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Assessment of bio climatic grapes in Ardabil province

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Abstract

In this study, daily, monthly and annual weather data of synoptic stations in Ardebi region was gathered from Iran Meteorological Organization and then, the homogeneity of data were examined by run test method. To study agro-climatic features of viticulture, deviation from optimal conditions and the degree of active days index (GDD) methods are used. Based on the analysis of deviations from optimal conditions at different altitudes in the study area, Meshkinshahr station has optimal conditions for planting, among the stations. This is important in terms of development of cultivation areas and commercial production of crops. Based on the agro-climatic analysis, western and central regions (Meshkinshahr and Khalkhal stations) are most suitable areas of viticulture in the region. While eastern, northwestern and southern (Parsabad, Ardebi stations) areas are next in this ranking.

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Introduction

In fact, temperature influences composition and quality of grapes (Coombe, 1987). In California (USA), the Thermal Index of Winkler has allowed the classification, in five large regions, according to the different categories of degrees-days established by this index (Amerine and Winkler, 1944; Winkler, 1962). These regions represent quite well the grape quality and some of the wine characteristics as a result of the climatic influence of this zone. Huglin (1978) has developed the Heliothermal Index of Huglin, which is applicable at a world-wide range, established over a period which is closest to the average cycle of the grapevine. It takes into account the length of the day for the highest latitudes, uses the daily temperatures and displays a good relation to the potential of sugar content of the grape. However, both above mentioned indices remain essentially thermal over the cycle, and are not able to weel distinguish the climates in a world-wide scale because other climatic factors have to be considered. During the ripening period, the air temperature plays a determinant role for grape maturation, including the aroma and the coloration, having an important effect on the characteristics of the wines (Jackson and Lombard, 1993). The day temperatures influence the coloration, but the effect of conditions of cool nights temperatures on it is even stronger (Singleton and Esau, 1969; Fregoni and Pezzutto, 2000). Different water level in the soil affects grape quality and reflects in wine quality (Conradie *et al.*, 2002). Jackson and Cherry (1988) show that in regions with a high rainfall the ripening capacity of grapes is lower to that predicted by the climatic thermal indices. It is observed that in temperate regions which do not generally suffer droughts, a certain lack of water during the ripening period is favorable to the organoleptic wine quality.

The increase of global temperature in recent decades and its effect on the environment were confirmed in the latest IPCC report (IPCC 2007).

Several studies have described the impact of climate change on viticulture (Jones & Davis 2000, Duchêne & Schneider 2005, Jorquera-Fontena & Orrego-Verdugo 2010, Malheiro *et al.*, 2010, Urhausen *et al.* 2011). since climate is one of the key elements influenc - ing grapevine yield and quality (van Leeuwen *et al.*, 2004, Jones *et al.* 2005).

In an earlier study of grapevine phenology in Bordeaux, (Jones & Davis 2000) observed an advance of phenological stages, a shortening of phenological intervals and an increase in potential wine quality, which a later study confirmed for other European wine regions (Jones *et al.*, 2005).

Global warming may also result in a shift in the distribution of grape cultivation, meaning that wine production might become profitable in regions formerly unsuitable or marginal for wine-growing (Lisek 2008).

Most wine-producing regions in Western and Central Europe have benefitted from in - creasing temperatures, but the impact of global warming obviously varies according to the type of wine produced and the geographical location (Webb *et al.*, 2007, Duchêne *et al.*, 2010, Hall & Jones 2010).

East of the Rhine River, the northern limit of wine production turns gradually southward as the moderating influence of the Gulf Stream and surrounding seas decline. In comparison to other European wine regions, the more continental climate in some parts of Central Europe is characterized by shorter growing seasons, abundant spring and summer rain and cooler temperatures (Jackson 2000).

Whereas increasing temperatures in these regions could lead to more consistent vintage quality, (Jones *et al.*, 2005). that they might be at, or close to, their optimum climate for producing the best quality wine with current grape cultivars.

The main wine-producing climate in Europe is found south of 50° N (Mullins *et al.*,1992), which makes German wine regions among the most northerly in the world. One of Germany's historical wine-producing regions is that of Lower Franconia in the federal state of Bavaria, where production dates back to the 8th century (Robinson 2006). The vineyards are located along the Main River, which has the effect of moderating temperature, while the steep hills receive maximum heat and light exposure, which enhances ripening (Jackson 2000).

