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MODELING OF BIOLOGY AND BIOCLIMATOLOGY APPLIED STUDIES ON PLANT IN PALESTINE

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ABSTRACT

Plum (*Prunus domestica L.)* is one of the most important export crops in Palestine and climate effects on plum yield and prediction of yield in commercial plum production were studied. Palestine is the leading fresh and dried plum producer all over the world. We analyzed the mean annual temperature and precipitation using data from tenth weathers stations from the Palestine Meteorological Department, recorded in the period from 1993-2008 (15 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 continentality index, compensated thermicity index, annual ombrothermic index, water deficit and soil water reserve. In concluded, yield level was positively correlated to several climatic parameters the year previous to the yield years; when we applied a principal component analysis (PCA), observed that the Salfit, Tulkarem areas type plots are located at the right of axis 2, and affected by the factors of the mean monthly temperature, deficit water, compensated thermicity index, while Bethlehem, Jenin, Qalqilia, and Jerusalem were represented highest in plant production, with a proportion of the variance explained by axes 1 (49.22%). Hebron, Ramallah and Nablus areas type plots are located at the left of the axes 1 and affected by the bioclimate factors as an annual ombrothermic index except Nablus area was affected by simple continentality index, precipitation and soil water reserve. Moreover, the optimum for the production of plum is achieved with value of annual ombrothermic index more than 2.5, simple continentality index value between 15-20, compensated thermicity index value between 270-450, the temperature between 21-26^{0}C, annual rainfall between 300-900 millimeters, with the dry to humid of ombrotype and with inframediterranean to mesomediterranean of bioclimate belts or thermotype.

INTRODUCTION

Plum *(Prunus domestica L.)* is a species of flowering plant in the family *Rosaceae*, a deciduous tree; it includes many varieties of the fruit trees known as plums in English, though not all plums belong to this species. Its hybrid parentage is believed to be *Prunusspinosa* and *Prunuscerasifera* (Khanizadeh, 2000).

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It is the most numerous and diverse group of fruit tree species (Blažek, 2007), but the extent of fundamental investigations concerning the prunes production is not appropriate to its importance. The growth of fruit trees is affected by many different factors: plant genetics, soil type, rootstock (Webster, 1995), climatic conditions (sunlight, temperature, rainfall, humidity) (Legave *et al.,* 2006), the phenology of flowering such as the type of fertilization (Williams RR, 1965), the age of the trees or branches (Robbie F A and Atkison CJ, 1994), even the orientation of the branches (Mateo, 2003). For successful plum production, it is necessary to know the technical and physicochemical properties of the plum fruit, for it to be subjected to the drying process (Robbie FA. 1993). Drying is one of the most widely used processing methods in the food industry. It is a well-known fact that in prune production, 25% of the total cost is the expenditure for drying (Bousignon *et al*., 1988). Properly conducted drying of fresh plum fruit gives a product of exceptional nutritional value and long shelf life, if properly packed (Sabarez *et al*., 1997). Mage and Gronnerod (2007) discussed growth of plum fruitlets in relation to time in the growing season and climatic conditions. Several authors have developed regression models with climate data as variables to predict the yield for various fruit crops; plums (Greenacre and Michael, 2007). Palestine has a Mediterranean climate characterized by long, hot, dry summers and short, cool, rainy winters, as modified locally by altitude and latitude. Like many other developing countries, Palestine has an important agricultural sector, which has been considered the backbone of its economy; it's the most suitable ecological conditions for growing table plum. There are types of plum in Palestine, the most important European species, in addition to the Japanese and American varieties. With the prospects of global climate change raising the likelihood of more frequent occurrences of high temperature episodes, we initiated a project to determine temperature parameters that affect pollen germination, pollen tube growth and fruit set in prune flowers. Plum fruit are mainly marketed as fresh consumption as well as for drying. Also, main processed products made from plums include compotes, pulp, candied fruit; frozen fruit, jams, jelly products. 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 2016 and Ana Cano Ortiz *et al*., 2014) have highlighted the influence of bioclimatology on yield, physiology, biology and growth of plant; however this is the first time the bioclimatic characterization of the different varieties has been under taken. Palestine is belonging to the inframediterranean to mesomediterranean of bioclimatic belts; and arid, semiarid, dry, sub-humid and humid of ombrotype (Ighbareyeh *et al*., a, b, c, d 2014). Aims study the effect of biology, bioclimatology and climatology on plum (*Prunus domestica L.*) to establish the variables that had the greatest influence on plant yield to increase economic in the region of Palestine, because plum are one of the most important fruit in 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 of the same years ago, so we are dependent in the bioclimatic analysis about used temperature and rainfall amount of data for Palestinian Meteorological Stations, elaboration the diagram bioclimatic according the professor Rivas Martinez Salvador in 1996 (Rivas Martínez, S., 1996, 2004, 2008 and 2011). An analysis was made of the independent and independent variables, independent variable consist of biocliamte 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 dificit (Df), while dependent variable is plum production (Table 2).

