Climatic Potential of Wheat in Western Azerbaijan Province using GIS

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Abstract
To have a successful farmer, due to environmental conditions and climate particularly important part of the study. Potential and limitations of climate and ecology of the need to consider the situation in the agricultural region Regarding the issue of sustainable development and food security ensures Before any development investment, Power continuous production of ecological agricultural products in diverse respects case studying and researching placed the purpose of this study is agro climatic zoning of dry land wheat in the Western Azerbaijan provinceFor this purpose, the long-term statistical data, meteorological and synoptic stations, as 4 synoptic stations out of this province were used and analyzed. The parameters we used in this study are: the probability of precipitation at a rate of 300 mm and more annually, autumnal precipitation, vernal rainfall especially in June, appropriate temperature for germination and temperature stresses during flowering and seed filling. Then, final map indicating climatic potentials for culturing dry land wheat in Western Azerbaijan Province was provided by utilizing favorable climatic conditions and classifying the dataset we collected through the mentioned parameters. This map indicated that the most appropriate regions for culturing dry land wheat were located in the north and the weakest ones existed in the southwest and southeast. Also, this study demonstrates that it is possible to identify appropriate regions for culturing wheat by utilizing the effective layers in dry land wheat GIS environment.
Keywords: Climatic, wheat, GIS, Western Azerbaijan

Introduction

Climatic conditions play a major role in all aspects of life especially plant life. The appearance of genera, varieties and other plant ecotypes can be affected by environmental factors particularly climatic ones. Although all mankind focused their attention on the awareness of the relationship between the environment and plant life from the beginning of agricultural evolution, but this subject has currently been taken into proper consideration by the appearance of new indexes relating to meteorology entitled 'Agro-climatology' or 'Crop-ecology'. Wheat is man's food stable stuff, planted in most parts of the world. Wheat generally grows between 30-50 degree north and 25- 40 degree south where dry land wheat constitutes 66% of the total area. Climatic conditions on the other hand from some of the most the important factors in fluctuation in dry land wheat production and yield. The prediction of wheat yield is a country's major concern for scheduling, food security, distribution appraisal, as well as for import/export issues. It is indispensable to schedule and plan the production of food industries. Many import/export industries provide food (such as baking flour and macaroni) presently, materials from wheat. Presently, many proposed prediction models of crop yield have been divided into two categories of mechanistic and empirical approaches (Poluektov and Topaz, 2001).The mechanistic models use mathematical functions to represent physical, biological, and chemical processes (Whisler et al., 1986). However, these models are suitable for areas outside the data range used for development. They tend to be complex and require many input parameters (Wang et al., 2002; Basso et al., 2001; Bolte, 1997). The Earth has warmed by 0.7˚C on average since 1900. Most of the warming since 1950 is due to human activities that have increased greenhouse gases (IPCC, 2001). Norwood (2000) carried out some studies about dry land wheat farming in vast plains of Kansas in the US. He concluded that evaporation and precipitation show the greatest effect on dry land wheat farming during the growth in comparison to other climatic factors. Veron et al (2004) divided Pampas's wheat cultivation region in to 5 zones according to regional precipitation

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values. has divided farming lands in India into 9 agro climatic zones for cultivating wheat by analyzing annual and monthly precipitation values. determined potato and wheat cultivation in the River Stour 12 by using climatic information, examining the soil as well as analyzing the topography of this region. Therefore, it is expected that climate change will have implications for possible fluctuation on wheat yield (Wrigley, 2006). The purpose of this study is to identify and determine potential climatic facilities as well as adjust them to what's needed in Northern Khorasan Province. For achieving this purpose, after considering climatic conditions of the region and adjusting them to physiological needs, we have classified the agricultural land zoning into three parts i.e. appropriate, medium and weak regions

Materials and methods

Geographical Location of the Region

With an area of 43,660 square kilometers, including Lake Urmia, the province of West Azerbaijan is located on the northwest of Iran. The climate of the province is largely influenced by the rainy winds of the Atlantic Ocean and Mediterranean. Cold northern winds affect the province during winter and cause heavy snow. According to meteorological data, local temperatures vary within the province. Average temperature differs from 9.4 °C in Piranshahr to 11.6 °C in Mahabad, while it is 9.8 °C in Urmia, 10.8 °C in Khoy, 9.4 °C in Piranshahr, and in Mahabad 11.6 °C. According to same data, the highest temperature in the province reaches 34 °C in July, and the lowest temperature is –16 °C in January. Maximum change of temperature in summer is 4 °C and in winter 15 °C. Average annual precipitation ranges from 870 millimetres (34 in) of rainfall equivalent in exposed southern areas down to around 300 millimetres (12 in) in Maku in the north, of which a substantial proportion is snow.

