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Determination of seed yield, yield components, and seed quality characteristics of some soybean (*Glycine max* (L.) Merr.) genotypes in Samsun, Türkiye*

Seyit Ahmet EROL[1]*, Celal BAYRAM[1], Meral ERGİN[1], Mehmet ERDOĞMUŞ[1]

[1]Black Sea Agricultural Research Institute, Samsun, Türkiye

***Corresponding author e-mail:** s.ahmeterol@gmail.com

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Abstract: This study assessed seed yield, yield components, and seed quality traits of some soybean (*Glycine max* (L.) Merr.) genotypes in Samsun, Türkiye. The experiment was conducted in two locations (Çarşamba and Bafra) in 2022. A total of twenty-four soybean genotypes were utilized, including three standards varieties (ARISOY, ATAEM-7, and SAMSOY), and twenty-one lines (F8 generation) developed by cross breeding. As a result of study, seed yield values ranked between 4.69 t ha-1 (KA14-09-04) and 3.38 t ha-1 (KA14-01-01), whereas plant height varied between 122.9 cm (ARISOY) and 92.8 cm (KA14-02-06). First pod height ranged from 17.9 cm (ATAEM-7) to 12.5 cm (KA14-02-04), and the number of pods per plant varied between 113.5 (KA14-09-04) and 69.3 (KA14-01-01). In addition, hundred seed weight differed between 20.70 g (KA14-05-04) and 15.59 g (KA14-01-14). Finally, seed oil content ranged from 22.64% (KA14-05-01) to 20.22% (KA14-02-06), and the seed protein content values varied between 45.28% (KA14-02-06) to 41.55% (KA14-05-01). In conclusion, KA14-09-04 and KA14-05-04 produced the highest seed yield in the ecological conditions of Samsun province in Türkiye. It can be suggested that the Bafra location is more suitable for high oil production, while the Çarşamba is more suitable for high protein production in terms of suitability for soybean cultivation.

Keywords: Soybean lines, cross breeding, seed yield, oil concentration, protein concentration.

Türkiye Samsun'da bazı soya (*Glycine max* (L.) Merr.) genotiplerinin verim, verim komponentleri ve tohum kalite özeliklerinin belirlenmesi

Öz: Bu çalışmanın amacı, bazı soya (*Glycine max* (L.) Merr.) genotiplerinin Samsun ili koşullarında tohum verimi, verim komponentleri ve tohum kalite özelliklerini belirlemektir. Çalışma 2022 yılında, iki (Çarşamba ve Bafra) lokasyonda yürütülmüştür. Çalışmada üç tescilli çeşit (ARISOY, ATAEM-7 ve SAMSOY) ve melezleme yoluyla geliştirilmiş yirmi bir adet ileri kademe (F8) hat kullanılmıştır. Çalışma sonucunda, verim 4.69 t ha-1 (KA14-09-04) – 3.38 t ha-1 (KA14-01-01), bitki boyu 122.9 cm (ARISOY) – 92.8 cm (KA14-02-06), ilk bakla yüksekliği 17.9 cm (ATAEM-7) – 12.5 cm (KA14-02-04), bitkide bakla sayısı 113.5 adet (KA14-09-04) – 69.3 adet (KA14-01-01) aralığında değerler almıştır. Ayrıca yüz tohum ağırlığı 20.70 g (KA14-05-04) – 15.59 g (KA14-01-14) arasında değişmiştir. Son olarak ham yağ oranı %22.64 (KA14-05-01) – %20.22 (KA14-02-06) ve ham protein oranı %45.28 (KA14-02-06) – %41.55 (KA14-05-01) aralığında değişim göstermiştir. Çalışma sonucunda Türkiye'nin Samsun ili ekolojik koşullarında KA14-09-04 ve KA14-05-04 hatları en yüksek tane verimine sahip olmuştur. Son olarak soya ekiminde amaca uygun olması bakımından yüksek yağ eldesi için Bafra lokasyonunun, yüksek protein eldesi için ise Çarşamba lokasyonunun daha uygun olduğu önerilebilir.

