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Effect of Sowing Date on Grain Yield and Yield Components of Wheat Cultivars under Dryland Condition

Galdi Mohammad Bahalkeh[1], Abbas Biabani[2,*], Hossein Sabouri[2], Hossein Ali Fallahi[3]

[1]Department of Ecological Agriculture Sciences, College of Agriculture and Natural resources, Gonbad Kavous University, Gonbad Kavous, Golestan Province, Iran.
[2]Department of Plant Production, College of Agriculture and Natural resources, Gonbad Kavous University, Gonbad Kavous, Golestan Province, Iran.
[3]Horticulture Crops Research Department, Mazandaran Agricultural and Natural Resources Research and Education Center, AREEO, Sari, Iran.

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***Corresponding author:** Abbas Biabani, Department of Plant Production, College of Agriculture and Natural resources, Gonbad Kavous University, Gonbad Kavous, Golestan Province, Iran.
Email: abs346@yahoo.com

Abstract

In order to study the effects of sowing date and spring wheat cultivars on yield and yield components a split plot experiment based on randomized complete blocks design with three replications was carried out in the Research Farm of Gonbad University, Iran in 2013-2014, 2014-2015. Sub-plots included planting dates (4th and 19th of November, 3rd, and 18th of December, 2nd, and 18th of January, 8th, and 23rd of February, and 9th of March). The main plots were spring wheat cultivars (Khazar 1, Falat, Zagros, Kuhdasht, and Kareem). The results showed that a delayed planting date reduced the number of days from planting to flowering, therefore plant height and removable storage material reduced in the seed. Delay in planting reduced number of spike, number of seeds per plant, grain weight per spike and grain weight, also reduced yield. The highest grain yield was obtained from the planting date i.e. 4th November in the year 2013-2014 with 4,178.3 kg ha^{-1} per hectare and in the year 2014-2015 with 3,194.13 kg ha^{-1}. The lowest grain yield was obtained from the delayed sowing date i.e. 9th March in the year 2013-2014 with 762.2 kg ha^{-1} and in the year 2014-2015 with 920.58 kg ha^{-1} respectively. Among the cultivar, Kuhdasht in years 2013-2014, 2014-2015 (2,005.7 and 2,244.99 kg, respectively) and in the year 2013-2014 Zagros (1,830.9 kg) and in the year 2014-2015 Falat (1,645.83 kg) had the highest and the lowest yield, respectively. In general, the best cultivar was Kuhdasht and the best planting date was 4th November.

Keywords

Falat, Grain Weight, Khohdasht Cultivar, Planting Date, Split Plot, Spike Weight, Wheat, Yield

1. Introduction

The growing population has so affected the existing resources. Hence, supplying the needed food, conventional methods of agriculture and strategies related to the optimization of land and increasing production of grains, especially wheat should be reconsidered more than ever. It is crucial to plant seeds at the right time to increase the grain yield of winter crops [1]. The area under wheat cultivation in the world is 220,417,745 hectares with an average yield of 3,307.4 kg ha-1; in Asia 102, 275, 561 hectares with an average yield of 3,132.1 kg ha-1; and in Iran is 7.3 million hectares under wheat cultivation with an average yield of 1,452.1 kg [2]. One of the basic aspects of the optimum agricultural management in the cultivation of a plant is to determine the planting date. Since sowing date is different in the climatic conditions of each region, it results in changes in the process of plant growth as well [3]. Planting date is a factor that often affects the physiological and morphological characteristics of the plant. Proper planting date creates suitable environmental conditions for seedling emergence and survival [4]. M. Mehrpouyan, G. Timas, and G. R. Aminzadeh [5] studied on wheat and showed that there is a significant difference between various planting dates regarding the biological yield; harvest index; plant height; growth duration; days to heading; the number of fertile tillers and spike length. The higher grain yield on this planting date was due to the period of growth, spike length, and greater number of tillers. Biological yield, number of spikes per area unit, days to booting, days to maturity and the amount of degree-day were affected by planting date. The highest biological yield (14,415 kg ha^{-1}) was achieved on November the 4th. In the delayed sowings, due to the late season heat and low soil temperature at the planting time; grain yield decreases [6]. Compared with the initial planting, the planting delay caused a significant loss of grain yield up to the amount of 7.98%. To get the highest yield on early planting, in the present study, the cultivar of KSU-106 was 2% and 11.3% more than the other two genotypes (KSU-105, Yecora Rojo). However, the wheat yield is significantly related to the cultivar choice [7]. Similarly, wheat planting in Gorgan on December 21th had the highest production in the number of spikes; spike weight; the weight of 1,000 grains; and biological yield [8]. Wheat planting at the wrong time, whether soon or late, leads to many adverse results; on the contrary, wheat planting at the optimal time leads to high germination percentage; tillering well; timely phenological growth; production of strong plants with strong roots; a reduction in dormancy; and an increase in grain weight for all types of wheat [9]. In delayed planting, due to shortening the growth phases more grains should be used. On the other hand, high temperature during the reproductive growth, especially during flowering period at the end of the season, along with humidity and heat stress cause yield loss [10]. The aim of this study was to evaluate the effect of sowing date on the yield and yield components of wheat cultivars.

