Scientific Papers. Series A. Agronomy, Vol. LXVI, No. 2, 2023
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PRODUCTION AND SUGAR CONTENT OF FOUR SUGAR BEET HYBRIDS FUNCTION OF ENVIRONMENTAL TEMPERATURE, PRECIPITATIONS AND AGRICULTURAL KEY INPUTS

Letiția Adriana BOCOȘ[1], Antonia ODAGIU[1], Camelia OROIAN[2], Cristian IEDERAN[1], Petru BURDUHOS[1]

[1]University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Faculty of Agriculture, 3-5 Calea Manastur, Cluj-Napoca, Romania
[2]University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Faculty of Horticulture and Business in Rural Development, 3-5 Calea Manastur, Cluj-Napoca, Romania

Corresponding author email: antonia.odagiu@usamvcluj.ro

Abstract

Sugar beet yields are highly influenced by a series of factors, both technological and environmental. This study aims to emphasize the effect of the environmental temperature and agricultural key inputs (fertilization and water) on production and sugar content function of sugar beet hybrid in the same growing area. A three factorial experiment was conducted (genotype x irrigation x fertilization) was organized from 2021 to 2022 in the experimental field located in Viișoara commune, Cluj County. Daily temperature and precipitations were monitored. The results of 2-years studies concerning the sugar content and yields for each experimental sugar beet variety (Vanghelis, Tesla, Penalty, and Gorilla) are recorded. The results of our study show that in Vanghelis variety are reported the highest average yields (66.60 t/ha), and sugar content (10.84%). The fresh and dry root yields and sucrose content did not differ significantly among Vanghelis and Gorilla varieties, but significant varieties are reported among these varieties, and the other two, Tesla, and Penalty, respectively. Strong and moderate correlations are identified between sugar beet yields and sucrose content on one hand, and environmental inputs on the other side, for each studied variety.

***Key words**: differences, dry matter, fertilizer, irrigation, water.*

INTRODUCTION

The natural stress produced mainly by temperatures and lack of precipitations influences the plants development, including sugar beet, in negative manner at great extent (Verma, and Deepti, 2016). It is well known that water deficiency may cause disorders in plants physiology, morphology, atomic, or even at biochemical cellular levels (Du et al., 2020). High environmental temperatures together with low rainfall regimen also have unfavorably impacts on photosynthesis and protein action in plants. The diminished photosynthesis rate and lack of accessible water in plants, led do the decrease of the rhythm of dry matter production (Gholami and Zahedi, 2019). It is obvious that above mentioned facts could be considered as serious threat for food supplying chain (Okorie et al., 2019; Verma and Deepti, 2016).

Beta vulgaris L. (sugar beet) is a valuable industrial plant, one of the main industrial sugar sources. According to Kühnel et al. (2011), sugar beet has a dry mass content framing within the interval 18%-23%, but much research has been conducted to obtain hybrids with enhanced values. It has variable content in protein (11.50-20.25%), and about 20-21% rough fiber (Berłowska et al., 2016; Ahmed et al., 2020). Besides its use at large scale as rough material for sugar industry, sugar beet is also used as feedstuff for dairy cattle (Münnich et al., 2017). Because of high importance as cash crop, due to its considerable potential for carbohydrate capacity saves, research has been orientated towards identifying new methodologies for improving both plant yields, resistance against mites and pathogens, and also adverse climatic conditions (Mukherjee and Gantait, 2023). In this way, there have been obtained both by selection and genetic engineering hybrids with improved yield potential and resistance against adverse environmental conditions.

The study was conducted to quantify the production performances of Gorilla, Vanghelis, Tesla, and Penalty sugar beet hybrids in terms of dry matter, yield, and sugar yield, and identify the interactions between the above-mentioned traits with environmental temperature and precipitations.

MATERIALS AND METHODS

A three factorial experiment was conducted (genotype x irrigation x fertilization) in two successive years, 2021 and 2022, respectively, in an experimental field located in Viișoara Commune, Cluj County.
The factor genotype has four graduations, meaning the sugar beet genotypes: Gorilla, Vanghelis, Tesla, and Penalty.
Irrigation, the second factor, has two graduations, no irrigation, and irrigation with a watering norm of 600 m^3/ha by round, using 7 rounds by entire vegetation period. The third factor, fertilization has three graduations: no fertilization, fertilization with NPK in ratio of 60-40-40 kg/ha, and NPK in ratio of 180-120-120 kg/ha. The experimental variants are organized as showed in Table 1.

