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ABSTRACT

of the dissertation submitted for the degree of Doctor of Philosophy

BIOMORPHOLOGICAL CHARACTERISTICS AND OPTIMAL CULTIVATION TECHNOLOGY OF TABLE BEET UNDER ABSHERON CONDITIONS

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Candidate: **Shaban Mustafa Magsudov**

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The dissertation was conducted at the Agro-biotechnology Department and Functional Analysis Laboratory of the "Vegetable Research Institute" Public Legal Entity under the Ministry of Agriculture of the Republic of Azerbaijan.

Scientific supervisor: Corresponding member of ANAS,
Doctor of biological sciences, professor
Ibrahim Vahab Azizov

Official opponents: Corresponding member of ANAS,
Doctor of biological sciences, professor
Magsud Rustam Gurbanov

PhD in agricultural sciences,
assistant professor
Azar Salman Shukyurov

PhD in agricultural sciences
Rahmina Mamash Zamanova

Dissertation Council FD 1.29 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at the Research Institute of Crop Husbandry of the Ministry of Agriculture of the Republic of Azerbaijan.

Chairman of the Dissertation council:

Doctor of agricultural sciences, professor
_______________ **Jalal Shamil Mammadov**

Scientific secretary of the Dissertation council:
PhD in agricultural sciences, assistant professor
_______________ **Sevda Kamal Hajiyeva**

Chairman of the Scientific seminar:
Doctor of agricultural sciences, assistant professor
_______________ **Islam Akif Bayahmadov**

INTRODUCTION

Relevance of the topic and degree of study. Table beet has been one of the oldest cultivated vegetable crops in Azerbaijan, valued for its content of biologically and physiologically active substances, vitamins, and mineral salts. It is considered one of the most important products in human nutrition and health preservation. According to the Azerbaijan State Statistics Committee (2022), in 2021, table beet was cultivated on 553.8 hectares, producing 10,745.4 tons of output, with an average yield of 19.4 tons per hectare. Considering that the global average yield of table beet is 30-35 tons per hectare, the lower yield in Azerbaijan can be attributed to improper cultivation techniques and the lack of intensive technologies.

To meet the demands of the country's population, at least 19,000 tons of table beet must be produced annually. Currently, only 53.7% of this demand is being met. In addition to fulfilling domestic needs, this valuable crop holds significant industrial importance in Azerbaijan. Therefore, alongside expanding cultivation areas, increasing table beet productivity is a pressing issue.

It is worth mentioning that Azerbaijan's soil and climatic conditions allow for large-scale cultivation of this valuable crop. Given that table beet is salt-resistant, its cultivation in the Aran economic region of the country is of great importance.

Until recently, only a small amount of table beet was used in Azerbaijan. However, as the country embarks on an independent development path, facing challenges in securing its food and industrial products, conducting research on this valuable food and medicinal plant has become an urgent necessity.

In this context, the subject of our research focuses on the key elements of cultivating table beet using intensive technologies. These elements include planting high-yielding varieties, determining the optimal planting time and scheme (selecting the plants' feeding area), and feeding with organic and mineral fertilizers. As such, our research topic remains relevant and will continue to be of significance in the future.

The theoretical and applied aspects of increasing the productivity and quality of table beet, as well as understanding the changes occurring during the plant's growth and development processes, have been reflected in the works of numerous researchers[1][2][3].

However, the productivity of table beet in the conditions of Azerbaijan, particularly in the Absheron economic region, as well as the quality changes due to the mentioned factors and the biomorphological changes occurring during the plant's growth and development, have not been studied. This gap in research forms the basis of our current study.

Research object and subject. The research object involves the high-yielding Bordo-237 variety of table beetroot, which has been well adapted to Azerbaijani conditions and sourced from the gene pool of the "Vegetable Research Institute" public legal entity.

The subject of the research is to study the biomorphological, physiological, and biochemical changes in the Bordo-237 variety of table beetroot, depending on planting schemes, planting times, and the application of mineral fertilizers and to determine the optimal planting time, planting scheme, and fertilizer rates based on these factors.

Purpose and objectives of the research. The main purpose of the research is to study the biomorphological characteristics and optimal cultivation technologies of table beetroot (Beta vulgaris var. esculenta L.) under Absheron conditions to achieve high and quality yields. To achieve this goal, the following tasks have been set: Of the Bordo-237 variety of table beetroot under Absheron conditions;

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[1] Bogomolov, D.V. Efficiency of fertilizing table beets on meadow-brown podzolized soils of the Primorsky Territory: Abstract of a PhD diss. in Agricultural Sciences. - Barnaul. - 2006. - 18 p.

[2] Gaplaev M. Ch., Pivovorov V.F. Influence of fertilizers and irrigation on the yield and quality of table beet roots. // Vegetables of Russia. Scientific and practical journal, - 2014. No. 1 (22), - p. 80-91.

[3] Kurbanova L.G. Influence of timing and density of crops on the yield and quality of table carrots in the flat zone of the Republic of Dagestan: Abstract of a PhD diss. in Agricultural Sciences. - Makhachkala, - 2017. - 27 p.

- To evaluate the biomorphological and physiological characteristics;
- To study its biochemical indicators;
- To monitor its development dynamics and determine the optimal sowing time, sowing scheme, and fertilizer rate;
- To assess the economic efficiency.

Research methods. The research methodology consisted of analyzing previous studies, evaluating the soil and climatic conditions of the economic region where the research was conducted, summarizing the objectives and tasks, and setting up and conducting field experiments. The methodological foundation of the research was based on commonly accepted methods and programs developed by various scientific institutions, as well as refined methodologies using modern equipment at the Vegetable Research Institute.
The results of the field studies were processed and analyzed using modern statistical methods, including correlation and variance analysis, as well as the T-test statistical analysis method.

