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Original Research Article

Modeling of Biology and Bioclimatology Applied on Plant in Palestine

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The peach (*Prunus persica L.*) is one of the most important export crops in Palestine and climate effects on plum yield were studied.We analyzed the mean annual temperature and precipitation using data from tenth weather stations from the Palestine Meteorological Department, recorded in the period from 1993-2008 (15 years), with the same year's 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 the bioclimatic classification of the Earth of Rivas Martinez Salvador, with regard to simple continentality index, compensated thermicity index, annual ombrothermic index, water deficit and soil water reserve. In concluded, both bioclimate and climate factors were influenced on plant production and growth activities, yield level was positively correlated to several bioclimatic and climatic parameters the year previous to the yield years because the histograms are positive. Moreover, the optimum for the production of peach is achieved with value of annual ombrothermic index more than 2.5, simple continentality index value between 15-22, compensated thermicity index value between 250-420, summer heat is required to mature the crop, with mean temperatures of the hottest month between 20 and 30 °C (68 and 86 °F), annual rainfall between 350-900 millimeters, the dry to humid of ombrotype and with upper inframediterranean to mesomediterranean of bioclimate belts or thermotype.

Keywords *Palestine, Bioclimate, Climatic, Biology,* peach*.*

INTRODUCTION

The peach (*Prunus persica L.*) is a deciduous tree, native to Northwest China, in the region between the Tarim Basin and the north slopes of the Kunlun Shan mountains, where it was first domesticated and cultivated (Faust, M. And Timon, B. L, 2010).The scientific name *persica*, along with the word "peach" itself and its cognates in many European languages, derives from an early European belief that peaches were native to Persia. The Ancient Romans referred to the peach as *malum persicum* "Persian apple", later becoming French pêche, hence the English "peach" (Campbell, Lyle, 2004). Although its botanical name *Prunus persica* refers to Persia (present Iran) from where it came to Europe, genetic studies suggest peaches originated in China, (Thacker, Christopher, 1985) where they have been cultivated since the early days of Chinese culture, circa 2000 BC. (Singh, Akath et al., 2007; Geissler, Catherine, 2009), the peach was brought to India and Western Asia in ancient times (Ensminger, Audrey H., 1994).

Moreover, peaches grow in a fairly limited range in dry, continental or temperate climates. Palestine has a Mediterranean climate characterized by long, hot, dry summers and short, cool, rainy winters, as modified locally by altitude and latitude. Important historical peach-producing areas are China, Iran, and the Mediterranean countries, such as France, Italy, Spain and Greece. The most productive farms for peaches and nectarines, on average, were in Austria. In comparison to world average yield of 13 metric tons per hectare, Austrian farm yields topped 40 metric tons per hectare for each of the years between 2006 and 2010, with a higher observed average yield of 56.8 metric tonnes per hectare in 2010 (Fao., 2011).

Recent studies (Ighbareyeh, J.M.H.et al., 2014a, b, c; Ighbareyeh, J.M.H. et al., 2015a, b, c, d, e, f; Ana Cano O. et al., 2014)have highlighted the influence of biology, climatology and bioclimatology on yield and growth of plants; however, this is the first time the bioclimatic characterization of the different varieties has been under taken. Palestine belongs to the inframediterranean to mesomediterranean of bioclimatic belts

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(thermotype); and arid, semiarid, dry, sub-humid and humid of ombrotype (Ighbareyeh, J. M. H. et al., 2014b).

Aims to study the effect of biology, bioclimatology and climatology on peach (*Prunus persica L.*) to establish the variables that had the greatest influence on plant yield to increase economy in the region of Palestine.

MATERIALS AND METHODS

Study area

Palestine is located between longitudes 34º15´ and 35º40´ east and between latitudes 29º 30´ and 33º15´ north. The geographic location of Palestine plays a major role in affecting the features of its climate and the climate diversity between the southern and northern parts.

