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ORIGINAL ARTICLE

Effects of Sowing Date on Yield of Canola Genotypes

Seyed Ahmad Kalantar Ahmadi*[1]and Mohammad Sedghi[2] and Alireza Shafiee Zargar[3]
1- Ph.D Student of University of Mohaghegh Ardabili, and Researcher of Safiabad Agricultural Research Center, Iran
2- Department of Agronomy and Plant Breeding, Faculty of Agriculture, University of MohagheghArdabili, Iran
3- Researcher, Safiabad Agricultural Research Center, Iran
Email: kalantar@uma.ac.ir

ABSTRACT
In order to study the effects of sowing date on yield of canola cultivars, an experiment was carried out in Safiabad Agricultural Research Center during 2010-2012 as a split plot based on completely randomized block design with 3 replications. The main plots were consisted of 3 sowing dates (1st Nov, 16th Nov and 1st Dec) and sub plots included 7 canola cultivars (Hyola60, Hyola308, Hyola330, Hyola401, Hyola420, RGS003 and Option500). The results showed that delaying in sowing date leads to a significant decrease in grain yield, biological yield, number of pods per plant and number of grains per pod. The highest grain yield (3352.3 kg/ha) was achieved at the first sowing date (1st Nov) while the last sowing date (1st Dec) produced the lowest (2602.84 kg/ha) grain yield in this experiment. There was a significant difference in grain yield and yield components between cultivars. The means of sowing date × cultivar showed that the highest (4316.88 kg/ha) grain yield belonged to Hyola420 at the first sowing date (1st Nov) while the lowest (2022.13 kg/ha) grain yield belonged to Option500 cultivar in the last sowing date (1st Dec) in both years of this experiment. Decreasing of grain yield due to delaying in sowing date for cultivars being investigated in this study occurred as a result of shortening of growth and flowering duration and coincidence of these periods with high temperatures.
Keywords: *Canola, Heat Stress, Sowing Date, Cultivar, Yield.*

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INTRODUCTION

Environmental stresses are the most important factor in distribution of plant species. Loviet declared that any environmental factor which has an unsuitable influence on plant's life may be considered as stress, and toleration to stress is related to the ability of plant to withstand unfavorable factors [1]. Delaying in sowing date and the heat stress resulted from it resulted may decrease the number of flowers and pods and increased pollen sterility number of flower, number of pods and sterility pollen during reproductive growth period [2]. Increasing temperature increase the rate of respiration, therefore grains do not receive sufficient sap [3]. Heat stress during flowering leads to a decrease in grain production in many plants and in canola, seed development and seed weight was decreased as a result of high temperature stress, but it did not have influence on flower production [4]. In the control treatment, 6000 flowers were formed and these flowers developed to 3000 pods, while 875 (14.6%) and 400(6.7%) pods developed from these flowers as a result of high temperature stress during first and second weeks, respectively [4]. Edward and Martin studied the effect of sowing date on the yield of canola reported that flowering duration decreased in later sowing date, also drier conditions in the first year reduced flowering duration compared to the second year[5]. They mentioned that drought and high temperatures reduced the duration of flowering [5]. Some studies have shown that the yield of canola decreases by delaying the planting date [6,7]. Hocking and Stapper reported that oil concentration declined by 3% as a result of delaying the sowing date for a month [7]. Allen and Morgan showed that in appropriate planting time declined the number of branches and pods per plant [8]. Raymer compared different canola cultivars and concluded that cultivars which have had more height, did not produce more yield while the and grain filling period did not encounter with high temperatures in early cultivars, therefore grain yield and 1000 seeds weight in such cultivars have increased [9]. Considering the fact that majority of farms in this area are under maize

cultivation which usually encounter with delayed harvests, there is not enough time to prepare the land for the next crops, such as canola. As a result of this, the sowing date of canola will be delayed. So, this study was conducted to investigate the response of canola cultivars to different sowing dates to determine the best sowing date of canola in this area.