Main points submitted for defense:

1. By sowing table beetroot seeds at different sowing times, and studying the biomorphological, physiological, and biochemical characteristics of the plant, the optimal sowing time was selected.
2. By sowing table beetroot seeds in different sowing schemes and tracking changes in the plant's biomorphological, physiological, and biochemical indicators, the optimal sowing scheme was selected.
3. By using organic and mineral fertilizers, the optimal fertilizer rate was determined by studying the biomorphological, physiological, and biochemical characteristics of the table beetroot plant.
4. The economic efficiency of cultivating table beetroot was studied under the optimal sowing time, sowing scheme, and fertilizer rate.

Scientific novelty of the research. For the first time, table beetroot was studied under Absheron conditions at different sowing times, and the optimal sowing time was determined. For the first time, the optimal sowing scheme for table beetroot was identified in different sowing schemes under Absheron conditions. The impact of organic and mineral fertilizers on table beetroot productivity was studied, and the optimal fertilizer rate for obtaining high-quality yields was determined.

Theoretical and practical significance of the research. The theoretical significance of the research lies in studying the biomorphological, physiological, and biochemical characteristics of table beetroot under Absheron conditions, depending on the sowing scheme, sowing time, and application of mineral fertilizers, and drawing relevant conclusions. It was determined that, due to the influence of these factors, the leaf surface area of the plants, the photosynthetic potential of the crop, the coefficient of economic efficiency of photosynthesis, the specific surface density of the leaves, and the chlorophyll content in the leaves significantly change. Under optimal sowing times, sowing schemes, and fertilizer rates, the values of the studied indicators remain at a balanced level for obtaining high-quality yields.

The practical significance of the research is that, for the first time, the optimal sowing time, sowing scheme, and fertilizer rate were determined to obtain high-quality yields of table beetroot in the Absheron economic region of the Republic of Azerbaijan.

Approbation and application. The main results of the dissertation were presented and discussed at the scientific councils of the "Vegetable Research Institute" public legal entity (2017-2024), at the IV International Scientific-Practical Conference (Ukraine, Kruty, 12-13.03.2019), at the International Scientific-Practical Conference (Baku, 28.12.2019), at the Republican Scientific-Practical Conference held at the Agrarian University (Ganja, 29.10.2019), at the Republican Scientific-Practical Conference "The Road from Theory to Practice" (Ganja, 23.06.2022), at the International Scientific-Practical Conference "Yesterday, Today, and Tomorrow of Soil Science" (Baku, 5-6.12.2022), at the scientific-practical conference "Heydar Aliyev and Agricultural Policy" (Ganja, 04.05.2023), and at the "Eurasia Science" International Scientific-Practical Conference (Moscow, 31.03.2024).

Based on the research materials, 17 articles (four of which were published in journals indexed in international databases) and conference materials reflecting the main content of the dissertation were published both domestically and internationally.

Name of the institution where the dissertation was conducted: The dissertation was conducted in the Agrotechnology Department and Functional Analysis Laboratory of the "Vegetable Research Institute" public legal entity under the Ministry of Agriculture of the Republic of Azerbaijan.

The total volume of the dissertation with a sign, indicating the volume of the structural units of the dissertation separately. The dissertation consists of an introduction, 6 chapters, conclusions, recommendations, a list of references, and appendices, totaling 186 pages. A total of 161 literature sources were used in the research, of which 93 are foreign publications. The dissertation contains 207,020 characters (excluding figures, tables, references, and appendices), with the introduction containing 11,179 characters, Chapter I containing 49,980, Chapter II containing 20,514, Chapter III containing 27,449, Chapter IV containing 29,311, Chapter V containing 46,189, Chapter VI containing 7,495, and conclusions and recommendations containing 8,850 characters. The dissertation includes 24 tables, 21 graphs, and 5 figures.

Chapter I. LITERATURE REVIEW

In this chapter, materials relevant to the research objectives were studied, the level of development of the topic was demonstrated, and a literature review on the importance of table beetroot, its brief botanical classification, biological characteristics, geographical origin and distribution, agronomy, and fertilization was provided[4][5].

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[4] Useynova N.S. The role of haying in strengthening the fodder base // - Baku: Scientific Works of the Institute of Agriculture–2017. Volume XXVIII, p. 247-249.

[5] Khalimbekov A.Ch. Influence of sowing patterns, distance in a row of growth regulator on the yield of table beet under drip irrigation on meadow soils of the Republic of Dagestan: Abstract of diss. candidate of agricultural sciences. / - Makhachkala: 2022. - 24 p.

Chapter II. SOIL AND CLIMATIC CONDITIONS, MATERIALS, AND METHODOLOGY OF THE RESEARCH

2.1. Soil and climatic conditions of Absheron. The soils of the Absheron Subsidiary Farm of the "Vegetable Research Institute" Public Legal Entity, where the field experiments were conducted, are predominantly gray-brown. The humus content in the arable layer varies between 0.86-1.45%. Absheron has a dry subtropical climate, with hot summers, sunny autumns, and mild winters.

2.2. Research material. The research material used was the locally adapted variety of table beetroot, Bordo-237, which has been cultivated in Azerbaijan.

2.3. Research methodology. The experiments were conducted in both field and laboratory conditions at the Absheron Subsidiary Farm of the "Vegetable Research Institute" Public Legal Entity. Nitrogen in plants was determined using the Kjeldahl method, phosphorus by the Lorenz method, exchangeable potassium by the Kinzburg and Shirlova method, and sugar content by the Vilfus method[6789].

