PhD THESIS

The climat impact on production traits in sugar beet

SUMMARY OF THE Ph.D THESIS

PhD student **Letiția-Adriana Bocoș**

Scientific coordinator **Prof. Antonia Cristina Maria Odagiu Ph.D.**

CONTENTS

INTRODUCTION III
LITERATURE REVIEW ....
1. The sugar beet culture III
2. The influence of climatic factors on sugar beet culture III
PERSONAL CONTRIBUTION ……………………………………………………………..
3. Research objectives III
4. Environmental pecularities of the experimental sit III
5. Material and method IV
6. Results and discussion IV
7. Conclusions and recommendations IX
SELECTIVE REFERENCES X

INTRODUCTION

The natural stress produced mainly by temperature and lack of precipitation influences the development of plants, including sugar beet, in a negative way to a large extent (VERMA AND DEEPTI, 2016).

1. The sugar beet culture

The sugar beet crop is one of the most important industrial crops, being a main source of sucrose, used in the production of sugar and other food products. Sugar beet needs certain soil conditions, climate and agricultural management techniques to reach its maximum production potential. The characterization of the sugar beet crop involves the analysis of aspects related to environmental requirements, cultivation technologies, disease and pest control, as well as its utilization (BOCOȘ LETIȚIA ADRIANA ET AL., 2023).

2. The influence of climatic factors on sugar beet culture

Climatic factors have a significant influence on sugar beet cultivation, determining both productivity and crop quality. Moderate temperatures and regular rainfall are essential for optimal development, as sugar beet prefers cool, moist growing conditions.

3. Research objectives

The objectives pursued are represented by the study of productive characteristics, dry matter content and the influence of climatic factors in the studied sugar beet cultivars.

4. Environmental peculiarities of the experimental site

The experiments took place in the experimental field located in the Tritenii de Jos commune area (46°35'10''N, 23°59'47''E). Triteni commune is located in Cluj County, in the Tritiului Valley basin, bordering Mureș County. It is located approximately 59 km southeast of Cluj-Napoca, the county seat. Tritenii de Jos commune, located in the eastern part of Cluj County, represents an interference zone between the Transylvanian Plain and the Someșan Plateau, characterized by a complex relief consisting mainly of gentle hills and slightly undulating plains. This region is in the center of the Transylvanian Depression, where a hilly relief predominates, with altitudes generally varying between 300 and 525 m above sea level, offering a diversified landscape. The relief is the result of complex geomorphological processes, combining elements of erosion and sedimentation, with the hydrographic network of the area as a major influencing factor, especially the presence of the Aries River in the vicinity of the commune. This river, together with its tributaries, shaped the relief through processes of lateral erosion and alluvial deposits, contributing to the creation of meadows and terraces that give the commune a fragmented and varied relief..

5. Material and method

In order to carry out the experiments, four sugar beet cultivars were considered, respectively Gorilla, Vanghelis, Tesla and Penalty. In both experimental years, meteorological data were collected, which characterize the climatic conditions in the Tritenii de Jos area in the two successive experimental years 2021 and 2022, respectively the ambient temperature (°C), the relative air humidity (%), the precipitation regime (mm) and the speed of the wind (km/h). The climatic indicators considered are: ambient temperature (°C), atmospheric pressure (mmHg), relative atmospheric humidity (%) and precipitation (mm). A three-factor experiment (cultivar x irrigation x fertilization) was carried out in two successive years, 2021 and 2022 respectively, in the experimental field located in Tritenii de Jos commune, Cluj county. The Cultivator factor has four gradations, namely: Gorilla, Vanghelis, Tesla and Penalty. Irrigation, the second factor, has two gradations, no irrigation and irrigation with a watering rate of 600 m3/ha per irrigation round, used 7 rounds throughout the growing season. The third factor, fertilization has three gradations: no fertilization, fertilization with the NPK complex in the ratio of 60-40-40 kg/ha, and NPK in the ratio of 180-120-120 kg/ha, according to the experimental scheme. Throughout the years 2021 and 2022, in which the experiments took place, with the help of the mobile climate monitoring station, the climatic factors were monitored, namely the ambient temperature (°C), the relative air humidity (%), the precipitation regime (mm) and the speed wind (km/h), in order to identify their impact on productivity, dry matter and sugar content in the four cultivars studied, depending on the experimental variants. The data were statistically processed using the "STATISTICA" program.