2. Materials and Methods

This experiment was conducted in 2013-2014, 2014-2015 at Gonbad Kavous University Research Farm, Iran. Gonbad Kavous (37° 15´ N and 45° 46´ E) has cold and humid winters and hot and dry summers. The 10-year average of rainfall in Gonbad Kavous has been 447 mm and average annual temperature of 17.7°C. Most of the precipitation in this city is in the form of rain in winter and spring. Totally, it has a warm and Mediterranean climate (Table 1). The study was done in a split plot in a randomized complete block design with three replications. Main plot was planting date and sub-plot was spring wheat cultivars. Spring wheat cultivars included Khazar 1, Falat, Zagros, Kuhdasht and Kareem and planting dates were 4th and 19th of November, 3rd and 18th of December, 2nd and 18th of January, 8th and 23rd of February, and 9th of March. Weather conditions in the area on these dates are indicated in Table 1. The dimensions of each experimental unit were 3×2 m; row spacing was 20 cm. The density was 350 grains per square meter. Seed were sown by direct planting. According to soil test results (Table 2), 150 kg ha^{-1} nitrogen fertilizer was given to the plots in three stages including before planting, during tillering, and booting. Weeds were manually controlled two times during tillering by hand. Phenological traits such as number of days to emergence; days to tillering; days to stem elongation; days to flowering and days to maturity were recorded according to the Feekes scale. Every growth stage was recorded in a plot as long as 50% of the plants achieved that stage. To study the spike length, spike weight, seed weight, number of seeds and number of spikelet, 20 spikes were randomly selected. At maturity stage, about 2 m^2 per plot was harvested in order to evaluate grain yield, biological yield, and harvest index. The harvest index was obtained by dividing the grain yield by the biological yield. Following examining the homogeneity of variances, analysis of variance was carried out using SAS software version 9.3.1. The means were compared by least significant difference (LSD) test at the 5% level.

