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Original Research Article

Effects of climatic factors on the geography of agricultural production (Wheat Case Study)

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Abstract

The investigation of fluctuation climate on agriculture products is in the field of meteorology. Climatic elements including precipitation, temperature, and humidity are among parameters that have important effects on agricultural activities. Therefore investigation of climatic elements in different geographical areas is very important. The main objective of this study is the investigation of the Impact of climate parameters on yield of wheat in Roshtkhar. The SPSS software has been used to analyze date. The results obtained showed reduced yield in recent years the city has Roshtkhar. Correlation coefficients showed a significant relationship between climate factors and yields of wheat. Wheat moisture performance was more significant.

Keywords: Climate, Solidarity SPSS, Wheat

INTRODUCTION

The stability of agricultural production is one of the most important aspects of sustainable agriculture. The climate and soil are among the most important factors of production and exploitation of land is mainly based on the quality of these two factors (Mirza Bayati, 2004).

Climate is among the main and decisive factors determining the agricultural geography (Koochaki and Khazanedari, 1997) and it is also the main determinant of global agricultural models (David Greek, 2009).

Agricultural production is highly correlated with annual precipitations and good climatic conditions. However, the climate is the only source that a man can use to any amount with paying no fees. In our country, due to very limited rainfalls, the overwhelming heat in summer and extremely cold temperatures in winter, the climate plays a special role in agricultural productions (Khayatzade Mahani, 2006). Among the great achievements in the field of breed, technology, irrigation, pest and weed control, and biotechnology, the climate has still remained as a major and determinant factor in agricultural geography (Koochaki and Khazanedari, 1997). Generally, agricultural planning associated with planting, growing and harvesting, controlling the pests and diseases, etc. will have little success without understanding the impact of and controlling the climate nature (Kaviani and Alijani, 2001).

Awareness of the right time of planting, growing and harvesting of garden and agricultural crops and identifying the climatic indicators make it possible for planners to think about the appropriate allocation of resources to different crops. Study of climate and environmental factors in determining the agricultural and gardening crop species of each region has become an essential matter. Today, agricultural management and increased production per unit area require optimal utilization of natural resources and further knowledge about these resources (Noori, 2004).

The climatic conditions such as light intensity, temperature, rainfall, wind speed, air humidity and their changes are the main factors that determine the type of

plants that are capable of growing and developing in a certain region. In order to grow farming and gardening products of a particular area in a certain region, we should inevitably carry out a detailed study of the weather conditions of the region (Mousavi Bayegi and Ashraf, 2009). Currently, the agricultural sector is one of the most important economic sectors of a country, to the extent that it can be said that a country's economic growth is not possible without increased agricultural growth. Since each agricultural crop requires certain climatic conditions and its growth is possible only within certain limits, among the factors affecting agricultural production, climate conditions are among the most important natural variables that even on a small scale and with spending high costs, the man is not able to control them. Inattention of farmers and agricultural specialists to the climate, causes great damages to the agricultural crops. The evidences of these effects can be annually found as frostbite, heat exhaustion, frost, etc. (Naseri, 2000).

Wheat is among the most important agricultural productions that in addition to providing the main food of human, it can be used to feed the birds and some domestic animals. It is also used in some industrial plants. Its stems and chaff can be used to provide the bedding for the livestock and can also be used in manufacturing paper and as ceiling cover of buildings and in most villages, it is used as fuel and even for feeding the animals and strengthening the farm lands. It plays an important role in agricultural, industrial and commercial employment (Khodabandeh, 1998).

In Iran, wheat is considered as one of the strategic agricultural products that due to supplying the main food for humans and livestocks, it is particularly important (Khosravi and Torkamani 2000).

Statement of the problem

Climate is one of the most important factors considered by the mankind throughout his history. The reason is the important role of climatic elements on human life and especially on agricultural products (Alijani, 2005).

In Iran, due to restrictions such as heavy rainfall, frost, rainfall fluctuations etc., the knowledge of climate plays an important role in agricultural success. Correct understanding of climate conditions of each region can help the farmers in timely planting and meeting the plants requirements during the growing season and thereby can help to develop the quantity and quality of agricultural products.

Today, there are concerns about climatic changes caused by human activities. Because, climate changes have impacts on agricultural productions and in the future, the climate changes will be considered as one of the influential factors of agricultural production (Hoodguest et al, 2000). The phenomenon of drought and wet years has been passed on from one generation to the next for many years. In today's life, in spite of all the advancements of human in technology, production and modification of all agricultural crops, the weather is still among the factors that have remained largely uncontrollable. Infection of plants to pests and diseases is also subject to weather conditions. The plant has also critical steps toward climate factors such as cold, heat, humidity, wind, etc. Knowledge of these steps in agricultural plants allows for appropriate decision making for timely farming operations (Kafi et al, 2000).

