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Study Effect of Biology and Bioclimatology Applied on Plant in the Area of Hebron at the South of Palestine

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Abstract: *Prunusarmeniaca L. (Rosaceae) is an important medicinal edible plant species commonly known as "apricot", and it is one of the most delicious and commercially traded fruits in the world. We analyzed the mean annual temperature and precipitation using data from one weather station of the Palestine Meteorological Department, recorded in the period from 1993-2009 (16 years), with the same years plant production (rainfed) 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 Rivas Martinez Salvador, with regard to simple continentaly index, compensated thermicity index, annual ombrothermic index, water deficit and soil water reserve. In concluded, when we applied a principal component analysis (PCA), observed that the apricot yield were influenced by the simple continentaly index, compensated thermicity index and precipitation during (1997-2008 except 1999-2000 and 2007-2008 years), with a proportion of the variance explained by axes 2 (15.47%); the plant production were influenced by water deficit and mean monthly temperature during the years (1996-1997 and 1999-2000), and located at the left of the axes 1with a proportion of the variance explained by axes 1(67.57%). Both bioclimate and climate factors affect a positive impact on the plant yield such as annual ombrothermic index, compensated thermicity index, precipitation, temperature, and soil water reserve because the histogram were positively for the plant yield, while negatively affecting by the water deficit and simple continentaly index. Biologically and ecologically in Hebron, we indicated that the inframediterranean to mesomediterranean environments, the optimum for the production of apricot is achieved with value of annual ombrothermic index more than 3, simple continentality index value between 17-22, compensated thermicity index value between 250-350, the temperature between* 20-25^{0}*C, with annual rainfall between 400-900 millimeters, and with the dry to humid of ombrotype.*

Keywords: *Apricot, biology, bioclimatology, annual ombrothermic index and yield.*

1. Introduction

An apricot is a fruit or the tree that bears the fruit, usually, an apricot tree is from the tree species *Prunusarmeniaca*, but the species *Prunusbrigantina*, *Prunusmandshurica*, *Prunusmume*, and *Prunussibirica* are closely related, have similar fruit, and are also called apricots [1].Apricot culture is greatly restricted by climatic conditions, especially those related to chill accumulation in several growing areas, with a significant influence on productivity [2, 3].MFRI[4] reported that rainfall, humidity and minimum temperature were the critical variables in flowering and planting period. Research results showed that there was strong relationship between climatic variables and the yield of apricot. Caprio and Quamme [5-7] described the effect of weather variables on poor production in apricot and other fruits trees. More than 80% of apricot (*Prunusarmeniaca L.)* production comes from the Mediterranean area and is concentrated in a period of 30–40 days, mostly in June [8].

Hebron is a Palestinian, [9-11] city located in the southern West Bank, 30 km (19 mi) south of Jerusalem. It is a busy hub of West Bank trade, responsible for roughly a third of the area's gross domestic product; it is locally well known for its grapes, figs, and other fruits. Hebron has a Mediterranean climate with mild and rainy winters, during the winter temperatures drop but remain pleasant. Especially during autumn a lot of rain can be expected, while during spring temperatures rapidly rise and the entire summer temperatures are pleasantly warm to even hot. Bioclimatology is the discipline that studies the relationship between climates and living organisms. Hebron bioclimatic belt belongs to the inframediterranean to mesomediterranean thermo type and arid to humid ombrotype [12]. Recent studies [12-20] have highlighted the influence of bioclimatology and climatology on yield and growth of plant; however this is the first time the bioclimatic characterization of the different varieties has been under taken. Apricot is growing in the city of Hebron, some of the varieties of apricots as Mestikawi, Manchurian, *Prunusarmeniaca* (Al-Kilabi) and others. Among the villages which are famous for the cultivation of apricots in the Hebron area are Halhoul, Beit Kahil, Arrub camp, Beit Ummar, Soref, Beit Safafaand others.

Aims study the effect of biology, bioclimatology and climatology applied on apricot (*Prunusarmeniaca L.*) to establish the variables that had the greatest influence on plant yield in the region of Hebron in Palestine.