6. Results and discussions

The ANOVA summary for sugar beet production shows that varieties (C) and fertilization (F) have a significant influence at the 1% probability level, also irrigation (I) and the interaction between variety and fertilization (C x F) influence productivity sugar beet, but at a 5% probability level. The interactions between variety and irrigation (C x I), irrigation and fertilization (I x F) and all three factors (C x I x F) highlight the fact that the genotype contributes to the total variation by 43.48%, the contribution of fertilization and supply of water being equal to 30.70% and 11.25%, respectively, while the interaction C x F with 10.65%. It is found that the other interactions had low contributions (Table 6.13).

Table 6.13

The summary of ANOVA analysis for fresh biomass yield in sugar beet (t/ha), in Tritenii de Jos area, 2021 – 2022

The source of variation	DF	SS	MS	F	% of SS
C	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
C x I	4	10.35	2.59	8.68	1.22
C x F	5	90.02	18.01	94.25*	10.65
I x F	2	4.16	2.08	3.61	0.49
C x I x F	7	18.36	2.62	25.89	2.17
Error	18	98.68	5.48	-	-

C – variety; I – irrigation; F – fertilization; SS – sum of squares; MS – mean squares; DF –degrees of freedom; *, ** – the significance levels at $p < 0.05$, $p < 0.01$.

According to ANOVA, the sugar yield is significantly affected only by the variety, at a probability level of 5%. Agricultural inputs (irrigation and fertilization) and interactions do not have significant influences on sugar production (BOCOȘ LETIȚIA ADRIANA ET AL., 2024b). The variety accounted for 39.73% of the variation, irrigation 26.81%, fertilization 24.25%, and interactions had little contribution (Table 6.26). CURCIC ET AL. (2018) also found that variety has a significant influence on sugar yield, although it is only responsible for 6.28%-7.75% of the variation, in an experiment with 5 sugar beet hybrids in different conditions.

Tabelul/Table 6.26

Sumarul analizei ANOVA pentru producția de biomasă uscată la sfecla de zahăr (t/ha), în zona Tritenii de Jos, 2021 – 2022

The source of variation	DF	SS	MS	F	% of SS
C	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
C x I	4	5.32	1.33	2.68	2.07
C x F	5	3.29	0.66	3.71	1.28
I x F	2	2.88	1.44	2.02	1.12
C x I x F	7	12.21	1.74	15.62	4.74
Error	18	23.54	1.31	-	-

C – variety; I – irrigation; F – fertilization; SS – sum of squares; MS – mean squares; DF –degrees of freedom; * – the significance levels at $p < 0.05$, $p < 0.01$.

Over the entire experimental period 2021 – 2022, for the studied sugar beet cultivars, the best results were obtained by combining irrigation with fertilization, thus demonstrating the importance of integrated management of water and nutrient resources to optimize sugar content (Tables 47-50). The experimental variant a2b3, which combines irrigation and intensive fertilization, led to the highest average sugar productivity of 9.86 kg/ha and a CV = 16.73%. This result suggests that in order to maximize the potential of sugar production in the Gorilla cultivar, an intensive resource management approach is required. The relatively high coefficient of variation in some treatments indicates a sensitivity of production to environmental factors and agricultural management.

