ISSN (Online) = 2522-6754 ISSN (Print) = 2522-6746
WORLD JOURNAL OF BIOLOGY AND BIOTECHNOLOGY
Research Manuscript www.sciplatform.com

Stability analysis of sugar beet genotypes in terms of yield and sugar ratios (*Beta vulgaris Var. saccharifera L.)*

[a] Mustafa Yasar [*], [b] Remzi Ekinci,

[a] Plant Production and Technologies Department, Faculty of Applied Sciences, Muş Alparslan University, Muş, Turkey,
[b] Field Crops Department, Faculty of Agriculture, Dicle University, Diyarbakır, Turkey.

Authors' Contribution	**Yasar, M.** and **R. Ekinci** contributed equally
Article History	[*]**Corresponding email address**: mustafa.yasar@alparslan.edu.tr **Digital Object Identifier (DOI): https://doi.org/10.33865/wjb.006.01.0386** **Received: 13 November 2020, Revised: 06 January 2021, Accepted: 16 January 2021, Published Online: 18 January 2021**

ABSTRACT

This study was carried out to investigate the ecological regions of Eskişehir, Konya, Kırşehir, and Çorum in terms of sugar beet root yield (kg da^{-1}), polar sugar rate (%), refined sugar rate (%) and sugar yield (kg da^{-1}), to determine stabilities of selected genotypes, and to assist future studies. The experiment was conducted in the ecological regions of Eskişehir, Konya, Kırşehir, and Çorum between 2013 and 2017, using the trial data from the Variety Registration and Seed Certification Center. 58 genotypes of foreign origin were used in the study. It was determined that the Çorum location could be considered as bad environment in terms of sugar beet root yield feature, the Çorum and Eskişehir locations in terms of polar sugar beet and refined sugar rate feature, and the Eskişehir location in terms of polar sugar rate feature. It was concluded that Sandrina, Bernache and Aigrette genotypes showed good adaptation under good environmental conditions and were stable in terms of sugar beet root yield; Garrot and Beetle genotypes in terms of sugar yield; Delano and Portofina KWS (5K618) genotypes in terms of polar sugar rate; Ametist (SV1634), Masai, and Eldorado genotypes in terms of refined sugar rate. Since the performances of genotypes in different environmental conditions differ, it is of great importance to examine the performances of new varieties in different ecological environments. In terms of sugar beet root yield characteristics, it is recommended to prefer warmer ecological locations.

Keywords: Polar sugar rate, refined sugar rate, root yield, stability analysis, sugar beet.

INTRODUCTION: Sugar plays a very important role in people's eating habits. Sugar has been an important nutrient of mankind throughout history and has been the subject of research in different scientific studies (Hakan and Bulut, 2016). Today, sugar beet accounts for the 22% of the world's sugar production, while sugar cane the remaining nearly 78% (FOASTAT, 2019). There are no differences in quality between sugar cane and beets. Sugar produced from sugar cane is less costly because of lower production costs and processing costs compared to sugar beet (Kaya, 2015). Sugar produced in 108 countries with a total of 178.7 million tons, 37.7 million tons from beet and 141 million tons from sugarcane. In the manufacture of sugar from sugar beet, Turkey is ranked fourth in the world by about 2.3 million tons of annual production, whereas the European Union (EU) third. Turkey's total sugar production capacity is 4.141 million tons of which 3.151 million tons is provided from sugar beet, and 990 thousand tons is starch based sugar. But due to insufficient capacity utilization, sugar production on average is around 2.5 million tons in Turkey (Eştürk, 2018). Sugar beet (*Beta vulgaris var. Saccharifera* L.) is an industrial plant grown to produce sugar. Sugar is a product of strategic importance in the world. Besides being the main ingredient of nutrition, sugar has become a protected product all over the world due to its significant contribution to agricultural production, by-products and great contribution to employment (Erdinç, 2017). Sugar beet farming is practiced in over 4.89 million hectares worldwide. On these lands, annual sugar beet production is 301.1 million tons and average root yield is 61.50 tons per hectare (FOASTAT, 2019). The Russian Federation, France, the United States, Germany, Turkey, Poland, and Ukraine are the greatest sugar beet producer countries of the world. Turkey ranks sixth in the world sugar beet production with 20.83 million tons of production from 338 thousand hectares (FOASTAT, 2019). According to the data of 2019; Turkey sugar beet cultivation area is 339,274 ha, it is seen that 21.149 million tons and production yield 62.41 ton ha^{-1}. In Turkey, sugar beet is intensively cultivated in Konya, Yozgat, Kayseri, Eskişehir, Sivas, Aksaray, Afyon, Amasya, Tokat and, Ankara in descending order. These provinces also account for approximately 70% of the sugar beet cultivation areas and 72% of the total production. In terms of yield, the average yield in these intensive cultivation areas is 61.1 ton ha^{-1}, which is equivalent to the world's average level. Sugar beet in Turkey has been playing an important role in the agricultural sector and agro-industrial production and continues to be important to create the added value. In addition to the economic value of sugar, the social benefit it creates, the size of employment and the key role that prevents farmers from migrating from village to city by making them dependent on agricultural production make sugar beet important (Eştürk, 2018). Sugar beet is one of the most important products which can be a solution for unemployment. Especially during hoeing and harvest periods, 250 thousand agricultural workers, small farmers and unemployed people are provided temporary employment for 100 days. It is to provide 18 times more employment opportunities in rural areas compared to wheat and 4.4 times more than sunflowers. Beet farming also supports seed, chemical fertilizer and agrochemical industries and also creates a market for the transportation sector during the dismantling period. While the initial sugar content of sugar beet was 1.3%, it has improved up to 24% today. With the development of dry matter in the beet

