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Changing the cultivation pattern and providing the growing degree-day for the phenological stages of three types of tropical legumes in the south of Kerman and its relationship with grain yield

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Abstract
In order to study the effect of changing the cultivation pattern in providing growth and development temperature in different phenological stages of three types of tropical legumes in the south of Kerman and to investigate the relationship between temperature and seed yield, a factorial experiment was conducted in the form of a randomized complete block design with three replications. It was implemented in Jiroft Agriculture and Natural Resources Research Center in 2019-2020. The experimental treatments included three planting dates, 30 Jan, 9 and 19 Feb, and three types of tropical legumes, including tepari or local Jiroft beans, cowpeas, and green mung beans. The results showed that the highest requirement for growth degree-days from planting to germination, from planting to greening and one to five leaf stages in all three planting dates was related to green mung bean. After mung beans, the highest need for growing degree-days in the above stages was observed in Tepari or Jiroft local beans and nightly beans, respectively. In the stages of flowering, pod formation and filling and ripening, the difference between mung beans and two types of beans in the number of degree-days of growth decreased. Although, the delay in planting in all three plants led to a decrease in the supply of growth degree-days from flowering to full maturity, but all three plants had more seed yield in the dates of cultivation than the common planting dates. So that mung bean had the same grain yield on all three planting dates with an average of 770 kg/ha. Tepari beans produced the highest yield in early cultivation, i.e. on 30 Jan, with an average of 2.3 tons per hectare. This legume was associated with a 39% decrease in seed yield on 9 and 19 Feb cultivation dates compared to the first cultivation date. Among the three tropical legumes, cowpea has the highest seed yield with an average of 4.6 tons per hectare and on 30 Jan and 19 Feb there was no difference in production and on the planting date of 9 Feb 26% decrease in seed yield was observed. In general, in the Jiroft region, the date of early winter crops, considering the provision of temperature and humidity necessary to complete the growth and development process and complete the phenological stages for tropical legumes, considering the negative effect of drought on the growth cycle of plants and also Their performance was completely superior to spring cultivation and this finding can be effective in managing the use of air temperature to reduce water consumption in the region.

Keywords: Cultivation history, Tepari beans, Cowpeas, Green mung beans, Climate change

Introduction

Feeding the people of the world is the most important challenge for the future of mankind. Because it is expected that the population of the planet will reach more than nine billion people by 2050. As a result, food production should increase (FAO. 2020). On the other hand, there are growing concerns about the effect of climate change on agricultural production. Climate change leads to global warming phenomenon, which will lead to changes in precipitation patterns in different regions. So that there will be floods in some areas and drought in other areas. As a result, general strategies to deal with climate change are adaptation to changed environmental conditions, such as changing the cultivation pattern (Schultze-kraft et al. 2018). It is expected that due to drought in hot regions, uncultivable land will increase in these regions (Schultze-kraft *et al.* 2018). Available statistics show that the reserves of water resources in many regions of Iran are under serious threat due to non-optimal exploitation and the continuation of this trend will have irreparable economic and environmental consequences in the region. will leave In line with the goals of sustainable development of agricultural products, the correct design of the cultivation pattern is necessary in order to achieve maximum production and increase income and save agricultural inputs, especially water. As a result, crop production can benefit from the benefits of changing the cultivation pattern and crop rotation (Zabel *et al.* 2014).

Agricultural plants use avoidance or tolerance strategies in order to survive environmental stress conditions. Early cultivation of plants has also been introduced as a strategy to escape from the stresses of the end of the season (Shunmugam *et al.* 2018). On the other hand, the efficiency of breeding and selecting plants to increase yield in different climatic regions depends on the reaction of different stages of plant development to the conditions of those regions. In different geographical regions, seasonal changes and temperature can affect the phenology, flowering structure, pod production and finally the final yield. Therefore, phenology is known as a key for the adaptation of plants in different geographical regions, and the examination and comparison of these stages in different plants provides valuable information about timely cultivation and finding the best cultivar adapted to the region. (Bannayan Aval *et al.* 2018). At the genetic level, genes controlling phenology and growth period are known. In addition to genetic knowledge, management methods such as optimizing the date of cultivation of any species can minimize its exposure to environmental stresses during critical growth periods. In the same way, using a wide range of cultivation dates in different places and years is a scientific method to test adaptation in different regions by adapting the high yield of cultivars in the desired climatic conditions (F. Richards *et al.* 2020). Hence, growing degree-days are a good estimate of plant growth stages. Because the degree-day accumulation for each stage of growth is relatively stable and independent of the cultivation date (M. I. Meleha *et al.* 2020). Temperature is one of the most important environmental factors that controls plant growth and performance. All biological processes react to temperature and all these reactions can be summarized in terms of three main temperatures, i.e. base temperature, optimum temperature and maximum temperature. The nature of the response to temperature between these main points, which is important for the calculation of phenology, indicates the adaptation and performance of different plants. Therefore, the current research using long-term meteorological data and drawing the ambrothermic diagram of the region with the change of the growing season from summer to spring in order to investigate the effect of temperature (cumulative growth degree-day) on the date of different plantings. It was designed and implemented based on the performance of two types of legumes with the aim of designing a new pattern of cultivation in accordance with the desired policies and goals of each region.

