Türkiye Tarımsal Araştırmalar Dergisi
dergipark.org.tr/tutad
Research Article
Turk J Agric Res
2023, 10(1): 109-120
© TÜTAD
ISSN: 2148-2306
e-ISSN: 2528-858X
doi: 10.19159/tutad.1253570

Agronomic Characteristics and Yield Values of Sesame (*Sesamum indicum* L.) Cultivars at Various Sowing Dates

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Received: 20.02.2023 **Accepted:** 28.03.2023

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Abstract: In this study, ten different sesame (*Sesamum indicum* L.) cultivars registered in Türkiye were investigated for their sowing dates as a second crop in the lowlands of Mardin province, in 2018 and 2019. In this study, ten different sesame cultivars were used; these were Arslanbey, Boydak, Cumhuriyet-99, Hatipoğlu, Muganlı-57, Orhangazi-99, Osmanlı-99, Sarısu, Tan-99, and Tanas. Four different sowing dates (June 5, June 15, June 25, and July 4) were examined for these cultivars. In this study, agricultural parameters such as plant height, number of lateral branches, number of capsules, seed yield, oil ratio, and oil yield of the sesame cultivars were investigated. Different sowing dates were found to have a significant effect on the sesame cultivars. The second sowing date resulted in the highest plant height, number of branches, number of capsules, seed yield, oil content, and oil yield (June 15). In terms of cultivars, the Boydak and Sarısu had the highest seed yield (2184 and 2149 kg ha^{-1}, respectively), the Osmanlı-99 (54.6%) had the highest oil ratio, and the Sarısu and Boydak had the highest oil yield (1075 and 1062 kg ha^{-1}, respectively). The Boydak and Sarısu cultivars are promising for high seed and oil yields in the second crop sowing, and a sowing date of June 15 is advised.

Keywords: Cultivar, oil ratio, oil yield, seed yield, *Sesamum indicum*, sowing date

1. Introduction

In the Pedaliaceae family, there are 16 genera and 60 species, including 37 species in the genus Sesamum. There is only one cultivable species in this genus, *Sesamum indicum* L. (2n= 26) (Kobayashi, 1981). In addition to having a large quantity and quality of oil (50-60% oil and 25% protein), sesame (*Sesamum indicum* L.) is one of the world's oldest and most important oil plants (Yermanos, 1978). Additionally, it provides nutritional sustenance for humans as well as edible oil. Unlike other vegetable oils, sesame oil contains polyunsaturated fatty acids, oleic and linoleic acids with ratios between 35 and 45% (Lyon, 1972; Liu et al., 1992). Sesame oil is also exceptionally oxidation resistant due to secondary components such as sesamin and sesamolin (Fukuda et al., 1986; Tashiro et al., 1990; Salunkhe et al., 1991). Sesame has a substantial amount of oil, proteins, carbs, important minerals, a lot of methionine and tryptophan, fibers, and secondary metabolites such as lignans, saponins, flavonoids, and phenolic compounds. Furthermore, the seeds are high in phosphorus, calcium, and iron, as well as vitamins B and E and trace minerals.

Sesame seeds are used in a variety of food goods, both raw and roasted, as well as industrial applications such as soaps, lubricants, lamp oil, cosmetics, pharmaceuticals, and animal feed (Bedigian, 2010). Sesame seed consumption in the world was USD 6559.0 million in 2018, and it is expected to reach USD 7244.9 million by 2024, with a CAGR (Compound Annual Growth Rate) of 1.7% (Myint et al., 2020). Worldwide sesame usage is constantly increasing, owing primarily to shifting consumer consumption habits and increased health consciousness. Nowadays, people demand items with high nutritional value. As a result, the demand for sesame seeds has increased due to their nutritious properties, which include vitamins, minerals, fiber, and healthy fat. Approximately 70% of the world's sesame seed is used to make oil and meal. Total yearly oil and food consumptions are approximately 65% and 35%, respectively (Morris, 2002). On a surface of about 10.6 million acres worldwide, 5.5 million tons of sesame was produced in 2014. Sudan (24.0%), India (18.9%), and Myanmar (10.2%) have the most sesame farming areas, respectively. Türkiye, on the other hand, accounts for barely 0.2% of the global sesame cultivation area. India (14.8%), Sudan (13.2%), and China (11.2%) account for a sizable proportion of global sesame production. China has the highest average sesame yield (1223 kg ha^{-1}), followed by Nigeria (729 kg ha^{-1}) and Tanzania (720 kg ha^{-1}) (Anonymous, 2021). There is no definitive date for the start of sesame farming in Türkiye, and the first official records were discovered in 1850. The Republican period saw significant advancements in sesame growth (Arıoğlu, 2014).

Because of its short growing season, the sesame plant is used in both main-crop agriculture and second-crop agriculture, and it may be included in crop rotation with practically any cultivated plant. This increases the appeal of growing sesame. It has recently been grown as a second crop after cereals in the Aegean, Mediterranean, and Southeastern Anatolia regions of Türkiye (Arıoğlu, 2014). Simultaneously, sesame is an essential plant due to its lack of soil selectivity, low nutrient requirement, drought tolerance, and lack of marketing concerns (Yol, 2011).