MATERIALS AND METHODS

This field experiment was conducted at Safiabad Agricultural Research Center in Khouzestan province of Iran (82.9 m a.s.l., 48° 26′ E, 32° 16′ N) during 2010-2012 growing seasons under irrigated and rain-fed conditions. The design was a split plot based on a completely randomized block design with 3 replications. Main plots consisted of 3 sowing dates (1st Nov, 16th Nov and 1st Dec) and sub plots included 7 canola cultivars (V1:Hyola60, V2:Hyola308, V3:Hyola330, V4:Hyola401, V5:Hyola420, V6:RGS003 and V7:Option500). The soil was a Clay Loam with pH=7.64 and EC= 0.57 ds/m. P and K were applied to supply 200 kg/ha and 150 kg/ha using potassium sulfate and triple super phosphate, respectively. Nitrogen was applied at 180 kg/ha (391 kg/ha urea) with a third of it applied at the time of sowing, a third at the beginning of stem elongation and the rest at flowering period. Plots were hand weeded during the season. The distance between ridges was 60 cm sowing 2 rows on each ridge. Plots were planted and after seedling establishment, the plants were tinned to achieve a density of 80 plants/m^2. Each sub plot consisted of 8 ridges. Main plots and sub plots were 1.5 m and 0.75 m apart, respectively. 10 plants were randomly selected from each plot, and then the number of branches, plant height, pods per plant, grain per pod and 1000 seeds weight were recorded. During the harvest (4 days after physiological maturity),ridges3, 4, 5 and 6 were cut by hand and air dried. Then the plants were threshed using a stationary combine to determine the grain yield. The plants were weighted prior to threshing, in order to determine the biological yield. Maximum and minimum temperatures and precipitations were also recorded (Figure 1). The oil concentration was determined using the NMR (Nuclear Magnetic Resonance) method. All obtained data were tested through the analysis of variance using MSTATC software and mean comparison was done according to the Duncan's multiple range test ($p \leq 0.05$).

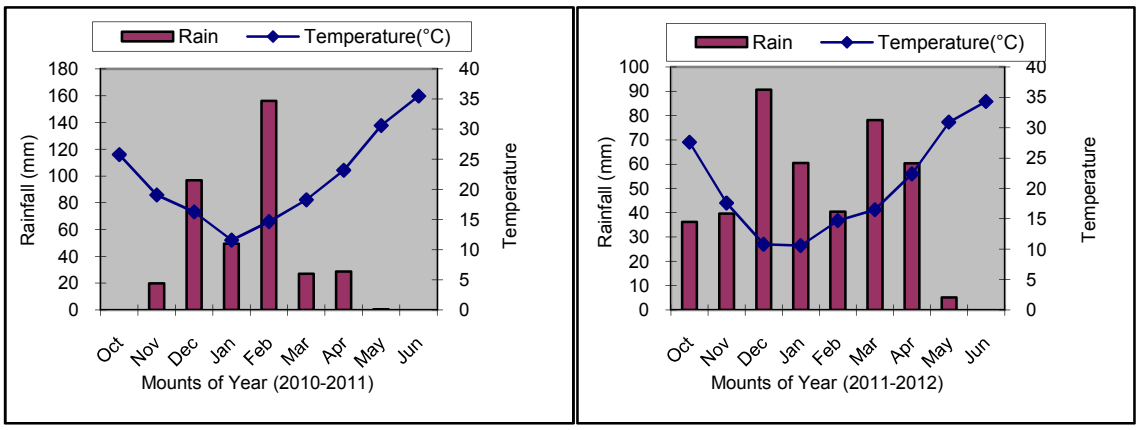

Figure 1- Temperature and Rainfall conditions during the experiment

RESULTS

In this study, the combined analysis of variance revealed the statistical significant effect of year on flowering initiation time, flowering duration, growth duration, height of plant, number of pods per plant, 1000 seeds weight and grain yield (Table 1). Sowing date had a significant effect on all traits except the oil concentration (Table 1). The mean comparison of sowing date×Cultivar showed that the shortest interval (79.5 days) between sowing date and flowering initiation belonged to Hyola308 at the first sowing date (Table 3). The longest interval (108.5 days) however, belonged toOption500 at the third sowing date (Table 3). The interaction between sowing date and cultivar showed the longest flowering duration (38 days) belonged to the sowing date of Nov 1st and RGS003 cultivar (Table 3). While the lowest ones (25.5 days) belonged to the last sowing date (1st Dec) in Hyola401 and Hyola420 cultivars (Table 3). Option500 cultivar had the highest height (169.33 cm) compared to other cultivars, but this factor did not result to an increase in grain yield (Table 2). Delaying the sowing date reduced the number of pods per plant in all cultivars (Table 3). The grain yield decrease in this experiment was happened mainly due to a decrease in number of pods per plant. Considering that the number f pods per plant is the most important factor to

