APPLICATION OF GIS TECHNOLOGY IN MAPPING OF CRITICAL THRESHOLD OF HEAT STRESS IN FARS PROVINCE, IRAN

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Abstract- Temperature is one of the most important parameters affecting plant growth and yield production. Increasing world population and the growing demand for food products in the world, has provided the context for emergence of stress to plants. In general, adverse conditions that do not cause immediate death and permanent, or temporary happen in a place is called stress. Tolerance of plants in relation to each of the meteorological parameters is limited and any abnormalities in these parameters can have a significant direct or indirect effects on agricultural production affect. In the present study, the critical threshold of heat stress for wheat cultivation in Fars Province was evaluated and the equations for each critical threshold is presented. Finally mapping of the entire province of heat stress has been done. According to the requirements of the average for wheat, thermal thresholds of 30, 35 and 40 ° C as the maximum temperature and 20 ° C as the minimum temperature has been considered. The evaluation results showed that the southern part of Fars Province consists mainly Larestan, Mohr and Khonj and northwestern parts including Kazeroon and Mamasani are more susceptible to heat stress and Meanwhile larestan and mamasani more than other areas suffer from stress. In most cases, periods of heat stress coincide during germination and flowering of wheat culture in Fars Province. Maps provided by climatological analysis helps to agriculture managers to estimate Probability of favorable or unfavorable atmospheric events in later stages of crop development with high accuracy. These predictions can be used in practical farming and long-term planning.

Keywords- Temperature, Heat stress, Mapping, Fars Province.

I. INTRODUCTION

Increasing world population and the growing demand for food products in the world, has provided the context for emergence of stress to plants. In general, adverse conditions that do not cause immediate death and permanent, or temporary happen in a place is called stress. Tension arises when an environmental factor affected outside the normal range of the plants .Occurrence of plant stress can cause the loss of the plant over a period of time climatic factors essential for plant growth and development, and are considered of those uncontrollable variables affecting agriculture .Tolerance of plants in relation to each of the meteorological parameters is limited. Minimum night temperatures above 20 ° C may be associated with worsening of breathing and loss of organic matter transported from the shoot to the storage organs. As a result, the unit provides functional decline (Mianabadi et al., 2009). Heat stress is a complex function of severity, duration, timing and rate of temperature increase, and depending on the likely period in which high temperatures occur (Kafi, 2009). Nuttal et al (1992) estimated that an increase of one degree Celsius maximum temperature in July which coincides with summer flowering canola in the Canadian West, Reduction 400 kg per hectare of grain yield (about ten percent of the total yield) cause. Morison (1993) reported that heat stress during flowering rapeseed cause more damage than the vegetative phase or stage of development. Li et al (2007) showed that temperature has a significant effect on occurrence, development, distribution and mobility of the pest. High temperatures caused flooding and insect behavior and the impact of pesticides on pest control effect.Therefore, the scrutiny of critical threshold temperature and thermal stresses importance and can reduce damage to crops. On the other hand with the spatial model, we can make maps that show the thermal stress conditions in different parts of the study area.One way to make value maps by which we can examine the phenomena of meteorological and hydrological is the use of geo statistical models and GIS systems technology.In this respect we can provide zoning maps.The purpose of zoning is to localize the form of digital data acquisition, storage, retrieval, modeling analysis, and will eventually be displayed as text and graphics (Bill and Fritsch, 1994). Nalder and Wien (1998) evaluated the spatial distribution of monthly rainfall, temperatures in the northern Canadian forests. The results showed that inverse-square method is more suitable than the other methods. Hernandez, and Gaskin (2007) by analyzing the time - place daily and monthly precipitation and temperature in the Basin of Mexico found that daily temperatures interpolation using the height as the second variable helps the estimation accuracy, though the two variables are weakly correlated.As the southern part of Iran faced with extreme temperatures therefore it shows the importance of these studies. The purpose of this study is the critical threshold for heat stress of wheat in Fars Province, creating and providing the appropriate equations for each of the critical threshold and mapping the thermal stress to determine vulnerable areas of Fars Province.

II. THE STUDY AREA

Fars Province with semi-arid and arid climates is one of the most important agricultural parts of the Iran. This province is located in the southern part of Iran, at 50° 30' to 55° 38' E longitude and 27° 3' to 31° 42' N latitude, with an arable land area of 1.32 million Km2. The annual mean of precipitation for the province ranges from 50 to 1000mm (Sadeghi et al., 2002).