2. Materials and Methods

2.1. Study Area

Hebron is located between longitudes 35°05 east and latitudes 31°32′ north, rises 1000 meters above sea level, and cover an area of74.102 km^2.The geographic location of Hebron plays a major role in affecting the features of its climate and the biodiversity between the southern and northern parts.

2.2. Data Analysis

Hebron, a city located in the south of Palestine, and is famous for the cultivation of grapes and almonds, plums, peaches, apricots and other fruit trees for hundreds of years ago because of the climate appropriate for agriculture, biological and biodiversity. Data were used from the meteorological station in Hebron for the years 1993 to 2009 (16 years), (Fig. 1) and for the same years for production of plant (**Table 1**). The bioclimatology of the aforementioned stations was studied, and the value of the bioclimatic indices as annual ombrothermic index (Io), simple continentally index (Ic), and compensated thermicity index (It/Itc) and the climatic factors were obtained according to Salvador Rivas-Martinez [21-25].

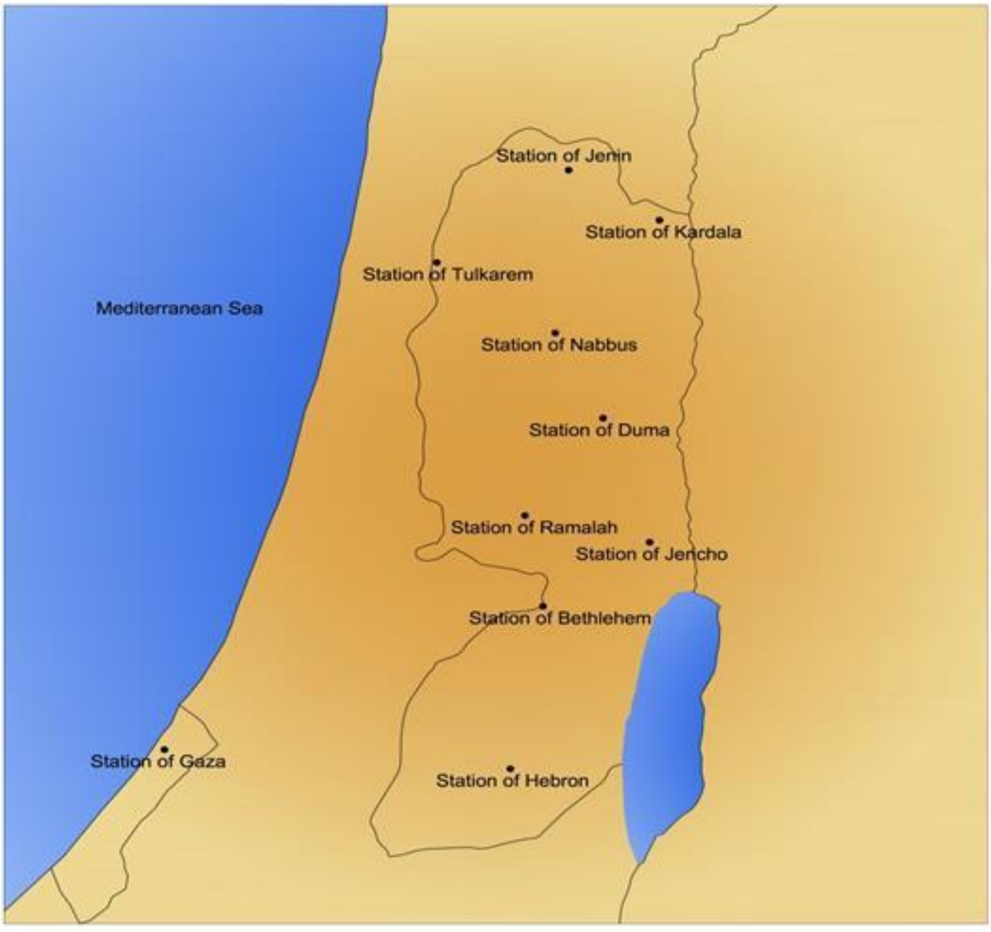

Fig1. *Location of the meteorological Palestinian stations*

Table1. *Independents variables (Climate and bioclimate factors) and dependent factors (Plant production) from 1993-2009.*

