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Effect of Planting Date and Density on Yield and Yield Components of Bean Genotypes (*Vicia faba* L.)

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ABSTRACT

In order to investigate the effects of planting date and plant density on the yield and yield components of bean (*Vicia faba* L.) cultivars, the experiment was conducted at Safi Abad Agricultural and Natural Resources Research Center in 2017 and 2018. The experiment was performed as the split factorial in the randomized complete block design with three planting dates (Oct. 12, Nov. 1, Nov. 21) as the main plot and three density levels (10, 15 and 20 plants/m^2) and two genotypes (Saraziri and line 62) as the subplots with three replications. The considered traits were the number of pods per plant, number of seeds per pod, 1000-seed weight, grain yield, biological yield and harvest index. The results of this study showed that the planting date, density and genotype, as well as their interactions had a significant effect at 1% and 5% probability level on the yield and yield components of bean.

Key words: Bean genotypes, Density, Planting date, Yield, Yield components.

INTRODUCTION

Faba bean is a cool-season grain legume crop originated in the Middle East in the pre-historic times and traditionally used as a main source of protein for human and animal nutrition (Multari *et al*., 2015). faba bean is considered as one of the most important pulse crops in the world. In recent years, cultivation of faba bean has received large attention in USA, Canada and Europe (Etemadi *et al*., 2018). Bean (*Vicia faba* L.) is one of the most important grain legumes with the cultivated area of 105113 hectares and average tonnage of 21000 hg/ha Iran In 2018 (FAO, 2020). The major cultivation areas include Gorgan, Khuzestan, Lorestan, Hormozgan and Gilan (Sharifi *et al*., 2016). Determining the most suitable planting date in each region is one of the most important aspects of crop improvement and also the successful cultivation of a crop, and since the planting date varies in each climate region, it is therefore possible that the variability occurs in the plant growth process. Under Iranian climate conditions, the soil moisture at the time of planting is generally not a limiting factor and the temperature is the main determinant of plant greening and establishment. Therefore, the purpose of determining the planting date is to find the planting date of a cultivar or a group of similar cultivars, so that the environmental factors happening at that time are suitable for the greening, establishment and survival of the seedlings. In addition, if possible, the plant should been countered with the desirable conditions rather than the adverse environmental conditions (Khajepour, 2014). Like other crops, variety or cultivar selection requires achieving a balance between adaptability to a specific environment, disease tolerance, purpose of cultivation and marketability (Zandvakili *et al*., 2019). The grain yield in the late planting is significantly more than the yield of dry matter (Dehghani *et al*., 2018). The results of the three years data revealed that sowing date significantly affected on plant height, number of pods per plant and seeds per pod of faba bean (Wakweya *et al*., 2016). Some researchers reported that the yield loss in the crops by the genetica factors can be greatly reduced by selecting a suitable cultivar (Shafaverdi *et al*., 2012). El-Kholy *et al*., (2019) reported that increasing planting density significantly decreased number of pods and branches/plant, and seed weight/plant as well as protein yield/fad., while, plant height and biological yield/fad., were significantly increased by increasing plant densities up to 120000 plants/fad. However, the crop management is an important factor in the changes in crop yield. One of the most important management practices for achieving the maximum yield of crops is to observe the appropriate density per unit area. In fact, the observance of proper plant density per unit area of the plants can have the maximum utilization of environmental resources and ultimately produce high grain yield and biological yield (Zeinali *et al*., 2013). In this connection, Kubure *et al*. (2015), found that weight of pods/plant, number of seeds/plant and weight of seeds/plant were increased significantly as plant density was decreased from 500000 to 444444 then to

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333333 plants/ha. Sharifi *et al*. (2018) also explored different planting densities in different planting dates and reported that the highest yield and yield components were obtained on the planting date of Nov. 17 with the yield of 4707.6 kg/ha under the density of 16 plants per square meter. The purpose of present study is to evaluate the yield and yield components in different planting dates and densities for the bean genotypes (*Vicia faba* L.).