There is a need for sowing experiments in various locations of sesame cultivars with a wide adaptation area, that is, varieties with high seed and oil yields that are suited for cultivation in various regions. Furthermore, growing sesame plants in different places is useful to contribute to bridging the food deficiency in Türkiye and around the world. Because the same plants have been planted consistently in the plain conditions of Mardin Province for many years, impoverishment and barrenness occur in the soil content day by day. Instead, different plants, such as sesame, might be planted. Additionally, two crops each year are possible in these lowland conditions.

In this study, ten distinct sesame (*S. indicum* L.) cultivars registered in Türkiye were investigated for their sowing dates as a second crop in the lowlands of Mardin province.

2. Materials and Methods

2.1. Experimental area and climate-soil conditions

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

During the summer, the lowlands of Mardin province are hot and dry, while during the winter they are humid and warm. Summer precipitation is significantly less than winter precipitation, and August is typically dry. Comparing data from the years of field trials and long years, the second year showed an increase in April and May values but similar temperatures and humidity levels (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 material

Ten different sesame (*S. indicum* L.) cultivars (Arslanbey, Boydak, Cumhuriyet-99, Hatipoğlu, Muganlı-57, Orhangazi-99, Osmanlı-99, Sarısu, Tan-99, and Tanas) were utilized as genetic material in this experiment. The plant material was obtained from the GAP Agricultural Research Institute and Aegean Agricultural Research Institute.

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

2.3. Experimental design and agricultural processes

The field trial design was split plots in the randomized complete blocks design with three replications. Sesame cultivars were sown as a second crop on four separate dates following the harvest of wheat, which was sown as the main crop. Using the sowing dates on the main plots and the sesame cultivars on the subplots, an experimental design was created. In both years of the experiment, the sowing dates were June 5, June 15, June 25, and July 4.

Trial plots were set up with three replications, each 3 m long, 65 cm row spacing, 15 cm in-row spacing, and a total of four rows. There was a 2 m space between the plots and a 3 m space between the blocks. Seeds were sown at a depth of 3-4 cm on average. In fertilization, 100 kg ha^{-1} of nitrogen and 100 kg ha^{-1} of phosphorus were employed as pure ingredients. The ground was irrigated with a sprinkler irrigation system prior to seeding. The soil was tilled on the third day, and the seeds were sown straight away. Following sowing, the seed beds were compressed using a roller. For each sowing date plot, a separate irrigation system has been set up. Crops were irrigated three times because precipitation was quite low in July, August, and September. Irrigation occurred three times: during the seedling stage, at the start of flowering, and in the midst of flowering. Weeding was done by hand and hoe. After the extra seedlings in the rows were purged and discarded, the soil was used to support the two sides of the remaining plants. The plants were collected and dried under the sun before the plant capsules opened and the lower leaves of the plant began to turn yellow and fall off. Plant height, number of lateral branches, number of capsules, seed yield, oil ratio, and oil yield values were evaluated in this study.

2.4. Statistical analyzes

The data obtained from the study were analyzed with the JMP package software according to the split plots in randomized complete 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

The difference between years (Y) in terms of plant height was statistically insignificant. Sowing date (S.Dt.), cultivar (C), factors, and S.Dt.xC and YxS.Dt.xC interactions were significant at the 1% level. Sesame plant height was significant at 5% in terms of YxS.Dt. and YxC interactions (Table 3).

Plant height values of sesame cultivars at different sowing dates are presented in Table 4. The highest plant height was determined in the Cumhuriyet-99 (145.9 cm), and the lowest plant height was determined in the Tanas (121.4 cm). When the sowing dates were examined, the highest plant height value was found at the second and third sowing dates at 138.3 cm and 137.0 cm, respectively, and the lowest value was determined at the fourth sowing date at 127.2 cm. Plant height

Table 3. Variance analysis results of some agronomic and yield-related values calculated as a result of different sowing dates of sesame cultivars

Variation sources	F value					
	Plant height	Number of lateral branches	Number of capsules	Seed yield	Oil ratio	Oil yield
Year (Y)	2.48^{ns}	1.12^{ns}	0.32^{ns}	29.79**	10.55**	11.42**
Error 1						
Sowing date (S.Dt.)	8.72**	16.86**	48.53**	6.60**	8.69**	5.08*
YxS.Dt.	4.72*	4.00*	19.57**	0.18**	1.97*	0.59*
Error 2						
Cultivar (C)	8.19**	24.02**	46.71**	28.04**	19.03**	18.62**
YxC	1.56*	1.23**	6.15**	2.51*	4.45**	1.47**
S.Dt.xC	4.56**	1.83*	7.18**	3.28**	2.65**	3.94**
Yx S.Dt.xC	1.25**	0.47**	1.33**	1.45**	3.06**	2.08**
Error 3						
CV (%)	9.33	18.67	14.85	9.55	4.53	10.34

CV: Coefficient of variation, *: Statistically significant at 5% (p<0.05), **: Statistically significant at 1% (p<0.01), ns: Not significant

