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Evaluation of Climatic Conditions of Grapes Harvest in Western Regions of Iran

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ABSTRACT

Understanding the climate and required parameters of crops, are of the most important factors in agricultural production. Making use of agro-climatic studies, one could identify the potentials in different areas and exploit them to the maximum extent. In this study, daily, monthly and annual weather data of synoptic stations in western regions were gathered from Iran Meteorological Organization and then, the homogeneity of data were examined by run test method. Data analysis was performed by deviations from optimal conditions and GDD index methods and using statistical soft wares EXCEL, SPSS. From the agro-climatic perspective, grapes cultivation, based on GDD total effective temperature method and temperature thresholds of phenological stages of grapes have been investigated and according to its results, climatic calendar in western regions, including the Kurdistan province is harvest in early August and for Kermanshah, harvest in the middle of August and for Hamedan, harvest in early September. Based on the analysis of deviations from optimal conditions at different altitudes in the study area, between stations in the western regions, Marivan of Kurdistan Province, Nahavand of Hamedan Province and Sarpolezahab of Kermanshah Province have the optimal conditions for grapes planting, respectively.

KEYWORDS: grapes, deviation from optimal conditions, phenology, western regions

INTRODUCTION

The increase of global temperature in recent decades and its effect on the environment were confirmed in the latest IPCC report [5]. Several studies have described the impact of climate change on viticulture [7, 2, 9, 11, 15], since climate is one of the key elements influencing grapevine yield and quality [16, 8]. In an earlier study of grapevine phenology in Bordeaux, [7] 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 [8].

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 [10].

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 [17, 3, 4]. 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 [6].

Whereas increasing temperatures in these regions could lead to more consistent vintage quality, [8] observed 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 [12], 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 [13]. 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 [6]. The cool conditions require the use of adapted grapevines (Vitis vinifera L.), which include frost resistant, late budding and early maturing cultivars [14]. 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 [13]. 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 [12]. The absence of hot weather during ripening and the cool harvest conditions favor 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

*Corresponding Author: Amir Hossein Halabian, Department of Geography, Payam Noor University, Tehran, Iran. Email: halabian_a@yahoo.com spoilage [1]. Thus, the unique character or typicity (the characteristic of a wine that makes it typical for the region or cultivar of origin) is assured [6]. While the majority of the highest quality wine-producing regions in Western Europe and Germany have benefited from an increase in quality ratings [11], the impact of global warming on Franconian wine and its varietal typicity has received little attention.

MATERIALS AND METHODS

To conduct any study, it is necessary to adopt methods which have the maximum performance in a minimum and assist in achieving the result and purpose of the survey. As the raised questions should be in line with the theme of the subject, selected methods and procedures should also be tailored so that the waste of time and the cost increase are prevented. In this study, the maximum and minimum daily temperature data during 2011-2001 period of selected synoptic stations of the provinces of Kermanshah, Hamedan, Kurdistan have been used (National Meteorological Organization, 2011-2001), Table (1).

Table 1. Characteristics of Western Region Meteorological Stations (Hamedan, Kermanshah, Kurdistan)

Statistical	Altitude	Longitude		Latitude		Station
I erioù	(ш)	Degrees	Minutes	Degrees	Minutes	
2001-2011	1749	48	32	34	51	Hamedan
2001-2011	1679	48	41	35	12	Nojeh
2001-2011	1725	48	49	34	17	Malayer
2001-2011	1658	48	24	34	09	Nahavand
2001-2011	1379.7	46	39	34	43	Ravansar
2001-2011	545	45	52	34	27	Sarpolezahab
2001-2011	1318.6	47	09	34	21	Kermanshah
2001-2011	1468	47	59	34	30	Kangavar
2001-2011	1883.4	47	37	35	53	Bijar
2001-2011	1373.4	47	00	35	20	Sanandaj
2001-2011	1522.8	46	16	36	15	Saghez
2001-2011	1286.8	46	12	35	31	Marivan



Figure 1. Study Area

Thermal Gradient Method

In order to study the relationship of temperature of study area with deviation from optimal condition in different altitudes or time optimal conditions, it was necessary to use the thermal gradient to obtain the temperature of altitude points where there was no station. To obtain the temperatures, the linear regression method was used.

