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Research Article

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Common bean, *Phaseolus vulgaris* L., planting date, growth stage, production

Determination of the Effect of Different Sowing Dates on Growth and Yield Parameters of Some Dry Bean (*Phaseolus vulgaris* L.) Varieties

Abstract
The experiment was carried out at Dicle University, Faculty of Agriculture Department of Field Crops in 2018 spring and summer season. The aim of this study was to evaluate the effect of different sowing dates (March 10, April 4 and May 4, 2018) on the phenological, morphological and yield performances of six dry bean varieties. The experiment was established randomized complete blocks design in split plots with three replications. The sowing dates significantly affected to the days to seed emergence, days to first flowering, days to 50% flowering, days to maturity, first pod height, number of branches per plant, pod width, plant weight, pod weight per plant, number of pods per plant, number of seeds per plant, seed yield per plant, biological yield and seed yield. As the sowing date was delayed, there was decreased in all traits. The early sowing date provided better growth in cold tolerance varieties. Among the sowing dates, in early to mid-March sowing date was the most favorable for all varieties and Diyarbakir ecological conditions.

INTRODUCTION

Dry beans (*Phaseolus vulgaris* L.) is constitute a large part of legume cultivation areas and total production. These crops are in the third place after chickpeas and lentils in terms of cultivation area and production in Turkey. Since dry beans are rich in protein and vitamins, they play a big role in meeting the food needs of people in world. In Turkey, the cultivated area of dry beans in 2020 is approximately 103 bin ha and reached 280 bin tons in 2020 with an increase of 24.2% compared to the previous year for the total production (TSI, 2020). The optimum sowing date plays an important role in getting potential yields. It stated that it was an important factor to explore the growth, maximum yield, harvest quality, yield and yield quality in crop production (Joshi and Rahevar, 2014). Early or delayed sowing drastically reduces the yield of the crops. However, varieties may also differ in productivity. The effect of the growth environment on the favorable growth of a variety is quite high. Different or same varieties may perform variously under changed environments. Thus, performance of varieties under different sowing date needs to be experienced. The appropriate sowing date have to for the day length and the climatic conditions such as rainfall, temperature and humidity (Mirzaienasab and Mojaddam, 2014). The soil temperature and moisture are the most important abiotic factors affecting germination and cause to delay emergence of seeds in early spring. This case, depending on the length of the frost-free growth period, can delay the maturing of the seed by causing serious consequences on the yield and seed quality due to poor seedling. Although it may vary depending on the varieties, high temperatures above 32 °C during flowering period bring about extreme flower drop and decrease drastically seed yield in late sown varieties. Additionally, these temperatures substantially reduce the leaf area, total dry weight, net assimilation of dry bean plants. Therefore, it is necessary to prevent the plant from exposed to stresses during critical growth periods to maximize yield with the choice of sowing date. Previous studies have shown that the suitable variety and sowing date is very important for the dry bean plant like other cultivated plants (Kahraman, 2014; Esmaeilzadeh and Aminpanah, 2015; Hlanga, 2017). In studies conducted in Turkey's different ecological environments noted that the most suitable sowing date for bean cultivation is middle of May for the Eastern Region, first of March for the Mediterranean coastline, and from late March to early April for the Southeastern Anatolia region. However, the changing climatic conditions with global warming also caused to changes in the sowing dates of dry bean plants. Therefore, it is necessary to try different combinations of sowing dates related to the sowing date of dry bean plants. In this study, we aimed to determine the suitable sowing dates for dry bean under Diyarbakir conditions when the temperature was different.

MATERIAL and METHODS

This research was conducted at Dicle University Faculty of Agriculture, Department of Field Crops experimental area during 2018 main cropping season.
The soil at experimental site was a clay loam texture, pH: 7.19, low organic matter and phosphorus content (Table 1).