Materials and methods

The present research was carried out at Jiroft Agriculture and Natural Resources Research Center in 2017 and 2018 crop years. This area is located at 57 degrees east longitude and 28 degrees north latitude and at an altitude of 630 meters above sea level. The data of temperature, relative humidity and average rainfall in the years of the experiment can be seen in Table 2. Before conducting the experiment, samples were taken from the farm soil, the results of which are presented in Table 1.

Table 1. Physical and chemical properties of soil

Depth of Sampling (cm)	K (ppm)	P (ppm)	N (%)	Electrical Conductivity ($ds.m^{-1}$)	pH	Texture
0-25	78.5	20.2	0.039	0.46	7.8	**Lomy-Sandy**
25-50	131.2	12.2	0.012	0.47	7.5	**Lomy-Sandy**

In this study, before the planting operation, to determine the physiological zero of the cultivars in question, and then with the help of the ambrothermic diagram of the region, which was drawn using long-term meteorological data (Table 2), to determine the most suitable range for selecting the planting season. Based on the ambrothermic diagram and according to the plant's need for cumulative temperature and growth day degree or GDD, it was done. Then, a field experiment in the form of a randomized complete block design with three replications for three types of tropical legumes, including Jiroft or Tepari beans (Phaseolus acutifolius), cowpeas (Vigna sinensis L.) and green mung beans (Vigna radiata) on three dates. Planting was carried out on 30 Jan, 9 and 19 Feb. Each experimental plot consisted of five planting rows, six meters long and 2.5 meters wide. The distance between planting rows was 50 cm, the distance between plots was 1 meter, and the distance between repetitions was 2 meters. In this experiment, triple superphosphate at the rate of 50 kg per hectare, potassium sulfate at the rate of 150 kg per hectare and 25 kg of urea fertilizer were also used as starter. For additional nutrition of plants, zinc and manganese sulfate fertilizers were used in the amount of 50 kg/hectare each, which were added to the ground before planting.

Table 2. Meteorological charactrictics during growing season of legumes

2017-2018	Minimum Temperature (C°)	Maximum Temperature (C°)	Minimum Humidity (%)	Maximum Humidity (%)	precipitation (mm)	Sunny hours
January	6.8	23	26	74	2.4	212.1
February	12.5	27.5	23	82	10.2	228.3
March	16.1	34.1	17	65	2.3	259.3
April	20.4	37.5	14	45	1.3	269.5
May	26.1	44.2	12	43	0	283.8
June	27.2	45.6	9	45	0	329.1
Average	18.1	35.3	16.8	59	2.7	263.6
			2018-2019			
January	7	20.9	33	85	72.1	190.5
February	9.1	22.9	31	87	49.7	235.8
March	15.3	28.5	32	85	52	173.3
April	18.2	36.3	15	65	5.6	248.5
May	22.8	42.8	9	49	1.6	312.1
June	26.8	45.7	12	60	0	301.4
Average	16.5	32.8	22	71.8	30.1	243.6

The phenological stages of plant growth and development included germination, greening, emergence of the first to fifth trifoliate stage, flowering, pod formation, pod filling and full maturity. A time calendar was recorded for each stage, and 50% treatment was considered in the pods in each plot.

Cumulative temperature measurement or cumulative growth degree-day (GDD) was calculated using weather data and maximum and minimum daily temperature during the growing season according to the following relationship:

$$GDD = \frac{\sum(T_{max} + T_{min}) - T_{base}}{2}$$

GDD: growth degree-day, T_{min} and T_{max}: minimum and maximum daily temperature, respectively, and T_{base}: base temperature for tropical legumes was considered 15 degrees Celsius. This is also called physiological zero temperature (Gimdil *et al.* 2013; Ghersa *et al.* 1995).