3. Results and Discussion

3.1 Phenological Characteristics

3.1.1 Days from Planting to Physiological Maturity and Grain Filling Period

The results of variance analysis showed that the effects of the following factors were significant at the one percent level ($P<0.01$); the factors include: year; different planting dates; the interaction of year and planting dates; cultivars and their effects on the number of days to emergence, tillering, stem elongation, booting and physiological maturity. The interaction between planting date and cultivar was significant at the level of one percent in traits such as the number of days to stem elongation and booting and at the level of five percent ($P<0.05$) in traits such as the number of days to emergence; tillering; and physiological maturity (Table 3). The interaction between year and cultivar was significant at the level of five percent in traits such as the number of days to stem elongation and physiological maturity and at the level of one percent in traits such as the number of days to emergence; tillering; and booting. The interaction among year, planting date, and cultivar was significant at the level of one percent in traits such as the number of days to stem elongation and booting and at the level of five percent in traits such as the number of days to tillering and physiological maturity. Regarding grain filling period of cultivars on different planting dates, there was a significant difference at the level of one percent (Table 3). Different planting dates were different in terms of temperature and day length (Table 1). These two factors affected the vegetative growth from cultivation stage to stem elongation. The results of average comparison, in traits from planting to emergence, showed that the grain germination depends on receiving moisture. In the first year of cultivation on the 19th of November, due to lack of rainfall, it took a long time for the seed to germinate and emerge. However, in the second year on the same date, since there was proper rainfall for seed germination (Table 1), the seed germinated faster and the plant grew more rapidly. On March 9th, the seeds planted in the first year germinated faster than the seeds planted in the second year. As a result, based on reviewing this comparison, we can conclude that planting date has a significant impact on the emergence of the seed and moisture is much more important in this regard. According to the results in traits such as the number of days to tillering; days to stem elongation; days to flowering; and days to physiological maturity, it can be concluded that the planting delay reduces the period of vegetative growth. Reducing the time between booting and physiological maturity reduce the period of grain weight filling. Studying the effects of different planting dates, in two years, on the period of grain weight filling showed that delayed planting decreased the period of grain weight filling (Table 4). Delayed planting reduces the grain filling period between the booting and physiological maturity. It is also influenced by the thermal stress at the end of the growing season that, in turn, reduces the yield. The results matched Ahmadi, et al.'s [11] findings. According to the tillering and stem elongation time on different planting dates, the results indicated that delay in sowing causes the plant to move to tillering and stem elongation stages faster and also spend its vegetative phase faster. On dates of delayed sowing, this fact gives the plant less time for the production and storage of dry matter transferrable to the grain; this, in turn, causes less transferrable dry matter to be transmitted to the grain in the weight filling period of the grain and as a result, grain weight is reduced in plant and it finally decreases the grain yield. It also reduces the vegetative growth period which reduces the amount of dry matter produced by plant and their biological function as well. According to mean comparison of the trait number of days to emergence, in the first and second years, the cultivar Kareem had the greatest number, and the cultivar Khazar 1 and Kuhdasht in the first year and Zagros in the second year needed the lowest number of days for germination (Table 5). In the trait such as number of days to tillering, in the first and second years respectively, the cultivars Kuhdasht and Kareem had the highest and the cultivars Falat and Zagros had the lowest number of days (Table 5). In the trait days to stem elongation, there was no significant difference between the cultivars in the first year and the cultivars Zagros and Kareem had the highest while the cultivar Khazar 1 had the lowest number of days. However, in the second year, there was a significant difference between the cultivars and Falat had the highest and Zagros had the lowest number of days to stem elongation (Table 5). In the trait of number of days to heading, in the first and second years respectively, the cultivars Falat and Kuhdasht had the highest number and the cultivars Zagros and Kareem had the lowest number of days. As a result, in the first year, the cultivar Falat had the longest vegetative growth period and the cultivar Zagros had the lowest vegetative growth period and in the second year, the cultivars Kuhdasht and Kareem had respectively the highest and the lowest vegetative growth period (Table 5). The vegetative growth period has a significant impact on grain yield as well as on the production and storage of the materials that can be transmitted to the grain. In terms of number of days to physiological maturity, in the first and second year, Falat had the highest number of days (139.51 and 136.03 respectively) and the cultivars Kareem and Khazar 1 had the least number of days to maturity (respectively 138.33 and 134.88). The interval between booting and physiological maturity has a great impact on filling grain weight. A comparison between the cultivars showed that in the first year Khazar 1 and in the second year Kareem had the highest and Falat had the lowest filling grain weight in two consecutive years (Table 5).

3.2 Grain yield and its Components

3.2.1 Plant Height

Based on the variance analysis, there is a significant difference at the level of one percent ($P<0.01$) among different planting dates and various cultivars as well as the interaction between year and planting date; and the cultivar and planting date (Table 6). The results of mean comparison on different planting dates in both years showed that planting delay decreases plant height (Table 6). It matches results of [5]. The reason why in late planting, plant height is reduced is that the time required for vegetative growth is decreased and the plant starts the reproductive phase earlier. According to the results of mean comparison, among the cultivars, Zagros was the highest and Falat and Kareem were the shortest (Table 8).

3.2.2 The Total Number of Spikes

Analysis of variance demonstrated that the total number of spikes per square meter per year; different planting dates; the interaction of year and planting date; and the interaction between year and cultivar were significant at the level of one percent (Table 6). The total number of spikes per square meter is one of the important components in grain yield by increasing of which, grain yield is also increased. In the first year Khazar 1 and in the second year Kuhdasht had the highest yield in terms of the total number of spikes per square meter on all studied planting dates and this increase in the number of spikes per square meter significantly influenced the grain yield in different planting dates (Table 8). As Bahrani and Tahmasebi Sarvestani [12] reported, increase in the number of spikes per square meter will result in an increase in grain yield. The results earned from different planting dates revealed that delayed planting reduces the number of spikes per square meter (Table 7). Reducing the time it takes to grow tillers, planting delay results in insufficient production of spikes per square meter and consequently decreases grain yield [13].

3.2.3 Grain Weight per Spike

Variance analysis showed different planting dates; cultivars; and interaction of year and planting date had a significant effect on grain weight, at the level of one percent ($P<0.01$) and interaction among year, planting date, and cultivar had a significant effect of five percent on grain weight (Table 6). A comparison of average results on different planting dates in two consecutive years showed that the highest and lowest grain weight per spike were observed respectively on November the 19th and March the 9th (Table 7). These results match those achieved by Afiuni, et al. [14]. Grain weight was affected by environmental conditions and grain filling period. Delayed planting causes the grain filling period to be reduced and, thus, plant deals with poor environmental conditions and due to slight and insufficient transition of photosynthetic materials to the grain, it will be small and thin reducing the weight of grains per spike. The mean comparison among various cultivars revealed that in the first year, Kuhdasht had the highest and Falat had the lowest grain weight per spike while in the second year, the cultivars Kareem and Kuhdasht had the highest and again Falat had the lowest grain weight per spike (Table 8).

