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CLIMATIC CHANGE IMPACTS ON MEDITERRANEAN VEGETATION: LIBYAN JUNIPER FORESTS AS CASE STUDY

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ABSTRACT

Shortage of rainfall in arid and semi-arid zones is one of the major factors that restrict the growth of plants, especially in the so-called critical period. The problem has been gaining in importance recently as climatic changes are bringing about more and more frequently long drought spells in the months of spring and summer. Preliminary studies have shown that determinate varieties of some plants are poorer yielders and are more sensitive to water deficit. Therefore, considerations on how weather conditions influenced those characteristics were based primarily on the analysis of the amount and distribution of precipitation over decades.

The Phoenician juniper is a species occurring naturally and distributes in the east part of Libya at El-Gabel El-Akhdar (Cyrenica) and it constitutes about 80% of the total vegetation of this area. The pattern of weather conditions in the study area modified the emergence, growth and development as well as the production of Juniper plants. Amount and distribution of rainfall have a strong impact on the development of morphological characteristics in this plant species. Shortage or uneven distribution of rainfall events in the period of spring and summer and increasing the drought period depress plant growth characteristics.

KEY WORDS: Libya: Climatic changes: Precipitations: Drought period; *Juniperus phoenicea*

INTRODUCTION

Shortage of water is one of the major factors that restrict the growth of plants, especially in the so-called critical period. The problem has been gaining in importance recently as climatic changes are bringing about more and more frequently long drought spells in the months of spring and summer especially in arid and semi-arid zones where the plants are rain fall dependent.

Recently, many studies focused on the possible impacts of climatic changes on plants and vegetation composition while during last decades, the amount of vegetation in the world has changed significantly. Changes in seasonal patterns, weather events, temperature ranges, and other related phenomena have all been reported(Clifton et al., 1997; Diamond et al.,1995). This attributed to "global climate change" .

Preliminary studies have shown that determinate varieties of some plants are poorer yielders and are more sensitive to water deficit. Therefore, considerations on how weather conditions influenced those characteristics were based primarily on the analysis of the amount and distribution of precipitation over decades.

Since the 1850s, the effects of climatic changes, have been anticipated by the rise of temperature(Purt et al., 2012). Vegetation changes in central Europe have been well documented. Even though the climate change impacts on alpine vegetation were clear and more pronounced than on vegetation at lower altitudes (Pauli et al., 2003), but these impacts can be not ignored in the arid and semi-arid zones because the availability of water (precipitations) in these zones, which companied by high temperature, are the largest factors influencing plant growth.

Wigley (1992) reported that temperatures over the Mediterranean region as a whole could rise by about 3.5C° at the latter half of the 21st century. According to climatic data calculations and analysis, about half of this rise between 1.4 and 2.6 C° could occur by the 2020s, in addition, calculations of precipitations for the 2020s suggest an overall decrease of between 1.5 and 7.3% (Rosenzweig and Tubiello, 1997).

Libya classified as one of arid zones (Elshatshat et al., 2009). Barely five percent of the country receives more than 100 mm of rain each year (Bindra et al., 2013). Like elsewhere, Libya is impacted by climate change in numerous ways and the effect of climatic changes on its vegetation is more pronounced. Changes in plant species distributions related to major climatic change have always occurred, sometimes leading to extinctions of plant species (Cox & Moore, 1993; Jordan, 1997).

Juniper is the common name for any of various ever green, coniferous trees or shrubs, up to 10 m high. Comprising the genus *Juniperus* of the cypress family Cupressaceae. Depending on the taxonomic scheme, there are between 50 and 67 species of juniper. The Phoenician juniper (*Juniperus phoenicea* L.) is distributed in different places of the world and it is occurring naturally in southern Europe, south Asia and northern Africa.

In Libya, *J. phoenicea* L**.** constitutes about 80% of the total vegetation cover (natural forests) of El-Gabel El-Akhdar (Cyrenica) area (Lamlum et al., 2013). In contrast, its distribution in western part of the country (Tripolintana) is rare. It is evergreen, aromatic, coniferous high shrub or tree, up to 10 m high. The bark is grey-brown or white-grey in ageing plants. Leaves are small, opposite, scale-like. The male cones are yellow and the female blackish-violet. They appear between February and April. The fruit is a berry-like globes cone, lustrous, dark reddish-brown, up to 1.5 cm in diameter, with 3-6 seeds (Figure 1).

This species is listed as threatened tree by IUCN Red List in different regions of the world (IUCN 2013). Bashir et al 2016 reported that abundance and distribution of this plant is decreased especially in southern parts when they used satellite images. On the other hand, some evidences revealed how it suffered from global and regional climatic changes(Ali and El shatshat 2015).