Fig 1

In this study, the long-term statistical meteorological and synoptic stations, 4 synoptic stations out of this province were used. Table (1) indicates meteorological stations specifications and In this study, lack of statistics was completed through differences and proportions. Also, for checking the randomness of statistical homogeneity some statistical tests such as Run Test were used.

Table 1

The required databases for this study (minimum, maximum and daily mean temperature as well as rainfall level) included location (latitude and longitude) and ecological needs for the crop which collected from several sources and then stored in GIS after essential assessment. Due to the fact that there were two registration dates for the data i.e. AD and Solar Calendars, total data were arranged based on Julio Calendar and then rainfall variables (annual rainfall, autumnal rainfall, vernal rainfall especially in June) and temperature variables (mean temperature at germination stage, daily maximum temperature at flowering stage, daily maximum temperature at seed filling stage and also the probability of temperature lower than 9 centigrade degree at flowering and seed filling stages) were extracted.

Accurate date of different stages in dry land wheat growth in various regions of the province can be determined through the following equation:

$$H_U = \sum_{i}^{n}\left[\frac{T_M + T_m}{2} - T_t\right] \quad \text{Equation (1)}$$

where,

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

In this study, for calculating GDD, we'll considere the base temperature as zero and if the mean daily temperature is equal or lower than base temperature then GDD = 0. For determining the date of different stage of growth Threshold Accumulated Temperature is used. Due to reaching the considered

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accumulated temperature degrees and required temperature for the wheat crop, sensitive initial and final stages i.e. germinating, flowering and seed filling are determined during different growing stages. Thus, the initial and final stages can be evaluated for each station per year and finally the following data were extracted with the 75% probability for each growing stage as initial and final ones. For analyzing the data, Arc / GIS and Arc / View were used as geographical databank. Finally, all the layers relating to the above mentioned maps in GIS environment were integrated through Weighted Classification Technique and subsequently the regions of Western Azerbaijan Province were zoned for dry land wheat farming.

Table 2

Notice that timely cultivating, germinating, growing and then tillering dry land wheat in timely manner can make it resistant against cold before snowfall so that it can survive when covered by the snow and the crop continues growing during the spring without significant damage resulting in higher yields. One of the indicative parameters for dry land farming is annual total rainfall level. Wheat in dry land farming requires rainfall at least in 300 mm at the growth stage. For this reason, the probabilities of rainfall level higher than 300 mm for the considered stations' annual rainfall levels were analyzed and measured based on the required level i.e. 300 mm.

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:

Equation (2)

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

Equation (3)

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

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.

Discussion Conclusion

Rainfall

A large area of the province has the mean rainfall (about 300 to 500 mm) that is economically the minimum rainfall level for dry land wheat production. In addition to overall annual rainfall level, rainfall distribution system during growth stages plays an important role in wheat growth. In the considered stations, despite the fact that rainfall dispersion is lower than required levels for dry land wheat farming, but daily rainfall dispersion during growth stages allows the possibility of the cultivation. So, rainfall dispersion systems during growth stage in Western Azerbaijan Province, autumnal rainfall, vernal rainfall especially in May as well as vernal, autumnal and winter rainfall levels were examined compared to annual rainfall rate. Iran Meteorological Organization has determined the appropriate autumnal rainfall level (appropriate rainfall level during germinating and tillering stages) between 40 and 60 mm. A research carried out by Giwi (1997) indicated that the most appropriate autumnal rainfall level could be 45 to 90 mm. Shows that the low rainfall areas of the North East and the Aras River and the success rate is less than 30% of dryland wheat. The regions of South and South-West provinces receive more rainfall and the possibility of meeting the water needs of plants to reach one hundred percent.