To study the variability of nitrogen, phosphorus, and potassium in the soil, the following methods were applied: total humus by I.V. Tyurin, total nitrogen by the Kjeldahl method, easily hydrolyzed nitrogen by the methods of I.V. Tyurin and M.M. Konaneva, nitrate nitrogen by the Grandville-Lyaju method, and water-soluble active ammonia was determined by the colorimetric method using absorbed ammonia.

The research aimed to study the effects of various elements of

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[6] Encyclopaedia of vegetable gardening (Terms, concepts and interpretations) / E.I. Allahverdiyev, F.N. Agayev, A.T. Asgarov [and others]. - Baku: "East-west" OJSC, - 2020. - 840 p.

[7] Methods of biochemical research of plants. /supervised Prof. A.I. Ermakova. - L. Agropromizdat. Leningrad. Department. - 1987. - 430 p.

[8] Radov A.S. Workshop on agrochemistry / A.S. Radov, I.V. Pustovoy, A.V. Kerkabkov; - M. Kolos. - 1978. - 352 p.

[9] Abdel-Gawad, A.A. Effect of nitrogen, potassium and organic manure on yield and chemical composition of fodder beet (*Beta vulgaris*, L.) / A.A. Abdel-Gawad, H.M. Abdel-Aziz, M.S. Reiad // Annals of Agricultural Science (Cairo), - 1997. 42 (2), -p. 377-397.

cultivation technology-such as sowing scheme, sowing time, and fertilizer rate-on the biomorphological characteristics and yield of table beetroot. Experiments were conducted in 5 variants with 3 repetitions for each, focusing on fertilizer rate, sowing time, and sowing scheme. Each experiment repetition was conducted on a plot size of 10 m², with a total experimental area of 850 m².[10]
In this case, for the Bordo-237 variety of table beetroot, the following sowing schemes were used:
55+55+70x10 cm (control)
45+45+70x10 cm
25+25+25+25+25+55x10 cm
60+10x10 cm
50+20x10 cm sowing dates were as follows:
01-05.III
10-15.III (control)
20-25. III
01-05.IV
10-15. IV from sowing periods
Without fertilizer (control)
20 t/ha manure (base)
Base + $N_{120}P_{60}K_{60}$
Base + $N_{120}P_{60}K_{90}$
Base + $N_{120}P_{60}K_{120}$ fertilizer rates were applied.

Throughout the entire vegetation period, phenological observations and biometric measurements were carried out on individual plants. Total yield, marketable and non-marketable product quantities were studied. Agronomic care was provided to the plants in a timely manner and in accordance with agricultural guidelines. Additionally, mineral fertilizers in the form of NPK (18:18:14) were applied in stages, taking into account the percentage of nutrients in the soil[11].[12]

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[10] Litvinov S.S. Methodology of field experiment in vegetable growing / S.S.Litvinov - M.: Russian Agricultural Academy. - 2011. - 648 p.

[11] Bagirova B.C., Bagirov H.C. The effect of fertilizers on the productivity of plants grown in different soil and climate conditions and soil fertility // - Baku: Soil science and agrochemistry, - 2018, № 1-2, - p.327-330

2.4. Calculation of the profitability level of table beetroot. Along with the profitability of assets, the profitability indicator of the product is also used in the analysis of entrepreneurial activity and is calculated using the following formula:

$$R_m = (M_s : M_{ü}) \times 100\ \% \qquad (2.4)$$

Here, **Ms** - represents the net income obtained from the sale of the product, and **Mü -** refers to the total cost incurred in the production of the sold product.

2.5. Methodology of biochemical and physiological research. Dry matter was determined using the thermostat-weight method by drying at 105°C. For this purpose, samples weighing 10±0.01 grams from leaves and petioles, and 25±0.01 grams from root crops were taken, after being chopped into small pieces beforehand. The samples were then dried in a thermostat at 105°C for 10-12 hours until a constant weight was obtained.

The amount of dry matter was calculated using the following formula:

$$X = \frac{a - a_1}{n} \cdot 100 \qquad (2.5)$$ Here,

X is the amount of dry matter, in percentage; **a** is the mass of the dry residue along with the Petri dish, in grams; **a1** is the mass of the Petri dish, in grams; **n** is the amount of sample taken, in grams; **100** is the coefficient to express the result in percentage.

To determine the sugar content in root crops using the refractometric method (RA-130, Japan), different parts of at least four root crops are cut, and an average sample of approximately 100-120 g is taken. Juice is extracted from this sample and filtered through 3-4 layers of gauze. From the resulting clear juice, 0.5-1 ml is poured into the refractometer's slot, and the device is turned on. After 20 seconds, the number displayed on the screen is recorded. This operation is repeated at least four times, every 20 seconds. The results are summed up, divided by the number of repetitions, and the

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[12]Mammadov G.M. The dynamics of nitrogen, phosphorus and potassium in brown soils under apple plants in different fertilization systems // Materials of the scientific-practical conference on "Heydar Aliyev's land reforms are a guarantee of food security". - Baku: ANAS, Institute of Soil Science and Agrochemistry, - 2013, No. 1, p. 24.

average sugar content is found (in percentage).

The leaf surface area in beet plants was measured using the LI-3000C portable device (Japan), chlorophyll content in leaves was determined with the SPAD-502 Chlorophyllemeter device (South Korea), and the nitrate content in root crops was measured with the Nitrometer (SOEKS) device. Dry matter in leaves, petioles, and root crops was determined by the thermostat-weight method by heating at 105°C.

