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# Determination of yield and quality characteristics of some sugar beet (*Beta vulgaris* L.) varieties by different analytical methods

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## Abstract

Sugar beet is known globally as one of the most important sources of sucrose. Sugar beet, which provides raw materials to many industries, creating an important employment opportunity in the regions where it is cultivated. In this study, yield and quality parameters of eight different sugar beet varieties were determined by different analytical methods. The experiment was carried out in 2024 at the experimental field of the Faculty of Applied Sciences, Muş Alparslan University, utilizing a randomized block design with three replications. Following a seven-month vegetative period, yield and quality analysis of the harvested beets were carried out, allowing for the determination of relationships between variety and traits. Statistically significant and important differences were found among the sugar beet varieties in terms of the parameters analyzed. Notably, the Lamberta variety came to the forefront in terms of storage root yield parameters (root weight, root length, single plant weight). Consequently, this variety displayed the highest average root yield compared to other varieties. While the Agatella variety demonstrated high averages for dry matter content and polar sugar content, it exhibited lower storage root and sugar yields. These findings suggest a negative correlation between sugar content and storage root yield and sugar yield. Overall, the Lamberta variety stood out in terms of root yield, while the Annamira variety stood out in terms of sugar yield. As a result of the research, sugar beet varieties varied between root diameters of 9.11-15.41 cm, root lengths of 15.34-18.43 cm, root weights of 646-2892 g, dry matter content of 20.87-24.40%, polar sugar content of 16.68-19.41%, root yields of 5196-8229 kg/da, and sugar yields of 908-1348 kg/da. According to the “which-where-won” model of GGE biplot analysis, the studied traits were clustered under 3 mega environments.

**Keywords:** Sugar beet, Yield traits, GGE biplot, ANOVA, *Beta vulgaris* L.

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## INTRODUCTION

Sugar beet is a root crop cultivated in temperate climates and known as a source of sucrose. Sucrose accumulates most abundantly in the transversely expanding root of vegetatively mature plants. Sugar beet (*Beta vulgaris* L.) is a plant belonging to the genus Beta in the Caryophyllales order of the Amaranthaceae family. Sugar beet possess either a diploid (2n=2x=18) and triploid (2n=3x=27) chromosome structure. Most of the hybrid varieties grown economically have diploid or triploid chromosome structure (Peto and Boyes, 1940). Most currently cultivated varieties of foutcrossed sugar beet are hybrids developed through cytoplasmic male sterility (CSM) (Mikami et al., 2011).

The continuous growth in the world population and advancements in technology have elevated the importance of sugar as key food product. Globally, sugar cane and sugar beet are the primary plant-based sources of sucrose. Sugar beet, which serves as a raw material for many industries due to its versatile applications, is a strategic crop in the agricultural systems of approximately 52 countries in the world (Stevanato, 2019). It is generally planted in the spring season, and its vegetative period varies between 5-9 months, depending on regional ecological factors (Zicari et al., 2019). Roots of sugar beet are rich in carbohydrates and hemicellulose, as well as having a high soluble sugar content. The pulp produced from the roots after sugar extraction is used as a valuable animal feed (Cardenaz-Fernandez et al., 2017). Molasses is also used in the production of bioethanol, vinegar, ethyl alcohol, sourdough, pharmaceuticals, and cosmetics (Pavlečić et al., 2010; Šantek et al., 2010; Yalınkılıç et al., 2024). The readily fermentable sucrose content in sugar beet facilitates the fermentation of various products (Gunes et al., 2004).

In Türkiye, sugar beet has an important place in the agricultural systems. It contributes both to the agricultural industry and animal nutrition with its by-products. Approximately 19 million tons of sugar beet production is carried out on an area of 3 million ha (TUIK, 2023). The key provinces with the highest production are Konya, Yozgat, and Kayseri, respectively (Anonymous, 2023). A primary objective of sugar beet farming is to maximize root yield per unit area. Additionally, achieving high sugar content in the roots is crucial for successful sugar beet production (Yalinkilic et al., 2024). Identifying varieties that exhibit high root yield and sugar content and are well-suited to the region’s ecological conditions is crucial for meeting the demands of both producers and sugar factories (Ozcan, 1993).