Results and discussion

Based on the results of analysis of variance (Table 3), the effect of the years of the experiment on the degree-day of green growth at the level of 1% and the emergence of two and five leaves at the level of 5% was significant. The effect of different planting date on the degree-day of germination, greening and appearance of the first, third, fourth, and fifth trifoliate and pod filling was significant. Legumes had significant differences in terms of the degree-day of germination, emergence of the first to fifth trifoliate, flowering, pod formation and filling. The interaction of year and planting date on degree-day growth, germination and greening also showed a significant effect. In addition, there was a significant difference at the 5% level on the degree-day growth of the first to fifth three leaves and pod filling. The interaction of year and leguminous type on degree-day growth of germination, greening and second trifoliate was significant at 1% level. The interaction of planting date and plant type also showed a significant effect on the growth degree-day of germination, greening and emergence of the first to fifth three leaves, but it did not have a statistically significant effect on other phenological stages According to Table 4, in the first year of the first and second cultivation dates, the degree-day showed less growth towards germination than the third cultivation date. While in the second year, the degree-day growth of the first planting date decreased compared to the other two planting dates. The highest degree-day of growth, with an average of 51.2 degree-days of cumulative growth, was related to cultivation on 30th of February 2017. The lowest value with an average of 46.8 was observed on the sowing date of 10 Bahman of the second year. Since several environmental factors such as temperature, humidity and physical characteristics of soil and quality traits of seeds have an effect on the germination of plants, therefore these differences can also be caused by the mentioned factors (Ahmed Alsajri *et al*. 2019). Germination and early growth of seedlings are more sensitive to the required temperature and humidity, and therefore, the optimal soil moisture conditions are one of the important factors in germination and suitable green surface of plants (Haji Babaee *et al*. 2015).The cumulative amount of growth degree-days required for germination increased in both years with planting delay. The reason for this could be due to the cool temperature of the soil during the selective planting season, which may require more growing degree-days to warm the soil enough and make germination possible (El-Zohiri and Farag. 2014) Based on the results of the interaction of year and type of legume, the highest degree-day of germination growth in both years of the experiment was related to green mung bean plant. So, in 2018, the mentioned legume required 7% more degree-days of growth than the first year for germination. Tepari bean and nightingale showed the same degree of germination in both years of growing degree-days, the amount of which in the second year (average of 42 growing degree days) was slightly lower than the first year (average of 42.5 growing degree days). Table 5.

The results of the interaction between different planting dates and the type of legume indicated that the number of growth degree-days required for the germination of mung beans was greater than that of two types of beans, in all three selected planting dates. In such a way that mung bean had the highest amount of this environmental index on the first and third planting dates with an average of about 62 degree growth days and without significant difference. Green mung bean recorded a lower growth rate of nearly 3% degree-days on the sowing date of 9 Feb. Tepari bean and Cowpeas also showed the highest number of degree-days of growth on the date of cultivation on 19 Feb with an average of 45 degree-days of growth and no statistical difference. By choosing early planting dates, the growth degree-days required for their germination decreased by 2% and 9% respectively when planting on 30 Jan, 9 Feb (Figure 1) .

As can be seen in Table 3, due to the relative decrease in air temperature on 19 Feb, the maximum degree-day of growth of the greening stage of plants in both years of the experiment is related to the mentioned date. Based on this, the highest degree-day of growth with an average of 62.6 degree-day of growth was observed on the third planting date of 2017, which had no statistically significant difference with the planting date of 30 Jan in the same year. The sowing date of 9 Feb also showed the lowest value with an average of 59.6 degrees growth days. In 2018, in all three planting dates, the growth degree-day decreased compared to the first year. So that the two sowing dates of 9 and 19 Feb, without any difference, had an average of 58 degrees of growth days, and the cultivation on 30 Jan with an average of 54 degrees of growth days had the lowest amount of growth degree-days of greening in two years. The experiment was accompanied. According to Table 4, green mung bean in both years 2017 and 2018, without significant difference, had the highest degree of growth days in the greening stage with an average of 73 degree days of growth. While the degree-day growth of tepari bean and nightshade bean decreased in the second year compared to the first year. In 1998, these two legumes had growth degree days of 47.8 and 50 degree days respectively, which showed a decrease of 15% and 8% respectively compared to the first year. Comparison of the average interaction between date and type of legume showed that in all three planting dates, the highest degree-day of green growth is related to green mung bean plant. So that the highest value with an average of 75.7 degree-days of growth corresponding to the sowing date of 30 Jan and the delay in planting until 9 and 19 Feb, without difference, reduced its growth degree-days by 6%. The degree-days of growth related to tepari bean and cowpeas showed an increase in the sowing dates of Jan, 9 and 19 Feb compared to 10 Bahman. So, on the date of cultivation, tepari beans on 30 Jan, 9 and 19 Feb respectively average 50.6, 52.7 and 53 degree days of growth and cowpeas average 47, 52.7 and 56.5 degree days respectively. They attributed the growth to themselves(Figure1).