Table 1. Condition of climate Zone Gonbad Kavous (37° 15´ N and 45° 46´ E)

Years 2013-2014							
		Temperature (Centigrade)		Soil Moisture (%)		Rainfall (mm)	Evaporation (mm)
Year	Month	min	max	min	max		
2013	October-November*	5.6	30.6	14	95	15.5	50.5
2013	November-December	-0.2	31.8	19	97	70.8	28.8
2013-2014	December-January	-3.6	21.2	27	100	6.5	23.7
2014	January-February	-9	27.2	23	100	25.7	25.9
2014	February-March	-0.6	25.4	35	100	46.8	43.3
2014	March-April	-0.2	32.4	26	100	55.4	77.3
2014	April-May	10.2	39.6	14	98	28.4	147.1
2014	May-June	18	44.6	18	98	42.4	195.9
Years 2014-2015							
2014	October-November	3	31.2	16	99	41.6	49.2
2014	November-December	-0.9	24.2	26	100	48.5	21.8
2014-2015	December-January	-1	28.1	17	100	14	33.8
2015	January-February	-3	25.1	31	100	40.9	33
2015	February-March	-0.8	21.9	26	100	76.9	35.1
2015	March-April	4.2	37.6	21	100	25.1	68.7
2015	April-May	6.6	35.8	13	98	8	143.2
2015	May-June	14.4	47.2	10	86	0.1	246.7

Table 2. Analysis of soil Zone Gonbad Kavous (37° 15´ N and 45° 46´ E)

Soil Texture Class	Nitrogen %	Potassium (ppm)	Phosphorus (ppm)	Organic matter %	EC (ds/m)	pH
Silt Clay Loam	0.13	447	10.9	1.5	1.7	7.9

Table 3. Analysis of variance for planting date effect on phenology and some agronomical traits of five wheat cultivars

S.O.V	D.F	Mean of squares					
		Days to emergence	Days to tillering	Days to stemming	Days to spiking	Days to physiological maturity	Grain filling duration
year	1	300.83^{**}	44.81^{**}	$3,666.75^{**}$	825.12^{**}	750.00^{**}	1.79^{ns}
Error a	4	1.68	0.29	0.28	1.22	0.46	1.47
Planting date	8	292.99^{**}	$1,840.19^{**}$	$7,902.00^{**}$	$25,984.51^{**}$	$32,367.24^{**}$	528.04^{**}
year× Planting date	8	348.82^{**}	211.84^{**}	452.08^{**}	775.32^{**}	446.56^{**}	77.50^{**}
Error b	32	1.36	0.45	0.31	1.01	0.36	1.12
Cultivar	4	7.04^{**}	3.86^{**}	1.88^{ns}	41.01^{**}	11.91^{**}	10.61^{**}
Cultivar× planting date	32	1.74^{*}	1.93^{*}	2.17^{**}	1.75^{**}	1.45^{*}	2.12^{**}
year× Cultivar	4	3.68^{**}	3.81^{**}	2.85^{*}	4.05^{**}	2.23^{*}	7.80^{**}
year× planting date× Cultivar	32	1.17^{ns}	1.68^{*}	2.13^{**}	2.08^{**}	1.51^{*}	2.61^{**}
Error	144	1.04	1.07	1.14	0.64	0.87	0.91
C.V. (%)		5.75	2.31	1.41	0.76	0.68	2.97

Notes. * and ** and ^{ns}: significant at 5% and 1% and no significant probability levels, respectively.

Table 4. Means comparison of different planting date effects on the studied phenology traits

