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The most important of climatic parameters affecting product performance potato ardabil province using the of GIS system

Mehrdad Esfandiari*[1], S.R. Hassanpour Avanji[2], M. Shojaei Poor[1], Navid adibifard[1]

[1]*Department of Agronomy, Islamic Azad University, Karaj Branch, Karaj, Iran*

[2]*Young Researchers and Elite Club, Karaj Branch, Islamic Azad University, Karaj, Iran*

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Abstract

The present article is aimed at study on agroclimatic conditions of cultivation of potato throughout selected substations at Ardabil Province by means of GIS system. In this investigation, meteorological data have been received from synoptic stations based on daily, monthly, and annually trend from Iran Meteorological Organization (IMO) at Ardabil Province and then homogeneity of data has been explored by (Wald- Wolfowitz) Run Test. Methodology of the research is of statistical descriptive type. Data analysis was carried out by means of Growing Degree Day (GDD) technique and method of Deviation from Optimum Percentage (DOP) plus phenology index as well as thermal potential within environment of statistical software (EXCEL and SPSS). Under agroclimatic conditions, the results of this survey may indicate that the time period among July and September is considered as active months in terms of agriculture based on thermal potential in this region. The early days of May are the best calendar for cultivation of potato month in all the aforesaid substations. Time of harvesting potato crop is middle August for Ardabil, parsabad, and Meshginshahr substations while this time is early September for Khalkhal substation. With respect to the phenological method, dates of cultivation until budding, flowering, and the end of flowering stage and maturation start respectively sooner in parsabad substation than other substations in this region.

***Corresponding Author:** Mehrdad Esfandiari ✉ mehrdad.esfandiary@gmail.com

Introduction

The potential yield is the maximum yield of a given species or cultivar possible achievable under the existing conditions of solar radiation flux density, with all the other environmental factors considered to be optimal. Therefore, the potential yield is determined by the biological properties of the cultivar and radiation resources available for utilization. This yield category practically expresses the solar radiation resources for cultivating a given genotype in yield units, whereas the commercial yield is the yield attainable under existing farm conditions that takes into account all the factors limiting the production process and the crop yield. Several researches have been conducted aiming at quantifying the effects of the environment on growth, development and yield of many agronomic crops. Among the main environmental factors that strongly govern all physiological processes of the plants one should bear in mind global solar radiation flux density, air temperature, and available soil water content (COELHO and DALE, 1980). Potato yield improvements might be obtained by increasing the net daily photosynthetically radiation (PAR) through higher solar irradiance or longer photoperiod (STUTTLE *et al.,* 1996). The photoperiod duration doubles from December to June at 50ºN, while PAR increases eightfold from 2.11 to 17.01 MJ m-2 day^{-1} due to higher elevation of the sun above the horizon with lengthening days. Gross carbohydrate production on standard clear days increases from 108 to 529 kg ha-1 day^{-1} at 50ºN, whereas it remains at about 420 kg ha^{-1} day^{-1} yearround near the equator. Low solar irradiance is a yield constraint at 30 to 40ºN in winter when potatoes are grown to escape the summer heat (HAVERKORT, 1990). solar radiation flux density, and photoperiod duration. Their data extended previous observationsof reduction in photosynthesis rate under elevated temperatures. Under field conditions reduced dioxide carbon assimilation rate could not explain the yield reduction observed; the temperature effect on assimilation was not as dramatic as it was on growth or yield. Other workers have reported a severe reduction in the rate of assimilation at air temperatures above 30Cº under controlled experimental conditions. In such cases, reductions in CO2 assimilation rate were shown to correlate well with reductions in growth and yield (KADAJA *et al.,* 2004; MIDMORE and PRANGE, 1992). These contrasting results reveal the complexity of plant responses to the combined effects of water and temperature stress, which inevitably occur in association under field conditions (PEREIRA and SHOCK, 2006).