The cool conditions require the use of adapted grapevines (Vitis vinifera L.), which include frost resistant, latebudding and early maturing cultivars (Unwin 1991). Grape cultivars most commonly planted are Müller- Thurgau, Riesling and Silvaner. These white cultivars are more suitable for cooler climates with less sunshine and earlier harvest (Robinson 2006).

Approaching harvest, the relative amounts of sugar and acid found in the grapes are the main quality characteristics and are an indicator of grape ripeness. With an increase in the concentration of sugar, the organic acids decrease (Mullins *et al.*, 1992).

The absence of hot weather during ripening and the cool harvest conditions favour the retention of grape acidity, result in lower alcohol and promote the development or retention of varietal flavours. This gives the resulting wine a fresh taste and helps restrict microbial spoilage (Conde *et al.*, 2007).

Thus, the unique character or typicity (the characteristic of a wine that makes it typical for the region or cultivar of origin) is assured (Jackson 2000). While the majority of the highest quality wine-producing regions in Western Europe and Germany have benefited from an increase in quality ratings (Malheiro *et al.*, 2010), the impact of global warming on Franconian wine and its varietal typicity has received little attention.

Therefore, the objectives of the current work were to undertake a long-term study (1949 to 2010) to evaluate climate effects on grapevines in Lower Franconia using reference vineyard observations. The main aim of this study is to explain relation between the climatic parameters and grape cultivate in Ardebi region.

Materials and methods

Each scientific reseach requires the application of appropriate methods throughout its scientific proces. It needs accurate data gathering and application of appropriate analytical methods.

So, in this study, in order to achieve the objectives and find the answers of research questions ,and approve or reject the hypothesis , local climatic elements are analyzed, using methods that would be discussed later. Next, the methods used in the study has been presented. In this study, mini and maxi daily temperature parameter of 2011-2001 period in Ardebi region have been used.

Data gathering

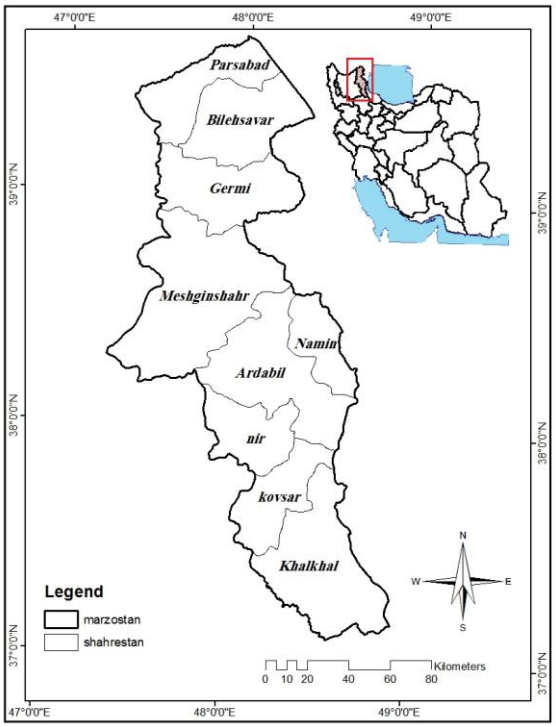

Fig. 1. Study area.

1-Method of deviation from the optimal conditions

Determination of the optimal time for each area, based on weather stations' data and daily temperature of crop growth is important. There are four phenological stages for grapes plant and each stage has an optimal temperature, at which the maxi growth rate occurs at this temperature. Identifying and determining the optimal point for each phenological stage and the mean daily temperature resulted from monitoring mini and maxi daily temperatures; one can determine various optimal times, particularly months of a year, and actually, the time which has the least deviation from the optimal condition, would be considered as the optimal time. In this method, to obtain the optimal of different time intervals, optimal points or optimal temperatures were first determined and then, considering the average of daily data, deviations from the optimal conditions were calculated for 3 decades of each month. For this reason, first, each month was divided into three different decades, and then, the average of each decade was calculated, that in total, the averages of 36 decades are calculated for each station. Next, the deviations of the averages from the optimal points are calculated; consequently, the deviations from the optimal conditions are obtained for the above time intervals and the results are tabulated.

2- Method of thermal coefficient or total degrees of active days.