MATERIALS AND METHODS

This experiment was conducted aiming to investigate the effects of different planting dates and densities on the bean cultivars (*Vicia faba* L.) during 2017-2018 crop years in Safi Abad Agriculture and Natural Resources, Research Center (Dezful, Iran). The experiment was conducted as the split factorial in the randomized complete block design with three planting dates (Oct. 12, Nov. 1, Nov. 21) as the main plot and three density levels (10, 15 and 20 plants/m^2) and two genotypes (Saraziri and line 62) as the subplots with three replications. Each plot consisted of five beds (five lines) of 8-m long and the planting row spacing of 60 cm. The studied traits were the number of pods per plant, number of seeds per pod, 1000-seed weight, grain yield, biological yield and harvest index. In order to calculate the grain yield and harvest index, the plants were harvested by removing one meter of the margin from the intermediate rows of each side and the calculation was done in kilogram per hectare. The analysis of variance and comparison of means were done using the least significant difference (LSD) method in SAS 9.2 software.

RESULTS AND DISCUSSION

Number of pods per plant

According to the results of analysis of variance, the number of pods per plant under different planting dates, density and genotype had a significant difference at 1% level. Also, the interaction between the planting date and the density and genotype had a significant effect on the number of pods per plant (Table 1). According to the results of comparison of means, the highest number of pods per plant in Saraziri cultivar was observed for the planting date of Oct. 12 with the density of 15 plants per square meter (71.5 pods per plant), which had a significant difference with other considered treatments. The lowest number of pods per plant was observed in line 62 cultivar for the planting date of Nov. 21 with the density of 20 plants per square meter (25.83 pods per plant) (Table 2). The results of this study are consistent with those of Sharifi *et al*. (2016), which reported that the delayed planting decreases the number of pods per plant. It seems that the main factor in increasing the number of pods at the early planting dates can be attributed to the longer vegetative and reproductive growth and the production of more reproductive organs. The early planting with earlier and higher development of leaf area causes more light absorption and the increased photosynthesis for the development of pods. The number of pods per plant is among the yield-sensitive components that is affected by environmental conditions such as moisture, heat and density, so that in the high densities, the reduced penetration of light into the lower parts of the plant reduces the pod formation and also the shatter of flowers and pods of the lower parts of the plant (Ahmadzadeh *et al*., 2018). Kianbakht *et al*. (2015) reported the effect of genotype on the number of pods per bean plant as significant. In parallel with the results of this study, Wakweya *et al*. (2016) reported significant effect of planting date on the number of pods per plant.

Number of seeds per pod

According to the results of analysis of variance, in addition to the simple effects of planting date, density and genotype treatments, the interactions of the treatments on the number of seeds per pod were significant at 1% level (Table 1). According to the results of the comparison of means, the highest number of seeds per pod in the Saraziri cultivar was obtained on the planting date of Oct. 12 with the density of 20 plants per square meter (6.6 seeds per pod) and the lowest number of seeds per pod was observed for the Line 62 cultivar on the planting date of Nov. 21 with the density of 10 plants per square meter and 20 plants per square meter (3.5 seeds per pod) (Table 2). Asgari *et al*. (2018) reported that the number of seeds per pod is reduced in the pea plant with the delayed planting, which is consistent with the findings of this research. It seems that the number of seeds per pod is decreased due to the delay in planting because of unfavorable weather conditions and insufficient vegetative and reproductive growth. Therefore, since the earlier planting date as November, although the plant is greened at more favorable temperature conditions, the shorter days and lowered temperatures slow down the growth rate and it seems that in later crops, the plants have less dry matter and less leaf area at the time of reaching the reproductive stage, and as a result, due to the shorter growth period of the pod and the period of grain filling, the pods and seeds in later crops become smaller and the number of seeds per pod and also the grain size is decreased. Wakweya *et al*. (2016) and El-Kholy *et al*. (2019) reported significant effect of sowing date on number of seeds per pod.

1000-seed weight

The results of combined analysis of variance showed that the 1000-seed weight of bean was also significantly affected by the interaction of planting date, density and genotype treatments (Table 1). According to the results of the comparison of means, the maximum 1000-seed weight in Saraziri cultivar was observed on the planting date of Oct. 12 with the planting density of 15 plants per square meter (115 g) and the lowest 1000-seedweightin line 62 cultivar was observed on the planting date of Nov.21 for the density of 10 plants per plant square meter (78.83 g) (Table 2). Ibrahim (2016) obtained that early sowing date gave the highest mean values for plant height, number of branches, number of pods, pods and seeds weight per plant, 100 seed weight

Table 1: Combined analysis of variance for yield and yield components of bean affected by year, planting date, density and genotype.