In scientific studies, visual representation of the performance of examined traits or genotypes is crucial, and it provides valuable insights into genotype characteristics (Yan and Tinker, 2006; Baran, 2025). In recent years, GGE biplot analysis has been known as one of the most important methods for the visual interpretation of bidirectional data (Akcura, 2011; Andırman & Baran 2023).

This study was carried out to compare the yield and quality traits of eight genetic monogerm sugar beet varieties using different statistical methods and to determine the varieties with superior performance in terms of the traits examined.

## MATERIALS AND METHODS

This study was carried out at the Research and Experimental field of the Faculty of Applied Sciences, Muş Alparslan University, in 2024 with three replications according to the randomized blocks experimental design. Soil properties of the experimental area are given in Table 1.

**Table 1.** Soil properties of the experimental area

| Depth (cm) | Composition Class | In Water Saturated Soil EC ($dSm^{-1}$) | In Water Saturated Soil pH | Lime (%) | Organic Matter (%) | Available Phosphorus ($P_2O_5$) (kg $da^{-1}$) |
|---|---|---|---|---|---|---|
| 0-30 | Clay-loamy | 0.61 | 7.76 | 1.61 | 2.21 | 2.20 |

The soil in the test area have a clayey-loamy texture. The pH value is 6.61, the available phosphorus is 2.20 kg/da, and organic matter content is 2.21% (Table 1).

The study used genetic monogerm sugar beet varieties such as Orthega, Preziosa, Allanya, Agatella, Lamberta, Annamira, Ludmilla and Anchana. These varieties were developed by KWS company in Germany and are widely used in Türkiye. The general characteristics of the sugar beet varieties constituting the plant material of the study are given in Table 2.

**Table 2.** Characteristics of sugar beet varieties used as material in the experiment

| Variety Name | Origin | Scientific Name | Distinguishing feature |
|---|---|---|---|
| Orthega | Germany | *Beta vulgaris* L. | Suitable for machine harvesting. High root and sugar yield. |
| Preziosa | Germany | *Beta vulgaris* L. | It has very high root and sugar yield. |
| Allanya | Germany | *Beta vulgaris* L. | It is a variety with very high root and sugar yield. |
| Agatella | Germany | *Beta vulgaris* L. | It has high sugar content. |
| Lamberta | Germany | *Beta vulgaris* L. | It is easy to uproot as it is smooth shaped and has high root yield. |
| Annamira | Germany | *Beta vulgaris* L. | It has high root yield and good sugar content. |
| Ludmilla | Germany | *Beta vulgaris* L. | It has high polar sugar content and is suitable for machine harvesting. |
| Anchana | Germany | *Beta vulgaris* L. | Suitable for machine harvesting. It has high root yield. |

The trial area was plowed about 25-30 cm with a plow in the fall season and the necessary field preparations were completed in the spring. Sowing began on April 18 for the 2024 sugar beet growing season, and harvesting was completed on October 20. The study, which was carried out in three replications using a random blocks experimental design, the distance between rows was kept into 20 cm intervals and the distance between rows into 45 cm intervals. The length of each plot, consisting of four rows was designed as 4 meters and the distance between the blocks was designed as 2 meters intervals. In the experiment, 25 kg of compound beet fertilizer (13-18-15+2MgO+10SO3+ME) was applied per decare as base fertilizer, and the other part of nitrogen was applied as 25 kg per decare at the second plowing. Necessary maintenance procedures were applied to the experimental area throughout the growing season. During the harvest period, observations were taken from the middle two rows of the plots. Root weight (g), root length (cm), root diameter (cm), single plant weight (g) (root + leaf) of twenty randomly selected plants were measured. Root yield was calculated in kg/ha by cutting the leaves of the plants in each plot, cleaning the roots, and weighing their weights. Sugar yield was calculated by multiplying root yield and sugar content and dividing the result by 100 (Ozceylan, 1986). After 20 beet roots taken randomly from each plot were cleaned and ground, the sample beet juice was cooled to 20 °C and dry matter ratios were calculated as Brix in a refractometer. For the determination of polar sugar content, beet samples were pulped according to the cold digestion method, and samples weighing approximately 24-26 g were mixed in 178.2 ml of 0.3% aluminum sulfate solution, then filtered and read on a polarimeter (Kavas and Leblebici, 2004).