root-stem, the sugar content can reach up to 20-25% (Sohrabi and Heidari, 2008). Different sugar beet types such as E, N, Z, NZ, EE, ZZ, CR and RI have been developed in terms of sugar ratio, yield and disease resistance. As in all plants, the performance of genotypes according to environmental conditions in sugar beet varies. This makes it important to carry out adaptation and stability studies of newly developed genotypes under different environmental conditions.

OBJECTIVES: This study was carried out to investigate the performance and stability of sugar beet in different ecological conditions (Eskişehir, Konya, Kırşehir and Çorum) in terms of sugar beet root yield (kg da^{-1}), polar sugar rate (%), refined sugar rate (%), and sugar yield (kg da^{-1}) properties.

MATERIALS AND METHODS: the experimental data of the Variety Registration and Seed Certification Center (VRSCC) conducted in the ecological regions of Eskişehir, Konya, Kırşehir, and Çorum between 2013 and 2017 were used in this research. Sugar beet root yield (kg da^{-1}), polar sugar rate (%), refined sugar rate (%) and sugar yield (kg da^{-1}) were investigated. 58 genotypes of foreign origin were used in the study. Information on genotypes is given in table 1. The adjusted data were obtained from raw data with the help of the following equation (Lozada and Carter, 2019).

$$Adjusted\ Data = Raw\ Data + \frac{(Sum\ Block - Sum\ Means\ St\ Varieties)}{(St\ Variesties\ Numbers)}$$

Average temperature changes between 2013-2017 for the locations examined, in figure 5; temperature differences change is given in figure 6 (Data of the meteorological provincial directorate). Considering the differences of the average temperatures of the locations examined, the Çorum location received the lowest value, while the Kırşehir location received the highest value (figure 6). Konya and Eskişehir locations are between these two locations.