increase the grain yield, the highest number of pods per plant (219.51), similar to most of the traits in this study, was observed at the first sowing date in Hyloa420 while the lowest number of pods per plant (124.34) belonged to Hyola330 at the last sowing date. Considering that the number f pods per plant is the most important factor to increase the grain yield, the highest number of pods per plant (219.51), similar to most of the traits in this study, was observed at the first sowing date in Hyloa420 while the lowest number of pods per plant (124.34) belonged to Hyola330 at the last sowing date (Table 3). The year did not have a significant effect on 1000 seeds weight (Table 1). The results showed that the rate of changesin 1000 seeds weight was less than that of the number ofpods per plant as a result of sowing date (Table 2). In both years the highest (3352.3 kg/ha) and the lowest (2602.84 kg/ha) grain yield was achieved in the first and the third sowing dates, respectively (Table 2). Grain yield was positively correlated with the number of pods per plant and as a result of this, the highest (4316.88 kg/ha) grain yield was achieved in the sowing date of the 1st Nov by Hyola420 and the lowest (2022.13 kg/ha) was achieved in the sowing date of the 1st Dec by Option500 (Figure 2). As shown in table 1, sowing date did not have a significant effect on oil concentration, but the effect of cultivar, year×sowing date and year×cultivar on this characteristic, was significant (Table 1).The means of grain yield of cultivars for both years showed that Hyola308, Hyola401 and Hyola420 had the highest most grain yield and were categorized in the statistical group(Table 2).There was a significant interaction between year and cultivar for all traits measured in this study(Table 1).The results of combined analysis revealed that the effects of sowing date, genotype and sowing date×genotype were significant for biological yield, but the effects of year, year×sowing date, year×genotype and year×sowing date× genotype were not significant for this trait (Table 1). The means of biological yield for sowing date×genotype showed that the highest (22116.13 kg/ha) and the lowest (11804.33 kg/ha) biological yield was achieved by Hyola60 genotype at the first and the third sowing dates, respectively (Table 3).The results of combined analysis revealed that the effects of year, sowing date, sowing date×cultivar and year×sowing date×cultivar were significant for on oil concentration (Table 1). There was a significant difference between cultivars and year×sowing date for oil concentration ($p<0.01$) (Table 1). The means of oil concentration showed that the lowest (43.15%) oil concentration belonged to RGS003 during two years while other cultivars ranked in the same group (Table 2).Correlation between studied parameters showed that grain yield had a significant correlation with the number of pods and the number of grains per pod (Table 4). The number of pods had a positive correlation with biological yield and plant height (Table 4). There was a negative correlation between the number of pods per plant and thousand seeds weight.

