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The survey of growing season length trend and its zoning in Iran

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Abstract

Growing cycle is a cycle that it's during enough humidity, lack of thermal limits; make the production of agricultural crops possible. Evidences show that time of germination season is getting longer about 10-20 days in recent decade. So that early starting is noticeable. This increase of germination season is associated with global warming. The general goal of this article is the survey of changes and zoning of growing season length based on thermal bases 5° and 10c° in 31 Iran synoptic stations during 20 years common statistical cycle using at least daily temperature from 1961 to 2009 DC (1366 -1386 Solar month). In this study is used 49 years data of Iran synoptic stations (1961-2009) to study how is starting and ending of changes trend and germination season length thermal bases 5° and 10° c. the random data is tested by Man-Cendal test, and the series having changes or trend with reliability level 0.05 α are determined . Then by the Man-Cendal graphical test how and starting time of trend or changes is determined and changes value measured. The research result show more changes in the series related to the starting and the ending of germination season with thermal bases 10°c to series with 5c°. In spite of other stations, Oroomiyeh, Khoramabad, Saghez, Shahrekord is faced with decreasing of germination season. Zoning maps showed that growing season length in the studied area is decreased from south to west and west north, so that in the studied thermal bases, Bandarabas station has longest and Shahrekord station has shortest growing season length among other stations.

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Introduction

Already it has widely accepted that greenhouse gases are increased in earth atmosphere in recent decades. The main impact the increase of greenhouse gases is caused by an increase of weather temperature (Zhang and Colleagues 2008, Basistha *et al*, 2009) and Deni *et al* 2010).

During 20th century the average global temperature is increased between 0.6-2.8c° that the most increasing was between 1976-2000 and this increase from 1990 to 2100 years, will reach 1.4 to 5.8c ° (I.P.C.C, 2001). Among this increase of global weather, Temperature, most of the phonological.

Climatological and satellite research show increase of germination season length result from increasing of temperature in the northern area during 20th (Song and colleagues 2010, Jeong *et al* 2011). Growing season is the cycle between germination and leaf falling that is particularly expected to get longer in high widths (EET 2004).

The changes of growing season length are useful climatic index and have several important climatic uses (Robeson 2002).

By decreasing of growing season length, it also happened changes in the cultivation time that can be decreased efficiency of agricultural crops. However it is possible that increase of growing season length make prior opportunity and make sure of seedling and even possibility of multitude harvests (considering availability of water). Because temperature is one of the most important elements in making of climate, its changes can be changed weather structure of every places. This is reason why the study of temperature trend in the different spatial and temporal large scale is specialized in climatology research.

The studies of researchers have showed that in most part of the world, temperature had been increasing during last century.

Many studies are done about germination season changes and temperature shifts in the different part of the world.

(Menzel *et al*, 2001) has studied phonological season in German during 1951-1996years and found the evidences about early starting of spring (0.23 to 0.28 days in year), however phonological changes had less shifts in the autumn (average 0.3 to 0.1 days in year). (Fitter2002) has studied the first flowering time of 385 plant species in Britain and concluded that the first flowering time is increased about 4.5 days.

(Kozlov & Berlina 2012) found that the germination season length during last 60 years is decreased resulting from spring delay and development of autumn and winter in the Kola Peninsula.(Jones *et al*, 2002) has studied sever temperature G.S.L and daily temperature by considering to last years in 18 century for 4 climatology stations (central England, Stockholm, Avsyala and St.petersburg).

They found that germination season in the north of Europe obviously was warmer than last years of 1960. (Yue *et al*, 2003) has studied monthly , yearly and season temperature of Japan in the last 100 and shown that yearly temperature of 46 stations that is measured by Man-Cendal test is increased from 1900 to 1996 years between 0.51° – 2.77° Celsius. In this cycle, season temperature is increased between 0.47°-3.69° Celsius that most increase is seen in the winter and spring. Dong and colleagues in the study of thermal germination season trend in Taibet desert in China concluded that starting of germination season is advanced about 1.82 days in decade, and germination season length is increased about 3.29 days in decade.

(Beck and colleagues, 2005) using MODISNDVI data have depicted advancing of spring from 2000 to 2004 in Fnvskandya and they found large spatial and temporal differences in this range in the starting of spring more than 2 month in the studied area and more than 1 month during year.

(Linderholm *et al*, 2006) showed that germination season is increased in Baltic area about 7.4 during 20th century that the largest change is happened during spring season.

