Türkiye Tarımsal Araştırmalar Dergisi
dergipark.org.tr/tutad

Research Article

Turk J Agric Res
2023, 10(1): 27-37
© TÜTAD
ISSN: 2148-2306
e-ISSN: 2528-858X
doi: 10.19159/tutad.1219472

Field Performance of Some Soybean [*Glycine max* (L.) Merr.] Cultivars Sown on Different Dates

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Received: 16.12.2022 **Accepted:** 28.03.2023

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Abstract: Soybean [*Glycine max* (L.) Merr.], with high oil and protein content, is one of the world's main nutritional sources and millions of hectares are given over to its cultivation. Intensive farming and producing multiple crops per year (such as second-crop soybean cultivation), can improve natural resource exploitation and productivity. The objective of this study was to examine the effects of some soybean cultivars on yield and yield components in lowland conditions in the Mardin province over the main-crop and second-crop seasons. This research was carried out in the lowland conditions of Mardin province in Türkiye in 2018 and 2019. The A-3127, Arısoy, Ataem-7, Blaze, Bravo, Cinsoy, Gapsoy-16, Lider, May-5312, Nova, SA-88, and Umut-2002 cultivars were used as plant material in this research. Since the region is suitable for growing double crops per year, soybean field trials were carried out both as a main crop and as a second-cropped. Sowing dates and 12 different soybean cultivars were taken as factors in the research. The first sowing took place on April 16, the second on April 25, the third on June 15, and the fourth on June 30 in both years of the research. Two sowings were the main crop, while the other two were second-crop. According to the results, the A-3127 (3700 kg ha^{-1}) and Gapsoy-16 (3694 kg ha^{-1}) cultivars produced the highest seed yield. The Arısoy (676 kg ha^{-1}), Gapsoy-16 (676 kg ha^{-1}), A-3127 (662 kg ha^{-1}), and Cinsoy (662 kg ha^{-1}) cultivars produced the most oil yield. The study determined that early sowing increases overall yield while late sowing decreases seed yield significantly (on average by 30%). For this region and in areas with similar agricultural environments where double-crop can be grown each year, early cultivars for a second crop may be recommended to reduce the vegetable food and oil deficit.

Keywords: Cultivar, *Glycine max*, oil content, oil yield, sowing date, yield

1. Introduction

Soybean [*Glycine max* (L.) Merr.] is a member of the Fabaceae family and is a photosensitive short-day plant with yields that are affected by the sowing date (Johnson et al., 1960; Sahoo et al., 1991). It is one of the most valuable crops in the world, with seeds containing more than 40% protein with a healthy amino acid profile and around 20% oil, half of which is unsaturated fatty acids that lower blood cholesterol levels. Fiber, lecithin, vitamins, mineral salts, and antioxidants are among the healthy constituents (Bellaloui et al., 2015). It is therefore a valuable raw ingredient in the food and feed sectors (extracted meal). Soybean oil accounts for approximately 29% of the global consumer vegetable oil supply (Anonymous, 2022). In many countries, soybeans are also utilized as a meat substitute because their protein has a set of amino acids in similar quantities to the reference protein (chicken egg) (Krishnan, 2005).

Photoperiod and temperature are the most significant factors impacting soybean growth and development, and they also severely limit the area in which the species can be cultivated. Soybeans are temperature sensitive throughout their whole life cycle, from germination to maturity (Cai et al., 2020). The ideal temperatures are 15-22 ºC during emergence, 20-25 ºC at flowering, and 15-22 ºC at maturity (Liu et al., 2008). To get high yields, it is necessary to select an acceptable cultivar and apply appropriate agricultural techniques to the current environmental conditions. Determining the sowing date of specific cultivars and genotypes is of great importance in terms of yield and quality (Park et al., 1987; Mayers et al., 1991; Tyagi et al., 2011).

Genetic improvement accounts for approximately half of the increase in soybean yield, while applied agricultural practices account for the other half (Rowntree et al., 2013). Climate change has a major effect on agricultural productivity (Mourtzinis et al., 2019). It is therefore vital to understand the climate factors that limit agricultural productivity. In soybean production, the sowing date is crucial since it affects the healthy growth of the plant's vegetative and generative organs, as well as the final biomass (Setiyono et al., 2007; Divito et al., 2016; Nico et al., 2019). Due to variations in environmental conditions (such as precipitation, temperature, relative humidity, soil moisture, and photoperiod), the sowing date can impact the phenological period of the plant and consequently determine soybean growth, maturation, and production (Julio, 1986). In some areas, late sowing coincides with spring droughts, whereas plants sown too soon in cool soil emerge slowly and sporadically (Uslu and Esendal, 1998). Soybean seed production is reduced when sown late. A drop in seed yield can be explained by the positive link between the number of branches per plant, the number of pods per plant, the number of seeds per plant, and the decline in seed weights in late sowing (Anderson and Vasilas, 1985; Board, 1985; Egli et al., 1987; Park et al., 1987; Uslu and Esendal, 1998).

Intensive farming, such as the use of second-crop soybeans, can help increase agricultural production and optimize the use of natural resources (such as soil, water, and sunlight). In any ecological environment, it is necessary to record the different environments to which the soybean is exposed in terms of factors such as precipitation, soil, and air temperature, relative humidity, soil moisture, day length, and sun exposure, and how the plant is affected by them (Anderson and Vasilas, 1985; Mayers et al., 1991; Onat et al., 2017). Crop performance can be significantly improved by using appropriate farming practices, genotype selection, and selecting an optimal sowing date. In some circumstances, different soybean cultivars and sowing dates from climatically similar regions might be applied to new places. However, it is necessary to validate adaptation studies of soybean cultivars in new agro-ecological areas. Furthermore, to satisfy rising global food demand, agricultural productivity per unit area and time must be increased (Evans, 1993).

Every year, hundreds of thousands of hectares of crops, primarily wheat and corn, are cultivated in the lowlands of Mardin in Türkiye's Southeastern Anatolia Region. Since both of these crops belong to the cereal family, they take similar nutrients from the soil, meaning the soil gets constantly poorer. While reducing the quantity of fertilizer needed to maintain soil bioactivity, growing soybeans after wheat rather than corn improves the soil by fixing pure nitrogen. Furthermore, because soybean cultivation as a second crop does not require as much water as corn, natural water resources will be somewhat protected. The province of Mardin was selected for this study because it is a new region for soybean farming and has a favorable environment for cultivating double crops.