Climate data for 2024 are given in Table 3. Rainfall after sowing sugar beet seeds is an important factor for seed germination and plant growth. When the sugar beet growing period of the region is examined, it is seen that the highest rainfall occurs in April and May. Rainfall in April and May meets the early water needs of the plant and does not require farmers to irrigate additionally. Monthly mean air temperature during the sugar beet growing season was similar to the long-term annual mean temperature. In this respect, the highest temperatures occurred in July and August. In addition, the average temperature being around 10 $^0$C in April had a positive effect on the germination of sugar beet.

**Table 3.** Meteorological data of Muş province for the 2024 season

| Months | Average Precipitation (mm) | | Average Temperature (°C) | | Average Relative Humidity (%) | |
|---|---|---|---|---|---|---|
| | Years | | Years | | Years | |
| | 1964-2024 (Multi-year) | 2024 | 1964-2024 (Multi-year) | 2024 | 1964-2024 (Multi-year) | 2024 |
| April | 101.6 | 48.8 | 9.3 | 11.6 | 62.1 | 54.9 |
| May | 69.9 | 126.4 | 14.8 | 13.5 | 58.7 | 64.3 |
| June | 26.5 | 6.4 | 20.2 | 21.1 | 45.2 | 43.4 |
| July | 7.6 | 7.2 | 25.0 | 25.8 | 33.9 | 23.2 |
| August | 5.6 | 0.4 | 25.1 | 26.4 | 30.9 | 17.3 |
| September | 15.6 | 40.2 | 20.2 | 21.4 | 35.5 | 25.6 |
| October | 62.5 | 43.8 | 12.8 | 15.2 | 56.0 | 45.4 |
| November | 87.4 | 61.4 | 4.8 | 6.7 | 68.1 | 73.7 |
| **Total** | **376.7** | **334.6** | - | - | - | - |

**Source:** General Directorate of Meteorology -2024

The data obtained from the study were analyzed using JMP (13.0.1 pro) and the GenStat statistical package program (GenStat 2009), and the results were interpreted by two-way ANOVA and GGE biplot models. The groups and inter-group differences among cultivars for the traits analyzed in the study were evaluated according to the LSD multiple comparison test ($p \leq 0.01$ and $p \leq 0.05$).

## RESULTS AND DISCUSSION

The results of the analysis of variance of the sugar beet varieties used as material in the study are given in Table 4. It was determined that there were statistically significant differences between the varieties in terms of the traits examined in the study, but there was no significant difference between the replications.

**Table 4.** Analysis of Variance (Mean Squares) of sugar beet varieties for the examined traits

| SV | DF | RD | RL | RW | SPW | DMR | PSR | RY | SY |
|---|---|---|---|---|---|---|---|---|---|
| Variety | 7 | 41.6648** | 3.59869* | 1621576** | 1900358** | 6.49** | 3.0298** | 3583508** | 93621** |
| Repetition | 2 | 11.32928 | 6.86620 | 8230 | 1641 | 3.21682 | 1.74174 | 4810 | 584.7 |
| Error | 14 | 0.43652 | 0.22831 | 2686 | 8326 | 0.33786 | 0.19175 | 3529 | 2436 |
| Total | 23 | | | | | | | | |
| CV (%) | | 0.833 | 2.796 | 2.876 | 4.497 | 2.633 | 2.460 | 0.886 | 4.326 |

**CV:** Coefficient of Variation, **DF:** Degree of Freedom, **SV:** Coefficient of Change, **RD:** Root Diameter, **RL:** Root Length, **RW:** Root Weight, **SPW:** Single Plant Weight, **DMR:** Dry Matter Ratio, **PSR:** Polar Sugar Ratio, **RY:** Root Yield, **SY:** Sugar Yield, ***,**:** Significant at 5% and 1% level, respectively.