Most biological changes such as the growth of plants and some hydrological phenomena are a function of the ambient temperature. For this purpose, the index of degree - days will be used as thermal need. Each process is activated from a certain temperature threshold, and the growth value depends on the number of degree - days more than this threshold. If the number of degree – days is zero or a negative value, that day would have no effect on growth. In order to grow in a specific area, each plant requires a certain number of degree-days that the area must be able to supply throughout the growth period. Otherwise, even if water is available in the area, the plant should not be recommended for planting in agricultural projects. Therefore, growth season in each area is defined as the longest continual period in which the number of degrees - days required to supply the plant is provided. To determine the thermal need of plants, method of the sum of effective temperatures is implemented. The principle of this method is to calculate the total summation of effective temperatures, i.e. temperatures above the base zero biological zero of a plant. This temperature depends on the type of the plant. 0 ° C for grapes is calculated by the following equation.

$$H_U = \sum_i^n \left[\frac{T_M + T_m}{2} - T_t \right] \qquad \text{Eq (1)}$$

H_U : Thermal unit (degree-days) accumulated in N days.

T_M : Maximum daily temperature

T_m : Minimum daily temperature

T_t : Base temperature

N: Number of days in a selected period

Since we intend to grow grapes and according to summation of positive value temperatures, grapes plant should acquire 3750 degree-days. Therefore, in this study we have used the method of calculating degree-days. In this study, the active method, amongst the most common methods to estimate thermal units, is used. To calculate the summation of temperature, there are two main methods including effective sum and active sum, and active sum method is used in this study.

A – Sum of degrees of active days

To sum up the temperature, the values of all daily temperature (without subtracting the base temperature) and during the period of active growth, are added together. Computational equation is as follows.

Eq (2)

$\frac{TMin + Tmax}{2}$ If the $\frac{TMin + TMax}{2} >= Tt$

In this equation, tmin, tmax are the mini and maxi daily temperature, respectively, and Tt is a biological temperature.

In active temperatures method that has been used in this study, the total sum of positive daily temperature is used; but only for the days when the average temperature is greater than the biological threshold or biological zero point. All values more than 5C° will be considered and values less than 5C° will not.

Results

Discussion

1- Deviation from optimal conditions

Four phenological stages have been considered in grapes plant which are significant in terms of agro-climatic matters; including: germination stage, flowering stage, stem maturation stage, and grapes ripening stage. Each stage has an optimum temperature, in which, the maxi growth rate occurs. In order to study the grapes plant species, phenologically, according to this study, mid-mature plant varieties which are more common in the region, are condidered as the basis. Table 2 shows the deviation from the optimal conditions for each phenological stage of sugar beet based on the average daily temperature at selected stations.

According to the results of germination and flowring stage, Meshkinshahr station has less deviation and more optimal conditions than the other stations. In the stem-maturation stage, Meshkinshahr station has less deviation than the other stations; however, there are not significant differences in terms of deviations from optimal conditions.

The fully ripening stage of grapes plant, Meshkinshahr Stations has lower deviations which is followed by Khalkhal and Parsabad stations and Ardebi and Kamyaran show more deviation; consequently, in all stages, Meshkinshahr station has least deviation from optimal condition, this means that this station has the optimum conditions for the grapes plant growth.

Table 1. Determining the deviation from optimal condition of grapes plant phenological stages in selected stations.

Growth stages / station	germination		Flowering		Stem maturation		Grapes ripening		Total deviations
	Deviation from condition	optimum	Deviation from condition	optimum	Deviation from condition	optimum	Deviation from condition	optimum	
Parsabad	-7.42	15-20	-15.32	25-30	-16.55	25-35	-11.67	25-35	-50.96
Ardebi	-6.87	15-20	-15.32	25-30	-15.87	25-35	-10.76	25-35	-48.82
Khalkhal	-6.44	15-20	-14.32	25-30	-15.09	25-35	-10.67	25-35	-46.52
Meshkinshahr	-6.22	15-20	-14.20	25-30	-14.90	25-35	-9.67	25-35	-44.99

2- Results of phonological analysis

Application of thermal coefficients in agricultural problems and the regulation of agricultural calendars in different areas is of significance. In spite of lack of the extensive phenological studies, using agricultural meteorological studies conducted by Quanta engineers with cooperation of Romanian consultants an applying their methods, active days degree and determination of length of phenological stages were studied according to various thresholds

3- Optimal time, based on active days degree method

Another method to determine the optimal time for agricultural climate, based on the latest incidence of mini thresholds at each phenological stage of grapes plant, is active temperatures' method that it is used in this study. The total daily temperatures with positive values are used, but only for the days when the temperature is greater than the average of biological thresholds or zero point of activity. In this study, the basis for calculating the thermal coefficients has two types: one based on a mini threshold of grapes plants

at each stage, and the other is zero degrees Celsius. Thermal thresholds of grapes plants in different phenological stages are illustrated in table 2.

