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Bioclimate of Jericho in Palestine

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Abstract: Jericho is an ancient Canaanite Palestinian city and one of the oldest cities in history, which dates back to more than 10.000 BC (Stone Age). It is located near to the Jordan River, north of the Dead Sea, and north of Jerusalem. Moreover, it considered the lowest area in the earth and has a unique climatic zone. during the study period (1975-1995), was utilized the Salvador Rivas Martinez scale to classify the bioclimate of the earth to analysis the climate and bioclimate data, which was obtained from one station from Palestinian Meteorology Department (Jericho station). The results revealed that the mean monthly temperature was 22.4 ^{0}C, mean maximum temperature was 34.8 ^{0}C, mean monthly minimum temperature was 15.3 ^{0}C, the value of the annual ombrothermic index was 0.6, the compensated thermicity index is very high around 1209/1209 and the simple continentality index was 16.7. The bioclimate of Jericho is located within the zones of the thermal model under the inframediterranean basin, the dry and arid regions. Jericho is belong to Mediterranean desertic-oceanic, the latitudinal belt as subtropical, while continentality is oceanic-low eu-oceanic.

***Keywords*:** Palestine, Jericho, bioclimatology, bioclimatic, climate, Mediterranean basin.

Introduction

Palestine is located in the Mediterranean region climatic zone which described as, hot, dry and short summers, cool, rainy and moderate winter, where the proportion of rainfall decreased and the temperature rises, whenever the direction is from north to south, with the exception of some areas, as in the Jordan Valley, Dead Sea region and Jericho city, that where are heat rises and lack of rain (Ighbareyeh et al., 2014a,b, c, 2015a).
Jericho is a Palestinian city located near to the Jordan River in the West Bank. Many researchers and scholars have believed it as one of the oldest inhabited cities in the world (Gates, 2003; Murphy O'Connor, 1998; Friedman et al., 2000), also the city that contains the oldest known protective wall in the world (Holman, 2006), and the heavy springs inside and around the city have attracted human habitation for thousands of years such as Ain Jedi, Ain al-Sultan and Ain al-Fashka (Bromeli, 1995). Jericho lies at a depth of 260 m. below sea level in an oasis in a valley as Wadi Al-Qalt in the Jordan Valley, making it the lowest city in the world (Murphy-O'Connor, 1998; Ring et al., 1994; Holman, 2006; Ighbareyeh et al., 2015c). Annual rainfall is between 145-205 mm, most of which is concentrated in the winter season until early spring, while the average temperature is 11 ° C in January and 31° C in July (Ighbareyeh et al., 2015c; Ighbareyeh and Cano, 2018a). In the other side, Jericho has a hot desert climate according to the Köppen climate classification, rich alluvial or deposit soil and abundant spring water has made Jericho an attractive place for stability and tourism. As for agriculture, it is another source of Palestine national income, along with tourism and commerce, especially banana and palm groves that grow in Jericho (Ighbareyeh et al. 2015a, b). Many researchers in the Mediterranean region have recently studied bioclimatology and bioclimate models and climate change impact on plants (Ighbareyeh et al., 2015b,c,d,e,f; 2016a, b, c, d; Leiva et al., 2017; Ighbareyeh et al., 2017a, b, c; Ighbareyeh et al., 2018a,b,c,d). The present work aimed is to analyze the physical factors of Jericho bioclimate.

Material and methods

Study area

Jericho's mild winter climate makes it a favorite place as a winter resort, an important agricultural area that produces fruits and vegetables throughout the year. The city of Jericho lies at a depth of 260 meters below sea level in Wadi Al-Qalt, and in an oasis of springs in the Jordan Valley, with coordinates (31.8606 °N and 35.44 °E), and some areas in the city of Jericho are shown through the satellite image in (Figure 1).

Figure 1. Represented Jericho city by satellite.

