Journal of Crop Nutrition Science
ISSN: 2423-7353 (Print) 2538-2470 (Online)
Vol. 8, No. 4, 2022
https://jcns.ahvaz.iau.ir/
OPEN ACCESS

Assess Using Paclobutrazol in Reducing Negative Effects of Late Sowing of Wheat (*Triticum aestivum* L.) Cultivars

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RESEARCH ARTICLE

ARTICLE INFO.
Received Date: *26 Sep. 2022*
Received in revised form: *29 Oct. 2022*
Accepted Date: *1 Dec. 2022*
Available online: *30 Dec. 2022*

To Cite This Article:
Neda Bakhtiyarinejad, Mehran Mombeini, Abdullah Bahrani, Mahroo Mojtabaie Zamani. Assess Using Paclobutrazol in Reducing Negative Effects of Late Sowing of Wheat (*Triticum aestivum* L.) Cultivars. ***J. Crop. Nutr. Sci.,*** 8(4): 9-23, 2022.

ABSTRACT

BACKGROUND: The use of plant growth regulators is a agronomic strategy that researchers are interested in to compensate or moderate the negative effect of environmental stress. One of the most important physiological effects of these factors is increasing the tolerance of plants to environmental stresses.

OBJECTIVES: This research was conducted with the aim of investigating the effect of delay in planting on leaf area index and seed growth process and yield formation of three wheat cultivars and how these cultivars respond to paclobutrazol consumption.

METHODS: Current research was done in two cropping years 2020-21 and 2021-22 in a farm located in Izeh city, in the northeast of Khuzestan province. It was implemented as a split factorial in the form of randomized complete block design (RCBD) with three replications. The main factor included planting date (November 16, December 11, and January 5) and the secondary factor factorially included bread wheat cultivars (Karim, Mehregan, and Chamran 2) and the use of paclobutrazol (0, 60, 120 $mg.lit^{-1}$).

RESULT: The results showed that with the application of paclobutrazol, the length of the filling period and seed yield increased significantly. The leaf area index increased up to the application of 60 $mg.lit^{-1}$, but the seed filling rate was not affected by the application of paclobutrazol. The highest seed filling period was observed on the sowing date of November 16 (21 days) and the lowest on the sowing date of January 5 (19 days). With delay in planting, the duration of seed filling period decreased. On the planting dates of November 16 and December 11, the use of 60 $mg.lit^{-1}$ of paclobutrazol and on the delayed planting date of January 5, the use of 120 $mg.lit^{-1}$ of paclobutrazol led to an increase in seed yield compared to the conditions of not using paclobutrazol. The effect of using paclobutrazol on seed yield is positive, and by increasing the use of paclobutrazol (120 $mg.lit^{-1}$), it moderates the negative effects caused by the delay in planting.

CONCLUSION: With the application of 60 $mg.lit^{-1}$ of paclobutrazol, the seed yield of Chamran 2 cultivar was higher on the two planting dates of November 16 (6940.85 $kg.ha^{-1}$) and December 11 (6779.47 $kg.ha^{-1}$) compared to other treatment levels.

KEYWORDS: *Grain filling, growth regulator, Leaf area, planting date, Seed yield.*