Data analysis and collections

The study was conducted in the occupied Palestinian territories during 1967, therefore, data were used from the meteorological stations in Palestine (Table 1) and (Figure 1). Mean temperature, precipitation data from ten stations with records from 1993 to 2008 (15 years) and for the same years in plant production (rain-fed) from the Palestinian Central Bureau of Statistics (PCBS), have been analyzed in this study. A bioclimatic and climate analyses have been made of the data from the Palestinian meteorological stations years ago.So we are dependent on the bioclimatic analysis on using temperature and rainfall amount of data for Palestinian

Meteorological Stations, elaborating on the diagram ofbioclimatic according to the professor Rivas Martinez Salvador in 1996 (Rivas Martinez, S., 1996, 2004, 2008; Rivas Martinez S. et al., 1999; Rivas Martinez, S. et al., 2011). An analysis was made of the dependent and independent variables independent variable consist of bioclimatic factors as compensated thermicity index (It/Itc), annual ombrothermic index (Io), simple continentality index (Ic), and climate factors as mean monthly temperature (T), precipitation (P), soil water reserve (R) and water deficit (Df), while dependent variable is peach production (Table 2).

. Moreover, we applied the analysis of variance (ANOVA) linear regression analysis to each of the eight independent and dependent variables. The three bioclimatic parameters variables and the four remaining physical variables (climate factors), and each of the dependent variable peach production, in order to obtain regression coefficient (R^2) Pearson correlation matrix analysis were subsequently applied in order to determine the influence of independent variables on production. These statistical analyses were done using the XLSTAT software.

RESULTS

Analysis of variance (ANOVA) and multiple regression analyses

Bioclimatology is an ecological science dealing with the relations between the climate and the distribution of the living species on the Earth. In the new "Worldwide Bioclimatic Classification System" proposed, five macrobioclimates, twenty-seven bioclimates and five bioclimatic variants are recognized. The five macrobioclimates are: Tropical, Mediterranean, Temperate, Boreal and Polar. In this study, we used the bioclimatic classification of earth to Salvador Rivas-Martinez to analyse the climatic factors and bioclimatic parameters (independent variables). After application of the Shapiro-Wilk normality test (Shapiro, S. and Wilk, M., 1965; Shapiro, S.et al., 1968; Jarque, C. And Bera, A., 1980, 1987), the p-value obtained from the variables studied tended to be below 0.05, a conventionally accepted value.

Analysis of variance (ANOVA) is probably the most useful technique in the field of statistical inference (Montgomery, Douglas C., 2001), the ANOVA, with a 95% confidence interval, applied to each of the peach production, with the seven independent variable factors (T, P, R, Df, Io, Ic and It/Itc), reveals significant differences in the case of peach yield. Implying the influence of the seven factors on the production of peach, maybe that, changes in climatic and bioclimatic factors have an impact on the sustainability of plant production.

In the multiple regression analyses, we observed that all bioclimatic factors has compensated thermicity index, annual ombrothermic index, simple continentality index, with the peach production showing a better linear regression correlation with the values of regression coefficient (R^2) (0.955, 0.984, 0.996) respectively, being close to 1, and climate factors as mean monthly temperature, precipitation, soil water reserve and water deficit, with the values of regression coefficient (R^2) (0.912, 0.889, 0.977, 0.991) respectively, being close to 1, whereas the correlation of peach yield and deficit water, simple continentality indexand annual ombrothermic index were larger than other variables, as R^2 is more than (0.991 and 0.996). The regression result indicated that the climatic variables have significant impacts on the peach yield.

Correlation matrix (Pearson n-1)

The correlation between variables was evaluated using Pearson's correlation coefficient (Snedecor, G. And Cochran, W., 1968). The correlation matrix can be seen as the covariance matrix of the standardized random variables, Table 3 shows the correlation matrix between the characters studied. The bioclimatic and climatic factors werenegatively correlated to plant production except water deficit (0.153), in this case, water deficit has a large influence on growth, development and productivity of plant. A high correlation was also observed between water deficit (0.153), and peach yield.–On the other side, regulated deficit irrigation (RDI) is commonly used on fruit trees to reduce the amount of irrigation water applied without or with only very small reductions in yield (Kriedemann P. E. And Goodwin I., 2003).
Table 3. Pearson's correlation matrix between the different variables.