The mean values and groups of yield and yield characteristics of sugar beet varieties are given in Table 5 and Table 6. Sugar beet varieties showed statistically significant differences from each other in terms of all traits examined. When the performances of the varieties were evaluated in terms of root diameter, it was determined that this value varied between 15.41 cm and 8.40 cm and Annamira was the superior variety in terms of root diameter (Table 5). In our study, the varieties with high root diameter also stood out in terms of root yield (Table 6) Hoffmann (2017) reported that there is a close and significant relationship between root diameter and yield parameters in sugar beet and that it is possible to estimate yield by looking at root diameter. Okut and Yildirim (2004) stated that root diameter trait is one of the important developmental criteria for sugar beet and this trait can be affected by ecological factors, cultivation technique and variety differences. When previous studies on the subject were evaluated, Sahiner and Demir (2020) reported that root diameter varied between 11.95 cm and 12.63 cm, Altunbay (2014) between 10.59 cm and 8.76 cm, Catal and Akinerdem (2013) between 7.4 cm and 8.5 cm, Kulan et al. (2013) between 12.37 cm and 10.93 cm. The root length values of sugar beet varieties varied between 15.34 cm and 18.43 cm and the Lamberta variety showed the highest value in terms of this trait. Preziosa and Agatella varieties had the lowest root length values. Tosun (2014) reported that the root length value among sugar beet varieties varied between 24-20.3 cm; Ozbay (2018) reported that root length values ranged between 21.8-6.5 cm. In the studies on the subject, many researchers stated that root length can be affected by both environmental factors and the genetic structure of the variety used (Leducke, 1956; Hozayn et al., 2013).

**Table 5.** Mean values and groups of agronomic characteristics of sugar beet varieties

| Varieties | Root diameter (cm) | Root length (cm) | Root weight (g) | Single plant weight (g) |
|---|---|---|---|---|
| Orthega | $11.23^{D}$ | $17.54^{B}$ | $1438^{E}$ | $1638^{E}$ |
| Preziosa | $9.11^{F}$ | $15.34^{C}$ | $949^{F}$ | $1413^{F}$ |
| Allanya | $10.41^{E}$ | $17.48^{B}$ | $1449^{E}$ | $1688^{E}$ |
| Agatella | $8.40^{G}$ | $15.45^{C}$ | $646^{G}$ | $772^{G}$ |
| Lamberta | $14.28^{B}$ | $18.43^{A}$ | $2892^{A}$ | $3200^{A}$ |
| Annamira | $15.41^{A}$ | $17.48^{B}$ | $2032^{D}$ | $2244^{D}$ |
| Ludmilla | $12.34^{C}$ | $17.39^{B}$ | $2486^{B}$ | $2797^{B}$ |
| Anchana | $14.30^{B}$ | $17.58^{B}$ | $2221^{C}$ | $2473^{C}$ |
| $LSD_{(0.05)}$ | 0.309 | 0.836 | 42.317 | 52.507 |

Values with different letters indicate significant groups at 5% significant level.

Statistically significant differences were determined among the sugar beet varieties in terms of root weight and the varieties were distributed in different groups in this respect. The highest value was obtained from the Lamberta variety with 2892 g, followed by the Ludmilla and Anchana varieties with 2486 g and 2221 g, respectively. The lowest root weight value was obtained from Agatella (646 g). Root weight in sugar beet has a significant effect on root yield per unit area (Sklenar et al., 1998). In the study, Agatella and Preziosa varieties were weaker than other varieties in terms of root diameter, root length and root weight. It is seen in Table 4 that the cultivars that stood out in terms of root weight and root length also had high values in terms of root weight. This supports the results of the researchers (Benjamin and Sutherland 1989; Badiu et al., 1996; Tsialtas and Maltaris, 2010) who argued that root diameter and root length have a significant effect on root weight. In similar studies on the subject, Sanlı et al. (2015) reported that root weight varied between 790 and 693.3 g; Sanghera et al. (2016) reported that there were significant differences between varieties in terms of root weight and this value varied between 1630 g and 820 g; Fasahat et al. (2021) reported that the average root weight among sugar beet genotypes was 898.8 g.

Table 5 shows that there were statistically significant differences among sugar beet varieties in terms of single plant weight (leaf + root). The highest value was obtained from the Lamberta variety, followed by the Ludmilla and Anchana varieties, respectively. The lowest value for single plant weight was obtained from the Agatella variety. The same table shows that single plant weight varied between 772 g and 3200 g, with significant variations among the varieties for this trait. Basalak and Karadoğan (2022) reported that the highest leaf weight was 1055.7 kg/da, root weight was 6947.0 kg/da, biological weight was 7896.3 kg/da and polar sugar yield was 1248.0 kg/da.

