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STUDYING THE IMPACT OF EARLY AUTUMN AND LATE SPRING FROSTS ON AGRICULTURAL CROPS YIELD IN IRAN

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Abstract:-

To study early autumn and late spring frosts and its relation to the yield of agriculture crops in Semnan province we used statistics the least daily minimum temperature of 6 stations in the months of October and November and April during the period (1993-2014) as well as information on yield of agricultural crops from horticulture department of agriculture Organization. Using Pearson correlation coefficient between yield and frequency of early autumn and late spring frosts were studied and finally induced to study the frosts trends for each station. Early frosts of autumn in the province date from 20 October to 23 November and latest frosts ranged from 3 to 23 April and Biarjomand station experience earliest autumn and latest spring frosts. The Relationship between crop yields with frost Occurrence frequency shows that by increasing the number of days of early autumn frosts reduced wheat yield. This condition is for crops such as peas, walnuts and grapes, too. Amongst, the greatest impact is on the potato crop, which is closely related to the pattern of cultivation and harvest. On the other hand, it was found that late spring frosts in the province have the greatest impact on horticultural crops such as cherries, peaches, walnuts and grapes. As a result, early and late frosts changes in Semnan and Miami has increased, which in coming years will be also affected by this situation. Also, early frosts of autumn at harvest time and late spring frosts during flowering have many effects on crop yield.

Keywords: *Frost, agricultural crops, Iran.*

INTRODUCTION

The water and air are the most important environmental factors affecting on agriculture. So that the high quantity and quality of agricultural crops is associated with environmental conditions. Product than other environmental factors largely is depend on the weather, but many products are traditionally planted in areas that the climatic conditions are not favorable. This consistency is achieved by determining the agriculture climates and determining the climates in the area of agricultural climate and is the valuable tool for controlling climatic potentials to produce crops. If the climatic condition is not recognized and managed properly, can cause a lot of problems in the agriculture sector and other aspects of human life. Such as drought, fire, overheating and frost, which in the absence of knowledge, will lead to considerable losses. In addition to identifying these factors in many cases, it is needed to anticipate long- term and seasonal the phenomena or other climatic phenomena, to take timely action to minimize the damage caused by them, or if possible, with proper management, to make adequate use. In the meantime, it is very important the frost impact on the performance of agricultural products. The frost refers to a situation, where the air temperature at a height of 1.2 meters from the ground, reaches zero or below zero degrees centigrade, but from the perspective of agricultural meteorology, it refers to low temperatures to the extent that results in damage to tissue in plants, which the frost is different due to the critical temperatures for each type of product.

Ice survey has always been of interest to researchers and climatologists external and internal. Including Rozenborg & Myres (1982: 90- 105) studied the historical events related to the early autumn and late spring frosts in ten locations in and around the platte valley in Elath Nebraska. They also are identified patterns of distribution of radial frosts or transitional of effective pressure patterns. They did predict for farmers using the normal distribution of ices. The results showed that 7 to 30 percent frosts by late spring and early autumn frosts of 17 to 42 percent are transferable. In another study of early autumn and late spring frost date of occurrence in Aiwa by Tam & Shaw (1958: 257-251) were evaluated and shown that the date of occurrence of the frosts follow of normal distribution and in addition, it was found, last spring frost and the first frost of autumn are independent from each other and thus it is possible to specify the length of the growing season for any eventuality. Early autumn frost data have been studied in ninth place in Gorengeska during the years 1947 to 1987 by Gachphez in Slovenia (1988: 211- 231). He obtained medium frosts and the first frost. In Central Florida also Violin (1988: 608- 628) by analyzing the probability of glacial features start date and end of freezing, has predicted the coldest temperature and the risk of cold periods and probability distribution them.