2.6. Determination of sugar by the refractometric method. Photosynthetic potential (PP) is calculated by accumulating the leaf surface area over the entire growing season and multiplying the average leaf surface area (Lor) by the length of the growing season (Tv) using the following formula[13]:

$$FP = Lor \cdot Tv \qquad (2.6.1)$$

The specific leaf area density (SLAD) is characterized by the amount of dry leaf mass (M_{leaf}) per unit leaf area (L) and is expressed in mg/cm². It is calculated as follows:

$$\text{SLAD} = \frac{M_{leaf}}{\text{L}} \quad (2.6.2)$$

The economic efficiency coefficient of photosynthesis (EECP) expresses the ratio of the dry mass of the economically important part of the plant (the root crop, M dry) to the dry mass of its vegetative parts (including generative organs like flowers, M veg) and is calculated using the following formula:

$$\text{EECP} = \frac{M_{DRY}}{M_{VEG}} \qquad (2.6.3)$$

The results of the research were statistically processed, and correlation relationships among various indicators were determined.[14]

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[13] Yusifov M.A. Physiology of watermelon / M.A. Yusifov; - Baku: Nur -2004. - p. 216

[14] Dospekhov B.A. Methodology of field honey fungus / B.A. Dospekhov. - Moscow: - ALDNS, - 2014. - 391s

Chapter III. THE EFFECT OF SOWING DATES ON THE BIOLOGICAL AND ECONOMIC CHARACTERISTICS OF TABLE BEET

3.1. Biomorphological characteristics of table beet depending on sowing dates. When looking at the effect of the sowing period on the morphological indicators of table beet, we see that the variants with the highest number of leaves and plant height (Figure 1; average over 3 years) were the control and the variants sown between March 1-5. The indicators were characterized as follows: the control variant recorded 32.0 leaves and a height of 37.5 cm, while the March 1-5 variant recorded 31.0 leaves and 46.9 cm in height.

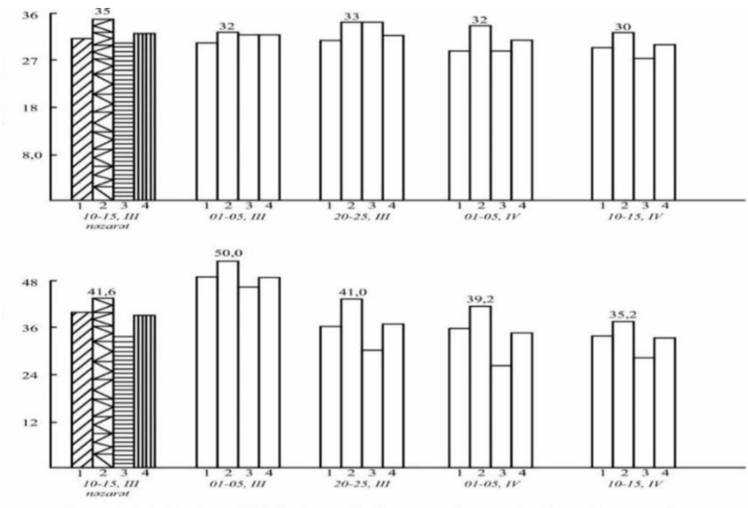
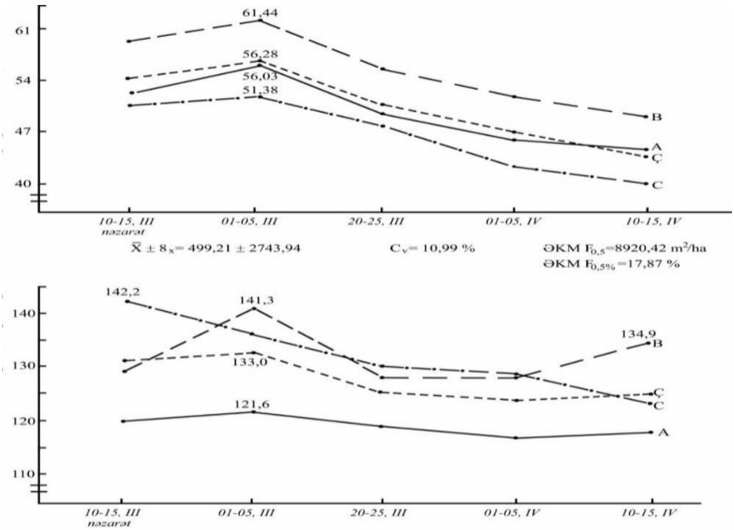


Figure 1. The number of leaves and height of table beet depending on sowing dates

Note: 1-2017; 2-2018; 3-2019; 4-3-year average.

The lowest values were noted for sowings in April (specifically, 28.7 leaves and 32.6 cm for the April 1-5 variant, and 27.3 leaves and 30.8 cm for the April 10-15 variant). The March 20-25 variant held an intermediate position. It has been determined that the optimal sowing period for table beet seeds in the Absheron region is the first half of March. Relatively long and thick-rooted beetroots were observed in plants sown during the first half of March (specifically, for the March 1-5 sowing, the root length was 106.7 mm and diameter 86.0 mm, while for March 10-15, they measured 104.6 mm and 84.5 mm, respectively).

3.2. The effect of sowing dates on some physiological parameters of table beet. During the study years, the leaf area of table beet ranged from 37,801.3 to 61,441.5 m²/ha, while the chlorophyll content in the leaves varied between 117.2 and 142.2 mg/100 g (see graph).



Graph. changes in leaf area and total chlorophyll content in table beet depending on sowing dates.