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1. BACKGROUND

Wheat is the most vital commodity in the household consumption pattern and the main food supplier for half of the world's people and is considered as a strategic product (Hosseinzadeh *et al*., 2018). According to FAO (2021), wheat is one of the most important crops in the world, with the first place in cultivated area (219 million hectares) and the second place in production (761 million tons). To achieve high yield in different wheat cultivars, it is necessary to create optimal environmental conditions, including observing the planting date. By adjusting the planting date, the thermal energy and radiation required to complete the plant development stages are received in an optimal amount for the plant (Bijand *et al*., 2017). The delay in planting causes a decrease in yield through a negative effect on the phenological, morphological, physiological and biochemical characteristics of the plant (Pradhan *et al*., 2012). The reproductive stage is the most sensitive stage of wheat development to high temperature and if there is a delay in planting and at the same time the flowering stage of wheat with high temperature at the end of the growing season, fewer pollen seeds are produced and due to the lack of fertility of the florets, the number of seeds per spike decreased, which is more severe in sensitive varieties (Omidi *et al*., 2014). In most areas, especially in Khuzestan and Fars province, due to the presence of weather conditions such as suitable temperature and light in autumn and winter, wheat has increased vegetative growth and has the potential to produce a good yield. On the other hand, in case of delay in planting wheat in these areas, the possibility of encountering the stages of flowering and seed filling of wheat with high temperatures is strengthened and the decrease in yield is aggravated (Mojtabaie Zamani, 2014). In general, in case of late planting, in addition to increasing the probability of encountering the seed filling period of irrigated wheat cultivars in Khuzestan with the heat at the end of the season, the period of germination and seedling establishment will also be longer. The lengthening of this stage causes a reduction in the length of subsequent growth periods, especially the stages of tillering and stem growth until flowering. By reducing the tillering period, the most important part of wheat yield, i.e. the number of fertile spikes per unit area, decreases. In addition, the reduction of the tillering periods and the growth of the stem affects the two important characteristic stages, i.e. the double ridge to the final spikelet, and therefore, the other important part of the yield, that is, the number of seeds per spike decreases. (Radmehr *et al*., 2014). Considering the significant relationship between the number of seeds per spike and the seed yield in the delayed planting date and the role of the length of the seed filling period in preventing the decrease in seed yield. It seems that the higher seed growth rate under stress conditions cannot alone guarantee higher seed yield in a genotype, and other factors such as the period of seed filling and the number of seeds in the spike are also of great importance (Mojtabaie Zamani *et al*., 2015). The use of plant growth regulators is another agronomic strategy that researchers are interested in to compensate or moderate the negative effect of environmental stress. One of the most important physiological effects of these factors is increasing the tolerance of plants to environmental stresses (Desta and Amare, 2021). Paclobutrazol is a plant growth regulator that belongs to the triazole group and inhibits the activity of the en-kaureine oxidase enzyme, which catalyzes the oxidation of en-kaureine to en-kaurenic acid in the gibberellin biosynthesis pathway (Sara *et al*., 2015 and Desta and Amare, 2021). The results of Nouriyani's experiment (2017) showed that in both favorable conditions and end-of-season heat stress, the use of growth regulator paclobutrazol significantly increased the effective period of seed filling, 1000 seed weight and seed yield, although the effect of this treatment on seed growth rate was not significant. The step-by-step regression results showed that length of effective seed filling period was most important attribute in justifying changes in final weight of seed, and after that, seed filling rate determined a major part of rest of its changes.

2. OBJECTIVES

This research was conducted with the aim of investigating the effect of delay in planting on leaf area index and seed growth process and yield formation of three wheat cultivars and how these cultivars respond to paclobutrazol consumption.

3. MATERIALS AND METHODS

3.1. *Field and Treatments Information*

This research was conducted in the two crop years of 2020-21 and 2021-22 in a field in Izeh city, Khuzestan province (at latitude 31 degrees and 52 minutes north, longitude 49 degrees and 45 minutes east, altitude 835 meters above sea level) as a split factorial in a randomized complete block design was implemented with three replications. The main factor includes three planting dates with twenty-five days intervals (November 16 (T_1), December 11 (T_2) and January 5 (T_3)) and the secondary factor in a factorial form including bread wheat cultivars (Karim (G_1), Mehrgan (G_2) and Chamran 2 (G_3)) and the use of paclobutrazol in three levels (including the use of 0 (B_1), 60 (B_2), 120 (B_3) $mg.L^{-1}.ha^{-1}$).

Table 1. Physiochemical characteristics of the soil in the experimental area

Soil texture	K ($mg.kg^{-1}$)	P ($mg.kg^{-1}$)	N (%)	OC (%)	pH	EC ($ds.m^{-1}$)	Depth (cm)
Loamy sand	113	6.4	0.097	0.96	7.18	2.04	0-30