Table 4. Average plant height values obtained as a result of the cultivation of sesame cultivars on four different dates (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	
Arslanbey	128.5b-g	164.4abc	142.1a-g	140.0a-g	129.6a-g	130.7a-g	134.0a-g	133.1a-g	143.8ab	131.9a-d	129.0 b-i	147.6 a-g	138.1 a-i	136.6 a-i	137.8 AB
Boydak	133.3a-g	161.5a-d	122.8c-g	119.2d-g	134.4a-g	136.8a-g	112.7fg	115.3fg	134.2a-d	124.8cd	133.9 a-i	149.1 a-f	117.7 hi	117.3 hi	129.5 BCD
Cumhuriyet-99	138.9a-g	155.6a-f	159.4a-e	137.8a-g	145.7a-g	139.5a-g	146.0a-g	144.3a-g	147.9a	143.9ab	142.3 a-h	147.6 a-g	152.7 abc	141.0 a-i	145.9 A
Hatipoğlu	151.7a-f	172.7a	119.1d-g	117.7d-g	138.7a-g	152.3a-f	129.3a-g	127.4b-g	140.3abc	136.9a-d	145.2 a-h	162.5 a	124.2 c-i	122.6 e-i	138.6 AB
Muganlı-57	116.1e-g	131.4a-g	170.2ab	141.0a-g	123.0c-g	134.4a-g	131.3a-g	126.9b-g	139.7abc	128.9b-d	119.5 g-i	132.9 b-i	150.8 a-e	134.0 a-i	134.3 BC
Orhangazi-99	121.9c-g	114.2fg	164.3abc	114.9fg	121.8c-g	122.4c-g	145.2a-g	133.4a-g	128.8b-d	130.7a-d	121.9 f-i	118.3 hi	154.7 ab	124.2 c-i	129.8 BCD
Osmanlı-99	150.1a-g	144.3a-g	135.3a-g	118.2d-g	152.7a-f	146.7a-g	141.9a-g	133.5a-g	137.0a-d	143.7ab	151.4 a-d	145.5 a-h	138.6 a-i	125.9 c-i	140.4 AB
Sarısu	134.4a-g	128.0b-g	143.0a-g	130.0a-g	140.3a-g	129.3a-g	139.0a-g	137.2a-g	133.8a-d	136.5a-d	137.4 a-i	128.6 b-i	141.0 a-i	133.6 b-i	135.1 ABC
Tan-99	116.9e-g	133.8a-g	134.5a-g	120.7c-g	129.9a-g	120.0d-g	127.2b-g	125.5c-g	126.5b-d	125.6b-d	123.4 d-i	126.9 b-i	130.8 b-i	123.1 d-i	126.1 CD
Tanas	128.3b-g	124.2c-g	121.8c-g	106.2g	124.6c-g	123.8c-g	121.4c-g	120.9c-g	120.1d	122.7cd	126.5 d-i	124.0 d-i	121.6 f-i	113.6 i	121.4 D
	Year x Sowing Date								Year		Sowing Date				
Mean	132.0ABC	143.0A	141.3AB	124.6C	134.1ABC	133.6ABC	132.8ABC	129.7BC	135.2	132.6	133.0AB	138.3A	137.0A	127.2B	

*: 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

was affected by sowing dates, and late sowings resulted in a significant reduction (Table 4).

In terms of sowing date x cultivar interaction, the highest plant height value was determined in the Hatipoğlu at the second sowing date with 162.5 cm, and the lowest value was determined in the Tanas at the fourth sowing date with 113.6 cm. In terms of year x cultivar interaction, the highest average was in the Cumhuriyet-99 cv. (147.9 cm) in the first year and the lowest in the Tanas cv. (120.1 cm) in the first year. When the year x sowing date interaction is examined, the highest value was obtained at the second sowing date of the first year (143.0 cm), and the lowest value was at the fourth sowing date of the first year (124.6 cm). Considering the three-way interaction, the highest plant height value was obtained in the Hatipoğlu (172.7 cm) at the second sowing date of the first year, and the lowest value was obtained in the Tanas (106.2 cm) at the fourth sowing date of the first year (Table 4).

According to Öz and Karasu (2010), the highest and lowest plant heights were found in the Orhangazi 99 and Cumhuriyet 99 cultivars, respectively (Öz and Karasu, 2010). According to Arslan et al. (2014), the highest and lowest values in cultivar and lines evaluated in Harran Plain were in Bozova 5 and Siverek 2 cultivars, respectively Differences in plant height can be attributed to genetic differences, as well as different agricultural practices.

3.2. Number of lateral branches

The number of lateral branches of the sesame plants was significant at 5% in terms of YxS.Dt. and S.Dt.xC interactions. Additionally, S.Dt., cultivar factors, YxC, and YxS.Dt.xC interactions were significant at 1%. The year factor was statistically insignificant (Table 3).