Table 1. The soil properties of experimental site prior to sowing

Depth (cm)	$CaCO_3$ (kg da^{-1})	pH	P_2O_5 (kg da^{-1})	K_2O (kg da^{-1})	Organic matter (%)	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})
0-20	11.40	7.19	1.32	121	0.79	3.76	1.31	0.41	3.84

Based on values provided by Diyarbakir Ministry of Agriculture and Forestry General Directorate of Food and Control

The maximum and minimum temperatures and rainfall for the months for experiment area were given Figure 1. The temperatures ranged from 23.6°C on April to 26.0 °C on May, and the highest temperature was the end of June and throughout July. The amount of rainfall in May was 114 mm above the long years. Since the rainfall in March and April was less than long years, a dry period was experienced (Figure 1). Thus, the area was irrigated by the sprinkler irrigation system to ensure seed emergence in the sowing date (on March 10 and April 04, 2018). In addition, the irrigation was regularly repeat at intervals 10 days during the flowering and pod podding periods.

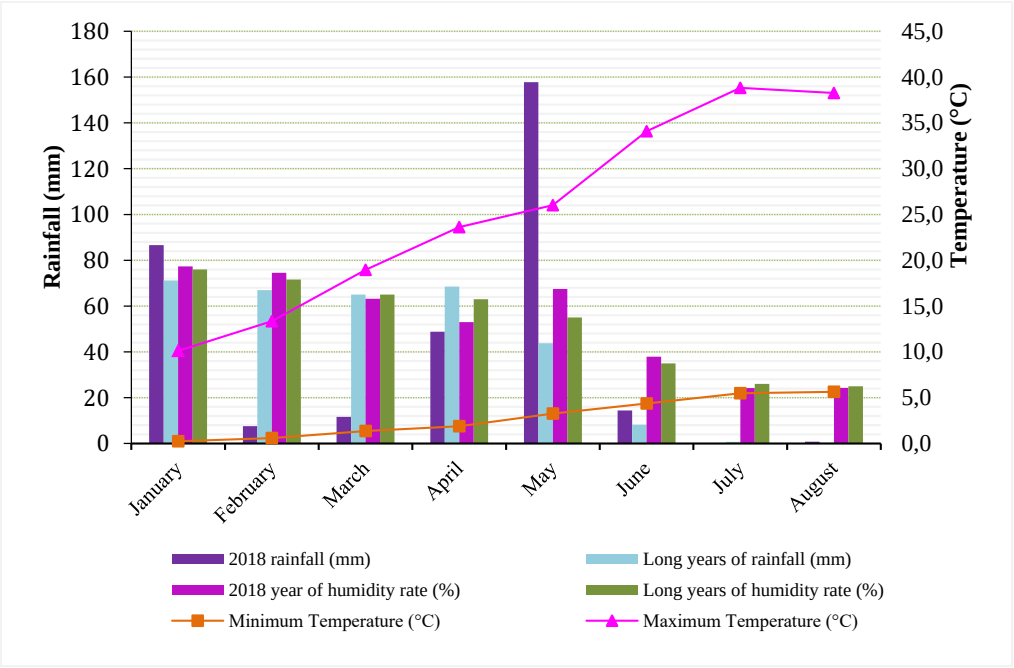

Figure 1. The experimental site climatic characteristics

The experiment was set up randomized complete block design in split plots with three replications, the main plots were sowing date and the subplots consisted of varieties. The experiment consisted of three sowing dates (10 March, 4 April and 4 May) and six bean varieties (Adabeyazi, Akman-98, Aras-98, Goynuk-98, Cihan and Ahlat). The sowings were on 10 March, 04 April and 4 May 2018. The experimental site was tilled with a plough in the autumn and leveled with leveler. Plots were in 4 m long and 0.45 m row spacing with 4 rows. At all sowing dates, a single rate of 50 kg ha^{-1} Diammonium phosphate fertilizers were applied with sowing date.

Harvest dates were on 21 June, 10 July and 3 August 2018 for the three sowing dates, respectively. Data analyzed by the MSTAT-C statistical program. The differences between the means were compared with the LSD (Least Significant Difference) test at the 0.05 significance level (Gomez and Gomez, 1984).

RESULTS and DISCUSSION

The effect of sowing dates on the phenological and morphological traits, yield and yield parameters were examined for dry bean varieties. The analyzed results were given in Table 2, Table 3 and Figure 2.