Wheat is the most important crop on earth. It is well known that every day, wheat is planted in some part of the earth and it is harvested at some other part, on the same day. This implies the very high adaptation capability of the plant to various climates. Globally, nearly 52 percent of the world's arable lands are devoted to growing cereals (Emam, 2005).

Due to creating employment and income in the world and particularly in developing countries, wheat cultivation is important. Wheat not only plays a very important role in feeding the human, but its grains are used to feed birds (poultry, etc.), for industrial applications (making papers, roof covers of buildings, etc.). Its stalks and chaff are used for livestock bedding, animal feed, boosting agricultural lands and medicinal purposes (production of various vitamins from the bran, etc.) (Khodabandeh, 1998).

Roshtkhar is located at an altitude of 1141 meters above sea level, between 34° 30' to 35° 13' northern latitudes and 59° 30' to 59° and 55' eastern longitudes. It is located in the central regions of Khorasan Razavi and has a dry climate. Its vast plains have provided favorable conditions for agriculture which is the main economic activity of the town. Therefore, during 2010-11, from a total of 31,606 hectares of infield lands in Roshtkhar, 13,500 hectares have been devoted to wheat cultivation (Jangi, 2012).

Given the dry climate of the region and the adaptability of the crop to the climatic and soil conditions of the region, it is the most important crop in the Roshtkhar region, so that it has the first rank among the crops produced by the town. It is therefore important to examine role and importance of climate in its production.

Research questions

1- What are the main climate factors affecting on irrigated wheat yield?

2- Do climate parameters have made changes in the rate of irrigated wheat yield of the town?

Research hypotheses

1- It seems that among the climate factors, the parameters of humidity, rainfall and temperature have the greatest effect on the yield of irrigated wheat.
2- It seems that in the last few years, major changes have occurred in the rate of irrigated wheat yield.

Research objectives

Defining a good research design will enable researchers to spend the least money for solving the concerned problems, objectively and accurately (Nabavi, 1995).

The overall goal of this research is to understand the existing opportunities and potentials of the region, so that with the knowledge about these features and proper planning and by raising the awareness among farmers toward agricultural development and finally the sustainable development of the region, the appropriate context is provided for the wheat cultivation in the suitable conditions of the region. Therefore, in addition to increasing economic productivity, employment, providing income and improving the social situation, it can prevent the migration of villagers. The overall objective of this research was providing an appropriate design and solution that can play a more effective role in the agricultural development of the region.

Research Background

In order to achieve the purpose of research, awareness and understanding of the background of the problem seems essential and necessary; because it makes the research and its contents clearer. Literature review by researchers could be important in several ways. Because, the authors carry out the research to assess the feasibility of its scientific application (Moulazadeh, 1998).

Nassabian and Sadralashrafi (2004) evaluated the effects of rainfall and temperature on the yield of strategic agricultural products. The results showed that the yields of irrigated wheat, potatoes, and irrigated cotton have the most reactions for a temperature rise equal to a Celsius degree in the provinces of Lorestan, Fars, Zanjan, Kermanshah and Khorasan, respectively. And the provinces of Khorasan, Fars, Zanjan and Kermanshah have the highest response for one millimeter rainfall increase.

Using Zicardian method, Vaseghi and Ismaili (2008) examined the economic effect of climate change on agricultural sector of Iran (Case study: Wheat). The results showed that an increase in temperature and decrease in rainfall will cause 41 percent reduction in the yield of wheat in the country up to next 100 years.

Zarrin and Farajzadeh (2002) modeled the wheat yield with regard to climatic and agricultural parameters in Western Azerbaijan and obtained the analytic functions of wheat yield for the area.

Using stochastic production function, Karbasi and Nodehi (2003) examined the effect of using inputs on production risk of wheat growers of Neishaboor. Results showed that fertilizer, the value of consumed seeds and the cost of machineries had a positive and significant effect on wheat production. Lamason (1974) studied the effects of rainfall fluctuations on agriculture success in eastern Montana. The results showed that the possibility to obtain a high yield in this area is once every 23 years while the complete destruction of the yield resulting from drought can be expected once every seven years.