Also, researches has been done on the frost impact on horticultural crops, including Ratigen & Hill (1996: 399- 404) were calculated the thermal requirements needed to break the winter dormancy and flowering for each cultivar with a choice of 12 varieties of *Amygdalus* during the seven- year period, by taking into account weather data. They concluded that thermal require different varieties is from 220 to 230 chilling units daily and 5300 to 8900 units above the 4 to 5 degrees Celsius. Winter (1986: 103) simulated the model regarding phenology and resistant against frost for *Golden cious* and used the thermal thresholds (-1°C to +8°C in winter) in flowering time and from a submodel used because of the close correlation between the degree of resistance to frost and phonological stage to calculate Lt50 for buds and flowers. Also Orlando and et al. (2002: 2- 8) in the years 1998 to 2000 studied the role of cooling units in the beginning spring reproductive period on the two types of olive cultivars, which have been based on the model Utah. The close correlation between the cold of winter and spring reproductive reaction has been in both species. Tritten (2002: 211- 220) states glacial last is leading cause of death for 10 to 90 percent of buds in the northern part of Michigan during the Ice Age May 9, 2002. He states the main cause slight damage in the south of the state is wind and cloudy sky. He said the continued freezing temperatures of 1 to 5 hours makes, the wind generator machines fail to protect the gardens from frost damages. Vilgolaski (2003: 407- 414) studied the time of buds break, flowering and ripening fruit for a number of trees in West Norway and investigated the data of phonological stages with different environmental factors as multiple regressions and concluded that temperature has the greatest impact on the growth and development of plants. Zenoni (2003: 1091- 1101) compared the factors affecting the cold and frost in north Italy with the central lowlands Italy. He introduced the best tool for frost diagnosis and the cold risk assessment in daily minimum temperature. He was studied the risk of cold and frost from 1987 to 2000 and identified the critical years. He announced the cause of the increased number of frost days is long winters and crosses spring cold with flowering apple.

Researches has been done about frost in Iran, one of the first cases is the work of Hashemi (1969). He calculated and analyzed the data of occurrence early autumn and late spring freezing based on the synoptic stations network information. He has determined four temperature threshold. The results of his study showed that the first critical temperatures at Dasht-e Kavir and Dasht-e Lut stations and Alborz and Zagros stations happen much earlier than the rest of the country and frostfree period is longer in the desert and adjacent areas of the Caspian Sea and the southern coast of the country from anywhere. Alizadeh and Kamali (1994) analyzed the date of the first autumn frost and the last spring frost using data from 15 meteorological stations in the province of Khorasan. In the research, the frosts in three thresholds (0 to -1), (1.5 to -3) and (-3) °C were classified into three categories: poor, mild and severe frosts, and finally the province was zoning in terms of the occurrence of freezing in the form of maps. In another study in this area Barati (1996) examined the causes, characteristics and forecasts of spring frosts over twenty years using daily data of 60 meteorological stations the country in terms of severity, duration and spatial spread. Rahimi (1999) evaluated the early autumn and late spring frosts with a choice of 7- altitudes weather station in the central Alborz. He concluded that there is a significant correlation between the period of freezing and station altitude at level 5 percent.

Azizi (2004) has studied the pervasive frosts the western half of Iran. He using the maps of the Earth's surface and 500 hPa level at zero hour showed that in all the days with frost observe a low height system in the North Caspian which usually is accompanied with the relatively strong low height system in the West and the Mediterranean. In this context,

Farid mojtahedi (2006) analyzed the frosts the southern coasts of the Caspian Sea by synoptic- statistical method and concluded, that peak of frost days in the area, showing the position of Naveh axis in the East Caspian Sea and Poshte axis is located in East Europe or East Black Sea. About the impact of frost on horticultural crops have been done researches in the country, including khalaji (2001) assessed the impact of late spring frost on the garden and agricultural crops Chahar Mahal and Bakhtiari and analyze the synoptic reasons. He with regard to statistical distribution, specified and offered the probability of occurrence of cold and frost for different locations the province. He states the temperature of -2.5 to -4 °C is dangerous for varieties of apple. In another study, Haj Mirzaee (2003) studied the glacial fluctuations in Aras Southern Basin and considering the weather deviation during the statistical period concluded that the date of the first frost in autumn to the first winter to and spring frosts have been displaced to mid- spring. Finally, early planting and late harvesting of agricultural products and trees bloom early in ten southern basin of Aras are more at risk of frost. Azizi and Shaemi (2004), with regard to the absolute minimum average monthly temperature, length the frost-free season have categorized into three type, at least, available and medium and the basis are considered by zero, 2 and 7 degrees for all three modes. They are considered these indicators and thresholds to determine kind of summer, heat the different needs of crops and vegetation reagents for fruitfulness and growth in response to the ecological conditions and characteristics. Scattered surveys in the field of ice done by Meteorological Organization in Yazd province (2004), among them can be noted to prepare harmful frosts calendar to the agricultural sector, cold spring survey on almond orchards the Yazd province.