Anahtar kelimeler: Soya hattı, melezleme, tohum verimi, yağ içeriği, protein içeriği

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1. Introduction

Soybean is an industrial plant that serves as a cost-effective and high-quality source of plant-based protein and oil on a global scale. Soybeans are an ideal raw materials for feed production, oil extraction, and biodiesel production with an oil content of 20% and a protein content of 40%. Additionally, they are used in cosmetics, nutraceuticals and for medicinal purposes (de Siqueira Gesteira et al., 2018). Due to the presence of essential amino acids, soybean proteins have high nutritional value (Singh et al., 2008). Soybean oil consists of 16% saturated and 84% unsaturated fatty acids, with an average fatty acid composition of 52% linoleic acid, 25% oleic acid, 12% palmitic acid, 6% linolenic acid and 5% stearic acid (Eren et al., 2012).

Türkiye is a suitable country for soybean production under both main crop and second crop conditions, especially in areas where irrigation is not an issue. With proper production planning, the soybean cultivation area and seed yield can be increased. Another method to increase production is through breeding programs aimed at developing new varieties that are superior in terms of seed yield and agricultural traits. This approach would allow for higher seed yields per unit area. While developing new varieties, it is crucial to set priorities according to specific conditions and direct breeding efforts accordingly. It is also a scientific fact that newly developed lines or varieties may show different results under different ecological conditions. In addition to genotypic traits, environmental factors play a significant role in the seed yield performance of genotypes. Therefore, data obtained from trials conducted in different environments should be evaluated. Variance analyses applied to such trials allow for the assessment of differences between genotypes and the performance of genotypes across different environments. For this reason, regional adaptation studies are a critical breeding stage, particularly for new varieties or lines. This is also true for soybean breeding, where the identification of genotypes with superior yield and quality traits across different environmental conditions is essential for success. Soybean was first cultivated in the Black Sea Region of Türkiye, it continues to be grown in the province of Samsun within this region. Therefore, it may be beneficial to develop soybean genotypes suitable for the region and to increase studies on improving yield and quality traits in different locations.

This study aims to determine the seed yield, yield components and seed quality traits of some soybean genotypes as a main crop under the ecological conditions of Samsun Province.

2. Materials and Methods

2.1. Experimental area climate and soil properties

This study was conducted in 2022 at two locations belonging to the Black Sea Agricultural Research Institute: Çarşamba (41° 13' N, 36° 40' E, altitude of 15 m) and Bafra (41° 36' N, 35° 55' E, altitude of 20 m). The soil characteristics of the locations where the study was carried out were determined in the Soil Science Laboratory of the Black Sea Agricultural Research Institute Directorate.

The soil texture of the Çarşamba experimental field is clay-loam, while the soil texture of the Bafra experimental field falls within the clay class. The organic matter levels of both locations are similar (1.33, 1.38) (Table 1).

According to meteorological data, the average temperature values in both locations are similar. The lowest average temperature was recorded in May, while the highest occurred in August. The total rainfall was 227 mm in the Bafra location and 276 mm in the Çarşamba location. The monthly rainfall was higher in Çarşamba during September, whereas it was higher in Bafra during June. In both locations, the lowest rainfall was recorded in July (Figure 1, 2).

Table 1. Soil properties of Çarşamba and Bafra locations.

Location	Years	Soil Texture	pH	EC Mmhos/cm	Organic matter%	P_2O_5 (kg/da)	K_2O (kg/da)	$CaCO_3$ (%)
Çarşamba	2022	Clay-Loam	7.54	0.023	1.33	3.86	113	5.99
Bafra	2022	Clay	7.57	0.051	1.38	2.57	103	9.52

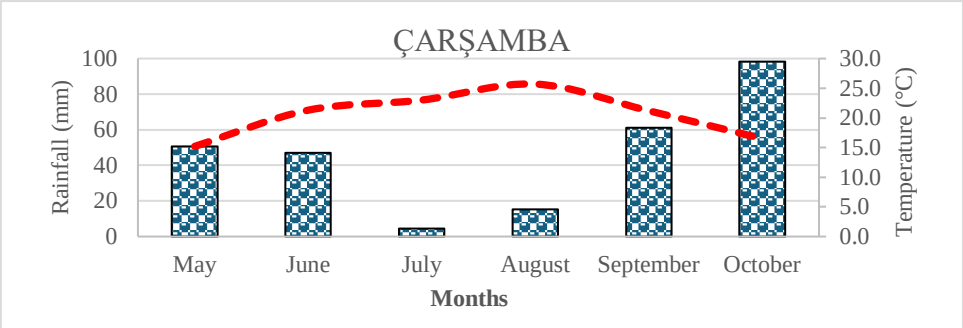

Figure 1. Monthly average temperature (°C) and rainfall (mm) data for Çarsamba location.