3.2. *Farm Management*

At the beginning of the stem growth stage (Zadox code 31), the treatment levels of paclobutrazol application were sprayed on the aerial parts of the plant and the treatment level without paclobutrazol application was sprayed with distilled water. In order to prepare the land, after irrigation, the land was plowed by plough. Then, using two perpendicular discs, the leveling operation was finished. The chemical fertilizer used in each plot based on the results of the soil test (Table 1), the amount of 270 $kg.ha^{-1}$ of triple superphosphate (equivalent to 124.2 $kg.ha^{-1}$ of P_2O_5) and 230 $kg.ha^{-1}$ of potassium sulfate (equivalent to 115 $kg.ha^{-1}$) K_2O) was basic and urea fertilizer was used at the rate of 360 $kg.ha^{-1}$ (equivalent to 165.6 $kg.ha^{-1}$ of nitrogen) in the form of top dressing in three stages (after seedling emergence, middle of tillering and beginning of booting). Each plot consisted of 10 planting rows, each 4 meters long with 20 cm intervals, which were planted with a density of 400 seeds per square meter. The first irrigation of the experimental plots was done after planting and the subsequent irrigations were done based on the plant's water needs.

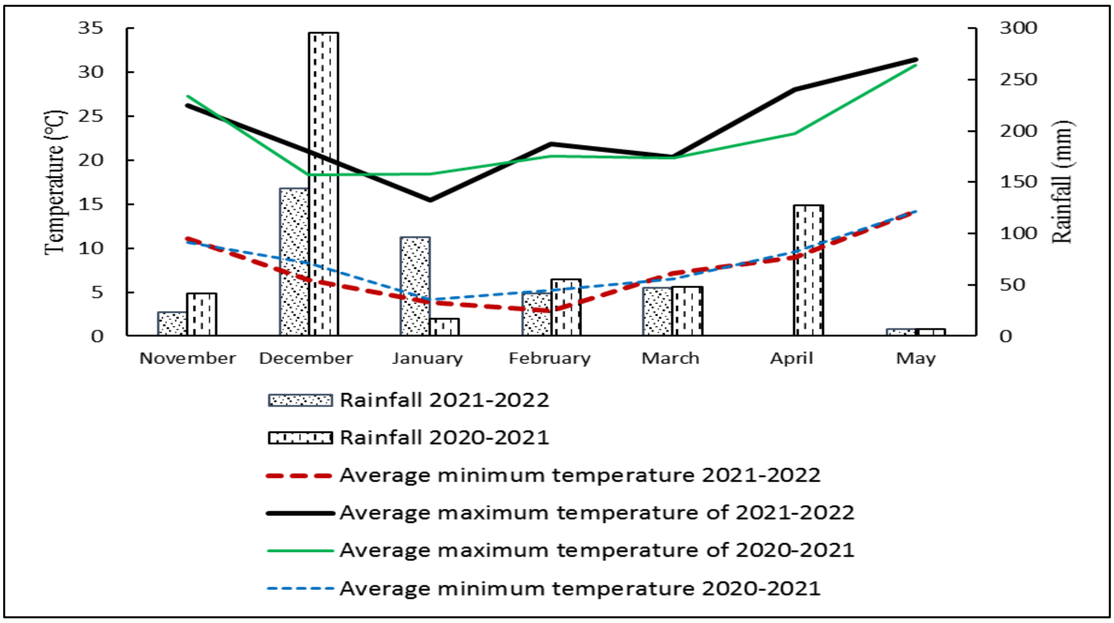

Fig. 1. Average maximum and minimum temperature and total monthly rainfall during the wheat period over tow years of 2020-21 and 2021-22.