The number of lateral branches of sesame cultivars at different sowing dates are presented in Table 5. The highest number of lateral branches was determined in the Tan-99 (4.9 number plant^{-1}), and the lowest value was determined in the Osmanlı-99 (2.5 number plant^{-1}). When the sowing dates were examined, the highest number of lateral branch values was found at the second and third sowing dates with 4.4 and 4.1 number plant^{-1}, respectively, and the lowest value was determined at the first and fourth sowing dates with 3.5 and 3.4 number plant^{-1}, respectively (Table 5).

In terms of sowing date x cultivar interaction, the highest average number of lateral branches was in the Tan-99 in the third sowing date (5.3 per plant), and the lowest was the Boydak in the first sowing date (2.1 per plant). In terms of year x cultivar interaction, the highest average was in the Cumhuriyet-99 and Tan-99 in both years and the lowest in the Osmanlı-99 in both years. When the year x sowing date interaction is examined, the highest number of lateral branches with 4.6 per plant was determined at the second sowing date of the first year, and the lowest value was determined at the fourth sowing date of the first year. Considering the three-way interaction, the highest number of lateral branch values was obtained in the Tan-99 (5.6 per plant) at the third sowing date of the first year, and the lowest value was obtained in the Boydak (1.9 per plant) at the first sowing date of the first year (Table 5).

According to Arslan et al. (2014), the highest value was in Bozova 5, and the lowest value was in Line 2. Karaaslan et al. (1999) determined that the number of branches ranged between 2.11 to 3.95 per plant, whereas Öz and Karasu (2010) determined that the number of branches ranged between 4.2 to 5.3 per plant.

3.3. Number of capsules

Sowing date and cultivar factors, and YxC, YxS.Dt., S.Dt.xC, and YxS.Dt.xC interactions were significantly effective at 1% level for the number of capsules per plant. The year factor was statistically insignificant (Table 3).

According to the results of the research, when the averages of the cultivars were examined, the highest number of capsules was found in the Tan-99 with 104.4 per plant, and the lowest value was found in the Osmanlı-99 with 54.1 per plant. When the averages of sowing dates were examined, the lowest values were determined on the first and second sowing dates, while the highest value was obtained on the third sowing date (Table 6).

The highest number of capsules was 133.1 per plant (Tan-99 and third sowing date) and the lowest was 48.2 per plant (Osmanlı-99 and fourth sowing date) in terms of sowing date x cultivar interaction. In terms of the year x cultivar interaction, the Tan-99 had the highest average in the first year (110.2 capsule plant^{-1}), and the Osmanlı-99 had the lowest average in the first year (50.4 capsule). When the year x sowing date interaction is examined, the highest number of capsules with 79.7 and 76.2 per plant was determined at the third and fourth sowing date of the first year, and the lowest value was determined at the first sowing date in the first year (61.1 per plant). Considering the three-way interaction, the highest number of capsule values was obtained in the Tan-99 (139.2 per plant) at the third sowing date of the first year, and the lowest value was obtained in Osmanlı-99 (42.8 per plant) at the fourth sowing date of the first year (Table 6).

Table 5. Average number of lateral branch values obtained as a result of the cultivation of sesame cultivars on four different dates (number 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	
Arslanbey	2.7d-k	4.5a-j	3.4a-k	2.1jk	3.6a-k	4.6a-j	3.9a-k	3.6a-k	3.2d-f	3.9a-e	3.1c-k	4.5a-e	3.7a-k	2.9f-k	3.5 CD
Boydak	1.9k	5.2abc	4.1a-k	2.5e-k	2.3i-k	4.4a-k	3.5a-k	3.5a-k	3.4b-f	3.4b-f	2.1k	4.8ab	3.8a-j	3.0e-k	3.4 CD
Cumhuriyet-99	4.6a-j	5.4ab	4.9a-g	3.7a-k	4.5a-j	4.8a-i	4.7a-i	4.3a-k	4.7a	4.6a	4.5a-e	5.1ab	4.8ab	4.0a-j	4.6 AB
Hatipoğlu	2.8c-k	4.3a-k	2.9c-k	2.3i-k	3.5a-k	4.1a-k	3.4a-k	2.5f-k	3.1ef	3.4c-f	3.2c-k	4.2a-h	3.2c-k	2.4jk	3.2 D
Muganlı-57	2.9b-k	4.0a-k	3.9a-k	2.4h-k	3.2a-k	3.7a-k	4.4a-k	4.6a-j	3.3d-f	4.0a-e	3.1d-k	3.8a-j	4.1a-h	3.5b-k	3.6 CD
Orhangazi-99	3.8a-k	4.4a-k	4.6a-j	3.5a-k	4.1a-k	3.8a-k	4.4a-k	3.7a-k	4.1a-e	4.0a-e	4.0a-j	4.1a-i	4.5a-f	3.6b-k	4.0 BC
Osmanlı-99	2.5f-k	2.6e-k	2.4g-k	2.3i-k	2.7d-k	2.4h-k	2.8c-k	2.5e-k	2.5f	2.6f	2.6h-k	2.5i-k	2.6g-k	2.4jk	2.5 E
Sarısu	4.3a-k	5.2abc	5.0a-e	3.3a-k	4.1a-k	4.9a-g	4.5a-j	4.0a-k	4.5ab	4.4abc	4.2a-h	5.1ab	4.7abc	3.7a-k	4.4 AB
Tan-99	4.7a-i	5.3abc	5.6a	4.3a-k	4.6a-j	4.9a-h	5.0a-f	5.1a-d	5.0a	4.9a	4.7a-d	5.1ab	5.3a	4.7abc	4.9 A
Tanas	3.5a-k	5.1a-d	4.3a-k	3.7a-k	3.9a-k	4.6a-j	4.1a-k	3.6a-k	4.2a-d	4.0a-e	3.7a-k	4.9ab	4.2a-g	3.6b-k	4.1 ABC
	Year x Sowing Date								Year		Sowing Date				
Mean	3.4BC	4.6A	4.1AB	3.0C	3.6BC	4.2AB	4.1AB	3.7BC	3.8	3.9	3.5B	4.4A	4.1A	3.4B	