Table 2. The effect of sowing dates on phenological and morphological traits of dry bean varieties

		Days to seed emergence	Days to first flowering	Days to 50% flowering	Days to maturity	Plant Height (cm)	First pod Height (cm)	Number of branches per plant
Sowing dates	10 March	17.60 a	60.50 a	68.50 a	101.70 a	34.08	21.57 c	2.70 a
	4 April	14.80 b	54.80 b	61.30 b	98.10 b	32.99	25.22 a	1.90 b
	4 May	11.10 c	43.00 c	48.10 c	92.80 c	31.92	22.94 b	1.70 b
	LSD %	2.45**	1.37**	1.34**	0.83**	2.27 ns	1.87**	0.33**
Varieties	Aras-98	14.30	53.5 b	58.80 b	98.80 c	32.04 b	23.36 bc	2.0 a-c
	Goynuk-98	14.00	51.6 c	58.70 b	100.20 b	32.52 b	21.76 cd	2.20 a
	Ahlat	14.80	46.10 e	52.80 d	90.30 e	36.33 a	22.84 b-d	1.90 c
	Adabeyazi	14.60	62.80 a	59.00 b	97.10 d	30.99 b	26.33 a	2.20 ab
	Cihan	14.60	49.40 d	56.00 c	97.30 d	31.17 b	24.70 ab	2.30 a
	Akman-98	14.60	53.10 bc	70.40 a	101.60 a	34.94 a	20.48 d	1.90 c
	LSD %	ns	1.69**	1.03**	1.29**	2.45**	2.56**	0.28**
Early to mid-March (10/03/2018)	Aras-98	17.60	58.30 cd	63.70 d	101.3 cd	33.40 c-e	19.37 fg	3.00 a
	Goynuk-98	16.00	57.6 cd	66.70 c	105.00 a	33.00 c-e	21.10 d-g	2.90 ab
	Ahlat	18.00	55.60 de	62.60 d	94.70 gh	41.50 a	22.83 c-f	2.20 de
	Adabeyazi	18.00	64.0 b	75.30 a	99.3 de	28.20 f	23.30 b-f	2.80 a-c
	Cihan	18.00	60.30 c	66.30 c	104.00ab	30.98 d-f	20.13 e-g	2.60 a-d
	Akman-98	18.00	67.30 a	76.30 a	106.00 a	37.40 b	22.67 c-f	2.50 a-d
Early April (04/04/2018)	Aras-98	11.00	58.30 cd	63.30 d	100.30cd	31.87 d-f	26.30 a-c	1.70 ef
	Goynuk-98	11.00	53.30 e	60.00 e	100.70cd	31.83 d-f	22.87 c-f	2.40 cd
	Ahlat	11.60	48.30f	56.30 f	88.30 ı	33.20 c-e	24.90 a-d	1.80 ef
	Adabeyazi	11.00	65.00 ab	60.00 e	97.70 ef	32.37 c-e	28.80 a	1.80 ef
	Cihan	11.00	49.00 f	57.30 f	99.70 de	32.60 c-e	27.53 ab	2.50 b-d
	Akman-98	11.00	54.60 e	70.60 b	102.0 bc	36.10 bc	20.93 d-g	1.20 g
Early May (04/05/2018)	Aras-98	14.30	44.00 g	49.30 g	102.0 bc	30.87 d-f	24.40 a-e	1.40 fg
	Goynuk-98	14.0	44.00 g	49.30 g	94.64 gh	32.73 c-e	21.30 d-g	1.40 fg
	Ahlat	14.80	34.30 ı	39.30 j	95.00 gh	34.30 b-d	20.78 d-g	1.70 ef
	Adabeyazi	14.60	59.30 c	41.70 ı	88.00 ı	32.40 c-e	26.90 a-c	1.80 ef
	Cihan	14.60	39.00 h	44.30 h	94.30 h	29.93 ef	26.43 a-c	1.70 ef
	Akman-98	14.60	37.30 h	64.30 d	88.30 ı	31.31 d-f	17.83 g	1.90 e
	LSD %	ns	2.93**	1.78**	2.24**	3.93**	4.44*	0.49**

