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EFFECT OF BIOCLIMATE FACTORS ON OLIVE (*OLEA EUROPAEA L.*) YIELD: TO INCREASE THE ECONOMY AND MAINTAINING FOOD SECURITY IN PALESTINE

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ABSTRACT

Olive (*oleae europaea L.)* is one of the most important agricultural crops production and plays a role in the Palestinian economy, we analyzed the mean monthly temperature and precipitation using data from nine weather stations from the Palestine Meteorological Department, recorded in the period from 1993-2008, with the same years plant production (rain-fed) from the Palestinian Central Bureau of Statistics (PCBS). Statistical tests included a bioclimatic analysis of Palestinian meteorological stations for the period previous by using bioclimatic classification of the Earth of Salvador Rivas Martinez, with regard to bioclimate factors as simple continentality index, compensated thermicity index, and annual ombrothermic index. In concluded, when we applied a correspondence analysis Bethlehem, Jerusalem and Ramallah areas were influenced by the annual ombrothermic index and simple continentality index, while Jenin, Nabuls, Tubas, Tulkareem and Salfite were affected by compensated thermicity index with large a proportion of the variance explained by axes 1 (84.98 %). We indicated that in the upper inframediterranean to mesomediterranean environments, the optimum for the olive production is achieved with value of annual ombrothermic index 3.6, simple continentality index value between 15-22 and compensated thermicity index value between 280-450.

INTRODUCTION

The olive, known by the botanical name Olea europaea, meaning "european olive", is a species of small tree in the family Oleaceae, found in the Mediterranean Basin. The species is cultivated in many places and considered naturalized in all the countries of the Mediterranean coast. Historically, it seems certain that the olive tree as we know it today had its origin approximately 6,000 to 7,000 years ago in the region corresponding to ancient Persia and Mesopotamia (Boskou, D., ed, 1996). Its origin can be traced to the Levant based on written tablets, olive pits, and wood fragments found in ancient tombs (Vossen, Paul, 2007; Di Giovacchino, Luciano, 2013). At least one cookbook writer writes that the most ancient evidence of olive cultivation is found in Syria, Palestine, and Crete (Lanza, Fabrizia, 2011).

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Olives are now cultivated in many regions of the world with Mediterranean climates, such as Palestine, Syria, Jordan, Lebanon, South Africa in areas with temperate climates as it is shown in the Figure 1. Olives are one of the most extensively cultivated fruit crops in the world (FAO, 2004) in 2011 there were about 9.6 million hectares planted with olive trees, according to the Food and Agriculture Organization, are all located in the Mediterranean region and produce 95% of the world's olives. In general, olive tree is a symbol of peace in the world and the presence of the Israeli occupation of Palestine in particular. Olive trees are a major commercial and agriculture crop for Palestine, and many families depend on it for their livelihood, where they are mostly grown for olive oil production. It has been estimated that olive production accounted for 57% of cultivated land in the Palestinian territories with 7.8 million fruit-bearing olive trees in 2011 (UNCTAD, 2015), around 100,000 households rely on olives for their primary income (Lodolini, *et al*., 2014). There are many important varieties of olives in Palestine as Suri, Muhasan Nabali, Baladi Nabali and Rumi, Rumi olive is

considered one of the more varieties tolerant to drought, climate change and other factors, it must be noted that the Palestinian oil is considered one of the finest oils in the world and has a global specification excellent. Palestine is located in the Mediterranean sea, the Mediterranean Region is the main area in the world devoted to the olive tree crop (*Olea europaea L.*), where it is one of the most important agricultural activities and economic.