Table 1. The experimental variants

Experimental variant	Description
a_1b_1	No irrigation (a_1)-no fertilization (b_1)
a_1b_2	No irrigation (a_1)-NPK 60-40-40 kg/ha (b_2)
a_1b_3	No irrigation (a_1)- NPK 180-120-120 kg/ha (b_3)
a_2b_1	Irrigation (a_2)- no fertilization (b_1)
a_2b_2	Irrigation (a_2)- NPK 60-40-40 kg/ha (b_2)
a_2b_3	Irrigation (a_2)- NPK 180-120-120 kg/ha (b_3)

The sugar beet was planted at density of 120,000 plants/ha, and soil moisture of 60%. 24 plots sized of 20 m^2, in three replications by each experimental variant were organized for the filed study.
The environmental temperature and precipitations data were obtained from the meteorological station iMETOS 3.3 placed in the experimental field, which perform daily recordings.
Data regarding sugar beet root weight, beet yield, and sugar yield were collected. The sugar beet yield was calculated by dividing the harvested roots weight to the plot area. The sugar was quantified using the methodology described by Legendre et al. (1972), and sugar yield by multiplying the root yield with sugar content.
Because no significant differences were reported between studied parameters were recorded, data concerning the environmental parameters temperature, and precipitations, and experimental factors are expressed as means by experimental years, 2021 and 2022.
The sugar beet root weight, beet yield, and sugar yield were subjected to statistical analysis. Basic statistics was used for the calculations of means, standard error of mean, ad variability. ANOVA analysis of variance was used for emphasizing the differences in genotypes and treatments (different irrigation and fertilization regimens) at 5% probability level. After testing linearity of parameters, the nonparametric Spearman test was used for calculation of correlation coefficient as alternative to Pearson parametric test (Merce and Merce, 2002).
Based on correlation matrix of the environmental factors temperature, and water supply, respectively, on one hand and sugar beet yield, and sugar yield by all hybrids, on the other hand, to know the importance of Sugar was determined according to each studied parameter indicated by its relative loading the eigenvector, Principal Components Analysis was (PCA) performed.

RESULTS AND DISCUSSIONS

During the vegetation period (April - August), the experimental site is characterized by mean temperatures that framed between 8.77°C (April) - 22.6°C (July), and an average of 17,82°C, by entire period (Figure 1), which are optimal for the development of the culture (Guș et al., 2004; Muntean et al., 2001; Pastor, 2002). In both experimental years a scarcity of rainfall water supply is reported and emphasized by a sum of 221.30 mm/year (Figure 2), which according to sugar beet production technology is very poor, irrigations being needed (Guș et al., 2004; Luca and Nagy, 1999).

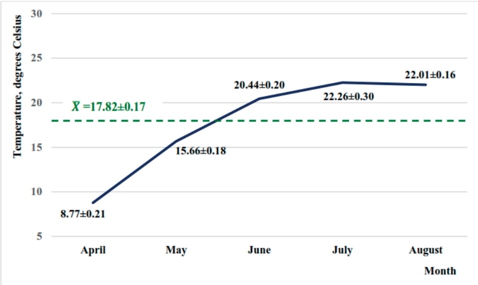

Figure 1. The mean monthly environmental temperature (°C), during vegetation period in experimental field, by 2021-2022

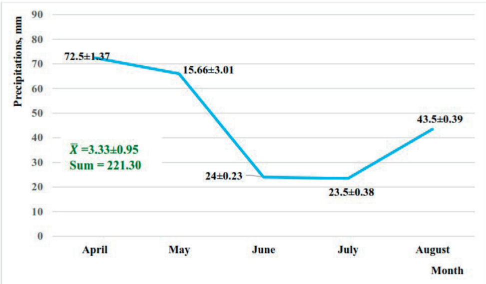

Figure 2. The mean monthly rainfall regimen (mm), during vegetation period in experimental field, by 2021-2022

