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ORIGINAL ARTICLE

The Effect of Some Climatic Variables on the Annual Growth of Poplar (Populus Deltoides L) in Saravan Plantations, the Guilan Province

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ABSTRACT
Poplar is considered as one of the fast-growing and exotic species in the plantations of the Guilan province. A study was performed on the growth rings of poplar in the Saravan plantations of Gilan province to analyze the effects of climatic variables on the annual growth of this species. A dendrochronological study including 45 Growth samples of poplar was performed during the period of 1987-2011. The relationship between climate and poplar's growth was analyzed by regression and Pearson coefficient correlation. The results suggested that poplar's growth is more sensitive to rainfall than monthly temperature in the under review region. The highest amount of correlation between the total rainfall from May to June (p<0/001, r=0/74) and the growth index was calculated which indicates that the early season drought has a negative impact on the growth of this species. In other words the growth of poplar in the under review region is strongly influenced by the rainfall during May to June.
Key words: Poplar, Saravan, Plantation, Dendrochronology, Climate.

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INTRODUCTION

Poplar is considered as one the most important woody species for producing wood during the short-term periods in the Northern Hemisphere. Poplar is a fast-growing species which the average volume growth of 29 m3 at the age of 12th has been reported for this species in some habitats [1]. The most major forest and plant ecosystems on the earth have been generated under the influence of two factors of moisture and temperature and also other climatic factors . The climatic changes caused by human interventions have changed the amount of atmospheric radiation [2]. The estimating models of climatic changes have calculated that from 1860 up to now, the average temperature on earth has increased about 0.5-0.7c comparing the normal condition. It can be predicted that increase of the amount of carbon dioxide in atmosphere may lead to an increase of 2c to 5c of the global temperature in the future century [3]. Undoubtedly, if the climatic changes continued like so, all the natural and artificial ecosystems would be influenced. The predicted temperature increase for the upper geographical belt in winter, and the middle belt in summer is more than the average global temperature [4] which can impose strong and significant influences on the natural forest ecosystems in the Northern Hemisphere [3]. Various species of coniferous and broad leaves have been studied and the climatic variables influencing their growth have been detected in terms of the current climatic conditions. The studies suggest that not only the species' competitions and human intervention affect the structure of forest, but also climate has an impact on it [5]. Changes in vegetations in most cases are due to the climate fluctuations which have the most impact on the radical growth and can impose changes across species and habitats [6]. Investigating the impacts of climatic variables on growth of wild trees species is effective in recognizing the species' ecological needs [7]. Recognizing the ecological needs of plants and their influenceability of climatic conditions is essential for Natural Sources management and constant development.

Denrdochronology is defined as the analysis of the growth rings of trees in order to study meaningful enviromental changes which have been caused by the climatical fluctuations, successively and during intermittent periods in the past. The purpose of dendrochronology is evaluating mathematical models of

climate variability [8]. This paper aims to study the growth of poplar and its reactions to the climatical variables in the plantations of Northern Iran (the Gilan province).

MATERIALS AND METHODS

The region under study

The selected region for performing the plan included forests located in the area of Saravan forest park started from the Lakan18 watershed area and covering about 137.5 hectares. Forests of this region are located at the latitude of 37º, 3′ northern, longitude of 49º, 33′ eastern and 100-200 meters higher than sea level (figure1). The plan of changing this region to a forest park has been performed from 1984. Based on geology the kind of sediments in this region is of quaternary. The alluviums which most of them have been originated from a river or a delta, refer back to the Plytvsn up to now. Based on the soil science, type of soil in this area is of low-lying forest land which the origion of its parental material is of quaternary sediments that lack stones and pebbles and the depth of this soil is more than 1meter. Its profile type is ABC and soil ph is varied between 5-7/4. The data reported by Rasht's synoptic station covering a 25 years statistical period (1987-2011) suggests that the average amount of annual rainfall is 1328 Mm. Also the average annual temperature is 16.3c.