Different climates of irrigated wheat and their recommended cultivars

There are different planting dates for different climates of the country. But wheat planting period in dry and hot climatic conditions of Roshtkhar region is from November 11th to December 21st and the best time is first half of December. The number of seeds used is 350-400 seeds per square meters and commonly early spring wheat is used for this purpose. Currently, land and bedding preparation for dry and hot areas is the same as land preparation for temperate climates. (Table 1)

Location and extent of the study area

The province of Khorasan Razavi with an approximate area of 127,600 square kilometers covers 7.7 percent of the total area of Iran. The Province is located between 34° to 38° northern latitudes and 57° to 61° eastern longitudes. Roshtkhar is a town of Khorasan Razavi Province located at a distance of 190 kilometers from the Capital of the Province (Mashhad). Roshtkhar has an approximate area of 3598 square kilometers and located between 34° 30' to 35° 13' northern latitudes and 59° 30' to 59° 55' eastern longitudes and its height from sea level is 1141 meters (Rahmanipour, 2013).

Figure 1 shows that the neighboring cities of this town are Dolat Abad Zaveh and Torbat Heidarieh to the north

Table 1. The relationship between performance and pre-season rainfall (mm). (Koochaki, 1985)

More than 199 mm	150-199 mm	100-149 mm	Less than 100 mm	Amount of rainfall
945	670	520	240	The average yield (kg/ ha)
4	9	8	0	the years with a yield of 650 kg per
~~4~~	~~17~~	~~20~~	~~9~~	hectare to the total number of years

Figure 1. Location Map of Roshtkhar in Khorasan Razavi province

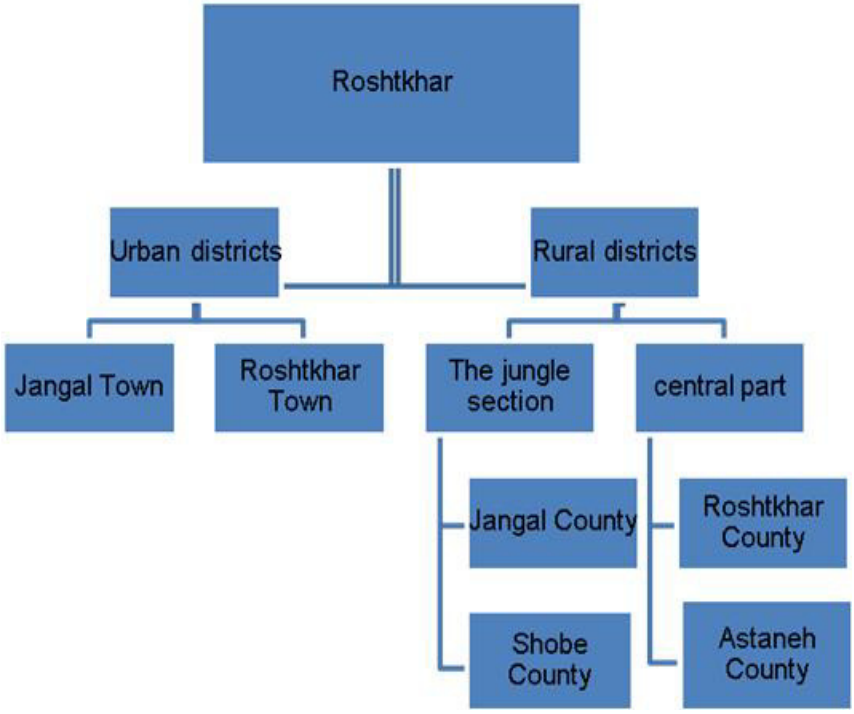

Figure 2. The pyramid of town separated into districts and counties

and northeast, Mah Velat to the west, central part of Gonabab to the south and southwest and Salami, Zuzan plain and central regions of Khaf to the south and southeast (Roshtkhar Statistical Yearbook, 2009).

According to Figure (2) and (3), it can be seen that the town has 70 villages, farms and rural areas in two districts and four counties.