In terms of means of dry matter (%), yield (t/ha), and sugar yield (t/ha), Vanghelis and Tesla hybrids show better performances compared to Gorilla and Penalty hybrids. Concerning dry matter, no significant differences are reported between treatments (irrigation and fertilization) within the same genotype. Lower values concerning dry matter content (9.51%-9.01%) are reported by Enchev and Bozhanska (2022) in an experiment involving sugar beet, fodder beet, and table beet. Even though better results are reported in dry matter content, sugar beet yield, and sugar yield, when NPK in ratio of 180-120-120 kg/ha (b_3) was administered, significant differences are emphasized only in sugar beet yields and sugar yields within each genotype between control and fertilization performed with NPK in ratio of 180-120-120 kg/ha (b_3) in both non-irrigated and irrigated experimental variants, at significance thresholds of 1%, and 5%, respectively (Table 2).

These results show, in overall, the positive influence of treatments consisting in irrigation and high NPK input on enhancing sugar beet yield, sugar yield and dry matter content. Lower yields (30.40-35.60 t/ha) compared with those obtained in our experiment are reported by Islamhulov et al. (2019) when different quantities of nitrogen inputs (N_{40} - N_{120}) were administered to Hercules sugar beet hybrid, and by Ijaz et al. (2023) in specific climatic conditions of Pakistan (6.80-13.20 t/ha), when organic fertilization was applied for two sugar beet genotypes.

Similar results concerning sugar beet yield (40.530-68.77 t/ha) are reported by Ahmad et al. (2012), but lower (with a single exception, the hybrid SD-PAK09/07) concerning sugar yield (4.44-7.08 t/ha) when testing NPK inputs 150-100-62.5, on 11 hybrids. Higher interval of sugar yield (6.80-13.20 t/ha), compared to our findings is reported by Ijaz et al. (2023) in specific climatic conditions of Pakistan, when organic fertilization was applied for California and Serenada sugar beet genotypes.

The ANOVA summary for the sugar beet yield shows that genotypes (G), and fertilization (F) have significant influence on probability level of 1%, also irrigation (I) and interaction between genotype and fertilization (G x F) influence the sugar beet yield, but at probability level of 5%. The interactions between genotype and irrigation (G x I), irrigation and fertilization (I x F), and all three factors (G x I x F). The genotype contribution participates to the total variance with 43.48%, the fertilization, and water supply contribution with 30.70%, and 11.25%, respectively, while G x F interaction with 10.65%. The other interactions had low contributions (Table 3). According to the same analysis (ANOVA) the sugar yield is significantly affected only by genotype, at probability level of 5%. The agricultural inputs (irrigation and fertilization), and interactions have no significant influences on sugar yields. The genotype accounted for 39.73% of variation, irrigation for 26.81%, fertilization for 24.25%, while the interactions have a low contribution (Table 4).

Curcic et al. (2018) also found that genotype has a significant influence on sugar yield even though is responsible only for 6.28-7.75% of variance, in an experiment with 5 sugar beet hybrids (including Tesla) within different environmental conditions.