DISCUSSION

Furthermore, the ANOVA, with a 95% confidence interval, applied to each of the peach production, with the seven independent variable factors (T, P, R, Df, Io, Ic and It/Itc), reveals significant differences, the linear regression correlation analyses between -the dependent variable (peach production) and the three independent bioclimatic variables have a different level of significance (Fig 2-8), there are a statistically significant differences in the case of peach production with all bioclimatic and climatic analysis because the histograms were positive (Fig. 2-8).with regard to another study observed that bioclimatic and climatic factors impact on yield and growth activities of plant as the temperature, precipitation and others(Ighbareyeh, J. M. H.et al., 2014a, b, c; Ighbareyeh, J. M. H. Et al., 2015a, b, c, d, e, f), and some evidence suggest that winter rest can occur at temperatures as high as 12.8°C (55°F) for some peach varieties (Aron, R. Gat, Z., 1991).

Table 1. Coordinates of meteorological stations in Palestine

Station	Latitude (North)	Longitude (East)	Elevation m
Jenin	32º28 N´	35º18 E	178 m
Tulkarem	32º19 N´	35º01 E	83 m
Nablus	32º13 N´	35º15 E	570m
Ramallah	31º89 N´	35º21 E	856m
Hebron	31º32 N´	35º06 E	1005 m
Jericho	31º51 N	35º27E	-260 m
Jerusalem	35º13 N´	31º52 E	750 m
Bethlehem	35º20 N´	31º71 E	276 m
Gaza	31º30 N´	34º27 E	13 m

Table 2. Represents of independents variables (bioclimate factors as annual ombrothermic index, simple continentally index and compensated thermicity index, and climate factors as a temperature, precipitation, deficit water, and soil water reserve); independents variable is Plum production.

Site	T	P	Df	R	It/Itc	Ic	Io	Production of Peach
Jenin	20.4	490	780	420	450	17.4	1.89	496
Tulkarem	22.4	601	830	445	480	17.2	2.44	423.3333
Nablus	17.9	683	614	474	350	19.1	3.21	254.6875
Qalqilia	22	600	700	480	466	17.6	2.63	370
Salfit	20.1	611	612	449	480	17.9	2.51	250.9375
Tubas	19.2	405	730	444	490	16.9	2.78	355
Ramallah	17.1	614	590	462	311	17.8	3.19	425
Jerusalem	18.8	549	580	413	390	17.4	2.33	334
Bethlehem	17.9	548	600	420	400	16.18	2.89	468.75
Hebron	16.6	595	583	417	297	18.11	3.19	521.6875

Table 3. Pearson's correlation matrix between the different variables.

Variables	**T**	**P**	**Df**	**R**	**It/Itc**	**Ic**	**Io**	**Production of Peach**
T	**1**	-0.226	0.668	0.302	0.845	-0.156	-0.694	-0.281
P	-0.226	**1**	-0.622	0.467	-0.539	0.708	0.476	-0.315
Df	0.668	-0.622	**1**	0.091	0.673	-0.228	-0.594	0.153
R	0.302	0.467	0.091	**1**	0.108	0.487	0.371	-0.545
It/Itc	0.845	-0.539	0.673	0.108	**1**	-0.409	-0.653	-0.339
Ic	-0.156	0.708	-0.228	0.487	-0.409	**1**	0.334	-0.419
Io	-0.694	0.476	-0.594	0.371	-0.653	0.334	**1**	-0.032
Production of Peach	-0.281	-0.315	0.153	-0.545	-0.339	-0.419	-0.032	**1**

Figure 1. Location of the meteorological Palestinian stations.

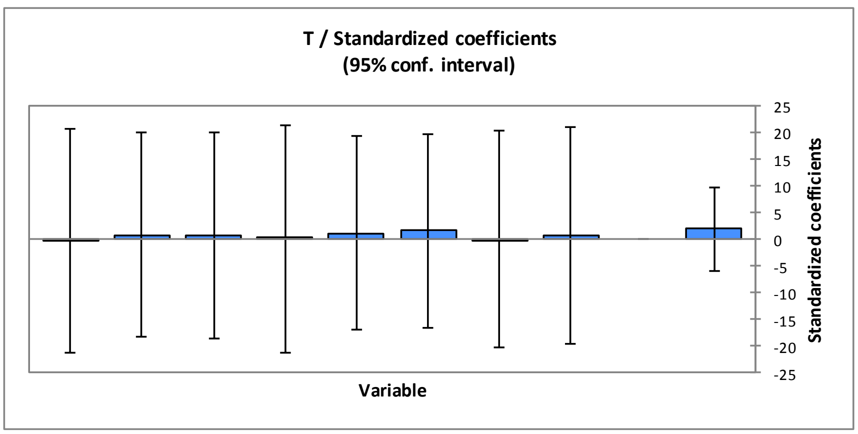

Fig. 2. *Regression coefficient (R^2) analysis of the mean monthly temperature and peach yield.*

