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Effect of Climatic Factors Ontree Ring Width of *Pinus halepensis* and *Juniperus phoeniceain*, East Libya

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ABSTRACT

This study was conducted in Al- Jabel AL- Akhdar region, east Libya to identify the impact of environmental variations on wood formation of *Pinus halepensis* and *Juniperus phoenicea* trees growing at different altitudes. The study manifested the effect variation of the environmental factor on growth rings at the three altitudes and this may ascribed to the condition at each altitude, since the multiple regressions (R^2) value obtained were significant forpine and juniper trees under the conditions of each altitude. However, the highest (R^2) was found at the altitude of 248m for Pine tree. Also, (R^2) was increased with the altitude for Juniper tree at the altitude of 413 and 780m, respectively. Furthermore, the results of this study allow to know precise information about the climate conditions on the previous early stages for the tested trees, which clearly reflected in tree ring patterns in the region of Al-Jabel Al- Akhdar. These comprehensive data described in this study was to point out that the climate factors (which differ from altitude level to another) have great influences on tree ring width.

تأثير الظروف المناخية على عرض حلقات نمو *Pinus halepensis* و *Juniperus phoenicea* في منطقة الجبل الأخضر شرق ليبيا

أمل طشاني أحمد الستاوي أحمد محارب

أجريت هذه الدراسة في منطقة الجبل الأخضر، شرق ليبيا للتعرف على تأثير التغيرات البيئية على تكوين خشب *Pinus halepensis* و *Juniperus phoenicea* التي تنمو على ارتفاعات مختلفة. أظهرت الدراسة تباين تأثير العامل البيئي على حلقات النمو عند الارتفاعات الثلاثة، وقد يعزى ذلك إلى تغير الظروف المناخية عند كل ارتفاع، إذ كانت قيمة (R^2) التي تم الحصول عليها معنوية لأشجار الصنوبر والعرعر تحت ظروف كل ارتفاع منها. أما أعلى (R^2) فقد تم العثور عليه على ارتفاع 248م لشجرة الصنوبر. أيضاً تزداد قيمة (R^2) لشجرة العرعر مع الزيادة في الإرتفاع 413 و 780 م على التوالي. تتيح نتائج هذه الدراسة معرفة معلومات دقيقة عن الظروف المناخية في المراحل المبكرة السابقة لنمو الأشجار التي تم اختبارها، والتي انعكست بشكل واضح على أنماط حلقات الأشجار في منطقة الجبل الأخضر. كانت هذه البيانات الشاملة الموصوفة في هذه الدراسة تشير إلى أن العوامل المناخية (التي تختلف من مستوى ارتفاع إلى آخر) لها تأثيرات كبيرة على عرض حلقات الشجرة.

INTRODUCTION

Al- Jabel Al- Akhdar (Green Mountain) is a heavily forested, fertile upland area in north eastern Libya. The Green Mountain area has a distinct environmental characteristic for being a permanent only evergreen forest area. It is characterized by great bio-diversity with more than 50% of the total plant species scattered in the entire public space. The number of plant species in this region up about 1100 species of the total plant species (Omar Al-Mukhtar University, 2005).The topography of this area includes three classes of different levels of altitude. These levels differ from each other in their climate. The first level close to sea shore represents plain lands and Mediterranean climate. The mean of its height above sea level does not exceed 200 m. The second level, with its maximum height of about 460 m above sea level, represents an intermediate case between the first and the third levels. The maximum height of the third level of the mountain is about 880 m above the sea level. This level is characterized by cold winter climate, but is hot in most of its parts during summer (Azzawam, 1995).

