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The effect of climatic factors on potato late blight disease in Ardabil plain of Iran

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Abstract

Late blight is the most important disease of potato crop throughout the world and in northwest of Iran, it can destroy the whole crop in epidemic years. According to the Ministry of Agriculture Bureau in Ardabil province, the late blight reached an epidemic level in 1997 in Ardabil plain and resulted in major damage to the crop. Climatic factors including temperature, relative humidity and rainfall play the major role in developing and spreading of this disease. In this research, the effects of temperature, rainfall and relative humidity on the incidence of the late blight was investigated in Ardabil plain. Daily, monthly and yearly weather data of Ardabil climatic station were obtained for the period of 1992-2002. Data were grouped and analysed using graphical and statistical methods. Initially, variance analysis was conducted using nested method between study years and within the months of years. Then study years were grouped using cluster analysis by the UPGMA method. It was found that there were significant correlations between climatic factors, particularly temperature and rainfall, with the incidence of the late blight. Study years grouping using climatic factors in the incidence period of late blight could discriminate the year 1997 from the rest of the years. Moreover, it was recognized that when an effective rainfall (about 30 mm) occurs in the growing season and mean daily temperature range is about 19ºC for 10 consecutive days, there is a possibility of occurrence and spreading of the disease and preventive measures must be taken.

Key words: Potato, late blight, climatic factors, Ardabil, Iran.

Introduction

Potato is an important food crop throughout the world and is cultivated in about 19,264,021 ha of farm lands in many countries all over the world [6]. In Iran about 160,000 ha of irrigated lands are allocated to potato production each year with a total annual production of 5,240,000 tons [6]. Ardabil province is located in northwest of the country not very far from the Caspian sea (Long. 47º50´ - 48º40´ and Lat. 37º35´ - 38º30´) and about 16 to 20 percent of the country's potato crop (about 600,000 t) is produced in about 25,000 ha of irrigated farms of this province [1, 11]. The most serious disease that threatens this crop is the potato late blight which is produced by *Phytophthora infestans*. In some years due to suitable weather conditions the disease becomes epidemic in some parts of the plain and destroys almost all the crop in these areas. In 1997 the disease reached an epidemic proportion in Ardabil province and caused an 80% crop loss in some regions and reduced the annual production of the crop in Ardabil province to about 50% of normal years [19].

Potato late blight is a widespread disease that occurs in many potato producing regions of the world and it can result in a complete destruction of the crop if reached an epidemic state [17]. Weather conditions, specially temperature, relative humidity and rainfall,are the most important factors in occurrence and spreading of the disease, but their effects vary with time of the growing season and the location. In Wichang region of China the relative humidity has been identified as the most influential weather factor in developing and spreading of the disease [24]. In humid regions, the disease occurs when the temperature is 4-29ºC but hot and dry weather prevents the spreading of the disease [4].

Duval [13] has reported that the suitable conditions for development of the disease in cool and humid regions are 10-18ºC and 80% relative humidity. In temperate regions when the mean daily temperature is 16-22ºC and relative humidity about 80% the spores of the *P. infestans* sporulate on the wet surface of the potato leaves and infect the plant. Under the hot and dry conditions of 30ºC and RH < 80% or under the lack of moisture on the leaf surface the growth of the fungus is stopped and it is unable to reproduce. It should be insisted that the higher temperature cannot stop the disease by itself, but the lower relative humidity is also needed to halt the spread of the disease. The optimal conditions for spreading the disease are provided when the night temperature is 12-13ºC coupled with an ample amount of dew or rainfall and followed by day temperature of 16-24ºC with rain, fog or an ample amount of water vapour. In cool weather, when temperature is about 7 to 23ºC and relative humidity is in saturated stage, pathogens can damage not only the foliage of potato but also the tubers [20].

Many useful forecasting methods have been developed to reduce the late blight damage in potatoes [8, 9, 18]. The forecasting methods can be categorized into two groups: a) methods that forecast the infection period and b) methods that concentrate on the trend of disease epidemics. The forecasting methods also can be grouped into a) observation and experience based forecasting methods and b) basic forecasting methods. The observation and experience based forecasting methods have been developed for different geographic regions by studying the recorded history of the disease and recorded weather conditions

during the epidemic periods of the disease.