3.3. *Measured Traits*

With continuous monitoring of one meter long flagellated to record the phenological traits in each plot, at the stages of tillering (Zadox code 21), on the stem (Zadox code 31), the appearance of swelling of the flag leaf sheath (booting: Zadox code 43), mid-emergence. The spike (Zadox code 55), pollination (Zadox code 65), the milky middle of the seed (Zadox code 75) and the doughy middle of the seed (Zadox code 85) of a half-meter line (equivalent to a square of 20x50 cm) from one of the rows Sampling (2, 3, 8, 9) was done in each floor plot. The leaf area index was determined using the copying method. In the stage of spike emergence, 40 stems from each plot were marked with spikes at the same time, in the second, third, eighth and ninth rows, which were used for destructive sampling related to seed filling process, and 10 spikes from The marked stems were used to calculate the number of seeds per unit area. From the time of pollination (as soon as the first anther emerged from the spikes) to the physiological maturity at five-day intervals, three spikes corresponding to the marked main stems were dried for 48 hours in an oven at 75 °C. By weighing the dry weight of two seeds belonging to the basal florets of the four middle spikes of each spike, the average weight of a single seed corresponding to the seeds in the middle of the spike of the main stem was calculated at each sampling time. After drawing the seed growth curve for each experimental unit, a four-point regression equation was obtained in the linear seed growth stage for the two variables of single seed dry weight and day after pollination. The slope of the line was considered as the seed filling rate in the linear stage of seed growth, and by dividing the average weight of a single seed per spike of the main stem at the time of harvest by the seed filling rate in the linear stage of seed growth, the effective period of seed filling was obtained (Egli, 2001). At the stage of spike emergence, 20 similar and uniform main stems in the second and seventh rows are marked with a yellow ribbon in each plot. The ten stalks marked with a yellow ribbon are harvested at the time of ripening, and the traits of length of spike without spike, length of spike with spike (distance from the base of the spike to the tip of the longest spike), length of the stem and height from the base of the stem to the tip of the spike in each stem with meters of fabric are measured. Twenty spikes corresponding to main stems marked with yellow ribbon will be placed in the envelope and dried in an oven at 75°C for 48 hours. After weighing the spikes, the seeds are separated, weighed and counted, and in this way, the weight and number of seeds in the spike of the main stem will be obtained. At the time of processing, by removing half a meter long from the beginning and end of the fourth and fifth rows, a surface equal to 1.2 square meters was taken to measure the seed yield.

3.4. *Statistical Analysis*

After ensuring the normality of the data (through the Shapiro-Wilk test), Bartlett's test was used to ensure the uniformity of the error variance of the field experiment. Because the difference between the error variance of the years was not significant, combine analysis and data correlation were performed using SAS software (9.1 version). In order to compare the mean interaction effects, LSD test was used at the 5% probability level.

4. RESULT AND DISCUSSION

4.1. *Leaf Area Index* (*LAI*)

Leaf area index is considered one of the important variables in ecological climate studies and the agricultural research, based on the shape of the change of leaf area index in every two cropping years in three planting dates, leaf area index in all planting dates, from the beginning of the growth period to Flowering had an upward trend and then decreased until the end of the growth period. The highest LAI was obtained on the planting date of November 16, with the development of the leaf area through the improvement of the number, size and surface of the leaves with the help of the occurrence of ideal environmental conditions as well as better absorption of plant nutrients, photosynthetic materials to produced enough to increase the leaf area. The lowest LAI was obtained on the planting date of January 5 (Fig. 2).

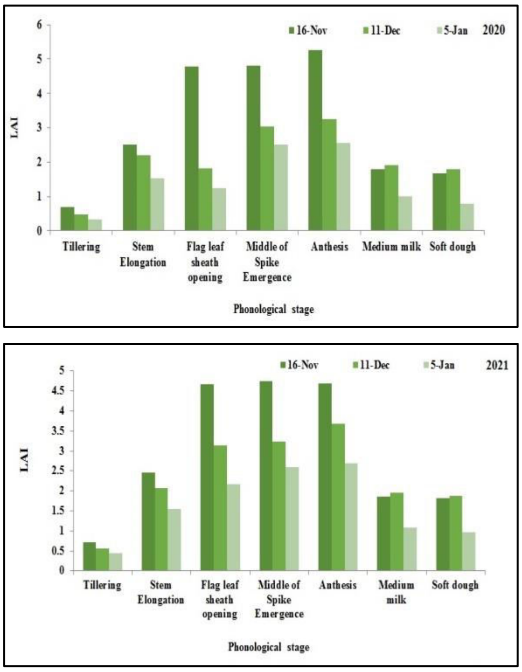

Fig. 2. Effect of planting date on LAI variation at diferent phonological stage (2020 and 2021).