**Table 6.** Mean values and groups of yield and sugar content of sugar beet varieties

| Varieties | Dry matter content (%) | Polar sugar content (%) | Root yield (kg/da) | Sugar yield (kg/da) |
|---|---|---|---|---|
| Orthega | $20.87^{E}$ | $16.68^{C}$ | $6304^{D}$ | $1069^{DE}$ |
| Preziosa | $22.82^{BC}$ | $17.99^{B}$ | $5393^{E}$ | $987^{EF}$ |
| Allanya | $21.61^{DE}$ | $16.97^{C}$ | $6305^{D}$ | $1044^{E}$ |
| Agatella | $24.40^{A}$ | $19.41^{A}$ | $5196^{F}$ | $908^{F}$ |
| Lamberta | $21.55^{DE}$ | $17.42^{BC}$ | $8229^{A}$ | $1296^{B}$ |
| Annamira | $22.69^{BC}$ | $17.84^{B}$ | $7621^{B}$ | $1348^{A}$ |
| Ludmilla | $21.31^{DE}$ | $16.91^{C}$ | $7225^{C}$ | $1144^{CD}$ |
| Anchana | $22.32^{CD}$ | $17.91^{B}$ | $7157^{C}$ | $1229^{BC}$ |
| $LSD_{(0.05)}$ | 1.016 | 0.766 | 48.505 | 40.305 |

Values with different letters indicate significant groups at 5% level.

Sugar beet roots contain an average of 22-24% dry matter, of which 75% is sugar, 25% is water-insoluble cell wall compounds and 5% is non-sugar compounds (Hoffmann, 2005). In the study, the dry matter content of the varieties varied between 24.40% and 20.87% and the Agatella variety stood out in terms of this feature (Table 6). However, the varieties were distributed in different groups in terms of dry matter content and the Orthega variety was behind the other varieties with the lowest dry matter content. In the studies conducted on the subject, Sahiner (2020) reported that dry matter content varied between 20.89-23.20%, Rashidi and Abbasi (2011) reported 20.3-23.9%, and Altunbay (2014) reported 21.52-23.96%. Lauer (1995) stated that there is a positive correlation between dry matter content and sugar yield and that beets with high dry matter content also stand out in terms of sugar yield.

The sugar content of sugar beet roots is the most important factor determining the economic value of the plant (Xiao et al., 2021). Sugar beet yield and sugar content are mainly affected by genotype, ecological factors and growing conditions (irrigation, fertilization) (Xie et al., 2022). In this study, polar sugar content values of sugar beet varieties varied between 16.68% and 19.04%. In addition, the Annamira variety showed the highest performance in terms of sugar content, while the Orthega variety was weaker than the other varieties in terms of the aforementioned trait (Table 5). It was noteworthy that varieties with high dry matter content also had high polar sugar content. Agatella and the Annamira varieties had higher values in terms of both dry matter content and polar sugar content compared to other varieties. Azam Jah et al. (2003) reported that polar sugar content varied between 14.4% and 15.8% among sugar beet genotypes, while El-Karouri and El-Rayah (2006) reported that sugar beet varieties had polar sugar content between 12.0% and 15.7%.