Research method

To do research at first step was got the statistic of all synoptic station s in Iran that having long time statistic s. in regard to, do this research the short time statistical cycle (about 50 years), was considered, 22 stations were left because they had short time statistical cycle or long stops and finally 31 synoptic stations are chosen that having 49 years common statistical cycles (1961-2009).

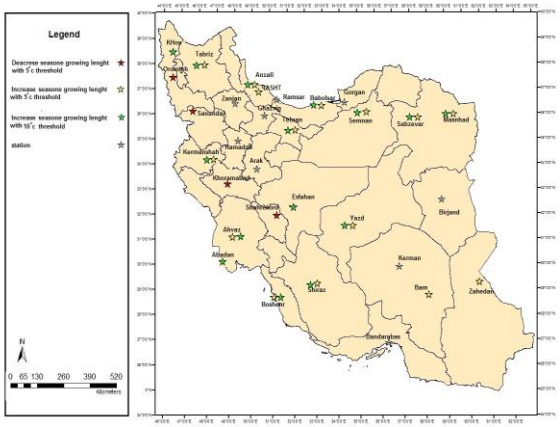

Fig. 1. Seasoan Growing changes in Iran.

Growing season length was measured for thresholds 5° and 10c°. For measuring growing season length the starting and ending date of thermal threshold 5° and 10° c was derived by using Zhylvsy coding (January 20 with code 1 and January 21 the ending of year with code 365).

Growing season length

There are multitude definitions for growing season length. The real growing season length has varied from year to year, and also it is possible growing of agricultural crops is limited to part of this growing season or even out of it. The determining of growing season in every zone has effective role for choosing crops and value and determining of cultivation time and other agricultural decision s. there are multitude definitions for this scope. Anon (1987) stated growing season is as a cycle that enough humidity and lack of thermal limits make production of agricultural crops possible. So 2 important factors for growing cycle are suitable temperature and enough humidity. According to stated definition from the variability group of climatology commission of global weather organization in the north hemisphere ,germination cycle is considered time range between the first cycle after July 1th (Tir 10th)that is at least continuous 6 days , the average of daily temperature is more than 5°c and the first 6 days cycle with the average daily temperature less than 5°c .In south hemisphere this time range is considered the January 1th. In this research because of different climatic conditions of studied area to use statistics of growing season length in cultivating of plant species that are adaptable to threshold 5°c (clod region plants)and 10°c(tropical plants) separately , the onset of growing cycle ,the first 6 day cycles with at least daily temperature($T_{min}\geq$ 10, $T_{min}\geq$5) is considered as the starting of growing cycle (for the onset growing of plant 5°c is necessary)and the last 6 day cycles with at least temperature (Tmin<10,Tmin<5) considered as the ending of growing cycle length.

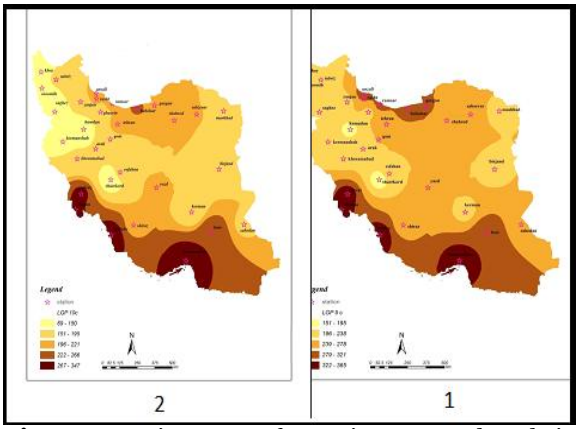

Fig. 2. Zonation map of Growing season length in selected stations based on (1) 5 temperature (2)10 temperature.

Determining trend

In many researches for determining of trend in short time series can be used climatology and hydrology data.

In this research for determining of trend in data used man-cendal nonparametric test.

The nonparametric methods have advantages to other parametric methods. To do test the steps are as follow:

A: the determining of man cendal statistic value by using following formula.

At first for doing this test statistical series is graded and for change value by trend is used following relation:

$$T=\frac{4P}{N(N-1)} \quad \text{Eq(1)}$$

T is man cendal statistic and N the total number of statistical years and P sum of grades more than of each n_i row that is place after it.

N: the total number X is of time series.