RESULTS AND DISCUSSION: When the sugar beet root yield values of genotypes were examined, it was observed that they varied between 7,242-10,153 kg da^{-1}. Sugar beet root yield values were 7,584 kg da^{-1}, 9,106 kg da^{-1}, 9,325 kg da^{-1}, and 8,869 kg da^{-1} in Çorum, Eskişehir, Kırşehir, and Konya locations, respectively. The overall average sugar beet root yield was found to be 8,721 kg da^{-1} (table 2). Nine of the genotypes were in region I; 18 of them are in region II; 28 of them are in region III and 3 of them are in region IV. In terms of sugar beet root yield, Çorum location is below the general average; all other locations appeared above the general average. In terms of sugar beet root yield feature, Sandrina, Bernache, and Aigrette genotypes were found to be higher than the general average and low b (stability) value. This suggests that these genotypes are stable and highly sugar beet root yield. It is understood that these genotypes are stable genotypes that are well adapted to good environmental conditions (figure 1). The results were similar with the findings of Kaya (2015). When the sugar yield values of genotypes were examined, it varied between 1,037-1,442 kg da^{-1}. Sugar yield values were determined as 1,080 kg da^{-1}, 1,128 kg da^{-1}, 1,416 kg da^{-1}, 1,356 kg da^{-1} in Çorum, Eskişehir, Kırşehir, and Konya locations, respectively. The overall average sugar yield was found to be 1,245 kg da^{-1}(table 2). Seventeen of the genotypes in region I; 19 of them are in region II; 15 of them are located in region III and 7 of them are in region IV. Çorum and Eskişehir locations are below average; all other locations appeared above the overall average. The results were similar with the study of Hakan and Bulut (2016). Garrot and Beetle genotypes were found to be higher than average and low stability value. This suggests that these genotypes are stable and highly sugar yield; it reveals that there are stable genotypes that are well adapted to good environmental conditions (figure 2). In terms of sugar beet root yield and sugar yield properties, it was similar between the locations (LI) and the temperature changes (figure 1, 2, 5 and 6).

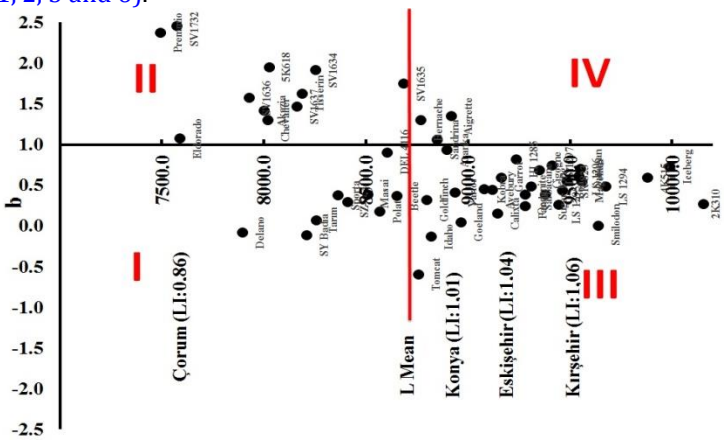

Figure 1: Stability analysis of sugar beet root yield feature of sugar beet genotypes in Çorum, Eskişehir, Kırşehir, and Konya locations between the years of 2013-2017. (L: location, LI: location index).

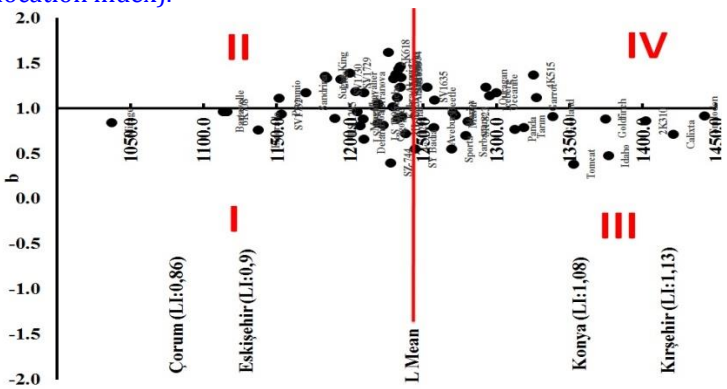

Figure 2: Stability analysis of sugar yield feature of sugar beet genotypes in Çorum, Eskişehir, Kırşehir, and Konya locations between the years of 2013-2017. (L: location, LI: location index)