Traits / Planting date	Number of day to emergence (day)		Number of day to tillering (day)		Number of day to stemming (day)		Number of day to spiking (day)		Number of day to physiological maturity (day)		Grain filling duration (day)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
4th November	23.00^{b}	10.53^{e}	51.00^{b}	44.06^{e}	99.93^{a}	84.60^{b}	154.80^{a}	130.33^{a}	192.06^{a}	175.80^{a}	37.26^{a}	45.46^{a}
19th November	12.00^{g}	17.20^{c}	40.93^{e}	47.06^{d}	94.93^{b}	87.93^{a}	140.86^{b}	129.80^{a}	175.60^{b}	165.00^{b}	34.73^{b}	35.20^{b}
3rd December	16.00^{e}	16.20^{cd}	49.73^{c}	52.20^{b}	94.20^{c}	88.06^{a}	134.13^{c}	125.93^{b}	165.06^{c}	156.53^{c}	30.93^{e}	30.60^{d}
18th December	22.80^{b}	19.20^{b}	58.46^{a}	54.20^{a}	91.93^{d}	80.20^{c}	122.06^{d}	117.80^{c}	153.93^{d}	150.06^{d}	31.86^{d}	32.26^{c}
2nd January	18.80^{d}	21.66^{a}	51.20^{b}	49.20^{c}	87.06^{e}	73.20^{d}	108.66^{e}	106.80^{d}	142.66^{e}	138.80^{e}	34.00^{c}	32.00^{c}
18th January	29.73^{a}	17.00^{c}	50.06^{c}	43.20^{f}	78.06^{f}	63.93^{e}	96.66^{f}	95.93^{e}	128.80^{f}	125.80^{f}	32.13^{d}	29.86^{d}
8th February	20.20^{c}	15.20^{d}	42.06^{d}	37.06^{h}	66.06^{g}	57.80^{g}	78.33^{g}	83.00^{f}	110.06^{g}	114.93^{g}	31.73^{d}	31.93^{c}
23rd February	13.80^{f}	16.93^{c}	35.06^{f}	38.20^{g}	55.06^{h}	60.06^{f}	68.20^{h}	75.60^{g}	96.93^{h}	102.06^{h}	28.73^{f}	26.46^{e}
9th March	12.80^{g}	16.20^{cd}	28.20^{g}	34.20^{i}	47.06^{i}	52.20^{h}	57.00^{i}	64.06^{h}	84.80^{i}	90.93^{i}	27.80^{g}	26.86^{e}
LSD	0.80	1.00	0.67	0.22	0.37	0.47	0.64	0.89	0.56	0.35	0.66	0.96

Note. Treatments followed by the same letter were not significantly different at $p > 0.05$.

Table 5. Means comparison of wheat cultivars on the studied phenology traits

Traits / Cultivars	Number of day to emergence (day)		Number of day to tillering (day)		Number of day to stemming (day)		Number of day to spiking (day)		Number of day to physiological maturity (day)		Grain filling duration (day)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Khazar 1	18.48^{b}	16.62^{b}	44.96^{ab}	44.33^{bc}	79.14^{a}	72.00^{abc}	105.29^{d}	102.62^{b}	138.51^{b}	134.88^{c}	33.40^{a}	32.25^{ab}
Falat	18.85^{ab}	17.07^{ab}	44.88^{b}	44.70^{ab}	79.29^{a}	72.51^{a}	108.25^{a}	104.11^{a}	139.51^{a}	136.03^{a}	31.25^{c}	31.92^{b}
Zagros	18.92^{a}	15.88^{c}	45.07^{ab}	43.88^{c}	79.51^{a}	71.55^{c}	106.33^{c}	102.85^{b}	138.48^{b}	135.22^{bc}	32.14^{b}	32.37^{ab}
Kuhdasht	18.48^{b}	16.51^{bc}	45.55^{a}	44.03^{c}	79.37^{a}	71.70^{bc}	107.44^{b}	103.66^{a}	139.37^{a}	135.96^{a}	31.92^{b}	32.29^{ab}
Kareem	19.22^{a}	17.29^{a}	45.48^{ab}	44.92^{a}	79.51^{a}	72.22^{ab}	106.40^{c}	103.00^{b}	138.33^{b}	135.62^{ab}	31.92^{b}	32.62^{a}
LSD	0.43	0.64	0.59	0.52	0.58	0.57	0.40	0.46	0.47	0.54	0.57	0.46

Note. The two treatments were not significantly different between at least one letter in common.

Table 6. Analysis of variance for planting date effect on yield, yield component and some agronomical traits of five wheat cultivars

S.O.V	D.F	Mean of squares								
		Plant height	Number of spikes	Grain weight per spike	Number of grains per spike	Number of spikelet per spike	Grain thousand weight	Seed yield	Biological yield	Harvest index
year	1	144.26^{ns}	138,663.79**	0.07^{ns}	5,351.12**	51.74**	3,927.58**	1,427,007.8*	130,921,135**	5,427.37**
Error a	4	23.10	2453.49	0.05	30.24	1.30	17.90	69,248.9	840,959	44.12
Planting date	8	3,949.23**	61,768.29**	1.99**	956.19**	65.29**	284.80**	24,597,710.0**	156,363,376**	198.08**
year× Planting date	8	120.04**	5,499.15**	0.17**	66.23**	10.31**	76.36**	2,147,293.9**	8,182,397**	155.55**
Error b	32	49.45	2,582.15	0.04	19.99	1.44	15.93	305,187.8	2,751,970	113.21
Cultivar	4	319.39**	1,425.04^{ns}	0.23**	221.27**	48.42**	432.03**	1,154,039.9**	1,157,459^{ns}	313.25**
Cultivar× planting date	32	62.47**	1,632.25^{ns}	0.02^{ns}	34.44**	1.88^{ns}	41.55**	249,482.3^{ns}	801,220^{ns}	56.68^{ns}
year× Cultivar	4	36.81^{ns}	4,989.42**	0.01^{ns}	26.34^{ns}	2.20^{ns}	7.48^{ns}	725,175.5*	2,553,352^{ns}	37.81^{ns}
year× planting date× Cultivar	32	6.68^{ns}	1,281.13^{ns}	0.03*	15.78^{ns}	1.35^{ns}	29.03**	219,156.5^{ns}	1,151,099^{ns}	65.49^{ns}
Error	144	28.10	1,195.30	0.02	18.15	1.51	10.93	158,517.5	1,249,137	44.39
C.V. (%)		6.87	16.33	16.19	12.94	7.22	10.96	25.91	19.65	18.33