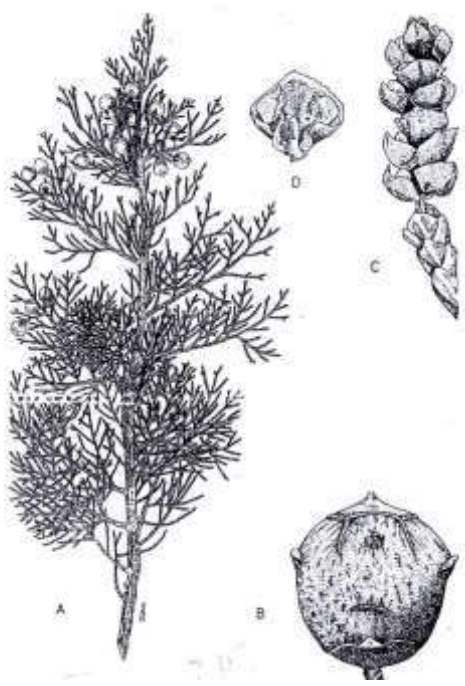

Figure 1; *Juniperus phoenicea* L**. note the fruiting branch and leaves(A), females cones (B), male inflorescence and (D) microsporophyll with microsporangia (from Sherif and El-Taife 1986).**

The objective of this study was to determine the effect of shortage and uneven distribution of rainfall which caused by climatic changes on growth characteristics of juniper trees by analyzing the climatic data during last 30 decades.

MATERIALS AND METHODS

Study area:

The study area lies on the Mediterranean coast in north eastern part of Libya (Figure 1). EL-Gabal EL-Akhdar (green mountain) extends for distance of about 250 km. Its topography includes three different levels of altitude above sea level. The vegetation and flora of EL-Gabal EL-Akhdar consists of a number of plant species using different strategies to avoid and escape from extreme climatic factors. These factors contrast the Mediterranean climatic conditions, which have the long period of drought and heat in summer with variable low precipitations in winter.

Climatic data analysis:

The data of climatic factors were obtained and collected from Libyan authority of Meteorology for last three decades. They were analyzed according to different literatures depending on the availability of precipitations, temperatures, winds and moisture. The percentages of wet and dry seasons were calculated.

Figure 2; location of study site which lies in north eastern part of Libya "EL-Gabal EL-akhdar"

RESULTS AND DISCUSSION

It is clear from the data analysis that the study area is characterized by Mediterranean climatic conditions where the precipitations mostly fall during winter months, while in spring and summer months they are lowered or stopped completely. The climatic diagram (Figure 3) showed that only around four months are rainy and by contrast, the other eight ones are dry. These months reflect the long drought period which extends from March to the end of October with some unaffected low precipitations(Table 1).

Table 1; the mean of temperatures and rainfalls in different months during last 30 years. Note the lowered and absence of rainfalls during spring and summer months.

Month	Max. temperature	Min. temperature	Rainfall
1	20.57	5.52	61.86
2	23.31	5.54	43.66
3	30.09	5.95	27.54
4	34.59	7.96	9.93
5	38.32	10.87	2.58
6	41.09	15.11	0
7	38.07	17.7	0
8	37.13	18.56	0.35
9	37.35	16.76	2.87
10	34.85	13.07	18.79
11	27.25	9.68	39.35
12	22.36	6.99	63.34

The results also reflected the long drought period which consists of spring and summer seasons (Figure 3). This period is more than eight months and this made the moisture availability in the soil very low. Calculations of rainfall percentages during different months showed that more than 77% of precipitations are fall in months of November, December, January and February while less than 23% were fallen in other eight months of the year(Figure 4), and the means were (208.21 mm) and (62.06 mm) for wet and dry season, respectively.

The results revealed also the uneven distribution of precipitations during last three decades as it shown in figure 5. The percentages of rainfalls during wet season which calculated for four months was differed among the years. The minimum amount was 28.1% and the maximum rainfall was 83.8%, while the average was 61.9%(Figure 5).