To measure meaning full of statistic T; critical statistic (t) is measured by the following relation.

$$t=0\pm tg\sqrt{\frac{4n+10}{9n(n-1)}} \quad \text{Eq(2)}$$

tg is the standard variant value (z) is like the possibility level of test which in this research according to possibility of %95 ; tg=1/9;and as a result the value of critical zone for 49 years the statistics of zone stations is t=/193.

If -0.193 < T < + 0.193 there is no trend and

If t > 0.193 there is positive trend and

If t < -0.193 there is negative trend

B: graphical Method: for determining of trend direction, kind and change time, we need cendal graphical test. So it is usually used special table.

So that at first data is graded and it statistic (the relation of I grade to prior grade) is measured.

Then we measure accumulation frequency of t_i statistic and then expected, variance and index of Man-cendal are measured based on following formula:

$$E_i=\frac{ni\,(ni-1)}{4} \quad \text{Eq(3}$$

$$V_i=\frac{ni(ni-1)(2ni+5)}{72} \quad \text{Eq(4)}$$

$$U_i=\frac{(\sum ti-Ei)}{\sqrt{Vi}} \quad \text{Eq(5)}$$

For the survey of changes, the U'I index should be determined. The measuring steps for U'_i are as follow.l.

Data is graded and t'_i statistic (the relation of I grade to post grade) determine, and then accumulation frequency is measured.

Expected, variance and index of U'_i is measured by the following formula.

$$E'_i=\frac{[N-(ni-1)](N-ni)}{4} \quad \text{Eq(6)}$$

$$V'_i=\frac{[N-(ni-1)](N-ni)[2(N-(ni-1)+5]}{72} \quad \text{Eq(7)}$$

$$U'_i=\frac{(\sum t'i-E'i)}{\sqrt{V'i}} \quad \text{Eq(8)}$$

In the relations (7), (8) N is a volume of studied statistical sample. In this method , the continuous values of ud_i,$u'd_i$ result from Man-cendal test is graphically showed that in this graphic if u,u' values of curves cross each other there is not any trend or changes. But if the curves cross each other, the curves of starting trend by changes are approximately showed.

Research finding

The onset of germination season

The understanding of passing date of 5c° is functionally very important. The average of starting date 5c° in the studied station is varied from Bahman 1th in Bandarabas station in the south of Iran to Ordibehesht 16th in Shahrekord stationin in zagros altitudes. The survey of passing date 10c° especially for tropical crops is very important. The average of starting time 10°c in studied station is varied from

Bahman 19th in Boushehr station in the south of Iran to Tir 6th in Sharekord station. The trends by 0.95 reliability levels are showed that it is seen noticeable decrease in the onset of germination season between studied stations.

so that between 31 stations, 11 stations in the onset of germination season in 0.95 reliability level and 5 station in 0.99 reliability level in both thermal thresholds were faced with negative and decreased Trend and 3 stations (Saghez.

Table 1. The result of Man-cendal test and the changing in the happening time of thermal threshold in terms of days in chosen stations.