Notes. * and ** and ^{ns}: significant at 5% and 1% and no significant probability levels, respectively.

Table 7. Means comparison of different planting date effects on the studied yield and yield component traits

Traits / Planting date	Plant height (cm)		Number of spike (m^{2})		Grain weight per spike (gr)		Number of grains per spike	
	2013	2014	2013	2014	2013	2014	2013	2014
4th November	91.28^{a}	88.65^{a}	293.11^{a}	279.45^{ab}	1.49^{a}	1.36^{a}	46.16^{a}	34.13^{a}
19th November	94.42^{a}	90.23^{a}	240.67^{b}	310.05^{a}	1.37^{a}	1.00^{bc}	41.42^{b}	30.72^{a}
3rd December	89.10^{a}	87.52^{a}	192.67^{c}	262.17^{bc}	1.14^{b}	1.05^{bc}	43.00^{ab}	31.10^{a}
18th December	78.05^{b}	79.14^{b}	178.00^{cd}	253.58^{bc}	1.12^{b}	1.12^{b}	42.59^{b}	32.43^{a}
2nd January	76.02^{bc}	75.87^{bc}	170.67^{cde}	213.56^{de}	0.88^{c}	1.01^{bc}	37.18^{c}	30.94^{a}
18th January	72.12+bc	75.29^{c}	167.56^{cde}	213.28^{de}	0.91^{c}	0.93^{cd}	37.70^{c}	26.95^{b}
8th February	70.20^{c}	74.05^{c}	173.11^{cd}	224.06^{cd}	0.77^{cd}	0.75^{ef}	33.83^{d}	24.77^{b}
23rd February	61.05^{d}	66.88^{d}	151.78^{de}	184.44^{ef}	0.66^{de}	0.81^{de}	29.30^{e}	24.99^{b}
9th March	55.39^{d}	63.15^{e}	133.56^{e}	168.44^{f}	0.59^{e}	0.60^{f}	25.08^{f}	20.10^{c}
LSD	6.46	3.60	38.82	38.92	0.16	0.16	3.33	3.70

Note. The two treatments were not significantly different between at least one letter in common.

Table 7 (Continued). Means comparison of different planting date effects on the studied yield and yield component traits

Traits / Planting date	spikelet per spike		Grain thousand weight (g)		Seed yield (kg ha^{-1})		Biomass yield (kg ha^{-1})		Harvest index	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
4 November	19.62^{a}	16.65^{abc}	32.67^{a}	40.39^{a}	4,178.3^{a}	3,194.13^{a}	10,033.3^{a}	8,854.2^{a}	44.26^{a}	36.22^{a}
19 November	18.48^{bc}	17.28^{ab}	33.53^{a}	33.05^{bc}	3,132.5^{b}	2,694.85^{b}	7,266.7^{b}	8,875.0^{a}	45.55^{a}	30.38^{c}
3 December	19.53^{a}	17.53^{a}	26.75^{b}	34.20^{bc}	2,082.8^{c}	2,582.04^{b}	6,900.0^{b}	8,259.7^{ab}	33.28^{b}	31.69^{c}
18 December	18.94^{ab}	17.44^{ab}	26.38^{bc}	34.87^{b}	1,862.4^{cd}	2,632.73^{b}	4,844.4^{c}	7,451.4^{b}	41.90^{ab}	35.39^{ab}
2 January	17.82^{c}	17.68^{a}	23.82^{cd}	33.24^{bc}	1,442.4^{de}	1,866.54^{c}	4,206.7^{c}	5,827.8^{c}	37.42^{ab}	31.95^{bc}
18 January	17.09^{d}	16.38^{bcd}	24.45^{bcd}	34.47^{b}	1,484.8^{de}	1,855.06^{c}	3,657.8^{cd}	5,719.4^{c}	43.53^{ab}	32.76^{abc}
8 February	16.18^{e}	16.08^{cd}	22.94^{d}	30.78^{c}	1,278.8^{ef}	1,473.92^{d}	3,533.3^{cd}	4,811.1^{d}	37.73^{ab}	30.50^{c}
23 February	15.62^{e}	15.49^{de}	22.79^{d}	32.83^{bc}	976.2^{ef}	1,289.09^{e}	2,500.0^{de}	4,116.7^{de}	41.37^{ab}	31.21^{c}
9 March	13.70^{f}	14.60^{e}	23.69^{d}	31.85^{bc}	762.2^{f}	920.58^{f}	1,955.6^{e}	3,516.7^{e}	42.25^{ab}	26.48^{d}
LSD	0.72	1.07	2.66	3.44	543.14	182.64	1,494.8	868.85	10.54	3.62

Note. The two treatments were not significantly different between at least one letter in common.