The investigation of other researchers showed that one of the factors of the greening of plants is the availability of more moisture due to rainfall. In such a way that planting dates that cannot provide the required moisture for several days after planting lead to non-germination of a number of seeds and their germination percentage decreases. (Ghanbari *et al.* 2012) that this matter was in full agreement with the findings of the present study.

Based on this, it has been stated that most legumes are sensitive to the lack of soil water, especially at the stage of seedling establishment in the field, and most of the time their cultivation relies on soil moisture reserves after rain (Moradi *et al.* 2013). In both years, with a delay in the degree-day cultivation, the growth required for the plants to turn green increased, which is due to the decrease in temperature. In agreement with the present results, Sharma et al. (Sharma *et al.* 2021) reported that the emergence of phenological stages occurs much faster with increasing temperature and the number of days related to emergence also decreases.

The results of determining the interaction between the year and the planting date showed that the highest growth degree-day of the one-leaf stage with an average of 173.4 degrees was related to the planting date of 30 Jan of 2018, which with the planting date of 9 Feb of the same year and 9 and 19 Feb 2017, there was no significant difference. The lowest value was also observed with an average of 160 degrees growth days on the planting date of 19 Feb of the second year (Table4).Also,the interaction of experimental treatments showed that the required growth degree-day of green mung bean plant in Jiroft region is higher than the other two types of legumes in all cultivation dates. The mung bean plant recorded the highest degree-day of growth with an average of 243.5 degree days of growth on the first planting date. The delay in planting was accompanied by a decrease in the number of degree-days of plant growth. The highest and lowest growth degree-days of Jiroft or Tepari local beans with an average of 144.2 growth days and 127 growth days were observed on the second and third planting dates, respectively. While cowpea had an average of 137 degree-days of growth on the two planting dates of 9 and 19 Feb without significant difference, and cultivation on 30 Jan caused a five percent decrease in its growth degree-days (Figure 1).

Based on the results of the interaction of year and planting date on the growth degree-day of the appearance of two leaves, there was no significance of the selected dates in both years of the experiment. The highest value with an average of 229.2 was observed on Feb 30, 2017, which was in the same statistical group with two other sowing dates in the same year and 2018. The lowest value with an average of 216.3 degrees of growth days was related to the planting date of 19 Feb of the second year (Table 4). Examining the interaction of year and type of legume also showed that all three plants in the second year needed less growth degree-days for the two-leaf stage than in the first year. The highest degree-day of growth with an average of 317.5 degree-days of growth was related to mung bean plant. In the same year, tepari beans and nightshade showed an average of 190 and 169 days of growth, respectively. While the average of Tepari, Cowpea and mung bean in the second year was 188, 170 and 303 degrees of growth days, respectively (Table 5).

According to Figure 1, the delay in planting led to an increase in the growth degree-days of the two-leaf stage of two types of beans. So that cultivation on 9 and 19 Feb compared to 30 Jan increased the number of degree-days required for the growth of tepari bean by 8% and 5% and in cowpea by 18% and 24%, respectively. On the contrary, planting on 9 and 19 Feb decreased the mung bean growth by 9% and 12% degree-days, respectively, compared to earlier planting.

According to Table 4, the lowest growth degree-day of the three-leaf stage was observed when the plants were grown on the planting date of 19 Feb 2018 with an average of 267.3 degree days of growth. The highest value with an average of 295 days of growth and no significant difference was related to the date of the second crop in both years. Based on the interaction of planting date and type of legume, mung bean plant had the highest growing degree-day with an average of 388 growing degree-days without any difference. While plant cultivation on 19 Feb, 4%, degree-days had lower growth.The lowest growth degree-day among the three legumes and in all cultivation dates was associated with cowpea. Cowpea recorded the lowest growth degree-day on the sowing date of 30 Jan with an average of 217 degree-days of growth (Figure 1).

The interaction of the year and the date of cultivation on the degree-day value of four-leaf stage growth (Table 4) indicated the highest value and no significant difference (average of 365 degree days of growth) in both years for cultivation on 9 Feb. The lowest value with an average of 328 degrees of growth days was obtained on 19 Feb 2018. Also, the interaction of experimental treatments showed that in all three planting dates, the cumulative temperature required by the mung bean plant has the highest value (average of about 500 degrees growth day) without significant difference. While cowpea obtained the lowest value in the first and third crop dates without statistical significance with an average of about 240 degree days of growth (Figure 1).

