separate analysis of early wood and late wood make an evident separation of climatic conditions which favors the formations of the two types of wood. Early wood it is influenced by the conditions of the year prior to the growing ring formation, the April and May temperatures are the ones creating the preceding stand for the vegetation start.

Since, physiologically speaking, leaves appear after the formation of the vessels through which the sap is carried, it is believed that the early wood made from this big lumen vessels, are formed based on the previous year resources. Late wood is the one responding truly to climatic conditions during the vegetation season. At this point, we can talk about a differentiation of the analyzed response for the studied species.

Thus, there's a positive influence to temperature in oak, which is somewhat normal, being so close to the upper limit of its vegetation, while sessile oak is much more receptive to the quantity of precipitations, also explicable through its positioning at the lower limit of the vegetation optimum.

This climatic study approach, by separating the growing ring in early and late wood is a step forward in the analysis of climatic intr-annual influence on trees growth.

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