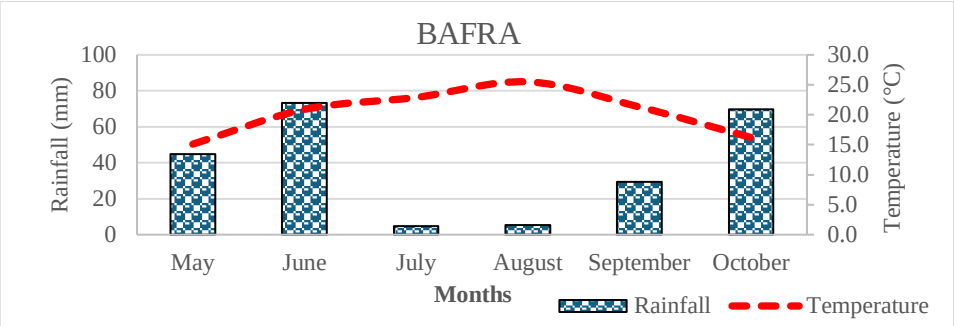

Figure 2. Monthly average temperature (°C) and rainfall (mm) datas for Bafra location.

2.2. Experimental design and management

The experiment was conducted in a randomized complete block design with three replications. The material used in the study consisted of 21 soybean lines (at the F8 generation) belonging to maturity group III, developed through cross breeding as part of the "Soybean Breeding Research Project for the Black Sea Region" conducted at the Black Sea Agricultural Research Institute. The standard varieties used were ARISOY, ATAEM-7, and SAMSOY.

The plot dimensions were planned with a plot length of 5 m, a row spacing of 70 cm, intrarow spacing of 4 cm and 4 rows per plot. The area of each plot was 14 m^2. Pre-sowing, the seeds were inoculated with *Bradyrhizobium japonicum* bacterial inoculant. Sowing was performed on May 17, 2022, using a seed drill. Based on the soil analysis, 40 kg N ha^{-1} and 8 kg P_2O_5 ha^{-1} fertilizers were applied before sowing. Irrigation was carried out four different times, based on the water requirements of plant and soil moisture status, using a sprinkler irrigation system. To control weeds, chemical control was applied before sowing using herbicide containing *pendimethalin* (300 ml/da) and mechanical control was conducted once during the V2 (second trifoliolate) stage. The plants were harvested using a parcel combine harvester on November 2, 2022.

2.3. Plant sampling and measurements

At the physiological maturity stage (R7), plant height and the height of the first pod were measured using a meter stick on 10 randomly selected plants from each plot. The number of pods per plant was determined by counting the pods on each plant. For seed yield calculation, two rows (7 m^2) located in the center of each plot were used. The 100 seed weight was determined by counting and weighing 100 seeds from the harvested seeds in each plot, with four replications. After that, 100 seed weight of plants was determined by calculating the average values of the weighing measurements. The seed yield and 100 seed weight of the plots were adjusted and calculated based on a seed moisture content of 13.5%. The oil and protein content of the seeds were determined using the NIRS (Near Infrared Range Spectrometer) method with an XDS MasterLab Rapid Content Analyzer NIR Spectrometer (FOSS, Denmark), calibrated appropriately. Approximately 500 g of seed samples from each plot were used for this analysis. Finally, the oil and protein content of the seeds were calculated as a percentage based on seed weight.

2.4. Statistical analysis

Analysis of variance (ANOVA) was used to analyze the data according to randomized complete block using

SAS-JMP 13.0 program. The differences among means were compared by Tukey's HSD multiple range test ($p \leq 0.05$).

3. Results and Discussion

Significant differences were found between the genotypes for plant height, first pod height, number of pods, 100-seed weight, oil and protein content (P<0.01), and seed yield (P<0.05). Significant differences were also observed between the Çarşamba and Bafra locations in terms of first pod height, seed yield, 100-seed weight, oil, and protein content (P<0.01), and number of pods (P<0.05). However, no statistically significant difference was found between locations for plant height. According to the genotype x environment interaction values, differences were found in terms of first pod height, number of pods (P<0.01), and protein content (P<0.05), although no significant differences were observed for plant height, seed yield, 100-seed weight, and oil content (Table 2).

Table 2. Combined (Çarşamba-Bafra locations) ANOVA statistical results.