The delay in planting caused a decrease in the leaf area index, so that with the delay in planting, the average air temperature increased and the length of the plant growth period and the leaf growth period decreased, with the beginning of the seed filling phase, the minerals stored in the leaves were transferred to the seeds and the leaves have started to turn yellow and fall, causing a decrease in the leaf area index in the flowering stage (Khan *et al*., 2017). The delay in planting causes shortening of time interval during development stages and occurrence of heat stress and increase of temperature to more than optimal temperature of growth of leaves during period of seed filling, and these factors cause a decrease in leaf area index (Ghatei *et al*, 2017). In examining differences in LAI of three wheat cultivars, it was observed that the maximum LAI in two years was obtained in the Karim cultivar at the flowering stage, then Chamran 2 and Mehregan cultivars ranked second and third respectively, and after that the LAI of three cultivars had a decreasing trend. Karim cultivar was recognized as the best cultivar by obtaining the highest leaf area index in the flowering stage (Fig. 3). The value of the LAI in the early stages of plant growth is low due to the few and small leaves and incomplete plant cover, but gradually with the growth and increase of the leaves of the plant, the increase of the photosynthetic level, the development of the plant canopy, the leaf area index also increases and it reaches its maximum and remains constant in this state for some time, then as the plant ages and the leaves fall, the leaf area index decreases (Jalili Honarmand and Aboutalebian, 2020). According figure, the LAI in each application levels of paclobutrazol had an upward trend from beginning of growth period to pollination and then it decreased until end of growth period.

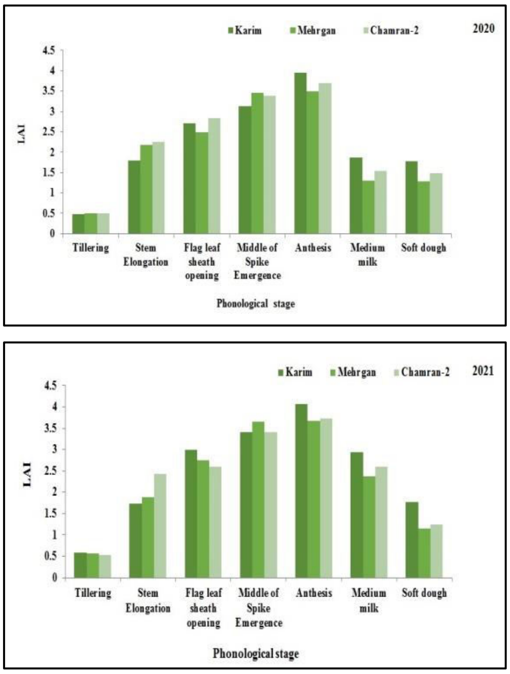

Fig.3. Effect of cultivars on LAI variation at diferent phonological stage (2020 and 2021).

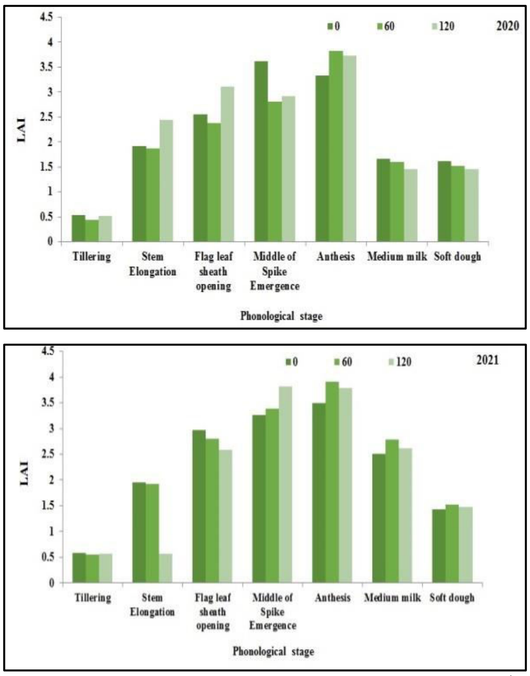

Fig. 4. Effect of Paclobutrazolon (mg.L^{-1}) LAI variation at diferent phonological stage (2020 and 2021).

The highest LAI was obtained in both years under conditions of application of paclobutrazol at level of 60 mg.lit^{-1}, and the lowest was obtained under the conditions of no application of paclobutrazol (Fig. 4). By reducing gibberellin application, paclobutrazol reduces amount of cell division in meristem plates and subsequently leaf area decreases (Yeshitela *et al*., 2004).