(KADAJA and TOOMING 2004) proposed a relatively simple model POMOD to calculate potato yield, which permits generalization of the knowledge in different disciplines on the potato crop yield levels, using the measured physiological, ecological, agrometeo-rological, and agronomical parameters of the plant. The input variables of the model can be divided into four groups: daily meteorological information, annual information, parameters of location and cultivar. The first group includes global radiation, air temperature, and precipitation. The location is characterized by geographical latitude and hydrological parameters.

As to the cultivar factor, the parameters of gross and net photosynthesis, the coefficients of growth and maintenance respiration, and albedo of the crop are also needed. Simulation models for potato growth and yield were proposed by many researchers all over the world and are widely described in the literature. Similarly to the potential productivity estimation model described by (VILLA NOVA *et al.* 2001) and employed by (VILLA NOVA *et al.* 2005) for sugar cane, we tested the performance of a model based on studies of maximum rates of carbon dioxide assimilation for a C^3 crop species as a function of air temperature, a fraction of global solar radiation flux density (PAR), photoperiod duration and leaf area index to estimate the potential productivity of potato crop, cultivar Itararé (IAC-5986), grown under adequate soil water supply conditions at four distinct sites of the State of São Paulo (Itararé, Piracicaba, Tatuí, and São Manuel), Brazil. In order to assess the performance of the proposed mathematical model, the estimated values of tuber yield were compared to observed productivity data under irrigation conditions for the studied sites.

The aim of this study the most important of climatic parameters affecting product performance potato Ardabil Province Using the of GIS System

Materials and methods

Data gathering

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.

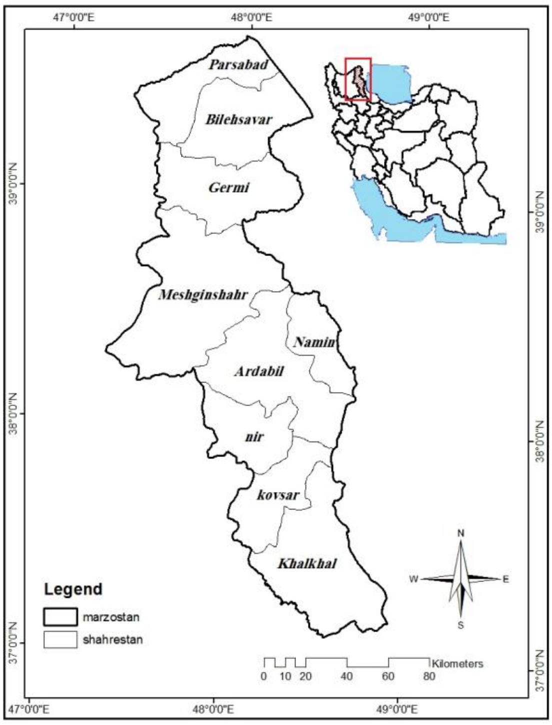

Fig. 1. Study region.

Thermal (temperature) Gradient Method

In order to explore into the studied region in terms of temperature and in relation with rate of deviation from optimum conditions at various heights or optimal time states based on height, it was required adapting thermal gradient technique to determine temperature in height of some points which lacked measurement substation. Linear regression method has been utilized to derive these temperatures. By the aid of linear regression, coefficients of temperature variance plus their height have been calculated for months of a year and total year. To compute line equation, the following formula was used:

$$(y = ax + b)$$

In this formula, y (independent variable) is the most important variable based on which it is predicted for the expected value (dependent variable) x. (a) denotes a fixed coefficient that is called intercept and (b) is slope or thermal (temperature) gradient that represents temperature loss along with height.

The following formulas are employed 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 derive the results and calculation of the above formulas, first a table is drawn for correlation among the components for selected substations and the studied time zones formed for each of them so that they will be mentioned as monthly and annual correlation elements for the selected substations.