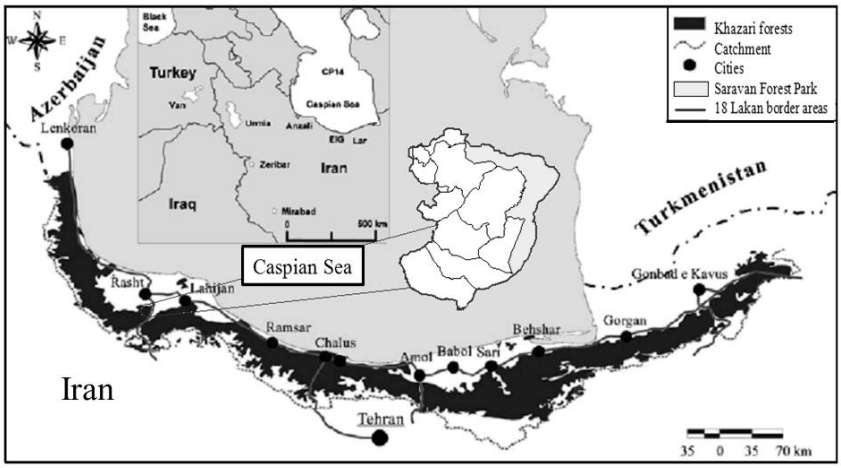

Figure 1. the geographical situation of the under reviewed region.

Methodology

For the purpose of study, a sample of 30 years old poplars was selected in the Saravan area. Then, 45 vegetative samples (from 45 trees) were removed from healthy and dominant trees applying a specific drill recognizing the age. Samples were selected randomly and among trees which were in appropriate condition. The samples were located inside wooden gutters to be dried in outdoor air, then for a better resolution the growth rings were prepared by sandpapers (from smooth to rough) for scan. By using a scanner the samples were scanned and the growth rings were measured applying the CorelDraw software by the accuracy of 0.001Mm. The equation It= Wt/Yt was applied in order to define the growth index. In the above-mentioned equation, Wt shows the measured width of ring and Yt the amount estimated by the regression model [9]. Rainfall and temperature data were obtained from the synoptic station of Rasht located at the distance of 14 kilometers from the under study area. The correlation between climate and poplar's growth was studied through regression and Pearson correlation coefficient.

RESULTS

3.1. Poplar's growth rings chronology in Saravan area

In this study the average sensitivity of trees to climate was measured from the minimum amount of 0.209 and maximum amount of 0.446. The average sensitivity of poplar trees in the under study region was calculated as 0.32 (table 1). The measured average amount of sensitivity shows the annual changes in growth rings records [9]. The sensitivity amount of 0.32 indicates the high amount of poplar growth rings' sensitivity.

Table1.The measured statistical parameters in terms of the average amount of poplar's sensitivity.

Max	min	Standard error	Standard deviation	vaiance	Average sensitivity	Region
0.446	0.209	0.073	0.110	0.005	0.32	Saravan

The growth response of poplar to rainfall

The findings about correlation between monthly rainfall and poplar's growth ring index have been represented in figure 2. Based on this figure, the amount of rainfall from April to July indicated a positive relation with poplar's growth. But except May ($p<0.05$, $r=0.459$) and June ($p<0.01$, $r=0.663$), the other months indicated no significant correlation at the level of %0.5. Negative correlation was found between rainfall and poplar's growth during July to February, but this correlation was not significant in none levels of %1and %5.

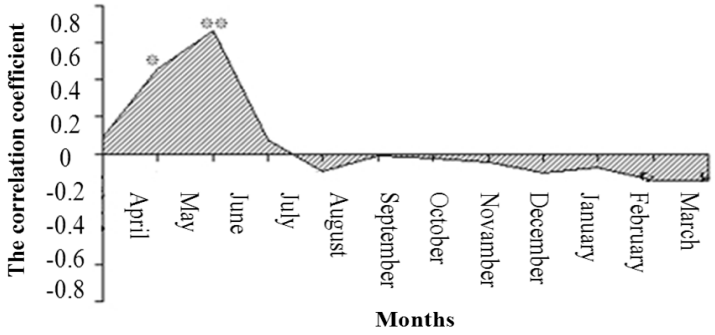

Figure 2. the correlation index between poplar's growth index and monthly rainfall. (Sings * and ** indicates significant correlation at the levels of 0.01 and 0.05, respectively).

The correlation between the total rainfall during various periods and poplar's growth index was analyzed. The findings have been represented in table2. Based on these findings, a significant correlation between poplar's growth and the total rainfall in some periods was observed. Specially, the months in spring and summer suggested stronger correlations. Based on the findings represented in table2, the total annual rainfall of the periods which indicated significant correlation at the level of %0.1 and %0.5 included: April up to June, April-November, April-August, May- August, May-July, and May-June. But except these periods, the total rainfall in other periods indicated no significant correlation.