Materials and methods

- Study area

Semnan province is located in longitudes 52 to 57 degrees east and latitudes 34 to 38 degrees north. The province is limited of East to Razavi Khorasan province, from the North and East North to provinces of North Khorasan, Golestan and Mazandaran, from the West to the provinces of Tehran, Qom and from to the south Isfahan. Because of spread the province in central Iran, southern areas with hot and dry weather and northern areas leading up to the Alborz mountain range have a temperate climate and mountainous (figure 1).

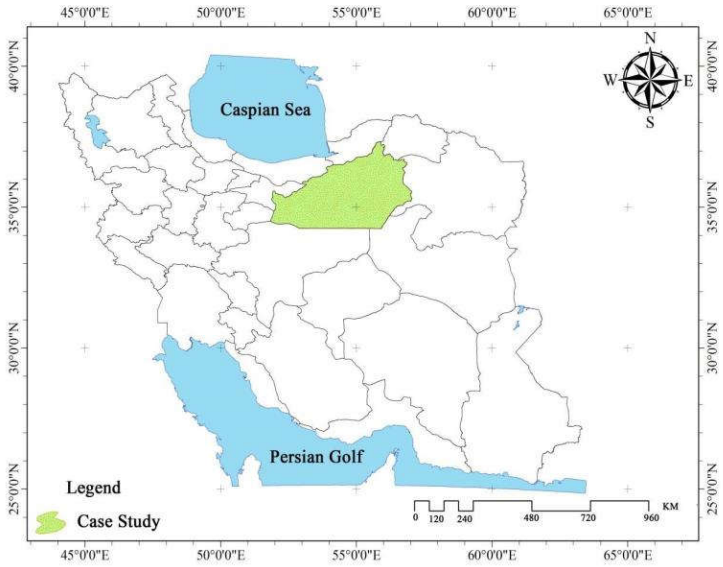


Figure 1: Study area in the country

The used data are daily minimum temperatures for the months of October- November for early frosts and for late frosts, April minimum temperature during the period (1992- 2012), which was received from the National Weather Service. Between daily minimum temperatures, days when the temperature was zero and below zero, was chosen as freezing days. Then the frequency of frost days for the months (as frost early and late) in each year of the study period were extracted monthly minimum temperature above were estimated for two months. Also, the yield of 9 agricultural products was received of Horticulture and Agriculture Department of Agriculture Jihad Organization, which are listed in Table 1. After the extraction of years with frosts early and late, was used the Pearson correlation coefficient to check and effectiveness of this frosts on garden and agricultural products. The coefficient calculates the correlation of between two distance or relative variables and the value is between +1 and -1. If the value is obtained be positive, this means that two variables change simultaneously to happen, in other words, by increasing each variable, another variable also increases and vice versa. If the value of r was negative, means that two variables act in the opposite direction, in other words, by increasing the value of a variable the values of the other variable decreases and vice versa. If the value obtained was zero, show that there is no relationship between the two variables and if +1, there is a full positive correlation and if -1, there is a perfect and negative correlation. Finally, to better display the date of early and late frosts and their frequency during the period at stations the province, was developed the zoning in Arc GIS software. Stations characteristics used in the study are shown in Table 2.