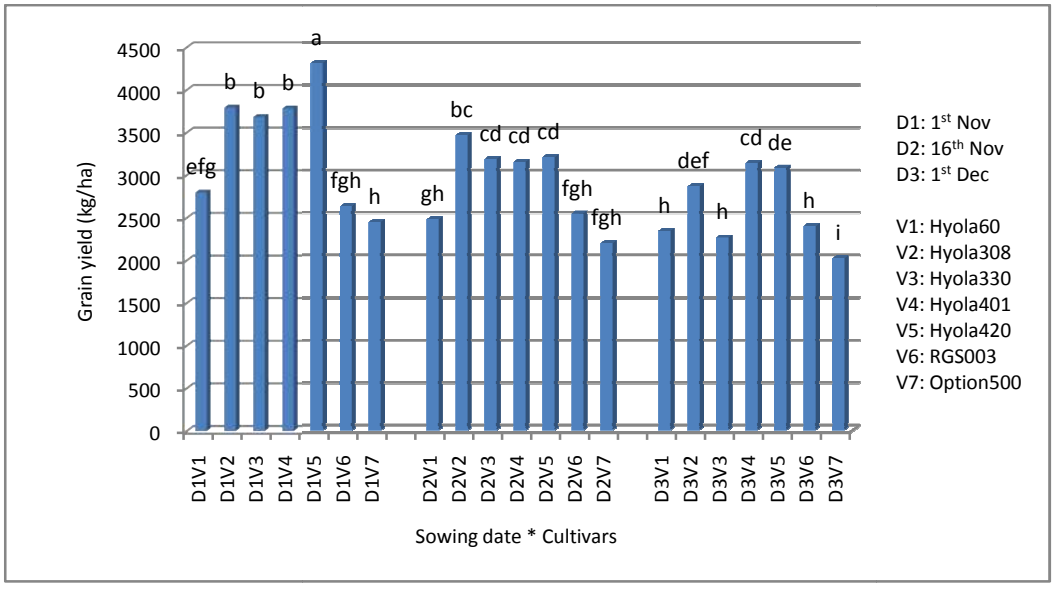

Fig 2- Means of sowing date × cultivar for grain yield

Table 1- Combined analysis of variance for studied parameters during two years

	Mean Square of Traits									
S.O.V	Start Of Flowering	Flowering duration	Growth duration	Plant height	No. of pods/plant	No. of grains/pod	1000 Seeds Weight	Grain Yield	Biological Yield	Oil %
Year	18.28**	85.84*	1.55*	4661.9**	550337.5**	29.49^{ns}	1.63**	58024643**	230443594^{ns}	0.44^{ns}
Replication	0.23^{ns}	1.079^{ns}	0.127^{ns}	36.22^{ns}	101.18	38.41^{ns}	0.29^{ns}	79475.93^{ns}	4346014.21^{ns}	1.74^{ns}
Sowing Date	1566.60**	7482.7**	135.96**	6148.49**	31772.98**	69.71*	1.32**	5900565**	87341990**	3.94^{ns}
Year*Sowing Date	91.81**	0.294^{ns}	43.008**	2002.61*	7360.42*	11.3^{ns}	0.287^{ns}	740632.11*	105292724**	23.46**
Error	0.183	10.03	0.198	289.61	1246.83	12.77	0.124	131506.9	7559580.8	2.32
Cultivar	441.12**	370.4**	117.43**	1058.31**	3828.92**	251.79**	2.92**	4114789**	121957641**	20.31**
Year*Cultivar	48.56**	0.36^{ns}	28.03**	454.21**	4666.27**	49.04**	0.97**	722908.2**	149233723.9**	5.62**
Sowing Date*Cultivar	20.72**	34.87**	30.09**	108.86^{ns}	1485.02*	13.74^{ns}	0.24^{ns}	466920.**	68736323.31**	3.24^{ns}
Year*Sowing date*Cultivar	230.06**	0.42^{ns}	37.71**	156.09*	3015.38**	15.21^{ns}	0.20^{ns}	413611.**	3891164109^{ns}	3.11^{ns}
Error	0.134	6.14	0.212	82.35	759.62	11.41	0.16	72722.48	3891164.09	1.76
CV (%)	0.40	1.52	1.51	5.66	16.17	13.78	11.63	9.07	12.32	2.93

*and**: Significant at the 5% and 1% levels of probability, respectively
ns: not significant

Table 2-Means of year, sowing date and cultivar for studied parameters during two years