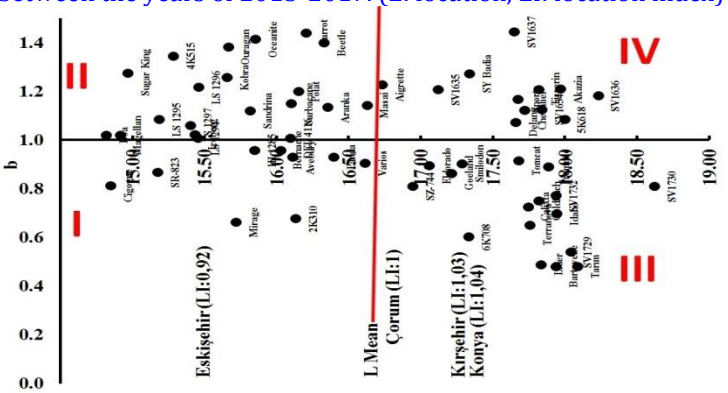

Figure 3: Stability analysis of polar sugar rate feature of sugar beet genotypes in Çorum, Eskişehir, Kırşehir, and Konya locations between the years of 2013-2017. (L: location, LI: location index).

Genotype	Company	Origin	Year of Registration
Aigrette	Dirik Dış Ticaret Memduh Zafer Dirik	France	10.4.18
Ametist (SV1634)	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	10.4.18
Anka (SV1635)	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	10.4.18
Aranka KWS	KWS Türk Tarım Tic.A.Ş.	Germany	5.4.11
Avebury	DLF TohumculukTic. Ltd. Şti.	Denmark	1.4.15
Balaban (SV1636)	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	10.4.18
Bartavelle	No data found		
Beetle	No data found		
Bernache	Dirik Dış Ticaret Memduh Zafer Dirik	France	19.4.16
Boa	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	19.4.16
Calıxta	KWS Türk Tarım Tic.A.Ş.	Germany	14.4.09
Chevalier	Dirik Dış Ticaret Memduh Zafer Dirik	France	10.4.18
Cigogne	Dirik Dış Ticaret Memduh Zafer Dirik	France	19.4.16
Danicia KWS (2K310)	KWS Türk Tarım Tic.A.Ş.	Germany	1.4.15
Delano	No data found		
Dora (SZ-744)	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	1.4.15
Eldorado	Beta Ziraat ve Tic.A.Ş.	Belgium	11.4.13
Faiz (DEL 4116)	KWS Türk Tarım Tic.A.Ş.	Germany	12.4.17
Garrot	Dirik Dış Ticaret Memduh Zafer Dirik	France	12.4.17
Goeland	No data found		
Goldfinch	Beta Ziraat ve Tic.A.Ş.	Netherlands	8.4.14
HI 1285	No data found		
Iceberg	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Holand	1.4.15
Idaho	Beta Ziraat ve Tic.A.Ş.	Netherlands	8.4.14
Jaguar (SV1637)	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	10.4.18
Kobra	Beta Ziraat ve Tic.A.Ş.	Netherlands	12.4.12
Labrador (SV1732)	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	12.4.19
Lider	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	19.4.16
LS 1295	No data found		
LS 1296	No data found		
LS 1297	No data found		
SR-803	No data found		
Magellan	No data found		
Masai	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Belgium	12.4.17
Mirage	No data found		
Oceanite	Dirik Dış Ticaret Memduh Zafer Dirik	France	12.4.17
Orthega KWS (6K708)	KWS Türk Tarım Tic.A.Ş.	Germany	12.4.19
Ouragan	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Belgium	12.4.17
Panda	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	1.4.15
Perfekta (LS 1294)	3 Efe Tohum Ltd.Şti.	Italy	1.4.15
Polat	KWS Türk Tarım Tic.A.Ş.	Germany	12.4.17
Portofina KWS (5K618) (5K618)	KWS Türk Tarım Tic.A.Ş.	Germany	10.4.18
Premmio	Alfa Tohum Ltd. Şti.	Denmark	12.4.19
Salama KWS(4K515	KWS Türk Tarım Tic.A.Ş.	Germany	12.4.17
Sandrina	KWS Türk Tarım Tic.A.Ş.	Germany	14.4.10
Sarbacane	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	1.4.15
Smılodon	Beta Ziraat ve Tic.A.Ş.	Netherlands	8.4.14
Sporta	DLF Tohumculuk Tic. Ltd. Şti.	Switzerland	8.4.14
Sugar King	KWS Türk Tarım Tic.A.Ş.	Germany	12.4.17
SY Badia	No data found		
Tarim	Trakya Tarım ve Vet Tic. Ltd.Şti.	France	8.4.14
Taurus (SV1729)	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	12.4.19
Terranova KWS	KWS Türk Tarım A.Ş	Germany	12.4.19
Tisserin	Dirik Dış Ticaret Memduh Zafer Dirik	France	10.4.18
Tomcat	Beta Ziraat ve Tic.A.Ş.	Netherlands	8.4.14
Tuna (SV1730)	Sesvanderhave Tr Tarım ve Tic.Ltd.Şti.	Netherlands	12.4.19
Varios	DLF TohumculukTic. Ltd. Şti.	Denmark	1.4.15
Yaiza KWS (Akazia)	KWS Türk Tarım Tic.A.Ş.	Germany	10.4.18

