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4.1.1. Общее земледелие и растениеводство (биологические науки, сельскохозяйственные науки)

ПРОДУКТИВНОСТЬ ГИБРИДОВ САХАРНОЙ СВЕКЛЫ В КРАСНОДАРСКОМ КРАЕ

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В статье приводятся результаты исследования (2023-2024 гг.), направленного на выявление наиболее продуктивных и качественных гибридов сахарной свеклы путем объективного их сравнения. Установлено, что максимальная урожайность корнеплодов сахарной свеклы зафиксирована для гибридов Мустанг и Анаконда – 36,83 и 35,89 т/га соответственно. Несколько ниже была урожайность гибридов Плутон и Бартавелла – 31,56 и 31,05 т/га соответственно. Минимальная урожайность наблюдалась у гибрида Кариока – в среднем 29,86 т/га, что ниже на 1,19-6,97 т/га или 3,98-23,3%, чем показатели по другим гибридам. Наибольший экономический эффект получен по гибриду Мустанг, где условно чистый доход составил 71935 руб./га, при максимальном уровне рентабельности 76,7%. Близкие к ним показатели получены по гибриду Анаконда: условно чистый доход – 67705 руб./га, уровень рентабельности – 72,2%. Минимальный уровень рентабельности (43,3%) в опыте получен по гибриду Кариока, что связано с более низкой урожайностью корнеплодов в сравнении с другими гибридами сахарной свеклы

Ключевые слова: СВЕКЛА САХАРНАЯ, ГИБРИДЫ, КОРНЕПЛОДЫ, САХАРИСТОСТЬ КОРНЕПЛОДОВ, УРОЖАЙНОСТЬ, КАЧЕСТВО, ЭКОНОМИЧЕСКАЯ ЭФФЕКТИВНОСТЬ

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4.1.1. General agriculture and plant growing (biological sciences, agricultural sciences)

PRODUCTIVITY OF SUGAR BEET HYBRIDS IN THE KRASNODAR REGION

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The article presents the results of a study (2023-2024) aimed at identifying the most productive and high-quality sugar beet hybrids through their objective comparison. The Mustang and Anakonda hybrids demonstrated the highest sugar beet root yields, at 36.83 and 35.89 t/ha, respectively. The Pluton and Bartavella hybrids had slightly lower yields, at 31.56 and 31.05 t/ha, respectively. The Carioca hybrid had the lowest yield, averaging 29.86 t/ha, which is 1.19-6.97 t/ha, or 3.98-23.3%, lower than the other hybrids. The Mustang hybrid achieved the highest economic benefit, with a net income of RUB 71,935/ha and a maximum profitability of 76.7%. Similar results were obtained for the Anakonda hybrid: a net income of RUB 67,705/ha and a profitability of 72.2%. The Carioca hybrid achieved the lowest profitability (43.3%), owing to its lower root yield compared to other sugar beet hybrids

Keywords: SUGAR BEET, HYBRIDS, ROOT CROPS, SUGAR CONTENT OF ROOT CROPS, YIELD, QUALITY, ECONOMIC EFFICIENCY

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Introduction. Sugar beet cultivation remains crucial to the economic development of the Russian Federation. This crop forms the basis for sustainable sugar production, a vital food product and an indispensable ingredient for the food industry.

The selection of high-yielding sugar beet hybrids contributes to a significant increase in crop yield, increased sugar content in root crops, reduced cultivation costs during soil cultivation, optimization of agricultural practices, and plant resistance to diseases and adverse weather conditions.

The cultivation of various sugar beet hybrids remains highly relevant in Russia, particularly in the southern regions of the country. These areas enjoy favorable climatic conditions that promote high yields and improved root crop quality [2]. Furthermore, the use of modern hybrids significantly contributes to a stable sugar supply, thereby supporting national food security and enhancing the competitiveness of the Russian agricultural sector in the global market. Furthermore, advances in breeding are leading to the creation of new varieties characterized by increased disease resistance, adaptability to various environmental factors, and overall resistance to biotic and abiotic stressors, emphasizing the importance of further research aimed at improving the varietal characteristics of sugar beet [3, 9].