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

Figure 1. Location of the meteorological Palestinian stations

Moreover, we applied the principal component (PCA), correlation matrix (Pearson n-1) and factors loading using XLSTAT software. The goal of PCA is to decompose a data table with correlated measurements into a new set of uncorrelated variables. The results of the analysis are presented with graphs plotting the projections of the units onto the components, and the loadings of the variables. Correlation between variables was evaluated using Pearson's correlation coefficient (Snedecor, G. and Cochran, W., 1968).

RESULTS

Effect of the Bioclimate and Climate Change on Plant Correlation matrix (Pearson n-1)

In this study, 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 (Jarque, C., Bera, A., 1980, 1987; Shapiro, S. and Wilk, M., 1965; Shapiro,

S., 1968), the p-value obtained from the variables studied tended to be below 0.05, a conventionally accepted value. 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 bioclimate factor as compensated thermicity index was positively correlated to plant production, in this case, compensated thermicity index has a large influence on growth, development and productivity of plant (positively), therefore a high correlation was also observed between compensated thermicity index (0.155), and plum yield. That means the quality and yield of plum were affected by the compensated thermicity index, while the rest of climatic and bioclimatic factors were influenced negatively.
Table 3.

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

Variables	T	P	Df	R	It/Itc	Ic	Io	Plum production
T	1	-0.196	0.832	0.263	0.917	-0.243	-0.744	-0.150
P	-0.196	1	-0.395	0.711	-0.31	0.703	0.695	-0.296
Df	0.832	-0.395	1	-0.041	0.684	-0.262	-0.781	-0.252
R	0.263	0.711	-0.041	1	0.095	0.507	0.261	-0.622
Itc	0.917	-0.31	0.684	0.095	1	-0.374	-0.813	0.155
Ic	-0.243	0.703	-0.262	0.507	-0.374	1	0.38	-0.279
Io	-0.744	0.695	-0.781	0.261	-0.813	0.38	1	-0.185
Plum production	-0.15	-0.296	-0.252	-0.622	0.155	-0.279	-0.185	1

Table 4. Factors of eigenvectors and eigenvalue of the PCA and variables data (dependent and independent factors)

8	F1	F2	F3	F4	F5	F6	F7
T	-0.401	0.367	0.147	-0.114	0.158	-0.016	0.746
P	0.362	0.358	0.352	-0.113	0.525	0.113	-0.352
Df	-0.41	0.252	-0.263	0.301	0.552	-0.364	-0.237
R	0.159	0.572	0.111	-0.315	-0.439	-0.543	-0.109
Itc	-0.429	0.214	0.388	-0.211	-0.097	0.576	-0.246
Ic	0.309	0.305	0.249	0.789	-0.152	0.157	0.202
Io	0.475	-0.034	-0.069	-0.34	0.393	0.097	0.385
Production of apricots	-0.096	-0.454	0.745	0.045	0.119	-0.441	0.048
Eigenvalue	3.938	2.379	0.832	0.553	0.238	0.033	0.028
Variance %	49.219	29.74	10.395	6.909	2.978	0.414	0.346
Cumulative %	49.219	78.959	89.354	96.262	99.24	99.654	100