	Start of Flowering (Days after Sowing)	Flowering duration (days)	Growth duration (days)	Plant height(cm)	No. of pods/plant	No. of grains/pod	1000 Seeds Weight (gr)	Grain Yield (kg/ha)	Biological Yield (kg/ha)	Oil %
Year										
First Year	91.41^{b}	30.57^{a}	162.63^{b}	154.32^{b}	236.5^{a}	24.02^{a}	3.55^{a}	3651.46^{a}	16777.92^{a}	45.49^{a}
Second year	92.1^{a}	30.34^{b}	164.28^{a}	166.48^{a}	104.32^{b}	24.99^{a}	3.32^{b}	2294.24^{b}	15993.34^{a}	45.37^{a}
Sowing Date										
1st Nov (D1)	97.66^{a}	32.21^{a}	176.95^{a}	172.47^{a}	193.05^{a}	23.35^{b}	3.6^{a}	3352.3^{a}	18379.99^{a}	45.26^{a}
16th Nov (D2)	92.23^{b}	30.54^{b}	163.16^{b}	160.46^{b}	178.38^{a}	25.9^{a}	3.25^{b}	2963.4^{b}	16950.58^{b}	45.24^{a}
1st Dec (D3)	85.47^{c}	28.61^{c}	150.26^{c}	148.27^{c}	139.8^{b}	24.27^{ab}	3.47^{a}	2602.84^{c}	13826.32^{c}	45.78^{a}
Cultivar										
Hyola60 (V1)	94.13^{b}	31.83^{b}	166^{bc}	166.31^{ab}	179.21^{a}	18.09^{d}	3.91^{a}	2541.69^{c}	1829.84^{b}	45.62^{a}
Hyola308 (V2)	86.33^{g}	29^{e}	157.77^{e}	150.15^{d}	174.99^{ab}	29.14^{a}	2.93^{c}	3377.19^{a}	16052.56^{cd}	45.95^{a}
Hyola330 (V3)	89.27^{e}	27.61^{f}	158.55^{de}	159.02^{c}	172.66^{ab}	26.97^{a}	3.31^{b}	3080.1^{b}	14553.96^{f}	45.43^{a}
Hyola401 (V4)	87.94^{f}	29.72^{d}	160.55^{d}	150.61^{d}	174.94^{ab}	24.59^{b}	3.85^{a}	3360.43^{a}	15364.78^{de}	46.19^{a}
Hyola420 (V5)	91.27^{d}	29^{e}	164.44^{c}	161.39^{bc}	189.13^{a}	27.26^{a}	3.77^{a}	3537.13^{a}	16388.23^{c}	45.37^{a}
RGS003 (V6)	92.27^{c}	35.38^{a}	167.55^{ab}	165.54^{ab}	146.17^{c}	21.92^{c}	3.24^{b}	2524.66^{c}	19310.52^{a}	43.15^{b}
Option500 (V7)	101.27^{a}	30.66^{c}	169.33^{a}	169.77^{a}	155.78^{bc}	23.57^{bc}	3.05^{bc}	2388.72^{c}	14738.51^{ef}	46.26^{a}

Means with at least one letter in common are not significantly different at the 5% probability level (Duncan's Multiple Range Test).

Table3- **Means of sowing date × cultivar for studied parameters during two years**