Table 1: List of agricultural crops in the research

Agricultural crops	Horticultural crops
Wheat	Cherry
Pea	Pea
Watermelon	Walnut
Potato	Grape
Sugar beet	

Table 2: Specifications weather stations studied in the research

Station	Longitude	Latitude
Semnan	53° 33 ′	35° 35′
Shahroud	54° 57′	36° 25′
Damghan	54° 19′	36° 09′
Garmsar	52° 16′	35° 12′
Biarjomand	55° 50′	36° 03′
Miami	56° 32′	36° 41′

Results and Discussion

To analyze the frequency of frost occurrence it was needed to obtain when the first frost early autumn and late spring last frost for each year. So, mentioned cases were extracted for 6 stations located in the province (Figure 2 and 3). In this regard, maps related to early autumn and late spring frosts were prepared in the Arc GIS software.

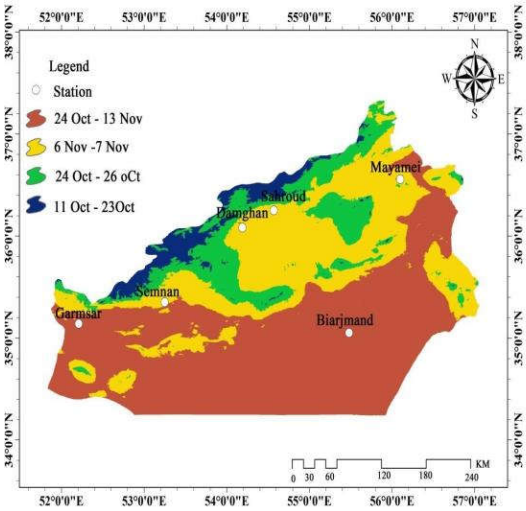


Figure 2: Zoning map of the time of the last frost late spring Semnan province

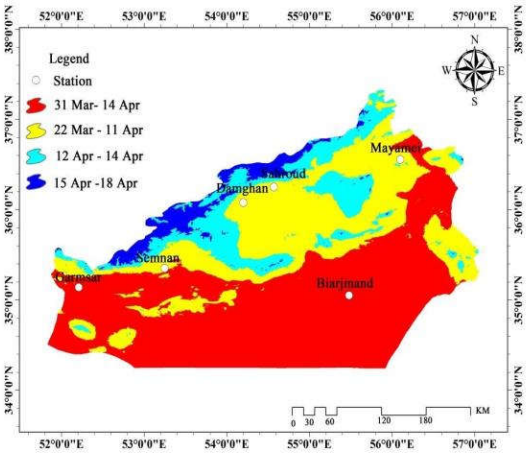


Figure 3: Zoning map of the time of the first frost early autumn Semnan province

According to the maps was found that when the date of first frost of autumn in the province is between 20 October to 2 November, that these conditions is based on the heights of the province. Early last frost date in the province between the dates October 3 to 23. These conditions also are in the lowest parts of the province, which can consider its representative stations such as Biarjomand and Garmsar. Late spring frosts were also being affected by highlands the Province, but are inconsistency so that, the date of the first frost late occurs in the 12 to 26 April. Due to locating Garmsar and Biarjomand stations in lowland areas they are representative of this class. The next class is related to Damghan, Shahroud and Semnan stations which takes place on 3 to 23 April late frosts. Miami station is the next class representative that late frosts can occur in 24 to 26 April, which is less affected the percentage of variability in the occurrence of this phenomenon.

The final class that matches altitudes above 1500 meters, the frost occurrence has been between 27 to 30 April. After surveying and mapping related to early and late frosts, to analyze the frequency of occurrence of this phenomenon for each station in the province. According to Figure 4, Biarjomand station by 38% and 8% of the total abundance of frosts early autumn in Garmsar station were accounted. Meanwhile, the cities of Damghan, Shahroud and Miami, all three 15 and 9% of total abundance in Semnan city were involved. In Figure 5, the city of Semnan and then Biarjomand respectively 29 and 22 percent and the city of Garmsar and Miami each 6% of the total abundance of late spring frosts have experienced.