4.2. *Seed filling process*

4.2.1. *Seed filling rate*

The combine analysis of data showed that the main effects of cultivar and the effect of year in planting date and the effect of year × planting date × cultivar on seed filling rate were significant, while between the three planting dates in terms of seed filling rate in the linear phase of seed growth there was no significant difference (Table 2). Karim cultivar had the highest (with an average of 2.45 mg.day^{-1}) and also Chamran2 cultivar had the lowest seed filling rate (with an average of 1.69 mg.day^{-1}) (Table 3). The use of paclobutrazol did not have a significant effect on the seed filling rate (Table 3). The results were consistent with Nouriyani's research (2017) who stated that with increase in paclobutrazol consumption, seed filling rate did not change much, this researcher believes that this component is more under genetic control.

Table 2. Composite variance analysis of the effect of planting date, cultivars and application of paclobutrazol on the investigated traits

S.O.V	df	Seed filling rate	Seed filling duration	Seed yield
Year (Y)	1	0.16ns	8.64ns	5714911.83^{ns}
R (Y)	4	0.02	1.58	412650.72
Planting date (PD)	2	0.00^{ns}	70.28**	14885062.63**
Y*PD	2	0.00**	0.22^{ns}	133731.16^{ns}
Main error	8	0.00	0.26	274243.93
Cultivars (C)	2	8.16**	398.02**	4425183.59^{ns}
Y*C	2	0.05^{ns}	2.29^{ns}	1001656.49^{ns}
C*PD	4	0.02^{ns}	3.18*	814636.10^{ns}
Y*PD*C	4	0.01**	0.40^{ns}	223674.94^{ns}
Paclobutrazol (PBZ)	2	0.02^{ns}	24.88**	27288728.65**
Y*PBZ	2	0.00^{ns}	0.35^{ns}	72430.31^{ns}
PD*PBZ	4	0.00^{ns}	0.24^{ns}	13486870.03**
Y*PD*PBZ	4	0.00^{ns}	0.15^{ns}	84618.57^{ns}
C*PBZ	4	0.00^{ns}	1.95**	1652615.91**
Y*C*PBZ	4	0.00^{ns}	0.12^{ns}	30303.07^{ns}
PD*C*PBZ	8	0.00^{ns}	0.24^{ns}	576998.18*
Y*PD*C*PBZ	8	0.00^{ns}	0.24^{ns}	109499.45^{ns}
Minor error	96	0.00	0.33	112967.70
CV (%)	-	2.9	2.85	6.3

$^{ns,\ *\ and\ **}$: non-significant, significant at 5% and 1% of probability level, respectively.

4.3. *Effective seed filling period*

The combine analysis of data showed that the main effects of planting date, cultivar and paclobutrazol, planting date × cultivar, cultivar × paclobutrazol on the effective seed filling period were significant (Table 2). There was a significant difference between the three planting dates in terms of effective seed filling period, and in response to the delay in planting, this trait decreased, so that the maximum seed filling period was on November 16, with an average of 21.28 days, and the lowest was on January 5, with an average of 19.01 days. Also, with delay in planting, the length of the filling period was reduced due to the exposure of the seed filling stage to high temperatures (Table 3). Flowering and seed filling period are the most sensitive stages of wheat growth to the environmental stresses at the end of the season, so that the occurrence of stress in the mentioned stages causes lack of proper fertility and shortening of the seed filling period. Therefore, the ability of the plant to adapt the sensitive stages of development to the conditions of no stress during the growing season can cause the plant to escape from environmental stress (Reynolds *et al*., 2012). When the plant faces stress before flowering and during fruiting, the stress causes a decrease in fertility and ultimately affects the number of seeds or the number of fertile tillers, while stress occurs after flowering and during the seed filling period affects the seed weight. The research findings of Darzi Ramandi *et al*. (2018) showed that the period of seed filling trend is the most important variable affecting seed yield. In late cultivation due to the shortening of the vegetative growth stage, the reduction of photosynthetic materials stored in the stem and the reduction of plant height, a decrease in seed yield was observed, while Souqi *et al*. (2020) stated that despite the difference of a month between the first and third planting dates did not affect the length of the seed filling period. Appropriate planting date is a necessary to minimize the negative effects of late season heat stress (Andarzian *et al*., 2015). Depending on the type of cultivar, the intensity of the reaction was different, and the longest seed filling period was observed in Chamran 2 cultivar with an average of 22.81 days and the lowest amount in Karim cuitivar with an average of 17.38 days (Table 3) and the length of the seed filling period also responded positively to the increase in the use of paclobutrazol, highest seed filling period was observed at the level of 120 $mg.lit^{-1}$ with an average of 20.62 days and the lowest level of no use of paclobutrazol with an average of 19.31 days (Table 3), which was consistent with the results of Nouriyan (2017). They stated that improve photosynthetic capacity and long seed filling time are related to increased seed yield at treatment levels of paclobutrazol matter.