Table2. The correlation index between growth rings of poplar and total monthly rainfall in different periods.

Correlation index	period	Correlation index	period
0.264	April - May	0.336*	Annual
0.377*	April -August	0.542**	April - June
-0.021	July -August	-0.019	July -September
0.305	May -September	0.252	October-December(fall)
0.456*	May -August	-0.023	January-March
0.584**	May - July	0.307	April -September
0.743**	May -June	0.496**	April -November(growth season)

The signs *, ** and *** indicate significant correlation at the levels of 0.05 and 0.01 and 0.001, respectively.

The highest amount of correlation between total rainfall and poplar's growth index belonged to May - June ($p<0.001$, $r=0.743$). Figure 3 shows poplar's growth rings index, its relationship with the total rainfall during May - June and the increase or decrease process between these two factors in a specific period of time. As it is observable in figure 6-4, in most cases, the total rainfall in May - June and the poplar's growth rings index show a constant process (increase or decrease).

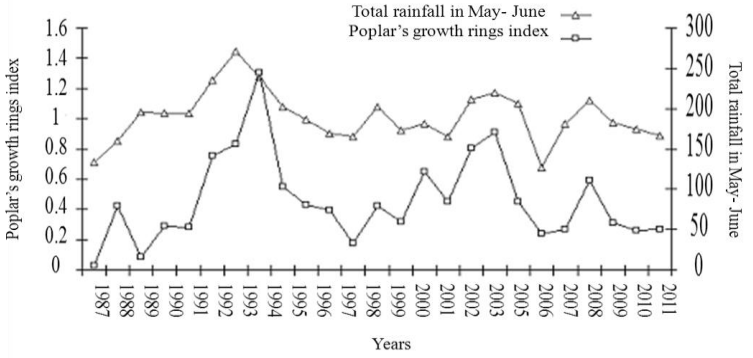

Figure3. The poplar's growth rings index and its relationship with the total rainfall of April-May.

Poplar's growth reaction to temperature

The curve for monthly temperature changes in the under study period has been represented in figure4. Based on this curve the highest amount of temperature in all the three characteristics (min, max and middle temperature) was observed in July and August. The least amount belonged to January and February.

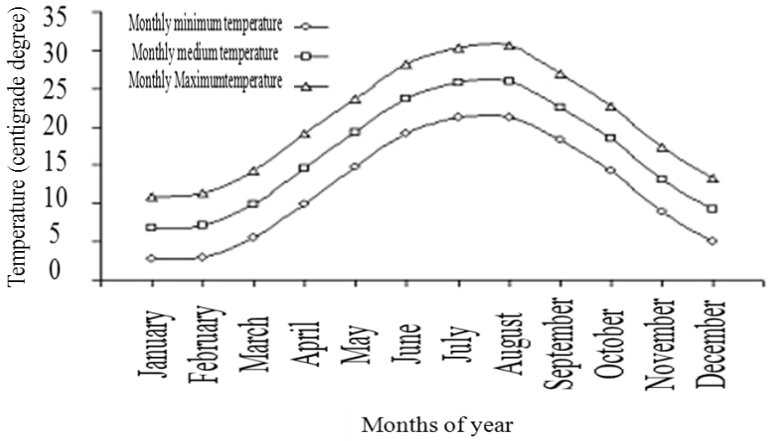

Figure4. The curve for min, max and middle temperature for a period of 25 years (1987-2011) in the region under study.

Table3 represents the correlation coefficient between the tree growth index and min, max and average monthly temperature. Generally, negative correlation was found between tree growth index and temperature in the years under study. Although positive correlation was found in some months (table 3-4), it was not significant at the level of %5. The highest amount of correlation belonged to June which included -0.517, -0.603 and -0.604 for min, average and max, respectively, all significant at the level of %1. Also a negative significant correlation between the growth index, the average ($p<0.05$, $r=-0.355$) and the maximum temperature ($p<0.05$, $r=-0.422$) in July was observed.

Table3. The correlation coefficient of poplar's growth rings index and min, max and average monthly temperature.

