*Pak. J. Bot.*, 55(6): 2269-2273, 2023. DOI: http://dx.doi.org/10.30848/PJB2023-6(27)

# DETERMINATION OF SOME AGRICULTURAL AND TECHNOLOGICAL PROPERTIES OF SOYBEAN GENOTYPES

**SERIF KAHRAMAN**

*GAP International Agricultural Research and Training Center, Diyarbakir, Türkiye*
*Corresponding email: mserif211@gmail.com*

**Abstract**

This study aims to determine the yield and quality parameters of soybean genotypes that are cultivable under the main crop conditions. The experiments were conducted in Diyarbakir province according to Randomized Complete Block Design in 2017 and 2019 years. The result of mean of two years showed that the highest grain yield was obtained from KA-08-09-1 (4361 kg $ha^{-1}$) however, the lowest grain yield was obtained from KA-08-09-2 lines (3023 kg $ha^{-1}$). Additionally, the lowest oil ratio was obtained from the Blaze cultivar (22.4%), while the highest oil ratio was obtained from KA-08-09-2 line (24.0%). According to GGE biplot analysis of traits and genotypes, the advanced line KA-08-09-1 and Blaze cultivar had the largest values for grain yield, number of pods and thousand grain weight. As conclusion, the result of two years of the study indicated that the candidate line (KA-08-09-1) had good results, therefore application for registration was made to the Seed Registration and Certification Directorate in 2021.

**Key words:** GGE biplot, Diyarbakır, Quality, Türkiye.

## Introduction

Soybean (*Glycine max L.*) is the world's foremost provider of high-quality protein and edible oil for both humans and animals (Morsy *et al*., 2015). The soybean cultivation area was 127 million hectares, production was 353 million tons and the yield was 2784 kg $ha^{-1}$ in the world in 2020 (Anon., 2022). Besides, in Türkiye, the soybean cultivation was 35134 ha, production was 155225 tons and the yield was 4420 kg $ha^{-1}$ in 2020. Moreover, in Diyarbakır, the soybean cultivation was 169 ha, production was 755 tons and the yield was 4480 kg $ha^{-1}$ in 2020 (Anon., 2021). Although it has high production and consumption in the world, soybean production did not reached to desired levels in Türkiye, where large acreage potential as the first and second crop exists. Whenever these areas are cultivated with appropriate soybean varieties, it may contribute to closing our quality feed and vegetable oil gap.

Soybean consumption in Türkiye has reached 1.8 million tons recently. However, only 9% of the consumption is met by local production (Yilmaz *et al*., 2019). The production of soybean, which may play a key role in the development of the agricultural industry, thus it should be increased its production.

Soybean production is affected by the biotic and abiotic environments. Thus, the adaptability and stability of a genotype grown should be known (Kocaturk *et al*., 2019). Genotype × feature biplots provide an easy way to visualize the relation between features and germplasm accessions. Thus, this is a good tool to help breeders rapidly select the desired genotypes based on features (Kuo *et al*., 2021). The GGE biplot could be used to interpret the relationships among genotypes, traits, and groups of traits (Kendal *et al*., 2016; Karaman, 2020). The use of established multivariate statistical algorithms is an important strategy for classifying germplasm, ordering variability for a large number of accessions, or analyzing genetic relationships among traits in any breeding material (Iqbal *et al*., 2008).

Domestic soybean production in Türkiye is at a very low level and thus most of the demand is compensated by importation. Expanding soybean cultivation in Türkiye is of great importance. Due to this deficiency, it is important to develop high yielding soybean varieties in Türkiye. In addition, determining the relation between seed yield and yield components can guide breeding studies. Aim of this study was to develop high yielding new soybean cultivars suitable for the main crop conditions.

