THE DENDROCLIMATIC SIGNAL IN QUERCUS ROBUR *L.* TREE-RING CHRONOLOGIES FROM THE NORTHERN ROMANIA

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Abstract
In 2010, 41 trees of pedunculate oak (Q. robur) werw sampled in the Satu Mare region. Were obtained, three series related with total ring with, earlywood and latewood. These chronologies were used for correlation, response function and temporal stability of correlation analyses. Two chronologies were highly similar, which points to identical responses to precipitations and temperature conditions. Precipitations in form of rain and snow in winter significantly influence the growth ring formation only in total ring and latewood. Temperature, unlike precipitation, determines significant correlations to early wood formation. Droughts in spring and summer, coupled with high air temperature, causes formation of narrow rings. Response functions coefficients are more distinct and with a higher statistical significance.

Key words: correlation, oak, tree - ring, response functions, temporal stability

INTRODUCTION

Climate influences the tree growth process in a strong manner. Formation and evolution of tree rings is modeled by different weather elements such as temperature, especially high and low temperature which produce early and late frosts, precipitation and moisture availability, sunshine duration or snow abundance (Fritts, 1976).

Impact of climate on the growth of oaks was a subject of many studies across Europe. Influence of temperature and precipitation on various characteristics of radial increment of oak in Europe was studied by Gray and Pilcher (1983), Rozas (2001), Lebourgeois et al. (2004), Wazny and Eckstein (1991), Čufar et al. (2008),Friedrichs et al. (2009).

Oak is an important tree in dendroclimatological studies because it contains valuable information about the influence of precipitations in areas reviewed (Dagmar et al. 2008; Nechita, 2013). The strong dependence of ring with in these species on the air temperatures of the summer June, July and precipitations for October, November, previous year of formatting tree ring, and May, June current year, creates the possibility of reconstructing thermal and precipitation regime prevailing in the past (Schweingruber, 1996; Nechita, 2013).

Analyses of past climate from tree ring proxy data provide knowledge of the climate system and its natural variability. This knowledge can be used to make predictions of the future climate evolution (Linderholm, et al., 2010).

Since climate and soil conditions are generally different in this site unlike other parts of Romania, as regard the fact that the climate is influenced by warm air currents, with Mediterranean origin and excess water from the soil due to the frequent flooding of the Someș River. From this point of view, we hypothesized those trees at this site will be more drought sensitive than at the other site already investigated.

The objective of this study was to assess how chronologies developed from tree ring with measurement performed when compared for assessing the radial growth – climate evolution of three oak features at intraspecific level. More specifically, we compared the ring width, late wood and early wood chronology types of Quercus robur trees growing in a floodplain from the northern Romania.

MATERIAL AND METHOD

The study area is located in the northern Romania, Satu Mare County (47°49′ N, 22°47′ E) in a stand of oak floodplain. The oak is the main species covering over 85 % of the stem number. The altitude range from 110 to 125 m a.s.l., stand is located to one side and the other of the river Someș.

Due to the low slope Someș River often flooding meadow, producing negative effects on tree growth due to stagnant water in the spring and sometimes even during the summer. For this reason, the sampling area was carefully selected to avoid obvious stand disturbance.

Tree ring data were collected from living trees, according with standard dendrochronological methods, at a height of 1.30 m (Fritts, 1976; Cook and Kairiukstis, 1990; Popa, 2004). All samples were processed, measured and checked for missing rings. Dating errors was performed using the program Cofecha, software through the analysis of the correlation on successive subperiods (Grissino-Mayer, 2001).

The growth series were standardized in order to eliminate the age- and size related trends from the individual series. To preserve the low frequencies in the tree ring series I chose a spline function with a length of 20 years. We used expressed populations signal (EPS) and inter series running correlations (Rbar) to assess the theoretical number of individual series needed to build a robust mean with a maximum climatic signal.

Climatic data were provided from meteorological grid box CRU TS3, with the grid resolution 0.5°, for the period 1901 – 2013 (Jones and Harris, 2008).