The objective of the study was to examine the effects of some soybean [*G. max* (L.) Merr.] cultivars on yield and yield components in lowland conditions in the Mardin province over the main-crop and second-crop seasons. The results obtained from studying the growth and production of soybeans in a new environment may help to offset the region's and the world's shortages in vegetable food and oil.

2. Materials and Methods

2.1. Experimental site and climate-soil conditions

A field experiment was conducted in the lowland climate of Mardin province, Türkiye, during the vegetation months of 2018 and 2019, at an altitude of 400 m, latitude of 37.131131 N, and longitude of 40.940215 E.

The lowlands of Mardin province are hot and dry in the summer and wet and warm in the winter. Winter precipitation is significantly higher than summer precipitation and there is typically no rain in August. When the experimental years (2018-2019) were compared to the climate statistics for long years, it became clear that more precipitation fell during the second year of the study's April and May than in long years, in particular (Table 1).

The soil in the experiment area has a clay-loam texture and contains little organic matter. The amount of available phosphorus (P) is insufficient, although available potassium (K) is rich in soils. The lime content is quite high, the pH is slightly alkaline, and there is no salinity problem (Table 2).

2.2. The plant genetic material

Twelve different soybean [*G. max* (L.) Merr.] cultivars were utilized as genetic material in this research. The genetic materials were obtained from GAP International Agricultural Research and Training Center. The maturity groups and origins of these cultivars were shown in Table 3.

Table 1. Meteorological values of long years (2000-2019) and 2018-2019 vegetation periods in Mardin province (Anonymous, 2019)

Months	Precipitation (mm)			Temperature (°C)			Humidity (%)		
	2000-2019	2018	2019	2000-2019	2018	2019	2000-2019	2018	2019
April	35.1	32.5	79.7	15.9	17.7	13.9	53.8	53.0	70.9
May	34.7	26.6	49.2	21.7	21.8	22.7	40.5	60.8	29.1
June	3.0	28.5	16.3	28.4	28.1	29.5	24.5	33.9	24.0
July	0.9	0.0	1.7	32.4	30.9	30.8	21.0	31.3	21.8
August	0.3	0.0	0.1	30.9	30.2	31.7	27.8	38.3	20.7
September	1.3	0.1	0.3	26.6	27.0	26.3	29.8	35.3	24.3
October	21.5	115.3	32.7	20.7	19.8	22.3	36.7	44.0	30.4
November	30.50	128.4	11.8	13.4	11.1	13.5	50.0	73.1	41.6
Total/Mean	127.3	331.4	191.8	23.8	23.3	23.8	35.5	46.2	32.9

Table 2. Soil analysis values of the trial area (0-20 cm)*

Parameters	Value
Texture class	CL
pH	8.01
Organic matter, %	1.06
Lime ($CaCO_3$), %	36.4
Total salt, %	0.020
Available P, kg P_2O_5 ha^{-1}	27.2
Available K, mg kg^{-1}	101.13

*: Soil analyses of the trial area were carried out in the MARTEST analysis laboratory, CL: Clay-loamy

Table 3. Cultivars and maturity groups were used in the field experiment

Cultivars	Originate	Maturity group
A-3127	Türkiye	III
Arısoy	Türkiye	III
Ataem-7	Türkiye	III-IV
Blaze	USA	IV
Bravo	USA	II
Cinsoy	Türkiye	III-IV
Gapsoy-16	Türkiye	III-IV
Lider	Türkiye	III-IV
May-5312	USA	III
Nova	USA	III
SA-88	Türkiye	III
Umut-2002	Türkiye	III

2.3. Experiment treatments and agricultural processes

Sowing dates and 12 different soybean cultivars were taken as factors in the research. The field experimental design was split plots in randomized complete blocks with three replications. On the main plots, different sowing dates were applied. Soybean cultivars were sown in subplots. In both years of the experiment, the first sowing date was April 16, the second was April 25, the third was June 15, and the fourth was June 30.

Trial plots were set up each 6 m long, with 60 cm row spacing, 5 cm in-row spacing, and a total of four rows. There was a 2 m separation between the plots and a 3 m separation between the blocks. Seeds were sown at a depth of 3-4 cm on average. In this study, 150 kg of diammonium phosphate (18-46-0%, N-P-K) fertilizer was used per hectare. The soil was irrigated with a sprinkler irrigation system prior to sowing. The soil was tilled on the third day, and the seeds were sown immediately. The seedlings were sown after being inoculated with *Bradyrhizobium japonicum* bacteria in sugar water in a shaded area. The irrigation system for each sowing plot was set up separately. Because the amount of precipitation is so low in July, August, and September, irrigation was carried out four times during the second-crop. The first irrigation was done when the plant reached 8-10 cm in height, the second irrigation was done when the plants first bloomed, the third irrigation was done when the pods started to swell, and the fourth irrigation was done 15 days after the third irrigation. Weeding was done manually and with a hoe.

Harvesting was done three days after the plant's leaves were yellowed and shed. The main crops were harvested between September 7 and 19 and the second crops were harvested between September 13 and October 11. The harvest was carried out entirely by hand. This research examined plant height, first pod height, number of pods per plant, seed yield, oil ratio, and oil yield values.

2.4. Statistical analyzes

The data obtained from the research were analyzed in the JMP package software according to split-plots in the randomized blocks design. According to the results of the F test, the differences between the groups were determined by the LSD (Least Significant Difference) multiple comparison test (Yurtsever, 1984).

3. Results and Discussion

3.1. Plant height

All factors and variations [year (Y), sowing date (S.Dt.), cultivar (C), CxS.Dt., YxS.Dt., YxC, and YxCxS.Dt.] in plant height in soybean plants were significant at 1% level (Table 4).