The use of synoptic charts and other weather stations data to forecast the occurrence of the potato late blight have been suggested by Bourke [3], Kean [15] and many other researchers. Bourke [3] found that two weather factors of lower air pressure and stagnate air and high temperature are the two main factors in the potato late blight development and its spread. The lower air pressure and stagnated air results in higher relative humidity and cloudiness. The occurrence of this condition for a 12 hour period with a relative humidity of 90% and the temperature of at least 10ºC is necessary for the development of the disease. In addition, enough rainfall is also required before or after the onset of infection. In other forecasting methods also the weather factors have played the major role [3, 5, 7, 9, 10, 12-14, 16, 21, 23, 24].

In Iran no research has been conducted in regard with determining the relations between the weather conditions and the potato late blight disease. Therefore, this study was conducted to investigate the relationship between the weather conditions, specially temperature, relative humidity and rainfall, with the development and spread of the potato late blight disease in order to use in forecasting and prevention of the disease.

Materials and Methods

The weather data, including temperature, relative humidity and rainfall, were obtained from the synoptic weather station of Ardabil for 10 year period of 1992 to 2001. Then, based on the available data the umbrothermic curves and relative humilities plotted in the form of graphs and the years were compared. Since the potato is planted in mid-April and harvested in mid-September, therefore five months period (15th April to 15th September) was considered as the growing season and the weather data were arranged and grouped for this period. To determine the differences between study years and different months of any year in the growing season the nested ANOVA was conducted. Since there were significant differences between the study years, the study years were grouped using cluster analysis by the UPGMA method. Since in year 1997 the outbreak of the potato late blight occurred during 26th June till 5th July in a 10 days period, therefore the study years were grouped once more according to the weather factors of this critical 10- day period. To analyze the data MSTATC and SPSS software were used.

Results and Discussion

The umbrothermic curves for the years from 1992 to 2001 are given in Fig. 1. The dry season in Ardabil plain usually begins from mid-May as it is evident in Fig. 1, but in year 1997 which is the outbreak year of the disease, there were more rainfall than in the usual years and the rainfall curve was above the temperature curve. In the late June and early July 1997, a 32 mm rainfall occurred in the study area. This rainfall compelled with suitable temperature (19.29°C), and relative humidity (RH 74.4%) was very effective and conducive in occurrence and outbreak of the potato late blight disease in the year 1997. Other researchers have also obtained similar results [12, 14]. Mean relative humidity of the potato growing region of Ardabil for the years from 1992 to 2001 is illustrated in Fig. 2.

Analysis of variance of weather factors for the study years indicated that there were significant differences ($P \leq 0.05$) between years (Table 1). The relative humidity in the five months of growing season and during the critical 10-day period (26th June until 5th July) for potato late blight disease outbreak in year 1997 was significantly higher than the mean relative humidity for the same period of non-outbreak years. In year 1997, the relative humidity of critical 10-day period has 74.4% (Table 2). Other investigators also have reported the occurrence of a relative humidity of around 80% during the disease outbreaks [2, 3, 16, 22, 23].

Nested ANOVA (where days were considered as replicates) for the weather factors indicated that there were significant differences ($p \leq 0.05$) among the study years and among the months of the growing season in regard to relative humidity and rainfall. However, with respect to the mean temperature of five months of growing period of study years no significant difference was detected among the study years (Table 1 and Fig. 3a).

