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Detect the effect of climatic factors on the growth and yield Biology of rapeseed in Kermanshah Provinceby means of GIS system

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Abstract

Weather and climatic parameters and their impact on farming plants are one of the foremost effective factors on improvement of crop yield. The potential facilities of various regions may be determined with agroclimatic study and exploit maximally from these facilities. In order to evaluate agroclimate of Canola cultivation throughout the selected substations at Kermanshah province in this current investigation, the statistics data related to daily temperatures within a 10- year statistical period were employed. Deviation from Optimum Percentage (DOP) technique, Growing Degree Day (Active Day Temperature), and thermal gradient methods have been adapted for computation and agroclimatic analysis. The results of this study indicate that the optimal date for cultivation of autumnal Canola in high and cold- weather lands (Kermanshah and Eslamabad West) is the end of October. Temperature gradient analysis and DOP technique in various heights at the studied region may show that there is one month postponement in deviation from the optimum conditions for optimal cultivation per 100m increase in height of given region. This point is important in terms of date of cultivation and production of commercial product. According to the acquired farming calendar, end of October is the most appropriate time for autumnal cultivation in this area and thus date of harvest will be the end of August.

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Introduction

Introduction and cultivation of new crops in a given environment require management practices and trait selection that enable the crop species to perform to its potential. Canola is an important oilseed crop (Downey 1990, Zhang *et al*. 2003) and its cultivation is expanding, particularly in the western world (FAO 2006), because of its importance as both an oilseed and a bio-diesel crop. Winter-grown canola has attracted attention from both producers and researchers since its introduction in the 1980s (Rife and Zeinali, 2003). Canola is cultivated both during winter and spring seasons in United States that expose the crop to winter kill and frost and high temperatures, respectively, during the reproductive period. The temperatures during winter and spring are known to influence all the crucial steps of the reproductive cycle including gametogenesis, pollination, fertilization and embryogenesis (Lardon and Triboi-Blondel 1994, Angadi *et al.* 2000). Temperature stress events, which are being experienced now, are expected to intensify because of an increase in emission of greenhouse gases and associated changes in climate. Climate models project an increase in the surface temperature of the Earth by 1 to 11C by 2100 (Houghton *et al.* 2001, Stainforth *et al.* 2005). Additionally, short episodes of extreme climatic events including low and high temperatures are predicted to occur more frequently in the near future (Meehl and Tebaldi 2004). Studies have shown that these projected changes in climate drastically reduce crop yields when they coincide with the reproductive stage of plant growth (Hall 1992, Reddy *et al.* 1992, 1997). The yield of canola crop grown both in winter and spring is reduced on exposure to low and high temperatures, respectively. Winter-grown canola blooms in March and April in the US mid-south and temperatures <10C are not uncommon during that period (Reddy *et al.* 1995). (JinLing, 1997) observed that low temperatures result in fewer mature seeds in canola because of the reduced fertilization potential of pollen grains. This could be due to the sensitivity of the binucleate stage of pollen grains to short periods of freezing temperature (3C) for4 h; Lardon and Triboi-Blondel 1994). Similarly, high temperatures inhibit reproductive success. (Angadi *et al.* 2000) reported that exposing Brassica species to 35/15C day/night temperatures for 7 days during early flowering rather than during early pod development caused greater yield reduction. The yield reduction was attributed to flower abortion caused by pollen infertility. Consequently, the early stages of anther development in Brassica oleracea var. italica L. showed high sensitivity to the temperature treatment of 35C for 7 days compared with the same stress during later growth stages (Bjo¨rkman and Pearson,1998).

Therefore, knowledge of the canola pollen germination processes, cardinal temperature and temperature adaptability range (TAR, Tmax–Tmin; Reddy and Kakani, 2007) will help us to design breeding strategies to sustain canola production in extreme climatic conditions expected in the future.

