Biological Forum – An International Journal **7**(1): 512-517(2015)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effects of Changes in Temperature and Rainfall on Potato Cultivation in South Khorasan Province using the Model LARS

Seyed Mohammad Mahdi Torabi* and Amir Hossein Halabian**
**Ph.D. Student of Agronomy, lslamic Azad University, Tabriz, IRAN*
***Assistant Professor, Department of Geography, Payam Noor University, Tehran, IRAN*

(Corresponding author: Seyed Mohammad Mahdi Torabi)
(Received 12 January, 2015, Accepted 04 March, 2015)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Needs of human life from the beginning has been a very important factor. Currently threatened by population growth, food security and good human beings with new science and technology plan to maintain their food security and the better it will work. In this investigation, meteorological data have been received from synoptic stations based on daily, monthly, and annually trend from Iran Meteorological Organization (IMO) at South Khorasan 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 within environment of statistical software (EXCEL and SPSS). Under agro climatic conditions, the results of this survey The early March to the late April are the best calendar for cultivation of potato month in all the aforesaid stations. Time of harvesting potato crop is Early August to the late September. 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 Ghaen substation than other stations in this region. The average annual temperature change results in model LARS WG South Khorasan shows an increase of 1.12C° That this increased temperature does not affect the cultivation autumnal canola plant. The results showed that the mean rainfall in the study area will have reduced of about 8.23 mm this reduced rainfall reduced canola yield in the region

Keywords: Agro climate, potato, DOP, Phenology, LARS-WG, South Khorasan

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 50°N, 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 50°N, whereas it remains at about 420 kg ha^{-1} day^{-1} year round 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 observations of 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 30°C under controlled experimental conditions. In such cases, reductions in CO_2 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, agrometeorological, 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 C3 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 Influences of temperature and rainfall climate in the cultivation of potato in South Khorasan province.

MATERIALS AND METHODS

A. Data gathering

Each scientific research 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, minimum and max daily temperature parameter of 2011-2001 period in South Khorasan region have been used.

B. 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: $y = b + ax$

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:

$$a = \frac{\sum(y)\sum(X^2) - \sum(x)\sum(xy)}{N\sum X^2 - (\sum X)} \qquad (1)$$

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

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.

C. 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.

D. 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:

$$\frac{TMin + Tmax}{2} \quad \text{If the} \quad \frac{TMin + TMax}{2} > =Tt \qquad (3)$$

Where in this formula, T_{max} and T_{min} are the maximum and minimum daily temperatures and *Tt* 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 10°C will be calculated while the values with less than 10°C 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:

$$n = A/(T-B) \qquad (4)$$

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.

E. Model introduction

General circulation models can provide the best information with atmosphere response to focus on increasing greenhouse gases. Now, the most valid tool is atmosphere-ocean general circulation model(AOGM) for producing climatic scenarios. These models depend on basis of physical values which are presented by mathematic relations. In order to simulate earth climate, main climatic processes (atmosphere, ocean, earth surface, crust of ice and biosphere) in separated secondary models are coupled and they form models of AOGCM. These models are performed in different centers which some of them include: CSIRO-MK2 model in CSIRO research center of Australia, HADCM3 and HADCM2 models in HCCPR research center in England, CGCM1 and CGCM2 models in CCMA center in Canada, GFDL-R15 model in GFDL center in America, IPCM4 in France, INCM3 in Russia and CCSR and NIES models in Japan are done in center with the same name (IPCC, 1996).

Important inputs of AOGCM models are amount of emission greenhouse gases in future periods. IPCC already presented different scenarios that SRES is the newest one. Each one of sub-SRES scenarios are related to one of B2, B1, A2, and A1 groups. In A1 family, emphasis is on rapid economic growth and population growth to middle of century and then it's reducing and introducing new and efficient technologies. Family of A1scenario divides development into 3 groups for changing technology in energy system which includes fossil energy (A1F1),non-fossil energy resources (A1T) and balance in all resources(A1B).Generally, It can be said that scenarios of A family have pessimistic scenarios and scenarios of B family have optimistic scenarios and AB scenarios have middle station. In this research, we compare 3 atmosphere general circulation models (INCM3, IPCM 4 and HADCM3).

By using B1, A2 and A1B emission scenarios are considered future climate of region to determine the best atmosphere-general circulation model and emission scenario for region.

Data of this research include daily data of min temperature, max temperature, rainfall and radiation of studied station from establishing time to 2012.

RESULTS

A. Analysis of Deviation from Optimum Percentage (DOP)

Potato plant includes four phenological phases, which are important from agro climatic 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 stations. With respect to derived results from the following table for potato plant at flowering stage, compared to other stations, Ghaen station has the min deviation with higher optimal conditions. Then Ferdos, stations have less deviation from this condition. As a result, compared to other stations, Ghaen station has less deviation from optimum status and this means that the aforesaid station possesses optimal conditions for cultivation of potato Table 1.

B. 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 stations and in all studied time intervals and a summary of its results has been illustrated as annual correlation elements for the selected stations 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 1: Determining deviation from optimum conditions at phenological phase in potato in selected stations.