For extraction of meteorological data, information of 14 synoptic Fars Province were taken from automated services of IRIMO and analyzed. This information includes temperature data to the end of year 2012. Because of the limit of statistical data in some stations, we use 18-year period for eight stations and for other 6 stations we use our data (less than 18 years). To determine better, analyzes were performed 2 times. First time for 8 stations with 18-year period and the second time regression coefficient was determined by considering all stations and According to the results number of stations were identified and finally equations were extracted. After identifying data base, we start to create a spatial data layers in GIS, that has been used to determine the location of stations. The location of the studied stations is shown in Figure 1

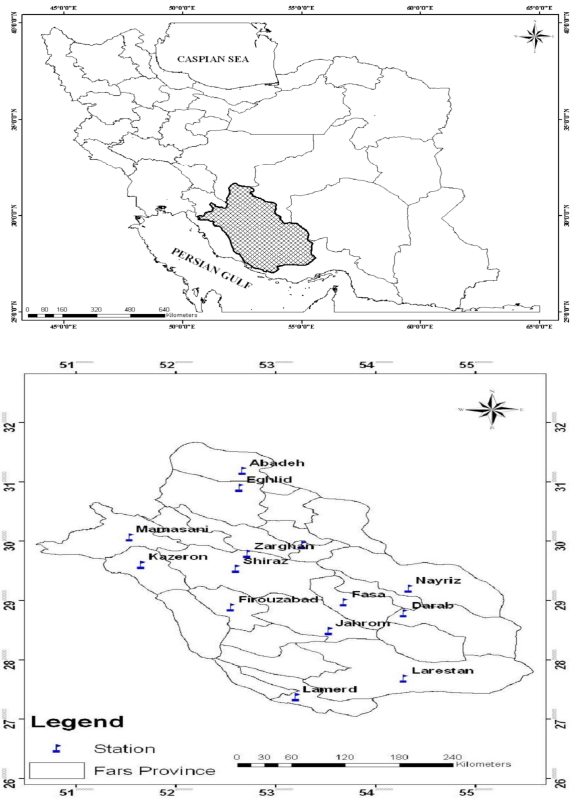

Figure 1- Regional map of Iran, Fars Province and location of studied Stations

III. METHOD

The study was conducted on daily data stations, According to the climatic conditions of the region and a maximum of 35 and 40 degrees, three thresholds at 30, 35 and 40 ° C were selected and Days that the daily maximum temperature was greater than this threshold, were studied. Because of the importance of heat stresses at nights, the number of days that the minimum temperature was higher than 20 ° C, was determined.Then by combining them with the number of days with maximum temperature above 30 ° C, the number of Days that the maximum temperature above 30 ° C and minimum temperatures were above 20 degrees, that has been determined. Then, according to geographical location of the station and temperature thresholds in two cases of 14 stations and 8 stations by SPSS, the equations were extracted. In both cases, regression coefficient for each equation were also determined. Based on the results, Zoning of heat stress was conducted in Fars Province. For mapping used software ArcGis 9.3 and geostatistical models of inverse distance weighting (IDW). In this way the value of a quantity at points with known coordinates, using the same quantity at different locations with known coordinates derived. On the other hand, In this way, the value of a given variable is calculated based on the average of neighboring regions. As the inverse distances weighting by the unknowns points. As the distance between the unknown points and known points reduced, the weight of points were increased and for unknown points, we estimate by using surrounding points at the specific radius (Booth, 2000). After running the model, the output were obtained by a raster maps. Then, several analyzes were performed on the resulting raster maps and maps were classified and raster code has been defined for them. The purpose of classification is identifying heat stress in different regions. After classification, spatial analysis was carried out on Maps, until the connection between the effects established. Finally, zoning maps were mapped with Fars Province map. accordind to the issue areas of vulnerability to heat stress was determined.

IV. RESULTS

As shown in figure (7), which corresponds to the critical threshold maximum temperature is over 30 degrees, it can be seen Lamerd city, the Southern district of Mohr and Khonj, mamasani Appropriate most critical days with maximum temperatures of 30 °C.

Generally In the case central region of Fars Province to the south side ,south and South- East, North-West of Fars Province can be concluded that on average more than 200 days per year is along with maximum temperatures over 30 ° C. According to statistics agriculture Jihad organization,wheat is mainly cultivated in the above area. In the case of wheat, temperatures above 30 ° C will be limited photosynthesis (Mianabadi et al., 2009). In the southern region of Larestan, Lamerd and Mamasani and Kazeroon,the number of days with temperatures higher than 35 ° C is between 140 and 180 days. Therefore, in these areas, there is a thermal stress at critical stages of germination and flowering. But

northern and central area that many critical days with temperature greater than 35 degrees are less than 40 days, are suitable for growing wheat. The number of days with maximum temperature above 40 ° C is almost similar to position of figure (8). Mainly in southern region and Mamasani, the number of days with temperatures higher than 40 ° C is between 100 and 140 days. Just as it is known in some parts, there is not the possibility of cultivate plants sensitive to temperatures greater than 40 degrees. But in most of Fars Province, the days with temperatures over 40 degrees in summer is so low that it is related to summer and not compatible with the sensitive plant condition.