The interaction of year and planting dates showed that cowpea cultivation in both years of the experiment has the highest growth degree-days of the five-leaf stage (an average of 438 growth degree days). However, the degree-day plant growth of mung bean in the first year was not significantly different from cowpea. But in the second year, with an average of 401 degree-days of growth, it had the lowest degree-days of growth (Table 4). According to Figure 1, the highest growth degree-day of the mentioned phenological stage is related to mung bean planting on 30 Jan, 9 Feb, without statistical significance. While cultivation on 19 Feb reduced mung bean growth by 6% degree-days. Although, tepari bean cultivation in all three planting dates did not show any differences with each other, but in cowpea, the lowest growth degree-day with an average of 285 growth degree days was related to the first planting date. According to the interaction of the year and the date of cultivation (Table 4) on the growth degree-days of pod filling, except for the third cultivation date in 2018, which showed the lowest value with an average of 945 growth days, the other cultivation dates in Both years had the highest degree-day of growth without statistical significance.

The results of other researchers showed that the delay in planting due to the increase in temperature leads to an increase in cumulative temperature, especially in the reproductive stages of the plant (Naderi. 2013). While the change in the cultivation pattern of tepari beans, chickpeas and mung beans in the region, due to the presence of lower temperature compared to the usual spring cultivation, did not show an effect on increasing the average degree-day growth of the cultivation dates, especially in the reproductive stages. Therefore, it seems that the dates of selective cultivation have led to the proper use of climatic factors, especially humidity.

According to the interaction of different planting dates and the type of legume and since three different types of legume were examined, differences in the yield of plants were observed. But the important point is the different performance of a legume in three cultivation dates. Tepari beans showed the highest yield in the sowing date of 10 Bahman with an average of 2.3 tons per hectare. While the delay in planting led to a decrease in its seed yield up to 1.4 tons per hectare. It should be mentioned that Tepari had a similar performance on 9 and 19 Feb. Cowpea had the highest yield in the first and third planting dates without significant difference and with an average of 4.6 tons per hectare, and showed a 26% decrease in yield in the second planting date. While mung bean had similar grain yield in all three planting dates without significant difference, the average was 0.7 tons per hectare (Figure 1).

Cowpea bean is one of the legumes that has the largest cultivation area among all types of legumes in tropical regions. Therefore, one of the effective factors in achieving the desired level of production potential, per unit area, is the identification of the most appropriate cultivation pattern for each region (Madani et al. 2010). In a two-year experiment in Jiroft, the highest yield of cowpea and tepari bean in summer cultivation was reported as 2.9 and 1.3 tons per hectare, respectively

(Afsharmanesh. 1994). While in the present study, the seed yield of cowpea and tepari was obtained as 4.2 and 1.7 tons per hectare respectively in spring cultivation. As a result, changing the cultivation pattern of the region had a significant effect on the grain yield of both types of legumes. The difference in the yield of the two seasons can be attributed to the amount of rainfall and the increase in the reproductive period in spring planting compared to summer planting, which is consistent with the findings of Ezeaku *et al.* (2015).

Reports have shown the average yield of mung beans in summer cultivation in different regions between 0.2 and 0.3 tons per hectare (Soleymani Fard and Naseri. 2020; Habibzadeh *et al.* 2006). While in the present study, the seed yield of 0.7 tons per hectare was obtained in all the planting dates without any significant difference. Therefore, in the case of green mung bean cultivation as well as two types of beans, the change of the planting pattern in the studied area compared to the history of the usual cultivation in the area, both in terms of ecology and the problems related to the reduction of water resources on the one hand and the increase of farmers' productivity On the other hand, it is recommendable.

According to Table 6, the correlation between the day of cumulative growth of the stages of germination and the filling of pods was observed to be positive and significant. The full ripening stage had a positive and significant correlation with the stages of flowering, pod formation and pod filling with a coefficient of 90% and did not show a statistically significant correlation with other stages. The relationship between leguminous seed yield with the stages of germination, greening, one to five leaves was negative and very significant, and with the stages of flowering, pod formation, pod filling and full ripening, there was no statistical significance.