Table 2. The yield, and sugar yield of studied sugar beets hybrids, 2021-2022

Hybrid	Experimental variant	n	Dry matter (%)		Yield (t/ha)		Sugar yield (t/ha)	
			$\overline{X} \pm s_{\overline{X}}$	CV%	$\overline{X} \pm s_{\overline{X}}$	CV%	$\overline{X} \pm s_{\overline{X}}$	CV%
Gorilla	a_1b_1	30	19.48ab±0.16	0.41	37.60abc±0.51	2.74	7.32ab±0.20	5.33
	a_1b_2	30	19.12ab±0.06	0.15	42.40abc±0.68	3.58	8.82ab±0.15	3.71
	a_1b_3	30	19.49ab±0.03	0.09	45.00abc±0.71	3.51	9.08ab±0.09	2.12
	a_2b_1	30	19.49ab±0.15	0.38	38.54abc±0.46	2.42	7.94ab±0.18	4.28
	a_2b_2	30	19.60ab±0.05	0.12	43.00abc±1.05	5.45	9.58ab±0.17	3.93
	a_2b_3	30	19.90ab±0.07	0.18	45.40abc±0.68	3.34	9.86ab±0.07	1.70
Vanghelis	a_1b_1	30	22.08ab±0.11	0.26	58.24abc±0.35	1.26	8.42ab±0.30	7.18
	a_1b_2	30	22.12ab±0.06	0.14	63.00abc±0.71	2.51	9.15ab±0.25	5.83
	a_1b_3	30	22.49ab±0.03	0.08	64.60abc±1.03	3.56	9.65ab±0.21	4.89
	a_2b_1	30	22.29ab±0.10	0.25	59.96abc±0.32	1.11	8.96ab±0.18	3.90
	a_2b_2	30	22.60ab±0.05	0.11	65.40abc±0.51	1.73	10.06ab±0.13	2.73
	a_2b_3	30	22.80ab±0.04	0.11	66.60abc±0.68	2.28	10.84ab±0.13	2.66
Tesla	a_1b_1	30	20.68ab±0.12	0.29	56.00abc±0.32	1.18	7.90ab±0.13	3.13
	a_1b_2	30	20.84ab±1.75	4.25	61.30abc±0.54	1.96	9.36ab±0.13	3.08
	a_1b_3	30	21.40ab±1.86	4.55	63.70abc±0.54	1.89	9.46ab±0.11	2.65
	a_2b_1	30	20.22ab±0.15	0.37	57.70abc±0.54	1.95	8.63ab±0.14	3.36
	a_2b_2	30	21.79ab±0.07	0.17	63.02abc±0.44	2.58	9.81ab±0.11	2.45
	a_2b_3	30	21.98ab±0.14	0.34	64.40abc±0.93	3.22	9.88ab±0.06	1.32
Penalty	a_1b_1	30	17.70ab±0.15	0.39	42.90abc±0.33	1.58	6.82ab±0.24	6.97
	a_1b_2	30	18.16ab±0.08	0.21	47.60abc±0.51	2.40	7.94ab±0.25	7.10
	a_1b_3	30	18.64ab±0.15	0.37	48.72abc±0.81	3.72	8.12ab±0.11	2.94
	a_2b_1	30	19.14ab±0.10	0.26	43.68abc±0.53	2.49	7.26ab±0.36	9.67
	a_2b_2	30	19.34ab±0.08	0.20	48.88abc±0.34	1.55	8.70ab±0.20	5.20
	a_2b_3	30	19.78ab±0.08	0.20	50.80abc±0.80	3.52	9.24ab±0.15	3.72

$\overline{X}$ - mean; $s_{\overline{X}}$ – standard error of mean; CV% - coefficient of variation; *Different letters signifies differences at significance threshold of 0.05%.

Table 3. Summary ANOVA for sugar beet yield by 2021-2022 period

Source of variation	DF	SS	MS	F	% of SS
G	2	367.54	183.77	480.65**	43.48
I	1	95.13	47.56	105.63*	11.25
F	2	259.47	259.47	401.55**	30.70
G x I	4	10.35	2.59	8.68	1.22
G x F	5	90.02	18.01	94.25*	10.65
I x F	2	4.16	2.08	3.61	0.49
G x I x F	7	18.36	2.62	25.89	2.17
Error	18	98.68	5.48	-	-

G - genotype; I - irrigation; F; fertilization; SS - sum of squares; MS - mean squares; G - genotype; I - irrigation; F - fertilization; DF - degrees of freedom; *, ** - the significance levels at $p < 0.05$, and $p < 0.01$.

Table 4. Summary ANOVA for sugar yield by 2021-2022 period

Source of variation	DF	SS	MS	F	% of SS
G	2	102.35	51.18	57.26*	39.73
I	1	69.07	69.07	29.68	26.81
F	2	62.48	31.24	25.12	24.25
G x I	4	5.32	1.33	2.68	2.07
G x F	5	3.29	0.66	3.71	1.28
I x F	2	2.88	1.44	2.02	1.12
G x I x F	7	12.21	1.74	15.62	4.74
Error	18	23.54	1.31	-	-

SS - sum of squares; MS - mean squares; G - genotype; I - irrigation; F - fertilization; DF - degrees of freedom; * - the significance level at $p < 0.05$.