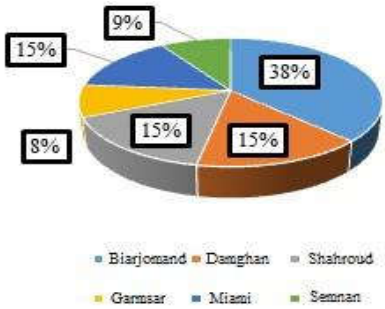


Figure 4: Diagram of frequency of frost late spring each weather station

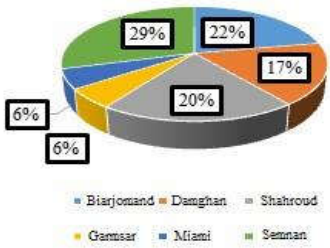


Figure 5: Diagram of frequency of frost early autumn each weather station

To better display the total frequency of early and late frosts during the period, the data point was transformed into different zones, which are shown in Figures 6 and 7.

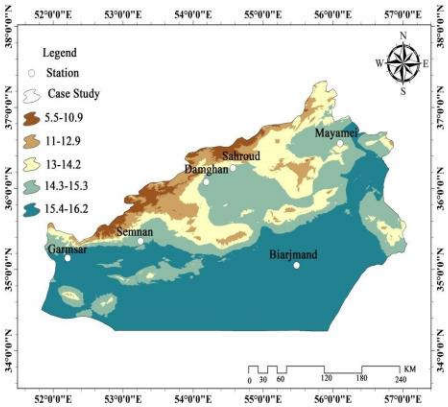


Figure 6: Frequency of occurrence of late spring frosts in Semnan province during the period (1992- 2012)

In Figure 6, which is related to early autumn frosts, high-altitude, are facing the lowest number of days with frost, but have been added to it by approaching the lower elevations. But in Figure 6, the most frequent late frosts are in perfect harmony with the altitude, so at altitudes the value is between 46 to 58 days and by approaching to the lowlands to be reduced by 34 to 36 days. After reviewing frosts occurred and identify the areas affected, was explored the relationship between yield 9 agricultural crops and early and late frosts. Correlation analysis between frosts and product yield demonstrated that each of the crops during cultivation and harvest time are affected the weather condition. In Table 3, by

increasing the number of days of early autumn frosts are faced with a reduction in wheat yield. On the other hand, the conditions for crops such as peas, walnut and grape as well. In the meantime, the greatest impact has been on the potato crop, which is closely related to the pattern of cultivation and harvest time. This plant in early autumn is harvest, sometimes has faced with events such as frostbite and irreparable damages creates for farmers. In Table 4 was found that late spring frosts in the provinces have the greatest impact on horticultural crops such as cherry, peach, walnut and grape.

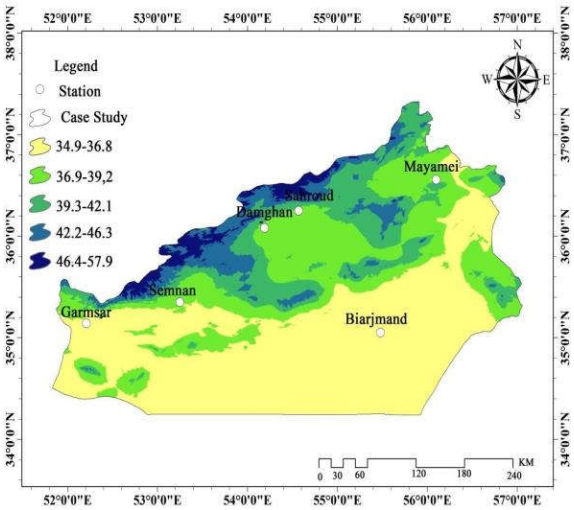


Figure 7: Frequency of occurrence of early frosts of autumn in Semnan province during the period (1992-2012)