Table 3. Analysis of variance of the effect of different planting dates on the degree-day growth of phenological stages of three types of legumes

Seed yield	Maturation	Pod Filling	Pod formation	Flowering	The fifth of three leaves	The fourth of three leaves	Third of three leaves	Second of three leaves	First of three leaves	Emergence	Germination	d.f	
1.7^{*}	1115^{ns}	1162^{ns}	226^{ns}	97^{ns}	997^{*}	396^{ns}	275.3^{ns}	364.3^{*}	23^{ns}	277^{**}	0.5^{ns}	1	**(Year)**
0.48^{ns}	139507^{**}	940100^{**}	77747^{**}	68072^{**}	17343^{**}	11868^{**}	7822^{**}	4801^{**}	2768.6^{**}	334	232	2	**(Replication)**
0.003	1	0.58	0.15	0.09	0.76	0.2	0.21	0.36	0.001	0.61	0.003	2	**(Year*Replication)**
1.8^{*}	1696.4^{ns}	6220^{**}	696.5^{ns}	990^{ns}	2897^{**}	3839^{**}	1816^{**}	59^{ns}	354^{**}	40^{**}	36^{**}	2	**(Planting Date)**
0.01^{ns}	607^{ns}	2123^{*}	256.6^{ns}	84^{ns}	1004^{*}	505.3^{*}	363^{*}	202.8^{*}	103.7^{*}	43^{**}	25.8^{**}	2	**Planting) (Date*Year**
58.6^{**}	869.3^{ns}	2874^{**}	7306^{**}	4302^{**}	448203^{**}	316459^{**}	137035^{**}	104645^{**}	56085^{**}	2600^{ns}	1915^{**}	2	**(Legume)**
0.37^{ns}	88.4^{ns}	600^{ns}	64^{ns}	272^{ns}	576.8^{ns}	268.7^{ns}	119^{ns}	304.2^{**}	18.4^{ns}	68.5^{**}	66.6^{**}	2	**(Legume*Year)**
1.1^{*}	350.4^{ns}	596^{ns}	394^{ns}	271.5^{ns}	2320^{**}	1121^{**}	431.8^{**}	2516^{**}	393.6^{**}	74.7^{**}	14^{**}	4	**Planting Date*Legume**
0.007^{ns}	153.6^{ns}	541^{ns}	325^{ns}	284.4^{ns}	515.7^{*}	422.4^{*}	245.7^{*}	294.4^{**}	38^{ns}	19.2^{**}	17.2^{**}	4	**Planting Date*Legume*Year**
29.6	2.2	2.2	2.2	2.2	3.3	3.3	3	3.3	3.2	2.5	2.4	-	**C.V. (%)**

* *, *, ns: respectively, significant at level of 1 and 5% and no-significant

Table 4. Interaction of year and planting date on degree-day cumulative growth of phenological stages and grain yield

Seed yield ($t.ha^{-1}$)	Maturation	Pod Filling	Pod formation	Flowering	The fifth of three leaves	The fourth of three leaves	Third of three leaves	Second of three leaves	First of three leaves	Emergence	Germination	Treatment
2.3^{ab}	1202.3^{a}	986.6^{a}	901.2^{ab}	845.2^{a}	416.8^{b}	345.2^{b}	282^{b}	221.5^{ab}	170^{ab}	61.7^{a}	48.3^{c}	**30Jan.2018**
1.7^{b}	1209.7^{a}	997.4^{a}	892.5^{ab}	835.5^{ab}	438.7^{a}	365.5^{a}	297.3^{a}	225.7^{ab}	170.3^{ab}	59.6^{b}	48^{c}	**9Feb.2018**
2^{ab}	1199^{ab}	979.2^{a}	896.7^{ab}	833.8^{ab}	427^{a}	345.7^{b}	282^{b}	229.2^{a}	166.2^{b}	62.6^{a}	51.2^{a}	**19Feb.2018**
2.7^{a}	1200.2^{ab}	992.7^{a}	902.6^{a}	844.3^{a}	418.2^{b}	346.7^{b}	281.7^{b}	220.8^{ab}	173.4^{a}	53.8^{d}	46.8^{d}	**30Jan.2019**
2^{ab}	1207^{a}	997.7^{a}	891.6^{ab}	836^{ab}	436.6^{a}	365.4^{a}	295.3^{a}	223.8^{ab}	169^{ab}	57.7^{bc}	50.6^{ab}	**9Feb.2019**
2.4^{ab}	1176.5^{b}	945^{b}	884^{b}	826.2^{b}	401.2^{c}	328^{c}	267.3^{c}	216.3^{b}	160^{c}	58.7^{bc}	50^{b}	**19Feb.2019**

Mean with same letter(s) in not significantly different using Duncan׳s multiple range tests ($p \leq 0.05$)

Table 5. Interaction of year and legumes on degree-day cumulative growth of phenological stages and grain yield