Table 5. Correlations between variables and factor loading

Variables	F1	F2	F3
T	-0.796	0.566	0.134
P	0.718	0.552	0.321
Df	-0.813	0.389	-0.24
R	0.316	0.883	0.101
It/Itc	-0.852	0.331	0.353
Ic	0.613	0.47	0.227
Io	0.943	-0.052	-0.063
Production of Plum	-0.191	-0.7	0.68

index, and accounts for 49.219%of the total variance and cumulative % (Table 4). That means domination may be caused by the effect of the variables (dependent and independent factors) on productivity, biological and growth of plant. Factor 2 is highly dominated by all climate and bioclimate factors except of annual ombrothermic index is negatively (-0.034), and accounts for (29.74%) of the total variance, this factor represents effects and interesting of all climatology and bioclimatology factors on plant yield. Factor 3 is dominated by all climate and bioclimate factors except of annual ombrothermic index, deficit water were negatively (-0.069) (-0.263) respectively, and accounts for (10.395 %) of the total variance. Factor 4 is dominated by simple continentality index, deficit water, and accounts for (6.909 %)

Principal component analysis

Principal component analysis (PCA) is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. PCA correspondence analysis creates orthogonal components and, for each item in a table, a set of scores (sometimes called factor scores). PCA was used to help identify the variables different, using factor extraction with an eigenvalue 1 after varimax rotation. The results of PCA, including the factor loadings with a varimax rotation as well as the eigenvalues, are tabulated in (Table 4). Seven of the eigenvalues were found to be 1 and the total variance for the two factors isabout 49.219%. Factor 1 was dominated by precipitation, soil reserve water, simple continentality index, annual ombrothermic

of the total variance. Factor 5 is height dominated by deficit water, precipitation, annual ombrothermic index, mean monthly temperature respectively and accounts for (2.978%) of the total variance. Factors 6 is dominated by precipitation, annual ombrothermic index, mean monthly temperature, compensated thermicity index, simple continentality index, while the factors of deficit water and soil water reserve were negatively, and accounts for (0.414%) of the total variance. Factor 7 is dominated by all climate and bioclimate factors except annual ombrothermic index, simple continentality index, and accounts for (0.346%) of the total variance. We observed that the plum production and growth were affected by climate and bioclimate factors as the temperature, because the temperature plays a role in the growth, production and fertilization processes, the optimum temperatures for pollen germination growth of *Prunusdomestica L* are approximately

22 to 24ºC, above this optimum, pollen tube growth decreased rapidly, at high daily maximum temperatures, pollen tubes began to senesce in the style; the effects of high temperatures on pollen tube growth can preclude fruit set. In the other side climate warming will advance both the date of the last springtime frost and flowering date, while the risk of late frost to affect floral buds remains generally unchanged (Rochette, P. *et al*., 2004), therefore plum trees are affected by weather conditions, especially during the flowering period and modern decade as rising temperatures in the period after the contract and the growth of fruits adversely affect the yield and fruit specifications.

Factor loading

Generally, Factor analysis is related to principal component analysis (PCA), but the two are not identical. Latent variable models, including factor analysis, use regression modelling techniques to test hypotheses producing error terms, while PCA is a descriptive statistical technique (Bartholomew, D.J., *et al*., 2008). The term "factor loading matrix" is used to refer to the matrix that contains the correlations between the variables and factors. The relationship of each variable to the underlying factor is expressed by the so-called factor loading. The output of a simple factor analysis looking at indicators of variables, with just eight variables and three resulting factors Table 5.

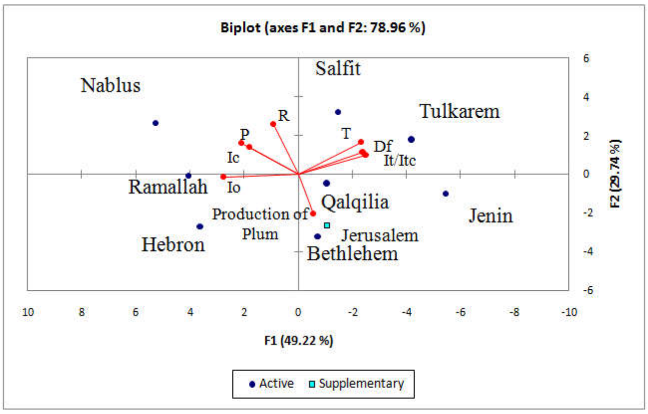

Figure 2. Graphic of principal component analysis between independent and independent variables