Years	T	P	Df	R	It/Itc	Ic	Io	Production of apricot
1993-1994	16.5	632	577	417	290	18.11	3.44	376
1994-1995	16.4	632	611	433	311	17.9	3.6	350
1995-1996	16.7	623	544	419	299	17.9	3.23	313
1996-1997	16.6	623	588	409	283	17.9	3.23	500
1997-1998	16.73	623	590	417	307	17.9	3.39	500
1998-1999	16.87	623	583	398	297	18.11	3.33	500
1999-2002	18.2	400	680	388	370	15.6	2.4	200
2000-2001	16.3	595	570	417	289	18.11	2.9	390
2001-2002	16.2	595	567	423	294	18.3	3.23	590
2002-2003	16.1	595	583	415	277	18.8	3.23	485
2003-2004	15.8	595	580	429	294	18.33	3.23	455
2004-2005	16.22	595	581	408	292	18.44	3.23	509
2005-2006	16.43	595	575	407	288	18.8	3.23	327
2006-2007	16.2	595	567	417	294	18.11	3.22	351
2007-2008	16.11	595	583	455	290	18.19	3.6	236
2008-2009	15.4	595	554	417	278	18.22	3.23	350

Yield: Kg. dunum.

Moreover, we analyzed the relationship between the dependent variable as apricot production; the independent variables (climate factors) such as mean monthly temperature (T), precipitation (P), soil water reserves (R), and deficit water (Df), in this study, the Shapiro-Wilk and Jarque-Bera normality tests were applied [26-29], and the p-value was obtained for the seven variables. We applied analysis of variance (ANOVA) linear regression analysis to each of the eight independent and dependent variables, the three bioclimatic variables and the four remaining physical variables (climate factors), and each of the dependent variable apricot production, in order to obtain the coefficient of regression (R^2) and the multiple regression line, and principal component analysis (PCA) were subsequently applied in order to determine the influence of independent variables on production. These statistical analyses were done using the XLSTAT software.

3. Results and Discussion

The Rivas Martinez methodology [21], determines a generic world-wide climate classification in five macrobioclimates (tropical, Mediterranean, temperate, boreal and polar) on the basis of bioclimatic indexes. We used the bioclimatic classification of earth to Salvador Rivas-Martinez to analyses of the climate factors and 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.

3.1. Analysis of Variance (ANOVA) and Multiple Regression Analyses

Analysis of variance (ANOVA) is probably the most useful technique in the field of statistical inference [30], the ANOVA, with a 95% confidence interval, applied to each of the apricot production, with the seven independent variable factors (T, P, R, Df, Io, Ic and It/Itc), reveals significant differences in the case of apricot yield, implying the influence of the seven factors on the production of apricot, may be that changes in climatic and bioclimatic factors have an impact on the sustainability of plant production, in the multiple regression analyses, we observed that precipitation, and simple continentaly index with the apricot production shows a better linear regression correlation with the values of regression coefficient (R^2)(0.984, 0.989)respectively, being close to 1, whereas the correlation of apricot yield and deficit water were small than other variables, as R^2 is low (0.877). The regression result indicated that the climatic variables have significant impacts on the apricot yield. The linear regression correlation analyses between of the dependent variable (apricot production) and the three independent bioclimatic variables have a different level of significance. There are no significant differences in the case of apricot production with deficit water and compensated thermicity index, but there is a statistically significant difference for apricot production and the rest of climate and bioclimate factors because the histograms were positive (**Fig. 2: a, b, c, d and e**).