Table 8. Means comparison of wheat cultivars on the studied yield and yield component traits

Traits / Cultivars	Plant height (cm)		Number of spike (m^{2})		Grain weight per spike (gr)		Number of grains per spike	
	2013	2014	2013	2014	2013	2014	2013	2014
Khazar 1	75.04^{bc}	77.39^{bc}	201.36^{a}	235.10^{a}	0.95^{bc}	0.96^{a}	41.14^{a}	31.23^{a}
Falat	73.44^{c}	76.50^{c}	200.62^{a}	218.05^{b}	0.87^{c}	0.87^{b}	36.90^{bc}	27.77^{b}
Zagros	81.21^{a}	80.23^{a}	178.02^{b}	231.00^{ab}	1.02^{ab}	0.96^{a}	35.23^{c}	27.01^{b}
Kuhdasht	78.21^{ab}	78.76^{ab}	182.84^{ab}	245.17^{a}	1.08^{a}	1.00^{a}	38.57^{b}	28.18^{b}
Kareem	74.11^{c}	76.45^{c}	182.22^{ab}	242.34^{a}	1.04^{ab}	1.01^{a}	34.97^{c}	28.08^{b}
LSD	3.47	2.11	20.89	16.35	0.09	0.07	2.34	2.28

Note. The two treatments were not significantly different between at least one letter in common.

Table 8 (continued). Means comparison of wheat cultivars on the studied yield and yield component traits

Traits / Cultivars	Number of spikelet per spike		Grain thousand weight (gr)		Seed yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Harvest index	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Khazar 1	19.08^{a}	17.74^{a}	23.01^{c}	30.80^{b}	1,970.3^{a}	1,981.28^{b}	5,376.5^{a}	6,415.1^{a}	39.49^{ab}	30.18^{b}
Falat	17.85^{b}	16.99^{ab}	23.30^{c}	31.22^{b}	1,838.5^{a}	1,645.83^{c}	5,037.0^{a}	5,929.0^{b}	37.61^{b}	28.20^{b}
Zagros	17.14^{c}	16.34^{b}	28.43^{ab}	35.58^{a}	1,830.9^{a}	2,197.39^{a}	4,827.2^{a}	6,562.5^{a}	41.11^{ab}	33.03^{a}
Kuhdasht	16.51^{d}	15.39^{c}	27.46^{b}	36.06^{a}	2,005.7^{a}	2,244.99^{a}	4,969.1^{a}	6,361.1^{a}	41.71^{ab}	34.94^{a}
Kareem	16.63^{cd}	16.37^{b}	29.48^{a}	36.15^{a}	1,910.4^{a}	2,213.26^{a}	4,733.3^{a}	6,638.9^{a}	44.13^{a}	32.87^{a}
LSD	0.54	0.76	1.54	2.01	367.49	143.43	788.64	336.81	4.63	2.14

Note. The two treatments were not significantly different between at least one letter in common.

3.2.4 Number of Grains per Spike

Results of variance analysis showed that the following factors made a significant difference at the level of one percent in the trait the number of grains per spike: year; different planting dates; various cultivars; the interaction of year and planting date; and the interaction between cultivar and planting date (Table 6). The highest and lowest numbers of grains per spike were observed respectively on the planting dates November the 19th and March the 9th (Table 7). These results matched those of a research was done by Kalatearabi, et al. [6]. The number of grains per spike is affected by planting date because as a result of delayed planting, plants encounter with thermal stresses at the end of their growing season. Temperature is quite effective in flowering, pollination, and seed formation; in addition, flowering time is reduced for seed production resulting in a decrease in seed production. In the first year, Khazar 1 had the highest and Kareem and Zagros had the lowest number of grains per spike while in the second year, Khazar 1 had the highest and Zagros and Falat had the lowest number of grains per spike (Table 8). The positive role of grain number in spike in selecting the most appropriate planting date for new cultivars of wheat is affirmed by researchers [15].