## Material and Methods

The research was conducted in 2017 and 2019, with Randomized Complete Block Design in the trial field of 'GAP International Agricultural Research and Training Center' in Diyarbakır/Türkiye. The experiments were arranged according to Randomized Complete Block Design with three replications in 2017 and four replications in 2019. The study area was located on the 37°56' Northern Latitudes and 40°15' Eastern Longitudes. The information on the genotypes used in the study is given in Table 1 and the meteorological results of the place where the study was carried out are given in Table 2. The soil samples were taken from 0-30 cm depth of trial field and they were analyzed for some chemical and physical properties. The trial soil was in clay loamy structure, lightly alkali (pH 7.65), medium limy (11.72% CaCO3), slightly salty (0.144%), poor in phosphorus ratio (33 kg $ha^{-1}$) and contains low organic material (1.0%) (Table 3).

Soybean seeds were sown with a seeder as taking place 50 plants per square meter on dates 12.05.2017 and 21.05.2019. Each plot consisted of 4 rows and 5 m long. Inter-row spacing was 70 cm and inter-row spacing was 4 cm. Lines of each plot were harvested mechanically for the grain yields on date of 17.10.2017 and 08.10.2019.

Seeds were not inoculated with *Rhizobium japonicum* bacteria and total base fertilizer application per hectare in pure forms were 127 kg nitrogen (N) and 100 kg phosphorus ($P_2O_5$). 27 kg per hectare of the nitrogen and the whole of the phosphorous were applied to the trial field before planting in DAP (Di ammonium phosphate)

which contains 18% N and 46% $P_2O_5$ form. The remaining 100 kg $ha^{-1}$ pure nitrogen was applied when plants were 30 cm tall. The irrigation was performed with sprinkler system until the plants were 30 cm tall, and after, the furrow irrigation method was started to be used. Irrigation was made 8 times in both years. In the study, protein ratio and oil ratio were determined by using NIT (Near-Infrared Transinittance) device, because of gives results soon by reading quality data directly from grain. Approximately 700 grams of unground sample taken from each plot was filled into the NIT container and analyzed. Analysis of variance across was calculated for each trait and LSD (Least significant difference) test was applied to match the variations (Steel & Torrie, 1980).

## Results and Discussion

Significant differences among the genotypes were determined in terms of the plant height, the grain yield, the oil ratio and the thousand-grain weight (Tables 3, 4 and 5). There were no significant differences among the genotypes in terms of the first pod height in 2017 and in a two-year mean (Tables 3 and 5) whereas significant differences between the genotypes were determined in 2019 (Table 4). There were no significant differences among the genotypes in terms of the pods number per plant in 2017 and 2019 (Tables 3 and 4) whereas in a two-year mean, significant differences among the genotypes were determined (Table 5). Significant differences among the genotypes were determined in terms of the protein ratio in 2019 and in a two-year mean (Tables 4 and 5) whereas no significant differences between the genotypes were determined in 2017 (Table 3).

The lowest plant height was obtained from KA-08-09-1 line (111.7 cm ) while the highest was obtained from UMUT-2002 cultivar (155.5 cm) in 2017 (Table 4). The lowest plant height was obtained from Samsoy (89.5 cm ) while the highest was obtained from SA-88 cultivars (112.5 cm) in 2019 (Table 5). In a two-year mean, the lowest plant height was obtained from KA-08-09-1 line (103.3 cm) while the highest was obtained from SA-88 cultivar (126.3 cm) (Table 6). Moreover, Bakal *et al*., (2017) reported that plant height ranged from 103.3 cm to 135.80 cm in Adana province. Besides, our results have also showed similarity with their findings.

The lowest first pod height was obtained from Samsoy cultivar (7.5 cm) while the highest was obtained from KA-08-09-2 line (15.7 cm) in 2019 (Table 5). Karaaslan *et al*., (2011) reported first pod height ranged from 12.0 cm to 19.3 cm in the main crop conditions in Diyarbakir province.