The differences among the means denoted by the same letters are not statistically significant.
*, **: significant difference at 5 and 1% of probability, ns=non-significant

The differences among sowing dates were significant for the days to seed emergence, days to first flowering, days to 50% flowering, days to maturity, first pod height, number of branches per plant, pod width, plant weight, pod weight per plant, number of pods per plant, number of seeds per plant, seed yield per plant, biological yield and seed yield. The days to seed emergence, days to first flowering, days to 50% flowering, days to maturity were decreased as delayed sowing dates. The low soil temperature in early spring were not provide the required temperature for the germination of bean seeds, thus the seed emergence during early stage of growth was weak in early sowing compared to late sowing. As the soil temperature increased, seed emergences also increased. Therefore, seed emergence was ideal in May sowing date. Among sowing dates, high and low flowering rates were in early to mid-March and in early May sowing dates, respectively. As the soil and air temperature increased, the number of flowering days also decreased. Varieties were affected by sowing dates. Ahlat variety was the earliest flowered variety in all sowing dates. Akman-98 variety was the latest flowered variety. For days to maturity, the highest values revealed in early to mid-March sowing dates. Since the air and soil temperatures are high in May, the plants maturity progressed faster. Among dry bean varieties, Akman-98 variety had late matured, Ahlat variety had early matured. The response of plant height to effect of sowing dates was not significant. However,

variety and variety × sowing dates interaction were significant. Plant height ranged from 31.92 cm to 34.08 cm for sowing dates, and varieties were from 30.99 cm in Akman-98 variety to 34.97 cm Ahlat variety. When variety× sowing date interaction revealed that Ahlat was the tallest variety (41.50 cm) in early to mid-March sowing, whereas Adabeyazi was the shortest variety (28.20 cm) in the same sowing (Table 2). Therefore, Ahlat variety was tolerant variety, and Adabeyazi variety was sensitive variety to low soil and air temperature.

Table 3. The effect of sowing dates on phenological and morphological traits of dry bean varieties