Table 6.47

The basic statistics for sugar content in Gorilla sugar beet, dry matter (t/ha), in Tritenii de Jos area, 2021 – 2022

Experimental variant	N	X	Minim	Maxim	s	CV%
a_1b_1	31	7.32	7.18	7.51	1.74	23.77
a_1b_2	31	8.82	8.63	9.11	1.36	15.42
a_1b_3	31	9.18	8.92	9.21	1.39	15.14
a_2b_1	31	7.94	7.72	8.12	1.48	18.64
a_2b_2	31	9.58	9.51	9.84	1.42	14.82
a_2b_3	31	9.86	9.51	9.92	1.65	16.73

1 – no irrigation (a_1), no fertilization (b_1); 2 – no irrigation (a_1), NPK 60-40-40 kg/ha (b_2); 3 – no irrigation (a_3), NPK 180-120-120 kg/ha (b_3); 4 – irrigation (a_2), no fertilization (b_1); 5 – irrigation (a_2), NPK 60-40-40 kg/ha (b_2); 6 – no irrigation (a_2)- NPK 180-120-120 kg/ha (b_3).

In the Vanghelis cultivar, both fertilization and irrigation have a significant positive impact on the sugar content. The best results are obtained when the two methods are used together, especially in the variant with intensive fertilization (a2b3), which presents an average productivity equal to 11.84 t/ha (Table 6.48).

Table 6.48

The basic statistics for sugar content in Vanghelis sugar beet, dry matter (t/ha), in Tritenii de Jos area, 2021 – 2022

Experimental variant	N	X	Minim	Maxim	s	CV%
a_1b_1	31	8.42	8.31	8.61	1.33	15.81
a_1b_2	31	9.15	9.16	9.35	1.19	13.11
a_1b_3	31	9.65	9.51	9.88	1.27	13.16
a_2b_1	31	8.96	8.71	9.11	1.14	12.72
a_2b_2	31	11.16	9.72	11.42	1.21	11.84
a_2b_3	31	11.84	11.64	11.12	1.16	9.81

1 – no irrigation (a_1), no fertilization (b_1); 2 – no irrigation (a_1), NPK 60-40-40 kg/ha (b_2); 3 – no irrigation (a_3), NPK 180-120-120 kg/ha (b_3); 4 – irrigation (a_2), no fertilization (b_1); 5 – irrigation (a_2), NPK 60-40-40 kg/ha (b_2); 6 – no irrigation (a_2)- NPK 180-120-120 kg/ha (b_3).

Over the entire experimental period, it can be seen that fertilization contributes significantly to the increase of sugar content in the Tesla cultivar. Even without irrigation, moderate and intensive fertilization significantly improve sugar production. Irrigation in combination with fertilization brings further improvement, but the effect is most pronounced when combined with adequate fertilization. Irrigation alone, without fertilization, has a lower impact compared to the combined use of both practices (Table 6.49).

Table 6.49

The basic statistics for sugar content in Tesla sugar beet, dry matter (t/ha), in Tritenii de Jos area, 2021 – 2022

Experimental variant	N	X	Minim	Maxim	s	CV%
a_1b_1	31	7.91	7.77	8.32	1.51	19.19
a_1b_2	31	9.36	9.21	9.72	1.23	13.14
a_1b_3	31	9.46	9.41	9.81	1.44	15.22
a_2b_1	31	8.63	8.51	8.91	1.37	15.87
a_2b_2	31	9.81	9.62	11.23	1.25	12.74
a_2b_3	31	9.88	9.72	11.21	1.61	16.31

1 – no irrigation (a_1), no fertilization (b_1); 2 – no irrigation (a_1), NPK 60-40-40 kg/ha (b_2); 3 – no irrigation (a_3), NPK 180-120-120 kg/ha (b_3); 4 – irrigation (a_2), no fertilization (b_1); 5 – irrigation (a_2), NPK 60-40-40 kg/ha (b_2); 6 – no irrigation (a_2)- NPK 180-120-120 kg/ha (b_3).

For the sugar beet cultivar Penalty, the comparison of the a1b1 and a1b3 variants shows that intensive fertilization significantly increases the sugar yield. Irrigation combined with fertilization gives the greatest increases in sugar content. This suggests that additional water, in combination with nutrients, supports optimal plant metabolism and maximum sugar accumulation (Table 6.50).