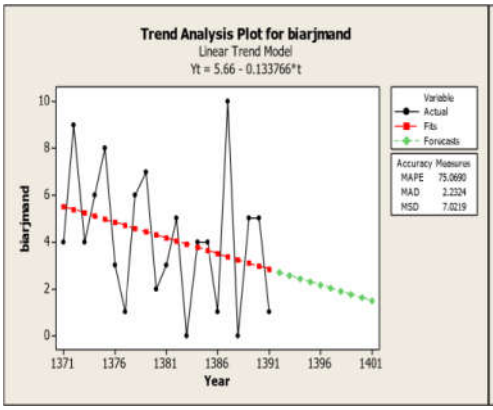
Table 3: Correlation between the crops yield and early frosts of autumn in the province

parameter	Equation	R^2	R	P-Value
Wheat yield and early frost	y = -15.8x + 3600.5	.13	-.321	.056
Pea yield and early frost	y = 3.3103x + 902.65	.11	.075	.747
Watermelon yield and early frost	y = -112.75x + 19985	.04	-.232	.011
Potato yield and early frost	y = 19.064x + 18156	.41	.80	.032
Sugar beet yield and early frost	y = -113.85x + 31981	.26	-.162	.482
Cherry yield and early frost	y = -16.716x + 7715.3	.07	-.100	.685
Peach yield and early frost	y = -67.769x + 13201	.29	-.126	.607
Walnut yield and early frost	y = 3.0621x + 3778	.22	.025	.919
Grape yield and early frost	y = -45.018x + 19550	.32	-.181	.459

Table 4: Correlation between the crops yield and late frosts of spring in the province

parameter	Equation	R^2	R	P-Value
Wheat yield and late frost	y = 16.779x + 3337.4	.21	.167	.469
Pea yield and late frost	y = 20.111x + 835.15	.14	.223	.331
Watermelon yield and late frost	y = 267.37x + 17341	.09	.270	.236
Potato yield and late frost	y = -20.293x + 18473	.07	-.042	.858
Sugar beet yield and late frost	y = 100.6x + 30191	.01	.070	.762
Cherry yield and late frost	y = -193.04x + 8397.3	.49	-.407	.074
Peach yield and late frost	y = -367.28x + 14086	.36	-.342	.018
Walnut yield and late frost	y = -55.273x + 4063.3	.02	-.390	.012
Grape yield and late frost	y = -165.55x + 19783	.51	-.235	.082

In spring the weather warms and the germination starts in garden products. The phenomenon will cause to irreparable damages in trees and shrubs, sometimes will cause to dry them and loss part of a tree. Finally, was studied the spring and autumn frosts. In this study, was used the linear model to predict the frost trend for six cities. The trend of early frosts changes in some city, including Biarjomand, Garmsar and Damghan has been a decreasing trend, but in Miami, Semnan and Shahrood this trend is positive (Figures 8 to 13).



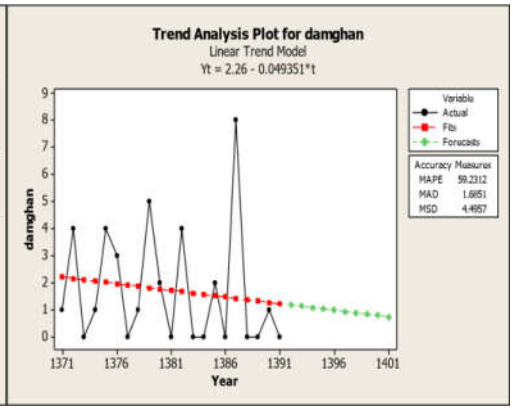
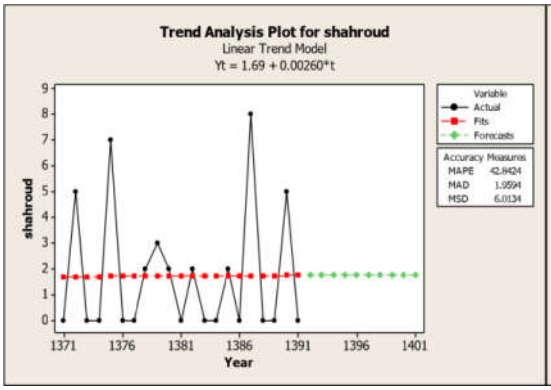


Figure 9: Trend of early frosts in the city of Biarjom **Figure 8: Trend of early frosts in the city of Damghan**