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Therefore, to achieve the objectives of the research and distribution of rainfall during the growing period in the West, the amount of precipitation in winter, spring precipitation and precipitation in June was studied as follows:

winter rainfall

To investigate how the distribution of winter rainfall in the province, winter precipitation values were calculated with 75% probability. Despite the provision of minimum water requirements of wheat in autumn in the province, in northern limits there. These limits are part of stations temperament, he mentioned the shores of Lake Urmia and the newly observed. The rest of the winter rains are satisfactory or very satisfactory.

rainfall in spring

Aras river and coast stations mentioned the severe limitations and Aksrmnatq spring rainfall in the north, Center and moderate limitations mentioned stations and other areas in South and South-West province on the North East coast of Lake Urmia spring showers are a good or very good.

Rainfall in June

West Azarbaijan wheat grain filling stage in the month or so the lack of moisture reduces the number and weight of grains is reduced. Precipitation important at this stage of growth to the extent that in some studies citing precipitation June, have identified wheat crop. In the south and center of the distribution of rainfall in June has severe limitations for approximately 7 percent of the average conditions are right and the rest of the region.

Temperature

Temperature is crucial at all plant growth stages. But there are some more important factors due to the sensitivity of the plants to climatic conditions that the most sensitive stages are: growing, flowering and seed filling. GDD (Growth Days Degree) was used for determining the date of the mentioned stages. The required temperature degrees for the crop (dry land wheat) to complete the abovementioned stages are as follows (Behnia, 1997):

Total Required Temperature Degrees during Planting and Growing Stages: 180 DG

Total Required Temperature Degrees during Planting and Flowering Stages: 1300 DG

Total Required Temperature Degrees during Planting and Seed Filling Stages: 2100 DG

Temperature has a significant effect on plants at initial stages especially during planting and growing ones. The appropriate temperature can be between 8 and 14 centigrade degree during germinating stage if the minimum temperature doesn't reach zero or below zero (Bazgir, 1999) i.e. the crop starts to germinate when sufficient moisture coexists with the appropriate temperature. So, the considered stations (synoptic) were examined from planting date (GDD) to the date in which temperature reached 180 centigrade degree under mean temperature condition. In this study, different probabilities for the appropriate temperature at germinating stage (between 14ºC and 8ºC) will be evaluated if the daily temperature doesn't reach zero. Then, the calculated probabilities in GIS environment turned into a digital map (Fig. 10). After that, the classified data were determined considering required climatic conditions for dry land wheat farming during germinating stage.

there is no temperature severe limitation in the considered region during this stage for the crop except 2% of the area in khosh while the rest (98%) have appropriate temperature. One of the sensitive stages in wheat phonology is flowering stage. According to climatic conditions of the region, the Cold Stress Threshold and Heat Stress Threshold were determined 9ºC and 25ºC respectively. Then, average limits of lower (9ºC) and higher (25ºC) temperatures were extracted for each station during statistical period. At this stage, male organs of the crop (wheat) will be barren if daily maximum temperatures increase over 25ºC and finally resulting in crop failure. It is essential to identify the date of this stage in order to consider and determine Western Azerbaijan Province's temperature during flowering stage. For this purpose, DDG was annually measured for each station from planting date to 1300 DD (Daily Degree).

At the next stage, the probability of maximum temperatures (25ºC and higher) was measured for each station during flowering stage. most regions (about 98%) have appropriate conditions except khosh with temperature limitations. Also, Geographical distribution of the mean cold stresses at flowering stage. except a small part of the province (about 3%)

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with the probability of lower than 9ºC (15 – 25 % probability at flowering stage), the probability of lower than 9ºC is 15% in other regions of the province; thus, there is no temperature limitation in the province. Also, one of the sensitive stages in wheat growth is seed filling stage (from the beginning till the end). If maximum daily temperatures are over 30ºC, it may result in crop failure because temperature rise can increase water evaporation and finally wrinkle and decrease the weight of the seeds. Also, 9ºC was regarded as Cold Stress Threshold at seed filing stage. For this reason, maximum temperature for each station was regarded as 9ºC to 30ºC at this stage. the northern and central regions of the province have appropriate temperature at seed filling stage (43%) except a small part in Khosh (2%); so, 55% of the area is semi-appropriate for dry land wheat farming. Also, the geographical distribution relating to the probability of mean temperatures lower than 9ºC at seed filling stage was provided. during this stage, cold stresses are rarely occurred. Mean temperature lower than 9ºC is lower than 15% and there is no temperature limitation.