Table 1: Information on genotypes of sugar beet (*Beta vulgaris* L.) used as material.

Genotypes	Sugar beet root yield (kg da-1)	Sugar yield (kg da-1)	Refined sugar rate (%)	Polar sugar rate (%)
Danicia KWS (2K310)	10153.75	1402.25	13.8	16.14
Salama KWS(4K515	9881.75	1325.44	12.82	15.29
Portofina KWS (5K618) (5K618)	8025.38	1226.38	14.72	18
Orthega KWS (6K708)	7866.75	1116	14.9	17.34
Aigrette	8917.13	1234.13	13.88	16.73
Yaiza KWS (Akazia)	8000	1229.63	14.9	17.97
Aranka KWS	8897.75	1234.48	13.57	16.35
Avebury	9120.63	1257.25	13.89	16.11
Bartavelle	7242.75	1113.25	14.65	17.94
Beetle	8651.75	1257.69	13.88	16.33
Bernache	8770.25	1219.21	13.46	16.03
Boa	9464.88	1209.06	12.13	14.82
Calıxta	9146.25	1420.75	15.53	17.75
Chevalier	8019.75	1204.13	14.8	17.72
Cigogne	9351.75	1222.81	12.52	14.85
Faiz (DEL 4116)	8603.13	1232.5	13.65	16.1
Delano	7897	1209.75	15.33	17.66
Eldorado	7588.67	1137.63	14.38	17.06
Garrot	9162.5	1327.19	13.86	16.21
Goeland	8967.75	1338.5	14.85	17.21
Goldfinch	8799.75	1374.5	15.6	17.82
HI 1285	9236.13	1232.88	13.46	15.85
Iceberg	9990.38	1295.25	12.96	15.43
Idaho	8819.5	1376.5	15.61	17.94
Kobra	9080.44	1229.34	13.24	15.66
SR-803	7813	1184.25	15.71	17.84
Perfekta (LS 1294)	9674.5	1237.88	12.87	15.46
LS 1295	9444.75	1189.63	12.66	15.19
LS 1296	9543.88	1219.25	12.88	15.46
LS 1297	9411.75	1207.13	12.89	15.4
Magellan	9559.25	1205	12.59	14.92
Masai	8507.75	1272.19	14.26	16.63
Mirage	8371	1037.5	15.45	15.72
Oceanite	9279.13	1299.81	13.43	15.86
Ouragan	9549.75	1293	13.07	15.67
Panda	9281	1312.63	14.18	16.4
Polat	8568.13	1235.5	13.78	16.15
Premmio	7495	1151.5	14.83	17.89
Sandrina	8849.75	1169.75	12.95	15.82
Sarbacane	9308	1279	13.79	16.1
Smılodon	9639.75	1442.5	14.93	17.29
Sporta	8363.5	1269.5	15.26	17.68
Lider	9485.25	1280.88	12.88	15.18
Sugar King	9378.75	1183.25	12.05	14.97
Ametist (SV1634)	8254.5	1234.63	14.67	17.84
Anka (SV1635)	8684	1252.5	14.22	17.12
Balaban (SV1636)	7928.63	1235	14.34	18.23
Jaguar (SV1637)	8162.25	1231.63	14.95	17.65
Taurus (SV1729)	7784	1200	13.57	18.04
Tuna (SV1730)	7467.25	1193.75	14.87	18.62
Labrador (SV1732)	7573	1153.25	14.61	17.94
SY Badia	8208.5	1244.75	15.16	17.34
Dora (SZ-744)	8408.88	1228	14.73	16.94
Tarım	8255.5	1319	15.92	18.09
Terranova KWS	8070	1209.75	14.86	17.76
Tisserin	8186.38	1233.38	14.73	17.82
Tomcat	8756.75	1353	15.4	17.68
Varios	8938.75	1270.38	14.27	16.62
Means	8721.69	1245.79	14.12	16.72