Note: A - 2017; B - 2018; C - 2019; D - Average over 3 years

The highest leaf area was recorded in 2018, which was favorable for beetroot cultivation (47,695.0-61,441.5 m²/ha), while the smallest leaf area was noted in 2019 (37,801.3-51,378.7 m²/ha). According to the average indicators over three years, the variation in dry biomass due to sowing dates was 10.36%, with a significant difference of 18.77 s/ha or 16.84%, while the corresponding figures for wet biomass were 9.18%, 145.39 s/ha, and 14.93%. The data presented indicate that the highest amounts of wet and dry biomass of the root crops were recorded during the 01-05 March sowing period, while the lowest amounts were noted during the 10-15 April sowing period. In the 01-05 March sowing period, both the leaf area and the photosynthetic potential (FP), the economic efficiency coefficient (FTS), and specific leaf area (SLA) of the crop, as well as the dry and wet biomass of the root crops, showed optimal values essential for the plant's development and yield.

3.3. Changes in biochemical indicators of table beet plants depending on sowing dates. It has been found that the sugar content was higher in March sowings compared to April. The highest sugar content was observed in 2018 during the 01-05 March period (14.0%), while in 2017 and 2019, it was noted during the 20-25 March sowing period (13.0% and 13.0%, respectively). The highest nitrate content was recorded in 2017 (90.6-117.2 mg/kg), while the lowest was in 2018 (52.1-79.2 mg/kg).

3.4. The effect of sowing dates on the structure (yield) of table beet and statistical analysis of results. Based on the three-year average values, it can be stated that the highest yield corresponds to the 01-05 March sowing period (724.6 q/ha). Moreover, this yield is statistically significantly different from both April sowing periods with 95% confidence (Table 1).

Table 1

The effect of sowing date on the yield of table beet

Variants	Productivity, c/ha			On average, c/ha	Product increase		number of plants per 1m^2, piece
	Years				c/ha	%	
	2017	2018	2019				
10-15 March (control)	665.8	725.3	656.5	682.5			28.57
01-05 March	722.9	776.5	674.4	724.6	42.1	6.1	28.57
20-25 March	667.8	664.9	628.7	653.8	28.7	4.2	28.57
01-05 April	628.3	664.7	625.6	639.5	43	6.3	28.57
10-15 April	573.2	624.9	706.4	634.8	47.6	6.9	28.57

$\overline{X}\underline{+}S_{\bar{x}}$=667,04±18,58 c/ha C_v=5,57% ƏKMF$_{05}$=60,4 c/ha or 9,1%

Chapter IV. THE EFFECT OF SOWING PATTERNS ON THE BIOLOGICAL AND AGRICULTURAL CHARACTERISTICS OF TABLE BEET

4.1. Biomorphological characteristics of table beet based on sowing patterns. It has been established that the sowing patterns 55+55+70x10 and 45+45+70x10 showed superior results in terms of leaf count, plant height, root length, diameter, and root index compared to other variants. These patterns exhibited higher values for the studied indicators, resulting in a greater marketability of the harvested roots, which were primarily characterized by an oval-conical shape.

4.2. The impact of sowing patterns on some physiological characteristics of table beet. The study of the assimilation surface area in table beet plants based on sowing patterns revealed that this indicator was consistently higher across all variants compared to the control (three-year average values: 42297.7-57593.0 m^2 vs. 39867 m^2). This is primarily due to a higher density of plants in the studied variants compared to the control.

The examination of changes in the wet and dry biomass of table beet plants showed that the nature of these indicators' variations corresponded to the changes in leaf surface area and photosynthetic potential (FP). However, the highest results were consistently observed in the 25+25+25+25+25+55x10 cm and 50+20x10 cm patterns, making them the most optimal for growing table beet in the Absheron region.

4.3. Changes in the biochemical composition of table beet based on sowing patterns. The highest sugar content was recorded in 2018 with the 50+20x10 cm sowing pattern (14%). The lowest sugar content across all variants was observed in 2019, which can be attributed to unfavorable conditions for the growth and development of table beet that year.

The climatic conditions during the study years also affected the nitrate content in the roots, with the highest levels recorded in 2018 under the 45+45+70x10 cm sowing pattern (149.0 mg/kg) and the lowest in the same year under the 50+20x10 cm pattern (56.0 mg/kg). Thus, the highest quality roots were recorded in the 25+25+25+25+25+55x10 cm sowing pattern.

4.4. The impact of sowing patterns on the structure (yield) of table beet and statistical analysis of results. The results regarding the change in root weight per table beet plant based on sowing patterns indicated that the highest values (three-year average) were found in the 55+55+70x10 cm and 45+45+70x10 cm patterns, which had the lowest plant density (359.2 g and 330.7 g per plant, respectively). In these two variants, the lower plant density allowed the plants to absorb more nutrients from the soil and utilize solar energy more effectively, resulting in increased yields per plant. Since the yield per plant does not reflect the overall characteristics of the planting area, the variations in plant density among different sowing patterns led to significant differences in overall yield (Table 2).

The yield of table beet per hectare across all variants was highest in 2018 (522.8-754.2 q/ha) and lowest in 2019 (452.1-658.8 q/ha). In this regard, 2017 held an intermediate position (463.1-724.5 q/ha).

Table 2

The yield of table beet per hectare based on sowing patterns

Variants	Productivity, c/ha			On average, c/ha	Product increase		Number of plants per 1m^2, pieces
	Years				c/ha	%	
	2017	2018	2019				
55+55+70x10 cm (control)	463,1	522,8	452,1	479,3			16
45+45+70x10 cm	558,8	566,2	476,1	533,7	54,4	11,2	18,86
25+25+25+25+25+ 55x10 cm	650,8	669,5	618,1	646,1	166,8	34,8	33,3
60+10x10 cm	621,4	644,3	526,0	597,2	117,9	24,5	28,57
50+20x10 cm	724,5	754,2	658,8	712,5	233,2	48,6	28,57

$\bar{X} \pm S_{\bar{x}}$=593,76±45,80 c/ha; C_v =15,43%; ƏKMF$_{05}$=145,44 c/ha; ƏKMF$_{05}$,%=24,5%

The highest yield was recorded in the sowing patterns of 25+25+25+25+25+55x10 cm and 50+20x10 cm (646.1 and 712.5 q/ha, respectively).