		Plant biomass (g)	Number of seed per pod (seed plant^{-1})	Number of pod per plant	Number of seed per plant	Pod length (cm)	Pod width (mm)	Pod weight per plant (g plant^{-1})
Sowing dates	10 March	19.83 a	3.50	17.57 a	10.30	9.96 a	13.44 a	12.27 a
	4 April	12.22 b	3.70	10.32 b	10.00	9.87 a	9.97 b	7.02 b
	4 May	9.65 c	3.2 0	6.18 c	9.83	8.45 b	8.39 c	6.13 c
	LSD %	1.39**	ns	1.68**	ns	0.89**	0.75**	0.59**
Varieties	Aras-98	15.58 ab	3.40 b	12.97 b	10.20	9.69 b	11.50 a	7.76 bc
	Goynuk-98	13.93 c	3.50 b	9.53 d	9.48	8.87 c	10.39 b	6.77 d
	Ahlat	11.66 d	3.40 b	11.48 bc	10.40	9.20 bc	10.68 b	7.34 cd
	Adabeyazi	15.82 a	4.10 a	14.69 a	10.60	10.42 a	10.69 b	12.60 a
	Cihan	12.13 d	3.20 b	9.90 cd	10.80	10.53 a	10.73 b	7.82 bc
	Akman-98	14.29 bc	3.10 b	9.57 d	8.77	7.85 d	9.61 c	8.50 b
	LSD %	1.44**	0.56 ns	4.85**	ns	0.69**	0.74**	0.94**
Early to mid-March (10/03/2018)	Aras-98	25.30 a	3.8 bc	22.40 a	10.80 a-d	10.75 ab	15.43 a	10.20 c
	Goynuk-98	19.23 b	3.50 b-d	16.80 b	10.20 a-f	9.34 d-f	13.57 b	8.53 d
	Ahlat	14.37 cd	3.90 a-c	13.17 c	10.40 a-e	10.57 a-c	12.27 c	7.97 de
	Adabeyazi	25.30 a	3.90 a-c	18.93 b	9.960 a-f	9.97 b-d	13.03 bc	25.47 a
	Cihan	14.50 c	3.00 c-e	16.67 b	11.60 a	11.57 a	13.13 bc	8.50 d
	Akman-98	20.30 b	2.70 de	17.43 b	9.36 c-f	7.60 g	13.23 bc	12.93 b
Early April (04/04/2018)	Aras-98	11.93 d-g	3.30 cd	11.87 cd	9.90 a-f	10.03 b-d	10.80 d	7.23 def
	Goynuk-98	12.67 c-e	3.30 cd	7.87 fg	8.90 def	8.73 e-g	9.77 de	6.17 f
	Ahlat	11.20 e-ı	3.30 cd	11.77 c-e	10.20 a-f	9.47 c-f	9.93 de	7.23 def
	Adabeyazi	13.13 c-e	4.80 a	16.23 b	11.20 a-c	10.90 ab	10.87 d	6.03 f
	Cihan	11.80 e-h	3.10 c-e	6.23 g-ı	11.30 ab	10.17 b-d	10.37 d	8.73 cd
	Akman-98	12.60 c-f	4.40 ab	7.93 fg	8.50 ef	9.90 b-e	8.07 f	6.70 ef
Early May (04/05/2018)	Aras-98	9.5 g-ı	3.00 c-e	4.63 hı	9.90 a-f	8.30 fg	8.23 f	5.83 f
	Goynuk-98	9.9 g-ı	3.70 bc	3.93 hı	9.30 c-f	8.53 fg	7.83 f	5.60 f
	Ahlat	9.40 hı	3.20 c-e	9.50 d-f	10.80 a-c	7.57 g	9.83 de	6.83 ef
	Adabeyazi	9.03 ı	3.60 b-d	8.90 e-g	10.80 a-c	10.40 a-d	8.17 f	6.43 ef
	Cihan	10.10 f-ı	3.40 cd	6.80 f-h	9.60 b-f	9.87 b-e	8.70 ef	6.23 f
	Akman-98	9.96 g-ı	2.30 e	3.33 ı	8.40 f	6.07 h	7.53 f	5.87 f
	LSD %	2.50**	0.91**	2.91**	1.88*	1.20*	1.28**	1.64**

The differences between the means denoted by the same letters are not statistically significant.
*, **: significant difference at 5 and 1% of probability, ns=non-significant.

High plant height in early sowing date could be due to extensity of sunlight stimulated to growth compared to in late sowing date. Similarly, Arslan et al., (2022) found that increased in plant height in early sowings. Actually, Acar et al., (2019) and Cetin (2020) emphasized that the plant height was a quantitative character affected by environmental factors such as soil type, sowing dates, irrigation, fertilizer etc. Moreover, Nosser and Behnan (2004) reported that early sowing dates compared to late sowing dates was important for the plant growth. The first pod height, which

might vary depending on earliness and plant height (Akcin, 1988), ranged from 21.57 cm to 25.22 cm, and the early April sowing gave the highest value. The highest first pod height was in Adabeyazi variety (26.33 cm).