**Table 1. Soybean lines and cultivars studied.**

| Line codes | Pedigree | Breeding organization/variety owner | Genotypes were cultivated |
|---|---|---|---|
| KA-08-03-1 | (Sprite 87 x Apollo) x Charleston | GAP International Agricultural Research and Training Center | in both years |
| KA-08-09-1 | (Macon x Apollo) x Atakişi | | |
| KA-08-09-2 | (Macon x Apollo) x Atakişi | | |
| KA04-03-05 | (NE3297 x Apollo) | Black Sea Agricultural Research Institute | in the second year |
| SO2-14-11 | (Macon x Defrance) | | |
| Registered varieties: Arısoy, Blaze, Bravo, SA-88 | | | in both years |
| Registered varieties: Umut-2002, Gapsoy-16, May 5312 | | | in the first year |
| Registered variety: Samsoy | | | in the second year |

**Table 2. Long-term and 2017-2019 climatic data of Diyarbakır province (Anon., 2019).**

| | Years | Months | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | April | May | June | July | August | September | October |
| Average temperature (°C) | 2017 | 12.8 | 18.8 | 26.9 | 32.3 | 31.1 | 26.8 | 17.2 |
| | 2019 | 11.8 | 20.2 | 28.3 | 30.4 | 31.0 | 25.2 | 19.1 |
| | Long Term | 13.8 | 19.3 | 26.3 | 31.2 | 30.3 | 24.8 | 17.2 |
| Average max. temperature (°C) | 2017 | 19.5 | 26.3 | 35.0 | 40.7 | 39.9 | 36.4 | 24.8 |
| | 2019 | 17.8 | 28.3 | 37.0 | 37.9 | 38.9 | 33.4 | 27.7 |
| | Long Term | 20.2 | 26.5 | 33.7 | 38.4 | 38.1 | 33.2 | 25.2 |
| Precipitation (mm) | 2017 | 98.8 | 30.6 | 2.6 | 0.0 | 0.0 | 0.0 | 22.0 |
| | 2019 | 152.6 | 45.8 | 1.0 | 0.0 | 0.0 | 0.4 | 52.0 |
| | Long Term | 68.7 | 41.3 | 7.9 | 0.5 | 0.4 | 4.1 | 34.7 |
| Average humidity (%) | 2017 | 68.5 | 57.6 | 30.0 | 19.4 | 22.8 | 22.3 | 39.2 |
| | 2019 | 78.3 | 58.0 | 32.0 | 24.8 | 25.2 | 27.9 | 50.9 |
| | Long Term | 63.0 | 56.0 | 31.0 | 27.0 | 28.0 | 32.0 | 48.0 |

**Table 3. Soil properties of trial areas.**

| Structure | Total salty (%) | pH | Lime CaCo3 (%) | Organic matter (%) | Phosphor (P2O5) (kg $ha^{-1}$) |
|---|---|---|---|---|---|
| Clay loamy | 0.144 | 7.65 | 11.72 | 1.00 | 33 |

**Table 4. Average values and groups of soybean genotypes at 2017 growing seasons.**

| Genotypes | Plant heigt (cm) | First pod height (cm) | Number of pods per plant | Grain yield (kg ha$^{-1}$) | Oil ratio (%) | Protein ratio (%) | Thousand grain weight (g) |
|---|---|---|---|---|---|---|---|
| KA-08-09-1 | 111.7 e | 11.1 | 72.3 | 3936 a | 23.8 ab | 37.9 | 148.4 bc |
| KA-08-03-1 | 130.8 bcd | 9.2 | 69.3 | 3254 bc | 23.2 b | 37.8 | 139.9 cd |
| KA-08-09-2 | 137.5 bc | 11.7 | 59.8 | 2818 c | 24.6 a | 36.3 | 126.2 e |
| Arısoy | 132.5 bcd | 12.8 | 64.4 | 3714 ab | 23.9 ab | 37.4 | 137.5 cde |
| Blaze | 117.5 de | 13.3 | 72.0 | 3885 ab | 23.3 b | 37.8 | 147.8 bc |
| Bravo | 122.3 cde | 11.1 | 61.5 | 3517 ab | 23.5 b | 38.8 | 141.6 cd |
| Gapsoy-16 | 139.5 ab | 7.8 | 70.9 | 3778 ab | 23.3 b | 37.2 | 168.4 a |
| May 5312 | 116.0 de | 12.2 | 74.8 | 4006 a | 24.7 a | 36.9 | 149.5 bc |
| SA-88 | 140.0 ab | 9.9 | 65.5 | 3433 abc | 23.4 b | 36.9 | 131.4 de |
| UMUT-2002 | 155.5 a | 11.7 | 59.4 | 3246 bc | 23.9 ab | 36.9 | 156.3 ab |
| Avergae | 130.3 | 11.1 | 66.9 | 3559 | 23.8 | 37.4 | 144.7 |
| CV | 7.51 | 18.6 | 9.61 | 10.5 | 2.3 | 2.8 | 5.1 |
| LSD | 16.79 ** | ns | ns | 64.06 * | 0.93 * | ns | 12.65 ** |