Climate data sources and its analysis

In the current study, was deal with the temperature including the monthly minimum and maximum temperatures and the amount of rainfall. Otherwise, monthly data on minimum and maximum temperatures (Tmin. and Tmax.) and precipitation (P or ppt) were obtained for one station from Palestinian Meteorology Department (http://www.pmd.ps/englishIndexPage.do) (Figure 2) county average monthly climate data record for January 1, 1975 - December 31, 1995 for the 20-years' time period. Moreover, the statistical analysis included climate and bioclimate factors for the Palestinian Meteorological Station for 20 years by using the bio-climatic classification of Salvador Rivas Martinez to the earth (http://www.globalbioclimatics.org) (1996), (Rivas-Martinez et al., 1999, 2011, 2017), and climate factors consisted of mean monthly temperature (T or Tm), precipitation (P or ppt) and soil water reserve (R); and bioclimatic factors as compensated thermicity index (It/Itc), annual ombrothermic index (Io), simple continentality index (Ic) and water deficit (Wdf or Df). Annual ombrothermic index, Io =Pp/Tp
(1)
Where is Pp = positive precipitation and Tp = positive temperature (in this case equivalent to annual precipitation and mean annual temperature divided by 12, as all the months have an average temperature above 0; bimonthly summer ombrothermic index, Is2 = P July + August/T July + August; trimonthly summer ombrothermic index, Is3 = P June + July + August/T June + July + August; and simple continentality index (Ic) = Tmax-Tmin
(2)
Tmax = maximum temperature of the averages of the warmest month of the year, and Tmin = minimum temperature of the averages of the coldest month of the year; thermicity index (It), where applicable compensated thermicity index, (It/Itc) = (T + M + m)*10
(3)
T = average temperature of the months; T = mean monthly temperature; M = average of the maximum temperature of the hottest month of the year, and m= average of the minimum temperature of the coldest month of the year, and P = precipitation of the months indicated.

Figure 2. Representing Palestinian meteorological stations, including Jericho city.

Results and discussion

Analysis of climate, bioclimate factors and bioclimate models

Bioclimate is the (biology and meteorology), a climate or climatic zone considered or defined in the relation between the living organisms and their distribution. Bioclimate indicators are directly linked to plant physiological processes that determine productivity (Leathwick et al., 2003, Ighbareyeh et al., 2014a), while, bioclimatology is an environmental science that deals with the relationships between climate and the distribution of living species on Earth, bioclimatology is included phenology, and used investigations of the correlations between climate and organism (Chu and Wan 1999; Zhao et al., 2013; Hsieh and

Chiou, 2013). In the last decade, biochemistry has received considerable attention and has become specific and decisive in studying the effects of climate change on the organisms (Lechowicz and Koike, 1995; Körner and Basler, 2010; Hänninen and Tanino, 2011).

However, the bioclimatic indicators were developed by Köppen (1900), used to monitor vegetation patterns and divide into five global climatic zones; Thorn thwaite invented (1948) or established a classification based on indicators of humidity and drought, and stressed the importance of developing better measures to represent the seasonal and wet plants available; Holdridge in (1947) designed a life area system using a three dimensional bioclimatic classification based on precipitation, bio-temperature and an aridity indexes; Emberger (1930) developed an tailored pluvial thermal designed to distinguish climatic areas in the Mediterranean Sea; and many recent classifications have been categorized using bioclimatic indicators of the terrestrial ecosystem distribution model (Sayer et al., 2009), they are now used basically to model climate change effects on vegetation, and bio-clmate classification of the earth by Martinez et al.(2011, 2017). Furthermore, by the methodology of Salvador Rivas Martinez defines a general global climate classification in five microclimates as (boreal, polar, moderate, Mediterranean and tropical) on the basis of bio-climate indices and thermotypic horizons of Mediterranean macrobioclimates classification as tabulated in table 1.

Table 1. Thermotypic horizons values of Mediterranean macrobioclimates (Rivas-Martinez et al., 1999).