RESULTS AND DISSCUSIONS

Average length of individual growth series is 119 ± 7 years; time period covered by individual series is between the years 1881 - 2011, having a number higher than 10 individual series after 1886. Mean of increase for individual series, ranging from 0.66 mm·an^{-1} to 3.75 mm·an^{-1} on RW. In contrast to this, early wood is much lower only 0.77 mm·an^{-1}, and late wood 0.87 mm·an^{-1} (Fig. 1).

The correlation between consecutive annual rings width is large and statistically significant, for RW (0.67 ± 0.14). The individual series of early wood value is 0.54 ± 0.13, and to LW series the coefficient reaches 0.60 ± 0.15. After applying the autoregressive model, the autocorrelation becomes insignificant, the maximum value being 0.17. The average correlation between individual series of growth and dendrochronological series is great for total wood (0.68) and late wood (0.62), and unspecific high to early wood (0.49).

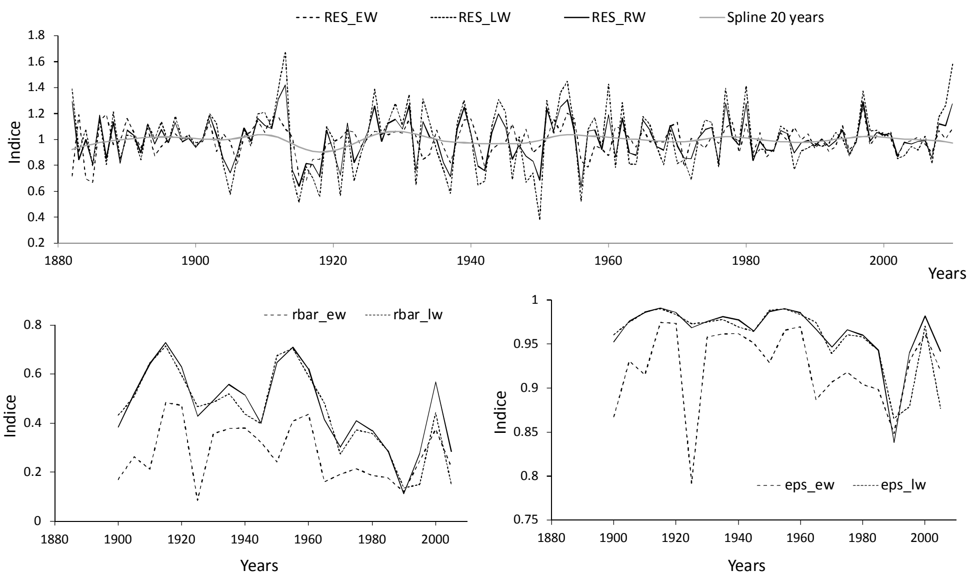

Fig. 1 Tree ring residual series, for ring width, earlywood, latewood. In the graphs below are represented values of rbar and EPS.

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Correlation between individual series, pairwise, has high values for wood later (0.51) and total wood (0.43). Early wood is characterized by low values (0.21). Residual indices series of late wood is similar to the amount calculated for radial growth series (0.50). A relatively small increase was also recorded in the early wood RES series (0.26).

Mean sensitivity of growth series is high, to growth series of late wood (0.41) and much lower amount was calculated to dendrochronological series of total wood (0.25) and early (0.22). Residual index series are characterized by low values reaching a maximum to late wood (0.30) and minimum to early wood (0.13). The signal to noise ratio has high values to total wood (46.55) and late wood (44.72), unlike the early wood, for which there was only, 17.39. High values are preserved even after standardization.

Variability explained by the first principal component exceeds 50% on mean series of RW and LW, both for average growth and residual index series. The mean value of the parameter EPS exceeds the 0.85, significance level, after 1940 with an average of 0.97.

