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Evaluation of the Impact of Climate on Cultivation of Spring Canola in Hamedan Province

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Abstract

Weather and climate parameters and their effects on crops, is one of the most effective factors in yield increase. Agro-climatic studies could be used to determine the potential of various regions and the exploit these resources to the maximum possible extent. In this study, in order to evaluate the agricultural climate of spring canola cultivation in selected stations in Hamedan province, the daily temperature data over a period of 10 years were used. The deviation from the optimum conditions, the degree of active days index and thermal gradient methods are applied to perform the agro-climatic calculations and analysis. The results show that late March the optimum time for planting spring canola for high-altitude and cold regions (Nahavand and Malayer). Thermal gradient analysis and deviation from optimal conditions at different altitudes in the study area show that for every 100 meters increase of altitude, the deviation from the optimal conditions of planting is delayed by one month. This point is important in terms of cultivating time and commercial crops production. According to the obtained agricultural calendar, the most appropriate time for spring planting and harvest in the area are in late March and late August, respectively.

Keywords: Agro-climate, Spring canola, Deviation from optimal conditions, Phenology, Hamedan

Introduction

Due to the trend of population increase all over the world, providing the basic food requirements for humans is an inevitable issue. Among the various factors affecting agricultural production, the weather condition is considered as the most important variable. Lack of attention to climatic potentials of any region and traditional cultivation of crops, leads to low and fluctuating yields of crops and even full destroy of crops in some years. Several studies have been conducted on effects of climate on canola growth. Withers et al (1995) conducted a study in Canada and concluded that the climatic factors can alter canola yield between 15 to 74 percent and among the major climatic factors, temperature and humidity are the most influential factors. Among these two factors, the temperature effect is much more important. This fact is also mentioned by (Kimber and Gregor, 1966) who studied effects of climatic factors on this plant. Despite the fact that canola plant reacts severely against the climatic element, it is frost-resistant; so that it can tolerate cold temperatures up to 20 - ° C. Bagli (2003) also stated that, in cold and semi-cold

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areas, planting should be done at a time, so that the rosette stage happens before the first frost incidence. Canola Association of Canada in 2006, stated that the growth stage of autumn canola (from planting until the rosette), based on 5 ° C, is about 400 to 600 GDD. Mendham et al (1981) showed that the performance of autumn canola is a function of spring growth and Carbohydrates transfer from the vegetative parts, as well. Canola is one of the most important oil crops; in terms of cultivation area, it has the second rank after soybean and in terms of oil production, has the third rank after soybean and palm oil (FAO, 2005). Like many other crops, canola plants get affected due to water deficiency stress. Studies show that the incidence of water deficit at different growth stages, particularly during reproductive growth, will affect the quality and quantity of produced oil (Angadi, 2003). The aim of the present study is to evaluate the agro-climatic condition of spring canola cultivation in selected stations of Hamedan province. This province, having an area of 19,445 square kilometers of western provinces of the country, accounts for 1.19% of the whole area of the country; geographically, it is located between 59 minutes and 33 degrees to 49 minutes and 35 degrees of north latitude and 34 minutes and 47 degrees to 36 minutes and 49 degrees of east meridian from Greenwich meridian. It has borders with Zanjan province in north; Lorestan province in south, Markazi province in east and Kermanshah and Kurdistan province in west. The province's highest point, Alvand mountain peak with altitude of 3574 meters, is located between Hamadan and Tuyserkan cities; the least altitude point is located in AmrAbad region along the Ghara-Chay River in Shara-va-Pishkhar Township.