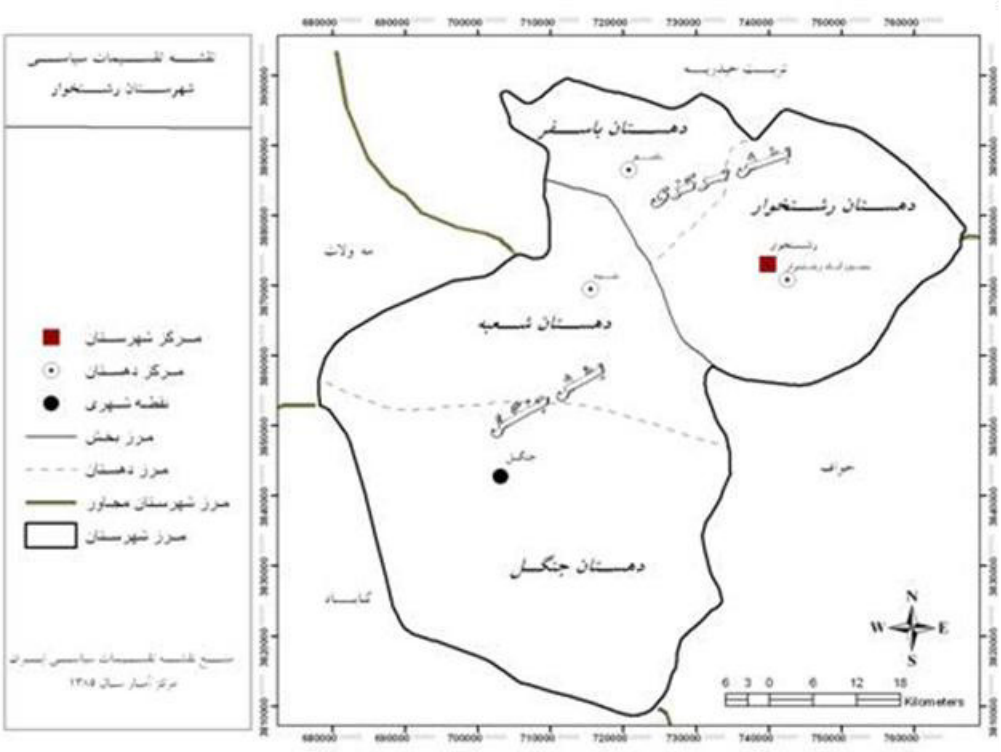

Figure 3. The map of the political subdivisions of Roshtkhar

Roshtkhar climatic parameters

Given that the climatic data were essential for the study and the necessity of using various and multiple parameters affecting the growth and yield of wheat required the use of synoptic stations, due to lack of such stations, the data of three stations of Torbat Heidarieh, Malek Abad and Khaf were inevitably used. The specifications of studied meteorological stations are presented in Table 1.

First, according to data gaps of Khaf station, Torbat Heidarieh synoptic station was considered as the reference station and using differences and ratios, statistical gaps of Khaf were filled.

To correct the suspicious data or filling the blanks in the statistical data set, the differences method was used for temperature, and the ratio method was used for precipitation and relative humidity.

RESEARCH METHODOLOGY

For data analysis, we evaluated the position and extension of agricultural lands of the study area and identified the yield of agricultural crops, including cereals (irrigated wheat). Then the cultivars were recognized. Given that in the past, there was much raining in the region and the weather was suitable for growing crops, the farmers had no problem with the cultivars and the land was ready and suitable for cultivation of any type. But in recent years, due to the changes in the type of precipitation and climate of the region, the authorities have decided to conduct research about the current changes and conditions. Therefore, among the adaptable cultivars for the climate of the region (used since 2010-11) that had high protein content, we can mention to Zare, Pishgam and Orum cultivars.

Then, the cultivated acreages of agricultural crops were compared for the town among which the most cultivated area is devoted to irrigated wheat and the dominant cultivation in the region occurs in winter. Also, changes in cultivated area and irrigated wheat yield of the town was determined for the statistical period (2002-2011) and provided as some curves. And finally, we investigated the relationship between the mean humidity, rainfall and temperature with yield of irrigated wheat. This means that the 10-year data of irrigated wheat yield and the restored data of the climate were fed into Excel for

Table 2. Specifications of meteorological stations

Malek Abad	Khaf	Torbat Heidarieh	Station specifications
Measurement of evaporation	Synoptic	Synoptic	Type of station
35-80	34-35	35-16	Latitude
59-23	60-90	59-13	Longitude
1196	998	1450	Height from sea level

Table 3. Cultivated area, production and yield of wheat in Roshtkhar during the 2009-10 agricultural year

Yield (ha/km)			Production (ton)			Cultivated area (Ha)			Agricultural crop	
Rain fed	Irrigated	total	Rain fed	irrigated	total	Rain fed	irrigated	Name of the crop	Type of crop
400	3200	44680	1480	43200	17200	3700	13500	wheat	cereals

Reference: Simaye Keshavarzi of Roshtkhar, 2009

Table 4. The cultivated area and agricultural production rate of the town separated into two categories of irrigated and rainfed crops for 2009-10 farming year