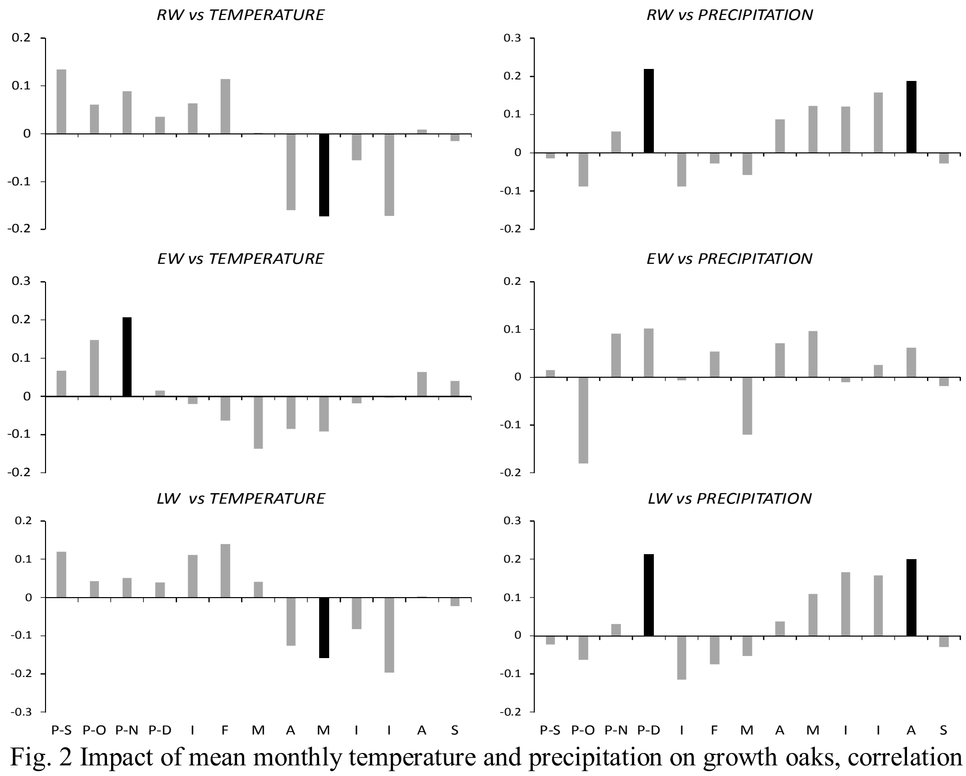

Fig. 2 Impact of mean monthly temperature and precipitation on growth oaks, correlation coefficients. Black bars indicate significant values

From the calculation of correlation coefficients between average precipitations, average temperatures and residual indices, significant values were obtained (Fig. 2). Thus, atmospheric precipitations in December are positively and significantly correlated with RW and LW (0.21). For these two series of indices was obtained significant values also in August, respectively: 0.19 (RW) and 0.20 (LW). Response functions have not generated significant value in case of correlative bond between precipitation and growth indices.

Mean temperature were significantly correlated in November last year with early wood series, the coefficient is 0.21. For the current year coefficients obtained are negative, the most representative value being calculated in July (-0.20). For late wood and total ring width was obtained significant coefficients in May, respectively -0.16 and -0.17. Also in this case response functions were obtained insignificant.

Among the extreme temperatures only the maximum determined to obtain significant values in November 0.22 (EW), May (-0.20; -0.19) and July (-0.21; -0.23). By analyzing the response functions were obtained significant coefficients in July -0.22 (RW) respectively -0.23 (LW).