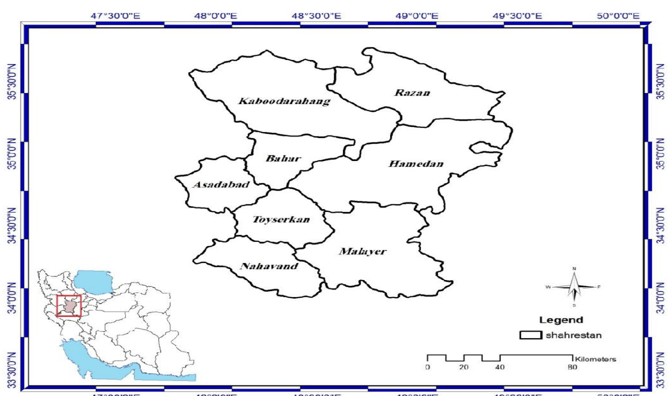

Figure 1. Study Area

Materials and Methods

In this study, the mini and maxi daily temperatures during the period of 2001-2011 from synoptic stations of Hamedan, Nahavand, Malayer, Nojeh and Dargazin have been used. Table (1) shows the characteristic of the selected stations.

Table 1. Characteristic of Meteorological Stations

Altitude, m	Latitude	Latitude	Station Type	Station
1749	3451	4832	Main Synoptic	Hamedan
1679	3512	4841	Main Synoptic	Nojeh
1725	3417	4849	Main Synoptic	Malayer
1658	3409	4824	Synoptic	Nahavand
1840	3521	4909	Climatic	Dargazin

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.(b+ ax= y)
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:

Eq (1)

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

Eq (2)

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

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

There are four phenological stages for spring canola plant and each stage has an optimal temperature, at which the maximum growth rate occurs at this temperature. 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 optimum locations in various periods of time, particularly months of a year, and actually, the location which has the least deviation from the optimal condition, would be considered as the optimum location. In this method, to obtain the optimum location, optimal points or optimal temperatures were first determined and then, considering the average of daily data, deviations from the optimal conditions were calculated for a whole year. Next, the deviations of the averages from the optimal points are calculated; consequently, the deviations from the optimal conditions are obtained for the above locations and the results are tabulated.

Method of thermal coefficient or total degrees of active days

Due to importance of total thermal units in study and locating of favorable regions of spring canola cultivation and determining the planting and harvest time, based on defined thresholds, calculation methods of degree-day have been implemented. These data were analyzed by functions of Microsoft EXCEL software. In this study, active method, amongst the common methods of thermal units' estimation, was used. There are two main methods of summarization of the temperature, including effective total and active total that active total method is applied in this study.

A – Sum of degrees of active days

Phenology is one of the topics of ecology, in which the life cycle of plant life from the germination to the onset of permanent winter sleep, are assessed. Start and end of each period, due to climate changes, particularly temperature and soil moisture varies in different years. 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 (3)

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

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.

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 the duration of each stage. Therefore, in order to determine the time between two phenological stages (the inter-stage time) based on the mini temperature, the following equation is used:

Eq (4)

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

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

Thermal Gradient

In order to evaluate the deviation from optimal conditions at different altitudes, or the optimal spatial position based on the altitude, first, using the linear regression, coefficients for changes in daily temperature as a function of altitude are calculated for months and whole year. Four phenological stages have been considered in spring canola plant which are significant in terms of agro-climatic matters; including: germination stage, flowering stage, rosette stage, flowering stage and 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 considered as the basis. Table 2 shows the deviation from the optimal conditions for each phenological stage of canola plant based on the average daily temperature at selected stations. According to the results flowering and ripening stages, Nahavand station has lower deviation and more optimal conditions than the other stations; which is followed by Malayer and Hamedan stations and Nojeh and Dargazin stations have higher deviations; consequently, Nahavand stations has the least deviation from optimal conditions than other stations; which means that this station has the optimum condition for cultivation of spring canola.