The Zoning of Western Azerbaijan Province Considering Climatic Potential of Dry Land Wheat Farming

After extracting the parameters used in the considered stations and adding them to GIS environment considering scientific resources as well as climatic conditions of the regions, Also, for measuring the layers in the same scale considering favorable climatic conditions for dry land wheat farming All layers were integrated in GIS environment by using Correlation Method (weighted and classified method) and the regions of the province were finally zoned for dry land wheat farming (Figure 2).

Analysis of deviations from optimal conditions

Four phenological stages in wheat plants that have been studied from the point of view Agroclimatic with Ahmytnd The steps include: Stage of germination, stem elongation, flowering and maturity of each stage of an optimum temperature for the maximum or optimum growth at this temperature is optimal. To study the phenological wheat varieties according to a survey conducted among clay base is more abundant in the region. Table (3) the degree of deviation from optimal conditions for each phenological stage based on the average daily temperature at selected stations show.

Results

In this study, agro-climatology zoning of Western Azerbaijan Province was provided for dry land wheat farming in GIS environment by analyzing climatic factors and statistical analyses. For this purpose, all the data extracted from meteorological stations was used and the regions with the same potential (equipotential regions) were identified by applying interpolation and correlation methods in GIS environment for dray land wheat farming. The results indicated that most regions had appropriate and medium conditions except a small area in the southern and southeast of the province (17%). The northeast, eastern and west parts of the province (about 22%) are appropriate for dry land wheat farming and about 62% of the area covered by medium regions. Growth rate can be increased by identifying favorable regions and also using optimal levels in agricultural lands of the province. Also, in addition to temperature and rainfall factors, there are other factors such as height, slope, geographical position, evaporation and transpiration during the process of wheat growth.

Fig 2

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Table 1 Characteristics of the weather station Western Azerbaijan

Statistical Period	Altitude (m)	Longitude		Latitude		Station
		Degrees	Minutes	Degrees	Minutes	
2001- 2011	1328	45	05	37	32	Orumieh
2001- 2011	1314	46	0	36	20	Miandoab
2001- 2011	1411	44	26	39	20	Makoo
2001- 2011	1455	45	08	36	40	Piranshahr

Table 2. Dry Land Wheat Farming Date

Row	City / Village	Appropriate Temperature for Cultivation with 75% Probability
1	Orumieh	October 11 th
2	Miandoab	October 20 th
3	Makoo	October 14 th
4	Piranshahr	October 25 th

Table (3) determining the deviation from optimal conditions for wheat phenological stages Ardabil Province

Total deviations	ripening		Growth		Stem elongation		Germination		Growth stages / station
	Deviation from condition	optimum	Deviation from condition	optimum	Deviation from condition	optimum	Deviation from condition	optimum	
- 33/13	- 10/32	+35	- 8/10	23-20	- 6/60	24 -16	- 8/11	25 - 22	Pars Abad
- 35/85	- 11/40	+35	- 8/89	23-20	- 6/80	24 -16	- 8/76	25 - 22	Khalkhal
- 31/75	- 9/80	+35	- 7/05	23-20	- 7/30	24 -16	- 7/60	25 - 22	Ardabil
- 26/16	- 8/10	+35	- 6/61	23-20	- 5/15	24 -16	- 6/30	25 - 22	Meshkin Shahr