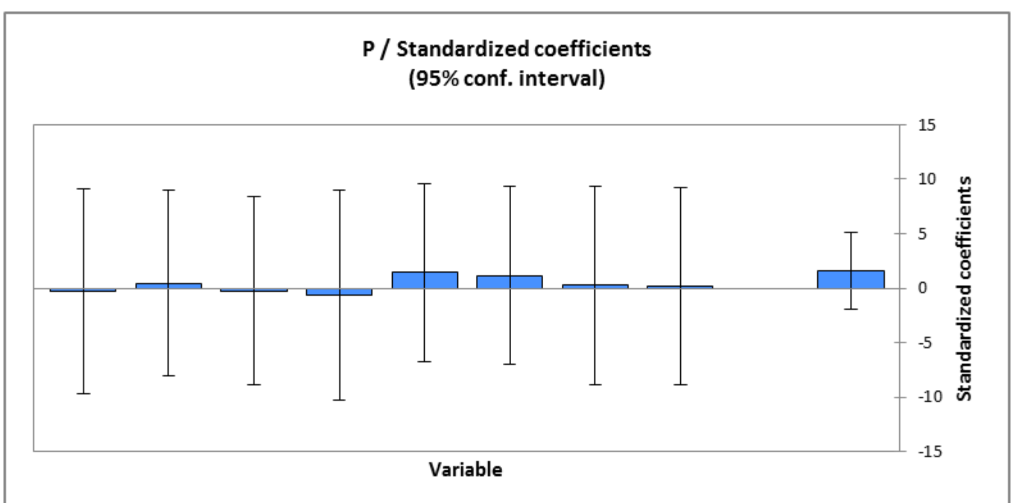

Fig. 3. Regression coefficient (R^2) analysis of precipitation and peach yield.

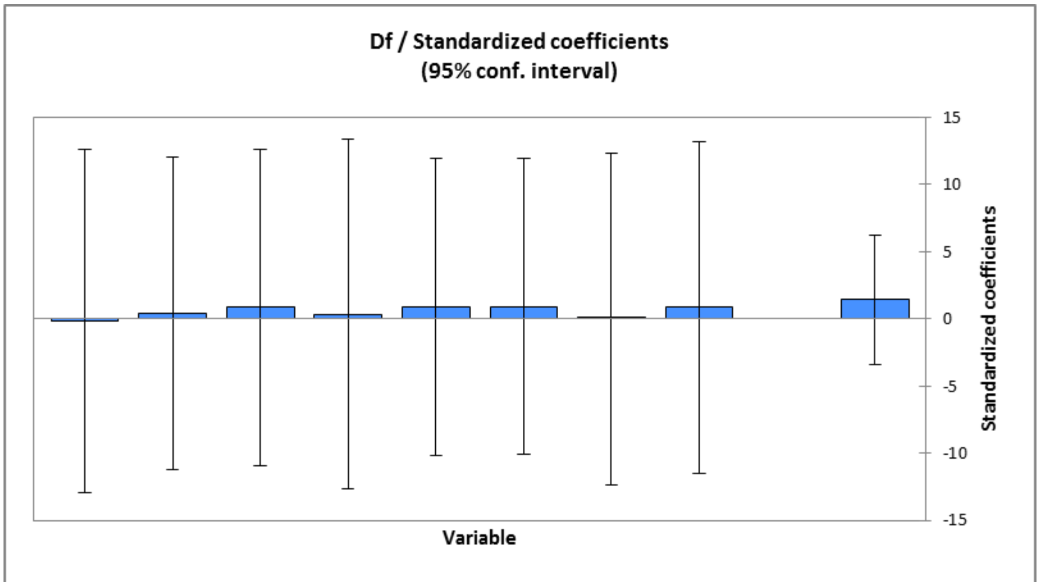

Fig. 4. Regression coefficient (R^2) analysis of the water deficit and peach yield.