Table 4. Two-year combined analysis of variance results for soybeans

Variation sources	F value					
	PH	FPHP	NPPP	SY	OC	OY
Year (Y)	54.94**	308.42**	107.85**	10.40ns	8.55ns	19.33**
Error 1						
Sowing date (S.Dt.)	152.92**	57.23**	71.19**	115.50**	10.21*	111.49**
YxS.Dt.	6.27**	11.24*	1.88**	0.68*	12.82*	0.70*
Cultivar (C)	19.58**	24.41**	11.31**	3.19**	2.79**	3.11**
YxC	1.89**	5.32**	5.62**	0.50ns	0.83*	0.45*
Error 2						
S.Dt.xC	1.54**	3.21**	3.04**	1.99**	3.88**	2.61**
YxS.Dt.xC	1.43**	1.48**	1.42*	0.61*	2.28**	1.06*
Error 3						
CV (%)	12.7	25.3	21.8	19.2	7.5	20.9

PH: Plant Height, FPHP: First Pod Height of the Plant, PNPP: Pod Number Per Plant, SY: Seed Yield, OC: Oil Content, OY: Oil Yield, CV: Coefficient of variation, *: Statistically significant at 5% ($p<0.05$), **: Statistically significant at 1% ($p<0.01$), ns: Not significant

The average plant height data of soybean cultivars is presented in Table 5. Plant height was affected by sowing dates, and late sowings resulted in a significant reduction. Cultivar averages were highest in the Gapsoy-16 (91.0 cm) and lowest in the A-3127 (58.2 cm). The highest value in sowing date averages was at the first sowing date of the second year (92.9 cm), and the lowest value was at the fourth sowing date (56.6 cm) in the first year. In terms of year x cultivar interaction, the highest average was in the Gapsoy-16 (96.4 cm) in the second year and the lowest in the A-3127 (57.8 cm) in the first year. When the cultivar x sowing date interaction was examined, the highest plant height was determined in Gapsoy-16 (102.9 cm) at the first sowing date and Umut-2002 (99.6 cm) at the second sowing date. The lowest plant height was found in the A-3127 (48.7 cm) at the fourth sowing date. In terms of year x sowing date x cultivar interaction, the highest plant height was 115.4 cm (Gapsoy-16), and the lowest was 45.6 cm (Blaze) (Table 5).

The plant heights of soybeans sown in June (second crop) were shorter than those sown in April (main crop). After June 21, when field trials are undertaken in the Northern Hemisphere where Türkiye is located, the days start to get shorter. During the vegetation period of second-crop soybean, the sunlight period of the plants naturally begins to decrease. Therefore, photoperiodic conditions in late sowings forced the plant to shorten the vegetative period, forcing it to enter the generative stage early. In second-crop soybeans, these decreases in plant height can be explained by the shorter vegetative period and lower canopy competition between plants. In addition, another reason for these differences between cultivars can be suggested as genetic potential differences (Beaver and Johnson, 1981; Parker et al., 1981; Uslu and Esendal, 1998).

3.2. First pod height of the plant

Since pod height is of great importance in machine harvesting in terms of preventing product loss, the first pod height of the plant (FPHP) was also measured. For the first pod height of the plant; the factors and variations of year, sowing date, cultivar, S.DtxC, YxC, and YxS.DtxC were significant at the 1% level, while the YxS.Dt variation was significant at the 5% level (Table 4).

In terms of cultivar averages, the Ataem-7 had the highest value (10.4 cm), while May-5312 had the lowest value (4.1 cm). The FPHP was affected by the sowing date, and late sowing resulted in a significant decrease. The average sowing date reached its highest point in the second year's first sowing period (12.1 cm) and its lowest point in the first year's fourth sowing period (3.5 cm). With regard to the year and cultivar interaction, Ataem-7 had the highest average value (11.3 cm) in the second year and May-5312 had the lowest (3.0 cm) in the first year. When the cultivar x sowing date interaction was examined, the highest FPHP was determined in Gapsoy-16 (13.3 cm) at the second sowing date. The lowest FPHP was found in the Blaze (2.9 cm) at the fourth sowing date. The FPHP ranged from 18.2 cm (Gapsoy-16) at its highest point to 1.2 cm (Blaze) at its lowest point depending on the year, sowing date, and cultivar (Table 6).

Incomplete vegetative development and early blooming resulted from late sowing (particularly in June), which is why the height of the first pod remained low in the short plants. Some combine harvester heads are unable to pick up the lowest pods that are too close to the soil surface, increasing harvest losses. Due to the low pod height of second-crop soybeans, harvest losses are typically higher (Grabau and Pfeiffer, 1989; Kang et al., 2017). It is known that late sowing in soybean shortens the

Table 5. Average plant height values and statistical groups of soybean cultivars sown at different times (cm)*

Cultivar	Year x Sowing Date x Cultivar								Year x Cultivar		Cultivar x Sowing Date				Mean (Cultivar)
	2018				2019										
	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	2018	2019	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	
A-3127	71.1 c-v	61.3 h-v	50.7 r-v	47.9 t-v	71.1 c-v	60.2 i-v	53.6 o-v	49.5 v-v	57.8 j	58.6 i-j	71.1 e-n	60.8 k-n	52.1 mn	48.7 n	58.2 E
Arısoy	88.4 a-o	94.4 a-i	52.6 p-v	49.8 s-v	96.4 a-g	96.2 a-g	78.1 b-v	61.1 h-v	71.3 e-j	83.0 a-f	92.4 a-f	95.3 a-d	65.4 h-n	55.5 k-n	77.1 BC
Ataem-7	86.6 a-q	94.7 a-i	94.3 a-i	71.8 b-v	106.1 ab	94.0 a-i	89.5 a-n	77.3 b-v	86.8 a-d	91.7 a-b	96.4 abc	94.4 a-d	91.9 a-f	74.5 c-m	89.3 A
Blaze	91.5 a-l	85.5 a-r	54.7 n-v	45.6 v	91.8 a-k	89.4 a-n	70.2 c-v	64.0 f-v	69.3 f-j	78.8 b-g	91.7 a-f	87.4 a-h	62.5 j-n	54.8 k-n	74.1 CD
Bravo	80.1 b-v	83.5 a-s	61.7 g-v	49.8 s-v	98.2 a-f	96.0 a-h	80.4 b-v	56.8 l-v	68.8 f-j	82.8 a-g	89.1 a-g	89.7 a-g	71.0 e-n	53.3 l-n	75.8 BD
Cinsoy	99.8 a-e	85.2 a-r	61.7 g-v	58.7 k-v	92.4 a-k	91.3 a-l	79.7 b-v	66.3 e-v	76.3 c-h	82.4 a-g	96.1 abc	88.2 a-g	70.7 f-n	62.5 j-n	79.4 BC
Gapsoy-16	90.5 a-m	96.4 a-g	80.7 a-u	74.5 b-v	115.4 a	102.4 a-d	90.3 a-m	77.6 b-v	85.5 a-e	96.4 a	102.9 a	99.4 ab	85.5 a-i	76.0 c-l	91.0 A
Lider	97.2 a-f	77.0 b-v	52.4 p-v	46.2 uv	90.3 a-m	76.2 b-v	74.8 b-v	70.5 c-v	68.2 g-j	77.9 b-h	93.8 a-e	76.6 b-k	63.6 i-n	58.3 k-n	73.1 CD
May-5312	76.9 b-v	63.8 f-v	59.0 j-v	55.6 m-v	76.4 b-v	75.9 b-v	66.8 e-v	64.8 f-v	63.8 hj	71.0 e-j	76.7 b-k	69.8 f-n	62.9 i-n	60.2 k-n	67.4 DE
Nova	92.6 a-k	80.9 a-u	65.9 e-v	52.1 q-v	85.6 a-q	87.0 a-p	83.3 a-s	77.5 b-v	72.9 di	83.3 a-f	89.1 a-g	83.9 a-j	74.6 c-m	64.8 h-n	78.1 BC
SA-88	94.8 a-i	102.0 a-d	56.8 l-v	65.6 e-v	86.3 a-q	79.2 b-v	71.4 b-v	69.9 d-v	79.8 bg	76.7 c-h	90.6 a-f	90.6 a-f	64.1 i-n	67.7 g-n	78.3 BC
Umut-2002	93.7 a-j	95.2 a-h	64.2 f-v	61.9 g-v	104.8 abc	104.0 a-d	81.7 a-t	64.9 e-v	78.8 bg	88.9 abc	99.2 ab	99.6 a	73.0 d-m	63.4 i-n	83.8 AB
	Year x Sowing Date								Year		Sowing Date				
Mean	88.6 A	85.0 AB	62.9 D	56.6 D	92.9 A	87.6 AB	76.7 BC	66.7 CD	81.0A	73.3B	90.7 A	86.3 A	69.8 B	61.6 C	