Yeald (Kg/ha)	Production (ton)	Cultivated land (Ha)	The type of crop	row
3200	43200	13500	Irrigated wheat	1
3700	10360	3950	Irrigated barley	2
2603	18578	10100	cotton	3
31000	66030	2130	Sugar beet	4
30000	9000	300	Onion	5
10	-	4500	Saffron	6
8	3200	4000	Rainfed wheat	7
850	2125	2000	Rainfed barley	8

analysis. Then, Spss was used to assess the impact of climatic parameters on the yield to determine which parameters have the greatest impact on the yield. Based on restored statistics for Roshtkhar in Tables of Appendices (3-2-1) and agricultural statistics provided by Agricultural Jihad of Khorasan Razavi province in Table of Appendix (7) and using Spss, some diagrams were plotted and in these diagrams, the coefficient of determination (R2) and their correlation values were also specified. (Table 2)

The most important areas of the town in terms of growing irrigated wheat are the villages of Astaneh, Roshtkhar, Shobe and Jangal. Rainfed wheat is also cultivated in certain lowland and mountainous areas with good rainfalls.

October is mostly the season for wheat cultivation in the town and the harvest begins in late June and early July. There is also a spring cultivation of wheat which usually happens in late March and according to the yearly rainfalls. Wheat production is mostly of the irrigated kind. If the rains are good, rainfed cultivation is also carried out and given the low cost of production, it is economical. It should be mentioned that the quality of rainfed wheat is much more than the irrigated wheat for baking breads. (Table 3)

Table (4) and the diagram of Figure (4) show that the town's most important crops are wheat, barley, cotton, saffron, sugar beets and onions. 13,500 hectares of lands are allocated to irrigated wheat and the dominant cultivation season in the region is winter. However, 4000

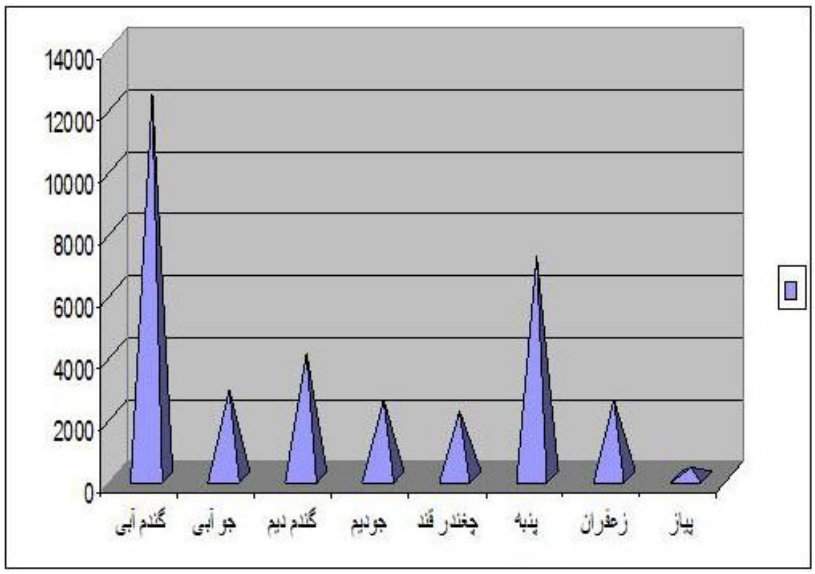

Figure 4. Comparing cultivated area of agricultural crops in Roshtkhar

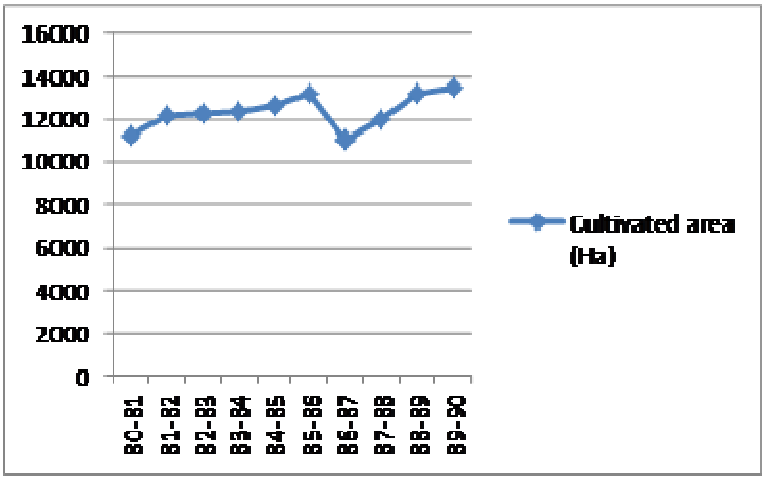

Figure 5. Changes in cultivated area and production of irrigated wheat in Roshtkhar (statistical period of 2002-2011

hectares of lands are allocated to rainfed wheat cultivation.