Thermotypic horizons	Abbr.	It, Itc	Tp: Ic>21, Itc<120
Lower inframediterranean	Imei	515-580	> 2650
Upper inframediterranean	Imes	450-515	2451-2650
Lower thermomediterranean	Tmei	400-450	2301-2450
Upper thermomediterranean	Tmes	350-400	2151-2300
Lower mesomediterranean	Mmei	285-350	1826-2150
Upper mesomediterranean	Mmes	220-285	1501-1825
Lower Supramediterranean	Smei	150-220	1201-1500
Upper supramediterranean	Smes	(120)-150	901-1200
Lower oromediterranean	Omei	-	676-900
Upper oromediterranean	Omes	-	451-675
Lower cryoromediterranean	Cmei	-	191-450
Upper cryoromediterranean	Cmes	-	1-190

Tp: Positive annual temperature.

Otherwise, ombrotypes is the threshold of ombrotype horizon estimates, based on the ombrothermic index (Io), that we recognize in the world are tabulated in table 2, and arid, hyper-arid and ultra-hyper-arid types only exist in tropical and Mediterranean macro-bioclimates.

Table 2. Ombrotypes horizon values of Mediterranean macrobioclimates (Rivas-Martinez et al., 1999).

Types	Io
Ultra-hyperarid	< 0.1
Lower hyperarid	0.1-0.2
Upper hyperarid	0.2-0.3
Lower arid	0.3-0.6
Upper arid	0.6-1.0
Lower semiarid	1.0-1.5
Upper semiarid	1.5-2.0
Lower dry	2.0-2.8
Upper dry	2.8-3.6
Lower subhumid	3.6-4.8
Upper subhumid	4.8-6.0
Lower humid	6.0-9.0
Upper humid	9.0-12.0
Lower hyperhumid	12.0-18.0
Upper hyperhumid	18.0-24.0

Ultra-hyperhumid	> 24.0

There is a difference between the values of the annual ombrothermic index where it starts from < 0.1 in the area of ultra-hyper arid and ends with a maximum value of up to > 24.0 in the area Ultra-hyper humid in the world.

Station On line   Altitude: -260 m.
Latitude: 31°51'N   Longitude: 035°27'E
Temperature observation period.: 0000-0000(0)
Rainfall observation period....: 0000-0000(0)

(C°/mm)	Ti	Mi	mi	M'i	m'i	Pi	PEi
Jan	13.2	91.1	7.4	0.0	0.0	36.0	18.6
Feb	14.4	20.9	8.3	0.0	0.0	31.0	22.7
Mar	17.4	24.3	10.5	0.0	0.0	25.0	45.2
Apr	21.7	29.3	14.2	0.0	0.0	10.0	85.7
May	25.6	33.7	17.6	0.0	0.0	2.0	147.2
Jun	28.5	36.7	20.4	0.0	0.0	0.0	178.8
Jul	29.9	37.8	22.1	0.0	0.0	0.0	196.9
Aug	30.0	37.6	22.4	0.0	0.0	0.0	188.0
Sep	28.6	36.1	21.2	0.0	0.0	0.0	156.9
Oct	25.1	23.3	17.9	0.0	0.0	7.0	115.0
Nov	19.6	26.4	12.9	0.0	0.0	22.0	53.1
Dec	14.7	20.4	9.0	0.0	0.0	33.0	24.3
Year	22.4	34.8	15.3	0.0	0.0	166.0	1232.3

Graphic 1. Represents the values of the Palestinian meteorological data for the Jericho station during 1975-1995.

In this study period (1975-1995), the mean monthly temperature was 22.4 0C, the average monthly maximum temperature was 34.8ºC, average monthly minimum temperature was 15.3ºC, precipitation was 166 mm and potential monthly evapotranspiration index Pei was 1232.