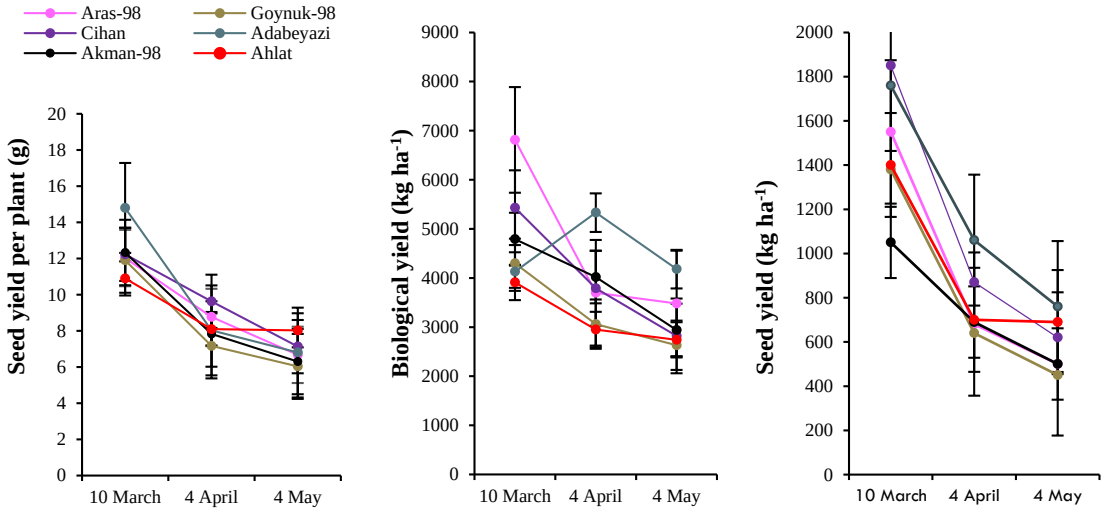

Figure 2. The effect of sowing date on seed per plant, biological and seed yield

This parameter is a character under genetic factors. Therefore, the first pod height of tall and developed plants for vegetative parts generally shows a high value. The experiment findings supported by reported findings of Tam (2008), who stated that sowing on 15-30th April increased the height of the first pod compared to sowing on 30th May. Number of branches per plant decreased linearly as sowing dates were delayed. The early to mid-March sowing produced the more branches (2.70) compared to other sowings (1.90 and 1.70, respectively). The superior performance in early to mid- March sowing dates were attributed to favorable soil moisture and a longer vegetation period for crops. Essentially, the day length and temperature are among the factors controlling flowering, thus the formation of high lateral branches is a desirable feature in dry beans, and late flowering encourages high branching. In this study, the highest branches per plant production was in Cihan and Goynuk-98 varieties (2.30 and 2.20, respectively), the least branching was in Ahlat and Akman-98 varieties (1.90) (Table 2). Plant biomass affected by sowing dates, and the highest value was in early to mid-March sowing (19.83 g). Late sowing date was decreased the plant biomass since the late sowing dates had shorter growing periods than ones. Therefore, late dated sowing (in early May sowing) produced less leaf, branches and pods per plants. The plant biomass varied depending on temperature and day length demands of the varieties. It ranged from 15.82 g in Adabeyazi to 11.66 g in Ahlat. This parameter has a significant effect on the yield and especially, the plants should form enough vegetative parts during the flowering period (Scully and Wainess, 1988). The amount of photosynthesis increase as the vegetative parts developed during this period (Poehlman, 1991). The response of the number of seed per pod to effect of sowing date was not significant. However, the variety and variety × sowing dates interaction were significant. The number of seed per plant ranged from 3.20