Table2. *Regression coefficient analysis R^2 between the dependent and independent variables.*

Variables (independent variables)	Regression coefficient analysis of variables R^2 (apricot yield)
T	0.900
P	0.984
Df	0.877
R	0.907
It Itc	0.879
Ic	0.989
Io	0.929

Moreover, the high linear regression correlation between the bioclimatic factors (simple continentaly index)and apricot production with value of R^2(0.984), and climate factors (precipitation, mean monthly temperature and soil water reserve) with the values of R^2(0.984, 0.900 and 0.907) respectively, shows the high influence of the independents variables of bioclimate and climate as Io, Ic, P, T and R except Df and It/Itcon the apricot yield (**Fig. 2**),also may be there are some of factors influenced on plant production as variety, plant disease, plant age, flowering and dormancy period, in this way, incomplete dormancy release affects tree behavior in three main ways: late bud break, a low level of flower bud break and a lack of uniformity of leafing and bloom, resulting in a higher flower bud drop [30-34], other physiological factors in addition to climate and bioclimate factors, so total rainfall in flowering period affected the apricot yield positively. Similarly, [35, 36] estimated that positively correlation between crop yield and rainfall and temperature. We noted that the apricot needs to frost during the period of dormancy in the winter period in order to be the growth process, and high quality fruits production, and that these results are very close, as conducted by Ighbareyeh, J. M.H.*et al.* [20, 14].