Parameters	Genotype			Location			Genotype x Location Int.		
	DF	MS	Prob.	DF	MS	Prob.	DF	MS	Prob.
Plant height	23	383.99	0.0003**	1	3094.14	0.0743ns	23	113.23	0.6953ns
First pod height	23	19.33	<.0001**	1	697.84	0.0006**	23	16.64	<.0001**
Pod number	23	860.55	<.0001**	1	2704.00	0.0268*	23	683.41	<.0001**
Seed yield	23	6439.66	0.0183*	1	8464.88	0.0011**	23	2041.04	0.9210ns
100 seed weight	23	9.09	<.0001**	1	125.53	0.0028**	23	1.19	0.8104ns
Oil content	23	2.47	0.0002**	1	60.50	0.0011**	23	1.19	0.1481ns
Protein content	23	3.48	0.0014**	1	121.78	0.0003**	23	2.61	0.0232*

**:*p<0.01*; *:*p<0.05*; ns: not significant

Table 3. Combined (Çarşamba-Bafra locations) ANOVA statistical results and statistical groups for plant height.

Genotypes	Plant Height (cm)			
	Çarşamba	Bafra	Mean	
KA14-01-01	113.3	107.5	110.4**	ab
KA14-01-03	121.2	100.5	110.9	ab
KA14-01-07	109.0	108.0	108.5	ab
KA14-01-14	108.0	98.0	103.0	ab
KA14-02-01	120.2	109.8	115.0	ab
KA14-02-02	117.0	106.5	111.8	ab
KA14-02-04	99.3	89.5	94.4	b
KA14-02-05	99.3	92.2	95.8	b
KA14-02-06	94.8	90.8	92.8	b
KA14-02-07	102.7	98.7	100.7	ab
KA14-03-01	117.7	101.2	109.5	ab
KA14-05-01	120.5	107.0	113.8	ab
KA14-05-04	128.3	102.2	115.3	ab
KA14-05-05	110.0	98.5	104.3	ab
KA14-05-07	119.2	96.2	107.7	ab
KA14-05-08	94.0	96.0	95.0	b
KA14-06-02	121.3	97.3	109.3	ab
KA14-09-01	106.5	106.7	106.6	ab
KA14-09-02	110.7	112.0	111.4	ab
KA14-09-03	115.0	108.8	111.9	ab
KA14-09-04	118.8	114.7	116.8	ab
ARISOY	132.5	113.2	122.9	a
ATAEM-7	115.0	119.5	117.3	ab
SAMSOY	101.0	98.2	99.6	ab
Mean	112.3	103.0	107.7	
CV (%)			10.9	

**:*p<0.01*; *CV*: coefficient of variation; Mean data for each trait followed by different letters differ significantly at $p < 0.05$ using Tukey's HSD test

According to the results of the variance analysis conducted with the data obtained from the study, significant differences were found between locations for all traits except plant height (Table 2). Therefore, a combined variance analysis was not performed for the other traits analyzed, except for plant height. Instead, the variance analysis for the locations was conducted separately, and the means were grouped accordingly.

3.1. Plant height (cm)

The highest plant height was observed in the ARISOY variety (122.9 cm), while the lowest plant height was recorded in the KA14-02-06 line (92.8 cm) (Table 3).

The effect of location on plant height was statistically non-significant (Table 2). The average plant height at the Çarşamba location was 112.3 cm, while it was 103.0 cm at Bafra. Average for both locations was 107.7 cm (Table 3). Several studies conducted in different regions of Turkey support the findings of this study (Sincik et al., 2009; Güngör and Üstün, 2015; Kocatürk et al., 2019; Kınay et al., 2020).

3.2. First pod height (cm)

The average first pod height was 17.1 cm in Çarşamba and 12.7 cm in Bafra and a statistically significant difference (P<0.01) was determined between the locations (Table 4). The reason why the first pod height was higher in Çarşamba location compared to Bafra location may be due to soil properties and rainfall regime (Figure. 1, 2 and Table 1). According to the average values of the locations, the highest first pod height was determined in ATAEM-7 variety (17.9 cm) while the lowest first pod height was determined in KA14-02-04 line (12.5 cm) (Table 4).

Table 4. ANOVA results and statistical groups for first pod height and pod number in Çarşamba and Bafra locations.