*: 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 number of capsules per plant obtained as a result of the cultivation of sesame cultivars on four different dates (capsule 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	
Arslanbey	59.7i-n	63.3h-n	130.5ab	104.6a-e	61.8i-n	57.4j-n	87.3d-l	65.1h-n	89.5bc	67.9d-g	60.8h-l	60.4i-l	108.9b	84.8b-h	78.7 B
Boydak	54.9j-n	74.3e-n	62.8h-n	60.0i-n	53.9k-n	72.0e-n	68.9e-n	65.1h-n	63.0f-h	65.0e-h	54.4j-l	73.2e-k	65.8f-l	62.5g-l	64.0 C
Cumhuriyet-99	56.0j-n	62.0i-n	90.0c-k	74.0e-n	91.4c-j	67.2f-n	87.5d-l	82.3d-m	70.5d-f	82.1cd	73.7e-k	64.6f-l	88.8b-f	78.2d-j	76.3 B
Hatipoğlu	60.6i-n	49.1mn	48.7mn	51.1l-n	75.7e-n	64.6h-n	55.7j-n	54.9j-n	52.4gh	62.7f-h	68.2f-l	56.9j-l	52.2kl	53.0kl	57.6 CD
Muganlı-57	64.9h-n	54.8j-n	62.3i-n	66.1g-n	75.8e-n	65.1h-n	66.9f-n	67.5e-n	62.0f-h	68.8d-f	70.4f-l	60.0i-l	64.6g-l	66.8f-l	65.4 C
Orhangazi-99	59.5i-n	67.8e-n	70.3e-n	77.5e-n	57.6j-n	56.2j-n	62.6h-n	64.1h-n	68.8d-f	60.1f-h	58.6i-l	62.0h-l	66.5f-l	70.8f-l	64.5 C
Osmanlı-99	55.4j-n	56.7j-n	46.5mn	42.8n	61.7i-n	60.8i-n	55.0j-n	53.5k-n	50.4h	57.8f-h	58.6i-l	58.7i-l	50.8k-l	48.2l	54.1 D
Sarısu	57.1j-n	78.0e-n	90.6c-k	99.5b-h	73.9e-n	69.3e-n	82.2d-m	95.0b-i	81.3cd	80.1c-e	65.5f-l	73.6e-k	86.4b-g	97.3b-e	80.7 B
Tan-99	83.1d-m	102.4a-g	139.2a	116.2a-d	81.8d-n	103.5a-f	127.0abc	82.0d-m	110.2a	98.6ab	82.5c-i	102.9bc	133.1a	99.1b-d	104.4 A
Tanas	59.3i-n	67.8e-n	55.7j-n	69.9e-n	65.8g-n	62.6h-n	60.9i-n	66.0g-n	63.2f-h	63.8f-h	62.6g-l	65.2f-l	58.3i-l	68.0f-l	63.5 CD
	Year x Sowing Date								Year		Sowing Date				
Mean	61.1D	67.6C	79.7A	76.2A	69.9C	67.9C	75.4AB	69.6C	71.1	70.7	65.5C	67.7C	77.5A	72.9B	

*: 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

The number of capsules in the plant varies depending on the cultivar, according to various studies. Both this study and previous studies have demonstrated that the change in environmental factors affects the number of capsules in the plant (Gür et al., 1998; Bilmez, 2015; Bakal and Arıoğlu, 2020).

3.4. Seed yield

The effect of year, cultivar, S.Dt, YxS.Dt, S.DtxC, and YxS.DtxC were significant at 1% on the seed yield. While YxC interaction was significant at the 5% level (Table 3).