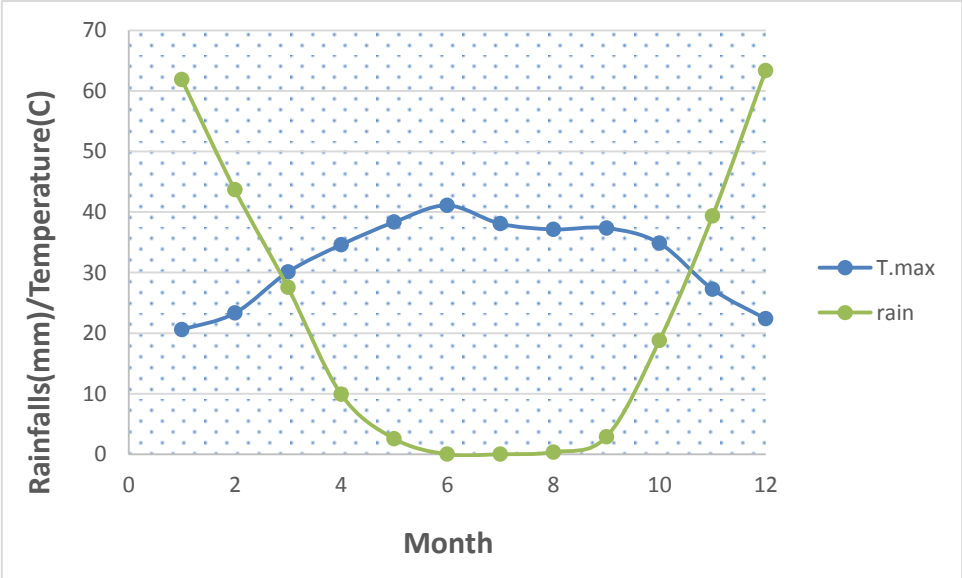

Figure 3; climatic diagram shows the means of precipitations and maximum temperature degrees of the study area in last three decades. Note the huge and long drought period which found between the climatic parameters.

In this study, the location usually experience uneven amounts of rainfall during the wet-season (November-February). This rainfall downpour is considered as the seasonal variation. The months from March to October were observed as the worst

calendar months of the year with a mean monthly accumulated rainfall of 62.06 mm.

Shortage of rainfall is one of the major factors that restrict the growth of plants, especially in the so-called critical period. Considerations on how weather conditions influenced those characteristics were based primarily on the analysis of the amount and distribution of precipitation over decades. The pattern of weather conditions in the study years modified the emergence, growth and development of Juniper plants.

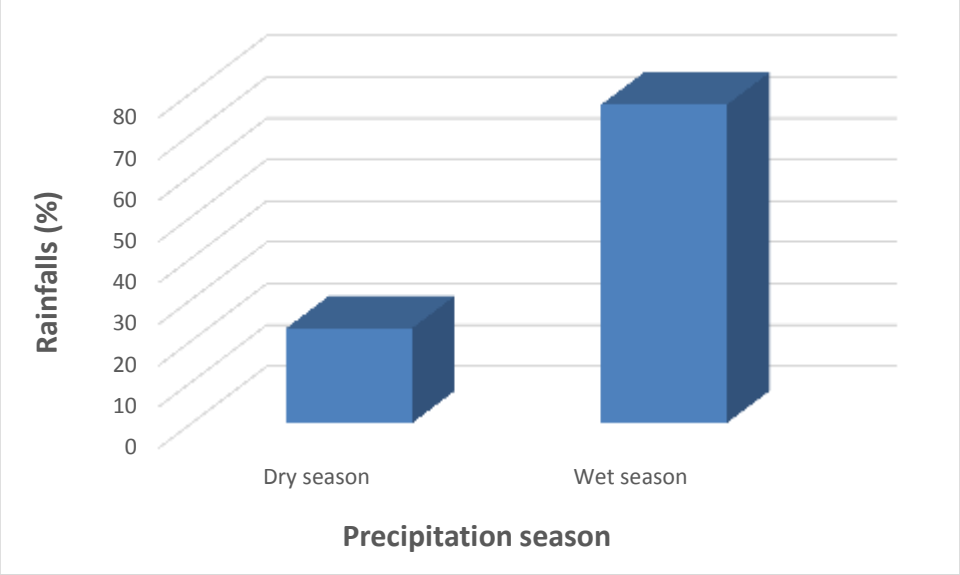

Figure 4; the percentages of dry and wet seasons. The data were obtained by calculations of precipitations during the whole year months.