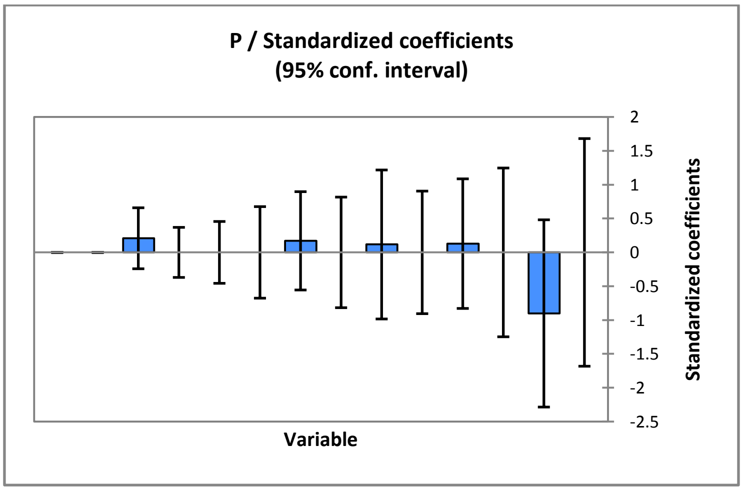

Fig a. *Regression analysis of the precipitation and apricot yield.*

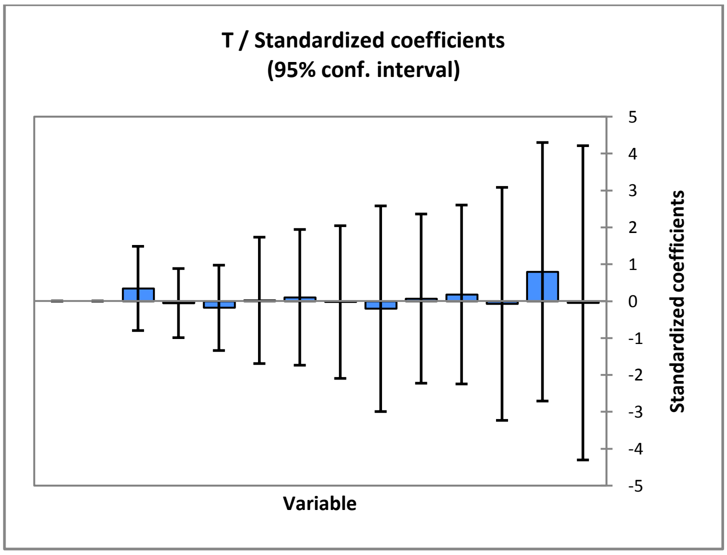

Fig b. *Regression analysis of the mean monthly temperature and apricot yield.*

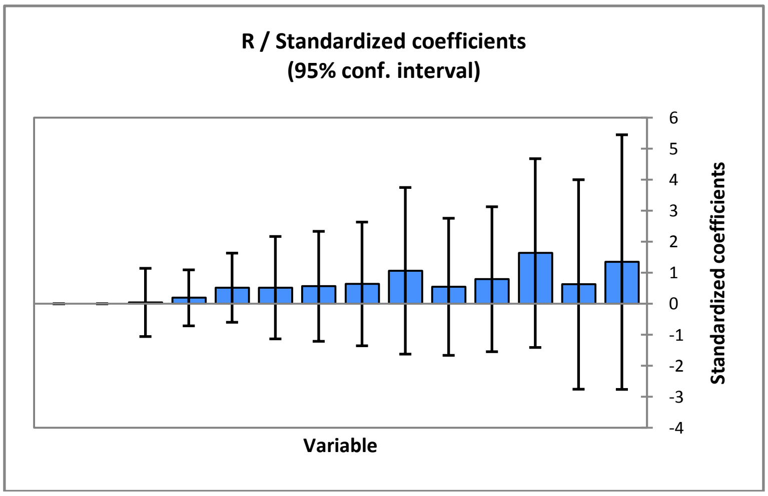

Fig c. *Regression analysis of the soil water reserve and apricot yield.*

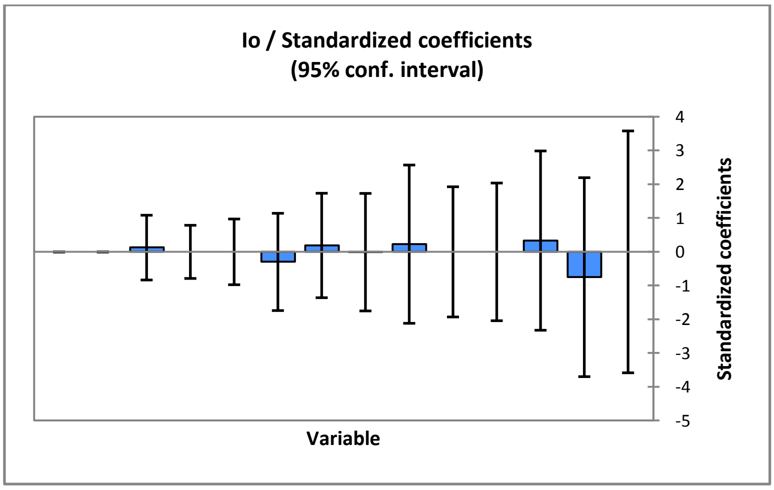

Fig d. *Regression analysis of the annual ombrothermic index and apricot yield.*

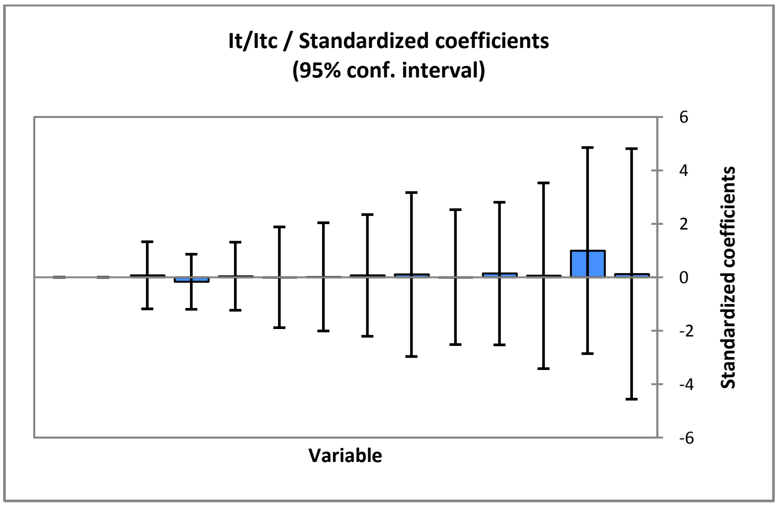

Fig e. *Regression analysis of and apricot yield.*

Figure2. Regression analysis of the dependent and independent variables (precipitation, temperature, annual ombrothermic index, compensated thermicity index, and apricot yield during the period of study from 1993-2009).

On the other hand, we observed that the apricot production were influenced by the climate change as water deficit and bioclimate factors as simple continentaly index because the histogram were negatively (Fig. 3), indicated that in some cases there is effect and antagonism between environmental factors, economic and productivity sustainability [14].