Sowing date ×Cultivar	Start of Flowering (Days after Sowing)	Flowering duration (days)	Growth duration (days)	Plant height	No. of grains/pod	1000 Seeds Weight	Biological Yield (kg/ha)	Oil%
D1*V1	99^{c}	35^{c}	179.66^{b}	182.25^{ab}	16.36^{f}	4.2^{a}	22116.13^{a}	45.06^{ef}
D1*V2	94.5^{f}	27.16^{k}	175^{c}	160.51^{e-h}	27.12^{a-c}	3.17^{f-j}	19103.33^{cd}	46.63^{a-c}
D1*V3	97.5^{d}	27^{k}	168.33^{de}	175.25^{a-c}	27.94a-c	3.25^{e-j}	15236.12^{f}	46^{a-e}
D1*V4	91.5^{i}	34.5^{c}	141^{d}	159.85^{e-h}	24.32^{cd}	3.88^{a-d}	18175.96^{de}	46.08^{a-e}
D1*V5	96.33^{e}	32de	178.66^{b}	169.18^{c-e}	26.69^{a-c}	3.98^{a-c}	19550.37^{c}	44.6^{d-f}
D1*V6	96.33^{e}	38^{a}	183.33^{a}	174.8^{a-c}	19.24^{ef}	3.25^{e-j}	18720.20^{cde}	42.52^{g}
D1*V7	108.5^{a}	31.83^{e}	182.66^{a}	185.2^{a}	21.81^{de}	3.48^{c-h}	15775.8^{f}	45.92^{a-e}
D2*V1	96.33^{e}	29.66^{gh}	165.33^{ef}	162.51^{d-g}	21.66^{de}	3.85^{a-d}	20952.08^{ab}	45.98^{a-e}
D2*V2	85^{p}	31^{f}	156^{i}	154.54^{f-i}	31.08^{a}	2.74^{j}	14354.13^{fgh}	45.36^{b-e}
D2*V3	88.5^{l}	28.5^{j}	160^{h}	156.99^{f-h}	26.22^{b-d}	3.09^{g-j}	15175.5^{f}	44.24^{ef}
D2*V4	89.33^{k}	29.16^{i}	161^{gh}	149.12^{hi}	24.55^{cd}	3.56^{c-h}	15703.76^{f}	45.26^{b-e}
D2*V5	92^{i}	29.66^{gh}	163.16^{fg}	162.95^{d-g}	27.84^{a-c}	3.62^{b-g}	17486.37^{e}	45.41^{a-e}
D2*V6	92.66^{h}	35.66^{b}	166.33^{e}	164.79^{b-d}	24.86^{b-d}	3.07^{h-j}	20015.29^{bc}	43.49^{fg}
D2*V7	101.83^{b}	30.16^{g}	170.33^{d}	172.33^{b-d}	25.06^{b-d}	2.81^{j}	14966.96^{f}	46.94^{ab}
D3*V1	87.16^{n}	30.83^{f}	153^{ij}	153.91^{f-i}	16.23^{f}	3.69^{a-f}	11804.33^{j}	45.83^{a-e}
D3*V2	79.5s	28.83^{ij}	142.33^{m}	135.41^{j}	29.23^{ab}	2.89^{ij}	14700.22^{fg}	45.87^{a-e}
D3*V3	81.83^{r}	27.33^{k}	147.33^{l}	144.83^{ij}	26.74^{a-c}	3.6^{b-h}	13250.28^{hi}	46.06^{a-e}
D3*V4	83^{q}	25.5^{l}	149.66^{kl}	142.87^{ij}	24.91^{b-d}	4.12^{ab}	12127.62^{ij}	47.23^{a}
D3*V5	85.5^{o}	25.5^{l}	151.5^{jk}	152.04^{g-i}	27.26^{a-c}	3.72^{a-e}	12127.94^{ij}	46.11^{a-d}
D3*V6	87.83^{m}	35.5^{d}	153^{ij}	157.04^{f-h}	21.67^{de}	3.41^{d-i}	19196.07^{cd}	43.45^{fg}
D3*V7	93.5^{g}	30^{g}	155^{i}	151.79^{g-i}	23.83^{cd}	2.85^{j}	13472.77^{ghi}	45.93^{a-e}

Means with at least one letter in common are not significantly different at the 5% probability level (Duncan's Multiple Range Test).