*: The difference between the means indicated by the same letter in the same column / in the same row / in the same group is not statistically significant

Table 6. Average first pod height of the plant values and statistical groups of soybean cultivars sown at different times (cm)*

Cultivar	Year x Sowing Date x Cultivar								Year x Cultivar		Cultivar x Sowing Date				Mean (Cultivar)
	2018				2019										
	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	2018	2019	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	
A-3127	5.2 k-q	5.8 i-q	4.9 k-q	2.6 n-q	7.5 c-q	13.4 a-e	7.1 d-q	4.3 l-q	4.6 j-l	8.1 c-h	6.4 f-m	9.6 a-i	6.0 g-m	3.4 lm	6.3 CD
Arısoy	9.0 b-n	2.7 n-q	3.5 m-q	2.4 o-q	12.0 a-ı	12.4 a-h	13.0 a-f	6.9 e-q	4.4 k-l	11.1 ab	10.5 a-f	7.6 b-l	8.3 b-k	4.7 j-m	7.8 BC
Ataem-7	10.3 b-l	9.7 b-m	11.0 b-k	7.2 d-q	12.0 a-ı	13.7 abc	12.5 a-h	7.0 d-q	9.6 a-f	11.3 a	11.1 a-d	11.7 abc	11.7 abc	7.1 d-m	10.4 A
Blaze	6.4 g-q	6.4 g-q	2.3 o-q	1.2 q	10.5 b-l	12.7 a-g	5.9 h-q	4.6 k-q	4.1 kl	8.4 b-g	8.5 b-j	9.6 a-i	4.1 k-m	2.9 m	6.3 CD
Bravo	5.1 k-q	7.4 c-q	2.3 o-q	1.8 pq	6.4 g-q	9.9 b-m	7.5 c-q	5.1 k-q	4.2 kl	7.2 e-j	5.8 i-m	8.7 b-j	4.9 j-m	3.5 lm	5.7 DE
Cinsoy	8.3 c-p	6.7 f-q	7.8 c-p	4.6 k-q	8.5 c-o	13.5 a-d	13.5 a-d	7.1 d-q	6.8 f-k	10.6 abc	8.4 b-k	10.1 a-h	10.7 a-e	5.8 h-m	8.7 AB
Gapsoy-16	5.9 h-q	8.3 c-p	4.3 l-q	3.5 m-q	11.8 a-j	18.2 a	5.4 j-q	5.7 i-q	5.5 h-l	10.3 a-d	8.9 b-j	13.3 a	4.8 j-m	4.6 j-m	7.9 BC
Lider	6.9 e-q	5.2 k-q	10.3 b-l	4.3 l-q	6.2 g-q	15.2 ab	9.4 b-m	4.1 l-q	6.7 g-k	8.7 a-g	6.5 e-m	10.2 a-g	9.9 a-i	4.2 klm	7.7 BC
May-5312	4.7 k-q	2.7 n-q	2.6 n-q	2.1 o-q	6.9 f-q	4.0 l-q	4.2 l-q	5.5 i-q	3.0 l	5.1 ı-l	5.8 i-m	3.3 l-m	3.4 lm	3.8 lm	4.1 E
Nova	8.5 c-o	5.3 j-q	6.4 g-q	5.1 k-q	6.6 f-q	8.1 c-p	6.4 g-q	4.6 k-q	6.3 g-k	6.4 g-k	7.6 b-l	6.7 e-m	6.4 e-m	4.9 j-m	6.4 CD
SA-88	6.8 f-q	6.1 g-q	2.5 n-q	2.6 n-q	8.3 c-p	10.2 b-l	10.0 b-m	7.1 d-q	4.5 j-l	8.9 a-g	7.5 c-l	8.2 b-k	6.3 f-m	4.8 j-m	6.7 CD
Umut-2002	7.4 c-q	9.8 b-m	8.6 c-o	5.1 k-q	10.3 b-l	13.8 abc	7.9 c-p	6.5 g-q	7.7 d-ı	9.6 a-e	8.8 b-j	11.8 ab	8.3 b-k	5.8 i-m	8.7 B
	Year x Sowing Date								Year		Sowing Date				
Mean	7.1 B	6.4 BC	5.6 D	3.5 BC	8.9 AB	12.1 A	8.6 B	5.7 BC	5.6 B	8.8 A	8.0 AB	9.2 A	7.1 B	4.6 C	

*: The difference between the means indicated by the same letter in the same column / in the same row / in the same group is not statistically significant

plant height and thus reduces the first pod height. It is a logical solution to increase plant density in the field to increase plant height and bottom pod height (Çalışkan et al., 2007). Differences in the FPHP were also detected between cultivars. Choosing the right cultivar is another important factor in increasing the lowest pod height. Both the sowing dates and the genetic differences between the cultivars can be argued to influence the FPHP (Board, 1985; Park et al., 1987; Rowntree et al., 2013).