to 3.70 values for sowing dates and from 3.10 to 4.10 for varieties (Table 3). There was decrease in the number of seeds per plant depending on the number of pods per plant. Adabeyazi variety showed highest value in early April sowing (4.80), whereas Akman-98 variety lowest value in early May sowing (2.30). These results agree with the work of some researchers (Acar et al., 2019; Cetin 2020). The number of pod per plant decreased, as the sowing date was delayed. The results show that early to mid-March sowings produced the highest number of pod per plant (17.57) compared to other sowings. Adabeyazi variety had the highest value (14.69), whereas Goynuk-98 (9.53) and Akman-98 (9.57) varieties were in low (Table 3). Dry bean plants are sensitive to temperature on the 6^{th} and 8^{th} days after the first flower (Singh, 1964). The meteorological data in the experiment year were show high temperature and humidity and low rainfall in the flowering and pod-fixing periods (Figure 1). Especially, the high temperature in the reproductive periods caused to lose pollens vitality and prevented to pollination and fertilization. In this study, vegetative parts such as branches and plant height and reproductive structures (pollen, flowers etc.) decreased in May sowing date. Conversely, early sowing dates produced more pods and ultimately more seeds than late sowing. Similarly, Zhang et al. (2010) reported higher number of pods per plant in early sowing than late sowing. The response of the number of seed per plant to effect of variety and sowing date was not significant, but the variety × sowing date interaction was significant (Table 3). The highest value was in Cihan variety (11.60) sown in early to mid-March sowing and the lowest value was in Akman-98 (8.40) variety sown in early May sowing. Conversely, Tunctürk et al. (2020) reported that delayed sowing dates increased the number of seed per plant. The response of the pod length to effect of variety, sowing date and variety × sowing date interaction was significant (Table 3). The highest pod length was obtained from variety Cihan (11.57 cm) sown in early to mid-March sowing, whereas the lowest pod length was obtained from variety Akman-98 (6.07 cm) sown in early May sowing. The highest pod width was in early to mid-March sowing date (13.44 mm). Aras-98 variety showed the highest value (11.50 mm), and Akman-98 variety showed the lowest (9.61 mm) value. The early to mid-March sowing, which has a long vegetation period according to other sowing date, increased the pod weight per plant (12.27 g). Adabeyazi variety performed higher value for the pod weight (12.60 g) compared to other varieties. The lowest pod weight was obtained from Göynük-98 variety (Table 3). This result could be due to in early sowings plants gets more rainfall in longer growing period preferred to higher yield, compromising the pod length. Since the vegetation period of the plants exposed to lower temperatures in early sowing was longer than in late sowing, the pod length decreased. This results show similarity the works of Peksen and Gulumser (2005) and Cinar (2015) reported that the pod length ranged from 8.9-30.5 cm and 8.6-11.5 cm, respectively. The highest seed yield per plant (14.80 g) was in Adabeyazi variety in early to mid-March. The lowest value (6.03 g) was in Ahlat variety in early May sowing (Figure 2). The superior performance of early to mid-March sowing was due inadequate vegetative growth caused by the lesser temperature at later growing stages, which cause restricted photosynthetic accessibility to the plants. The findings about the seed yield per plant were lower than Iyigun (2018) and Serengul (2019) findings. The biological yield was higher with early sowing date than late sowing. The highest value was obtained from variety Aras-98 (6810.90 kg ha^{-1}) sown in early to mid-March sowing and the lowest values Goynuk-98 (2630.10 kg ha^{-1}) sown in early May sowing (Figure 2). During the experiment period, negative environmental conditions reduced the biological yield in later sowings (Figure 1). Serengul (2019) also reported that the

biological yield was affected by sowing dates. The response of seed yield to effect of sowing dates was significant. The highest seed yield was in early to mid-March sowing date, but the lowest early May sowing date. Cihan and Adabeyazi varieties showed the highest seed yield (1850.30-1760.30 kg ha^{-1} respectively,). The lowest seed yield was in Goynuk-98 variety (450.60 kg ha^{-1}) (Figure 2). The differences among the varieties could possibly be genetic, which Cihan and Adabeyazi varieties might be more tolerant to low temperature in early sowing dates than Goynuk-98 variety. Since late sowings provide an increase in vegetative and reproductive structures, crops speedy flowered. In addition, insufficient irrigation in late sowings caused vegetative parts was not sufficiently developing, thus the seed yield decreased in this study. Kaul et al., (2018) reported reproductive period of the crops sown late exposed to cool temperatures, thus productivity of crops significantly decreased. Seyum (2014) also determined that yield reduced in late sown crop due to shortening of vegetative growth period.

CONCLUSIONS

In this study, we aimed to evaluate the effect of sowing dates, which is one of the environmental factors that significantly effect on some dry bean varieties growth and yield parameters. In conclude, the early to mid-March sowing date on the yield and yield components of bean varieties was higher compared to other sowing dates. Although early sowing provided irrigation savings, late sowings occurred to disadvantage. The extending growth periods in early sowing increased the photosynthetic capacity of the plants and yield. Additionally, in the early sowing dates the growth and yield depends on the selection of cold tolerant varieties. In the study, Adabeyazi, Cihan and Ahlat varieties more tolerant to low temperatures, the early sowing of these varieties in Diyarbakır ecological conditions allow to producers. However, the regular irrigation applications are required to protect the plants from high temperatures in April and May sowing dates. Therefore, in this dates sowing are not appropriate to plant in site where irrigation is not possible.

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