Deviation from Optimum Percentage (DOP) technique

There are 4 phenological phases in potato plant and it has one optimum or optimal temperature per phase where its maximum growth occurs at this optimum temperature. Through identifying and determination of these optimum values for any phenological phase and mean daily temperature derived from detection of minimum and maximum daily values, one could characterize spatial optimums within various temporal intervals, particularly months of a year and in fact the points with minimum deviation from optimum conditions serve as optimal location. To achieve several spatial optimums in this method, first the optimums or optimal temperatures were determined and then by considering daily statistical mean values, derived difference from the given values about optimum point was computed and at next step, the rate of deviation from optimum conditions were acquired for the above-said locations and their results were identified as tables.

Thermal coefficient method or sum of Growing Degree Day (GDD)

With respect to importance that is attached to temperature cumulative units (degree/day) in identification and topology of appropriate regions for potato cultivation and determination of cultivation and harvest dates for this crop based on the given thresholds, Growing Degree Day (GDD) technique has been adapted for this purpose. The above data were processed and analyzed by means of functions in Excel software. In this investigation, the active method (GDD) was used among the common techniques for approximation of thermal units. There are two major techniques for summation of temperature as follows:

Sum of effective and active degree day method where sum of active degree day technique has been employed in this study.

a) Sum of active degree day technique

Phenology or know ledge of phenomena is one of the scientific topics in ecology in which plant's life cycle, which ranged from time of germination to permanent hibernation, is explored. With respect to climatic variations, especially temperature and soil moisture, dates of start and termination points for each period may differ in several years. To temperature, all diurnal temperature values (without subtracting base temperatures) and during active germination days are added.

The calculation formula is as follows:

(eq.3)

$$\frac{TMin+TMax}{2} \quad if \quad \frac{TMin+TMax}{2}=Tt$$

Where in this formula, T_{max} and T_{min} are the maximum and minimum daily temperatures and T_t is biological temperature in this equation. In method of sum of active degree day, which has been also used in this research, sum of daily temperature degrees was used with positive values, but they have been used only for those days in which mean temperatures were higher than biological threshold or biological zero point. All values with quantities greater than 10C° will be calculated while the values with less than 10C° will be excluded from this computation.

b) The method determining interval within the stages in phenological studies

To improve efficiency and properly use from irrigation and implementation of farming operation at any phase of growing the potato plant, the needed planning may be executed for growth of crop with determination of the necessary period for both phenological phases based on statistical daily temperature and indentifying interval in the given stage. For this reason, the following formula is used in order to determine the necessary time interval between two phenological phases or (inside stage) based on min temperature:

(eq.4)

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

n denotes the needed time between two phenological phases, (A) is thermal coefficient for its completion at the given step, (B) as biological threshold of crops, and (T) is daily temperature.

Findings

Analysis of Deviation from Optimum Percentage (DOP)

Potato plant includes four phenological phases, which are important from agroclimatic point of view and reviewed in this investigation. These stages in potato are as follows: Cultivation till budding, flowering, end of flowering, and total maturation. Any phase includes an optimum or best temperature in which the plant may grow at max level in this optimal temperature. In order to conduct phenological study on potato and with respect to the executed investigation, the mid- matured varieties of this crop with the most frequency were considered as base crop. Table (1) shows the rate of deviation from optimum conditions at any phenological stage based on mean daily temperature throughout the selected substations. With respect to derived results from the following table for potato plant at flowering stage, compared to other substations, Ardabil station has the min deviation with higher optimal conditions. Then Meshginshahr, substations have less deviation from this condition. As a result, compared to other substations, Ardabil station has less deviation from optimum status and this means that the aforesaid station possesses optimal conditions for cultivation of potato.

Table 1. Determining deviation from optimum conditions at phenological phases in potato in selected substations.