Sources of Changes	Degree of Freedom	Mean Square (MS)					
		No. of pods in plant	No. of seed in pod	1000-seed weight	Grain yield	Biological yield	Harvest index
year	1	0.15ns	0ns	10.08*	6896.01ns	68.5 ns	2.27ns
block	2	62.11**	0.009ns	71.36**	6953.93ns	667.4**	1.96ns
year × block	2	1.04ns	1.03ns	1.03ns	7853.04ns	35.9ns	2.3314ns
planting date	2	10139.69**	37.12**	5788**	33076270.62**	79334917**	2339.29**
planting date × year	2	1.009ns	0.19ns	0.33ns	6874.06ns	65.7ns	2.08ns
planting date × year× block	8	3.85*	0.39ns	2.69ns	8058.65ns	50.5ns	2.40ns
density	2	1111.19**	11.73**	516.58**	3303416.04**	7043142.1**	190.48**
density × year	2	0.7315ns	0.25ns	0.25ns	7241.15ns	12.9ns	2.13ns
planting date × density	4	110.31**	2.07**	29.58**	192518.61**	341306**	10.96**
planting date × density× year	4	0.43ns	0.41ns	1.08ns	7140.25ns	17ns	2.19ns
error	24	1.43	0.38	3.17	7221.45	67.1	2.19
genotype	1	1408.34**	5.34**	389.12**	5041008.23**	9005246.3**	350.59**
genotype× year	1	0.34ns	0.15ns	0.75ns	7383.79ns	12ns	2.31ns
planting date × genotype	2	106.58**	0.58ns	32.26**	206601.62**	31441.7**	5.37ns
planting date × genotype× year	2	0.19ns	0.17ns	0.78ns	7610.29ns	10ns	2.36ns
density × genotype	2	7.69**	0.69ns	0.63ns	185903.37**	220766.7**	10.53*
density × genotype× year	2	0.19ns	0.17ns	3.03ns	7536.15ns	48.2ns	2.41ns
planting date × density × genotype	4	6.61**	2.41**	29.59**	21930.05*	48583.1**	7.83*
planting date × density × genotype× year	4	0.47ns	0.25ns	0.55ns	7539.86ns	9.4ns	2.24ns
Total Error	36	1.41	0.49	1.66	7825.22	49.6	2.34
CV	-	2.58	14.12	1.33	4.05	0.12	4.22

ns, * and ** mean non-significant and significant at probability level of 5 and 1 per cent.

Table 2: Comparison of means of interaction of planting date, density and genotype on yield and yield components of bean cultivars.

Planting Date	Planting Density	Genotype	No. of pods in plant	No. of seeds in pod	1000-seed Weight	Grain Yield	Biological Yield	Harvest Index
Oct. 12	10 plants/m^2	Saraziri	56.5d	4.67fg	106.17c	2757.83d	6827.17e	40.39cd
		Line 62	47.17f	4.83ef	103.83d	2424e	6233.33i	38.88de
	15 plants/m^2	Saraziri	71.5a	6.5ab	115a	3713.17a	7604.33a	48.83a
		Line 62	61.5c	6.5ab	106.67c	3018c	6968d	43.32b
	20 plants/m^2	Saraziri	62.17c	6.6667a	113.8333a	3337.33b	7418b	44.99b
		Line 62	52.67e	6abc	109.67b	2755.33d	6777.83f	40.65c
Nov. 1	10 plants/m^2	Saraziri	52.833e	5.5cde	94.5f	2221.33f	5748k	38.65e
		Line 62	41.17h	3.5i	89g	1875.67g	5396.5l	34.76f
	15 plants/m^2	Saraziri	63.83b	5.5cde	103d	3046.67c	7009.17c	43.478b
		Line 62	56.83d	5.17def	100.83e	2441.83e	6244.33h	39.11cde
	20 plants/m^2	Saraziri	53.17e	5.5cde	102.33de	2744d	6729.667g	40.78c
		Line 62	45.5g	5.83bcd	95.5f	2191.83f	6051.17j	36.23f
Nov. 21	10 plants/m^2	Saraziri	26.33kl	3.83hi	82.67i	1083.5ij	3900.83p	27.78h
		Line 62	22.5m	3.5i	78.83j	890.83k	3612.17r	24.63i
	15 plants/m^2	Saraziri	30.83i	4ghi	86h	1550.67h	4963m	31.245g
		Line 62	27.33jk	3.83hi	84.5h	1116.5i	4197o	26.61h
	20 plants/m^2	Saraziri	28.33j	4.5fgh	85.33h	1138.5i	4208n	27.16h
		Line 62	25.83l	3.5i	85.83h	990.17k	3730.17q	26.545h
	LSD (0/05)		1.37	0.74	1.66	99.87	8.05	1.74