3.2.5 The Number of Spikelet per Spike

Results of variance analysis showed that the following factors had a significant effect at the level of one percent on the trait the number of spikelet per spike: year; different planting dates; various cultivars; the interaction of year and planting date (Table 6). Among the planting dates in the first year November the 19th and March the 9th and in the second year January the 2nd and March the 9th had respectively the highest and lowest number of spikelet per spike (Table 7). Delay in planting causes a shortening of the time span for spikelet to emerge and also shortens the growth period of spikes as long as the last spike is formed; the result is the reduction of spikelet per spike which accords with the results of a study by [16]. The mean comparison among various cultivars revealed that Khazar 1 had the highest and Kuhdasht had the lowest number of spikelet per spike in both studied years (Table 8).

3.2.6 Weight of One-thousand Grains

The weight of a thousand grains is one of the major components of yield. Results of this study indicated that the effects of year; different planting dates and various cultivars; the interaction of year and planting date made a significant difference at the level of one percent in this component (Table 6). A comparison of average results on different planting dates in two consecutive years showed that in the first year November the 19th had the highest and March the 9th had the lowest weight of a thousand grains. In the second year, the highest and lowest weight of a thousand grains were observed respectively on November the 19th and February the 8th (Table 7). Reduced grain weight per spike indicated that, due to delayed planting, fewer stored materials are transmitted to the grain. Delay in planting causes spikes to appear late. As a result they have to deal with adverse environmental conditions and the heat. The plant, then, produces weak secondary tillers without enough nutrients, photosynthetic, or water to produce full weight grains. These results accord with the findings of [14, 17]. The mean comparison among various cultivars revealed that the cultivars Kareem, Zagros, and Kuhdasht had the highest while Khazar 1 and Falat had the lowest weight of a thousand grains in both studied years (Table 8).

3.2.7 Grain Yield

Results of the study showed that among different planting dates; cultivars; and interaction of cultivar and planting date, there is a significance difference in terms of yield at the level of one percent and in the effects of year and interaction between year and cultivar, a significant difference of five percent was observed (Table 6). The grain yield is influenced by traits of yield components including the total number of spikes; spike length; spike weight; grain weight per spike; number of grains per spike; number of spikelet per spike; and a-thousand-grain weight. By comparing different planting dates and yield components, it was found that delayed planting reduces yield of the measured traits; and, thus, reduces the grain yield (Table 7). The results of this study match those of the researches were done by [6, 17, 18, 19]. Wheat yield significantly depends on the selection of a suitable cultivar [7]. The results of comparing mean grain yields of different cultivars revealed that Kuhdasht in the two studied years had the best yield while the cultivar Zagros in the first year and Falat in the second year had the lowest yield (Table 8). Evaluation of results on the measured traits of yield and its components showed the total number of spikes per square meter; a-thousand-grain weight; and grain weight per spike had the greatest impact on grain yield of various cultivars.

3.2.8 The Biological Yield

Results of variance analysis showed that there is a significant difference at the level of one percent among different years; different planting dates; and the interaction of year and planting date (Table 6). According to the results of evaluating the traits the number of days to emergence; days to tillering; the number of days to stem elongation; the number of days to physiological maturity; and plant height, delay in planting reduced their yield. Vegetative growth affects biological function and its reduction causes biological yield to reduce. The results of this study approve those of the researches done by [6]. According to the results of mean comparison of different planting dates, delayed planting reduces the biological function and yield (Table 7).

3.2.9 Harvest Index

Results of variance analysis for harvest index showed a significant difference at the level of one percent ($P<0.01$) for effects of year; different planting dates; various cultivars; and the interaction of year and planting date (Table 6). Results of the present study matched with [20]. Given that there is a direct relationship between harvest index and grain yield, grain yield decreased with delay in planting date resulting in a decline in harvest index (Table 7). Results of comparing the harvest index of various cultivars showed that Kareem and Kuhdasht had the highest harvest index

(44.13 and 34.94) respectively in the first and second years while Falat had the lowest harvest index (37.61 and 28.20) in the two consecutive years (Table 8).

4. Conclusions

Results of this study indicate that plant growth is affected by ambient temperature and selecting the optimum planting date is one of the key conditions for wheat production. Delayed planting reduces vegetative growth and, thus, plants enter reproduction phase faster. This reaction of the plants on delayed sowing dates reduces their biological function and also reduces the time required to store transferrable materials to grain; it, thus, declines the grain yield. The delay in planting reduces grain filling period resulting in a reduction of grain weight and grain yield. In total, the delay in planting reduces plant height, number of spikes per square meter, spike weight, grain weight per spike, number of grains per spike, number of spikelet per spike and thousand-grain weight; it consequently declines the grain yield. According to the mean comparison of the results obtained in this study, 4th November was the best planting date in terms of yield and its components and Kuhdasht had the best yield among cultivars in Gonbad Kavous region.

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