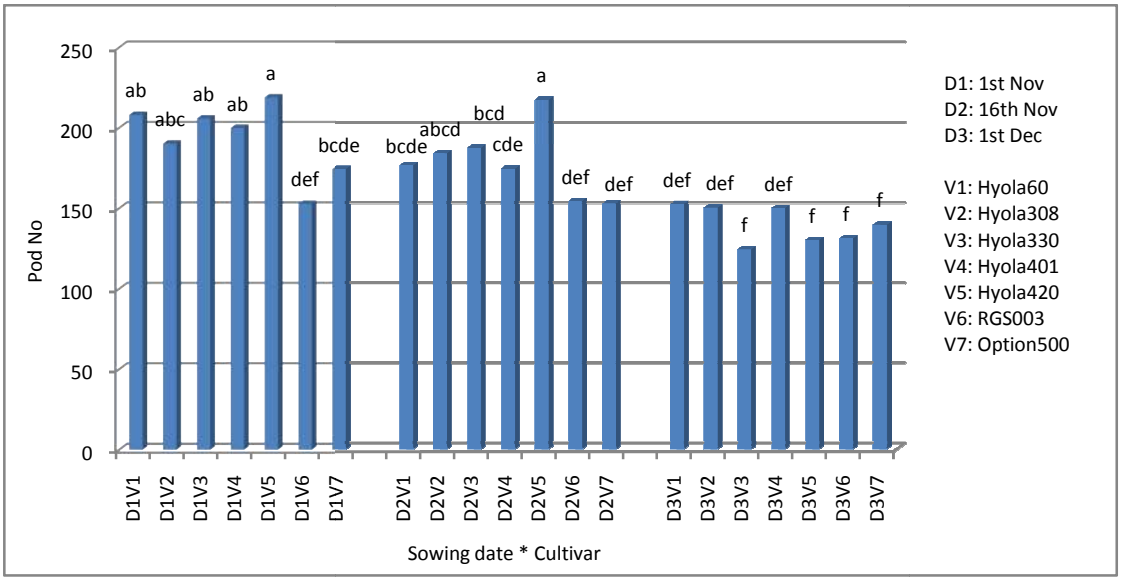

Fig 3- Means of sowing date × cultivar for the number of pods/plant

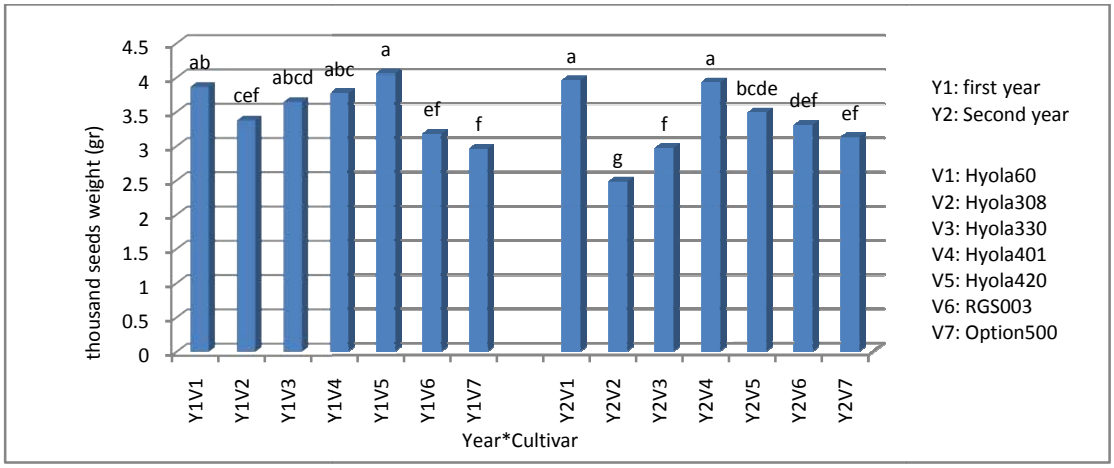

Fig 4 - Means of year × cultivar for 1000 seeds weight

Table 4- Correlation between grain yield and studied parameters

	Grain Yield	Biological Yield	No. of pods/plant	No. of pods/plant	1000 Seeds Weight (gr)	Start of Flowering (Days after Sowing)	Flowering Duration (days)	Growth duration (days)	Plant height	Oil%
Grain Yield	1**									
Biological Yield	0.186	1								
No. of pods/plant	0.708**	0.488*	1							
No. of pods/plant	0.478*	-0.285	0.112	1						
1000 Seeds Weight (gr)	0.228	0.225	0.254	-0.427	1					
Start of flowering (Days after Sowing)	-0.051	0.473*	0.417	-0.364	0.033	1				
Flowering duration (days)	-0.177	0.631**	0.091	-0.534*	0.003	0.352	1			
Growth duration (days)	0.08	0.54*	0.428	-0.311	0.036	0.821**	0.344	1		
Plant height	0.044	0.548*	0.489*	-0.398	0.117	0.916**	0.484*	0.846**	1	
Oil%	0.066	-0.481*	0.001	0.263	0.122	-0.055	-0.742**	-0.308	-0.256	1