stations	The onset of germination season with thermal threshold 5°c		The ending of germination season with thermal threshold 5°c		The onset of germination season with thermal threshold 10°c		The ending of germination season with thermal threshold 10°c	
	The value of changes	Time and kind of changes	The value of changes	Time and kind of changes	The value of changes	Time and kind of changes	The value of changes	Time and kind of changes
Abadan	-	-	-	-	Δd=-4.5	CD 1994	-	-
Ahvaz	Δd=-17.8	CD1981	-	-	Δd=-32.4	TD 1967	-	-
Esfahan	-	-	-	-	Δd=-19.4	CD 2008	-	-
Arak	-	-	-	-		-	-	-
Anzali	Δd=-10.9	Cd 1998	-	-	Δd=-10.4	Cd 1996	-	-
Oroomiye	-	-	-	-	-	-	Δd=10	CI 1970
Babulsar	-	-	Δd=18.8	CI 1968	Δd=-21.6	CD 1999	-	-
Bandarabas	-	-	-	-	-	-	-	-
Bam	-	-	Δd=14.4	CI 1990	Δd=- 3.1	-	-	-
Busher	Δd=- 4.1	CD 1974	-	-	Δd=-21.4	CD 1991	-	-
Birjand	-	-	-	-	-	-	-	-
Tabriz	Δd=-11.5	CD 1968	-	-	Δd=- 2.1	CD 2000	-	-
Tehran	Δd=-10.1	CD 1998	Δd=10.4	CI 1983	Δd=- 19	CD 1992	Δd=-12.3	CI 1989
Khoramabad	Δd=18.9	CI 1976	Δd=-11.8	CD 1976	Δd=12.5	CI 1981	Δd=-19.6	CD 1971
Khoy	-	-	-	-	-	-	ΔD=4.2	CI 1999
Sabzevar		-	Δd=13.7	CI 1975	Δd=-10.9	CD 1970	Δd=24.5	CI 1986
Saghez	Δd=16.9	CI 1996	-	-	Δd=19.9	CI 1992	Δd=- 4.7	CD 1995
shahrood	Δd=-13.2	CD 2001	Δd=14.1	CI 1987	Δd=-13.6	CD 1984	Δd=18.1	CI 1994
Sharekord	-	-	Δd=-17.3	CD 2003	Δd=23.2	CI 1987	Δd=-21.5	CD 1978
Shiraz	-	-	Δd=11.6	CI 1988	Δd=-16.1	CD 1974	Δd=16.7	TI 1979
Ramsar	-	-	-	-	-	-	-	-
Rasht	Δd=- 6.2	CD 2001	-	-	-	-	-	-
Zahedan	-	-	Δd=16.4	CI 1996	-	-	-	-
Zanjan	-	-	-	-	-	-	-	-
Qazvin	-	-	-	-	-	-	-	-
Kerman	-	-	-	-	-	-	-	-
Kermanshah	-	-	-	-	Δd=- 7.2	CD 1978	Δd=10.2	CI 1990
Gorgan	-	-	-	-	-	-	-	-
Mashhad	Δd=-17.4	CD 2001	Δd=18.9	CI 1994	Δd=-13.6	CD 1985	Δd=16.9	CI 1997
Hamadan	-	-	-	-	-	-	-	-
Yazd	-	-	Δd=15.3	TI 1991	Δd=-12.3	CD 2008	Δd=13.3	CI 1997

$\alpha = 0.95$ **

$\alpha = 0.05$ *

Khoramabad,Sharekord) had positive and increased trend. In time series of the onset germination season with 5c° threshold, as showed the result s of table (2), most stations have meaningfull, sudden and decrease changes. Except of Khoramabad and Saghez stations that having sudden and increased trend in 1996 and 1976 respectively about 18.9, 16.9 days, other stations

show decreased trend. Anzali and Tehran stations had under gone decreased and sudden change about-10.9, -10.1 and respectively , in the last 1990s in the end of 20th century in1998 .in the early 21th century in 2001 in Shahrood, Rasht,Mashhad stations decreased and sudden change is showed-13.2,-6/2, -17.4 days respectively. But Ahvaz and Tabriz stations was

showed decreased and sudden changes in 1981, 1988 about -11.5 and 17.8 days respectively. Of course is should be noted that since germination season length in Abadan,Ahvaz,Bandarabas,Busher and Anzaly include all of year and the starting and ending of 5° and `10c° happen at the same time ,in the survey of this stations was only considered to days with temperature less than studied threshold and had studied its changes. The study of series the onset of germination season with 10c° shows that Abadan,Ahvaz,Anzaly and busher were faced with decreasing of days with temperature less than 10c° in 1994,1967,1999 and 1991respectivelyabout-4.5,-32.4,-10.4,21.4 days and Esfahan, Babulsar, Bam,Tabriz ,Tehran, Sabzevar, Shahrood, Shiraz, Kermanshah, Mashhad and yazd had sudden and decreased changes in 2008,1999, 2000, 1992, 1970, 1984, 1974, 1978, 1985 and 2008 about -19.4, -21.6, -3.1, -12.1, -19, -10.9, -13.6, -16.1, -7.2, -13.6, 1.3 days, but Khoramabad, Saghez and Shahrekord had sudden and decreased changes in 1981, 1992, 1987 about 12.5, 19.9, 32.2 days (table 1).

Table 2. Grouping of growing season length for thermal bases 5° and 10c°.