***Pinus halepensis* Mill.** (the Aleppo Pine) is a species native to Al- Jabal Al- Akhdar region, It can grow up to 18-25 m tall (Zunni and Bayoumi, 2006) .This species is found mainly in the western Mediterranean (Morocco and Spain), in the countries of the northern Mediterranean (southern France, Italy, Croatia and Greece), through the eastern Mediterranean in Syria, southern Turkey, Jordan and Israel; it is not found so frequently in the countries of eastern North Africa **(,** but it is found in the north east of Libya (Zunni and Bayoumi 2006).*P. halepensis* source of wood in many Mediterranean countries it is used forvarious purposes including firewood as well as raw material for the pulp and paper industry. In the past it was also used for mine props, railway sleepers and telephone poles It is often used for improving water infiltration on hilly slopes and to prevent soil erosion on dry slopes. There is some use for pallets and chipping for particleboards as well as for boat making at a local scale (Chambel *et al*. 2013).

***Juniperus phoenicea* L.**(*Phoenician juniper*) is a Mediterranean tree typically found in coastal sites in the Mediterranean Basin, ranging from Portugal and the Canary Islands to Turkey and the northwest mountains of Saudi Arabia (Fisher, 1997). In Libya *J. phoenicea*is abundant in the Al- Jabal Al- Akhdar region(Hegazy *et al* .2011;Kabiel, *et al* .2016),The *Juniperusphoenicea* in Al- Jabal Al- Akhdar region accounts for 70% of the Libya total vegetation cover. This species has been the dominant forest tree in the Mediterranean forest region. It forms very small pure groups among the maquis belt which covers large areas below 400 meters along the coast (Omer Al Mukhtar University. (2005). Wood of *Juniperus phoenicea* is rose-coloured, hard, solid and resinous with an aromatic fragrant, fine in grain, appreciated, as other juniper woods, for small manufactured objects and inlay works. In Algeria, Tunisia and Libya when the trunk grows straight it is used for joinery and carpentry. In Africa, its wood is used mainly as fuel and for the production of charcoal. The reddish fruit cones can be used in cooking and alcoholic beverages. The leaves and the berries have been used in form of infusion, decoctions, tinctures and extracts in various fields and in folk medicine against several diseases. The essential oil was utilized centuries ago in cosmetics and now there is interest in its pharmaceutical properties. Some varieties have been selected for horticultural purposes (Caudullo *et al*,2016). The term dendro is from dendron, the Greek word for tree, and chronology means the assignment of dates to particular events in a time series (Fritts 1987).Forests are the major source of livelihood to humans since time immemorial. Human civilization evolved alongside forest ecosystems. During the ancient time, this relationship was in the balance due to low population pressure and due care of forests by society. In recent times, heavy industrialization and increasing human population have put a severe pressure on the forest ecosystems.The exponential increase in industrialization has further accelerated the process of climate change (Marotzke *et al*. 2017).

Dendrochronology is the branch of science which deals with annual rings of trees and infers the information about their age, growth rate, past events of forest fires and insect pests' outbreaks, wood quality (density) and tree species interaction with the past environment with high temporal resolution,Though tree-ring width records are among the most important and commonly used annually resolved climate proxies (Sheppard, 2010).Touchan *et al*. (2003) studied the preliminary reconstructions of spring precipitation in southwestern Turkey from tree-ring width of two reconstructions. The results showed that there is a relationship between spring precipitation and anomalous atmospheric circulation in the region. They concluded that tree rings provide a valuable natural archive to study past climate variability in the eastern Mediterranean region.One of the most important proxy archives for past climate variation is tree rings. Tree-ring parameters offer valuable knowledge regarding how trees respond and adapt to environmental changes. Trees encode all environmental changes in different tree-ring parameters (Popa *et al*.2022).

Dendrochronology and dendroanatomy offer opportunity to study above characters on different time scales and help in understanding the genetic and physiological traits of tree species related to climatic adaptation. Generally, tree-ring series can be used to reconstruct over several centuries, and occasionally millennia, past variations in precipitation, temperature, soil moisture, river flow, the frequency of extreme droughts, forest fires, major forest pest outbreaks, and several other `variables. What can be reconstructed depends on those factors that limit tree growth.

The aim of this identifying the impact of environmental variations on tree ring formation of *Pinus halepensis* and *Juniperus phoenicea* trees growing at different altitudes in Al- Jabal Al- Akhdar region.