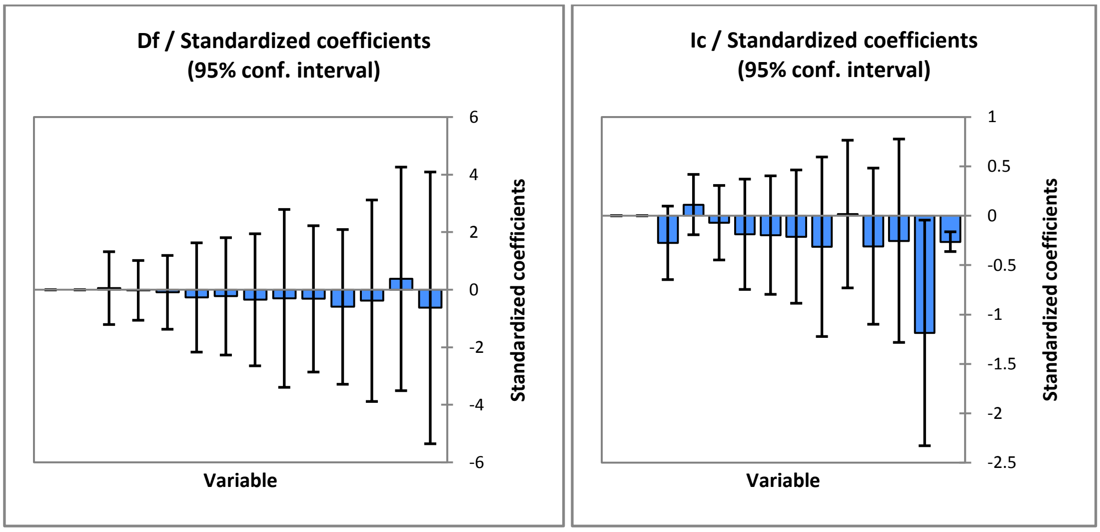

Fig3. *Regression analysis of the dependent and independent variables (apricot yield, and simple continentality index and water deficit during the period of study from1993-2009).*

3.2. Principal Component Analysis

Principal component analysis can be done by eigen value decomposition of a data covariance (or correlation) matrix or singular value decomposition of a data matrix, usually after mean centering (and normalizing or using Z-scores) the data matrix for each attribute [37]. Nevertheless, when the multiple regression correlation analysis is applied to each of the dependent variables and the seven physical parameters (independent variables), significant differences ($p < 0.05$) can once again be observed in all cases.

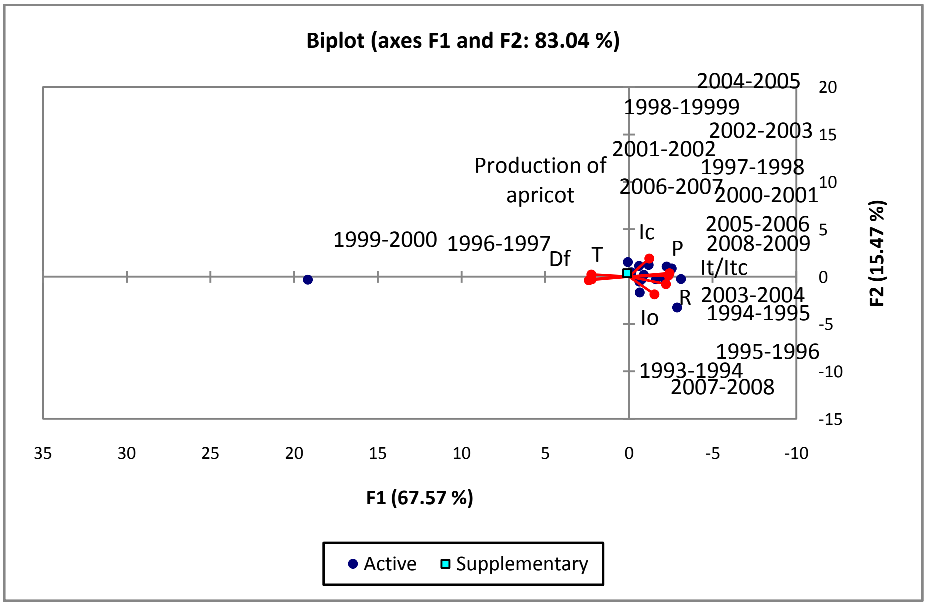

Fig4. *Graphic of principal component analysis between independent and independent variables during the period of study from 1993-2009.*