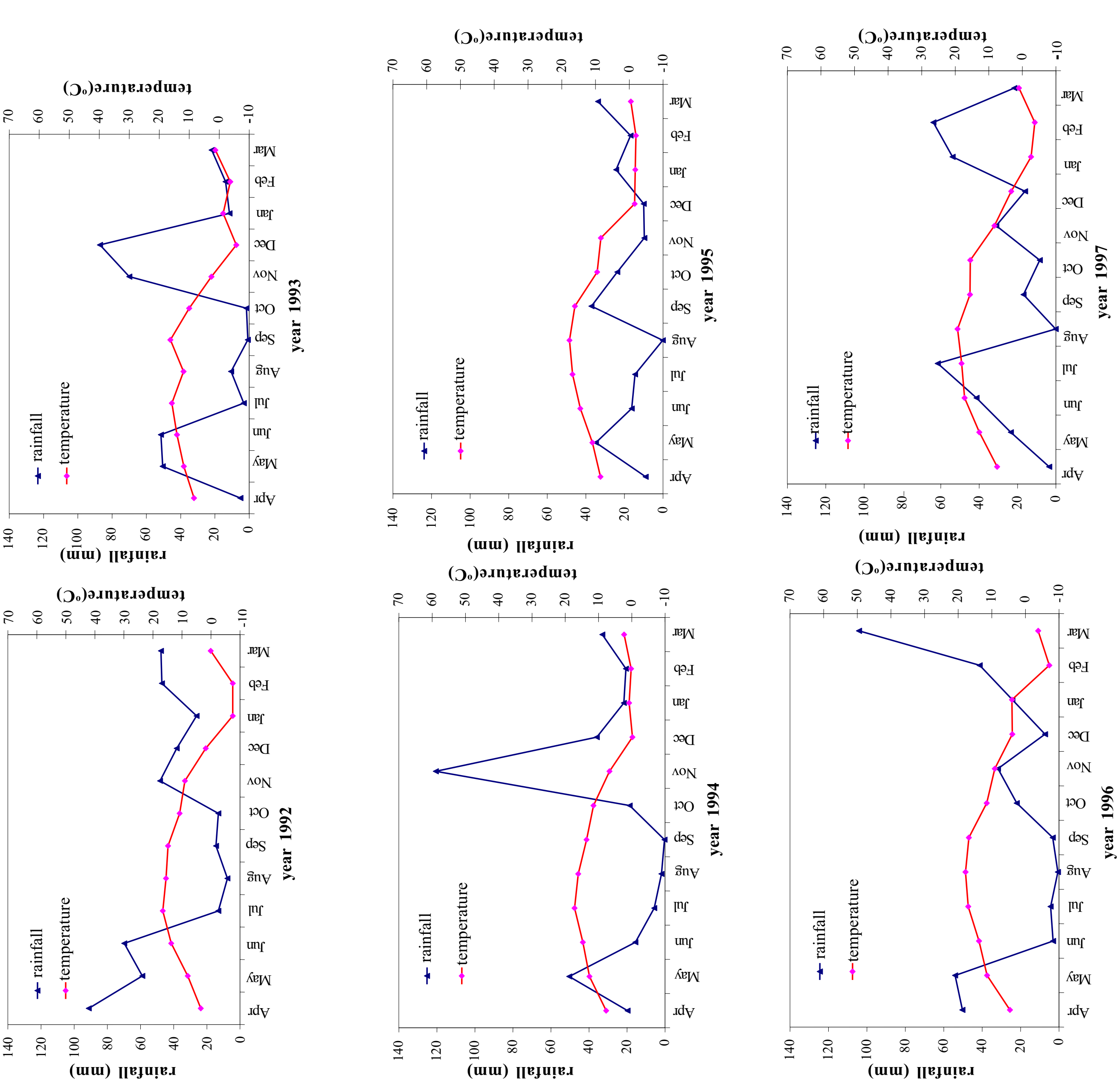
Using the cluster analysis by UPGMA method, years were grouped based on mean daily maximum and minimum temperature, relative humidity and rainfall. The years 1993, 1996 and 1997 were grouped in the same class and 1997 was not isolated from the years 1993 and 1996 (Fig. 3a). There was no report on the potato late blight outbreak in years 1993 and 1996. There has been a 32 mm rainfall during the late June and early July in 1997, and the outbreak of the disease had occurred in this period. Also the rainfall in the growing season of year 1997 was higher than in the rest of study years, except 1992.

Since the outbreak of the disease in year 1997 occurred during a 10-day period of 26th June to 5th July, therefore the weather factors of the study years are presented in Table 2 for comparison. Hyre [12] and Krause *et al.* [16] also have reported that the outbreak will happen within a 7-10 days period when the weather conditions are suitable.

When study years were grouped based on the rainfall, mean temperature and relative humidity of this critical 10-day period, the year 1997 was completely separated from the rest of the study years (Fig. 3b). The relative humidity in Ardabil is usually high during the growing season of potatoes. The mean relative humidity for the 10 critical days of disease outbreak for 10 study years was 73.4%, which is suitable for the outbreak, but in non-outbreak years the lack of rainfall and occurrence of lower temperature prevented the outbreak of the disease, wherein 1997 the occurrence of a rainfall and higher temperature results in weather conditions that were suitable for the outbreak.