*and**: Significant at the 5% and 1% levels of probability, respectively

DISCUSSION

The significance of year × cultivar could be attributed to longer flowering period during the first year of this experiment that caused more flowers to be transformed into pods and ultimately increased the number of remaining seed pods at the harvest. Decreases of vegetative growth lead to a decrease in the number of pods per plant due to delaying the sowing date (Table 2). The significance of sowing date × cultivar was also due to different number of pods per plant of genotypes in different sowing dates (Table 3).The interaction of sowing date × cultivar on the number of pods showed that delaying the sowing date until 16th Nov did not have significant effect on Hyola420 cultivar and this cultivar had more stability compared to other cultivars (Figure 3). The plants that were planted in the first sowing date due to favorable environmental conditions produced more pods. Delaying the sowing date lead to a decrease in the number of pods per plant by 27.59% in the third sowing date (1st Nov) compared to the first one (1st Dec) probably due to the increase of temperature during the flowering period and pod initiation stage. These results are in agreement with Whitfild findings [3].

Improvement in environmental conditions, favorite temperature and moisture at the end of growth season and increasing the grain filling duration are attributed to the rise of thousand seeds weight. It seems that longer grain filling period happened due to the above mentioned factors in the second years of this study

compared to the first year. These results were in agreement with Mendam findings (Mendham and Shipway, 1981).

The trend of changes in thousand seeds weight did not affected directly by delaying sowing date; therefore, the first and the third sowing dates were placed in the same group (Table 2). The lowest thousand seeds weight (3.25 gr) was obtained in the second sowing date (Table 2).The climatic changes during two years of this experimented to different cultivars reaction in terms of thousand seeds weight, so that the maximum (4.06 gr) and the minimum (2.97 gr) thousand seeds weight was achieved byHyola420 and Hyola308 cultivars in the first year (Figure4).

Figure 4 shows that the rate of changes for thousand seeds weight was less in Hyola60, Hyola401, RGS003 and Option500 compared to other cultivars during two years.

The differences for the oil concentration between cultivars are due to genetic differences between the cultivars used in this study. Cultivars reaction to changes weather conditions caused to make significant differences between cultivars. In other words, the effect of environmental factors is less than that of genetic characteristics for oil concentration. Sana et al. [10] attributed the highest oil concentration to the genetic structure of any cultivar. Although, climatic conditions and sowing date affect oil concentration; but the potential of plant depends to the adaptation of growth and development stages to the environmental conditions [10].Genetic traits of a cultivar are considered as the main factor affecting its oil content [11]. Climate conditions and sowing date had also an influence on oil concentration. In other words, the potential oil content of a plant is related to the synchronization of its growth and development stages with environmental conditions [10].

Higher grain yield in the first year (3651.46 kg/ha) compared to the second year (2294.24 kg/ha) in this experiment, was related to difference climate conditions during both years of experiment and temperature increase during the grain filling stage in the second year compared to the first year. Increasing in temperature led to decrease in thousand seeds weight and grain yield in the second year (Table 2).

Generally, favorite climate conditions increased the grain yield in all of sowing dates of the first year compared to the second year. Heavy winds caused the plants to lodge in the first and second sowing dates of the second year. Not only the lodged plants did not recover, but also the flowering process was initiated in the branches of these plants. The flowers produced during this process were not useful because they confronted high temperatures and did not form any grains.

On the other hand, some materials, which had to be used for filling grains, were utilized by branches and flowers that were completed recently and this caused an intense decrease of grain yield in the second year compared to the first year of this experiment. These results were in agreement with those of Scarisbrick [12]. The rate of reduction of grain yield in RGS003, Hyola330, Hyola60, Option500, Hyola420, Hyola308 and Hyola401 was 54.34%, 45.83%, 43.19%, 33.55%, 32.28%, 31.06% and 21.69%, respectively in the second year compared to the first year. It can be concluded that unfavorable environmental factors had less impactonHyola401 compared to the other cultivars. There was an intense lodging in RGS003, Hyola60 and Option500 cultivars. However, there was a positive correlation between the number of pods per plant and plant height but we have to consider that higher plant heights are not always suitable because they increase the risk of lodging.

CONCLUSION

The early sowing date of1st Nov lead to an increase in grain yield as a result of increasing the number of pods per plant and 1000 seeds weight. Considering the results of this experiment, the early Nov sowing date and Hyola420 cultivar could be recommended for North Khouzestan conditions.

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