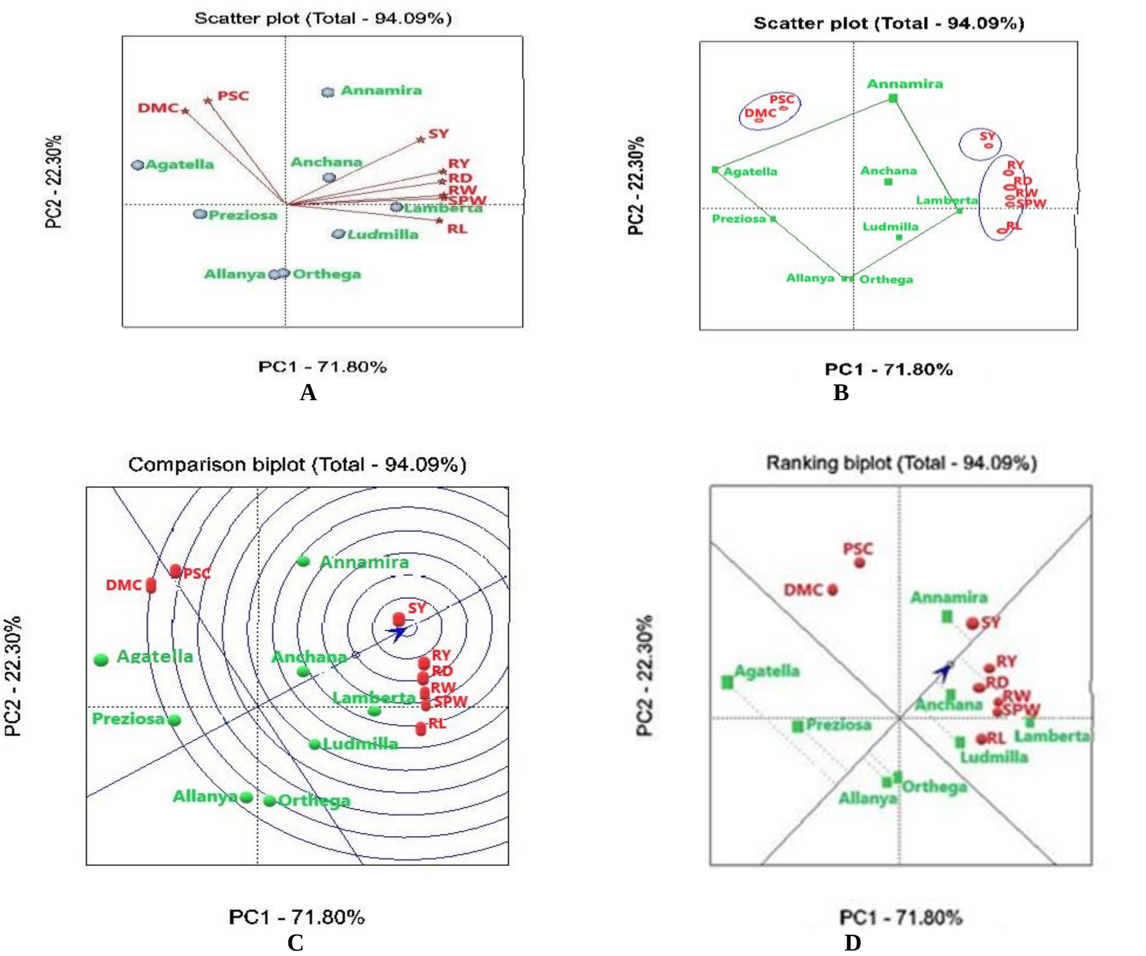


**Figure 1**- **A, B, C, D**. Genotype-Trait Relationships of Different Sugar Beet Varieties. **RD:** Root Diameter (cm), **RL:** Root Length (cm), **RW:** Root Weight (g), **SPW:** Single Plant Weight (g), **DMC:** Dry Matter Content (%), **PSC:** Polar Sugar Content (%), **RY:**Root Yield (kg/da), **SY:** Sugar Yield (kg/da).

There was a statistically significant difference between sugar beet varieties in terms of root yield (Table 5). The root yields of sugar beet varieties varied between 5192 and 8229 kg/da and it was determined that there was a wide variation among the varieties in terms of this trait. The variety with the highest root yield was Lamberta, followed by Annamira, Ludmilla, and Anchana varieties. The lowest value in terms of the aforementioned trait was obtained from the Agatella variety. Sugar yield values of the varieties varied between 908 and 1448 kg/da. The variety with the highest sugar yield was Annamira, while Lamberta ranked second. Agatella variety lagged behind the other varieties in terms of sugar yield. Sugar yield and root yield are two of the most important parameters for growers (Hoffmann et al., 2009). When the studies conducted by researchers on the subject were examined, Rychcik and Zawiślak (2002) stated that root yield varied between 5880 and 6090 kg/da among sugar beet varieties; El-Karouri and El-Rayah (2006) stated that it was between 7150 and 8100 kg/da. Erciyes et al. (2016) stated that there is a strong relationship between root yield and sugar yield and the main objective of sugar beet farming is to obtain a high sugar yield from a unit area. Şanlı et al. (2023) stated in their study with seven sugar beet varieties in Isparta that root yield varied between 6680-9745 kg/da and polar sugar ratios varied between 14.5-18.6%. Genotypes with high root yield and sugar content also have high sugar yields per unit area (Hassani et al., 2018). Hoberg et al. (2016) emphasized in their study that environmental factors have a significant effect on sugar yield.