Genotypes	First Pod Height (cm)					Pod number (piece)				
	Çarşamba		Bafra		Mean	Çarşamba		Bafra		Mean
KA14-01-01	15.0**	bc	10.3**	bc	12.7	49.7**	f	88.8**	a-f	69.3
KA14-01-03	15.0	bc	10.8	bc	12.9	93.2	a-e	58.3	g	75.8
KA14-01-07	13.3	c	12.5	a-c	12.9	86.0	b-e	77.0	e-g	81.5
KA14-01-14	22.5	a	11.5	bc	17.0	80.7	c-f	72.3	fg	76.5
KA14-02-01	20.0	a-c	13.7	ac	16.9	112.5	a-c	102.8	ab	107.7
KA14-02-02	16.7	a-c	11.8	bc	14.3	113.8	a-c	80.5	c-f	97.2
KA14-02-04	15.0	bc	10.0	bc	12.5	104.7	a-d	85.5	a-f	95.1
KA14-02-05	13.3	c	12.5	a-c	12.9	90.5	a-e	105.3	a	97.9
KA14-02-06	14.2	bc	11.7	bc	13.0	108.0	a-d	79.0	d-g	93.5
KA14-02-07	16.7	a-c	13.3	a-c	15.0	89.3	a-c	74.8	fg	82.1
KA14-03-01	16.7	a-c	8.8	c	12.8	106.0	a-d	100.0	a-d	103.0
KA14-05-01	20.8	ab	14.2	a-c	17.5	113.2	a-c	77.5	e-g	95.4
KA14-05-04	20.0	a-c	12.5	a-c	16.3	119.2	ab	100.3	a-d	109.8
KA14-05-05	16.7	a-c	12.3	a-c	14.5	85.2	c-e	77.0	e-g	81.1
KA14-05-07	20.0	a-c	15.0	a-c	17.5	77.5	d-f	104.2	a	90.9
KA14-05-08	14.2	bc	13.2	a-c	13.7	101.8	a-d	75.3	e-g	88.6
KA14-06-02	22.5	a	11.2	bc	16.9	101.3	a-d	96.8	a-e	99.1
KA14-09-01	15.8	a-c	12.0	bc	13.9	59.5	e-f	88.8	a-f	74.2
KA14-09-02	18.3	a-c	14.5	a-c	16.4	98.0	a-d	103.0	ab	100.5
KA14-09-03	13.3	c	15.3	ab	14.3	111.8	a-c	100.2	a-d	106.0
KA14-09-04	15.8	a-c	15.0	a-c	15.4	120.7	a	106.3	a	113.5
ARISOY	19.2	a-c	12.2	a-c	15.7	82.7	c-f	102.3	a-c	92.5
ATAEM-7	17.5	a-c	18.3	a	17.9	99.5	a-d	72.5	f-g	86.0
SAMSOY	17.5	a-c	11.7	bc	14.6	114.2	a-c	82.0	b-f	98.1
Mean	17.1**	A	12.7	B	14.9	96.6*	A	87.9	B	92.3
CV (%)	14.0		7.6			11.0		7.9		

**:*p<0.01*; *:*p<0.05*; *CV*: coefficient of variation; Mean data for each trait followed by different letters differ significantly at p < 0.05 using Tukey's HSD test

First pod height is a significant agricultural trait for machine harvesting. The development and productivity of pods on the soybean plant are not uniform. Pods located at the lower part of the plant tend to be more productive than those at the upper part. Therefore, the pods situated at the lower section of the plant are particularly important in terms of harvest seed yield and it can lead to losses during harvesting. Ramteke et al. (2012) and Tkachuk (2019) reported that the first pod height in soybeans should be at least 12 cm for efficient mechanical harvesting. The first pod height values possessed by the genotypes in this study are within the suitable range for machine harvesting. The first pod height values obtained in this study are consistent with the findings of Beiküfner et al. (2019), Şahin and İşler (2021), and Richard et al. (2023).

3.3. Pod number (piece)

A significant difference (p<0.05) was determined between the locations in terms of the number of pods per plant. It was determined that the average number of pods was higher in Çarşamba location than in Bafra location. According to the average values of the locations, the number of pods varied between 69.3 pieces (KA14-01-01) and 113.5 pieces (KA14-09-04) (Table 4). Arslanoğlu and Aytaç (2010) conducted a study across eight different locations in Türkiye with eight different soybean genotypes and found an average pod number of 73.2 at the Çarşamba location and 87.3 at the Bafra location. Yıldırım et al. (2022), in a two-year study in İzmir involving ten soybean genotypes, including seven lines and three varieties, reported that the number of pods per plant varied between 84.0 and 129.6. The number of pods per plant in this study was found to be close to the values determined by the researchers. Gümüş and Beyyavaş (2020), in their study conducted in the ecological conditions of Mardin province with ten different soybean varieties, reported a pod count ranging from 81.5 to 133.9, indicating that they achieved higher pod count values than those obtained in our study. Conversely, Andırman and Baran (2023), in their research with seven different soybean varieties in Batman province, found a pod count ranging from 31.3 to 49.2, which is lower than the values obtained in our study. In conclusion, genotype and location differences in soybean have a significant impact on the number of pods per plant.