Using linear regression, coefficients of variation of temperature with altitude, were calculated for the months of the year and the whole year. Following equation was used to calculate the curve equation:

$$(y=ax+b$$

In this equation, (y) the expected value (dependent variable), (x) the most important variable which predictions will be based on that (the independent variable), (a) constant coefficient known as intercept and (b) line slope or thermal gradient slope showing the thermal decrease with altitude.

Following equations are used to calculate a and b:

$$a = \frac{\sum(y) \sum (X^2) - \sum(x) \sum (xy)}{N\sum X^2 - (\sum X)}$$

$$b = \frac{N\sum XY - (\sum X)(\sum Y)}{N\sum X^2 - (\sum X^2)}$$

To achieve results and calculate the above equations, first, table of correlation elements for selected stations and time intervals was formed; that will be mentioned as the monthly and annual correlation elements of selected stations.

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 maximum growth rate occurs. Identifying and determining the optimal point for each phenological stage and the mean daily temperature resulted from monitoring minimum and maximum 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.

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° for grapes is calculated by the following equation.

$$H_U = \sum_{i}^{n} \left[\frac{T_M + T_m}{2} - T_t \right] \quad \text{where,}$$

Equation (3)

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

Equation (1)

Equation (2):

 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.

Equation (4) $\underline{TMin + Tmax}_{2}$ If the $\underline{TMin + TMax}_{2} > =Tt$ 2

In this equation, tmin, tmax are the minimum and maximum 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.

B – Method of determining the duration of stages in phenological studies

To enhance the performance, the proper use of irrigation and farming operations at every stage of grapes plant growth, an individual can provide required planning for crops' growth through determining the time each phenological stage takes, based on daily temperature and determining duration of each stage. Therefore, in order to determine the time between two phenological stages (the inter-stage time) based on the minimum temperature, the following equation is used:

Equation (5)

$$n = \frac{A}{T - B}$$

where, N is time between the two phenological stages, (A) is temperature coefficient for completion of that stage, (B) is biological threshold of crop and (T) is daily temperature.

RESULTS

Analysis of 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 maximum 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, selected provinces of western region (Hamedan, Kermanshah and Kurdistan) Nahavand, Sarpolezahab and Marivan stations, respectively, have less deviation and more optimal conditions than the other stations; however, there are not significant differences in terms of deviations have less deviations, which are fully ripening stage of grapes plant, Nahavand, Sarpolezahab and Marivan Stations have lower deviations which are

followed by Malayer, Ravansar and Sanandaj stations, respectively and Noje, Kangavar and Bijar Stations have more deviations from optimal condition; consequently, in all stages, Nahavand, Sarpolezahab and Marivan stations have least deviation from optimal condition, which means that these stations have the optimum conditions for the grapes plant cultivation.

Table 2. Determining the deviation from optimal condition of grapes plant phenological stages in top stations
of western regions

Total	Grapes ripening		Stem maturation		Flowering		Germination		Growth
deviations	Deviation	Optimum	Deviation	Optimum	Deviation	Optimum	Deviation	Pptimum	stages
· ·	from condition		from condition		from condition		from condition		Station
-47.85	-9.85	25-35	-15.30	25-35	-15.86	25-30	-6.85	15-20	Marivan
-51.33	-11.09	25-35	-15.84	25-35	-161.8	25-30	-7.59	15-20	Sarpolezahab
-47.21	-9.38	25-35	-15.87	25-35	-14.65	25-30	-7.31	15-20	Nahavand

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

Optimal time, based on active days degree method

Another method to determine the optimal time for agricultural climate, based on the latest incidence of minimum 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 minimum 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 3.