3.3. Number of pods per plant

The number of pods per plant (NPPP) is one of the important factors that directly affect the seed yield. The factors and interactions of year, sowing date, cultivar, YxS.Dt, S.DtxC, and YxC were significant at the 1% level, while the YxS.DtxC interaction was significant at the 5% level for the NPPP (Table 4).

The data pertaining to the number of pods of soybean cultivars is presented in Table 7. According to the results, the Bravo had the highest cultivar means (220.2 pod plant^{-1}), and the Umut-2002 had the lowest (140.8 pod plant^{-1}). In terms of sowing dates, the highest values were determined in the first two sowing dates, and the lowest values were determined in the last two sowing dates. When the cultivar x sowing date interaction was examined, the highest NPPP was determined in the Nova (274.9 pod plant^{-1}) at the first sowing date. The lowest NPPP was found in the Umut-2002 (59.6 pod plant^{-1}) at the fourth sowing date. Regarding the YxC interaction, the Blaze had the highest average value in the second year (246.0 pod plant^{-1}), and the A-3127 had the lowest average value in the first year (89.8 pod plant^{-1}). The second sowing date of the second year had the highest average NPPP (239.3 pod plant^{-1}), and the fourth sowing date of the first year had the lowest average NPPP (122.5 pod plant^{-1}). According to the three-way interaction (YxS.DtxC), the highest NPPP (312.7 pod plant^{-1}) was determined in the Nova at the first sowing date of the second year, and the lowest NPPP (53.5 pod plant^{-1}) was determined in Umut-2002 at the fourth sowing date of the first year (Table 7).

The study found that the plants sown in the second-crop period did not have sufficient time for the growth of their aboveground and underground parts. The general progress of the plant was also negatively affected by this condition. It may be concluded that the photoperiod at this time may have caused a significant decrease in the number of soybean pods (Pang and Liu, 1986; Uslu and Esendal, 1998; Kumlar Medida et al., 2006).

3.4. Seed yield

In terms of seed yield, sowing date, cultivar, and S.DtxC were significant at the 1% level, while the YxS.Dt. and YxS.DtxC interactions were significant at the 5% level. The year and YxC interaction were statistically insignificant (Table 4).

When the cultivars were examined, the highest seed yield was determined as 3700 and 3694 kg ha^{-1} in A-3127 and Gapsoy-16, respectively. The lowest seed yield was determined in May-5312 (3006 kg ha^{-1}) and SA-88 (3048 kg ha^{-1}). Significant differences between cultivars were found between May-12 and SA-88 and other cultivars. In general, the seed yield decreased with the delay of the sowing date. The highest seed yield was determined at the first and second sowing dates (4072 and 3794 kg ha^{-1}, respectively), while the lowest value (2549 kg ha^{-1}) was determined at the fourth sowing date. When the cultivar x sowing date interaction was examined, the highest seed yield was determined in Cinsoy (4714 kg ha^{-1}) at the second sowing date. The lowest seed yield was found in the Nova (2085 kg ha^{-1}) at the fourth sowing date. According to the YxS.Dt. interaction, the highest seed yield was obtained from the first sowing date in both years, while the lowest seed yield was determined at the fourth sowing date in the first year. Considering the three-way interactions (YxS.DtxC), the highest seed yield (5082 kg ha^{-1}) was determined in the Cinsoy at the second sowing date of the first year, and the lowest seed yield (1904 kg ha^{-1}) was determined in Nova at the fourth sowing date of the first year (Table 8).

In terms of seed yield, there were generally noticeable decreases in soybean. Soybean plants are sown after mid-June and entered flowering and pod-filling periods in August. Due to the short days in this season, the plants were forced to complete their formation early. Therefore, soybean seed yields in the late sowing period were generally low (Ibrahim and Mahmoud, 1985; Joshi et al., 1986; Pfeiffer and Pilcher, 1987; Kumlar Medida et al., 2006; Hu and Wiatrak, 2012; Okcu, 2020; Jarecki and Bobrecka-Jamro, 2021). However, the response of different soybean cultivars to day length may differ (Whigham and Minor, 1987). In the second-crop soybean trial on different sowing dates and seed amounts, it was reported that the highest soybean yield was obtained from the soybean sowing carried out after harvesting the grains of the main product, wheat, at high humidity (Rod et al., 2021). It has also been reported that agricultural practices and genetic differences between cultivars affect yield (Gulluoglu et al., 2016; Ilker et al., 2018). Sufficient moisture in the soil provides earlier and uniform germination of seeds. This means that the plant

Table 7. The average number of pods per plant and statistical groups of soybean cultivars sown at different times (pod plant^{-1})*