BIOCLIMATIC INDEX AND DIAGNOSIS

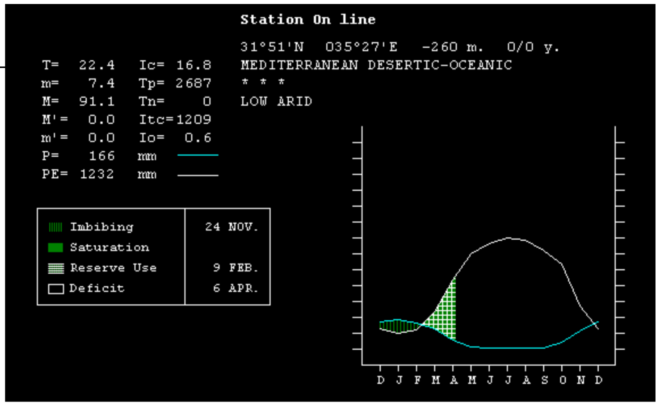
Thermicity index	(It)	1209
Compensated thermicity index	(Itc)	1209
Simple continentality index	(Ic)	16.8
Diurnality index	(Id)	83.7
Annual ombrothermic index	(Io)	0.62
Monthly estival ombrothermic index	(Ios1)	No
Bimonthly estival ombrothermic index	(Ios2)	No
Threemonthly estival ombrothermic index	(Ios3)	No
Fourmonthly estival ombrothermic index	(Ios4)	0.02
Annual ombro-evaporation index	(Ioe)	0.13
Annual positive temperature	(Tp)	2687
Annual negative temperature	(Tn)	0
Estival temperature	(Ts)	884
Positive precipitation	(Pp)	166

N°of	P>4T	P:2T a 4T	P: T a 2T	P<T	T<=0
Years	0	3	2	7	0

Latitudinal Belt...: Subtropical
Continentality.....: Oceanic - Low Euoceanic
Bioclimate.........: MEDITERRANEAN DESERTIC-OCEANIC
Bioclimatic Belt...: * * * LOW ARID

Graphic 2. Values of bioclimatic indexes and diagnosis during years 1975-1995.

The annual ombrothermal index is equal to 0.62 and the bimonthly and quarterly summer or estivalombrotheric indexes are equal to zero, since there is no rain-full or there is no compensation. Otherwise, the thermity index (It) and compensated thermal index (Itc), (It/Itc) are the same values (1209/1209), and the simple continentality index Ic equal 16.8, also the value of annual ombrothermal indexis very low, which originate an arid ombrotype and the value of compensated thermal index is value that takes us to the infra-mediterranean region.



Graphic 3. Represents of bioclimatic value during years 1975-1995.

The excess water (EW) equals zero, that is to say, that there is no period of (EW) and period during which precipitation (P) is higher than evapotranspiration (ETP), also losing the surplus of water by percolation or surface runoff). There is a use of the reserve (RU) from February 9 to April 6 (the P <ETP but there is still enough water in the reserve of land to compensate for the deficit). Water deficit occurs from April 6 to November 24 around 7 months, there is no rain-full, in this case, the ETP is greater than P and there is no water left in the soil. The plant activity is therefore interrupted, except in strongly adapted species. Water accumulation occurs from November 24 to February 9 (The P again exceeds the ETP). The plant activity can be resumed but no excess water is produced until the soil reserve has been saturated, which in this case there is no saturation at any time.

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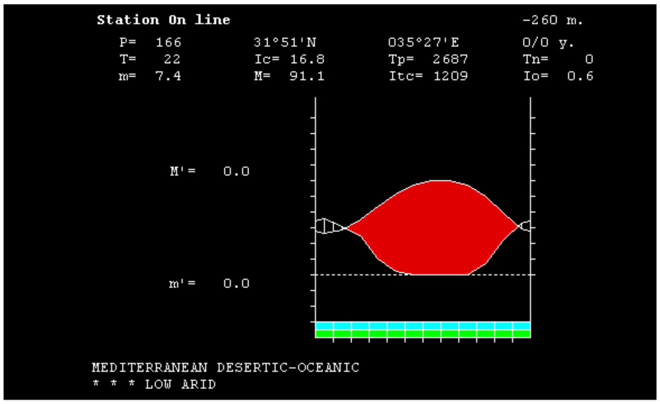

Graphic 4. Diagram represents climatic and bioclimatic factors during years 1975-1995.