3.4. Seed yield (t ha^{-1})

The average seed yield at the Çarşamba location was determined to be 3.34 t ha-1, while at the Bafra location, it was found to be 4.87 t ha-1. The average seed yield

across both locations was calculated to be 4.11 t ha-1. According to the average of the locations, the lowest seed yield was determined in KA14-01-01 (3.38 t ha-1) and KA14-01-03 (3.61 t ha-1) lines, while the highest seed yield was determined in KA14-09-04 (4.69 t ha-1) and KA14-05-04 (4.66 t ha-1) lines. The seed yields of the standard varieties in the study were determined as follows: SAMSOY (4.24 t ha-1), ARISOY (4.16 t ha-1), and ATAEM-7 (3.96 t ha-1) (Table 5). As a result of the study, although the number of pods per plant affecting the seed yield was higher at Çarşamba location, the average seed yield value was higher at Bafra location. This was due to the higher 100 seed weight value at Bafra location compared to Çarşamba location. The significant difference in seed yield between the locations may be attributed to the higher amount of rainfall recorded at the Bafra location in June compared to the Çarşamba. Eren et al. (2012) conducted a study with 22 genotypes, at the Antalya location, where they reported seed yields ranging from 3.11 to 4.48 t ha-1. Çubukçu et al. (2021) investigated 14 different soybean genotypes as a second crop at four different locations: Adana, Antalya, Şanlıurfa, and İzmir. Their findings indicated seed yields in Adana ranging from 3.32 to 3.95 t ha-1, in Antalya from 2.63 to 3.61 t ha-1, in Şanlıurfa from 3.16 to 4.15 t ha-1, and in İzmir from 3.09 to 3.68 t ha-1. Göksoy et al. (2019) evaluated 15 soybean genotypes over three years at three different locations: Samsun, Konya, and Bursa. The seed yield varied between 2.65 and 4.22 t ha-1 at the Bursa location, 2.33 and 3.85 t ha-1 at the Konya location, and 3.44 and 4.08 t ha-1 at the Samsun location. The results indicated that the seed yield values obtained from the Bafra location were higher compared to findings from other studies conducted in Türkiye.

3.5. 100 seed weight (g)

A significant difference ($p<0.01$) was determined between the locations in terms of 100 seed weight. The average 100 seed weight was determined higher in the Bafra location than in the Çarşamba location. According to the average values of the locations, the lowest 100 seed weight was determined in the KA14-01-14 line (15.59 g) while the highest was determined in the KA14-05-04 line (20.70 g) (Table 5). The results of some studies conducted in different regions of the world (Flajšman et al., 2019; Staniak et al., 2021; Thakur et al., 2022; Rani et al., 2023), as well as some studies conducted in Türkiye (Gül and Arslanoğlu, 2020; Ekberli and Kars, 2021; Bakal et al., 2021), are consistent with the findings obtained in this study.

3.6. Oil content (%)

The average oil content was determined to be %20.72 in the Çarşamba location and %22.02 in the Bafra location. The overall average for both locations was calculated to be %21.37. The reason why the oil content of the seeds was higher in the Bafra location than in the Çarşamba location may be due to ecological differences. According to the average values of the locations, the KA14-05-01 line (22.64%) was determined as promising in terms of oil content (Table 6). Arslanoğlu et al. (2011) reported significant effects of genotypes, locations, and genotype x location interactions on the oil content of seeds in their study conducted across various locations in the provinces of Tokat (Erbaa and Turhal), Amasya (Gökhöyük and Suluova), Samsun (Çarşamba and Bafra), and Sinop (Kabalı and Boyabat). Additionally, the researchers found that the average oil content of soybean genotypes varied between %20.52 and %21.80, with average oil contents of %21.00 and %21.58 in the Çarşamba and Bafra locations of Samsun province, respectively. The findings of our research are supported by results from other studies conducted in various regions of Türkiye regarding the oil content of seeds (Gölükçü, 2019; Erbil, 2020; Kaya, 2020).

