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Article

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

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Abstract: The sowing date is one of the environmental factors that significantly affected the growth and development of dry beans. Recently, the rapid change of climate required arrangement in its sowing dates. This study aimed to evaluate the effect of different sowing dates (10/03/2018, 04/03/2018, and 04/05/2018) on the phonological, morphological, and yield performances of six dry bean varieties. The experiment was carried out at Dicle University, Faculty of Agriculture Department of Field Crops in the 2018 spring and summer seasons. The experiment established randomized complete blocks design in split plots with three replications. The sowing dates significantly affected 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, and 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 a decrease in all traits. The highest biological and seed yield was in early to mid-March sowing (10/03/2018) date in Cihan and Aras-98 varieties (1610.90 kg ha-1, 1850.30 kg ha-1, respectively). The early sowing date provided better growth and development in cold tolerance varieties. Adabeyazi, Cihan and Ahlat varieties were the most tolerant to low temperatures, thus the crop growth and yield increased for these varieties in the early to mid-March sowing date.

Keywords: dry bean; *Phaseolus vulgaris* L.; sowing date; variety; yield.

1. Introduction

Dry beans 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 the world. In Turkey, the cultivated area of dry beans in 2020 is approximately 103 bins ha and reached 280 bin tons in 2020 with an increase of 24.2% compared to the previous year for the total production [22].

The yield in dry beans can vary with the effect of many environmental factors. The optimum sowing date is one of the significant environmental factors, which plays an important role in getting potential yields. It stated that it was important to explore the growth, maximum yield, harvest quality, yield, and yield quality in crop production [9]. 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 changing environments. Thus, the performance of varieties under different sowing dates needs to be experienced.

The appropriate sowing date has to be for the day length and the climatic conditions such as rainfall, temperature, and humidity [12]. The soil temperature and moisture are the most important abiotic factors affecting germination and cause delays in the 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 the flowering period bring about extreme flower drops and decrease drastically seed yield in late sown varieties. Additionally, these temperatures substantially reduce the leaf area, total dry weight, and net assimilation of dry bean plants. Therefore, it is necessary to prevent the plant from being 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 are very important for the dry bean plant as other cultivated plants [6,8] and [10]. Studies conducted in Turkey's different ecological environments noted that the most suitable sowing date for bean cultivation is the middle of May for the eastern region, the middle of April for the inner Anatolian region, the first of March for the Mediterranean coastline, and from late March to early April for the Southeastern Anatolia region [4,10,21]. However, the changing climatic conditions with global warming also caused 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 beans under Diyarbakir conditions when the temperature was different.

2. Materials and Methods

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

Table 1. The soil properties of the experimental site before sowing*.

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

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

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

The experiment was set up randomized complete block design in split plots with three replications, the main plots were sowing dates 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 plow in the autumn and leveled with a leveler. Plots were in 4 m long and 0.45 m row spacing with 4 rows. On all sowing dates, a single rate of 50 kg ha^{-1} Diammonium phosphate fertilizers was applied with the sowing date.

Harvest dates were on 21 June, 10 July and 3 August 2018 for the three sowing dates, respectively. Data were 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 [7].