The means with common letters in each column do not have significant difference.

and seed yield. According to Khajehpour (2014), with the increase in the density per unit area due to the competition from the food shortage and environmental factors such as light and water in the medium around the root, the 100-seed weight is reduced. Khalil *et al*. (2015) who found that Nubaria 1 variety achieved the superiority on seed yield/ feddan, number of branches per plant, seeds weight and 100- seed weight while the superiority went in harvest index and protein % to Sakha 1 variety. These results are in harmony with those found Hassan (2016) and Mahdy and HA (2018).

Grain yield

As shown in Table 1, the grain yield under the interaction between the planting date and the density and genotype had a significant difference at the 5% level. According to the results of the comparison of means, the highest grain yield was observed in Saraziri cultivar on the planting date of Oct. 12 with the density of 15 plants/m^2 (3713.17 kg/ha). Also, the lowest grain yield was observed in line 62 cultivar on the planting date of Nov. 21 with the density of 20 plants per square meter (990.17 kg/ha). The decrease in the grain yield seems to be due to the fact that the plants cultivated on the first planting date had a longer vegetative period and thus, could better utilize the soil water and food. Mansourian (2015) and Sheikh *et al*. (2017) also reported that the bean seed yield is significantly different when affected by the genotype. Similar results were obtained by Wakweya *et al*. (2016); Hassan (2016) and Mahdy and HA. (2018).

Biological yield

Similar to other components of yield, the biological yield was affected by the interaction between planting dates and different densities and genotype at 1% level (Table 1). The highest biological yield was also observed according to the results of comparison of means for the Saraziri cultivar on the planting date of Oct. 12 with the density of 15 plants/m^2 (7406.33 kg/ha) and the lowest biological yield was observed in line 62 cultivar on the planting date of Nov. 21 with the density of 10 plants/m^2 (3612.6 kg/ha) (Table 2). It seems that the on-time planting date increases the vegetative growth time and the ideal density by providing a suitable ratio of canopy area to the light and food sources to balance the plant in the production of vegetative and reproductive tissues and to produce the highest yield in terms of both biological and grain yields. Some researchers believe that the greater distance between the plants makes it possible for each plant, due to the greater surrounding space, to receive more light and perform higher photosynthetic activity and to grow better than the plants that are closer to each other. Similar results were report by El-Ghareib *et al*. (2019); Hassan (2016) and Mahdy and HA. (2018).

Harvest index

The results of combined analysis of variance showed that under the interaction of planting dates, density and genotype, the harvest index showed a significant difference at 5% level (Table 1). Based on the results of the comparison of means, the highest harvest index was obtained for the Saraziri cultivar on the planting date of Oct.12 with the density of 15 plants per square meter (48.82%) and the lowest harvest index was also observed in line 62 cultivar on the planting date of Nov. 21 with the density of 10 plants per square meter (24.66%) (Table 2). El-Kholy *et al*., (2019) Reported that increasing planting density up to 120000 plants/fad.

significantly increased biological yield. Zeleke (2019) Sowing date significantly affected harvest index (HI) with late sown crops having higher HI. Sheikh and Sekhavat (2017) reported the significant bean harvest index under the influence of genotype.

CONCLUSION

In general, the findings of this study indicate that yield and yield components of bean are affected by planting date, proper plant density and genotype, and the delayed planting results in a significant reduction in these traits. The results of this study showed that the best planting date in the climate conditions of the site was on the Oct. 12, the best density was 15 plants per square meter, and the best cultivar is Saraziri, because it had the highest level of measured traits. It seems that observing proper planting dates is necessary for providing enough vegetative growth period to produce sufficient green area and store photosynthetic materials to the extent required for the reproductive growth. Also, the suitable density is necessary for the proper access to light and food to achieve the best yield. In addition, the results showed that the bean yield components can be affected by different genotypes, and hence, the Saraziri cultivar is recommended for the study area.

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