Through the biplot technique, the relationships between genotypes and traits can be examined with graphs obtained from mean values from different angles. The GT biplot plot shows the relationship between two traits, the relationship of one trait with other traits, or the relationship of genotypes with each other according to the traits using the angles between the trait vectors (Yan et al., 2000; Yan and Tinker, 2006; Baran et al., 2022). In this study, the performance of eight different sugar beet varieties in terms of the traits examined were presented with biplots.

According to the scatter biplot method, PC1 (1st principal component) accounted for 71.80%, PC2 (2nd principal component) accounted for 22.30% and 94.09% of the total variation. Figure 1-A graph visualizes the relationship between the sugar beet varieties included in the study and the yield and quality traits of these varieties. In the graph, as the angle view between the vectors representing the traits narrows, positive and high correlation is indicated, and as the angle view widens, weak correlation is indicated. In this case, it can be said that most of the yield and yield parameters have positive and high correlation. In addition, a strong and positive correlation was observed between dry matter content and polar sugar content, while a weak correlation was observed between polar sugar content and root yield. Genotypes positioned near some traits represent good results according to the parameters they are positioned. In this context, the Agatella variety stood out in terms of dry matter content and polar sugar content, while the Lamberta variety showed high performance in terms of root diameter, root weight, single plant weight and root yield. The Annamira variety showed high performance in terms of root yield and sugar yield. In Figure 1-B, the genotypes showing the highest values for one or more traits were identified by using the polygon view of the biplot. Thus, the sugar beet varieties in the center of each sector represent the variety or varieties with the highest performance in that sector and related traits. In the study, the biplot was divided into four sectors. It is seen that the Lamberta variety, located in the middle of the second and third sectors, represents high averages in terms of yield and yield characteristics. In addition, the Agatella variety in the fourth sector stood out in terms of quality characteristics such as dry matter content and polar sugar content. With the comparison biplot created over the average data, it was tried to determine the suitability of sugar beet varieties according to the ideal center. In the graph, the area in the coordinate plane indicated by the blue arrow is accepted as the center point. In this direction, the center indicated by the blue arrow is the most ideal region. Varieties can be categorized according to their distance and proximity to this region (Mohammadi, 2019). Thus, it is seen that the Anchana variety is located in the ideal center. This shows that the Anchana variety exhibits high performance in terms of the parameters examined in the study. In addition, the stability of the varieties in terms of all traits with the Ranking biplot graph is presented in Figure 1-D. The varieties Anchana and Annamira were the closest to the stability line drawn representatively and these varieties were more stable than the other varieties in terms of all the traits examined. Many researchers have evaluated the performance of sugar beet varieties and genotypes through biplot analysis (Hassani et al., 2018; Mostafavi et al., 2018; Taleghani et al., 2023; Abu-Ellail et al., 2024).

## CONCLUSION

Statistically, the sugar beet varieties used as material in the study differed significantly from one another in terms of the traits examined. These differences were presented with graphs created by the GGE biplot method. By GGE biplot analysis, the eight traits examined in the study were divided into three mega clusters. One of these clusters included polar sugar content and dry matter content, the second cluster included sugar yield, and the third cluster included root diameter, root length, root weight, single plant weight, and root yield. In the study, when the projections of the varieties according to the point where they were located were evaluated, it was determined that the Agatella variety showed superior performance in terms of polar sugar ratio and dry matter ratio, the Annamira variety showed superior performance in terms of sugar yield, and the Lamberta variety showed superior performance in terms of storage yield and root yield. As a result, it was concluded that GGE biplot graphs will be useful in determining the performance of varieties in terms of the traits examined and in selecting suitable varieties for a particular trait. In addition, it would be more useful to expand the scope of similar studies by conducting them in multiple years and in different locations.

**Compliance with Ethical Standards**
**Peer-review**
Externally peer-reviewed.
**Declaration of Interests**
The authors declare that they have no conflict of interest.
**Author contribution**
The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the text, figures, and tables are original and that they have not been published before.

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