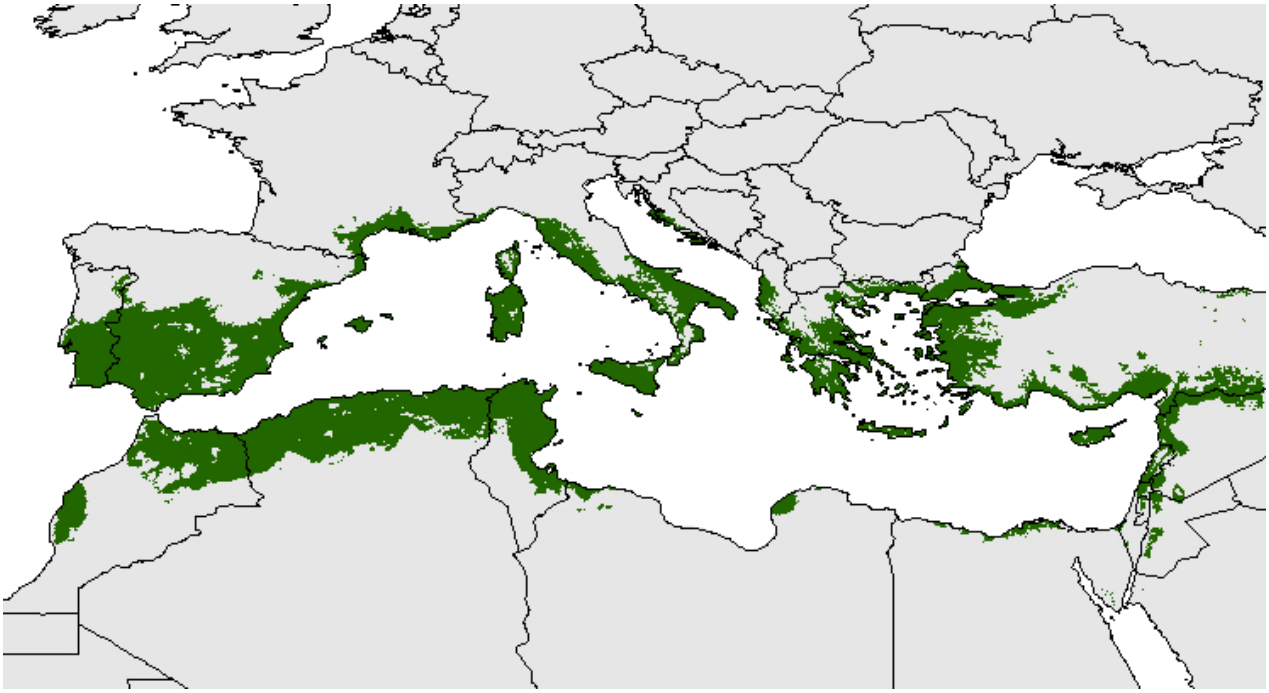

Figure 1. Potential distribution of olive tree over the Mediterranean Basin (Oteros Jose, 2014)

The Mediterranean Basin is a climate change (Giorgi F., 2006) and biodiversity (Myers N. *et al*., 2000), hot spot where substantial warming is predicted in the next few decades. A major agro-ecosystem in the Basin is olive (*Olea europaea L.*), an ancient ubiquitous crop of considerable socioeconomic importance (Loumou A, Giourga C., 2003). Recent studies (Ighbareyeh *et al*., a, b, c, d, 2014; Ighbareyeh *et al*., a, b, c, d, e, f, g, h, I, 2015; Ighbareyeh *et al*., a, b, c, 2016; Ana Cano Ortiz *et al*., 2014 and Cano, *et al*., 1997) have highlighted the influence of biology, bioclimatology, physiology on plant yield and growth, Palestine is belonging to the inframediterranean to mesomediterranean of bioclimatic belts; and arid, semiarid, dry, sub-humid and humid of ombrotype (Ighbareyeh *et al*., 2014b). Both climatic and bioclimatic factors affecting on production and growth plant, and with the continuation of the time there will be a significant economic losses in Palestine for this must study these factors and work to find solutions to them. The objective is to study effect of the bioclimatic factors on plant production (olive) in Palestine.

MATERIALS AND METHODS

Study Area

Palestine is located between longitudes 34˚15' and 35˚40' east and between latitudes 29˚30' and 33˚15' north, this has allowed a central location for the world to be a factor reached between the old world continents of Asia, Africa and Europe. The site Palestine plays a major role in influencing the climate features and nature, therefore it has a vital diversity is unique in the world; and the region bordering the Mediterranean Sea and historical region in the Middle East, therefore study area is characterized by a Mediterranean climate.

Data Analysis

Bioclimates are basic units of the typological system of the current bioclimatic classification of the Earth (Global Bioclimatic). It is a biophysical space delimited by certain types of vegetation and their corresponding climatic values. Twenty-seven types of bioclimates have been recognized on Earth in the five macrobioclines. The bioclimatology of the aforementioned stations was studied (Table 1), and the value of the bioclimatic factors such as annual ombrothermic index (Io), simple continentality index (Ic), and compensated thermicity index (It/Itc) were obtained according to Silvador Rivas-Martinez (Rivas Martínez, S., 1996; Rivas Martínez, S., 2004; Rivas Martínez, S., 2008 and Rivas Martínez, S. *et al*., 2011). Moreover, we used the following formulas to calculate the values of the various index Silvador Rivas Martínez (1996) as: annual ombrothermic index (Io) = Pp/Tp, (Pp) = positive precipitation and (Tp) = positive temperature; bimonthly summer ombrothermic index (Is2) = P July + August / T July + August; trimonthly summer ombrothermic index (Is3) = P June + July + August / T June + July + August, (P) = precipitation; simple continentality index (Ic) = Tmax – Tmin, Tmax = maximum temperature of the averages of the warmest month of the year; Tmin = minimum temperature of the averages of the coldest month of the year; (It) thermicity index, or where applicable compensated thermicity index (It/Itc) = (T + M + m)10, (T) = mean monthly temperature of the year, M = mean maximum temperature of the coldest month of the year; and m = mean minimum temperature of the coldest month of the year. The present work is based on data from nine meteorological stations in Palestine as it is shown in the (Table 1, Figure 2) for the years 1993 to 2008, and to the same years for plant production (Table 2), data were selected due to their location either in or near or a few far areas of olive cultivation. On the other hand, we analyzed the relationship between the dependent variable as yield; and the independent