MATERIALS AND METHODS

Whole tree samples from the two species, *Pinus halepensis* Mill and *Juniperus phoenicea* L. ,Three trees were collected from three locations at different altitudes in Al- Jabal Al- Akhdar region, east Libya ,i.e. 248 m, 413 m and 830m for *P.halepensis* and 248 m, 413 m and 780 for *J. phoenicea* (Table, 1).

Table (1): Description of study Locations.

Altitude (m)	Longitude	Latitude
248	32° 510' 9.4"	21° 39' 60.5"
413	32° 40' 23.9"	21° 33' 00.1"
780	32° 36' 435"	21° 56' 000"
830	32° 32' 165"	21° 47'466"

METHODS:

Annual increment ring width:

Samples for tree ring width were extracted from a disk, (5 cm in thickness) taken at breast height from dominant trees, then air-dried and mounted on wooden holders. After sanding with progressively finer sandpaper until the annual rings and tree ring morphology became clearly visible. whole ring were measured to the nearest mm, connected years of starting its from formation the pith to bark). The nature of annual increment rings and its relation with prevailing circumstances as described by Touchan *et al*. (2003) was adopted in this work.

Climatic data:

The climatic data pertaining the site were obtained of NASA website(**https://power.larc.nasa.gov/data-access-viewer/)**. It had been relying on the annual averages of climatic factors (temperature, rain, relative humidity)

Statistical analysis:

The multiple regression was used to determine the relationship between the annual increment ring width and climatic factors. Simple phenotypic correlations were determined for all traits using SPSS ver.16 package. The multiple regression function between climatic factors and each the studied trait was predicted according to Kleinbaum and Kupper (1978).

RESULTS AND DISCUSSION

Presented the analysis of variances of tree ring width, at different altitudes in *Pinus halepensis* and *Juniperus phoenicea*.The results reported here clearly showed high significant differences for all investigated at different altitudes in *P.halepensis*. we was summarized the relationship in form of linear multiple regression between tree ring and it's contents as dependent factors and different climate elements, namely temperature, rainfall and relative humidity (RH %) as independent factors during the period from 2002-2010 at different altitudes. The extracted information from this test could be concluded astable (2) showed the values of R^2 among the investigated climate factors (temperature, full rain and relative humidity) and tree ring width were significantly varied at different altitudes with highest R^2 value (0.448) at 830m and the lowest R^2 value (0.236) at 280m. Also, it was found that the temperature factor has great influences on tree ring formation followed by the rainfall and relative humidity, respectively.

Table (2): Linear multiple regression of the increment of ring width of wood of *Pinus halepensis* growing at different altitudes.

Altitude (m)	Regression equation	R2
248	$Y= -0.802+ 0.75 x_1+ 0.020 x_2 +0.016 x_3$	0.236
413	$Y= -9.635 + 0.156 x_1+0.061 x_2 +0.099 x_3$	0.442
830	$Y= 9.738 - 0.240 x_1+ 0.15 x_2 – 0.060 x_3$	0.448

X_1=Temperature, X_2= Rain, X_3= Relative humidity, R^2= Cofficient of determination,

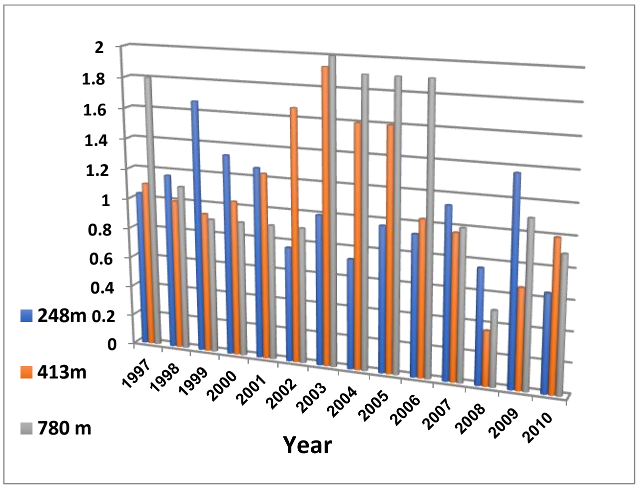
For tree ring width of *J.phoenicea*,Table (3) indicates multiple linear regression between IRW from one hand and the set of climatic conditions from the other hand during the period from 1997-2010 at different altitudes, however, the highest R^2 value (0.4279) has been obtained in the trees growing at the altitude of 248 m. On the other hand, the lowest R^2 value (0.284) was detected in the trees growing at altitude of 413 m.From the whole of data gathered, it is became obvious that the climate conditions have an important role in terms of the increment ring formation with a considerable effect for the temperature factor when it compared to the amount of rainfall and the relative humidity.