Cultivar	Year x Sowing Date x Cultivar								Year x Cultivar		Cultivar x Sowing Date				Mean (Cultivar)
	2018				2019										
	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	2018	2019	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	
A-3127	112.1 f-q	103.6 i-q	78.1 n-q	65.3 pq	261.5 a-e	217.8 a-m	217.1 a-n	193.0 a-p	89.8 ı	222.3 a-d	186.8 a-j	160.7 b-j	147.6 d-k	129.2 e-k	156.1 C-F
Arısoy	169.6 b-q	168.9 b-q	159.0 b-q	96.4 k-q	250.2 a-f	228.2 a-l	169.1 b-q	116.2 f-q	148.5 e-ı	190.9 a-e	209.9 a-e	198.5 a-h	164.0 b-j	106.3 i-k	169.7 B-F
Ataem-7	173.0 b-q	208.2 a-o	173.1 b-q	180.3 a-q	244.0 a-g	214.3 a-o	215.0 a-o	138.8 c-q	183.6 b-g	203.0 a-e	208.5 a-f	211.3 a-e	194.0 a-i	159.6 b-j	193.3 AB
Blaze	133.9 d-q	124.6 e-q	177.0 a-q	166.4 b-q	261.9 a-e	276.1 abc	232.9 a-k	213.3 a-o	150.5 e-h	246.0 a	197.9 a-h	200.3 a-h	204.9 a-g	189.9 a-j	198.3 AB
Bravo	217.0 a-n	204.9 a-o	199.6 a-p	194.7 a-p	207.8 a-o	229.6 a-l	243.2 a-h	265.2 a-d	204.0 a-e	236.5 abc	212.4 a-e	217.3 a-e	221.4 a-d	230.0 a-d	220.2 A
Cinsoy	175.5 a-q	183.6 a-q	80.8 m-q	87.3 m-q	166.1 b-q	244.1 a-g	155.7 b-q	113.6 f-q	131.8 f-ı	169.9 d-h	170.8 b-j	213.9 a-e	118.3 f-k	100.5 jk	150.8 DEF
Gapsoy-16	149.4 b-q	205.9 a-o	180.7 a-q	174.5 a-q	175.7 a-q	274.6 abc	233.8 a-k	103.8 i-q	177.6 d-g	197.0 a-e	162.6 b-j	240.3 abc	207.2 a-f	139.1 d-k	187.3 A-D
Lider	236.5 a-j	177.5 a-q	176.4 a-q	165.0 b-q	183.8 a-q	196.0 a-p	130.1 d-q	167.0 b-q	188.9 a-f	169.2 d-h	210.1 a-e	186.7 a-j	153.3 c-j	166.0 b-j	179.0 B-E
May-5312	195.8 a-p	115.4 f-q	91.3 l-q	104.2 h-q	239.7 a-i	212.9 a-o	130.5 d-q	107.0 g-q	126.7 g-ı	172.5 d-h	217.8 a-e	164.1 b-j	110.9 h-k	105.6 i-k	149.6 EF
Nova	237.0 a-j	216.6 a-n	127.8 d-q	76.0 o-q	312.7 a	274.3 abc	227.3 a-l	154.4 b-q	164.3 d-h	242.2 ab	274.9 a	245.5 ab	177.6 b-j	115.2 g-k	203.3 AB
SA-88	237.9 a-j	239.3 a-i	134.4 d-q	106.0 g-q	218.8 a-m	219.0 a-m	205.5 a-o	182.0 a-q	179.4 c-g	206.3 a-e	228.3 a-d	229.2 a-d	170.0 b-j	144.0 d-k	192.9 ABC
Umut-2002	158.7 b-q	163.5 b-q	99.5 j-q	53.5 q	172.0 b-q	284.3 ab	129.2 d-q	65.7 pq	118.8 h-ı	162.8 e-h	165.4 b-j	223.9 a-d	114.4 g-k	59.6 k	140.8 F
	Year x Sowing Date								Year		Sowing Date				
Mean	183.0 BC	176.0 BC	139.8 CD	122.5 D	224.5 AB	239.3 A	190.8 ABC	15.7CD	155.3 B	201.6 A	203.8 A	207.6 A	165.3 B	137.1 B	

*: The difference between the means indicated by the same letter in the same column / in the same row / in the same group is not statistically significant

Table 8. Average seed yield values and statistical groups of soybean cultivars sown at different times (kg ha^{-1})*

Cultivar	Year x Sowing Date x Cultivar								Year x Cultivar		Cultivar x Sowing Date				Mean (Cultivar)
	2018				2019										
	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	2018	2019	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	
A-3127	3903 a-j	3852 a-j	2999 a-j	3921 a-j	4265 a-i	3933 a-j	3482 a-j	3246 a-j	3669	3732	4084 a-f	3892 a-j	3241 a-l	3584 a-l	3700 A
Arısoy	3696 a-j	4222 a-i	2456 c-j	2410 c-j	4339 a-f	4608 a-c	3516 a-j	2631 b-j	3196	3774	4017 a-g	4415 abc	2986 b-l	2521 g-l	3485 AB
Ataem-7	3865 a-j	3440 a-j	2696 b-j	2868 a-j	4005 a-j	3013 a-j	3053 a-j	2302 d-j	3217	3094	3935 a-i	3227 a-l	2875 d-l	2585 f-l	3155 AB
Blaze	3464 a-j	3220 a-j	3785 a-j	3020 a-j	3704 a-j	3574 a-j	3200 a-j	2566 c-j	3373	3261	3584 a-l	3397 a-l	3493 a-l	2793 e-l	3317 AB
Bravo	3796 a-j	4009 a-j	3528 a-j	2227 e-j	4295 a-h	3645 a-j	3809 a-j	3065 a-j	3390	3704	4046 a-f	3827 a-j	3669 a-k	2646 e-l	3547 AB
Cinsoy	4305 a-g	5082 a	2248 e-j	1985 ij	4303 a-g	4346 a-f	3102 a-j	2425 c-j	3405	3544	4304 a-d	4714 a	2675 e-l	2205 kl	3475 AB
Gapsoy-16	4244 a-i	4545 a-d	3333 a-j	2157 f-j	4873 ab	4361 a-f	3233 a-j	2802 a-j	3570	3817	4559 a	4453 ab	3283 a-l	2480 i-l	3694 A
Lider	3982 a-j	2778 b-j	2884 a-j	2690 b-j	4289 a-h	3336 a-j	2783 b-j	3175 a-j	3084	3396	4135 a-e	3057 b-l	2834 d-l	2932 c-l	3240 AB
May-5312	4033 a-j	3229 a-j	2106 f-j	2207 f-j	3735 a-j	3369 a-j	2693 b-j	2676 b-j	2894	3119	3884 a-j	3299 a-l	2399 j-l	2442 i-l	3006 B
Nova	4360 a-f	3853 a-j	2623 b-j	1904 j	4519 a-e	3646 a-j	2815 a-j	2266 d-j	3185	3312	4440 ab	3749 a-j	2719 e-l	2085 l	3248 AB
SA-88	3958 a-j	3544 a-j	2332 c-j	2019 g-j	4164 a-j	3476 a-j	2686 b-j	2202 f-j	2964	3132	4061 a-f	3510 a-l	2509 h-l	2111 l	3048 B
Umut-2002	3731 a-j	3860 a-j	2579 b-j	2007 h-j	3900 a-j	4111 a-j	3381 a-j	2413 c-j	3044	3451	3816 a-j	3986 a-h	2980 b-l	2210 kl	3248 AB
	Year x Sowing Date								Year		Sowing Date				
Mean	3945 A	3803 AB	2798 CD	2451D	4199 A	3785 AB	3146BC	2647CD	3249	3444	4072 A	3794 A	2972 B	2549 C	

*: The difference between the means indicated by the same letter in the same column / in the same row / in the same group is not statistically significant

gains extra time to complete its development. The reduced yield associated with delayed sowing can be attributed, in part, to the shorter seed-filling period.

3.5. Oil ratio

One of the factors that determine the quality of soybean seeds is their oil content. In terms of oil, cultivar, S.DtxC, and Yx S.DtxC were significant at the 1% level, while the sowing date, YxS.Dt., and YxC interactions were statistically significant at the 5% level. The year was statistically insignificant (Table 4).