variables (bioclimatic factors) as annual omrothermic index, simple contenentality index, and compensated thermicity index, also the Shapiro-Wilk and Jarque-Bera normality tests were applied (Jarque, and Bera, A., 1987; Jarque, and Bera, A., 1980; Shapiro, S. and Wilk, M., 1965 and Shapiro, S. and Wilk, *et al*, 1968). By applying bioclimatic indexes, Loidi J. and Silvador Rivas Martinez (1999) were able to establish a close relationship between bioclimatic data and plant yield, thus enabling the characterization of each area. Analysis of Variance (ANOVA) is a statistical method used to test differences between two or more means, thus during the study process analysis, we applied an analysis of variance linear regression analysis to each of the three independent and dependent variables to obtain the coefficient of regression (R^2), the multiple regression line, and canonical correspondence analysis (CCA) were subsequently applied to determine the influence of bioclimate factors on plant production, it must be noted that these statistical analyzes were done using the XLSTAT software.

Table 1. Coordinates of meteorological stations Palestinian

Site	Latitude (north)	Latitude (east)	Elevation m
Jenin	32°28 N´	35°18 E	178 m
Tulkarem	32°19 N´	35°01 E	83 m
Nablus	32°13 N´	35°15 E	570m
Ramallah	31°89 N´	35°21 E	856m
Hebron	31°32 N´	35°06 E	1005 m
Jericho	31°51 N	35°27E	-260 m
Jerusalem	31°52 N´	35°13 E	750 m
Salfite	32°05 N´	35°10 E	570 m
Bethlehem	35°20 N´	31°71 E	276 m

Figure 2. Palestinian meteorological stations sites that have been studied

RESULTS

Effect of the Bioclimate factors on Plant: We used the bioclimatic classification of earth to Salvador Rivas-Martinez to analyses of the bioclimatic parameters (independent variables). After application of the Shapiro-Wilk normality test, the p-value obtained from the variables studied tended to be below 0.05, a conventionally accepted value.

Table 2. Represents of independent variables (bioclimate factors) and independent variable (olive production)

Site	T	P	It/Itc	Ic	Io	Olive production
Jenin	20.4	490	450	17.4	1.89	207
Tulkarem	22.4	601	480	17.2	2.44	122
Nablus	17.9	683	350	19.1	3.21	170
Salfite	22	588	466	17.6	2.63	111
Ramallah	17.1	614	311	17.8	3.19	90
Jerusalem	18.8	549	390	17.4	2.33	92
Bethlehem	17.9	548	400	16.2	2.89	64
Hebron	16.6	595	297	18.1	3.19	141
Jenin	20.4	490	450	17.4	1.89	207

Yield: Kg. dunum.

In the other side, the analysis of variance (ANOVA), with a 95% confidence interval, applied to plant production (olive), with the three bioclimate factors (Io, Ic and It/Itc) reveals significant difference on plant production, which indicates that there is the impact of bioclimate factors on the maturity, physiology, growth and production of olive, and in the multiple regression analyses, olive production show a better linear regression correlation with the value of regression = 0.911, being close to 1, the linear regression correlation analyses between of the dependent variable (plant production) and the three independent bioclimatic variables have a different level of significance therefore, there are no significant differences in olive yield with the factor annual ombrothermic index and compensated thermicity index, while there is a statistically significant difference with the factor simple continentality index because the histogram is positive (Figure 3), this is quite similar to a study previously conducted by (Ighbareyeh *et al*., 2014 and Ighbareyeh *et al*., 2015d).