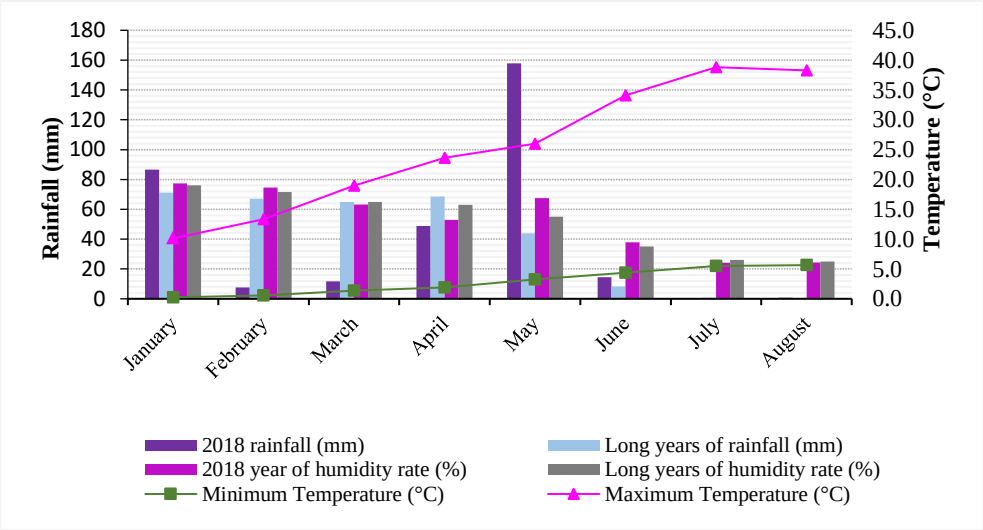

Figure 1. The experimental site's climatic characteristics.

3. Results and Discussion

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

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, plant biomass, number of pods per plant, pod length, pod width, pod weight per plant, seed yield per plant, biological yield and seed yield.

The days to seed emergence, days to first flowering, days to 50% flowering, and days to maturity were decreased as delayed sowing dates. The low soil temperature in early spring did not provide the required temperature for the germination of bean seeds, thus the seed emergence during the early stage of growth was weak in early sowing compared to late sowing. As the soil temperature increased, seed emergences also increased. Therefore, seed emergences were ideal for the May sowing date. Among sowing dates, high and low flowering rates were in early to mid-March and 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 were revealed in early to mid-March sowing dates. Since the air and soil temperatures are high in May, the plant's maturity progressed faster. Among dry bean varieties, Akman-98 variety had late matured; Ahlat variety had early matured (Table 2).

The response of plant height to the 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 a tolerant variety, and Adabeyazi variety was a sensitive variety to low soil and air temperature. High plant height on early sowing date could be due to the extensity of sunlight stimulated to growth compared to on late sowing date. Acar et al. [1] and Cetin [3] emphasized that plant height was a quantitative character affected by environmental factors such as soil type, sowing dates, irrigation, fertilizer, etc. Moreover, Nosser and Behnan [13] reported that early sowing dates compared to late sowing dates were important for plant growth.