Table 2: The property values of genotypes investigated.

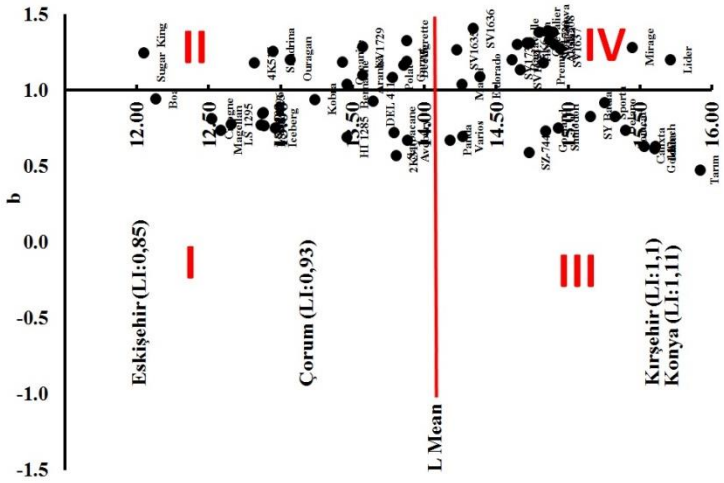

Figure 4: Stability analysis of refined sugar rate feature of sugar beet genotypes in Çorum, Eskişehir, Kırşehir, and Konya locations between the years of 2013-2017. (L: location, LI: location index).

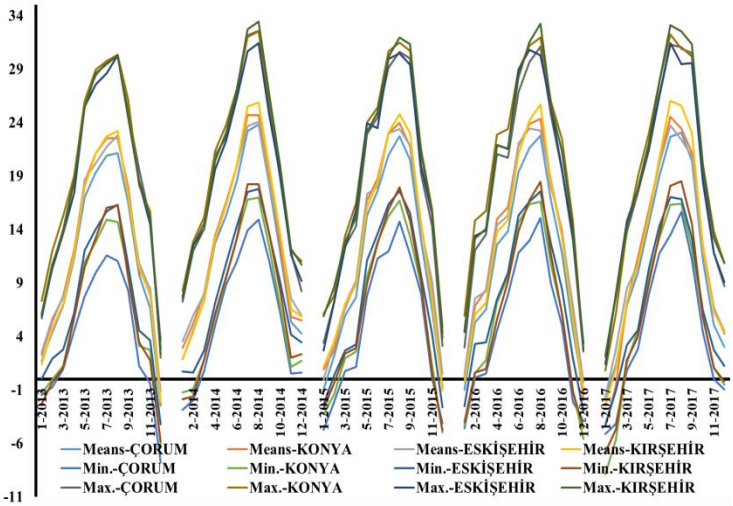

Figure 5: Monthly Minimum Maximum and Average Temperature Changes of Çorum, Eskişehir, Kırşehir and Konya Locations between 2013-2017.