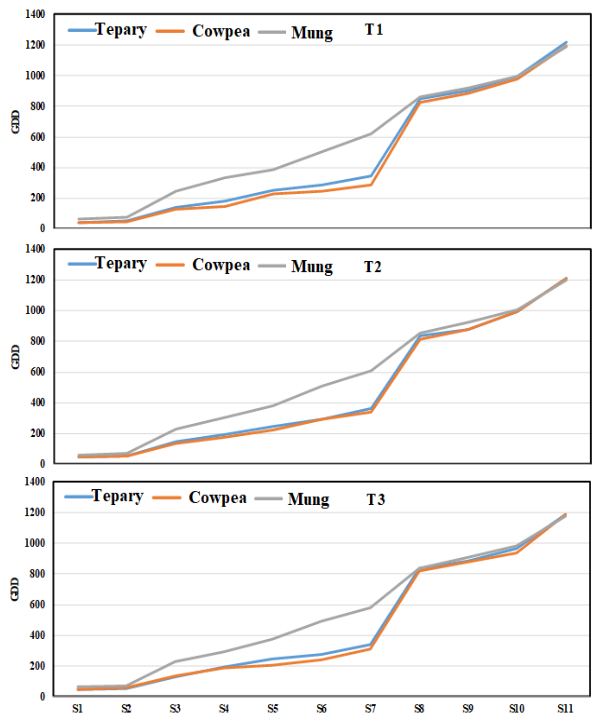
Seed yield (t.ha^{-1})	Maturation	Pod Filling	Pod formation	Flowering	The fifth of three leaves	The fourth of three leaves	Third of three leaves	Second of three leaves	First of three leaves	Emergence	Germination	Treatment	
1.6^{c}	1209.3^{a}	993.8^{ab}	890.6^{b}	839.4^{a}	355.4^{c}	286.5^{c}	249.6^{c}	190^{c}	137^{b}	56.5^{b}	44.5^{c}	2018	Tepary bean
3.8^{b}	1202.5^{ab}	967.2^{bc}	878.8^{b}	818.8^{b}	312.4^{d}	261^{d}	229^{d}	169^{d}	135.2^{b}	54^{c}	44.5^{c}		Cowpea
0.66^{d}	1199^{ab}	1002.2^{a}	921^{a}	856.3^{a}	414.5^{a}	509^{a}	388^{a}	317.5^{a}	234^{a}	73.4^{a}	59^{b}		Green mung beans
1.8^{c}	1202.5^{ab}	978.3^{b}	885.3^{b}	840.4^{a}	350.8^{c}	285^{c}	245.2^{c}	188^{c}	138^{b}	47.8^{e}	42^{d}	2019	Tepary bean
4.5^{a}	1196.2^{ab}	971.3^{bc}	879^{b}	821.4^{b}	312.6^{d}	260.6^{d}	220.7^{d}	170^{d}	133.4^{b}	50^{d}	42^{d}		Cowpea
0.77^{d}	1185^{b}	985.8^{ab}	914^{a}	844.7^{a}	593.2^{b}	449.7^{b}	378.3^{b}	303^{b}	231^{a}	72.4^{a}	63.3^{a}		Green mung beans

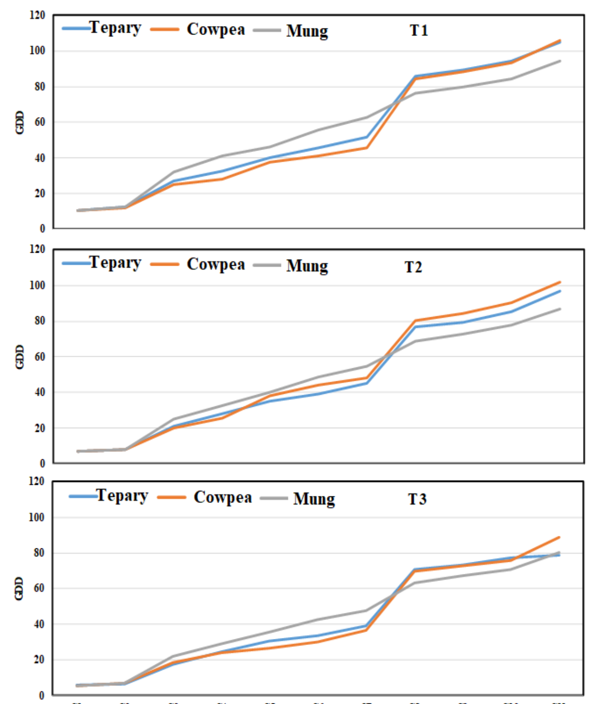
Mean with same letter(s) in not significantly different using Duncan's multiple range tests ($p \leq 0.05$)