The differences between the averages of the cultivars and sowing dates were significant. The highest oil ratio was determined in Arısoy (19.6%) and the lowest was in A-3127, Blaze, Bravo, May-5312, and Nova (17.7-18.0%). A significant difference between the cultivars in terms of oil content has emerged between A-3127, Blaze, Bravo, May-5312, and Nova with other cultivars. As the sowing date progressed, the oil content decreased. Accordingly, the highest oil ratio was obtained on the first and the lowest was on the fourth sowing date (Table 9).

When cultivar x sowing date interaction was evaluated, the highest oil content was obtained on the fourth sowing date in the Arısoy (21.5%), while the lowest value was 15.7% in the Nova at the second sowing date. For the year x cultivar interaction, the highest value was obtained in the Arısoy in both years (19.5 and 19.6%, respectively) and in 2019 in the SA-88 with 19.5%. On the other hand, the lowest values were in Blaze and May-5312 in 2018 with 17.2% oil ratios. In general, as the sowing date was delayed, even though oil content was reduced, the third sowing date in the first year and fourth sowing date in the second year had increased oil contents. This situation caused significant year x sowing date interaction. When three-way interaction was evaluated, the highest oil content (23.2%) was in the Nova on the first sowing date of the second year. On the other hand, the lowest oil content was also in the Nova on the second sowing date of 2019 (14.5%) (Table 9).

In this study, there were irregular changes in the oil content of the seeds according to the sowing dates. Other studies, however, suggest that sowing dates do not affect oil content (El Toum et al., 2020; Jarecki and Bobrecka-Jamro, 2021). Some studies have shown that oil content decreases as the sowing period is delayed (Robinson et al., 2009; Umburanas et al., 2018). According to some studies, higher air temperature during seed filling is a significant cause of a low oil content in mature seeds of the delayed sowing date (Rotundo and Westgate, 2009; Li et al., 2014). The oil content of soybean seeds is thought to be determined by the sowing dates as well as the cultivars.

3.6. Oil yield

For oil yield, year, sowing date, cultivar, and S.Dt.xC variations were significant at 1%, while YxS.Dt., YxC, and YxS.Dt.xC variations were significant at 5% (Table 4).

The average values for the oil yield of soybean cultivars are presented in Table 10. Arısoy (676 kg ha^{-1}), Gapsoy-16 (676 kg ha^{-1}), Cinsoy (662 kg ha^{-1}), and A-3127 (662 kg ha^{-1}) created statistically the highest group in terms of average yield among cultivars, while May-5312 had the lowest value (538 kg ha^{-1}) on oil yield. Similar to many other parameters, as the sowing date was delayed, oil yield was reduced. For the cultivar x sowing date interactions, the highest oil yield was obtained in the Nova (943 kg ha^{-1}) and the lowest yield was also obtained in the same cultivar with 347 kg ha^{-1}. When year x cultivar interaction was analyzed, the second year's Arısoy and SA-88 cultivars and the first year's Arısoy had the highest average oil content. On the other hand, the lowest values were obtained on May-5312 and Blaze in the first year. In general, similar to previous observations, as the sowing date was delayed, oil yield was reduced, and the first sowing of the second year had higher oil yield compared to same sowing of the first year, which may be the cause of the significant interaction. The highest oil yield, determined by the interaction of year, sowing date, and cultivar, was 1046 kg ha^{-1} in Nova on the first sowing date of 2019, while the lowest was 321 kg ha^{-1} in Cinsoy on the fourth sowing date of 2018 (Table 10).

The average oil yield values show a considerable decline in second-crop soybean. The short vegetative stage and forcing of the plant to the generative period resulted in a significant decrease in yield in soybean sown as a second crop (Joshi et al., 1986; Pfeiffer and Pilcher, 1987; Hu and Wiatrak, 2012). Low seed yield in late sowing resulted in low oil yield since oil yield is computed by multiplying the seed yield by the oil rate. Low precipitation and excessive evaporation during the generative stage have been identified as major determinants with a negative effect on late-season plant production (Uslu and Esendal, 1998). In one study, the standard sowing date yielded more seeds and oil than the late sowing date (Mandić et al., 2020). In early sowing, the plant can find sufficient time for seed filling and suitable environmental conditions (such as temperature and sun exposure). Therefore, the desired overall yield was high since both the seed weight and the amount of oil content was high.

Table 9. Average oil content values and statistical groups of soybean cultivars sown at different times (%)*

Cultivar	Year x Sowing Date x Cultivar								Year x Cultivar		Cultivar x Sowing Date				Mean (Cultivar)
	2018				2019										
	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	2018	2019	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	
A-3127	16.6 d-i	17.1c-i	19.1a-i	17.4c-i	17.1 c-i	18.5 a-i	17.5 c-i	19.8 a-h	17.6 ab	18.2 ab	16.9 e-g	17.8 c-g	18.3 a-g	18.6 a-g	17.9 B
Arısoy	18.7 a-i	18.0c-i	20.0a-h	21.5a-e	19.8 a-h	20.0 a-h	17.0 c-i	21.5 a-d	19.5 a	19.6 a	19.3 a-f	19.0 a-f	18.5 a-g	21.5 a	19.6 A
Ataem-7	17.4 c-i	20.9a-f	16.8d-i	17.2c-i	19.3 a-i	19.8 a-h	17.5 c-i	19.4 a-i	18.1 ab	19.0 ab	18.3 a-g	20.4 a-d	17.2 d-g	18.3 a-g	18.5 AB
Blaze	17.7 c-i	16.5e-i	16.6d-i	17.9c-i	18.6 a-i	19.6 a-h	17.4 c-i	17.5 c-i	17.2 b	18.3 ab	18.2 b-g	18.1 b-g	17.0 e-g	17.7 d-g	17.7 B
Bravo	17.9 c-i	18.1c-i	18.6a-i	16.2f-i	17.7 c-i	19.4 a-h	15.9 g-i	18.5 a-i	17.7 ab	17.9 ab	17.8 c-g	18.8 a-g	17.3 d-g	17.3 d-g	17.8 B
Cinsoy	21.8 abc	19.8a-h	17.3c-i	16.2f-i	20.2 a-h	18.0 c-i	17.2 c-i	19.4 a-i	18.8 ab	18.7 ab	21.0 a-c	18.9 a-g	17.3 d-g	17.8 c-g	18.8 AB
Gapsoy-16	16.0 f-i	17.3c-i	20.3a-h	19.5a-h	19.9 a-h	18.2 b-i	17.6 c-i	18.3 a-i	18.3 ab	18.5 ab	17.9 c-g	17.8 d-g	18.9 a-f	18.9 a-f	18.4 AB
Lider	18.4 a-i	17.7c-i	19.2a-i	18.5a-i	18.7 a-i	18.0 c-i	18.5 a-i	18.6 a-i	18.5 ab	18.4 ab	18.6 a-g	17.8 c-g	18.8 a-g	18.5 a-f	18.4 AB
May-5312	18.4 a-i	15.5hi	17.7c-i	17.1c-i	18.9 a-i	18.2 b-i	16.6 d-i	19.5 a-h	17.2 b	18.3 ab	18.7 a-g	16.9 e-g	17.2 d-g	18.3 a-g	17.8 B
Nova	19.2 a-i	16.9c-i	19.4a-i	17.0c-i	23.2 a	14.5 i	17.6 c-i	16.3 f-i	18.1 ab	17.9 ab	21.2 ab	15.7 g	18.5 a-g	16.7 fg	18.0 B
SA-88	17.8 c-i	17.1c-i	17.8c-i	18.5a-i	20.0 a-h	23.1 ab	16.9 c-i	17.9 c-i	17.8 ab	19.5 a	18.9 a-f	20.1 a-e	17.3 d-g	18.2 b-g	18.6 AB
Umut-2002	20.5 a-g	18.3a-i	17.8c-i	19.2a-i	19.6 a-h	18.9 a-i	18.2 b-i	18.7 a-i	19.0 ab	18.9 ab	20.1 a-e	18.6 a-g	18.0 b-g	18.9 a-f	18.9 AB
	Year x Sowing Date								Year		Sowing Date				
Mean	18.4AB	17.8B	18.4AB	18.0AB	19.4A	18.9AB	17.3B	18.8AB	18.1	18.6	18.9A	18.4 AB	18.3AB	17.9B	