Group	Germination season length with thermal threshold 5°	station	Germination season length with thermal threshold 10°	Station
1	150 - 200	Oroomye,Khoy,Saghez,Sharekord , Kermanshah , hamadan	50 - 100	Sharekord, Hamadan
2	200 - 250	Arak,Esfahan,Birjand,Tabriz,Khoramabad,Sabzevar,Qazvin, Kerman, Mashhad, Zanjan	100 - 150	Oroomihe,Arak, Khoy, Qazvin, Kerman, Kermanshah, Saghez
3	250 - 300	Tehran,Rasht,Zahedan,Shiraz,Gorgan, Yazd, Shahrood, Mashhad	150 - 200	Esfahan, Birjand , Tabriz , Khoramabad, Zahedan, Shiraz, Sabzevar, Mashhad, Zanjan
4	300 - 350	Anzali,Bam, Babulsar,Ramsar	200 - 250	Anzali, Babulsar, Tehran, Ramsar, Rasht, Gorgan,Yazd
5	>350	Ahvaz,Abadan,Badar abas,Bushahr	250 - 365	Ahvaz, Bandar abas, Busher, Abadan, Bam

Ending of growing season

The average of first ending date in 5c° in studied station s is varied from Mehr 12th in sharekord station to Day 30th in Abadan, Ahvaz, in western south and Bandar abas, Busher in south.

By determining the last date that weather temperature in studied station for 6 days reach to less than 10c°, we can measure the growing season length in 10c°. The average of ending 10c° in the studied station is varied from Shahrivar 13th in sharekord station in Zagros altitudes to Day 17th in Bandar abas station in the south of Iran. The Man-cendal trend test shows that most of studied station during last 50 years had positive and decreased trend in the ending of germination season. So that by thermal bases 5c°, 5 stations in 0.95 reliability level and 4 stations with 0.99 reliability level had increased trend and with thermal bases 10c°, to stations with 0.95 reliability level and 6 stations with 0.99 reliability level have positive trend, but Saghez, Sharekord, Khoramabad and Oroomyeh stations show decrease trend. Between times series of germination season ending with threshold 5°c, according to table (1), show the following results:

Except Khoramabad and Sharekord stations that having sudden and decreased changes in 1976, 2003 respectively about - 11.8 and – 17.3 days. Other stations have increased changes. Tehran, Shahrood

and Shiraz are faced with sudden and increased changes in 1980s in 1983, 1987 and 1988.

The measured change value for them during the length was 10.4, 14.1, and 11.6 respectively.

Bam,Zahedan and Mashhad stations in 1990s in 1990,1996,1994 show increased and sudden changes about 14.4,16.4 and 18.9 days.

Babulsar and Sabzevar stations show sudden and increased changes in 1968, 1975 about 18.8, 13.7 days. Yazd station shows increased and slow changes in 1991 about 12.3 days. Between the series of germination season ending in 10c°, Oroomyeh, Tehran, Khoy, Sabzevar, Shahrood, Shiraz, Kermanshah, Mashhad and Yazd stations except Shiraz station have increased and slow changes in 1979 about 16.7 days.

Others stations show increased and sudden changes in 1970, 1989, 1999, 1986, 1994, 1990, 1997 and 1997 respectively. The value of this changes during statistical cycle are 10, 12.3, 4.9, 24.5, 18.1, 10.2, 16.9, 13.3 days respectively.Khoramabad,Saghez and Sharekord stations show sudden and decrease changes in 1971, 1995, 1978 about – 19.6, - 4.7, - 21.5 days(table 1).

Growing season length

as it was showed in the series of starting and ending of germination season with threshold 5c° except of khoramabad ,saghez, sharekordstation that was faced with increasing of germination season length ,other stations that having. Meaningful changes, show increasing of germination season.

In Ahvaz, Anzali, Bushehr, days with temperature less than 5c° has increased about 17.8, 10.9, 4.1days respectively. In Tabriz and Rasht stations only the onset of germination season are started earlier, and in Babulsar, Bam, Sabzevar, Zahedan and Yazd are delayed the ending of germination season. But in Tehran, Shahrood and Mashhad stations have changed the onset and ending of germination season and changes value of germination season had been 20.5, 27.3 and 36.3days respectively.

Khoramabad station was faced with decreasing of germination cycle length from both sides. so that the germination season is decreased in this station about 30.7 days.saghez station was faced with delaying in the onset germination season and germination season length in this station is decreased 16/9 days and in shahrekord station the ending of germination season is advanced and the length of germination season 17.3 days get shorter (table1). according to table 1, the number of days with temperature less than 10c° in Abadan, Ahvaz, Anzali and Bushehr is decreased -4.5, -32.4, -10.4 and -21.4 days respectively.