The aim of this study detect the effect of climatic factors on the growth and yield_Biology of rapeseed in kermanshah provinceby means of GIS system

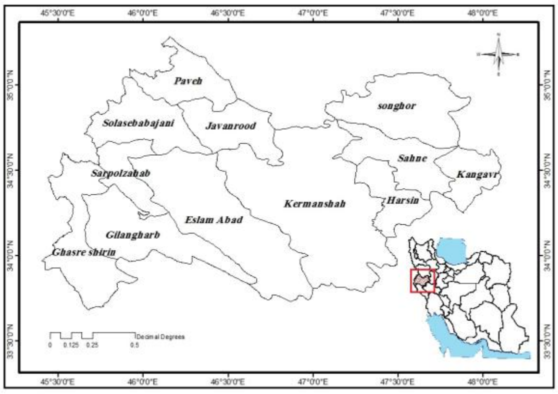

Fig. 1. The studied region.

Materials and methods

Data gathering

Thermal (temperature) Gradient Method

In order to examine the studied region in terms of temperature regarding deviation from optimum conditions with several heights or temporal optimums based on height; it necessitates using thermal gradient for temperature in points at the height level where there is no substation for measurement. Linear regression method was adapted for acquiring these temperatures. The variance coefficients for temperature together with the height were computed for months of a year and total year by means of linear regression method. The following formula has been used for calculation of line equation:

$$(y = ax + b)$$

In this equation, y denotes the expected value (dependent variable); x is the paramount variable based on which the prediction is done (independent variable); a is a constant coefficient which called intercept; and b expresses slope or temperature gradient, which represents temperature loss along with height. The following formulas are used to calculate a and b :

$$a = \frac{\Sigma(y)\Sigma(X^2) - \Sigma(X)\Sigma(XY)}{N\Sigma X^2 (\Sigma X)} \quad \text{(Eq. 1)}$$

$$b = \frac{N\Sigma(XY) - (\Sigma X)(\Sigma Y)}{N\Sigma X^2 (\Sigma X^2)} \quad \text{(Eq. 2)}$$

In order to derive the given results and computation of above equations, firstly, elements correlation table is made up for the selected substations within the studied time intervals and it will be mentioned as monthly and annual correlation elements for the selected substations.

Deviation from Optimum Percentage (DOP)

There are 4 phenological stages in production of Canola crop and each of these stages has an optimum or optimal temperature that Canola has the maximum growth at this optimum temperature. With identifying and determining these optimums for any phenological stage and mean daily temperature derived from minimum and maximum daily detections, the spatial optimum can be characterized within several time intervals, particularly months of a year and in fact the points with the minimum deviation from optimum conditions will be considered as optimal location. To acquire several spatial optimums in this technique, initially optimums or optimal temperatures are determined and then by taking mean daily statistical data into consideration, values of deviation from optimum conditions were calculated for total year and then at next step difference among the given mean values was calculated from optimum limits consequently the rate of deviation from optimum conditions might be derived for the above locations and their results could be given in some tables.

Temperature coefficient method or sum of active days (temperature)

With respect to the importance, which is considered for temperature cumulative units (degree/day) in identifying and topology of the susceptible regions for Canola cultivation and determination of cultivation and harvest dates of this crop based on the given thresholds, Growing Degree Days (GDD) techniques were employed. The above data were processed and analyzed by means of functions of Excel software. In this study, active day temperature method was utilized to estimate temperature units among the prevalent methods. There are two major techniques for summation of temperature including Sum of active or effective day temperature methods where sum of active day temperature technique has been employed in this investigation.