ns: None significant, * Significant at 0.05 level, **: Significant at 0.01 level

**Table 5. Average values and groups of soybean genotypes at 2019 growing seasons.**

| Genotypes | Plant heigt (cm) | First pod height (cm) | Number of pods per plant | Grain yield (kg ha$^{-1}$) | Oil ratio (%) | Protein ratio (%) | Thousand grain weight (g) |
|---|---|---|---|---|---|---|---|
| KA-08-09-1 | 95.0 cd | 11.0 bcd | 60.7 | 4787 a | 22.3 d | 36.5 ab | 154.6 a |
| KA-08-03-1 | 100.3 bc | 11.0 bcd | 61.3 | 3933 bc | 22.5 d | 36.6 ab | 133.7 cde |
| KA-08-09-2 | 108.3 ab | 15.7 a | 58.0 | 3227 cd | 23.3 ab | 35.3 bc | 126.6 de |
| KA04-03-05 | 111.0 a | 13.8 ab | 55.5 | 3481 bcd | 23.1 bc | 34.1 c | 144.8 abc |
| SO2-14-11 | 90.3 cd | 12.5 abc | 55.5 | 3088 d | 23.8 a | 35.4 abc | 150.6 ab |
| Arısoy | 109.5 ab | 9.5 cd | 57.1 | 4263 ab | 22.6 cd | 37.0 a | 139.6 bcd |
| Blaze | 94.3 cd | 11.3 bcd | 61.6 | 4302 ab | 21.5 e | 36.6 ab | 145.6 abc |
| Bravo | 99.5 bcd | 9.9 cd | 54.1 | 2948 d | 22.8 bcd | 35.7 ab | 130.4 de |
| SA-88 | 112.5 a | 13.0 abc | 56.9 | 4141 ab | 22.4 d | 35.9 ab | 125.7 e |
| Samsoy | 89.5 d | 7.5 d | 54.9 | 2768 d | 22.8 bcd | 35.8 ab | 137.2 cde |
| Avergae | 101.0 | 11.5 | 57.5 | 3694 | 22.7 | 35.9 | 138.8 |
| CV | 7.1 | 22.5 | 9.3 | 15.6 | 1.90 | 3.03 | 6.5 |
| LSD | 10.4 ** | 3.75 ** | ns | 83.7 ** | 0.64 ** | 1.57 * | 13.1 ** |

ns: None significant, * Significant at 0.05 level, **: Significant at 0.01 level

In a two-year mean, the highest pods per plant was obtained from Blaze cultivar (66.8) and KA-08-09-1 line (66.5) whereas the lowest pods per plant Bravo cultivar (57.8) (Table 6). On the other hand, Mert & Ilker (2016) reported that lower pods number per plant ranged from 36.33 to 48.33 in the main crop growing conditions in Aksaray province. Moreover, Kahraman *et al*., (2014) reported that pods number per plant ranged from 49.58 to 64.40 in the main crop growing conditions in Diyarbakir province.