The correlations between the environmental temperature and precipitations on one hand, and on the other hand sugar beet yield or sugar yield, function of agricultural inputs (irrigation, fertilization) are positive and strong or moderate to strong, in all cases (Table 5).

According to PCA, we identify the result of reducing the genotypes and production traits, in their components, which describe the variability of dry matter, root yield, and sugar yield, in specific climatic conditions.

Four principal factors were identified: genotype, production, agricultural inputs, environmental factors (Table 6), but the total variability of both yield traits may be summarized in two components accounting for 42.24%, and 25.08% of variance, and correspond to genotype, and production (Figure 3).

Table 5. Correlation matrix between sugar beet yield (Y), and sugar yield (SY), environmental temperature, and precipitations, function of experimental treatment within each studied genotype, by 2021-2022 period

Issue	Gorilla hybrid					
	Ya_1b_1	Ya_1b_2	Ya_1b_3	Ya_2b_1	Ya_2b_2	Ya_2b_3
Temperature (°C)	0.871	0.864	0.859	0.814	0.876	0.837
Precipitations (mm)	0.625	0.653	0.699	0.668	0.614	0.700
	Vanghelis hybrid					
	Ya_1b_1	Ya_1b_2	Ya_1b_3	Ya_2b_1	Ya_2b_2	Ya_2b_3
Temperature (°C)	0.734	0.735	0.749	0.735	0.761	0.773
Precipitations (mm)	0.624	0.625	0.679	0.630	0.706	0.689
	Tesla hybrid					
	Ya_1b_1	Ya_1b_2	Ya_1b_3	Ya_2b_1	Ya_2b_2	Ya_2b_3
Temperature (°C)	0.778	0.719	0.780	0.818	0.802	0.783
Precipitations (mm)	0.648	0.670	0.655	0.696	0.667	0.605
	Penalty hybrid					
	Ya_1b_1	Ya_1b_2	Ya_1b_3	Ya_2b_1	Ya_2b_2	Ya_2b_3
Temperature (°C)	0.778	0.752	0.685	0.804	0.766	0.758
Precipitations (mm)	0.629	0.598	0.616	0.594	0.770	0.739
	Gorilla hybrid					
	SYa_1b_1	SYa_1b_2	SYa_1b_3	SYa_2b_1	SYa_2b_2	SYa_2b_3
Temperature (°C)	0.754	0747	0.721	0.811	0.752	0.690
Precipitations (mm)	0.617	0.661	0.620	0.635	0.627	0.563
	Vanghelis hybrid					
	SYa_1b_1	SYa_1b_2	SYa_1b_3	SYa_2b_1	SYa_2b_2	SYa_2b_3
Temperature (°C)	0.782	0.826	0.849	0.788	0.735	0.806
Precipitations (mm)	0.564	0.627	0.694	0.669	0.639	0.668
	Tesla hybrid					
	SYa_1b_1	SYa_1b_2	SYa_1b_3	SYa_2b_1	SYa_2b_2	SYa_2b_3
Temperature (°C)	0.732	0.807	0.790	0.784	0.835	0.889
Precipitations (mm)	0.560	0.640	0.611	0.570	0.550	0.601
	Penalty hybrid					
	SYa_1b_1	SYa_1b_2	SYa_1b_3	SYa_2b_1	SYa_2b_2	SYa_2b_3
Temperature (°C)	0.754	0.725	0.804	0.770	0.706	0.758
Precipitations (mm)	0.524	0.571	0.664	0.710	0.575	0.539

Table 6. The eigenvalues of correlation matrix

Nr. crt.	Eigenvalue	% Total-variance	Cumulative-eigenvalues	Cumulative (%)
1	28.96	39.14	28.96	39.14
2	18.85	25.47	47.81	64.60
3	13.68	18.48	61.48	83.08
4	12.52	16.92	74.00	100.00