*: The difference between the means indicated by the same letter in the same column / in the same row / in the same group is not statistically significant

Table 10. Average oil yield values and statistical groupings of soybean cultivars sown at different times (kg ha^{-1})*

Cultivar	Year x Sowing Date x Cultivar								Year x Cultivar		Cultivar x Sowing Date				Mean (Cultivar)
	2018				2019										
	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	2018	2019	S.Dt-1	S.Dt-2	S.Dt-3	S.Dt-4	
A-3127	651a-k	661a-k	575b-k	679a-k	741a-k	726a-k	612a-k	649a-k	642 ab	682 ab	696 a-l	693 a-m	594 c-o	664 a-n	662 A
Arısoy	690a-k	751a-k	491d-k	519c-k	860a-f	923a-e	605a-k	566b-k	612 a	738 a	775 a-f	837 a-d	548 d-o	543 d-o	676 A
Ataem-7	658a-k	711a-k	452f-k	492d-k	767a-k	599a-k	527b-k	443f-k	578 ab	584 ab	713 a-l	655 a-n	489 f-o	468 g-o	581 AB
Blaze	618a-k	534b-k	624a-k	538b-k	690a-k	704a-k	559b-k	452f-k	579 b	601 ab	654 a-m	619 b-o	592 c-o	495 f-o	590 AB
Bravo	670a-k	737a-k	659a-k	361i-k	759a-k	704a-k	608a-k	568b-k	607 ab	660 ab	715 a-k	720 a-j	634 b-o	465 h-o	633 AB
Cinsoy	941a-d	981ab	391g-k	321k	869a-f	784a-j	537b-k	470e-k	658 ab	665 ab	905 ab	883 abc	464 i-o	396 m-o	662 A
Gapsoy-16	679a-k	781a-j	675a-k	425f-k	970a-c	794a-i	568b-k	513c-k	640 ab	712 ab	825 a-e	787 a-f	622 b-o	469 m-o	676 A
Lider	733a-k	495d-k	553b-k	498d-k	800a-i	599a-k	516c-k	590a-k	570 ab	626 ab	767 a-g	547 d-o	534 e-o	544 d-o	598 AB
May-5312	748a-k	501d-k	378h-k	378h-k	707a-k	620a-k	448f-k	523b-k	501 b	574 ab	727 a-j	561 d-o	413 l-o	451 i-o	538 B
Nova	841a-g	653a-k	502d-k	325jk	1046a	530b-k	493d-k	370i-k	580 ab	610 ab	943 a	591 c-o	497 f-o	347 o	595 AB
SA-88	716a-k	606a-k	413f-k	374h-k	833a-h	810a-i	451f-k	395g-k	527 ab	622 a	774 a-f	708 a-l	432 j-o	385 no	575 AB
Umut-2002	766a-k	706a-k	458f-k	386g-k	764a-k	778a-k	617a-k	451f-k	579 ab	653 ab	765 a-h	742 a-i	538 d-o	419 k-o	616 AB
	Year x Sowing Date								Year		Sowing Date				
Mean	726AB	676B	514C	441C	817A	714AB	545C	499C	589B	644A	772A	695B	530C	470C	

*: The difference between the means indicated by the same letter in the same column / in the same row / in the same group is not statistically significant

4. Conclusions

The growth stages and yield (particularly sowing after mid-June) of soybean sown on different dates were affected at different rates due to factors such as the change in the number of sunny days and photoperiod, air temperature, precipitation amount, and distribution. It has been shown in this research and previous studies that soybean cultivated as a second crop results in significant decreases in yield compared to the main crop soybean. However, given the advantages of this and similar regions where two crops can be harvested per year, sowing soybean as a second crop is more efficient and profitable. It is recommended that soybeans are sown as a second crop as soon as possible after the main cereal crop (for example, wheat). Sowing should be done on annealed soil and, if necessary, irrigation should be done immediately after sowing for early germination. More crucially, it is considered that sowing soybeans rather than corn, which is sown as a second crop after wheat, may help to meet food and oil needs while conserving the world's natural resources (such as soil and water). For this region and in areas with similar agricultural environments where double-crop can be grown each year, early cultivars for a second crop may be recommended to reduce the vegetable food and oil deficit. More research is needed on early cultivars developed especially for second-crop production.

Funding

This research received no external funding.

Acknowledgments

Prof. Dr. Sibel DERVİŞ was incredibly kind with her support throughout the article's writing.

Declaration of Conflicts of Interest

No conflict of interest has been declared by the author.

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CITATION: İzgi, M.N., 2023. Field Performance of Some Soybean [*Glycine max* (L.) Merr.] Cultivars Sown on Different Dates. *Turkish Journal of Agricultural Research*, 10(1): 27-37.