Table 6. correlation between degree-day growth of penological stages with yield of three legumes

Germination	Emergence	First of three leaves	Second of three leaves	Third of three leaves	The fourth of three leaves	The fifth of three leaves	Flowering	Pod formation	Pod Filling	Maturation	Seed yield	
12	11	10	9	8	7	6	5	4	3	2	1	
											1	1
										1	-0.6**	2
									1	0.9**	-0.6**	3
								1	0.9**	0.9**	-0.6**	4
							1	0.9**	0.9**	0.9**	-0.7**	5
						1	0.9**	0.9**	0.8**	0.9**	-0.7**	6
					1	0.9**	0.9**	0.9**	0.8**	0.9**	-0.7**	7
				1	0.9**	0.9**	0.9**	0.9**	0.9**	0.9**	-0.7**	8
			1	0.3**	0.3**	0.4**	0.4**	0.4**	0.4**	0.4**	-0.1ns	9
		1	0.9**	0.4**	0.4**	0.4**	0.4**	0.4**	0.5**	0.5**	-0.1ns	10
	1	0.9**	0.9**	0.3**	0.3**	0.3**	0.3*	0.3*	0.3**	0.3**	-0.1ns	11
1	0.9**	0.9**	0.9**	0.1ns	0.1ns	0.1ns	0.1ns	0.1ns	0.2ns	0.2ns	0.01ns	12

**, *, ns: respectively, significant at level of 1 and 5% and no-significant





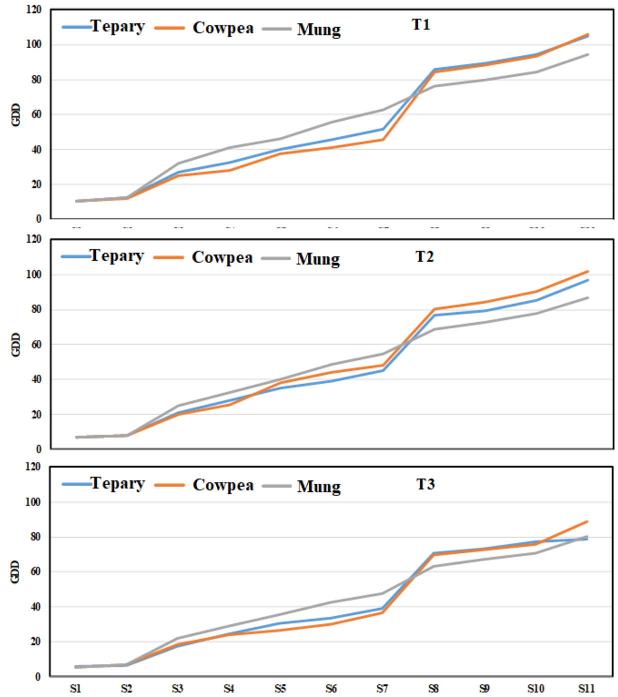


Fig 1. Interaction of different planting dates and legume types on the degree-day growth of phenological stages T1-T3: 30 Jan. 9 and 19 Feb. respectively

S1-S11: Germination, Emergence, First of three leaves, Second of three leaves, Third of three leaves, the fourth of three leaves, the fifth of three leaves, Flowering, Pod formation, Pod Filling, Maturation

Conclusion

In tropical climates, similar to the south of Kerman province, due to the significant difference in the range of temperature changes in different seasons of the year and in order to reduce the stress caused by the plant encountering the intensity of summer temperature in these areas, which causes a negative effect on the different stages of growth and The growth of plants and shortens the time of each phenological stage, which not only reduces the yield of the plant, but also increases the production costs due to the lack of irrigation water. The modification of the cultivation pattern for tropical legumes, which was carried out based on the intelligent change of planting date, was aimed at studying the effect of temperature on the natural needs of tropical legumes in the study area, and the change of planting season in this research not only resulted in the natural completion of the phenological stages of legumes. Rather, this change could not reduce the grain yield in them. According to the results of the present research, due to the possibility of rainfall in the months of February to April and the need to pay attention to the increase of water productivity in the region, it is suggested to change the cultivation pattern from spring to winter. Also, due to the decrease in the supply of degree-days for the phenological stages of the growth of the local beans of Jiroft or Tepari, Cowpea and Mung beans on the planting date of 10 Bahman compared to the planting dates of 9 and 19 Feb, planting at the earliest opportunity in winter can lead to It helps to provide the necessary temperature to complete the growth stages. In addition, due to the increase in grain yield of two types of legumes in winter cultivation compared to spring cultivation, changing the cultivation pattern will significantly increase the income of farmers.

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