Table 6.50

The basic statistics for sugar content in Penalty sugar beet, dry matter (t/ha), in Tritenii de Jos area, 2021 – 2022

Experimental variant	N	X	Minim	Maxim	s	CV%
a_1b_1	31	6.82	6.71	7.43	1.71	24.93
a_1b_2	31	7.94	7.78	8.15	1.39	17.51
a_1b_3	31	8.12	8.11	8.26	1.44	17.73
a_2b_1	31	7.26	7.21	7.51	1.36	18.73
a_2b_2	31	8.71	8.61	9.14	1.68	19.29
a_2b_3	31	9.24	9.11	9.41	1.52	16.45

1 – no irrigation (a_1), no fertilization (b_1); 2 – no irrigation (a_1), NPK 60-40-40 kg/ha (b_2); 3 – no irrigation (a_3), NPK 180-120-120 kg/ha (b_3); 4 – irrigation (a_2), no fertilization (b_1); 5 – irrigation (a_2), NPK 60-40-40 kg/ha (b_2); 6 – no irrigation (a_2)- NPK 180-120-120 kg/ha (b_3).

Regardless of the type of variety or trait treated (fresh mass productivity, dry mass productivity, dry matter content and sugar) three main factors were identified, respectively: variety, climatic conditions and agronomic inputs (BOCOȘ LETIȚIA ADRIANA ET AL., 2024a).

Principal Component 1 (PC1), i.e. "The variety", shows the significant contributions of beet cultivars (both positive and negative) and is less influenced by weather variables. Principal Component 2 (PC2), namely "Climatic conditions" is strongly influenced by both weather variables (such as temperature and precipitation) and the productive and nutritional characteristics of sugar beet. Principal Component 3 (PC3), namely "Agronomic Inputs", has contributions from both the fertilization and irrigation levels. These highlight differences between cultivars in terms of productive and nutritional characteristics of sugar beet depending on agricultural inputs and climatic conditions, suggesting variability between different treatments and/or cultivars. (BOCOȘ LETIȚIA ADRIANA ET AL., 2024b)PC1 (The variety) is responsible for 46.05% of the total variance in fresh biomass production in the studied sugar beet varieties, and PC2, respectively "Climatic conditions" for 32.92% of the total variance. This suggests that together PC1 and PC2 account for most of the variability. PC3 (Agronomic inputs), is responsible for 21.03% of the total variance (Table 6.67).

Tabelul 6.67

The Eigenvalues of the correlations matrices for the fresh biomass yield (t/ha), in studied sugar beet varieties, 2021 – 2022

Factor	Eigenvalues	% Total variance	Cumulative	Cumulative variance
PC1	7.2951	46.0540	7.2951	46.0540
PC2	6.4188	32.9242	13.7139	78.9782
PC3	4.7529	21.0218	18.4668	100.0000

PC1 (The variety) is responsible for 51.16% of the total variance in fresh biomass production in the sugar beet cultivars studied, and PC2, respectively "Climatic conditions" for 31.28% of the total variance. This suggests that together PC1 and PC2 account for most of the variability. PC3 (Agronomic inputs), is responsible for 21.66% of the total variance (Table 6.68). PC1 (The variety) is responsible for 54.55% of the total variance in fresh biomass production in the sugar beet cultivars studied, and PC2, respectively "Climatic conditions" for 25.69% of the total variance. This suggests that together PC1 and PC2 account for most of the variability. PC3 (Agronomic inputs), is responsible for 18.26% of the total variance (Table 6.69). PC1 (The variety) is responsible for 54.55% of the total variance in fresh biomass production in the sugar beet cultivars studied, and PC2, respectively "Climatic conditions" for 25.69% of the total variance. This suggests that together PC1 and PC2 account for most of the

variability. PC3 (Agronomic inputs), is responsible for 18.26% of the total variance (Table 6.70).