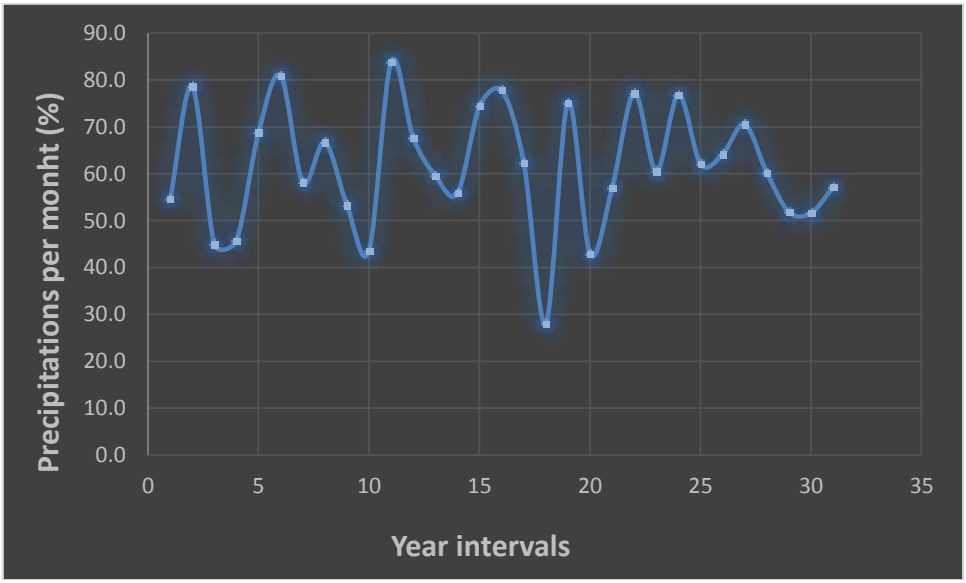

Figure 5; Fluctuation and uneven distribution of precipitations during wet season in study area. The values are percentages of November, December, January and February months during last decades. The high value was 83.8% while the lowest was 28.1%.

Amount and distribution of rainfall have a strong impact on the development of morphological characteristics in Juniper. Shortage or uneven distribution of rainfall events in the period of spring and summer depress plant growth characteristics(Figure 6).

Figure 6; Decline of Juniper plants in EL-Gabal EL-Akhdar area. The symptoms are appeared first on the top of trees(behind) and subsequently, the total death of the plants(in front).

Moisture availability is very important factor and thus, its changes effect is more than changes in precipitation or temperature alone. Low levels of moisture availability are affected by droughts which related to temperature (Figure 3). While when temperature increases, evapotranspiration will also increase. Both water gains from precipitation and water losses through runoff and evapotranspiration are limitation factors in moisture availability.

From the observations in the field, and according to EL-Gabal EL-Akhdar topography, the most juniper plants are occurred and distributed on the northern facing slopes which receive more precipitations, while the southern slopes of the mountain on the opposite side are rain-shadowed and subsequently, the plants became more affected (Figure 7).

Our observations and results were agreed with Bashir et al., (2016) who reported that remote sensing data analysis indicated that the Juniper trees at elevated areas and near coastal area of EL-Gabal EL-Akhdar are more vulnerable to Juniper decline and deterioration. Their results also showed that the regions located at a lower elevation have a higher probability of juniper decline beside the slopes faced to the NW and SE directions.

the slopes increase water runoff during precipitations even the amounts of rainfalls are enough. This can be clearly noticed in the study area, while the juniper plants those grow in the bottom of the mountain were appeared in a good and healthy vigor, because of accumulation of rainfalls, and by contrast, the ones on the top of slopes are depressed.

Figure 7; Southern facing slopes which located in the rain-shadowed area. Note the absence of Juniper plants because of shortage of precipitations.

The Mediterranean vegetation is well adapted to difficult ecological conditions (summer drought and wildfires) and to increase the ability of plant communities to grow and reproduce. Mechanisms of response which plants have to face environmental stresses include morphological, phenological and physiological adaptations(Scarascia-Mugnozzaa et al., 2000).

Typical characteristics of the Mediterranean region include a pronounced, climatic biseasonality with dry and hot summers and moist and cool autumns and winters; also, a large year-to-year variability of total rainfall as well as frequent strong and dry winds that cause the spread of forest fires (Scarascia-Mugnozzaa et al., 2000).

The rapid and acute changes in climatic conditions within the next 100 years is expected to produce an important impact on the Mediterranean forests (Regato &Korakaki 2010).

Vegetation patterns, habitat loss (Scalercio 2009) and seed production (Sánchez-Humanes & Espelta 2011) will be affected by climate change, with direct effects to plant communities. Changes in atmospheric CO_2 concentration will have severe impacts on plant populations (Lenoir et al. 2008), by affecting plant productivity and water use efficiency (Richebusch et al., 2008; Higgins & Scheiter 2012). Besides its impact on vegetation composition, phenology and reproductive process is also affected by precipitation and temperature changes (Morin et al., 2010; Klein et al., 2013).

Although the main reason for fire increase in the last decades is probably changes in land use, but climatic factors should be considered as a contributing factor. Fires tend to be concentrated in summer when temperatures are high, and air humidity and fuel moisture are low (Juli et al., 1999). Predictions on climate warming in the Mediterranean basin indicate an increase in air temperature and a reduction in summer rainfall (Houghton et al. 1996). This might explain firing of thousands of hectares of wild forests including juniper trees in EL-Gabal EL-Akhdar area(Figure 8).

Figure 8; the effect of fire on Juniper plants in study area.

Despite of losing natural and cultivated forests in Libya, the Juniper forest still constitutes the largest forest type by area (Bashir et al., 2016). According to Al-Idrissi 1996, the forest and Juniper losses are due to the prolonged drought and decrease in water supplies.

In order to meet regional climate change challenge, continue monitoring and research concerning climate change patterns and impacts on vegetation composition on regional scales must take in account. In addition, using different scenarios to find out suitable method to conserve the area from disturbance that caused by human or climatic change impacts.

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