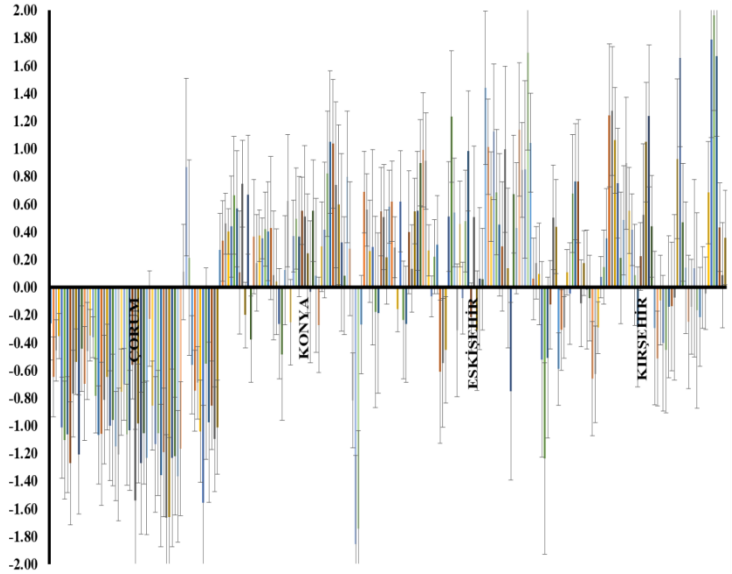

Figure 6: Monthly average temperature differences between Çorum, Eskişehir, Kırşehir and Konya locations between 2013-2017.

Polar sugar rate values of genotypes varied between 14.80%-18.6%. Polar sugar rate values were determined as 16.74%, 15.48%, 17.25%, and 17.38% in Çorum, Eskişehir, Kırşehir, and Konya locations, respectively. The overall average polar sugar rate was 16.72% (table 2). Nine of the genotypes are in region I; 20 of them are in region II; 17 of them are in region III and 12 of them are in region IV. Eskişehir location is below the overall average; all other locations outperformed the overall average. Delano and Portofina KWS (5K618) genotypes were found to be higher than average and low stability value. This condition is stable in terms of the traits studied of these genotypes and has a high polar sugar rate; it reveals stable genotypes that are well adapted to good environmental conditions (figure 3). When the refined sugar rate values of genotypes were examined, it varied between 12.0% -15.9%. The refined sugar rate values were 13.18%, 12.01%, 15.58%, and 15.72% in the Çorum, Eskişehir, Kırşehir, and Konya locations where the study was conducted, respectively. Similar findings were found by Erdinç (2017). The overall mean refined sugar rate was 14.12% (table 2). Fifteen genotypes are in region I; 12 of them are in region II; 13 of them are in region III and 18 of them are in region IV. Çorum and Eskişehir locations are below average; all other locations appeared above the overall average. Ametist (SV1634), Masai, and Eldorado genotypes were found to be higher than average and low stability value. This condition is stable in terms of the characteristic examined of these genotypes and has a high refined sugar rate; it reveals stable genotypes that are well adapted to good environmental conditions (figure 4). When the temperature data of the locations are compared, the order of the locations is similar to the sugar beet root yield and sugar yield properties. This shows that these two characteristics are shaped by the ecological conditions being highly affected by the temperature change (figure 1, figure 2, and figure 5).

CONCLUSION: According to results, the direct effect on the seed yield, which was positive and high, the number of pods per plant should be taken into consideration by the breeders. In addition, this feature is an important criterion in selection for breeders due to its high indirect effect on seed yield over a thousand seed weight.

CONFLICT OF INTEREST: Authors have no conflict of interest.

REFERENCES: Erdinç, Z., 2017. Development of sugar industry in turkey and policies in the sugar industry. Anadolu university journal of social sciences, 17(3): 9-26.

Eştürk, Ö., 2018. The importance of the sugar industry in turkey, and an assessment of the future. Anatolian journal of economics and business, 2(1): 67-81.

FOASTAT, 2019. Food and agriculture organization of the united nations.

Hakan, K. and I. Bulut, 2016. The place and significance of the province of yozgat in sugar beet production in turkey. Turkish journal of geography(67): 33-40.

Kaya, F., 2015. The effects of the global and regional policies to sugar factories in turkey an example; agri sugar factory. Journal of geography, 31: 33-40.

Lozada, D. N. and A. H. Carter, 2019. Accuracy of single and multi-trait genomic prediction models for grain yield in us pacific northwest winter wheat. Crop breeding, genetics genomics, 1(1): 1-23.

Sohrabi, Y. and G. Heidari, 2008. Influence of withholding irrigation and harvest times on yield and quality of sugar beet (beta vulgaris). International journal of agriculture biology, 10(4): 427-431.