The highest average grain yield was obtained from May 5312 cultivar (4006 kg ha$^{-1}$) and KA-08-09-1 (3936 kg ha$^{-1}$) whereas the lowest was obtained from KA-08-09-2 line (2818 kg ha$^{-1}$) in 2017 (Table 4). The highest average yield was obtained from KA-08-09-1 line (4787 kg ha$^{-1}$) while the lowest average yield was obtained from Samsoy cultivar (2768 kg ha$^{-1}$) in 2019 (Table 5). In a two-year mean, the highest average yield was obtained from KA-08-09-1 (4361 kg ha$^{-1}$) while the lowest average yield was obtained from KA-08-09-2 lines (3023 kg ha$^{-1}$) (Table 6). Bakal *et al*., (2017) reported that higher yield ranged from 4288 kg ha$^{-1}$ to 5377 kg ha$^{-1}$. Sincik *et al*., (2008) reported that lower yield ranged from 2100 kg ha$^{-1}$ to 2483 kg ha$^{-1}$ in Bursa province. Kahraman *et al*., (2014) reported that lower yield ranged from 2514.3 to 3781.8 kg ha$^{-1}$ in Diyarbakir province. Arslan *et al*., (2018) reported grain yield ranged from 2044.3 kg ha$^{-1}$ to 2950.0 kg ha$^{-1}$ (in 2012) and ranged from 2892.9 kg ha$^{-1}$ to 4464.3 kg ha$^{-1}$ (in 2013) in main crop conditions in Sanlıurfa province. Karaaslan *et al*., (2011) reported that lower yield ranged from 2130 kg ha$^{-1}$ to 3438 kg ha$^{-1}$ in Diyarbakir province. Tayyar & Gul (2007) reported that lower yield ranged from 1890 kg ha$^{-1}$ to 3302 kg ha$^{-1}$ in Biga. Mert & Ilker (2016) reported that yield ranged from 2810 kg ha$^{-1}$ to 4980 kg ha$^{-1}$ in Aksaray province. Besides, our results have also showed partly similarity with their findings. In addition, the average and average maximum temperatures during the growing season of 2017 (July, August and September) were higher than those of 2019 (Table 2) and the higher temperatures may have resulted lower grain yields of the genotypes (except the bravo variety) in 2017.

The lowest oil ratio was obtained from KA-08-03-1 line (23.2%) while the highest oil ratio was obtained from May 5312 cultivar (24.7%) in 2017 (Table 4). The lowest oil ratio was obtained from Blaze cultivar (21.5%) while the highest oil ratio was obtained from SO2-14-11 line (23.8%) in 2019 (Table 5). In a two-year mean, the lowest oil ratio was obtained from Blaze cultivar (22.4%) while the highest oil ratio was obtained from KA-08-09-2 line (24.0%) (Table 6). On the other hand, Kahraman *et al*., (2014) reported that oil conten ranged from 20.10% to 22.15% in the main crop conditions in Diyarbakir province. Karaaslan *et al*., (2011) reported that oil ratio ranged from 19.57% to 22.61% in the main crop conditions in Diyarbakir. Demir (2021) reported that oil conten ranged from 21.45% to 26.6% in a semi-arid region crop conditions. Differences may be due to environmental conditions, different genotypes used, from the oil analysis method and applications.

**Table 6. Average values and groups of soybean genotypes in two-year mean growing seasons.**

| Genotypes | Plant heigt (cm) | First pod height (cm) | Number of pods per plant | Grain yield (kg ha$^{-1}$) | Oil ratio (%) | Protein ratio (%) | Thousand grain weight (g) |
|---|---|---|---|---|---|---|---|
| KA-08-09-1 | 103.3 d | 11.0 | 66.5 a | 4361 a | 23.1 b | 37.2 a | 151.5 a |
| KA-08-03-1 | 115.5 bc | 10.2 | 65.3 ab | 3594 cd | 22.8 bc | 37.2 a | 136.8 cd |
| KA-08-09-2 | 122.9 ab | 13.9 | 58.9 bc | 3023 e | 24.0 a | 35.8 b | 126.4 e |
| Arısoy | 121.0 ab | 10.9 | 60.8 abc | 3989 abc | 23.2 b | 37.2 a | 138.5 bc |
| Blaze | 105.9 cd | 12.1 | 66.8 a | 4093 ab | 22.4 c | 37.2 a | 146.7 ab |
| Bravo | 110.9 cd | 10.4 | 57.8 c | 3232 de | 23.2 b | 37.3 a | 136.0 cd |
| SA-88 | 126.3 a | 11.7 | 61.2 abc | 3787 bc | 22.9 bc | 36.4 ab | 128.6 de |
| Average | 115.1 | 11.5 | 62.5 | 3726 | 23.1 | 36.9 | 137.8 |
| CV | 7.80 | 20.5 | 8.56 | 11.80 | 1.90 | 2.57 | 5.59 |
| LSD | 9.90 ** | ns | 6.75 * | 48.49 ** | 0.48 ** | 1.05 * | 8.49 ** |