4.4. *Seed yield*

The results of combine analysis showed that the effect of planting date, application of paclobutrazol, the interaction effect of planting date × paclobutrazol on seed yield at the 1% of probability level and the interaction effect of planting date × cultivar × paclobutrazol on this trait at the 5% of probability level were significant (Table 2). Delayed planting on January 5 compared to the planting date of November 16 led to a 16% decrease in seed yield. The highest seed yield was observed on the planting date of November 16 (with an average of 5623.34 $kg.ha^{-1}$) and the lowest yield was observed on the planting date of January 5 with an average of 4718.84 $kg.ha^{-1}$ (Table 3). The decrease in wheat seed yield due to the delay in planting and the difference in the response of different wheat varieties to the delay in planting have been reported by different researchers, and according to the cultivar, the area of the research implementation and the date of delayed planting, the severity of the decrease in yield has been different (Bijandi *et al*., 2017; Musavi *et al*., 2021 and Baygi *et al*., 2018). The change of day length and temperature changes in different phenological stages of the plant due to the delay in sowing causes shorter vegetative growth and reproductive stages of the plant. The shortening of the vegetative growth period will result in the reduction of the aerial and underground organs of the plant. In the reproductive stage, due to the increase in air temperature, length of the period from stemming to pollination and from pollination to ripening is reduced, which is insufficient opportunity for seed formation and accumulation of materials in the seed, along with the plant's inability to absorb enough radiation, due to the insufficient expansion of the green surface, it will result in a decrease in seed weight, seed number, and finally seed yield (Liu *et al*., 2023, Bijandi *et al*., 2017 and Moshattati *et al*., 2018). The results of the main effect of paclobutrazol application showed a positive role in increasing seed yield, so that the treatment of 120 mg.lit^{-1} of paclobutrazol application had the highest seed yield with an average of 5861.23 kg.ha^{-1} and the lowest with an average of 4518.70 kg.ha^{-1} belonged to the treatment of not using paclobutrazol. The application of 120 mg.lit^{-1} paclobutrazol resulted in a 30% increase in seed yield per unit area on average compared to not using it (Table 3).

Table 3. Comparison of the average of planting date, cultivar, and application of paclobutrazol on the studied traits

Treatment		Seed filling duration	Seed filling rate	Seed yield (kg.ha^{-1})
planting date	November 16	2.03a	21.28a	5623.34a
	December 11	2.02a	19.94b	5632.99a
	January 5	2.02a	19.01c	4718.84b
LCD		0.04	0.39	302.81
Cultivars	Karim	2.45a	17.38c	5003.30a
	Mehrgan	1.93b	20.04b	5420.50a
	Chamran-2	1.69c	22.81a	5551.40a
LCD		0.19	4.30	828.73
Application of paclobutrazol	0	2.04a	19.31b	4518.70c
	60	2.01a	20.29a	5595.24b
	120	2.03a	20.62a	5861.23a
LCD		0.05	0.49	222.85

Means followed by similar letters in each column show non- significant difference according to LSD tests at 5% level.

It was observed that foliar application of paclobutrazol increased vegetative growth, which increases the LAI and maintains flow of photosynthesis. therefore, as the period of greenness of leaves becomes longer, more carbohydrate is transferred to seed. So, decreasing leaf area duration, cause a sharp drop in production of plant material by photosynthesizing organs, which will eventually reduce the seed yield (Shourbalal *et al*., 2019; Peake *et al*., 2020 and Mi *et al*., 2018). In Nouriyani's (2014) study, use of paclobutrazol increased average seed yield compared to non-use of paclobutrazol by 17% in favorable conditions and 23% to end of season heat stress conditions. The average seed yield of all cultivars, Karim, Mehrgan and Chamran2, was not significantly different, although two cultivars of Chamran2, Mehrgan have higher seed yield than Karim. According significance of cultivar × paclobutrazol interaction and planting date × cultivar × paclobutrazol, reaction of cultivars at different levels of paclobutrazol use and at different planting dates was different.