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	17.6 ^{a}	60.5 ^{a}	68.5 ^{a}	101.7 ^{a}	34.08	21.57 ^{c}	2.70 ^{a}
	4 April	14.8 ^{b}	54.8 ^{b}	61.3 ^{b}	98.1 ^{b}	32.99	25.22 ^{a}	1.90 ^{b}
	4 May	11.1 ^{c}	43.0 ^{c}	48.1 ^{c}	92.8 ^{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	14.3	53.5 ^{b}	58.8 ^{b}	98.8 ^{c}	32.04 ^{b}	23.36 ^{bc}	2.0 $^{a-c}$
	Goynuk-98	14.0	51.6 ^{c}	58.7 ^{b}	100.2 ^{b}	32.52 ^{b}	21.76 ^{cd}	2.2 ^{a}
	Ahlat	14.8	46.1 ^{e}	52.8 ^{d}	90.3 ^{e}	36.33 ^{a}	22.84 $^{b-d}$	1.9 ^{c}
	Adabeyazi	14.6	62.8 ^{a}	59.0 ^{b}	97.1 ^{d}	30.99 ^{b}	26.33 ^{a}	2.2 ^{ab}
	Cihan	14.6	49.4 ^{d}	56.0 ^{c}	97.3 ^{d}	31.17 ^{b}	24.70 ^{ab}	2.3 ^{a}
	Akman-98	14.6	53.1 ^{bc}	70.4 ^{a}	101.6 ^{a}	34.94 ^{a}	20.48 ^{d}	1.9 ^{c}
	LSD %	ns	1.69**	1.03**	1.29**	2.45**	2.56**	0.28**
Early to mid-March (10/03/2018)	Aras-98	17.6	58.3 ^{cd}	63.7 ^{d}	101.3 ^{cd}	33.40 $^{c-e}$	19.37 ^{fg}	3.0 ^{a}
	Goynuk-98	16.0	57.6 ^{cd}	66.7 ^{c}	105.0 ^{a}	33.00 $^{c-e}$	21.10 $^{d-g}$	2.9 ^{ab}
	Ahlat	18.0	55.6 ^{de}	62.6 ^{d}	94.7 ^{gh}	41.50 ^{a}	22.83 $^{c-f}$	2.2 ^{de}
	Adabeyazi	18.0	64.0 ^{b}	75.3 ^{a}	99.3 ^{de}	28.20 ^{f}	23.30 $^{b-f}$	2.8 $^{a-c}$
	Cihan	18.0	60.3 ^{c}	66.3 ^{c}	104.0 ^{ab}	30.98 $^{d-f}$	20.13 $^{e-g}$	2.6 $^{a-d}$
	Akman-98	18.0	67.3 ^{a}	76.3 ^{a}	106.0 ^{a}	37.40 ^{b}	22.67 $^{c-f}$	2.5 $^{a-d}$
Early April (04/04/2018)	Aras-98	11.0	58.3 ^{cd}	63.3 ^{d}	100.3 ^{cd}	31.87 $^{d-f}$	26.30 $^{a-c}$	1.7 ^{ef}
	Goynuk-98	11.0	53.3 ^{e}	60.0 ^{e}	100.7 ^{cd}	31.83 $^{d-f}$	22.87 $^{c-f}$	2.4 ^{cd}
	Ahlat	11.6	48.3 ^{f}	56.3 ^{f}	88.3 ^{i}	33.20 $^{c-e}$	24.90 $^{a-d}$	1.8 ^{ef}
	Adabeyazi	11.0	65.0 ^{ab}	60.0 ^{e}	97.7 ^{ef}	32.37 $^{c-e}$	28.80 a	1.8 ef
	Cihan	11.0	49.0 ^{f}	57.3 ^{f}	99.7 ^{de}	32.60 $^{c-e}$	27.53 ^{ab}	2.5 $^{b-d}$
	Akman-98	11.0	54.6 ^{e}	70.6 ^{b}	102.0 ^{bc}	36.10 ^{bc}	20.93 $^{d-g}$	1.2 ^{g}
Early May (04/05/2018)	Aras-98	14.3	44.0 ^{g}	49.3 ^{g}	102.0 ^{bc}	30.87 $^{d-f}$	24.40 $^{a-e}$	1.4 ^{fg}
	Goynuk-98	14.0	44.0 ^{g}	49.3 ^{g}	94.6 ^{gh}	32.73 $^{c-e}$	21.30 $^{d-g}$	1.4 ^{fg}
	Ahlat	14.8	34.3 ^{i}	39.3 ^{j}	95.0 ^{gh}	34.30 $^{b-d}$	20.78 $^{d-g}$	1.7 ^{ef}
	Adabeyazi	14.6	59.3 ^{c}	41.7 ^{i}	88.0 ^{i}	32.40 $^{c-e}$	26.90 $^{a-c}$	1.8 ^{ef}
	Cihan	14.6	39.0 ^{h}	44.3 ^{h}	94.3 ^{h}	29.93 ^{ef}	26.43 $^{a-c}$	1.7 ^{ef}
	Akman-98	14.6	37.3 ^{h}	64.3 ^{d}	88.3 ^{i}	31.31 $^{d-f}$	17.83 ^{g}	1.9 ^{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 first pod height, which might vary depending on earliness and plant height [2], 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) (Table 2). 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 were supported by reported findings of Tam [21] who stated that sowing on 15-30th April increased the height of the first pod compared to sowing on 30th May.

The number of branches per plant decreased linearly as sowing dates were delayed. The early to mid-March sowing produced more branches (2.7) compared to other sowings (1.9 and 1.7, respectively). The superior performance in early to mid-March sowing dates was 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 were in Cihan and Goynuk-98 varieties (2.3 and 2.2, respectively), and the least branching was in Ahlat and Akman-98 varieties (1.9) (Table 2).