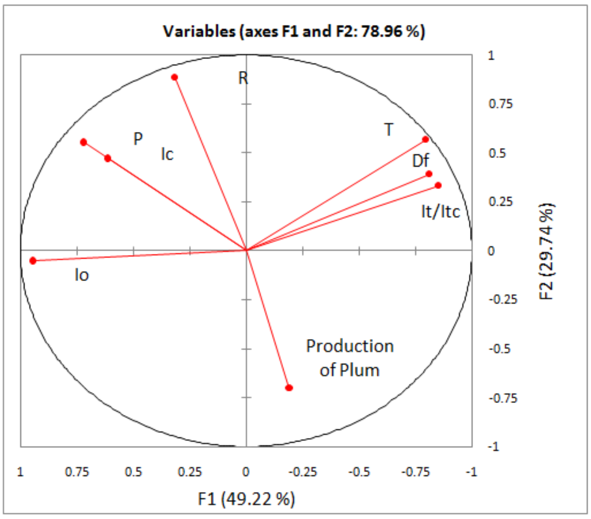

Figure 3. Graphic of the correlations between variables and factor loading

DISSCUSION

Moreover, when we applied a principal component analysis (PCA), observed that the Salfit, Tulkarem areas type plots are located at the right of axis 2, and affected by the factors of the mean monthly temperature, deficit water, compensated thermicity index, while Bethlehem, Jenin, Qalqilia, and Jerusalem were represented highest in plant production, and Jerusalem area is represented case supplementary, with a proportion of the variance explained by axes 1 (49.22%) (Figure 2). Hebron, Ramallah and Nablus areas plots are located at the left of the axes 1 and affected by the bioclimate factors as an annual ombrothermic index except Nablus area was affected by simple continentality index, precipitation and soil water reserve, plums require full sun and well-drained, sandy soil in order to thrive. They prefer a soil with a pH that ranges from 5.5 to 6.5. In Palestine, the decline in the quantity of production of plum, many fruit trees, vegetables, and field crops not only due to climatic and bioclimate factors but also to the lack of arable land due to seizure by the Israelis, plant diseases, the genetic characteristics of different cultivars, do not use modern technologies in agriculture and other factors, as in some other studies, there are many factors such as cultivar selection, site of growth, climate and agricultural practices affect the quality of the fruit (Guerra, M. and Casquero, P. A. 2009; Crisosto, C., 1995; Vangdal, E., 2005). When we analyzed the correlations between variables and factor loading, factor 1 was dominated by precipitation, soil reserve water, simple continentality index, annual ombrothermic index, and negatively affected to the plant yield (Table 5), also the variable with the strongest association to the underlying latent variable factor 1, is annual ombrothermic index, with a factor loading of (0.943), and with a proportion of the variance explained by axes F 1 (49.22%) (Figure 3). Factor 2 was dominated by all climate and bioclimate factors except the annual ombrothermic index (-0.052) and has negatively affected to the plant yield (Table 5), with a proportion of the variance explained by axes F 2 (29.74%) (Figure 3). Factor 3 was dominated by mean monthly temperature, precipitation, soil reserve water, simple continentality index, and negatively affected to the plant yield (0.680) (Table 5). Plum (*Prunusdomestica L.*) is an important commercial fruits, which has been traditionally cultivated in most of the areas of Palestine, Mediterranean and the world. Both climate and bioclimatic factors were affected on growth, yield and fruit quality of plant, addition to the physiology and genetics factors. Plum production in the southern regions was highest from the north regions except Qalqilia which is the highest value of production in Palestine. However, the optimum for the production of plum is achieved with value of annual ombrothermic index more than 2.5, simple continentality index value between 15-20, compensated thermicity index value between 270-450, the temperature between 21-26^{0}C, annual rainfall between 300-900 millimeters, with the dry to humid of ombrotype and with inframediterranean to mesomediterranean of bioclimate belts.

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