Chapter V. THE EFFECT OF POTASSIUM FERTILIZER ON THE BIOLOGICAL AND ECONOMIC PROPERTIES OF TABLE BEET

5.1. Investigation of the biomorphological characteristics of table beet according to potassium fertilizer. Throughout all years, the lowest indicators were recorded in the control (non-fertilized) variant, while the highest were observed in the variant with Base+$N_{120}P_{90}K_{120}$. Similar to sowing patterns and dates, the highest values for these indicators were recorded in 2018, which was favorable for the development of table beet, while the lowest values were observed in 2019. The application of potassium fertilizers increased the number of leaves by 1.59-1.77 times and the height of the plants by 1.35-1.47 times compared to the control. The highest value of the root vegetable was recorded in the variant with 20 t/ha of manure (Base).

This means that when only organic fertilizers are applied, more elongated root vegetables are formed, negatively affecting the appearance and market quality of the product. The application of mineral fertilizers, especially potassium fertilizers, increases the diameter of the root vegetable, giving it an oval shape and thereby improving the market quality of the product.

5.2. The effect of potassium fertilizer on some physiological indicators of table beet. The highest amount of chlorophyll (162.4 mg/100g) was recorded in the non-fertilized variant in 2019, while the lowest amount was also in that variant in 2018 (128.2 mg/100g). The application of organic and mineral fertilizers significantly affected the leaf area of table beet and also considerably increased the crop's photosynthetic potential (FP). The highest value of FP was recorded in 2018 (2552.0-3795.2 thousand m².day/ha), while the lowest was in 2019 (2119.2-3210.3 thousand m².day/ha). The maximum level of FP across all variants was observed in the Base+N120P90K120 variant during the research years (3544.1 in

2017, 3795.2 in 2018, and 3210.3 in 2019, with an average of 3516.5 thousand m².day/ha over three years). The increase in FP in the organic fertilizer variant was 1.28 times compared to the control, while the application of mineral fertilizers in addition to organic fertilizers increased this indicator by 1.37-1.52 times. This indicates that the combined effect of mineral fertilizers with organic fertilizers was stronger, leading to better growth and development of the plants.
The highest value of the economic efficiency coefficient (EECP) was observed in 2018 (2.6-3.1), while the lowest was in 2017 (1.8-2.2). The highest value of the specific leaf area (SLA), which is one of the most important indicators of photosynthesis (9.0 mg/cm²), was recorded in 2018 in the Base+$N_{120}P_{90}K_{120}$ variant, while the lowest value was in the non-fertilized variant in 2019 (5.7 mg/cm²).

5.3. The effect of potassium fertilizer on the development dynamics of table beet. Based on the phenological observation schedule, the inter-phase periods were calculated, and the effect of potassium fertilizer on the development dynamics of table beet was studied. It was found that the application of fertilizers accelerated the growth phases, leading to quicker growth and earlier yields. In the control (non-fertilized) variant, the number of days from sowing to mass emergence was 21-22 days, while in the Base variant, this number decreased to 13-14 days, and with the application of mineral fertilizers, seedlings emerged even earlier (7-12 days). The earliest mass germination was observed in the Base+$N_{120}P_{90}K_{120}$ variant (7-8 days after sowing).

5.4. The study of biochemical composition of table beet based on potassium fertilizer dosages. The increase in dry matter in the leaves due to potassium fertilizer dosages was 1.9-4.3%, while in the root vegetables it was 1.0-3.1%. The highest amounts of dry matter in the leaves and root vegetables were recorded in 2018 (19.0-23.5% and 15.0-18.3%, respectively), while the lowest amounts were observed in 2019 (18.0-22.0% and 13.8-16.0%, respectively). Meteorological conditions also significantly influenced the amount of dry matter collected in the plants. During the research years, the highest amounts of sugars were recorded in the non-fertilized variant (14.0% in 2017, 13.5% in 2018, and 12.8% in 2019), while the lowest amounts were observed in the Base+$N_{120}P_{90}K_{120}$ variant (10.4% in 2017, 9.3% in 2018, and 9.0% in 2019). The conducted research determined that the application of organic and mineral fertilizers negatively affected the sugar content in root vegetables, with increasing doses of potassium fertilizers leading to a reduction in sugar content by 2.9-3.8% compared to the control. The highest amounts of nitrates were recorded in the Base+$N_{120}P_{90}K_{120}$ variant in 2018 (186.0 mg/kg), while the lowest were in the non-fertilized variant in 2017 (66.0 mg/kg). Interestingly, in 2018, which was favorable for the development of table beet, nitrates were more concentrated compared to other years (134.0-186.0 mg/kg), except for the non-fertilized variant. The meteorological conditions during the research years also significantly affected the accumulation of nitrates.

5.5. The effect of potassium fertilizer on the structure (yield) of table beet and statistical analysis. When examining the effect of potassium fertilizer on the yield of table beet (average over three years), it was found that the highest yield was observed in the Base+$N_{120}P_{90}K_{120}$ fertilizer norm (998.8 q/ha), while the lowest yield was recorded in the non-fertilized (control) variant (528.7 q/ha) (Table 3).