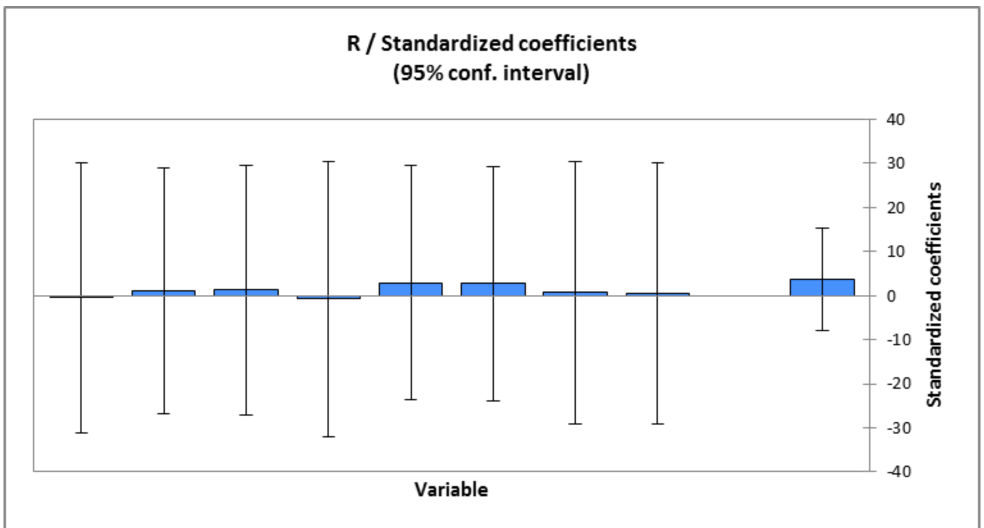

Fig. 5. Regression coefficient (R^2) analysis of the soil water reserve and peach yield.

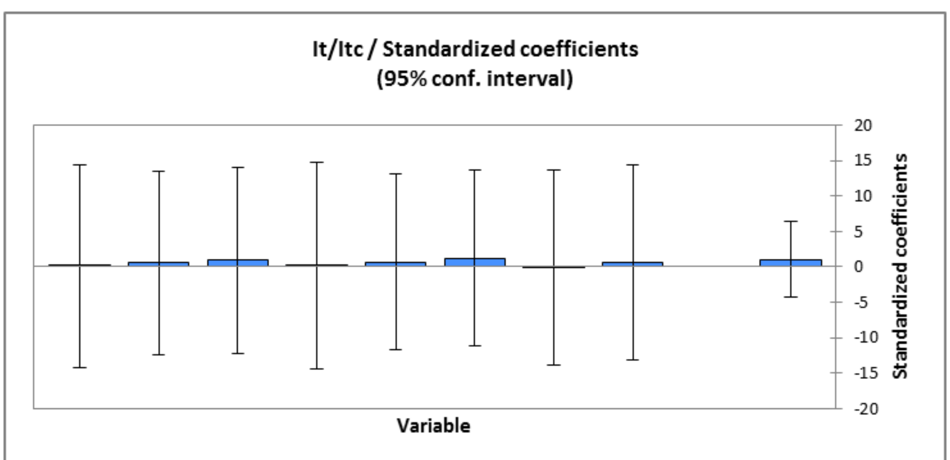

Fig. 6. Regression coefficient (R^2) analysis of the compensated thermicity index and peach yield.

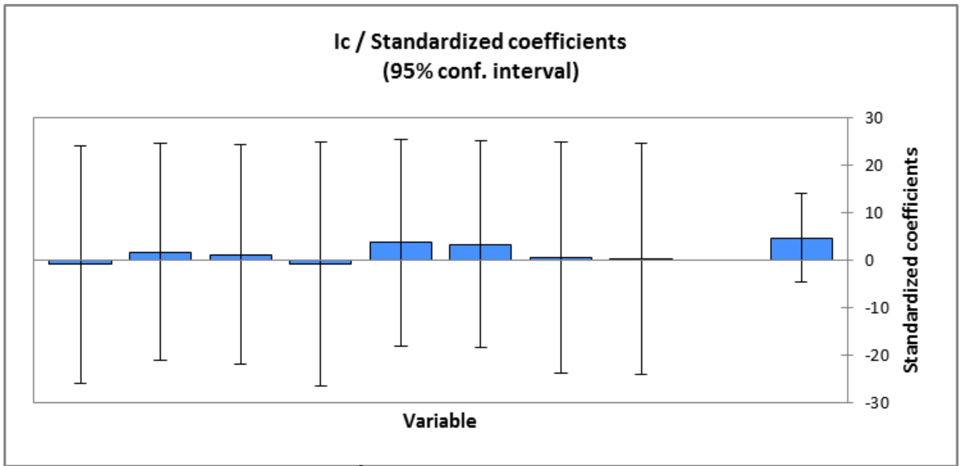

Fig. 7. Regression coefficient (R^2) analysis of simple continentaly index and peach yield.