I) Sum of active day temperature

Phenology or knowledge of phenomena is one of scientific topics in ecology in which plant's life cycle is explored from time of starting germination to permanent hibernation. With respect to climatic changes, especially weather temperature and soil moisture in several years dates of start and end of any period may vary. All values of daily temperatures (without subtraction from base temperatures) are added together and during active germination days to summate temperature. The calculation formulas are as follows:

$$\frac{TMin + TMax}{2} \quad if \quad \frac{TMin + TMax}{2} = Tt \quad \text{(Eq. 3)}$$

Where *Tmin* and *Tmax* denote respectively the minimum and maximum daily temperatures and *Tt* is biological temperature in this formula. In method of active day temperature, which has also been employed in this study, sum of daily temperature was used with positive values but this is only for those days in which mean temperature is at biological threshold or higher than biologic zero point. All values higher than 5°C temperature will be computed while all temperatures below 5°C will be excluded.

Research Findings

Thermal (temperature) gradient

In order to examine rate of deviation from optimum conditions in several heights or temporal optimum situation based on height, firstly temperature variations with height has been calculated for months of a year and total year by means of linear regression technique. To achieve the results and calculation of the above formulas, initially table of correlation elements was drawn for the selected substations and in all studied time intervals where the summary of their results are mentioned in Table (1) as monthly and annual correlation elements for the selected substations.

Table 1. Annual correlation in selected substations from Kermanshah province during phenological periods for Canola (temperature gradient).

Period / Coefficients	Germination	Rosette	Flowering	Maturation
B	0.06	0.006	0.01	0.005
A	4.54	28.56	10.5	0.34
R	0.88	0.82	0.97	0.95

Canola plant has respectively four phenological phases that are important in terms of agroclimatic aspect, which have been studied. In Canola plant, these stages comprise of germination, rosette, flowering, total maturation, any phase includes an optimum or optimal temperature where the maximum growth of Canola occurs at this optimal temperature. In order to conduct phenological analysis on Canola, the mid- maturated varieties of Canola with more frequency in this region have been considered as base with respect to the conducted surveys. Table (2) indicates the rate of deviation from optimum conditions at any phenological stage based on mean daily temperature throughout the selected substations. Given those derived results for Canola plant, flowering and total maturation phases in Kermanshah substation has the less deviation from optimum conditions than in other substations. After Kermanshah, Eslamabadwest and Ravansar substations has lower deviation while Kangavar substations have more deviation from optimum conditions than other substations. As a result, compared to other substations, Kermanshah substation has the lowest deviation from optimum conditions and this means that this substation possesses optimal conditions for cultivation of Canola.

Temporal optimum based on active degree day technique

Active degree day method is one of the other agroclimatic techniques to determine temporal optimums based on date of the latest event of minimum thresholds at phenological stage (Canola) so this method has been employed in this survey. Sum of daily temperatures was used with positive values but this is only for those days in which temperature is higher than mean biological limited degree or zero point of this activity. Active temperature coefficients are used as base point for calculation in this study based on plant's (Canola) minimum thresholds at each of phenological stages and the other base is zero point (0C°). Given these plant species are extremely dependent on temperature so phenology of plant species (Canola) has been adapted from statistical data of daily temperature as minimum and maximum detections for this purpose. Date of completion for each of phenological stages has been computed with identifying thresholds at plant's (Canola) phenological phases and with daily temperatures accurately. Date of minimum threshold of biological event has been considered greater than 5 for activation of plant (Canola) in all substations. To acquire completion date for plant (Canola) cultivation phenological stage, it necessitates using 150, 613, 935, and 1450 (BTU) thermal unit higher than zero degree (0C°) respective at stages of germination, rosette, flowering, and maturation in this plant. With respect to the given Table 4, dates of germination, rosette, flowering, and maturation of Canola plant start earlier in Kermanshah, Eslamabadwest, and Ravansar. Completion dates for plant's (Canola) phenological stages in the selected substations are shown in Table (4).

Table 2. Identifying deviation from optimum conditions in Canola at phenological phases with selected substations.