Growth phases Substation	Cultivation to budding		Flowering		End of flowering		Total matured		Sum of deviations
	Opti-mum	Deviated from conditions	Opti-mum	Deviated from conditions	Opti-mum	Deviated from conditions	Opti-mum	Deviated from conditions	
Ardabil	15	-7.44	20	-3.32	20	-7.70	18.5	-6.98	-25.44
Meshginshahr	15	-8.89	20	-6.06	20	-7.40	18.5	-6.72	-29.07
Khalkhal	15	-10.08	20	-8.55	20	-9.65	18.5	-7	-35.28
parsabad	15	-8.87	20	-7.55	20	-7.30	18.5	-7.09	-30.81

2 The rate of deviation from optimum conditions based on height

Thermal (temperature) gradient

In order to review on rate of deviation from optimum conditions at various heights or spatial optimum conditions based on height, initially coefficients of variance for daily temperatures in respect of height have been calculated for months of a year and total year by means of linear regression technique. To derive the given results and computation of above formulas, firstly correlation elements table was made for the selected substations and in all studied time intervals and a summary of its results has been illustrated as annual correlation elements for the selected substations in Table (2).

Benefitted from regression formula, we calculated thermal gradient table, which denotes status of variable of daily temperature in several heights and moths of a year in Excel software environment and by means of the given linear regression regarding the relationship among rate deviation from optimum conditions at any phenological phase and all of its stages and drew its diagram. Due to high R^2, zoning operation became possible in GIS environment.

Table 2. Annual correlation elements of Ardabil province selected substations during phenological phases (Thermal gradient) for potato.

Period / Coefficients	Cultivation to budding phase	Flow-ering	End of flowering	Matu-ration
B	0.001	0.009	0.004	0.002
A	6.22	4.85	4.65	3.8
R	0.55	0.76	0,34	0.51

Results of phenology

Application of thermal coefficients in farming issues and codification of a farming calendar in various regions is crucially important. Despite of the absence of phenological primary studies in this field at large scale and with benefitting from the agroclimatic studies conducted by quanta engineers and through cooperation with Romanian advisors and employing their used techniques, active degree days and determination of the intervals within phenological stages are explored based on various thresholds.

Temporal optimum based on method of active degree days

Active temperature degrees are one of the other agroclimatic methods for determination of optimum times based on the date of latest min threshold events at any phenological stage (potato) that has been used in this investigation. Sum of daily temperatures was used with positive values but only for those days with temperatures, which are higher than average biological level or zero degree of activity. In this study, the basis point for calculation of active thermal coefficients is determined based on two modes: One is based on the min thresholds of the plant (potato) at each of phenological stages and the latter is zero point (0C°). Given these plant species extremely depend on temperature so statistical daily temperature has been used as min and max detection data for phenology of plant species (potato). Date of completion for each of phenological stages has been determined with identifying accurately each of thresholds in plant's phenological phases (potato) and daily temperatures. Date of the min biological threshold event was considered more than 15C° to activate the plant (potato) in each of substations. With respect to Table (3), date of cultivation until budding, flowering, end of flowering, and maturation of potato crop start sooner respectively in Meshginshahr, and Ardabil substations than other stations. Given the related Table (3), date of cultivation until budding, flowering, end of flowering, and maturation of potato plant begin earlier correspondingly in Meshginshahr and Ardabil substations than other stations.

Table 3. Date of completion of phenological stages in potato plant.

Substation	Height	Date of minimum threshold event	Cultivation until budding	Flowering	End of flowering	Total maturation
Meshginshahr	1485	4st April	15th April	16th June	16th July	22^{h} August
Ardabil	1365	3st April	13th April	13th June	11th July	20th August
parsabad	75	28th April	11th May	12nd June	8rd July	25th August
Khalkhal	1806	12st May	30th May	25th June	22th July	26th August

The date of completion for each of phenological stages is considered as the appropriate method to determine the best cultivation time (potato) based on its vital thresholds. The acquired dates are complied with temporal optimums.

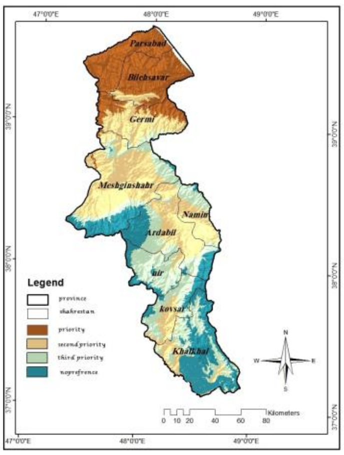

Fig. 2. Total deviation from the optimal conditions for potato.