Plant biomass is affected by sowing dates, and the highest value was in early to mid-March sowing (19.83 g). Late sowing dates decreased the plant biomass since the late sowing dates had shorter growing periods than ones. Therefore, late-dated sowing (in early May sowing) produced fewer leaves, branches, and pods per plant. The plant biomass varied depending on the temperature and day length demands of the varieties. It ranged from 15.82 g in Adabeyazi to 11.66 g in Ahlat (Table3). This parameter has a significant effect on the yield and especially, the plants should form enough vegetative parts during the flowering period [17]. The number of photosynthesis increases as the vegetative parts developed during this period [16].

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

		Plant biomass (g)	Number of seed per pod	Number of pod per plant	Number of seed per plant	Pod length (cm)	Pod width (mm)	Pod weight per plant (g plant^{-1})
	10 March	19.83 ^{a}	3.5	17.57 ^{a}	10.30	9.96 ^{a}	13.44 ^{a}	12.27 ^{a}
Sowing dates	4 April	12.22 ^{b}	3.7	10.32 ^{b}	10.00	9.87 ^{a}	9.97 ^{b}	7.02 ^{b}
	4 May	9.65 ^{c}	3.2	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**
	Aras-98	15.58 ^{ab}	3.4 ^{b}	12.97 ^{b}	10.2	9.69 ^{b}	11.50 ^{a}	7.76 ^{bc}
	Goynuk-98	13.93 ^{c}	3.5 ^{b}	9.53 ^{d}	9.48	8.87 ^{c}	10.39 ^{b}	6.77 ^{d}
	Ahlat	11.66 ^{d}	3.4 ^{b}	11.48 ^{bc}	10.40	9.20 ^{bc}	10.68 ^{b}	7.34 ^{cd}
Varieties	Adabeyazi	15.82 ^{a}	4.1 ^{a}	14.69 ^{a}	10.60	10.42 ^{a}	10.69 ^{b}	12.6 ^{a}
	Cihan	12.13 ^{d}	3.2 ^{b}	9.90 ^{cd}	10.8	10.53 ^{a}	10.73 ^{b}	7.82 ^{bc}
	Akman-98	14.29 ^{bc}	3.1 ^{b}	9.57 ^{d}	8.77	7.85 ^{d}	9.611 ^{c}	8.50 ^{b}
	LSD %	1.44**	0.56 ^{ns}	4.85**	ns	0.69**	0.74**	0.94**
	Aras-98	25.30 ^{a}	3.8 ^{bc}	22.40 ^{a}	10.8 $^{a-d}$	10.75 ^{ab}	15.43 ^{a}	10.20 ^{c}
	Goynuk-98	19.23 ^{b}	3.5 $^{b-d}$	16.80 ^{b}	10.2 $^{a-f}$	9.34 $^{d-f}$	13.57 ^{b}	8.53 ^{d}
Early to mid-March	Ahlat	14.37 ^{cd}	3.9 $^{a-c}$	13.17 ^{c}	10.4 $^{a-e}$	10.57 $^{a-c}$	12.27 ^{c}	7.97 ^{de}
(10/03/2018)	Adabeyazi	25.30 ^{a}	3.9 $^{a-c}$	18.93 ^{b}	9.96 $^{a-f}$	9.97 $^{b-d}$	13.03 ^{bc}	25.47 ^{a}
	Cihan	14.50 ^{c}	3.0 $^{c-e}$	16.67 ^{b}	11.6 ^{a}	11.57 ^{a}	13.13 ^{bc}	8.50 ^{d}
	Akman-98	20.30 ^{b}	2.7 ^{de}	17.43 ^{b}	9.36 $^{c-f}$	7.60 ^{g}	13.23 ^{bc}	12.93 ^{b}
	Aras-98	11.93 $^{d-g}$	3.3 ^{cd}	11.87 ^{cd}	9.9 $^{a-f}$	10.03 $^{b-d}$	10.80 ^{d}	7.23 ^{def}
	Goynuk-98	12.67 $^{c-e}$	3.3 ^{cd}	7.87 ^{fg}	8.9 ^{def}	8.73 $^{e-g}$	9.77 ^{de}	6.17 ^{f}
Early April	Ahlat	11.20 $^{e-ı}$	3.3 ^{cd}	11.77 $^{c-e}$	10.2 $^{a-f}$	9.47 $^{c-f}$	9.93 ^{de}	7.23 ^{def}
(04/04/2018)	Adabeyazi	13.13 $^{c-e}$	4.8 ^{a}	16.23 ^{b}	11.2 $^{a-c}$	10.90 ^{ab}	10.87 ^{d}	6.03 ^{f}
	Cihan	11.80 $^{e-h}$	3.1 $^{c-e}$	6.23 $^{g-ı}$	11.3 ^{ab}	10.17 $^{b-d}$	10.37 ^{d}	8.73 ^{cd}
	Akman-98	12.60 $^{c-f}$	4.4 ^{ab}	7.93 ^{fg}	8.5 ^{ef}	9.90 $^{b-e}$	8.07 ^{f}	6.70 ^{ef}
	Aras-98	9.5 $^{g-ı}$	3.0 $^{c-e}$	4.63 ^{hı}	9.9 $^{a-f}$	8.30 ^{fg}	8.23 ^{f}	5.83 ^{f}
	Goynuk-98	9.9 $^{g-ı}$	3.7 ^{bc}	3.93 ^{hı}	9.3 $^{c-f}$	8.53 ^{fg}	7.83 ^{f}	5.60 ^{f}
Early May	Ahlat	9.400 ^{hı}	3.2 $^{c-e}$	9.50 $^{d-f}$	10.8 $^{a-c}$	7.57 ^{g}	9.83 ^{de}	6.83 ^{ef}
(04/05/2018)	Adabeyazi	9.033 ^{ı}	3.6 $^{b-d}$	8.90 $^{e-g}$	10.8 $^{a-c}$	10.40 $^{a-d}$	8.17 ^{f}	6.43 ^{ef}
	Cihan	10.10 $^{f-ı}$	3.4 ^{cd}	6.80 $^{f-h}$	9.6 $^{b-f}$	9.87 $^{b-e}$	8.70 ^{ef}	6.23 ^{f}
	Akman-98	9.967 $^{g-ı}$	2.3 ^{e}	3.33 ^{ı}	8.4 ^{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.