Therefore, most of the produced wheat of the region is of the irrigated kind.

According to the diagram of Figure (5), it is concluded that in 2007-2008 farming year, the wheat cultivated area was reduced to 11000 hectares which shows a reduction of 2100 hectares compared to the its precedent year and the year 2010-11 farming year has had the greatest increase with a cultivated area of 13,700 hectares.

Figure (6) shows that the irrigated wheat yields were almost constant during 2003, 2004, 2005 and 2006. In years 2007 and 2008 wheat production had declines. The highest wheat yield was in 2008-2009(3700 kg/ha) and the lowest was in 2010-2011 (1180 kg/ha).

The factors resulting in reducing the yield and production of 210-2011 were reduced and scattered precipitations and high temperatures in June. The factors resulting in reducing the yield and production of 2007-2008 were lower temperatures and frostbites in 2007 and

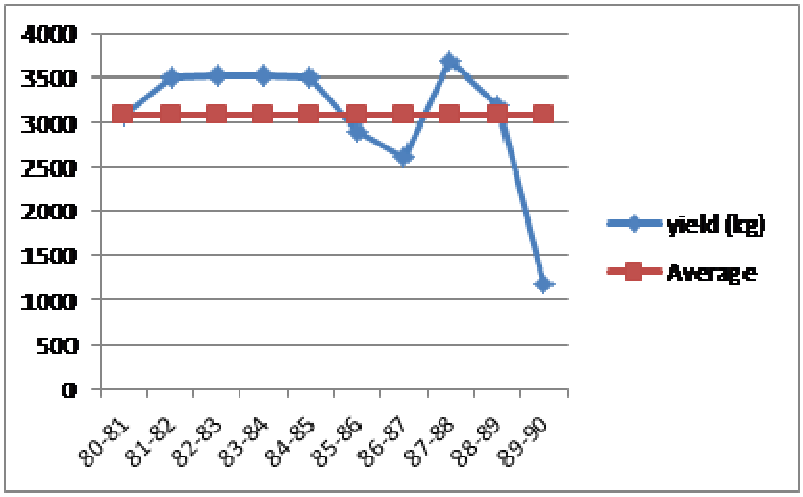

Figure 6. Changes in yield of irrigated wheat of Roshtkhar (statistical period: 2002-2011)

Table 5. Descriptive statistics for study variables in the period (2002-2011)

Average of minimum temperatures	Average of maximum temperatures	Average rainfall	Average humid	Average temperature	Yield	
2 /61	17/05	17/79	51/37	11/18	3072/5	Average
3/52	17/07	18/92	51/44	11/20	3153/27	Standard deviation
12/38	291/52	357/87	2646/53	125/53	9943142/5	variance
-0/34	15/63	7/13	48 /30	10/39	1180	minimum
6 /02	18 /66	25/66	55 /94	12/87	3700	maximum

unprecedented warmth in 2008.

However, the wheat cultivation in Roshtkhar is considered as the dominant cultivation which is due to suitable climate and desirable temperature conditions.

Data Analysis

Data analysis means sorting, arranging, processing and summarizing the data, instead of answering the research questions.

The purpose of the analysis is determining the data in such a way that it can be changed and understandable, thereby the relations between different variables that are relevant to the problem of research, can be studied (Khaki, 2005). The required climatic factors were extracted from the climatic variables table as follows:

1- Average Temperatures

2- Average maximum and minimum temperatures

3- Precipitation

4 - Relative Humidity

The mentioned parameters are among those variables that have an impact on the yield of agricultural products and the results are in presented in Table (4).

Evaluation of wheat yield and climatic variables using Pearson method

Since the subjective estimates cannot always be trusted for showing the extent of the relationship between two variables, a quantitative index should be used.

Pearson method is used to calculate the correlation coefficient for two statistical populations, the individuals of which are measurable or in other words, they are quantitative, (Jabbari, 2006).