The number of days with minimum temperatures over 20 ° C in Lar, Lamerd, Mohr, mamasani and Kazeroon with high intensity is visible in the figure (9). minimum temperatures is an important factor in some plants to compensate transpiration because of reduction in temperatures in night that loose a lot of water due to high temperatures and transpiration.In mentioned region, in addition to get reach to high maximum temperature of 40° C, it seems in terms of the minimum temperature there is critical situation as minimum temperature as well as 120 to 140 days a year on average more than 20 ° C. Therefore, these areas in terms of thermal stress are in critical condition. But status of minimum temperature has been favorable in the North and central areas and number of days with minimum temperature more than 20 degrees to an average of 20 days is less. Figure (10) shows a similar situation to the role of zoning (9). This map shows that the areas of the South and the north-west are not suitable for the plants that are sensitive to maximum and minimum temperatures greater than 30 ° C to 20 ° C, and the cultivation of these plants is not recommended in these areas.

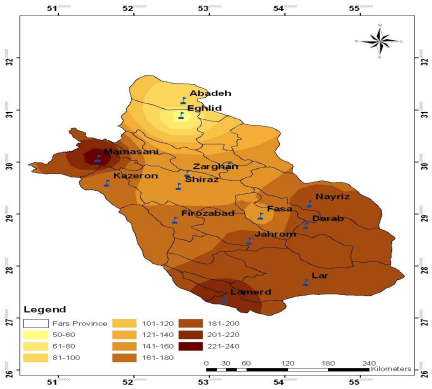

Figure7- Mapping of Fars Province based on the number of days with maximum temperature above 30 °C.

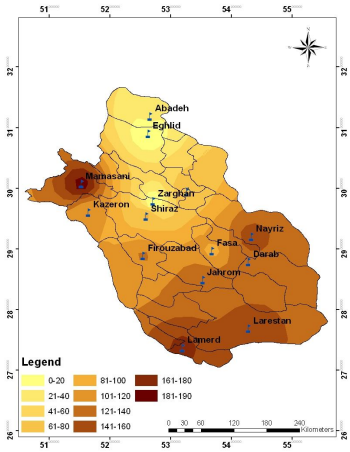

Figure8- Mapping of Fars Province based on the number of days with maximum temperature above 35 °C.

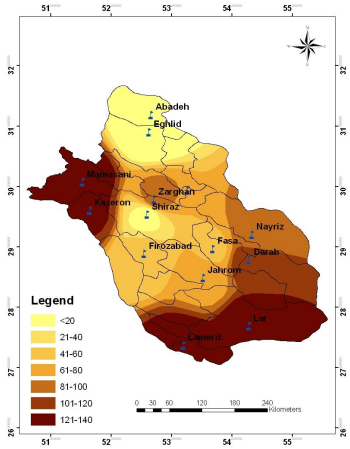

Figure 9- Mapping of Fars Province based on the number of days with minimum temperature above 20 °C.

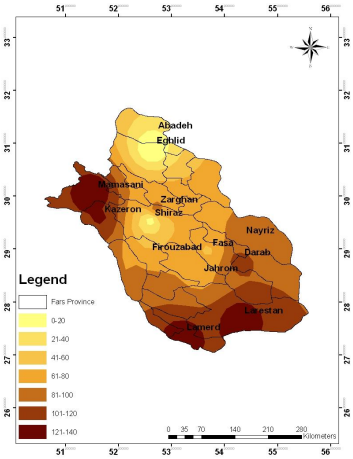

Figure10- Mapping of Fars Province based on the number of days with maximum temperature above 30 °C and minimum temperatures higher than 20 ° C

DISCUSSION AND CONCLUSIONS

Stress reduced the growth and development of plants strongly and while its not studied in regular program automatically in this field, serious risks will threat the life of all living creatures, specially the life of human. Water and climatic factors have fundamental role in

the growth and development of plants and are considered as a bunch of uncontrollable and effective variables in agriculture. In most cases, periods of heat stress coincide during germination and flowering of wheat in Fars Province. Maps provided by climatological analysis helps to agriculture managers to estimate probability of favorable or unfavorable atmospheric events in later stages of crop development with high accuracy. These predictions can be used in practical farming and long-term planning.

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