ns: None significant, * Significant at 0.05 level, **: Significant at 0.01 level

**Table 7. Correlation coefficients among the inspected features in two-year mean.**

| | Grain yield | Plant heigt | First pod height | Number of pod per plant | 1000 grain weight | Oil ratio |
|---|---|---|---|---|---|---|
| Plant heigt | -0.288* | | | | | |
| First pod height | 0.1617 | 0.1345 | | | | |
| Number of pod per plant | 0.0712 | 0.2202 | -0.0832 | | | |
| 1000 grain weight | 0.637** | -0.1432 | 0.0633 | 0.2687 | | |
| Oil ratio | -0.585** | 0.588** | 0.0449 | 0.2066 | -0.349* | |
| Protein ratio | 0.324* | 0.2724 | -0.0400 | 0.438** | 0.576* | -0.0615 |

*Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level

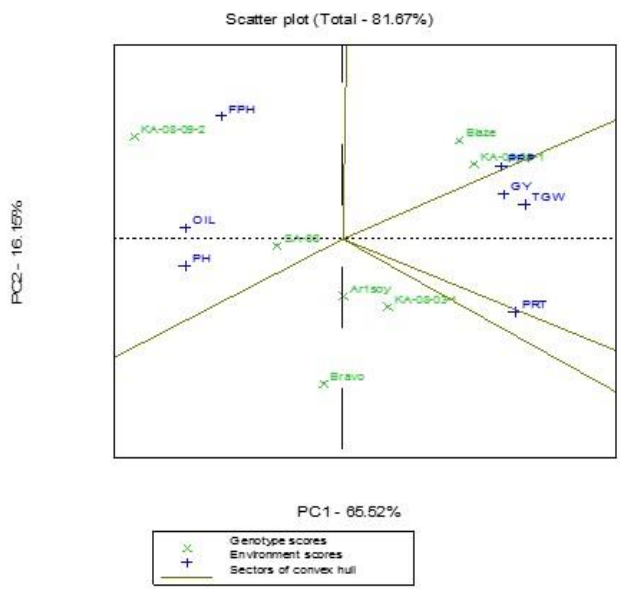


Fig. 1. The GGE biplot graph showing among the genotypes and the inspected features (in two-year mean).

Many researchers have stated that there is a positive relationship between the vectors of two traits as the angle value (>0-<90º) gets narrower, and a negative relationship as the angle value (90º>-<180º) increases (Mohammadi & Amri, 2011). As in all research, many statistical models and programs are used to evaluate the data obtained from agricultural research (Kendal, 2019).

The lowest protein ratio was obtained from KA04-03-05 line (34.1%) while the highest protein ratio was obtained from Arısoy cultivar (37.0%) in 2019 (Table 5). In a two-year mean, the lowest protein ratio was obtained from KA-08-09-2 line (35.8%) while the highest protein ratio was obtained from Bravo cultivar (37.3%) (Table 6). Moreover, Bakal et al. (2017) reported that the protein ratio ranged from 35.0% to 37.6% in the main crop growing in Adana province. Sincik *et al*., (2008) reported that the protein ratio ranged from 35.5% to 39.2% in the main crop conditions in Bursa province. Besides, our results have also showed similarity with their findings.