According to Table (5), it is observed that the relationship between the average irrigated wheat yields and climatic variations is specified with its value for the significance level of 0.05. There is a negative correlation between the

Table 6. Pearson correlation between variables

Average maximum temperature	Average precipitation	Average humidity	Average temperature	Variable / Index	
-0/57	-0/40	-0/43	-0/19	Pearson's value	Average yield
Smaller than the error level of 0.05	Smaller than the error level of 0.05	Smaller than the error level of 0.05	Smaller than the error level of 0.05	Sig	
10	10	10	10	numbers	
average and adverse	average and adverse	average and adverse	Very small and negligible	interpretation	

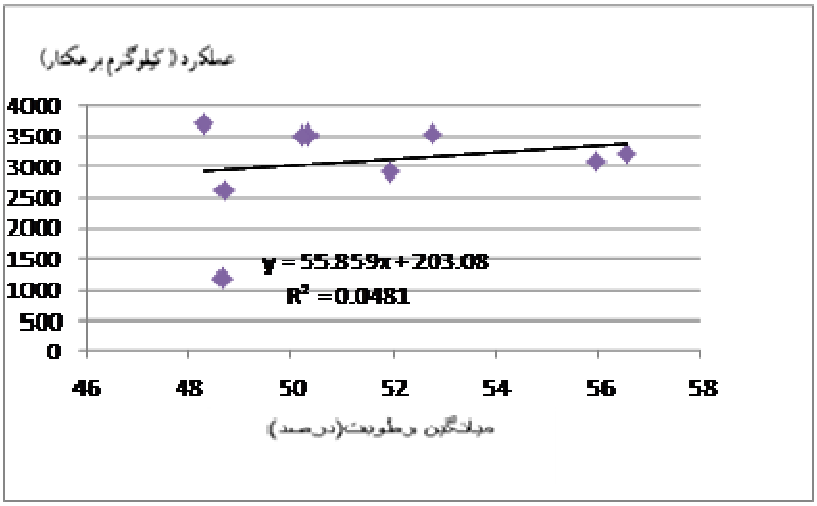

Figure 7. The effect of average humidity on the yield of the statistical period (1989-2010)

wheat yield and all the studied climatic parameters which means that if one variable increases, the other variable decreases. In this table, the highest correlation coefficient is associated with the humidity and the lowest correlation coefficient is associated with the average temperature.

Investigation of the relationship between average humidity and irrigated wheat yield

The plotted diagram (Figure 7) shows that the humidity is depicted on the x-axis as the independent variable and the wheat is depicted on the y-axis as the dependent variable. The left to right slope of the regression line indicates that if one variable increases, the other variable decreases and the type of relationship is an inverse or negative correlation.

Based on the scatter of points relative to each other or relative to the line, the correlation value can be guessed and the scatter of points in Figure (7) shows a low correlation between the two variables.

R2 (coefficient of determination) is equal to 0.18. Coefficient of determination is the ratio of changes that the two variables make simultaneously and it ranges from zero to one. If multiply 0.18 by 100, it can be represented as a percentage. This means that 18 percent of the wheat yield is affected by humidity and 82 percent of the wheat yield is dependent on other variables.

Investigating the relationship between average rainfall and irrigated wheat yield

For creating precipitation, wet weather, water vapor and its ascendance are necessary. Given that the vast

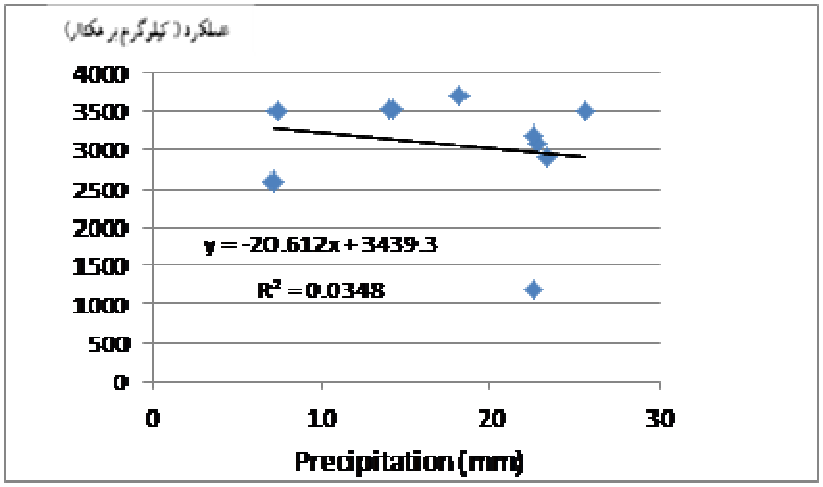

Figure 8. The effect of average precipitation on wheat yield, statistical period (1989-2010)