Nevertheless, when we applied a principal component analysis (PCA), observed that the apricot yield were influenced by the simple continentaly index, compensated thermicity index and precipitation during (1997-2008 except 1999-2000 and 2007-2008 years), with a proportion of the variance explained by axes 2 (15.47%) (Fig.4); the plant production were influenced by water deficit and mean monthly temperature during the years (1996-1997 and 1999-2000), and located at the left of the axes 1with a proportion of the variance explained by axes 1(67.57%) (Fig.4); while plant production were affected by the bioclimate factors as an annual ombrothermic index(Whenever this factor was the biggest whenever the amount of output higher) and soil water reserve, in soils like these, fertilization can cause a numerous management problems, especially by changing soil pH which affects, in general, the availability of plant nutrients, and there by plant growth, productivity and fruit quality, Addition to poor soil physicochemical characteristics are also high problem [38], most soils used for fruit production are sandy-loams, loamy-sands and/or sands with low content of organic matter and low soil pH which are also low in buffering capacity [39]. We indicate that apricot of Hebron can be adapted to climate in this region; with cold winters to allow a proper dormancy and a dry climate are good for fruit maturation; and soil rosary as rich in organic matter and others elements components. The tree is slightly more cold-hardy than the peach, tolerating winter temperatures as cold as -30 °C (-22 °F). Furthermore, apricot is adapted in dry to humid regions which are characterized by temperate summers with temperature between 15- 30^{o}C, which had to obtain high quality of production, addition to in the other studies temperature is the major driver of such changes, as confirmed by numerous experimental studies [39-42].

Furthermore, most of limiting factors for its growing are evident such as blossoms killed by spring frosts, sudden (premature) wilting – Apoplexy, winter killing of flower buds prior to bloom, Plum pox virus infection in apricot trees, absence of quality rootstock and modern growing technologies [43].Here it should be noted that not only the environmental factors that affect only the production, growth and plant biology but also other factors such as cultivars, genetic factors, plant diseases, the period of dormancy and flowering, the age of the plant and other factors, as the role of these factors in the growth and development of the plant have a role in increasing the national economic output.

4. Conclusion

Apricot (*Prunusarmeniaca* L.) is one of the most important export crops in Palestine; it is one of the most sensitive fruit ecological responses to bioclimate and climate change. when we applied a principal component analysis (PCA), observed that the apricot yield were influenced by the simple continentaly index, compensated thermicity index and precipitation during (1997-2008 except 1999-2000 and 2007-2008 years), with a proportion of the variance explained by axes 2 (15.47%); the plant production were influenced by water deficit and mean monthly temperature during the years (1996-1997 and 1999-2000), and located at the left of the axes 1with a proportion of the variance explained by axes 1(67.57%).

Both bioclimate and climate factors affect a positive impact on the plant yield such as annual ombrothermic index, compensated thermicity index, precipitation, temperature, and soil water reserve because the histogram were positively for the plant yield, while negatively affecting by the water deficit and simple continentaly index. Also apricot production has fluctuations because of climate change in Hebron region. Mediterranean and lower mesomediterranean environments, the optimum for the production of apricot is achieved with values of simple thermicity index more than 17 and annual ombrothermic index between 3 - 4.6, and compensated thermicity index between 270-350 for the production of apricot in Hebron. Furthermore there are other factors that affect the growth, development, sustainable and production, biology, quality and quantity of the plant in addition to bioclimate and climate factors and the most important are varieties, breeding, age, abiotic factors, diseases, and period of dormancy and flowering of the plants.

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