When the average seed yield values of sesame cultivars were examined, the highest seed yield was determined in the Boydak (2184 kg ha^{-1}) and Sarısu (2149 kg ha^{-1}) cultivars. The lowest seed yield was determined in the Osmanlı-99 with 1531 kg ha^{-1}. In the study, in terms of sowing dates, the highest seed yield was obtained on the second sowing date (2002 kg ha^{-1}), while the lowest values were determined on the first and fourth sowing dates (1907 and 1870 kg ha^{-1}, respectively). In terms of the year x cultivar interaction, the Tan-99 had the highest average (2231 kg ha^{-1}) in the second year and the Osmanlı-99 had the lowest average (1473 kg ha^{-1}) in the first year. The highest seed yield was 2287 kg ha^{-1} (Boydak and third sowing date) and the lowest was 1399 kg ha^{-1} (Osmanlı-99 and fourth sowing date) in terms of sowing date x cultivar interaction. When the year x sowing date interaction was examined, the highest seed yield with 2054 kg ha^{-1} was determined at the second sowing date of the second year, and the lowest value was determined at the first and third sowing dates in the first year (1853 and 1806 kg ha^{-1}, respectively). Considering the three-way interaction, the highest seed yield value was obtained in the Sarısu (2310 kg ha^{-1}) at the third sowing date of the second year, and the lowest value was obtained in the Osmanlı-99 (1374 kg ha^{-1}) at the fourth sowing date of the first year (Table 7).

The obtained seed yield results were higher than those of previous reports (İşler et al., 1996; Kapıcı, 1996; Cürat, 2010; Bakal and Arıoğlu, 2020). This study, as well as numerous other reports, have shown that seed yield varies according to cultivars or lines (Baydar, 2005; Öz and Karasu, 2010; Arslan et al., 2014; Kurt, 2015). According to another study, pelleting the seeds increased the yield, therefore, this technique could be an alternative to increasing the yield in sesame planting (Doğan and Zeybek, 2009). According to different studies, there is a strong and positive interaction between seed yield and the number of capsules in the sesame, and this relationship has a direct effect on seed yield (Rong and Wei, 1989; Chowdhury et al., 2010).

3.5. Oil ratio

Year, S.Dt, cultivar factors, and YxC, and S.Dt.xC, YxS.Dt.xC interactions had a significant (1%) effect on the oil content. YxS.Dt interaction was significant at the 5% level (Table 3).

When the average oil ratio of sesame cultivars was examined, the highest oil ratio was determined in the Osmanlı-99 (54.6%), and the lowest oil ratio values were determined in other cultivars (47.9-50.0%). In the study, the oil ratio of sesame cultivars increased due to the delay in sowing dates. However, there was no significant difference between other sowing dates except for the first sowing date (Table 8).

The highest oil ratio was 55.6% (Osmanlı-99 and fourth sowing date) and the lowest was 44.8% (Arslanbey and first sowing date) in terms of sowing date x cultivar interaction. In terms of year x cultivar interaction, the Osmanlı-99 had the highest average (54.1 and 55.1%, respectively) in both years and the Arslanbey had the lowest average (46.3%) in the second year. In terms of the oil content of sesame cultivars, the highest values were measured in the second, third, and fourth sowing dates of the first year. On the other hand, in the second year, significant differences were obtained in the oil ratio, especially in the first, second, and third sowing dates. This situation caused the interaction of year x sowing date to be significant. Considering the three-way interaction, the highest oil ratio value was obtained in the Osmanlı-99 (56.0%) at the fourth sowing date of the second year, and the lowest value was obtained in the Hatipoğlu (42.8%) at the fourth sowing date of the first year (Table 8).

A study with 108 distinct genotypes found significant differences in seed yields between plants (Arriel et al., 2007). According to a study conducted with different cultivars and lines, the oil ratios in the seed exhibited substantial variances (Baydar et al., 1999). Another study found that the oil ratio ranged between 44.2% and 50.9% (Bakal and Arıoğlu, 2020). According to another study, the oil ratios of sesame lines and cultivars ranged between 43.2% and 56.4%. According to reports, the oil content of the world's sesame crops ranges between 40.5% and 59% (Yermanos et al., 1972). The oil content of Turkish sesame cultivars and populations ranged between 35.1–62.0% (Baydar et al., 1999). The cause for the changes in oil content across years is most likely due to variances in environmental conditions that affect seed composition (Were et al., 2006). In addition to genetic factors, farming techniques, and environmental factors influence the oil content of the seed.