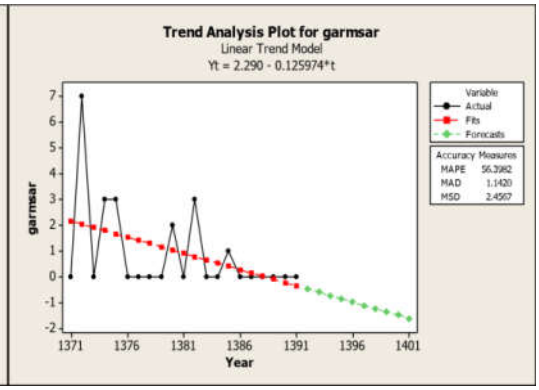
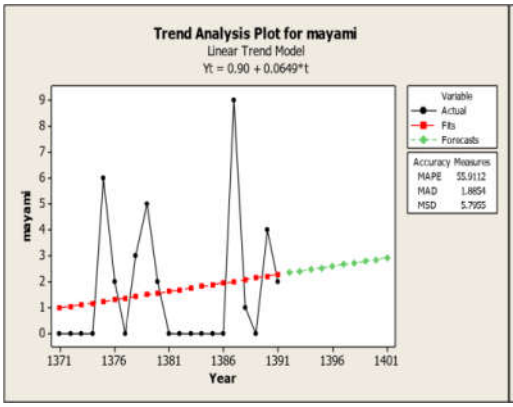


Figure 11: Trend of early frosts in the city of Shahroud **Figure 10: Trend of early frosts in the city of Garmsar**



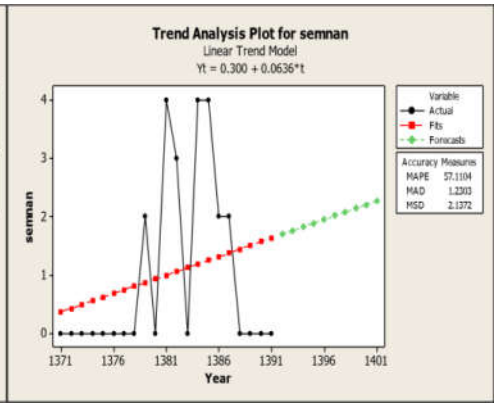
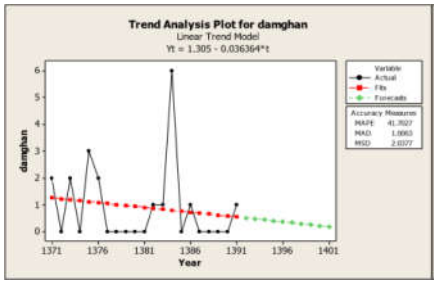


Figure 13: Trend of early frosts in the city of Miami **Figure 12: Trend of early frosts in the city of Semnan**

In the diagrams prepared, black curve, frequency, red curve, the trend during the period and the green curve is forecasting frost trend. Early frosts increase over the next 10 years is considered an overview of the threat this extreme phenomenon. Late frosts in the cities of Biarjomand, Damghan, Shahroud and Garmsar have decreasing trend, but in the cities of Miami and Semnan growing trend was observed (Figs. 14 and 19). By evaluating the trends early and late frosts in Semnan province can be conclude that, the cities of Semnan and Miami in both cases has been rising, over the coming years will be affected by this situation.



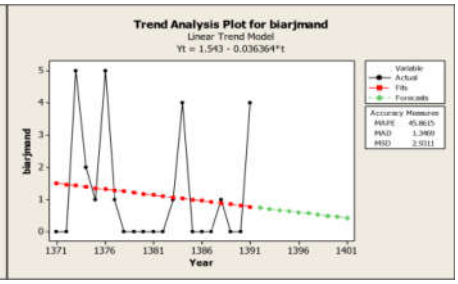
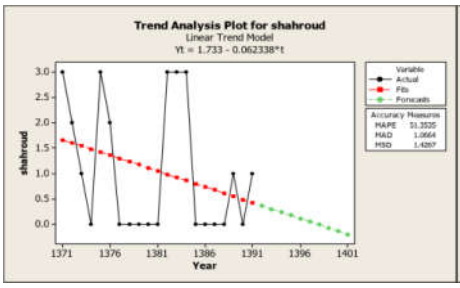