Hyre [12] has reported that the higher temperature and occurrence of rainfall are responsible for the disease outbreak. Other investigators have considered the higher temperature and higher relative humidity the main weather conditions that cause the development and spreading of the disease [20, 23, 24].

Our findings indicated that the year 1997 was clearly different from the rest of the study years with respect to the temperature and rainfall of 10-day critical period for the potato late blight outbreak. During this critical period, there was a 32 mm rainfall in the region and the mean daily temperature rose to 19.29ºC. Zangzhi *et al.* [24] and Schwartz *et al.* [20] reported that besides the rainfall and higher temperature, the relative humidity is also important in development of disease. In 1997 the mean relative humidity during the critical period was 74.14% which is suitable for the development of the potato late blight disease. Hyre [12] also found that a 30 mm rainfall and higher temperature of about 25ºC were required for the disease development.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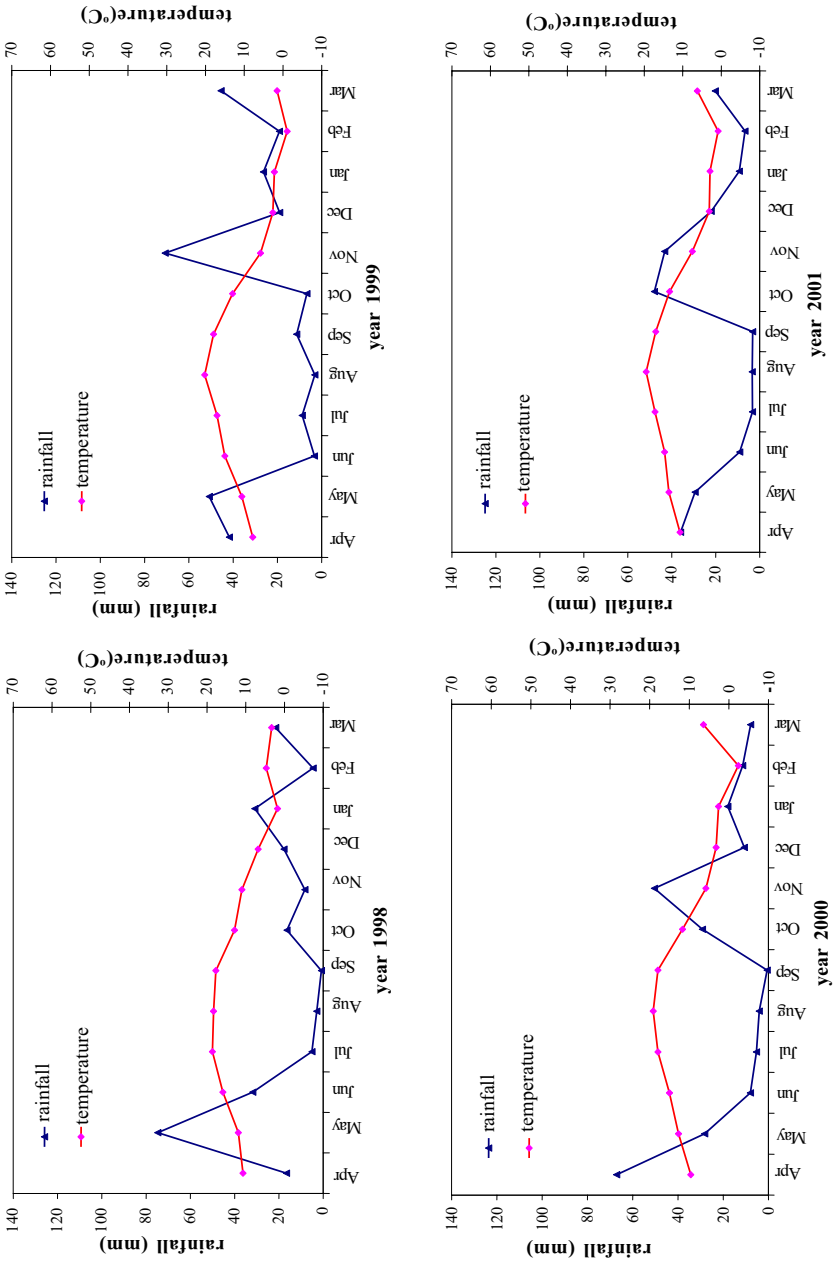

Figure 1. The umberothermic curves of Ardabil station for the years from 1992 to 2001.