Table 7. Average seed yield values obtained as a result of the cultivation of sesame cultivars on four different dates (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	
Arslanbey	1610c-j	2035a-i	1582e-j	1549g-j	2009a-j	2315a	2007a-j	2046a-i	1694f-i	2094a-d	1810c-k	2175a-e	1795d-k	1798d-k	1894 CD
Boydak	2144a-h	2188a-g	2259abc	2183a-g	2137a-h	2303a	2315a	1944a-j	2193ab	2175ab	2140a-f	2245ab	2287a	2064a-h	2184 A
Cumhuriyet-99	1645b-j	1625c-j	2097a-h	2106a-h	2085a-h	1950a-j	1831a-j	1915a-j	1868c-g	1945b-f	1865a-j	1788d-k	1964a-i	2011a-i	1907 C
Hatipoğlu	1837a-j	2087a-h	1574f-j	1836a-j	1979a-j	2141a-h	1940a-j	1939a-j	1833d-h	2000a-e	1908a-i	2114a-g	1757e-k	1888a-j	1917 C
Muganlı-57	1727a-j	1762a-j	1581e-j	1578e-j	1897a-j	1863a-j	1626c-j	1770a-j	1662g-i	1789e-h	1812c-k	1813c-k	1604i-k	1674h-k	1726 D
Orhangazi-99	1726a-j	1942a-j	1994a-j	1797a-j	1715a-j	1813a-j	2216a-f	2109a-h	1865d-g	1963a-f	1720f-k	1877a-j	2105a-g	1953a-i	1914 C
Osmanlı-99	1601d-j	1420ij	1497h-j	1374j	1635c-j	1546g-j	1751a-j	1425ij	1473i	1589hi	1618i-k	1483jk	1624i-k	1399k	1531 E
Sarısu	2111a-h	2192a-g	2105a-h	2153a-g	2055a-i	2149a-g	2119a-h	2310a	2140abc	2158ab	2083a-h	2170a-e	2112a-g	2232abc	2149 A
Tan-99	2286ab	2148a-g	1940a-j	1750a-j	2250a-d	2226a-e	2241a-d	2207a-f	2031a-e	2231a	2268ab	2187a-d	2091a-h	1979a-i	2131 AB
Tanas	1844a-j	2105a-h	2150a-g	1733a-j	1856a-j	2232a-d	2175a-g	1668a-j	1958b-f	1983a-e	1850b-j	2169a-e	2163a-e	1701g-k	1971 BC
	Year x Sowing Date								Year		Sowing Date				
Mean	1853C	1950ABC	1878BC	1806C	1962AC	2054A	2022AB	1933ABC	1872B	1993A	1907B	2002A	1950AB	1870B	

*: 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 oil ratio values obtained as a result of the cultivation of sesame cultivars on four different dates (%)*

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	
Arslanbey	46.3g-k	52.8a-h	52.0a-h	48.0b-k	43.3jk	46.5g-k	46.6f-k	48.9a-k	49.8bc	46.3d	44.8h	49.7b-h	49.3c-h	48.4d-h	48.1 B
Boydak	46.0h-k	47.3d-k	50.5a-k	51.0a-j	50.8a-j	49.2a-k	48.4a-k	45.6h-k	48.7bd	48.5bd	48.4d-h	48.2d-h	49.4c-h	48.3d-h	48.6 B
Cumhuriyet-99	49.1a-k	47.9b-k	47.8b-k	49.7a-k	47.8b-k	47.0f-k	47.5b-k	47.8b-k	48.6bd	47.5bd	48.5d-h	47.5d-h	47.6d-h	48.8d-h	48.1 B
Hatipoğlu	52.6a-h	52.7a-h	53.9a-g	42.8k	47.4b-k	45.7h-k	43.6i-k	48.3a-k	50.5bc	46.2d	50.0b-g	49.2c-h	48.8d-h	45.6gh	48.4 B
Muganlı-57	46.2g-k	48.5a-k	47.1e-k	47.9b-k	47.7b-k	48.0b-k	47.4c-k	50.6a-k	47.4cd	48.4bd	46.9e-h	48.3d-h	47.3d-h	49.3c-h	47.9 B
Orhangazi-99	46.1g-k	51.9a-h	47.3d-k	52.5a-h	47.5b-k	48.1b-k	49.9a-k	51.4a-i	49.5bd	49.2bd	46.8f-h	50.0b-g	48.6d-h	52.0a-e	49.4 B
Osmanlı-99	55.0a-e	53.3a-h	53.0a-h	55.3ab	54.5a-f	54.9a-e	55.2abc	56.0a	54.1a	55.1a	54.7ab	54.1a-c	54.1abc	55.6a	54.6 A
Sarısu	47.5b-k	47.4b-k	49.6a-k	52.2a-h	47.9b-k	48.9a-k	55.0a-d	51.4a-i	49.2bd	50.8b	47.7d-h	48.2d-h	52.3a-d	51.8a-f	50.0 B
Tan-99	48.5a-k	49.0a-k	47.7b-k	50.0a-k	47.6b-k	48.0b-k	47.7b-k	50.4a-k	48.8bd	48.4bd	48.0d-h	48.5d-h	47.7d-h	50.2b-g	48.6 B
Tanas	47.9b-k	50.9a-j	50.1a-k	50.9a-j	46.5g-k	49.1a-k	48.6a-k	48.9a-k	50.0bc	48.3bd	47.2d-h	50.0b-g	49.4c-h	49.9b-g	49.1 B
	Year x Sowing Date								Year		Sowing Date				
Mean	48.5AB	50.2A	49.9A	50.0A	48.1B	48.5AB	49.0AB	49.9A	49.7A	48.9B	48.3B	49.4A	49.4A	50.0A	

*: 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

3.6. Oil yield

Year and cultivar factors and YxC, S.Dt.xC, and YxS.Dt.xC interactions had significant (1%) effects on oil content. Sowing date and YxS.Dt had a significant effect at a 5% level (Table 3).