Table (3):Linear multiple regression of the increment ring width (IRW) of wood of *Juniperus phoenicea* growing at different altitudes.

Altitude (m)	Regression equation	R2
248	$Y = 6.29946 - 0.02814\ x_1 + 0.0115\ x_2 - 0.07374\ x_3$	0.428
413	$Y = -4.700 + 0.031x_1 + 0.013\ x_2 + 0.067x_3$	0.284
780	$Y = -6.669 - 0.063\ x_1 + 0.022\ x_2 + 0\ .118x_3$	0.334

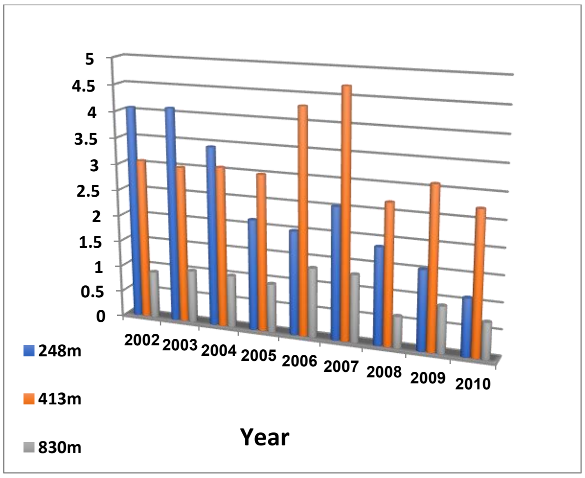
X_1=Temperature, X_2= Rain, X_3= Relative humidity, R^2= Cofficient of determination.

To prove the effectiveness of climate conditions on the width of the tree annual ring, a climate data from the trees site (Al- Jabal Al- Akhdar region) was collected in App.(248,413 and 830m). The data in fig. (2) showed years of forming the narrow and petition tree ring at different altitudes in *P.halepensis*. The data were gathered from 2002 till 2010. The measured petition rings were found in the period ranged from 2002 to 2007, and the annual ring for the year of 2007 was the widest at 413m while the narrowest was found in 2008 in the wood of tree growing 830m. When reviewing the precipitation rate, the temperature and their distribution during the years, it can be concluded that the petition rings were formed during the years of 2002, 2003, 2004, 2006 and 2007,whenever the rainfall rate recording a highest amount when compared with the years of 2008 and 2010, which showed the narrowest annual rings. Also, the temperature factor seems to have an important role in forming these petition rings, when compared with the temperature rate in the years of narrow rings. The overall conclusion in this important part is that the tree annual increment rings are good indictor thereby reflected the climate conditions *in site* during its life and it can be good recorder for such climate factors. On the other hand, the data in fig. (1) show years of forming the narrow and petition tree ring at different altitudes in *J.phoenicea*. The gathered data were from the year of 1997 till the year of 2010. The annual ring for the year of 2003 was the widest at 780m while the narrowest was found at the year of 2010 at 248m. When reviewing the precipitation, the temperature and their distribution during the years, it can be concluded that the petition rings were formed during the years of 1997, 2001, 2003 and 2009 where the rainfall rate recording a highest amount when compared with the years of 2004, 2005, 2006 and 2010 which showed the narrowest annual rings. Also, the temperature factor seems to have an important role for forming these petition rings when compared with the temperature rate in the years of narrow rings. Furthermore, it has been found that there a strong relationship between thickness of increment rings and rain fall level, this was very clear during Jun, 2004. This it can be said that, the higher the rainfall ratio, the wider (or thicker) the increment rings take place. Over viewing the climatic data, it has been found a surged rain fall during March, 2003 and various rainfalls in autumn, especially during October as well. On the other hand, the lowest rainfall amount was recorded in Feb. 2003. The thin increment rings of *J.* ***phoenicea*** trees were also related with the lowest rainfall level, particularly in Feb, 2000.The thin increment rings were developed also concomitant with low rainfall during March, 2002 and poor summer rainfall as well. The surged temperature during the winter (December, 1999) has brought forth development of thin increment rings.