3.7. Protein content (%)

The protein content was determined to be 44.24% at the Çarşamba location and 42.41% at the Bafra location. Based on the average of the locations, the protein content of the seeds is approximately 43.33%. The protein content was determined to be low in the Bafra location where the fat content is high, and the protein content was determined to be high in the Çarşamba location where the fat content is low. According to the results of the average of the locations, the protein content of the seeds ranged from 41.55% (KA14-05-01) to 45.28% (KA14-02-06). Among the standard varieties included in the study, the protein contents were ranked as follows: ARISOY (44.18%), ATAEM-7 (43.28%), and SAMSOY (42.93%). (Table 6). The findings related to the protein content of the seeds in our study are similar to the results reported by Yıldırım and İlker (2018), and Demir et al. (2020). However, the findings in de Siqueira Gesteira et al. (2018), Yılmaz et al. (2022), and Sümer (2022) seed yielded lower protein content results compared to those obtained in our study. We believe that the

differences between the results of our study and those found in the literature are due to the variations in ecological conditions under which the studies were conducted and the differences in the genotypes examined.

Table 5. ANOVA results and statistical groups for seed yield and 100 seed weight in Çarşamba and Bafra locations.

Genotypes	Seed Yield (t ha^{-1})					100 Seed Weight (g)				
	Çarsamba		Bafra		Mean	Çarşamba		Bafra		Mean
KA14-01-01	2.73*	d	4.02*	d	3.38	17.22**	a-c	20.48**	a-c	18.85
KA14-01-03	3.02	cd	4.20	cd	3.61	14.94	bc	17.12	cd	16.03
KA14-01-07	2.96	cd	5.00	a-c	3.98	17.16	a-c	19.54	a-d	18.35
KA14-01-14	3.14	bc	4.34	cd	3.74	14.40	c	16.77	d	15.59
KA14-02-01	3.57	ab	5.40	ab	4.49	19.32	ab	21.28	ab	20.30
KA14-02-02	3.18	bc	5.21	a-c	4.20	17.20	a-c	18.79	a-d	18.00
KA14-02-04	3.10	bc	5.16	a-c	4.13	18.94	a-c	20.61	ab	19.78
KA14-02-05	3.63	ab	4.55	bc	4.09	18.29	a-c	21.26	ab	19.78
KA14-02-06	3.45	ab	4.73	a-c	4.09	17.38	a-c	19.70	a-d	18.54
KA14-02-07	3.27	bc	4.47	bc	3.87	18.26	a-c	19.51	a-d	18.89
KA14-03-01	3.87	a	4.91	a-c	4.39	18.69	a-c	19.68	a-d	19.19
KA14-05-01	3.40	ab	4.90	a-c	4.15	16.22	a-c	19.57	a-d	17.90
KA14-05-04	3.94	a	5.37	ab	4.66	19.64	a	21.75	a	20.70
KA14-05-05	3.15	bc	4.57	bc	3.86	17.86	a-c	18.74	a-d	18.30
KA14-05-07	3.31	bc	4.79	a-c	4.05	19.74	a	21.10	ab	20.42
KA14-05-08	2.88	cd	5.12	a-c	4.00	18.71	a-c	19.40	a-d	19.06
KA14-06-02	3.60	ab	5.11	a-c	4.36	17.90	a-c	19.07	a-d	18.49
KA14-09-01	2.89	cd	4.35	cd	3.62	17.74	a-c	19.42	a-d	18.58
KA14-09-02	3.47	ab	5.26	a-c	4.37	19.10	ab	20.74	ab	19.92
KA14-09-03	3.41	ab	5.54	ab	4.48	16.61	a-c	20.60	ab	18.61
KA14-09-04	3.79	a	5.58	a	4.69	19.05	ab	21.16	ab	20.11
ARISOY	3.44	ab	4.88	a-c	4.16	17.48	a-c	18.24	b-d	17.86
ATAEM-7	3.35	bc	4.56	bc	3.96	17.98	a-c	18.57	a-d	18.28
SAMSOY	3.58	ab	4.90	a-c	4.24	17.85	a-c	19.39	a-d	18.62
Mean	3.34	B	4.87**	A	4.11	17.82	B	19.69**	A	18.76
CV (%)	14.0		11.7			8.1		5.3		

**:*p<0.01*; *:*p<0.05*; *CV*: coefficient of variation; Mean data for each trait followed by different letters differ significantly at p < 0.05 using Tukey's HSD test.