Growth phases Substation	Germination		Rosette		Flowering		Total matured		Sum of deviations
	Optimum	Deviated from conditions	Optimum	Deviated from conditions	Optimum	Deviated from conditions	Optimum	Deviated from conditions	
Kermanshah	22.5	-3.09	-2	15.77	14	5.41	17.5	-8.21	-0.94
Eslamabadwest	22.5	-3.09	-2	17.34	14	-3.81	17.5	-7.52	2
Ravansar	22.5	-2.95	-2	17.10	14	-4.32	17.5	-7.83	2.93
Kangavar	22.5	-3/09	-2	17.34	14	-3.81	17.5	-7.52	2.66

Table 3. Date of completion for Canola plant at phenological stages.

Substation	Height	Date of minimum threshold event	Germination	Rosette	Flowering	Total maturation
Kangavar	1679	October 7th	October 14th	November 20th	April 24th	June 9th
Eslamabadwest	1725	October 7th	October 14th	November 15th	April 5th	June 1st
Ravansar	1749	October 7th	October 14th	November 16th	April 11th	June 5th
Kermanshah	1658	October 7th	October 14th	November 15th	April 5th	May 29th

Appropriate regions for types (Canola) cultivation
Based on agroclimatic analyses, southern lowlands (Kermanshah and Eslamabadwest substations) and central and eastern regions (Ravansar) are the best areas for cultivation of Canola.

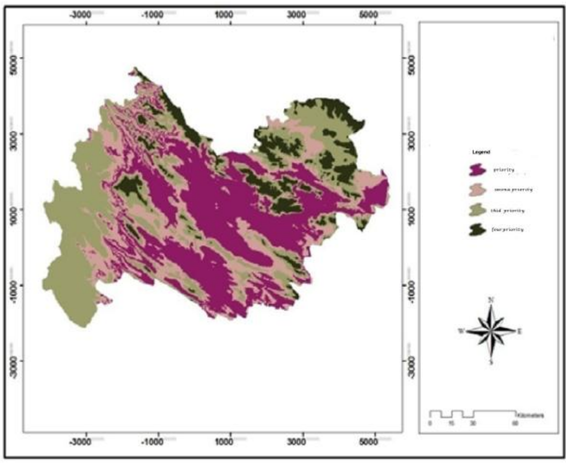

Fig. 2. Sum of deviation from optimum conditions in Canola plant.

Conclusion

The environment, where we live, is a group of several factors including the related phenomena in meteorological conditions and climatic consequents. One of the factors, which determine type of plants that could be cultivated and developed in a region, is climatic conditions. Agricultural activities are interrelated with natural phenomena, weather, and ambient conditions. Climatic conditions are placed on top of the effective natural agents in farming activities that their elements may separately or jointly affect on agriculture. Having special climate, our country (Iran) has provided appropriate platform for production of varieties of strategic agricultural crops and climatic indicators suggest several various types of climate in this land. This investigation was carried out with being aware of these divinely granted gifts and necessity for conducting a survey of this type in the region that indicate agroclimatic potential of this area regarding Canola cultivation. Canola is one of oilseeds which its seed contains of 40-45% oil and 23-35% protein. This plant has two types of spring and winter growth varieties where winter variety needs to hibernation (passing through winter) for occurrence of flowering stage in this plant. Completion date for phenological phases (of Canola) occur sooner in lower height regions (Kermanshah substation) than in other substations. In general, Kermanshah substation may experience sooner phenological periods as well as complementary phenological stages for cultivation of Canola plant. The interim period of Canola at phenological stage is important, based on biological threshold and active thermal coefficients at any step to rising efficiency and proper use and implementation of farming operation (Canola). Early October is the optimal cultivation calendar based on agroclimatic analysis for Canola cultivation in all substations. Early June is date of Canola cultivation for Kermanshah, Ravansar, Eslamabadwest, and Kangavar substations. According to agroclimatic analyses, the low height regions (Kermanshah and Eslamabadwest substations) are the best areas for Canola cultivation while northern and central regions of the province (Kangavar, and Ravansar substations) are ranked after them in this order.

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