The annual ombrotheric index (Io) is equal 0.6, there is no rainfall around 10 months that is represented in red in the diagram, the bimonthly and quarterly summer or estival ombrothermical indexes are equal zero, simple continentality index is equal 16.8, and the mean precipitation is 166 mm.

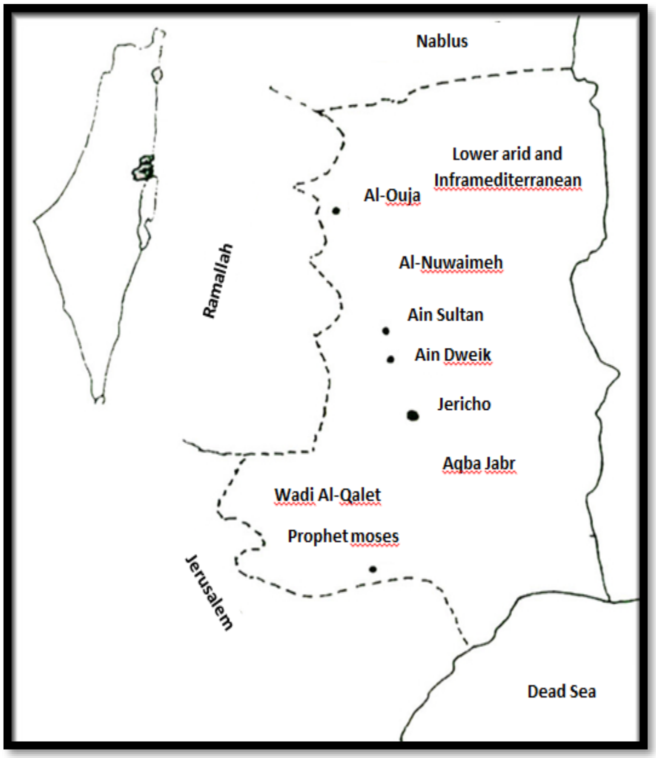

Figure 3. Thermotype and ombrotype of Jericho in Palestine.

The current investigation observed that all the areas located within the Jericho area or Governorate, shown in (Figure 3), are located in the lower arid area of ombrotype and inframediterranean of thermotype such as Nu'aym, Ain-Sultan, Ain-Dweik, Nabi Musa, WadiQelt, AqabatJaber and other neighboring. However, according to the vegetation analysis, there are some of plants have been adapted in the area of Jericho such as, *Arbutus andrachne* L., *Cupressus sempervirens* L., *Ceratonia siliqua* L., *Pinus halepensis* - Miller, Pinus pinea L., *Pistacia lentiscus* L., *Pistacia atlantica* Desf., *Pistacia saportae* Burnat, *Pistacia palaestina* Boiss., *Quercus spp*., *Tamarix aphylla* L. Karsten, *Tamarix arvensis* Zohary, *Tamarix jordani* L., *Tamarix amplexicaulis* Ehrenb, *Tamarix tetragyna* Ehrenb, *Tamarix parviflora* DC. etc..

Conclusion

Due to the difference in climatic and bioclimate factors, where the value of the annual ombrothermic index was very little as 0.6, the compensated thermicity index is very high, and the simple continentality index was 16.7. The bioclimate of Jericho is belong to Mediterranean desertic-oceanic; the latitudinal belt is subtropical and continentality is oceanic-low eu-oceanic. Whereas, Jericho is lies in the lower arid of ombrotype and infra-mediterranean thermotype. It can be admitted that from the phytosociological point, the Jericho is located in the part of the Mediterranean territories deserted are dominated by communities belonging to the *Tamarix* class, being dominant communities plants as *Tamarix spp. Cupressus spp*., *Pinus spp.*, *Pistacia spp.*, *Quercus spp. Arbutus andrachne* L., *Ceratonia siliqua* L. and others.

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