Growth phases Substation	Cultivation to budding		Flowering		End of flowering		Total matured		Sum of deviations
	Optimum	Deviated from conditions	Optimum	Deviated from conditions	Optimum	Deviated from conditions	Optimum	Deviated from conditions	
Ghaen	15	-6.44	20	-4.32	20	-8.70	18.5	-7.98	-27.44
Birjand	15	-7.89	20	-5.06	20	-7.40	18.5	-8.72	-28.07
Ferdos	15	-7.87	20	-4.55	20	-7.30	18.5	-8.09	-27.81

Table 2: Annual correlation elements of South Khorasan province selected stations during phenological phase (Thermal gradient) for potato.

Period / Coefficients	Cultivation to budding phase	Flowering	End of flowering	Maturation
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

C. 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.

D. Temporal optimum based on method of active degree days

Active temperature degrees are one of the other agro climatic 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.

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

station	Cultivati nuntil budding	Flowering	End of flowering	Total maturation
Ghaen	10 March	10 June	16 July	10 August
Birjand	34 April	29 June	25 July	21 August
Ferdos	11 March	13 June	11 July	15 August

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 (0°C).

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 15°C to activate the plant (potato) in each of stations. With respect to Table 3, date of cultivation until budding, flowering, end of flowering, and maturation of potato crop start sooner respectively in Ghaen, and Ferdos stations than other stations Table 3. 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.

E. The appropriate regions for types of cultivation (potato)

Based on agro climatic analysis, the best cultivation calendar (of potato) are respectively Northern, and North West areas at this province Fig. 1.

F. GTM model

GTM model can provide the best information with atmosphere response to increasing greenhouse gases' focus. In this research, by using exit of GCM models under emission. Scenario of B1, A2 and A1B of province climate evaluated.

As seen in shapes 1 to 6, rainfall and observed temperature of stations are compared with rainfall and produced temperature by LARSE-WG under GCM models (3 models of HADCM3, INCM3, and IPCM4) and different scenarios of emission.

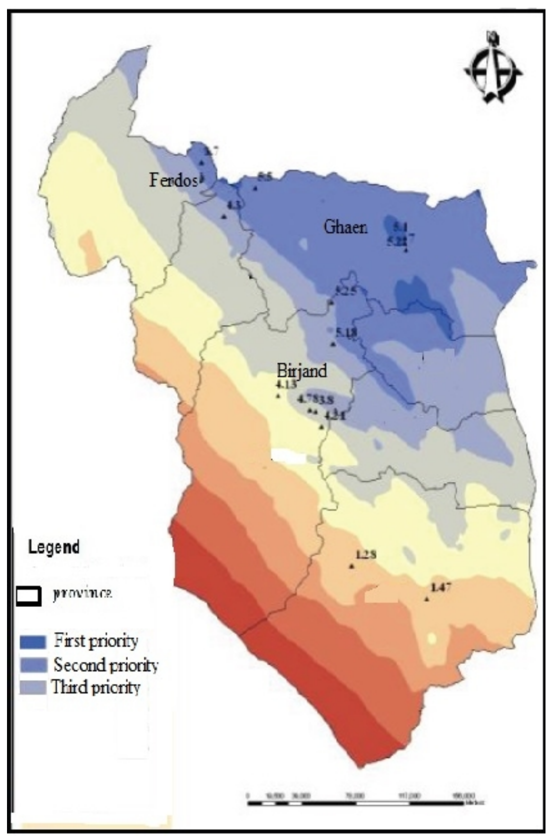

Fig. 1. Total deviation from the optimal conditions for potato.

For better conclusion, weight of each model is determined and finally mean of all models are determined with each weight Interference (Ensemble). In present research, mean of all models is used by noticing at their weight for producing climatic elements by surveying different climatic models and different scenarios and determining weight of each model that results of temperature increasing are obtained 1/12 centigrade. Rate of daily rainfall of surveyed stations is computed in period of 2011-2039 by using LARSE-WG model and GCM models. It has more weight among different models and scenarios of HADCM3 model with B1 emission scenario in South Khorasan stations and HADCM3 with A2 scenario. So it is more suitable for producing future rainfall. This model has better coincidence for models' mean. Results of these models South Khorasan, annual rainfall rate in 2011-2039 periods in comparison with statistical period (1988-2010) that has decreased to 8/23 centigrade.

CONCLUSION

The identification of the relationships between climatic variables and crops produced by farming are economically and socially crucial to each region. In most regions, main agricultural crops are traditionally produced by relying on experience without any proper consideration so that bio-climatic needs neglected by farmers; thus, their performance may decrease and ultimately result in the loss of climatic facilities. Therefore, accurate identification of climatic needs of plants and cultivation of such crops in an appropriate region can play a crucial role in utilizing optimal bio-climatic conditions. If we can identify appropriate regions for cultivating agricultural crops considering required temperatures and moisture content, we'll achieve higher levels of utilization of the land and promote economic growth of our farmers as well as national income levels. Under agro climatic conditions, the results of this survey The early March to the late April are the best calendar for cultivation of potato month in all the aforesaid stations. Time of harvesting potato crop is Early August to the late September. 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 Ghaen substation than other stations in this region. . The average annual temperature change results in model LARS WG South Khorasan shows an increase of 1.12°C. That this increased temperature does not affect the cultivation autumnal canola plant. The results showed that the mean rainfall in the study area will have reduced of about 8.23 mm this reduced rainfall reduced canola yield in the region

REFERENCES

Coelho DT, Dale RF. (1998). 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. and 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 CO_2, 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.