Also the onset of germination season in Esfahan, Babolsar,Bam and Tabriz is advanced, and the ending of germination season in Oroomye stations is delayed. Tehran, Sabzevar, Shahrood, Shiraz, Kermanshah, Mashhad and Yazd are stations that germination season is increased from both side ,and these values are increased 31.3, 35.4, 31.7, 32.8, 17.4, 30.5 and 25.6 days respectively; that most increases is related to Sabzevar station with 35.4 day. This noticeable change value can have certainly noticeable impact in the life cycles of plants in this zone, and can be followed by noticeable economic impact.

Also Khoramabad, Saghez and Khoramshahr stations had decrease of germination cycle length with 5c° thermal threshold, they show the decrease of germination cycle length with thermal threshold, about 32.1, 24.6 and 45.7 days that the changes value of 3 stations are particularly noticeable in Shahrekord station. In the study it was determined that in 3 stations take place a moving.

Oroomiye station with 10c° shows decrease of germination season. By viewing of result related to the onset and ending of germination season can be concluded that most changes are related to west

south, west and east north of Iran. Between west south and west stations Khoramabad, Shahrekord and Saghez was faced with decreasing of germination cycle length. In west north stations, Tabriz station has 2 noticeable changes, and other stations only have one change, and oroomiye station was faced with decreasing of germination season. Between northern stations Babulsar has only 2 changes, and other stations didn't have changes or they had only one change. Between central Iran stations and the east of Iran most changes are related to Yazd station (picture 1). The average of growing season length for 5c° in studies stations is varied from 151 days, in Shahrekord station to 365 days, in Bandar abbas station (table 2). According to table (2) the average of growing season length in 10c° in studied stations is varied from 69 days in Sharekord station to 347 days, in Bandarabas station.

The classifying of growing season length in the chosen station of country for thermal bases 5° and 10c° For determining homogeneous groups of growing season length for thermal bases 5° and 10c° is considered to zoning group.

By understanding of growing season length of plants in every zone, farmers can cultivate agricultural plants and determine the harvest and cultivate date of crops. Areas that based on 5c° have homogeneous condition s and was placed in the same group. The result of this study is presented in table (2) The growing season length for thermal bases 5° and 10c° is classified into 5 groups and it's zoning maps is depicted. The zoning of growing season length based on 5c° shows that growing season length is increased from the south to west of country (picture 2). In northern area because of nearby Caspian Sea and having humidity and high temperature, growing season length get longer to western areas (picture 2). According to this picture, the zoning of growing season length in 10c° show that the growing season length is more in the southern area and is decreased toward the west. in most studied stations the germination season length is increased in both thermal thresholds, in Khoramabad , Saghez and Sharekord are decreased germination season length.

Conclusion

The survey of changing trend of germination season with 5° and 10c° shows that most of the changes were suddenly and limited number of it had slow trend. For example the ending germination season in Shiraz station with threshold 10° and the ending of germination season in Yazd with 5c° are slow trend. The changes between series with 10°c have better frequency and order to threshold 5c°. Also the directions of changes between 2 thresholds are the same. For example the onset of germination season with 5° and 10° has the decreased trend in Tehran, and the ending germination season in both of them has the increased trend. Among germination season changes with 5° and 10°c the changes in Khoramabad, Sharekord, oroomye and Saghez are noticeable. In four stations the changes trend is opposite of changes direction in other stations, and germination season length is get shorter in these stations. While the results of other stations show that the germination season lengths get longer. The increase of germination season is obviously influenced on plants life. The studies show that the frequency of germination season changes in the west south, west and east north is more in Iran, but in central station, east and north is less than others. one of the reason is, the lack of stations in east of Iran with long term statistics for doing this research .the results of growing season length zoning based on thermal thresholds 5° and 10c° in Iran show that onset of 5° and 10c° in the southern of country,the starting of growing season is earlier and in the western and western north is later. Northern areas have earlier starting because of humidity and high temperature to western areas. In zoning of the en ding date in 5° and 10c°, in the western area the ending of growing season because of earlier decrease of weather temperature is faster than other areas, and the ending of growing season is later in the southern and northern of country. In the study of growing season length is determined that growing season length is

decrease from southern area to western and western north. The growing season length in thermal bases 5°and 10°c can be classified into 5 groups. Generally the understanding of length and starting and ending time of growing season of plants in thermal bases 5° and 10c° can be help to plan for farming in cultivation and harvest of crops and choosing of species that are adaptable to thermal bases and area conditions.

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