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

Table 3 Temperature thresholds of grapes plants in phonological stages

Reference: Quanta, 1974

Since plant species are highly dependent on temperature, the monitored daily minimum 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 minimum threshold of grapes plant activation at greater than 0° 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 4, the date of germination, flowring and stem maturation of grapes plant occurs earlier in Marivan, Sarpolezahab and Nahavand stations than other stations, but, grapes ripening in occurrs earlier in Marivan, Sarpolezahab and Nahavand stations. However, completion date of phenological stages of grapes plant in selected stations of western region are shown in Table 4.

Table 4 Com	pletion date p	henological stages	s of grapes 1	plant in selected	stations of wester	n region
			· · · · · · · · · · · · · · · ·			

Grapes ripening on	Stem maturation date	Flowering date	Germination date	Minimum threshold incidence date	Altitude	Station
27 September	18 June	12 May	28 April	23 March	1658	Nahavand
23 September	11 June	1 May	19 April	21 March	1286	Marivan
18 August	16 June	4 May	24 April	23 March	545	Sarpolezahab

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

Areas suitable for viticulture

According to the results, at the germination and flowering stages, selected provinces of western region (Hamedan, Kermanshah and Kurdistan), Nahavand, Sarpolezahab and Marivan stations, respectively, show less deviation from optimal conditions than other stations. At stem-maturation stage, Nahavand, Sarpolezahab and Marivan stations show less deviation from optimal conditions followed by Noje, Kangavar and Bijar stations; however, no significant differences could be observed in deviation from optimal conditions. At grapes ripening stage, Nahavand, Sarpolezahab and Marivan stations have lower deviation, followed by Malayer, Ravansar and Sanandaj stations, respectively, and Noje, Kangavar and Bijar stations have highter deviations; therefore, Nahavand, Sarpolezahab and Marivan stations have, in all stages, the least deviation from the optimal conditions, which means that these stations possess the optimal condition for grapes cultivation. According to agro-climatic analysis, most favorable viticulture areas are located in Kurdistan provine (northwest), Kermanshah province (west) and Hamedan province (southwest) which are Nahavand, Sarpolezahab and Marivan stations, respectively.



Figure (2) The total deviation from optimal conditions for grapes plant

The proposed varieties for viticulture according to climatic conditions of western regions of Iran According to the agro-climatic conditions of the study area, grapes varieties suitable for the cultivation include Black grapes for Marivan station, Raisins, Askari and Fakhri for Nahavand station and Askari and Yaghouti for Sarpolezahab station.

Conclusions

Currently, agriculture is considered as one of the most important sectors of the economy. Meanwhile, the incorrect use of arable land is one of the most important factors to be considered in the present-day problems and arising

issues. Due to the economic status of the grapes in the country, and the its economic value in foreign currency making, it is necessary to put extra efforts to present the characteristics of grapes, climatic requirements and climatic conditions of cultivation. Existing varieties of grapes in Iran, typically require a long growing season. Relatively, high temperature in summers and low relative humidity and rain-free growing seasons and aslo mild winters are favorable to these varieties. American grapes varieties, have better compatibility with mild and wet weather. Cold tolerance is an important factor in the development of cultivation of European grapes varieties. Frosting of young sprouts occurs at -180° to -230° temperatures, and trunks and main branches, are severely damaged at temperatures below - 23C°. Internal quality of grape grains is affected by climate change. Cool weather, usually leads to sourness increase and sweetness decrease . While high temperatues in summer leads to sourness decrease and sweetness increase. Usually, a long growing season and lower temperatures in European grapes varieties, increase the quality and yield. From the agro-climate view, grapes cultivation based on GDD total effective temperature method and temperature thresholds of grapes phenological stages are investigated. According to these results, climatic calendar of western regions including Kurdistan Province is early October harvest, harvest in mid -to-late August for Kermanshah province and early September harvest for Hamedan province. According to analysis of deviations from optimal conditions at different heights in the study area, Marivan station form Kurdistan province, Nahavand station from Hamedan province and Sarpolezahab station from Kermanshah province, possess optimal conditions for cultivation of grapes.

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