The appropriate regions for types of cultivation (potato)

Based on agro climatic analysis, the best cultivation calendar (of potato) are respectively Center, and east and northeast areas at this province.

Conclusion

Whereas one of the important problems in modern world is production of more foods and nutrients with higher quality and since producing agricultural crops and capabilities of any region depend on its weather and climatic and ambient specifications thus it is crucially important to study on the effective meteorological and environmental on agriculture. Today, It is deemed as a secured and undeniable platform for accurate development of agriculture. In terms of agroclimatic aspect, potato is considered as one of active monthly agricultural crops based on thermal potential method from June to mid October in this region. According to agroclimatic analyses, the best cultivation calendar belongs to the optimal cultivation calendar for potato plant in all substations at the early of may. Potato is harvested in Ardabil, Meshginshahr, and parsabad in end August while it is harvested in Khalkhal substation at mid September. With respect to phenological method, dates of cultivation up to budding phase, flowering stage, end of flowering, and maturation of potato plant start sooner respectively in Ardabil and Meshginshahr than in other substations. In Ardabil substation, potato has the less deviation and more optimum conditions than other substations at total maturation stage. After Ardabil, Meshginshahr and Khalkhal stages have less deviation while compared to other stations, parsabad substation has more deviation; as a result, in comparison with other substations, Ardabil substation has less deviation from optimum conditions; namely, this substation possesses optimal conditions for cultivation of potato.

References

Coelho dt, Dale rf. 1980 An energy-crop growth variable and temperature function for predicting corn growth and development. Planting to silking. Agronomy Journal, Madison, v.**72**, p.503-510,.

Haverkort aj. 1990 Ecology of potato cropping systems in relation to latitude and altitude. Agricultural Systems, Amsterdam, v. **32**, p.251-272,.

Kadaja J, Toominc, H. 2004. Potato production model based on principle of maximum plant productivity. Agricultural and Forest Meteorology, Amsterdam, v. **127**, p.1-16.

Midmore dj, Ppange rk. 1992. Growth responses of two Solanum species to contrasting temperatures and irradiance levels: relations to photosynthesis, dark respiration and chlorophyll fluorescence. Annuals of Botany, London, v.**69**, p.13-20.

Pereira ab. Shock cc. 2006. Development of irrigation best management practices for potato from a research perspective in the United States. Sakia.org e-publish, Australia, v.1, p.1- 20,. Available on-line at http://www.sakia.org/.

Stuttle GW. Yorio NC. Wheeler RM. 1996. Interacting effects of photoperiod and photosynthetic photon flux on net carbon assimilation and starch accumulation in potato leaves. Journal of the American Society of Horticultural Science, v.**121**, p.264-268,.

Villanova NA. Santlago AV. Rezende FC. 2001. Energia Solar. Aspectos físicos de captura pela biomassa. Piracicaba: Departamento de Ciências Exatas/ ESALQ/USP,. 20p.

Villanova NA. Pilau FG. Dourado neto D. Manfron PA. 2005. Estimativa da produtividade de cana-deaçúcar irrigada com base na fixação de CO2, radiação solar e temperatura do ar. Revista Brasileira de Agrometeorologia, Piracicaba, v.**13**, n.3, p.405-411.

Urhausen S, Brienen S, Kapala A, Simmer C. 2011. Climatic conditions and their impact on viticulture in the Upper Moselle region. Clim Change, doi:**10**.1007/s10584-011-0059-z

van Leeuwen C, Friant P, Chone X, Tregoat O, Koundouras S, Dubourdieu D. 2004. Influence of climate, soil, and cultivar on terroir. American Journal of Enology and Viticulture **55**:207–217

Webb LB, Whetton PH, Barlow EWR. 2007. Modelled impact of future climate change on the phenology of winegrapes in Australia. Aust J Grape Wine Res **13**,165–175