Table 4. Comparison of the average interaction effects of planting date, cultivar, and application of paclobutrazol on the studied traits

Planting date	Cultivar	Paclobutrazol (mg.L^{-1})	Seed yield (kg.ha^{-1})
November 16	Karim	0	4329.79op
		60	5022.62hij
		120	5835.48cde
	Mehrgan	0	5168.69gh
		60	5958.45bcd
		120	6343.54b
	Chamran-2	0	5081.81ghi
		60	6940.58a
		120	5929.09bcd
December 11	Karim	0	4486.63mno
		60	5453.67efg
		120	5960.49bcd
	Mehrgan	0	5119.35ghi
		60	6163.14bc
		120	5988.01bcd
	Chamran-2	0	4731.23lmn
		60	6779.47a
		120	6014.94bcd
January 5	Karim	0	4192.56qr
		60	4510.48mno
		120	5237.54l
	Mehrgan	0	3829.93qrs
		60	4615.78mno
		120	5597.96def
	Chamran-2	0	3728.28t
		60	4912.98ghijk
		120	5844.01def

Means followed by similar letters in each column show non- significant difference according to LSD tests at 5% level.

Shirinzadeh *et al*. (2017) reported that the highest yield was obtained in the planting date of November in Chamran 2 cultivar due to the superiority of weight and number of seeds per spike and seed filling period. Awan *et al*. (2017) reported that the highest seed yield was achieved in the planting date of December, and delaying planting from December onwards causes a sharp drop in seed yield. The changes in seed yield of wheat cultivars in response to the interaction effect of planting date and the cultivar in the application of paclobutrazol showed that in all planting dates, the cultivars showed a positive reaction to the use of paclobutrazol. Chamran 2 cultivar obtained the highest seed yield per unit area on the two planting dates of November 16 and December 11 at the treatment level of 60 mg.lit^{-1} of paclobutrazol, 6940.58 and 6779.47 kg.ha^{-1}, respectively. The lowest seed yield belonged to Chamran2 cultivar on the planting date of January 5, in the condition of not using paclobutrazol, with an average of 28.3728 $kg.ha^{-1}$, followed by Mehregan cultivar, in the condition of not using paclobutrazol, with an average of 3829.93 $kg.ha^{-1}$. On the delayed planting date of January 5, the seed yield was not significantly different between the two levels of non-use and 60 $mg.lit^{-1}$ paclobutrazol, and the highest yield was obtained in the condition of 120 $mg.lit^{-1}$ paclobutrazol. Although there was no significant difference between the three cultivars in the consumption level of 120 $mg.lit^{-1}$ of paclobutrazol in the delayed planting date, but Chamran 2 seed yield was higher than the other cultivars with an average of 5844.01 $kg.ha^{-1}$. The reaction of cultivars to the application of paclobutrazol in the delayed planting date was different and Chamran2 cultivar showed the most positive reaction, So that with the use of 120 $mg.lit^{-1}$ of paclobutrazol compared to not using it, the seed yield of Chamran 2 cultivar increased by 57%, Mehrgan cultivar by 46%, and Karim cultivar by 25% (Table 4).

5. CONCLUSION

The results of the research showed that the use of paclobutrazol significantly increased the seed filling period and seed yield. Leaf area index increased up to 60 $mg.lit^{-1}$ paclobutrazol, but seed filling rate was not affected by paclobutrazol. The highest seed filling period was observed on November 16 (21 days) and the lowest on January 5 (19 days). The application of 60 $mg.lit^{-1}$ of paclobutrazol, the seed yield of Chamran 2 cultivar was higher on the two planting dates (November 16 (6940.85 $kg.ha^{-1}$) and December 11 (6779.47 $kg.ha^{-1}$) compared to other treatment. The effect of using paclobutrazol on seed yield is positive, and by increasing use of paclobutrazol (120 $mg.lit^{-1}$), it moderates the negative effects caused by the delay in planting.

ACKNOWLEDGMENT

The authors thank all colleagues and other participants, who took part in the study.

FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

FUNDING/SUPPORT: This study was done by support of Department of Agronomy, Islamic Azad University, Ahvaz Branch.

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