When the average oil yield values of sesame cultivars were examined, the highest oil yield was determined in the Boydak (1062 kg ha^{-1}) and Sarısu (1075 kg ha^{-1}) cultivars. The lowest oil yield was determined in the Muganlı-57 with 827 kg ha^{-1}. In the study, in terms of sowing dates, the highest oil yield was obtained on the second sowing date (985 kg ha^{-1}), while the lowest values were determined on the first sowing date (919 kg ha^{-1}). In terms of the year x cultivar interaction, the Sarısu and Tan-99 cultivars had the highest oil yield (1097 and 1080 kg ha^{-1}, respectively) in the second year and the Muganlı-57 and Osmanlı-99 cultivars had the lowest oil yield (787 and 797 kg ha^{-1}, respectively) in the first year. The highest oil yield was 1153 and 1130 kg ha^{-1} (Sarısu fourth sowing date and Boydak third sowing date) and the lowest was 758 kg ha^{-1} (Muganlı-57 and third sowing date) in terms of sowing date x cultivar interaction. When the year x sowing date interaction was examined, the highest oil yield with 993 kg ha^{-1} was determined at the second sowing date of the second year, and the lowest value was determined at the first sowing date in the first year (897 kg ha^{-1}). Considering the three-way interaction, the highest oil yield was obtained in the Sarısu (1186 kg ha^{-1}) at the fourth sowing date of the second year, and the lowest value was obtained in the Arslanbey (738 kg ha^{-1}) at the first sowing date of the first year (Table 9).

According to the results of the study, yield values and agronomic characteristics differ depending on the sowing date and cultivar. The average oil yield in Antalya, Turkey, was between 444 and 743 kg ha^{-1}, according to another research (Baydar, 2005). In another research study, the oil yield was determined to be between 72.6 and 647.8 kg ha^{-1} in a study of 103 cultivars and lines cultivated in Türkiye (Uzun et al., 2008). According to Ozkan and Kulak (2013), irrigation practices influence plant development factors and consequently seed yield but have no statistical effect on oil yield. It has been stated that N-fixing bacteria fertilizer and urea reduce the oil content of sesame seeds while increasing oil yield due to increased seed yield (Shakeri et al., 2016). Another study found that the main crop and second crop sowing dates had a significant effect on seed yield, 1000 seed weight, oil, and protein yields (Söğüt, 2008).

4. Conclusions

The findings of this study suggest that sesame may be planted successfully as a second crop in the plains of Mardin province in Türkiye's southeast. Furthermore, when both seed and oil yields are considered, the Boydak and Sarısu cultivars can be produced as a second crop in this region and others with similar climate-environmental features. As a result, it is recommended that sesame can be sown in the broad plains of this region in mid-June for successful and sustainable production.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

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

All authors declare that there is no conflict of interest related to this article.

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Table 9. Average oil yield values obtained as a result of the cultivation of sesame cultivars on four different dates (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	
Arslanbey	738j	1073a-j	828b-j	744ij	871a-j	1076a-j	936a-j	1000a-j	846de	971a-d	805h-j	1075a-e	882b-j	872c-j	908 C-E
Boydak	987a-j	1035a-j	1140a-c	1114a-f	1086a-i	1132a-d	1120a-e	885a-j	1069ab	1056ab	1037a-g	1084a-d	1130a	999a-i	1062 A
Cumhuriyet-99	806c-j	779e-j	1002a-j	1047a-j	996a-j	916a-j	871a-j	917a-j	909c-e	925b-e	901b-j	848f-j	937a-j	982a-j	917 C-E
Hatipoğlu	963a-j	1102a-g	850a-j	786e-j	939a-j	976a-j	849a-j	936a-j	925b-e	925b-e	951a-j	1039a-g	850e-j	861d-j	925 CD
Muganlı-57	797c-j	854a-j	745ij	750h-j	905a-j	897a-j	772f-j	893a-j	787e	867de	851e-j	876c-j	758j	821g-j	827 E
Orhangazi-99	800c-j	1009a-j	940a-j	949a-j	815c-j	873a-j	1106a-f	1086a-i	925b-e	970a-d	807h-j	941a-j	1023a-h	1018a-h	947 BC
Osmanlı-99	880a-j	756g-j	793d-j	759g-j	890a-j	847a-j	966a-j	798c-j	797e	875de	885b-j	801h-j	880c-j	779ij	836 DE
Sarısu	1004a-j	1041a-j	1046a-j	1121a-e	984a-j	1050a-j	1167ab	1186a	1053a-c	1097a	994a-i	1045a-g	1107ab	1153a	1075 A
Tan-99	1109a-f	1051a-j	925a-j	875a-j	1070a-j	1068a-j	1070a-j	1111a-f	990a-d	1080a	1089abc	1060a-f	997a-i	993ai	1035 AB
Tanas	886a-j	1071a-j	1077a-j	883a-j	862a-j	1095a-h	1061a-j	816c-j	979a-d	959a-d	874c-j	1083a-d	1069a-f	850e-j	969 BC
	Year x Sowing Date								Year		Sowing Date				
Mean	897B	977AB	935AB	903AB	942AB	993A	992 AB	963AB	928B	972A	919B	985A	963AB	933AB	

*: 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

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CITATION: İzgi, M.N., Bulut, B., 2023. Agronomic Characteristics and Yield Values of Sesame (*Sesamum indicum* L.) Cultivars at Various Sowing Dates. *Turkish Journal of Agricultural Research*, 10(1): 109-120. .