Table 3

The Effect of Potassium Fertilizer on the Yield of Table beet

Variants	Productivity, c/ha			On average, c/ha	Product increase		Number of plants per 1m^2,piece
	Years				c/ha	%	
	2017	2018	2019				
Without fertilizer (Control)	551,4	573,8	461,0	528,7	-	-	28,57
Manure (Base) 20 t/ha	737,5	747,7	639,0	708,0	179,3	33,9	28,57
Base+ $N_{120}P_{90}K_{60}$	843,5	935,6	823,1	867,4	338,7	64,0	28,57
Base+ $N_{120}P_{90}K_{90}$	922,6	1025,4	868,3	938,7	410,0	77,5	28,57
Base+ $N_{120}P_{90}K_{120}$	1042,3	1142,3	911,9	998,8	470,1	88,9	28,57

$\bar{X} \pm S_{\bar{x}}$=808,32±95,20 c/ha; C_v=23,56%; ƏKMF$_{05}$=309,51 c/ha; ƏKMF$_{05}$, %=38,3%

Thus, both the application of organic and mineral fertilizers and the meteorological conditions during the research years significantly influenced the yield of table beet, resulting in an increase of 179.3-470.1 q/ha compared to the control. However, only the increases in the 4th and 5th variants were statistically significant. Therefore, it is recommended to apply 20 t of manure + $N_{120}P_{90}K_{90}$ and $N_{120}P_{90}K_{120}$ when cultivating table beet in the Absheron region.

5.6. Correlation Relationships Among Various Economically Important Indicators of Table beet Depending on Sowing Dates, Sowing Patterns, and Fertilizer Norms. To assess the correlation coefficient among various economically important indicators and to determine the statistical dependence of different quantitative indicators on qualitative indicators, the Cheddock scale is used. A high correlation coefficient exists between dry matter in leaves-sugars (0.859), sugars-dry matter in root vegetables (0.794), and total wet biomass-total dry biomass (0.895), indicating a direct and very strong relationship among these traits according to the Cheddock scale (Figure 2).

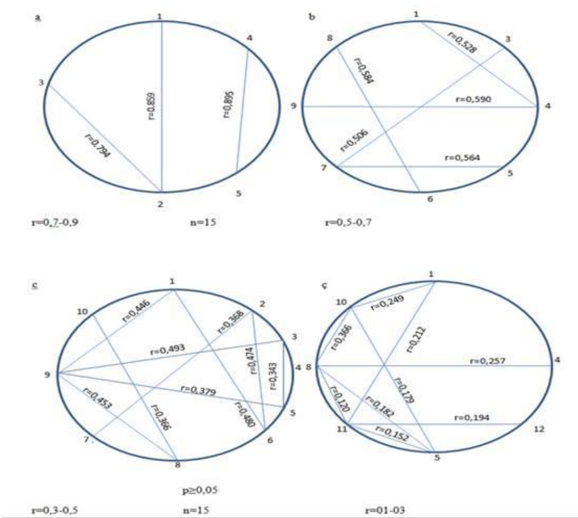


Figure 2. Correlation relationships among various

physiological and biochemical indicators in table beet

Note 1. Dry matter in leaves, %; 2. Sugars, %; 3. Dry matter in root vegetables, %; 4. Total wet biomass, s/ha; 5. Total dry biomass, s/ha; 6. Yield, s/ha; 7. Nitrates, mg/kg; 8. Photosynthetic potential, min m². days/ha; 9. Leaf area, min m²/ha; 10. Chlorophyll, mg/100g wet mass; 11. Specific leaf area (SLA), mg/cm²; 12. Photosynthetic efficiency coefficient (PEC).

Chapter VI. ECONOMIC EFFICIENCY OF TABLE BEET

In this chapter, the economic efficiency based on planting dates, planting schemes, and fertilizer norms has been calculated. It was found that under optimal planting conditions, the profitability level in the control variant was 94.10%, while it was 100.5% during the planting period of March 1-5. In the optimal planting scheme, the profitability levels were 63.10% and 98.7%, and in the optimal fertilizer norm, they were 84.10% and 90.8%.

It was determined that although the costs incurred for fertilized areas were higher compared to those for table beet cultivation, the net income obtained from the application of fertilizer norms was significantly higher than that obtained from areas cultivated by other methods. This indicates that if organic and mineral fertilizers are used correctly, high yields and profits can be achieved from table beet crops.

Results

1. Effects of Planting Dates on Table beet: The study of changes in biomorphological (number of leaves, leaf mass, aboveground mass, root mass, root length, diameter and index, plant height), physiological (leaf assimilation area, photosynthetic potential of crops, photosynthetic efficiency coefficient - PEC, specific leaf area - SLA, chlorophyll content in leaves), and biochemical indicators (dry matter content in leaves, stems, and roots, sugar and nitrate content in roots) showed that planting in the first half of March positively affects plant development. It increases

the leaf area, FP, PEC, and chlorophyll content while decreasing SLA, resulting in higher quality roots (with dry matter, sugars, and nitrates at more optimal levels compared to April plantings).

2. Statistical Analysis of Planting Dates: Based on statistical analysis, plantings in the first half of March were deemed more optimal, with the number of leaves, mass, and aboveground mass (32.66 leaves, 89.76 g, and 158.9 g respectively), FP (2941.3 thousand m².days/ha), leaf area (56283.1 m²/ha), and root wet and dry biomass (1074.2 s/ha and 118.9 s/ha respectively) being 1.16–1.41 times higher than those from April plantings. This facilitates the production of high-quality table beet (with yields 1.08–1.19 times greater than April plantings).