Table 2. Temperature thresholds of grapes plants in phonological stages.

Phonological stages	Minimum Temperature, degrees Celsius	Favorable Temperature, degrees Celsius	Maximum Temperature, degrees Celsius
Germination	9	15-20	30
Flowering	14-15	25-30	45
Stem maturation	10	25-30	More than 35
Grapes ripening	-5	25-35	More than 35

Reference: Quanta, 1974

Since plant species are highly dependent on temperature, the monitored daily mini temperature is used for phenology of the grapes plant. By specifying thresholds of phenological stages of grapes plant and accurate daily temperatures, completion date of each stage is calculated. For all stations, incidence date of mini threshold of grapes plant activation at greater than 0 C^{o} is considered. In order to obtain the completion date of phenological stages of grapes plant in germination stage 320, the flowering stage 475, stem maturation stage 1200 and fully ripening stage of grapes plant, 3750 thermal units are necessary.

According to Table 3, the date of germination, flowring and stem maturation of grapes plant occurs earlier in Meshkinshahr and Khalkhal stations. Completion date of phenological stages of grapes plant in selected stations are shown in Table 4.

Table 3. Completion date phenological stages of grapes plant.

Station	Altitude	Minimum threshold incidence date	Germination date	Flowering date	Stem maturation date	Grapes ripening on
Parsabad	75	22 March	25 April	4 May	17 June	17 September
Ardebi	1365	23 March	24 April	6 May	15 June	10 September
Khalkhal	1806	20 March	28 April	8 May	22 June	22 September
Meshkinshahr	1485	16 March	20 April	3 May	8 June	18 September

Completion date of each phenological stages is a favorable method to determine the best time of viticulture based on critical threshold, as well. Calculated dates are consistent with the optimum time.

4- Areas suitable for viticulture

According to the results, at the germination and flowering stages, Meshkinshahr station shows less deviation from optimal conditions than other stations. At stem-maturation stage, Meshkinshahr shows less deviation from optimal conditions than other stations, however, a no big difference in deviation from optimal conditions could be observed. At ripening stage of grapes, Meshkinshahr has lower deviation, followed by /Khalkhal and /kamyaran stations., and Ardebi and Parsabad stations have highter deviations; therefore, Meshkinshahr station has the least deviation from the optimal conditions, at all stations. According to agro-climatic analysis, best viticulture areas are located in the western and central regions (Meshkinshahr and Khalkhal stations).

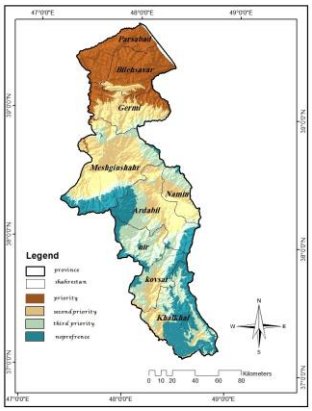

Fig. 2. The total deviation from optimal conditions for grapes plant.

While, northwestern, northeastern and southern regions (Ardebi, Kamyaran and Parsabad stations) are next in the ranking. This means that these stations (Meshkinshahr and Khalkhal) enjoy the optimal conditions for viticulture.

5- The proposed varieties for viticulture according to climatic conditions

According to the climatic conditions of each region, suitable grape varieties should be selected for cultivation of grapes plant. According to the agro climatic conditions of the study area, grapes varieties suitable. Suitable varieties of grapes for cultivation in Ardebi region Shahani, owners, Khalili, a light Aldvrq Galin official Barmaghy.

Conclusions

Agricultural activities are highly interconnected with natural factors and climate and environmental conditions.

Weather conditions is on top of the natural factors affecting agricultural activities, by which it affect the agriculture, either with a single element or a combination of several elements. Iran, having a special climate in each area, has suitable ground for production of various strategic agricultural crops and climatic parameters, illustrate different types of climates in the territory. Knowing the God-given gifts and the need of the region for researches like this, which shows the local agro-climatic potentials for cultivation of grapes plant, this study is conducted. Based on analysis of deviations from optimal conditions at different altitudes of the stations, Meshkinshahr station has the optimum conditions for grapes planting, among selected stations. This is important in terms of development of cultivation areas and commercial crops cultivation, as well. Based on agro-climatic analysis, most suitable viticulture areas are located in western and central regions (Meshkinshahr and Khalkhal stations). While eastern, northwestern and southern regions (Parsabad, Ardebi stations) are next in this ranking.

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