The lowest thousand-grain weight was obtained from KA-08-09-2 (126.2 g) while the highest was obtained from Gapsoy-16 cultivar (168.4 g) (Table 4). The lowest thousand-grain weight was obtained from SA-88 cultivar (125.7 g) while the highest was obtained from KA-08-09-1 line (154.6 g) in 2019 (Table 5). In a two-year mean, the lowest thousand grain weight was obtained from KA-08-09-2 (126.4 g) while the highest was obtained from KA-08-09-1 lines (151.5 g) (Table 6). On the other hand, Mert & Ilker (2016) reported that lower thousand grain weight ranged from 106.89 g to 144.58 g in the main crop conditions in Aksaray province. Sincik *et al*., (2008) reported that higher thousand grain weight ranged from 135.5 g to 162.7 g. in conditions in Bursa province.

A correlation analysis was conducted to determine the relationship among the yield of soybean genotypes and all other parameters (Table 7). It was determined that there were positive and significant relationships among the grain yield and the thousand grain weight and the protein ratio whereas there were negative and significant relationships among the grain yield and the plant height and the oil ratio. Moreover, there were positive and significant relationships among the oil ratio and the plant height while there were negative and significant relationship among the oil ratio and the thousand grain weight. Ozkan *et al*., (2019) reported that statistically significant positive relationships was found between the grain yield and the thousand grain weight.

As can be seen in the Figure 1, the traits that are positively related to each other are gathered in a sector. Grain yield (GY), number of pod (PPP) and thousand grain weight (TGW) which had a positive relationship, in the same sector. KA-08-09-1 line and Blaze cultivar in the same sector came to the forefront in terms of these traits by being located within the sector. Morewer, positive correlation was found between protein ratio (PRT) and grain yield (GY), number of pod (PPP) and thousand grain weight (TGW). KA-08-09-1, KA-08-03-1 lines Blaze, Bravo and Arısoy cultivars had higher protein ratio (PRT) than other genotypes. Additionally, among the traits, such as plant height (PH), oil ratio (OIL) and first pod height (FPH) formed in a sector where these three traits are positively related. KA-08-09-2 line had higher oil ratio (OIL) and first capsule height (FPH) than other genotypes. SA-88 and Arısoy varieties located in the center of Figure 1, therefore they had to the close average of traits.

## Conclusion

Domestic soybean production in Türkiye is at a very low level and thus most of the demand is compensated by importation. For this purpose, in this study, the KA-08-09-1 line had high values in terms of grain yield, protein ratio, number of pods and thousand-grain weight. Therefore, the result of two years of study the indicated that the candidate line (KA-08-09-1) had significant results, therefore application for registration was made to the Seed Registration and Certification Directorate in 2021.

## Acknowledgments

This work was supported by General Directorate of Agricultural Research and Politicies. (Project No: TAGEM/TBAD/14/A04/P01/06-2).

### References

Anonymous. 2019. Turkish State Meteorological Service: Meteorological Data Information Sales and Presentation System.

Anonymous. 2021. *https://biruni.tuik.gov.tr/medas/?kn=92*, (Accessed August 24, 2021)

Anonymous. 2022. *https://www.fao.org/faostat/en/#data/QCL*, (Accessed March 10, 2022)

Arslan, H., M. Karakuş, H. Hatıpoglu, D. Arslan and Ö.V. Bayraktar. 2018. Assessment of performances of yield and factors affecting the yield in some soybean varieties/lines grown under semi-arid climate conditions. *Applıed ecology and env. res.*, 16(4): 4289-4298.

Bakal, H., L. Gulluoglu, B. Onat and H. Arioglu. 2017. The Effect of growing seasons on some agronomic and quality characteristics of soybean varieties in mediterranean region in Turkey. *Turk J. Field Crops*, 22(2): 187-196.

Demir I. 2021. Relationship between photosynthetic pigments and seed yield components in soybean cultivars in a semi-arid region *Pak. J. Bot.*, 53(3): 859-863.