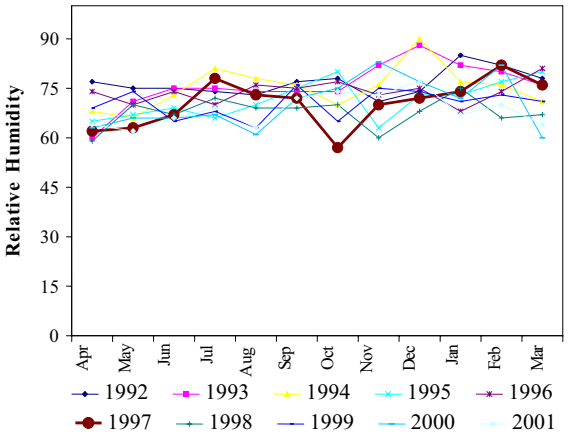

Figure 2. The relative humidity curves of Ardabil station for the years from 1992 to 2001.

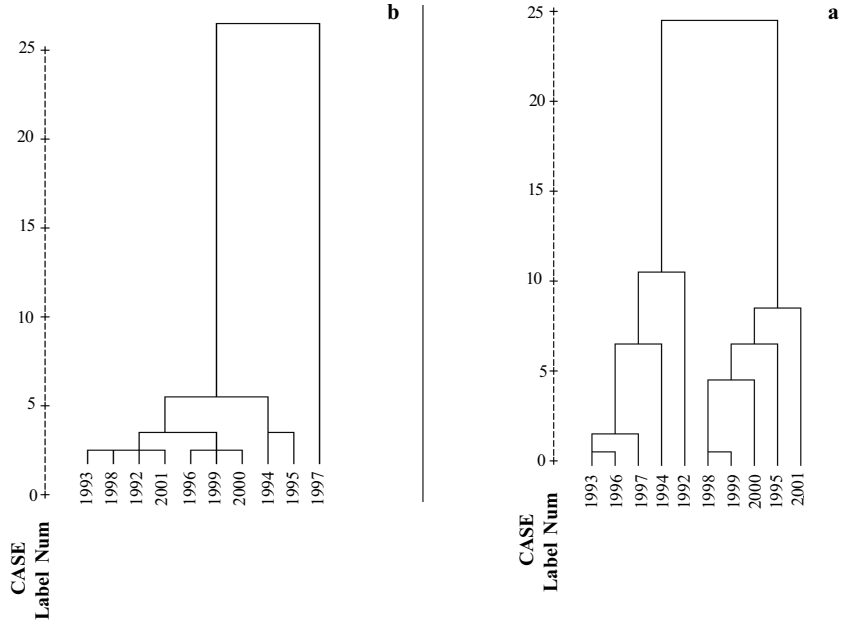

Figure 3. The dendrogram of cluster analysis (UPGMA) for 10 studied years based on climatic factors: a) 5 month of growing season and b) 10 days of critical period for disease outbreak.

Table 1. Analysis of variance of weather factors for 10 years period (1992-2001).

S.O.V.	df	Mean of square		
		Rainfall (mm)	Temperature (°C)	Relative humidity (%)
Year	9	26.8*	163.3ns	1958.3*
Month/Year	40	10.9*	163.4**	716.1**
Error	1450	4.4	7.4	150.6

ns, * and ** not significant and significant at 5 and 1% probability.

Table 2. Rainfall, mean temperature and relative humidity for 10 critical days of disease outbreak (26th June till 5th July).

Year	Rainfall (mm)	Mean temperature (°C)	Mean relative humidity (%)	Year	Rainfall (mm)	Mean temperature (°C)	Mean Relative Humidity (%)
1992	0	17.92	72.25	1997	32	19.29	74.14
1993	0.1	17.54	74.26	1998	0	18.06	73.88
1994	5.2	12.59	78.1	1999	0	17.84	68.69
1995	0	17.69	83.86	2000	0	17.51	64.07
1996	2.7	16.93	67.49	2001	0	15.21	78.75

Conclusions

It was found that there were significant correlations between climatic factors, particularly temperature and rainfall, with the incidence of the late blight. It can be concluded that under the condition of about 30 mm rainfall and higher temperatures of about 19°C during the critical period of the growing season, we must expect the development of the potato late blight disease and must use preventive measure immediately.

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