3. Planting Schemes: According to biomorphological indicators, the planting schemes 55+55+70x10 cm and 45+45+70x10 cm exhibited higher values (1.20–1.79 times) compared to other studied variants, leading to superior marketability of the produced roots, characterized mainly by an oval-conical shape. These variants also excelled in aboveground and root mass (180 and 359.2 g, and 170.6 and 338.7 g respectively) compared to other variants (107.0-149.3 and 233.0-297.5 g). The planting schemes 25+25+25+25+25+55x10 cm and 50+20x10 cm stood out in terms of assimilation area, photosynthetic potential, PEC, and SLA. The dry matter, sugars, and nitrate contents in roots from the 25+25+25+25+25+55x10 cm scheme (17.4%, 12.2%, and 70.7 mg/kg respectively) were superior to other variants (14.1-16.8%, 10.3–11.7%, and 75.9–126.7 mg/kg). Overall, the optimal values for biomorphological, physiological, and biochemical indicators were recorded in the 25+25+25+25+25+55x10 cm and 50+20x10 cm schemes, with yields (646.1 and 712.5 s/ha) significantly higher than other variants (479.3–597.2 s/ha), showing a high negative correlation between sugars and toxic substances - nitrates ($r= -0.85$, $P>0.01$).

4. Statistical Analysis of Indicators: The statistical analysis of biomorphological, physiological, and biochemical indicators, as well as root yields under different planting schemes using both classical (according to Dospexov and Litvinova) and T-test methods,

confirmed that the observed differences in the 25+25+25+25+25+55x10 cm and 50+20x10 cm schemes compared to other variants were statistically significant, with variation coefficients ranging from 6.27% to 24.03%, and AKMF05 from 2.15% to 30.3%.

5. Impact of Mineral Nutrients and Organic Fertilizers: The optimal and proper application of mineral nutrients and organic fertilizers accelerates biomorphological, physiological, and biochemical processes in plants, enhancing photosynthetic activity, positively affecting plant height and development, and consequently leading to an increase in total biological mass, which ultimately conditions the high yield and quality of roots. For instance, with the application of Base(20 t manure) + $N_{120}P_{90}K_{60\text{-}120}$, the number of leaves increased by 1.59-1.77 times, plant height by 1.35-1.47 times, aboveground mass by 1.88-2.20 times, root mass by 1.65-1.98 times, leaf area by 1.50-1.68 times, FP by 1.37-1.52 times, SLA by 1.25-1.42 times, total wet biomass by 1.74-2.02 times, and total dry biomass by 1.91-2.48 times compared to the control (unfertilized) variant.

6. Effect of Potassium Fertilizer Doses: The various doses of potassium fertilizer (120-90-120 kg of active substance) applied alongside organic fertilizers and N120P90 accelerated the growth phases of table beet, leading to earlier harvests. In variants with potassium fertilizers, the number of days from sowing to mass technical maturity was reduced by 9-12 days compared to the control and background variants. The best result (12-13 days) was recorded in the Fon+$N_{120}P_{90}K_{120}$ variant, where during the vegetation period, the number of leaves compared to the control variant increased by 1.89 times, leaf mass by 1.87 times, aboveground mass by 2.08 times, and yield by 1.89 times, making it the optimal fertilizer norm for table beet cultivation in the Absheron region.

7. Cost Analysis of Production: The production cost of yields per hectare using the Fon+$N_{120}P_{90}K_{120}$ fertilizer norm (4954.3 manats) was 1.76 times higher than that of the unfertilized variant (2812 manats), yet due to higher yields (998.8 s/ha compared to 528.7 s/ha), the net income (21362.7 manats) was approximately 10-

13 times greater than that obtained from areas cultivated with other crops (2105 and 1660 manats respectively), emphasizing the necessity of proper use of organic and mineral fertilizers in table beet cultivation.

8. Correlation Relationships Among Indicators: The study of correlation relationships among various agricultural indicators (42 indicators) based on planting dates, schemes, and fertilizer doses (increasing doses of potassium) revealed that these physiological, biochemical, and yield indicators exhibited high correlations (r=0.7-0.9, with dry matter in leaves and sugars (0.859), sugars and dry matter in roots (0.794), total wet biomass and total dry biomass (0.895)) at a significance level of P>0.05, with notable correlations (r=0.5-0.7, dry matter in roots and nitrates (0.506), dry matter in leaves and total wet biomass (0.528), total dry biomass and nitrates (0.564), yield and FP (0.584), total wet biomass and leaf area (0.590)). These relationships can be effectively utilized in managing plant life.

Recommendations

1. To achieve high-quality yields in the Absheron region, it is recommended to cultivate the Bordo-237 variety of table beet seeds during the optimal planting period (March 1-15) and using the optimal planting schemes (25+25+25+25+25+55x10 cm and 50+20x10 cm).

2. Utilizing the Fon+$N_{120}P_{90}K_{120}$ fertilizer norm accelerates plant growth and development, thereby enhancing leaf area, photosynthetic potential, and the overall productivity of table beet, enabling high yields from the Bordo-237 variety in the Absheron region.

List of scientific works published on the dissertation topic

1. Agayev F.N., Sadigova L.G., Magsudov Sh.M. Biomorphological and biochemical indicators of vegetative organs and root vegetables of table beet depending on sowing dates. / Materials of the International Scientific-Practical Conference. Within the framework of the III Scientific Forum “Science Week in Kruty-

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The dissertation defense will take place on "30th" October 2024 at 11⁰⁰ o'clock during the meeting of the Dissertation Council FD 1.29 operating under the Agricultural Scientific Research Institute of the Ministry of Agriculture of the Republic of Azerbaijan.

Address: AZ1098, Pirshaghi Settlement, No. 2 Sovkhoz, Agricultural Scientific Research Institute, Baku, Azerbaijan Republic.

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