Maximum temperature	Minimum temperature	Average temperature	months
0.047	-0.069	0.005	April
-0.079	-0.085	-0.090	May
-0.604 **	-0.517 **	-0.603 **	June
-0.422 *	-0.138	-0.355 *	July
-0.243	-0.239	-0.294	August
-0.054	-0.088	-0.073	September
0.017	-0.330	-0.151	October
-0.225	-0.264	-0.266	November
-0.228	-0.045	-0.153	December
-0.061	0.119	0.021	January
-0.228	0.030	-0.137	February
0.094	0.062	0.090	March

The sign * indicates a significant correlation at the level of 0.05.

In this study, the highest amount of significant negative correlation was observed between the maximum temperature in May ($p<0.001$, $r=0.604$) and growth rings of poplar.

Building a multiple regression model for predicting poplar's growth index through applying a stepwise regression model

One of the basic purposes of statistical studies is finding a relation between or and among two or more variables. This relationship may be in various shapes including linear or nonlinear. Regression methods refer to kinds of statistical modeling which are responsible for interpreting such relationships. The magnitude of the relationships between independent and dependent variables is defined using correlation coefficient. The researcher doesn't rely on any predictable aspect but aims to predict or estimate some characteristics based on having knowledge about other characteristics applying the regression methods. This purpose will be gained through regression modeling [10].

The most used method for choosing the appropriate model is the stepwise method, similar to the forward method, but the only difference lies in the fact that in stepwise method after adding a variable to the

model, all the variables added before predicting no significant relation are removed. In other words the variables which loose importance because of adding other variables are removed. In this case two principles are required, one for adding a variable to the model, and the other for removing it. First we add two variables to the model based on the forward method, second analyze them based on the backward method to see which one is appropriate for being removed. When no variable is qualified for being added to this model, the process will be stopped. In this study, poplar's ring growth index as the dependent variable and the climatic variables (rainfall and temperature) as the independent variables were added to SPSS software, then the significant variables were kept by applying the stepwise regression model and other climatic variables indicating no significant correlation with the growth index of trees were removed from the stepwise model. Finally, the following model was represented as the best one.
Width index of growth rings=0.811+0.002(the total rainfall of April-May).

In this equation, the amount of R^2 determination index and the modified determination index were calculated as 0.553 and 0.533, respectively. The analysis and variance of this model are represented in table 4.

Significance level	F	Average of squares	The degree of freedom	Sum of squares	Model
0.000	28.427	0.381	1	0.381	Regression
		0.013	23	0.309	Remaining
			24	0.690	Total

DISCUSSION AND CONCLUSION

The results of this study indicate that poplar's growth is sensitive to climatic factors : temperature and rainfall. The average sensitivity index of 0.32 suggests the high amount of sensitivity of this species. Generally poplar's growth in the under review region indicated more sensitivity to rainfall than monthly temperature. The highest amount of correlation between the total rainfall and the growth index was observed during April to May ($p<0.001$, $r=0.743$) which shows that draught of the early season imposes negative influence on the growth of this species and its growth is strongly affected by the rainfall amount during the growing period. Also, temperature had negative influence on poplar's growth in some cases. The photosynthesis and breathing processes in plants happen at a wide range of temperature which may impose different influences on any process [9]. The minimum temperature for photosynthesis varied between -2 to -5c [11]. Also the maximum temperature may impose limitations for both breathing and photosynthesis processes. Over all the impure photosynthesis shows increase in the temperature range of 0 to15◌ c. Higher temperature may impose small changes in the amount of photosynthesis. Also the optimal temperature for pure photosynthesis varies across species, seasons and habitats. In different lightning conditions, the obtainable moisture and the tree's previous condition are different [9]. The optimal temperature for pure photosynthesis of species in tropical and subtropical regions is mostly between 25 to 30^0c for species that are located in colder latitudes between 15 and 20 degrees Celsius [9]. In the north of Iran, the starting and end points of the process of plant's growth depend on the days which the temperature reach 10c and shows increase and decrease [12]. This period in north of Iran includes 180 to 240 days per year [12]. This amount of temperature starts from the early May and continues up to the early October. In the literature, the average minimum annual temperature is mentioned between 8 to 16◌ c, the average maximum 30 to 34 and the average middle annual temperature of 15 to 25◌ c for the optimal growth of poplar [13]. According to findings in figure 1, the under review habitat isn't in an appropriate condition for the optimal growth of poplar during October to March. And its influence on the growth rings is completely obvious. Furthermore the findings of the study indicated that poplar shows more sensitivity to a more than one month dryness. Also the tolerance of this kind to dryness has been mentioned between 0 to 2 months [13].

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