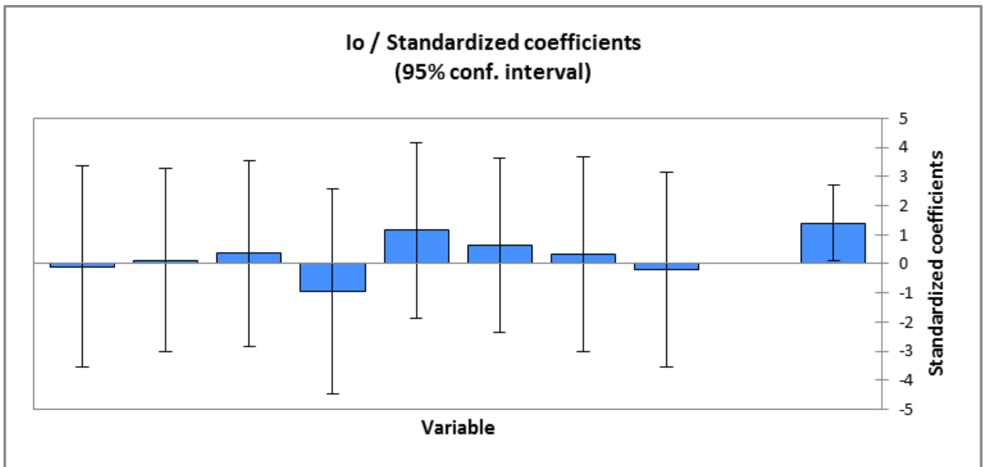

Fig. 8. Regression coefficient (R^2) analysis of the annual ombrothermic index and peach yield.

Most researchers have considered 7.2°C (45°F) as a critical threshold temperature for the rest (Sanders, C. G., 1975; Weinberger, J. H., 1967; Scalabrelli, G. AND Couvillon, G. A., 1986). Flower bud death begins to occur between −15 and −25 °C (5 and −13 °F), depending on the cultivar and on the timing of the cold, with the buds becoming less cold tolerant in late winter (Szalay, L. Et al., 2000).

However, when we applied Pearson's correlation matrix between the different variables, water deficit has a large influence on growth, development, sustainability and productivity of plant (positively), because a high correlation observed between water deficit (0.153), and peach yield. While the quality and yield of peach were influenced negatively by the rest of climatic and bioclimatic factors,RDI imposes a period of water stress that is controlled in terms of its intensity and the period of application (Goodwin I. And A. M. Boland, 2002). This period corresponds generally to slow phases of fruit growth where a tree is relatively most tolerant to water deficit. Also the great variability in production is due to the occurrence of stressful climatic factors such as frost and drought (Agoumi A., 2003; Balaghi R. Et al., 2011).

Generally, we observed thatboth climatic and bioclimatic factors were affected on growth,-yield and fruit quality of the plant. Also, there are many factors that may be influenced by plant diseases, the genetic characteristics of different cultivars, plant physiology, agricultural practices, age of plant, flowering and dormancy period, the quality of soil and other factors.

CONCLUSION

The peach (*Prunus persica L.*) is an important commercial fruit, which has been traditionally cultivated in most of the areas of Palestine, Mediterranean and in the world. Both bioclimatic and climatic factors were influenced on plant production and growth activities, yield level was positively correlated to several bioclimatic and climatic parameters to the yield years because the histograms are positive. Moreover, the optimum for the production of peach is achieved with value of annual ombrothermic index more than 2.5, simple continentality index value between 15-22, compensated thermicity index value between 250-420, summer heat is required to mature the crop, with mean temperatures of the hottest month between 20 and 30 °C (68 and 86 °F), annual rainfallbetween 350-900 millimeters, the dry to humid of ombrotype and with upper inframediterranean to mesomediterranean of bioclimate belts or thermotype.

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