Table 2. Determining the deviation from optimal conditions of phenological stages of spring Canola in selected stations

Total Deviations	Ripening		Flowering		Rosette		Germination		Growth Stages / Station
	Deviation	Optimal	Deviation	Optimal	Deviation	Optimal	Deviation	Optimal	
-0.94	-8.21	17.5	5.41	14	15.77	-2	-3.09	22.5	Nahavand
2	-7.52	17.5	-3.81	14	17.34	-2	-3.09	22.5	Malayer
2.93	-7.83	17.5	-4.32	14	17.10	-2	-2.95	22.5	Hamedan
2.66	-7.52	17.5	-3.81	14	17.34	-2	-3.09	22.5	Nojeh
26.13	-2.75	17.5	4.37	14	23.21	-2	1.31	22.5	Dargazin

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 spring Canola 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 is as follows. Based on minimum thresholds of spring Canola plants at each stage, and the other is zero degrees Celsius. Since plant species are highly dependent on temperature, the monitored daily minimum temperature is used for phenology of the spring Canola plant. By specifying thresholds of phenological stages of Canola plant and accurate daily temperatures, completion date of each stage is calculated. For all stations, incidence date of minimum threshold of Canola plant activation at greater than 5 ° C is considered. In order to obtain the completion date of phenological stages of spring Canola plant in germination stage 150, the rosette stage 613, the flowering stage 935and fully ripening stage of grapes plant, 1450 thermal units, more than 0 degrees Celsius, are necessary. According to Table 4, the date of germination, rosette, flowering and ripening of spring Canola plant occurs earlier in Nahavand, Malayer and Hamedan stations than other stations. The completion date of phenological stages of spring Canola plant in selected stations are shown in Table (3).

Table 3. Completion date of phenological stages of spring Canola

Ripening	Flowering	Rosette	Germination	Minimum threshold incidence date	Altitude	Station
21 August	5 June	16 May	6 April	6 March	1679	Nojeh
17 August	8 June	17 May	14 April	3 March	1725	Malayer
11 August	18 June	11 May	2 April	6 March	1749	Hamedan
10 August	155 June	19 May	30 March	21 February	1658	Nahavand
13 August	19 June	13 May	5 April	27 February	1840	Dargazin

Areas suitable for cultivation of spring Canola

Based on the agro-climatic analysis, most favorable areas for a spring Canola cultivation are in southern lowlands (Nahavand and Malayer stations) and central and eastern regions (Hamedan station), while northern and western regions (Nojeh and Dargazin stations) are next in this rank.

Best calendar of harvest (spring Canola)

Timing of harvesting a crop is considered as one purpose of any agro-climatic research; since, optimal timing of harvest is achieved through the study of climatic conditions. For harvest calendar, climate is the main factor. Among the climatic elements, the temperature has an important role. According to analysis carried out, based on different agro-climatic methods and phenological studies, best calendar for harvest of spring canola in selected stations of the study area are illustrated in Table (4).

Table 4. Calendar of Harvest of spring Canola in selected stations

Harvest Date	Stations
21 August	Nojeh
17 August	Malayer
11 August	Hamedan
10 August	Nahavand
13 August	Dargazin

Conclusion

The environment, in which we live, consists of a series of factors including weather conditions and climatic related phenomena Weather conditions, is one of the factors determining the type of plants that are cultivated in any region. Agricultural activities are highly interconnected with natural factors and climate and environmental conditions. Weather condition is on top of the natural factors affecting agricultural activities, by which it affects 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 Spring Canola, this study is conducted. Canola is an oilseed plant containing 45-40 percent oil and 35-25 percent protein. This plant has both spring and winter growth types that the winter type needs to be overwintered to have the flowering stage. Completion date of phenological stages (spring Canola) in the lowlands (Nahavand station) occurs earlier than other stations. Overall, Nahavand station experiences earlier both phenological stages and complementary phenological stages of spring Canola growth. Inter-stage phenological length of spring Canola is of significant for performance increase and proper use and agricultural activities of spring Canola plant, based on biological threshold and active thermal coefficient of each stage. According to Agro-climatic analysis, best planting calendar of spring Canola for all stations is in mid-March. Harvesting of spring Canola in Nahavand, Hamedan, Nojeh and Dargazin stations, is in late August. According to agro-climatic analysis, most favorable areas for cultivation of spring Canola are located in southern lowlands (Nahavand and Malayer Stations); while, it is followed by northern and central areas (Nojeh, Dargazin and Hamedan stations).

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