The response of the number of seeds per pod to the effect of the sowing date was not significant. However, the variety and variety × sowing dates interaction were significant. The number of seeds per plant ranged from 3.2 to 3.7 values for sowing dates and from 3.1 to 4.1 for varieties. There was a decrease in the number of seeds per plant depending on the number of pods per plant. Adabeyazi variety showed the highest value in early April sowing (4.8), whereas Akman-98 variety lowest value in early May sowing (2.3) (Table 3). These results agree with the works of Acar et al. [1] and Cetin [3].

The number of pods per plant decreased, as the sowing date was delayed. The results show that early to mid-March sowings produced the highest number of pods 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 low (Table 3). The response of the number of seeds per plant to the effect of sowing dates and varieties was not significant. However, variety × sowing dates interaction was significant. Among all varieties, Cihan variety had the highest value (11.6) on the early to mid-March sowing date. However, Akman-98 variety had the lowest value (8.4) on the early May sowing date. Dry bean plants are sensitive to temperature on the 6th and 8th days after the first flower [20]. The meteorological data in the experiment year showed 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 loss of pollen vitality and prevented pollination and fertilization. In this study, vegetative parts such as branches and plant height and reproductive structures (pollen, flowers, etc.) decreased on the May sowing date. Conversely, early sowing dates produced more pods and ultimately more seeds than late sowing. Similarly, Zhang et al. [23] reported a higher number of pods per plant in early sowing than in late sowing.

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. The superior performance of early to mid-March sowing was due to inadequate vegetative growth caused by the lesser temperature at later growth stages, which cause restricted photosynthetic accessibility to the plants. The findings about the seed yield per plant were lower than Iyigun [14] and Serengul [18] findings.

The biological yields were higher with early sowing dates than with 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 [18] also reported that the biological yield was affected by sowing dates.

The response of seed yield to the effect of sowing dates was significant. The highest seed yield was in the 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 be genetic, which Cihan and Adabeyazi varieties might be more tolerant to low temperatures on early sowing dates than Goynuk-98 varieties. Since late sowings provide an increase in vegetative and reproductive structures, crops speedy flowered. In addition, insufficient irrigation in late sowings caused vegetative parts not to be sufficiently developed, thus the seed yield decreased in this study. Kaul et al. [11] reported reproductive period of the crops sown late exposed to cool temperatures, thus productivity of crops significantly decreased. Seyum [19] also determined that yield was reduced in late sown crops due to the shortening of the vegetative growth period.