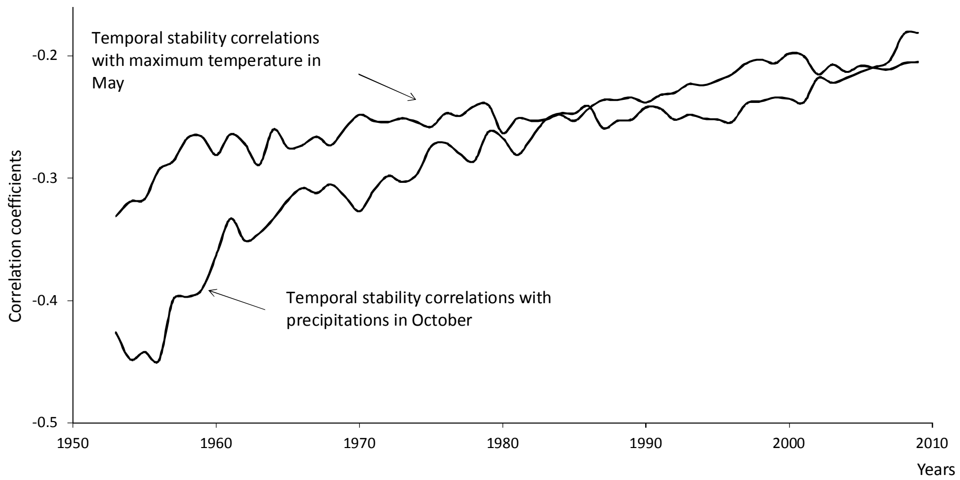

Fig. 3 Temporal stability of correlations between residual indices and maximum temperature from May and precipitations in October

Temporal stability of correlation, showed only one month with values above significance level in October for precipitations and also one month for temperature in May (Fig. 3). Analysis was performed for the climatic parameters, calculated by reference to residual indices of latewood series. The most significant coefficient obtained is 0.45 for the years 1936 – 1956. During 1989 – 2009 significance level decreases progressively to the lower limit, minimum value calculated being -0.18. By calculating the response functions have not achieved significant intervals with values stable over time.

CONCLUSIONS

Mean tree ring width of analyzed oaks is similar to the values reported in studies from other areas in Romania. In western Romania – Banloc area – oak recorded values of trees increases about 3.07 mm·an^{-1} (RW), 1.02 mm·an^{-1} (EW), 1.50 mm·an^{-1} (LW) (Nechita and Popa, 2012) ; in Transylvania – Bistrita Depression – the mean growth has values of 2.09 mm·an^{-1} (RW), 0.93 mm·an^{-1} (EW), 1.15 mm·an^{-1} (LW) (Nechita, 2013); in eastern Romania are values from the Podu Iloaiei, respectively 3.06 (RW), 1.37(EW), 2.21 (LW) (Nechita, 2012). In Moldova, Codri reservation, average growth is 3.34 (RW), 1.01 (EW), 1.86 (LW), in Danube Delta is 2.26 (RW), 0.92 (EW), 1.33 (LW), and in southern Romania values are 1.98 (RW), 0.76 (EW), 1.22 (LW) (Nechita 2013).

Results presented in the analyses conducted to date confirm a negative temperature influence on radial increment of oaks in May, for the total ring width and late wood. Early wood is positively influenced by temperatures from November previous year of growth ring formation. Precipitations are benefic in case of total ring with and late wood, both the previous and current year.

In Poland Wazny and Eckstein (1991) shows that the thermal condition from August and October of the previous year have a negative influence on the ring formation process. This negative influence of temperature on radial increment of oaks is mentioned in other studies from all around the Europe. In contradiction with the temperatures are precipitations which have a positive character in relationship with radial increment, that suggest their vulnerability to hydric deficit during the vegetation period. In most of the studies done on the relationship between climate and radial growth oaks are positively dominated by precipitation, especially from April to August.

Response function analysis allowed determining the common macroclimatic factor which makes the dendrochronological curves comparable between them. In this case analyzed there were no identified significant values of response functions, which is why we can say that the tree studied are in oak species climatic area.

Maximum temperature is a stress factor for the oak from the studied area, which decreases steadily in recent decades. Stability of the temporal correlation between maximum temperature and growth shows this process. Noteworthy is the fact that precipitations from October tend to be insignificant. These observations are meant to attract attention on local climate changes recorded by behavior trees analyzed. The analyzed oaks from this site have a growth pattern comparable with ones known from previous studies concerning that species.

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