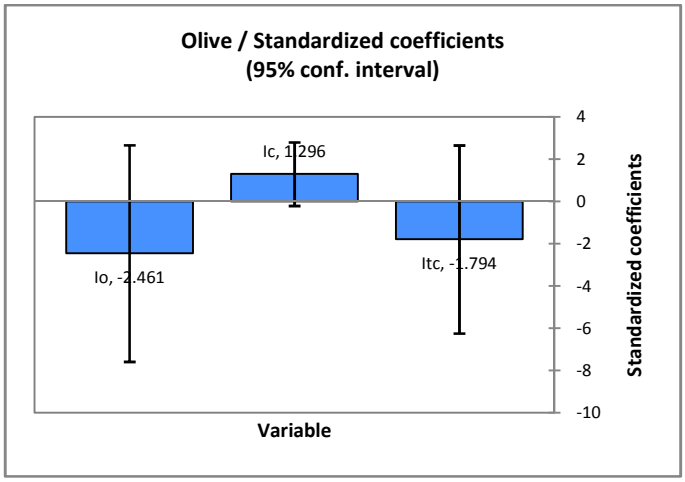

Figure 3. Regression correlation analysis for the dependent and independent variables

When we applied canonical correspondence analysis (CCA), Nablus, Jenin, Tubas, Tulkarem and Salfite type plots were most affected by the bioclimate factors as compensated thermicity index, whereas, Hebron, Bethlehem, Jerusalem, and Ramallah plots showed the influence by annual ombrothermic index and simple continentalility index (Figure 4 and Table 2), also, in case of the canonical correspondence analysis, the variance were (84.98%) (Figure 4) between production and bioclimate factors (It/Itc) explained by axis 1 with a type plots Tubas, Nablus, therefore may be this cities yield depends on this factor, whereas Bethlehem, Jerusalem and Ramallah, production depends on annual ombrothermic index and simple contenintality thermicity index factors, as in the upper thermomediterranean and lower mesomediterranean

environments, the optimum for the production of olive is achieved with values of simple continentalility index <18, annual ombrothermic index = 3.6 - 4.0 (Ana Cano Ortiz *et al*., 2014), and compensated thermicity index between (280 – 450) for plant production (Ighbareyeh, *et al*., 2015d), and climate is one of the key controlling factors in olive yield (Ighbareyeh Jehad *et al*., 2014c, 2015g).

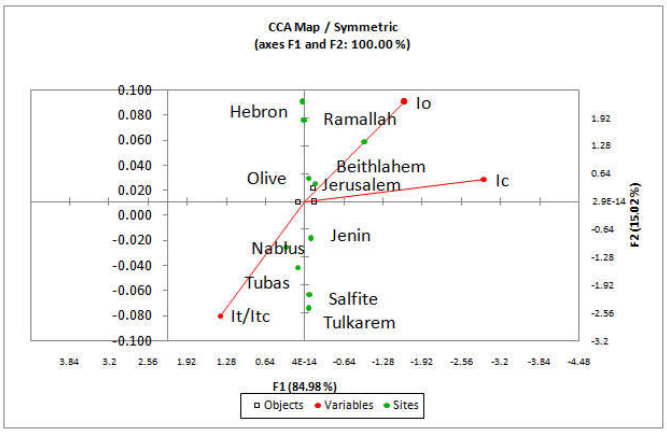

Figure 4. Canonical correspondence analysis (CCA), with independent variables (bioclimate factors) and dependent variable

DISCUSSION

However, we indicated that the correlation the correlation between the indexes for the Mediterranean macrobioclimate and the distribution of olive cultivations clearly highlights the typically Mediterranean character of *Olea europaea L*. due to factor of temperature, rainfall, as well as other bioclimatic factors as trimonthly summer ombrothermic index, monthly summer ombrothermic index and simple thermicity index. Nevertheless, olive is a long lived drought tolerant species limited by frost and high temperatures, with well-drained soils; its need full sun for fruit production and slight winter chill for the fruits to set, therefore olive trees should not be planted in areas where temperature falls below -8°C because they do not tolerate very low temperatures; and annual rainfall <450 mm to increase productivity, growth and sustainability. Palestine has a Mediterranean climate characterized by long, hot, dry summer's short, cool, and rainy winters. Furthermore, when we applied correspondence analysis (CA) was observed that the Hebron, Tubas and Nablus type plots are located at the left of axis 1, with a proportion of the variance explained by axes 1 (84.98%), axes 2 (15.02%), (axes F1 and F2 100%) and affected by compensated thermicity index, except Hebron area, while Ramallah, Jenin, Salfite, Tulkarem, Bethlehem and Jerusalem are located at the right of axis1, and affected by simple continentality index and annual ombrothermic index, with large a proportion of the variance explained by axes (axes F1 and F2 100%). However, so that we can achieve optimal production of olive, it is imperative that to be a annual ombrothermic index value greater than 3.6, simple continentality index value between 15-22, compensated thermicity index value between 280-450, the mean monthly temperature between 18-30^{0}C, and the upper inframediterranean to mesomediterranean environments in Palestine. Olive trees are a major commercial crop for Palestine, and many families depend on it for their livelihood, and its production contributes to about 38.2% of the fruit trees production income. Historically, and in the fact the olive was native to Asia Minor and spread from Iran, Syria and Palestine (highland of Nablus) to the rest of the Mediterranean basin 6,000 years ago.

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