Tabelul 6.68

The Eigenvalues of the correlations matrices for the dry biomass yield (t/ha), in studied sugar beet varieties, 2021 – 2022

Factor	Eigenvalues	% Total variance	Cumulative	Cumulative variance
PC1	9.038259	51.16641	7.2951	46.0540
PC2	6.173855	31.28915	13.4690	77.3432
PC3	3.399513	22.65696	16.8685	100.0000

Tabelul 6.69

The Eigenvalues of the correlations matrices for the dry biomass yield (t/ha), in studied sugar beet varieties, 2021 – 2022

Factor	Eigenvalues	% Total variance	Cumulative	Cumulative variance
PC1	9.669822	54.53508	7.2951	56.0540
PC2	4.112686	25.68817	11.4078	81.7422
PC3	4.021036	18.25784	15.4288	100.0000

Tabelul 6.70

The Eigenvalues of the correlations matrices for the sugar content (t/ha), in studied sugar beet varieties, 2021 – 2022

Factor	Eigenvalues	% Total variance	Cumulative	Cumulative variance
PC1	17.07596	60.98557	17.07596	60.98557
PC2	3.16966	21.32022	20.2456	82.3058
PC3	2.81784	17.69420	23.0635	100.0000

9. Conclusions and recommendations

The variance analysis indicates that genotype and fertilization have a significant influence on sugar beet productivity, contributing majorly to the total variation in yield (43.48% and 30.70% respectively). Irrigation and interactions between variety and fertilization, although significant, had smaller contributions to total variability. This suggests that the correct selection of varieties and the appropriate application of fertilization are essential factors for optimizing sugar beet production.

Also, according to the ANOVA analysis, sugar yield in sugar beet is significantly influenced only by genotype at the 5% probability level. Environmental factors such as irrigation and fertilization, as well as the interactions between these factors, had no significant influence on sugar production. The variety contributed 39.73% to the variation in yield, while irrigation and fertilization contributed 26.81% and 24.25%, respectively. The interactions between these factors contributed little to the total variation, suggesting that selection of genotypes is the most important factor for optimizing sugar production.

In the analysis of the sugar content of sugar beet roots, a high correlation between the variables is highlighted, most of them being grouped in the PC1 x PC2 plane. This suggests a strong interdependence between variety, and climatic conditions. The complex relationship between the three main components shows that they together influence the variability of fresh biomass and sugar content, highlighting the importance of the interaction between variety, climatic conditions and agronomic inputs in determining the final results of sugar beet crops.

Following the studies, we believe that the following recommendations can be formulated: ▶ the use of irrigation with intensive fertilization, for the cultivation of sugar beet, regardless of the variety. This approach has demonstrated the best results in terms of productivity and yield stability, highlighting the importance of integrated water and fertilization management; ▶ to maximize sugar beet productivity and quality, careful selection of variety type (PC1), adaptation to specific climatic conditions (PC2) and efficient use of agronomic inputs such as fertilization and irrigation (PC3) are essential. This integrated approach will ensure reduced variability and increased consistency of results, emphasizing the importance of the interaction between these factors in the optimization of sugar beet crops.

SELECTIVE REFERENCES

1. **BOCOȘ, LETIȚIA ADRIANA, ANTONIA ODAGIU, CAMELIA OROIAN, C. IEDERAN, P. BURDUHOS, 2023, Production and Sugar Content of Four Sugar Beet Hybrids Function of Environmental Temperature, Precipitations and Agricultural Key Inputs, *Scientific Papers. Series A. Agronomy, 66(2),* 134-140.**
2. **BOCOȘ LETIȚIA ADRIANA, CAMELIA OROIAN, C. IEDERAN, ANTONIA CRISTINA MARIA ODAGIU, 2024, Testing the Interaction between Agricultural Inputs and SiteSpecific Climatic Factors in Sugar Beet Production, *ProEnvironment, 17 (57),* 68-71.**
3. **BOCOȘ LETIȚIA ADRIANA, CAMELIA OROIAN, P. BURDUHOS, C. IEDERAN, ANTONIA CRISTINA MARIA ODAGIU, 2024, Sugar Beet Yield in Different Varieties Function of Irrigation and Fertilization Strategy, *ProEnvironment, 17 (58),* 76-79.**
4. 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.
5. VERMA, A. DEEPTI S. (2016). Abiotic stress and crop improvement: current scenario. *Adv Plants Agric Res, 4*, 345–346.