Table 6. ANOVA results and statistical groups for oil content and protein content in Çarşamba and Bafra locations.

Genotypes	Oil Content (%)					Protein Content (%)				
	Çarşamba		Bafra		Mean	Çarşamba		Bafra		Mean
KA14-01-01	21.08**	ab	22.12**	ab	21.60	43.73**	ac	42.03*	ab	42.88
KA14-01-03	20.32	ac	21.90	ab	21.11	44.77	ab	43.09	ab	43.93
KA14-01-07	21.11	ab	22.23	ab	21.67	44.34	ab	42.33	ab	43.34
KA14-01-14	21.07	ab	21.67	ab	21.37	43.95	ac	44.07	a	44.01
KA14-02-01	22.27	ab	22.49	ab	22.38	42.71	bc	42.50	ab	42.61
KA14-02-02	22.06	ab	21.46	ab	21.76	43.31	bc	43.32	ab	43.32
KA14-02-04	21.20	ab	22.57	ab	21.89	44.84	ab	41.94	ab	43.39
KA14-02-05	20.61	ac	23.13	a	21.87	44.08	ac	41.62	ab	42.85
KA14-02-06	19.31	c	21.13	ab	20.22	46.09	a	44.47	a	45.28
KA14-02-07	20.45	ac	21.30	ab	20.88	44.66	ab	42.81	ab	43.74
KA14-03-01	20.17	bc	23.19	a	21.68	45.24	ab	40.21	b	42.73
KA14-05-01	22.42	a	22.86	ab	22.64	42.23	c	40.88	ab	41.55
KA14-05-04	20.51	ac	22.00	ab	21.26	44.29	ab	42.12	ab	43.21
KA14-05-05	21.84	ab	22.89	ab	22.37	42.53	bc	41.79	ab	42.16
KA14-05-07	19.88	bc	22.54	ab	21.21	44.37	ab	41.45	ab	42.91
KA14-05-08	20.43	ac	22.03	ab	21.23	45.01	ab	42.58	ab	43.80
KA14-06-02	19.97	bc	21.69	ab	20.83	45.12	ab	42.65	ab	43.89
KA14-09-01	20.31	ac	21.45	ab	20.88	44.59	ab	42.94	ab	43.77
KA14-09-02	20.64	ac	22.21	ab	21.43	45.94	a	42.33	ab	44.14
KA14-09-03	19.75	bc	20.73	b	20.24	42.58	bc	43.05	ab	42.82
KA14-09-04	19.61	bc	21.65	ab	20.63	44.35	ab	41.92	ab	43.14
ARISOY	19.26	c	21.81	ab	20.54	46.08	a	42.27	ab	44.18
ATAEM-7	21.64	ab	21.95	ab	21.80	43.82	ac	42.73	ab	43.28
SAMSOY	21.45	ab	21.45	ab	21.45	43.24	bc	42.62	ab	42.93
Mean	20.72	B	22.02**	A	21.37	44.24**	A	42.41	B	43.33
CV (%)	5.1		3.5			2.8		2.7		

**:*p<0.01*; *:*p<0.05*; *CV*: coefficient of variation; Mean data for each trait followed by different letters differ significantly at p < 0.05 using Tukey's HSD test

4. Conclusion

According to the research findings, KA14-09-04 and KA14-05-04 soybean lines stood out as the ones with the highest seed yield in the ecological conditions of Samsun province of Türkiye. It can be suggested that the Bafra location is more suitable for high oil production, while the Çarşamba location is more suitable for high protein production in terms of suitability for soybean cultivation. Finally, it was concluded that conducting similar studies in more locations and over extended periods would be beneficial for assessing the impact of environmental factors on soybean genotypes regarding seed yield, yield criteria, and seed quality traits.

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Conflict of interest

The authors declare no conflicts of interest.

Authorship contribution statement

S.A.E: Methodology, Planning and conducting the experiment, performing statistical analyses, Writing-Original draft preparation, Writing- Reviewing and Editing. C.B: Conducting the experiment, taking observations and measurements. M.ERG: Conducting the experiment, taking observations and measurements. M.ERD: Conducting the experiment, taking observations and measurements.

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