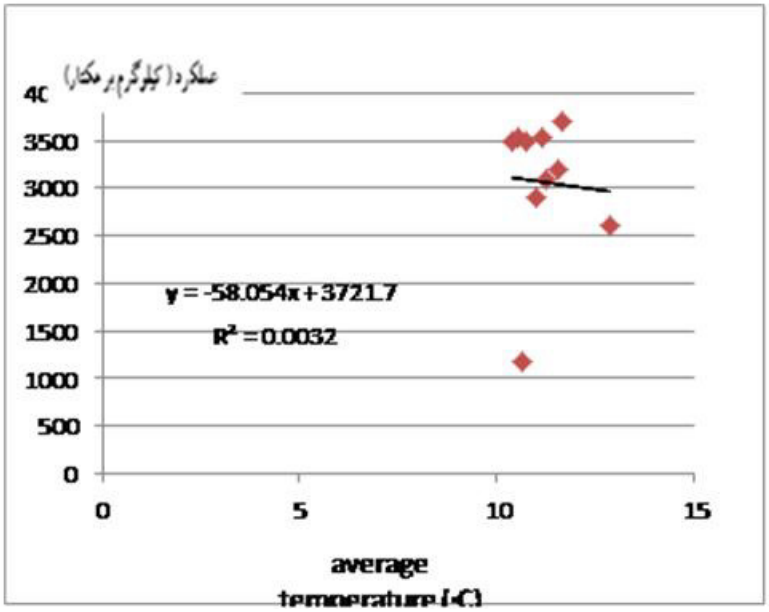

Figure 9. Effect of average temperature on the irrigated wheat yield for (1989-2010) statistical period

territory of Iran has no large and significant inland water resource, the required water vapor should come from abroad (Alijani, 2001).

Except for the northern parts and southern shores, the precipitation regime occurs in the winter. This area is affected by the cyclones formed over the Mediterranean Sea. Westerly winds draw these cyclones toward Iran and in the cold season, they are associated with precipitation. All forms of receiving moisture from the atmosphere in the horizon of an area are called precipitation (Vaghar Mousavi, 2002).

In order to investigate the relationship between precipitation and wheat yield using reconstructed climatic statistics of Roshtkhar and wheat yield statistics, the following diagram was drawn using Spss.

The graph of Figure (8) shows that precipitation act as

the independent variable and the yield act as the dependent variable. In this diagram, R2 is the coefficient of determination which is equal to 0.16. The scatter of points suggests that its impact on yield is low and it has an adverse relationship. Based on the coefficient of determination, 16% of variations of the wheat yield are explained by the average rainfall and 84 percent of the wheat yield depends on other variables.

Investigation of the relationship between the average temperature and irrigated wheat yield

Some of the solar radiation energy is absorbed by the land features on earth and is converted into thermal energy. This energy manifests through "temperature".

The main cause of temperature rise is due to the absorbance of solar short-wave length radiation at the surface of the earth (Kaviani, 2001).

Figure (9) shows that the index of the average temperature has a correlation of -0.19 with increases in the yield of irrigated wheat for the (2002-2011) statistical period. The value of this correlation is low and negative. The increase in one variable results in decreases of the other variable. Based on the coefficient of determination, 3% of the irrigated wheat yield is affected by the average temperature and 97% of the irrigated wheat yield depends on other variables.

DISCUSSION AND CONCLUSIONS

1- During the past 10 statistical years, the wheat yield of Roshtkhar has been fluctuating constantly. So that, due to favorable weather conditions, it had an ascending trend since the 2001-2002 crop year up to the end of the 2006-2007 crop year. During the 2007-2008 crop year, due to lower rainfall, it suffered a downward trend. The grain yield increased again in 2008-2009 crop year and since 2009-2010 crop year up to 2010-2011, the yield decreased again.

2- Based on statistical analysis performed using Pearson method for the climatic parameters of temperature, humidity, rainfall and frost, it became clear that based on the coefficient of determination, the parameters of humidity, rainfall and temperature had the first, second and third priorities in determining the yield, respectively.

3- In addition to climatic parameters, the most important factors affecting wheat yield loss are as follows:

A) Low level of scientific and applied knowledge of farmers

B) Failure in timely supply and distribution of agricultural inputs (seeds, fertilizers, pesticides, etc.)

C) High level of wastes in various stages of production

D) Damages caused by pests, plant diseases, weeds and the lack of proper management in controlling them

E) Limited water resources or lack of proper irrigation system in many areas of the country

F) Lack of proper and optimal use of chemical fertilizers, their shortage or failure in timely supply and distribution of them

G) Improper and irregular application of agricultural machineries and equipment

H) Lack of agricultural mechanization development in many operating systems.

I) Lack of equipment, tools and credits in various fields of agricultural research, promotion, and training

J) Lack of investment in production of agricultural crops

K) Failure of national policies and programs for production of agricultural crops

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