Figuer (1):The years of forming the narrow and petition tree ring of *Juniperus phoenicea* growing at different altitudes.

Overviewing the Climatic data obtained, wherein *P.halepensis* and *J.phoeniciea* are already growing in the Al- Jabal Al- Akhdar region, there is a body of evidence that is influence the behaviour of tree growth for the studied species, notably, average of different climate factors such as annual rate of precipitation, temperature, and relative humidity. It is noted that the climate conditions varied significantly through the three tested altitudes which interpreted the previously discussed variation in wood properties. Also, it can be gathered from the metrological data that the third elevation has the highest rate of precipitation (600mm/year) as it compared with both first and second ones. In addition, wide variations were observed among the rest of recorded climate factors. In this study, we found distinct variation in the mean of ring width with increasing elevation



Figuer (2):The years of forming the narrow and petition tree ring of Pinus halepensis growing at different altitudes.

The obtained findings were in agreement with those obtained by Splechtna *et al*. (2000);Gou *et al*. (2005); Wang *et al*. (2005); Filippo *et al*. (2007) and Liang *et al*. (2010). They, however, found strong correlations between tree ring width with temperatures and precipitation. In our study, the values of R^2 has manifested significant differences among the three tested altitudes and the tree ring width for both tested tree species. The low r^2 (regression coefficient) at the third elevation could be attributed tomore complicated impacts of the low temperature, strong wind exposure, shallow soil with low nutrient availability and shortened growing season. Also, it could be attributed to the slope and the topographical features at the third altitudes which facilitate the movement of rain towards the lower elevation and not giving the chance for the trees at this level to obtain their adequate water requirements (Salhab *et al.* ,2012). Concerning wood formation, the results of this study showed that the temperature factor has the considerable and the important influences on the tree ring width. This observation was confirmed by the obtained regression equations between temperature and tree ring width and this was in agreement with the findings of Salhab *et al*. (2012), Grand *et al*. (2013), Wang, *et al*. (2013), Xu, *et al*. (2014) and ILmen *et al*. (2014). This also could be interpreted by the cambial activity, which is seemingly influenced by temperature, the decisive factor. The early wood -to-late wood translation time varies depending on the start of the growing season and on the start of the cell formation rate year-to- year climatic variations, such as soil or water deficits (Xu *et al*., 2014). (David *et al*. 2007) reported that the growth rate may decline with altitude, because of reduced air and soil temperatures (an adiabatic effect), shorter growing seasons, increased exposure to wind, and reduced supply of nutrients. Furthermore, physiological studies have revealed also that there substantial losses of productivity with altitude in mountain beech stands, resulting from falls in both photosynthetic and respiration. In fact, seriously low precipitation, a high temperature and human interference, taken together, might cause narrow ring width in the stem (Hosseini,2006).

CONCLUSION

This study showed that the temperature factor possess the highest influence on wood formation followed by precipitation factor and the humidity, this was confirmed by the linear multiple regression equations. Based on such notion, it can be concluded that the climate factors have an important role in tree growth in the tested locations, which changed significantly due to the different altitudes. Furthermore, the results of this study allow to know precise information about the climate conditions on the previous early stages for the tested trees, which clearly reflected in tree ring patterns in theregion of Al- Jabal Al- Akhdar region. east Libya.

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