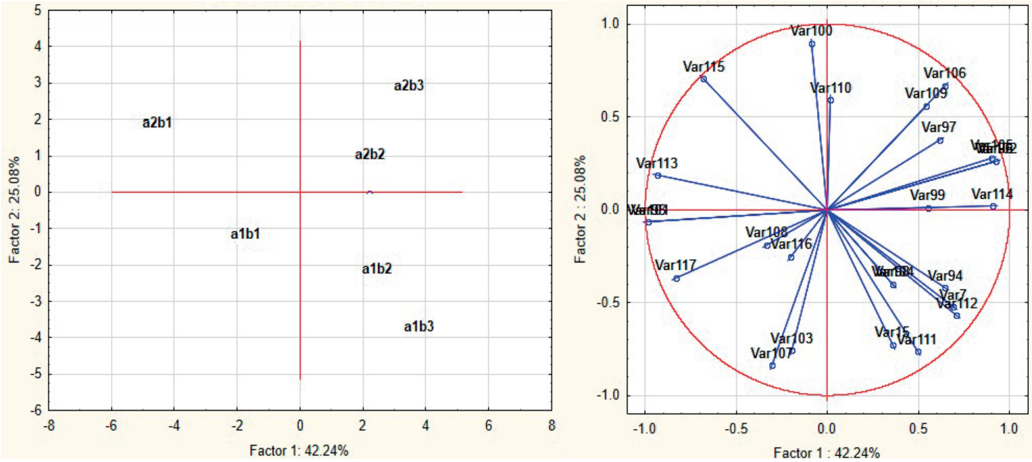

Figure 3. The PCA plot of the cases and variables on the factor plane

The first principal component (PC1) is related to all four genotypes. Irrigation (a_2) and culture supply with NPK in ratios of 60-40-40 kg/ha (b_2), and 180-120-120 kg/ha (b_3) contribute to PC1 increases, meaning these treatments have positive effects in all genotypes.

The same, irrigation (a_2) and no fertilization (b_1) and fertilization with NPK in ratios of 60-40-40 kg/ha (b_2), and 180-120-120 kg/ha (b_3) contribute to PC2 increases, meaning these treatments have positive effects for dry matter, root yield, and sugar yield. The negative direction of both PC1 and PC2 is related to lack of irrigation and fertilization.

Positive loadings for PC 1 (genotype) are identified for both environmental factors temperature (Var 7), and precipitations (Var 15), while for PC2 (productions), negative loadings are reported for the same factors (Figure 3). This suggest that low temperature and water inputs led to dry matter, root yield, and sugar yield decrease in all genotypes, and this finding is consistent with the results of the correlation matrix (Table 5).

CONCLUSIONS

To identify influence of environmental temperature, precipitations and agricultural key inputs (irrigation and fertilization) on analyzed sugar beet hybrid performances, dry matter, yield, and sugar yield, were quantified and correlated with environmental factors temperature and precipitations. The best results in terms of all analyzed production traits are reported in Vanghelis and Tesla hybrids when cultures are irrigated and fertilized with NPK in 180-120-120 kg/ha ratio. The roots yield is significantly influenced by genotype, irrigation, and interaction between genotype and fertilization, while sugar yield only by genotype. The correlations between the environmental temperature and precipitations, and analysed production traits, function of agricultural inputs (irrigation, fertilization) are positive, strong or moderate to strong. Four principal factors were identified, production, agricultural inputs, environmental factors, but the total variability may be summarized in two components accounting for 42.24% (genotype), and 25.08% of variance (production).

REFERENCES

Ahmad, S., Zubair, M., Iqbal, N., Cheema, N.M., Mahmood, K. (2012). Evaluation of Sugar Beet Hybrid Varieties under Thal-Kumbi Soil Series of Pakistan. *International Journal of Agriculture &Biology, 11*. 605–608.

Ahmed, S., Shahzad, F., Rahman, H., Rajab, M. (2020). Effects of Sugar Beet Pulp Based Total Mixed Ration on Growth Performance and Blood Profile Status in Male Nili Ravi Buffalo Calves. *Turk. J. Vet. Anim. Sci.*, *44*. 928–933.