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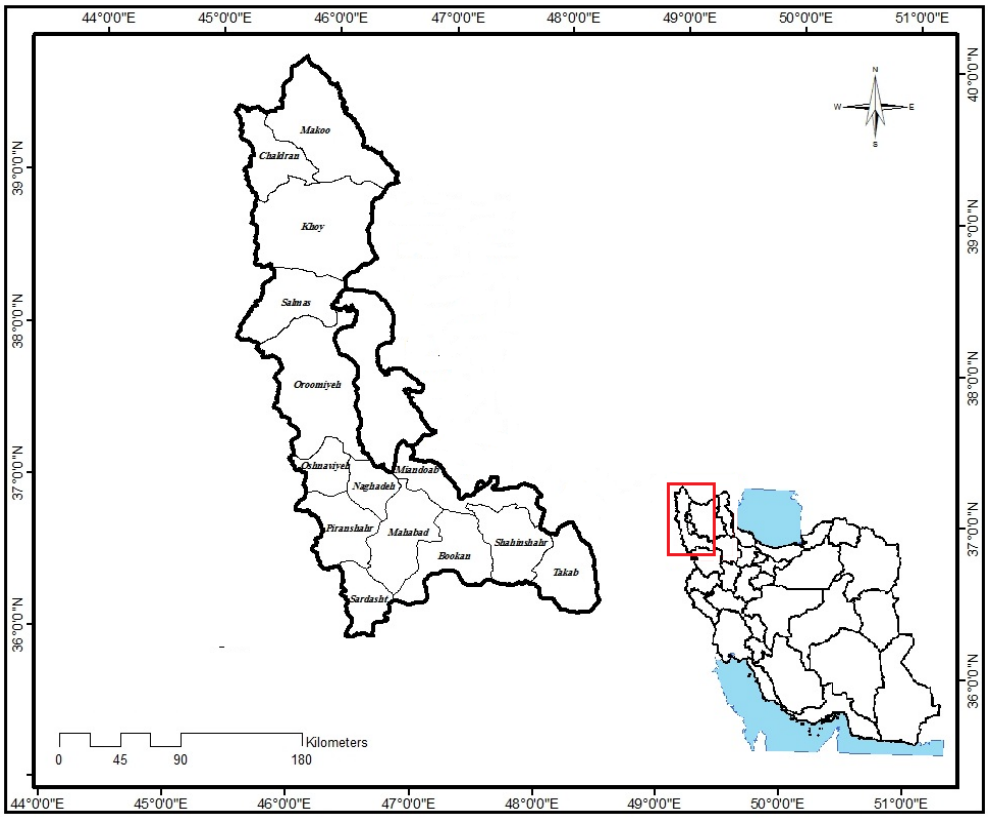

Fig 1. the studied region

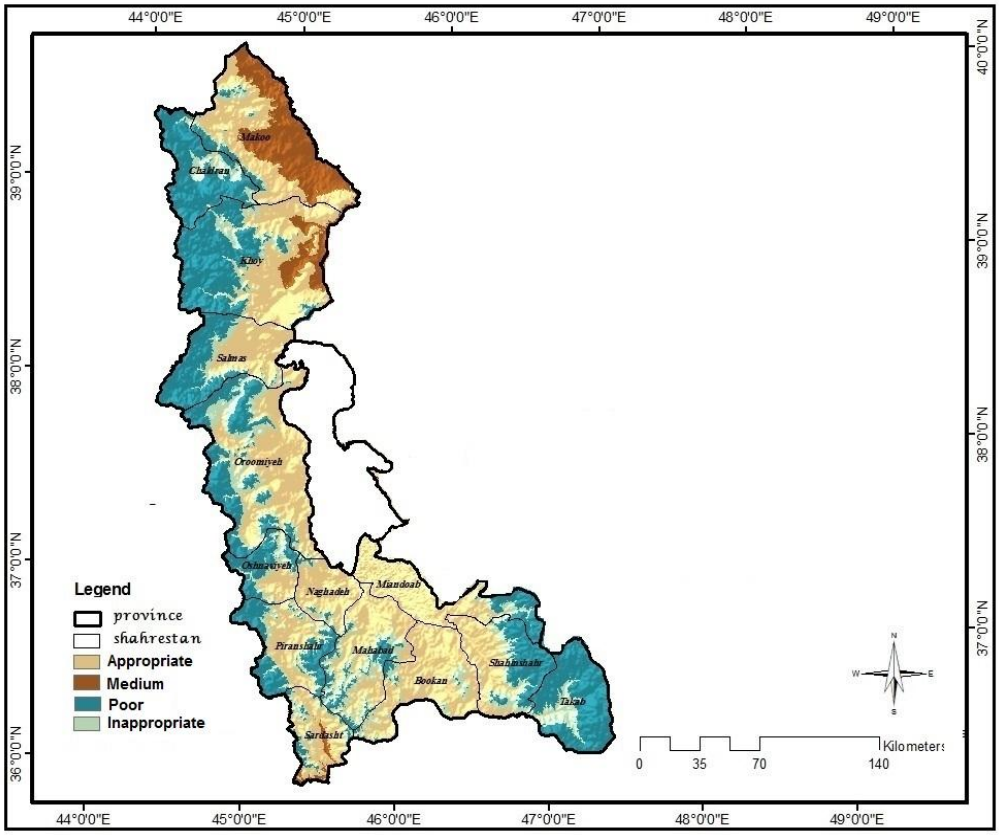

Fig. 2. The final map of suitable regions for wheat cultivation

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