Iqbal, Z., M. Arshad, M. Ashraf, T. Mahmood and A. Waheed. 2008. Evaluation of soybean [*Glycine max* (L.) Merrill] germplasm for some important morphological traits using multivariate analysis. *Pak. J. Bot*., 40(6): 2323-2328.

Kahraman, S., D. Karaaslan, S. Aytac and M. Erdogmus. 2014. Determination of some soyabean lines yield and quality components grown as a main crop ın diyarbakır conditions. *International Mes. Agri. Cong*., 22-25 September, Diyarbakır. S, 456-460.

Karaaslan, D., A.N. Nazlıcan and A. Hatipoglu. 2011. The potential of different soybean lines in diyarbakır conditions. *Agri. Cong.*, 09-12 May 2011, Sanlıurfa, 309-313.

Karaman, M. 2020. Evaluation of the physiological and agricultural properties of some of bread wheat (*Triticum aestivum* L.) genotypes registered in Turkey using biplot analysis. *Pak. J. Bot*., 52(6): 1989-1997.

Kendal, E. 2019. Comparing durum wheat cultivars by genotype× yield× trait and genotype× trait biplot method. *Chilean J. of agric. research*, 79(4): 512-522.

Kendal, E., M.S. Sayar, S. Tekdal, H. Aktas and M. Karaman 2016. Assessment of the impact of ecological factors on yield and quality parameters in triticale using GGE biplot and AMMI analysis. *Pak. J. Bot.*, 48(5): 1903-1913.

Kocaturk, M., P. Cubukçu, A.T. Goksoy, M. Sincik, E. Ilker, A. Kadiroglu, Y. Vurarak, Y. Sahin., M. Karakuş and U.A. Yildirim. 2019. GGE biplot analysis of genotype × environment interactıon in soybean grown as a second crop. *Turk. J. of Field Crops*, 24(2): 145-154.

Kuo, H.I., H.Y. Dai, Y.P. Wu and Y.C.T. Seng. 2021. Germplasm evaluation for agronomic traits and disease resistance under a two-season cropping system in Taiwan. *Agri.*, 11(12): 1277.

Mert, M. and E. İlker. 2016. Studies on adaptation abilities of some soybean (*Glycine max* (L.) Merill) varieties and lines under main crop conditions of aksaray region. *J. of Cen. Res. Ins. for Field Crops*, 25 (2): 176-181.

Mohammadi, R. and A. Amri. 2011. Graphic analysis of trait relations and genotype evaluation in durum wheat. *J. of Crop Imp.*, 25(6): pp. 680-696.

Morsy, A.R., W.M. Fares, S.B. Ragheb and M.A. Ibrahim. 2015. Stability analysis of some soybean genotypes using a simplified statistical model. *J. Plant Produc, Mansoura Univ*., 6 (12): 1975-1990.

Ozkan, R., M. Bayhan, O. Albayrak, D. Karaaslan and M. Yildirim. 2019. Second crop potential of soybean lines for Diyarbakır location on the yield and quality. *Int. J. Agric. Environ. Food Sci*., 3(3): 121-126.

Sincik, M., H.S. Oral, A.T. Goksoy and Z.M. Turan. 2008. Determination of some yield and quality characters of different soybean (*Glycine max* L. Merr.) lines under bursa ecological conditions. *J. of Agri. Facul. of Uludag Univ.*, 22(1): 55-62.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. A biometrical approach. 2nd edition. *McGraw-Hill, New York, USA*, pp. 20-90.

Tayyar, Ş. and M.K. Gul. 2007. Performances of some soybean (*Glycine max* (L.) Merr.) genotypes as main crop in biga conditions. *Yuzuncu Yil Uni. J. Agri. Sci*., 17(2): 55-59.

Yilmaz, H., P. Cubukcu, M. Gul, A.K. Sahar and M.G. Akpınar. 2019. Development in soybean production and foreign trade in Turkey. *Interna. J. of Agri, For. and Life Sci*., 3(1): 84-88.

(Received for publication 27 June 2022)