The response of the pod length to the effect of variety and sowing date was not significant, but the variety × sowing date interaction was significant (Table 3). The highest pod length was obtained from variety Cihan (11.6 cm) sown in early to mid-March sowing, whereas the lowest pod length was obtained from variety Akman-98 sown in early May sowing.

The highest pod width was in early to mid-March and early April sowings (respectively, 9.96 and 9.87 mm). Cihan and Adabeyazi varieties showed the highest values (10.53 and 10.42 mm, respectively), and Akman-98 variety showed the lowest (7.85 mm) value. The early to mid-March sowing, which has a long vegetation period according to another sowing date, increased the pod weight per plant (13.44 g). Aras-98 variety performed higher value for the pod weight (11.50 g) compared to other varieties.

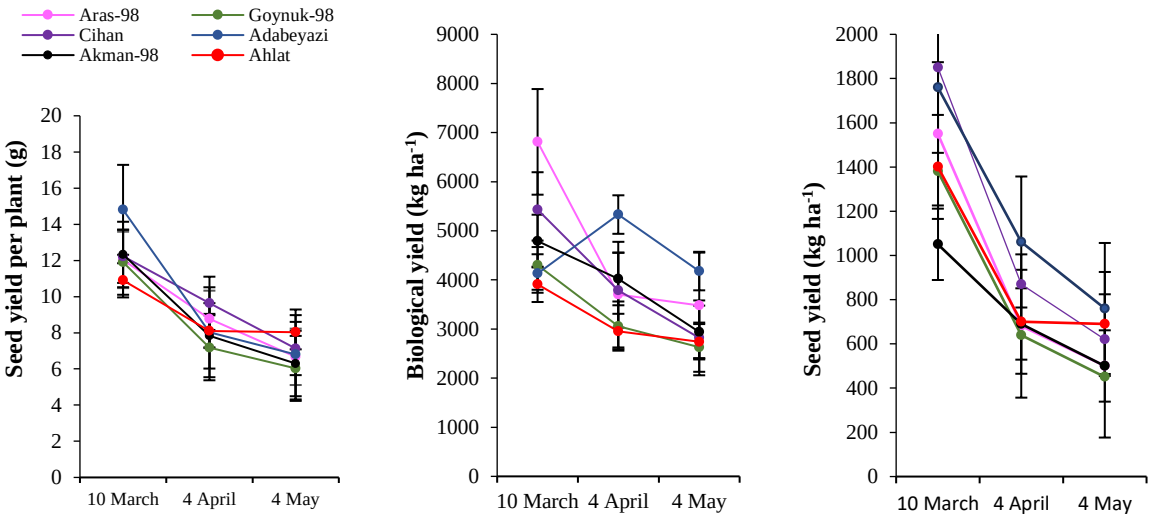

Figure 2. The effect of sowing date on seed per plant, biological and seed yield.

The lowest pod weight was obtained from Akman-98 variety (Table 3). This result could be due to early sowings plants getting more rainfall in a 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. These results show similarity to the works of Peksen and Gulumser [15] and Cınar [5] reported that the pod length ranged from 8.9-30.5 cm and 8.6-11.5 cm, respectively.

4. Conclusions

In this study, we aimed to evaluate the effect of sowing dates, which is one of the environmental factors that significantly affect some dry bean varieties' growth and yield parameters. In conclusion, 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 a 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 depend on the selection of cold-tolerant varieties. In the study, Adabeyazi, Cihan, and Ahlat varieties are more tolerant to low temperatures, and the early sowing of these varieties in Diyarbakır ecological conditions allows for producers. However, regular irrigation applications are required to protect the plants from high temperatures on April and May sowing dates. Therefore, on these dates sowing are not appropriate to plant on site where irrigation is not possible.

Conflicts of Interest: The authors declare no conflict of interest.

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