Berłowska, J., Pielech-Przybylska, K., Balcerek, M., Dziekońska-Kubczak, U., Patelski, P.; Dziugan, P., Kręgiel, D. (2016). Simultaneous Saccharification and Fermentation of Sugar Beet Pulp for Efficient Bioethanol Production. *BioMed Res. Int.*, 3154929.

Curcic, Z., Ciric, M., Nagl, N., Taski-Ajdukovic, K. (2018). Effect of Sugar Beet Genotype, Planting and

Harvesting Dates and Their Interaction on Sugar Yield. Front. *Plant Sci., 9,* 1041, doi: 10.3389/fpls.2018.01041.
Du, Y., Zhao, Q., Chan, L., Yao, X., Zhang, W., Zhang, B., Xie, F. (2020). Effect of drought stress on sugar metabolism in leaves and roots of soybean seedlings. *Plant Physiology and Biochemistry, 146*, 1–12.
Enchev, S. & Bozhanska, T. (2022). Chemical composition of sugar beet, fodder beet and table beet depending on the harvest period, *Bulgarian Journal of Agricultural Science, 28*(6), 1034–1039.
Golami, R., Zahedi, S.M. (2019). Identifying superior drought-tolerant olive genotypes and their biochemical and some physiological responses to various irrigation levels. *Journal of Plant Nutrition, 42*(17), 2057–2069.
Guş P., Rusu T., Bogdan, I. (2004). Agrotechnics [In Romanian], Risoprint Publishing House, Cluj-Napoca, Romania.
Ijaz, M., Ul-Allah, S., Sattar, A., Hussain, I., Nawaz, A. (2023). Evaluation of Various Organic Amendment Sources to Improve the Root Yield and Sugar Contents of Sugar Beet Genotypes (*Beta vulgaris* L.) under Arid Environments. *Sustainability, 15*. 3898. https:// doi.org/10.3390/su15053898
Islamgulov, D., Alimgafarov, R., Ismagilov, R., Bakirova, A., Muhametshin, A., Enikiev, R., Ahiyarov, B., Ismagilov, K., Kamilanov, A., Nurligajnov, R. (2019). Productivity and technological features of sugar beet root crops when applying of different doses of nitrogen fertilizer under the conditions of the middle Cis-Ural region Damir. *Bulgarian Journal of Agricultural Science, 25*(Suppl. 2), 90–97.
Kühnel, S., Schols, H.A., Gruppen, H. (2011). Aiming for the Complete Utilization of Sugar-Beet Pulp: Examination of the Effects of Mild Acid and Hydrothermal Pretreatment Followed by Enzymatic Digestion. *Biotechnol. Biofuels*, *4*. 14.
Legendre, B.L., Henderson, M.T. (1972). The history and development of sugar yield calculations. *J. Am. Soc. Sugarcane Technol., 2*. 10–18.
Luca. E. & Nagy. Z. (1999). The irrigation of cultures, [In Romanian], Genesis Publishing House, Cluj-Napoca, Romania.
Mukherjee, E., Gantait, S. (2023). Genetic Transformation in Sugar Beet (*Beta vulgaris* L.): Technologies and Applications. *Sugar Tech., 25*. 269–281.
Münnich, M., Khiaosa-ard, R., Klevenhusen, F., Hilpold, A., Khol-Parisini, A., Zebeli, Q. A (2017). Meta-Analysis of Feeding Sugar Beet Pulp in Dairy Cows: Effects on Feed Intake, Ruminal Fermentation, Performance, and Net Food Production. *Anim. Feed Sci. Technol.*, *224*, 78–89.
Muntean, L.S., Borcean, I., Axinte, M., Roman, Gh.V. 2001. Phytotechny, [In Romanian], „Ion Ionescu de la Brad" Publishing House, Iaşi, Romania.
Okorie, V.O., Mphambukeli, T.N., Amusan, S.O. (2019). Exploring the political economy of water and food security nexus in BRICS. *Afr. Insight, 48*. 21–38.
Pastor I. (2002). The integrated system of sugar beet production and industrialization in Transylvania-Past and future- [In Romanian], Tipomur Publishing House, Târgu-Mureş, Romania.
Verma, A. & Deepti, S. (2016). Abiotic stress and crop improvement: current scenario. *Adv. Plants Agric. Res., 4*. 345–346.