Figure 15: Trend of late frosts in the city of Biarjomand **Figure 14: Trend of late frosts in the city of Damghan**



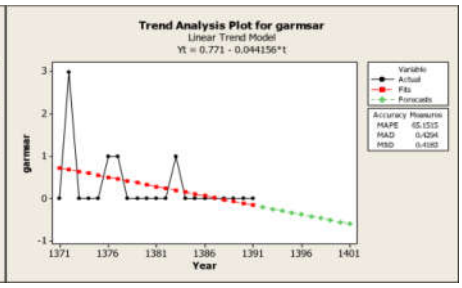
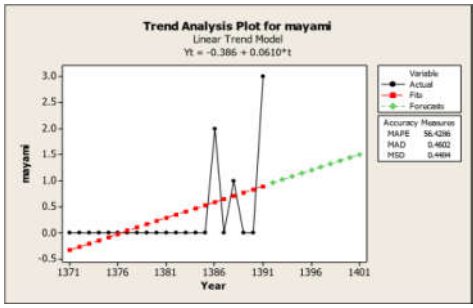


Figure 17: Trend of late frosts in the city of Shahroud **Figure 16: Trend of late frosts in the city of Garmsar**



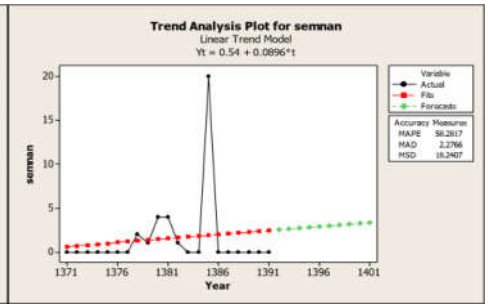


Figure 19: Trend of late frosts in the city of Miami **Figure 18: Trend of late frosts in the city of Semnan**

Conclusion

Given the specific topographical diversity of Semnan province and also its location in arid areas of the country have caused frosts changes effect on the area with its temporal and spatial changes. It was needed to review and analysis this weather phenomenon on the yield of agricultural production, including farming and gardening (Table 1). For this purpose, and study the impact of early autumn and late spring frosts and its impact on crops yield were used the daily statistics, at least daily minimum temperature during the months of October, November and April during (1992- 2012). In this regard, the crop yield data were also used during the period, to determine whether a relationship exists between these two? After the surveys Biarjomand station by 38% and 8% of the total abundance of frosts early autumn in Garmsar station were accounted. The cities of Shahroud, Damghan and Miami, all three 15% and 9% of total abundance in Semnan city were involved. Semnan city and then Biarjomand, respectively 29 and 22 percent and the cities of Garmsar and Miami, each with 6 percent of the total abundance of late spring frosts have experienced. Each of crops differently are affected this weather phenomenon according to during planting and harvest time. By increasing the number of days of early autumn frosts are faced with a reduction in wheat yield. This condition is for crops such as peas, walnuts and grapes, too. Amongst, the greatest impact is on the potato crop, which is closely related to the pattern of cultivation and harvest. On the other hand, was found that late spring frosts in the province have the greatest impact on horticultural crops such as cherries, peaches, walnuts and grapes. Then, the frosts trend analysis and forecasts using linear model. The results showed that the trend of early frosts in some cities, including Biarjomand, Damghan and Garmsar has been a decreasing trend, but in Miami, Semnan and Shahrood this trend is positive. Late frosts in the cities of Biarjomand, Damghan, Shahrood and Garmsar has been a decreasing trend, but in the cities of Miami and Semnan growing trend was observed, over the coming years will be affected by this situation. Based on the data and evidences obtained in this study could be concluded that, early frosts of autumn at harvest time and late spring frosts if the plant is flowering effects on the crop yield.

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