Modern varieties and hybrids of sugar beet are capable of producing high yields even in conditions of insufficient moisture and unfavorable weather factors [8].

Scientific research into developing new varieties of sugar beet began in 1922 at the Ramon Experimental Breeding Station and was subsequently continued at the VNIISS, which was founded on its premises. Currently, 47 sugar beet varieties and hybrids created by VNIISS staff and its branch network have been registered.

Research aimed at studying the nature of interactions between the genotypic characteristics of plants and the effect of applied fertilizers, carried out at the Penza State Agrarian University, revealed that with the application of moderate rates of mineral fertilizers (N88P71K113), the greatest increase in yield was demonstrated by hybrids of the Dominika (+14.8%), Marathon

(+11.4%), Manon (+9.7%) and LMS 94 (+1.1%) varieties. An increase in the rate of mineral nutrition led to a deterioration in the yield indicators of the above-mentioned hybrids. On the contrary, against the background of increased levels of application of mineral fertilizers ($N_{173}P_{121}K_{206}$), high efficiency was ensured by hybrids LMS 78 (+15.1%), Kristella (+13.0%), Kiva (+9.8%), Evelina (+6.7%) and Pobeda (+5.3%) [11].

Experimental studies conducted in meadow-gray soils at the Zhambyl branch of KazNIIZiR LLC from 2012 to 2014 revealed that peak root crop weight gain occurs in the second phase of the growing season. The E-2244 hybrid demonstrated the greatest root crop weight. With a row spacing of 60 cm, the root crop weight was 355.0 g, and with a row spacing of 45 cm, it was 424.8 g. By harvest time (October 1), the root crop weight of this hybrid reached an impressive 573.7 g (with a row spacing of 60 cm) and 671.7 g (with a row spacing of 45 cm). These figures significantly exceed standard values: by 20.0% and 40.5%, respectively. It has been experimentally confirmed that when studying the influence of the row spacing (45 and 60 cm) on the characteristics of various hybrid varieties, samples E-2244 and E-2282 stand out, demonstrating superior results in terms of root crop weight and sugar accumulation volume: the increase in root crop yield is 14.0 t/ha (29.3%) and 2.38 t/ha (32.0%), and sugar collection is 13.2 t/ha (27.6%) and 2.19 t/ha (29.4%) in relation to the control sample with 60 cm row spacing [9].

Yu. S. Ionitsoy [6], based on the results of pot experiments aimed at studying the impact of different doses of mineral fertilizers on the technological characteristics of sugar beet roots of various biological types, established that modern varieties and hybrids of this crop are characterized by a lack of universality in their response to applied fertilizer doses. Each variety requires individual optimal nutritional conditions, which require systematic study and clarification.

T.A. Shchegolikhina, after analyzing the current state of sugar beet breeding in Russia, concluded that achieving complete self-sufficiency in sugar beet seeds in Russian agriculture requires increasing domestic seed production by 2,900 tons. This goal can be achieved through intensifying breeding and seed production efforts and optimizing agricultural practices for sugar beet cultivation.

Kuban researchers K.E. Tyupakov, A.V. Moiseyev, and N.V. Batrakova, having conducted a comprehensive analysis of the current state of the domestic sugar beet breeding and seed production complex, concluded that the key problems hindering the effective functioning of the industry are the insufficient level of equipment of specialized institutions with modern material and technical resources, including a shortage of appropriate instrumental and analytical equipment; insufficient government funding for R&D in sugar beet breeding and seed production; and the absence of a unified management system for breeding, seed production, processing, and marketing of sugar beet seeds.

Experimental work conducted at the Penza State Agricultural Academy (FSBEI HPE) examined the physical and mechanical properties of modern sugar beet hybrids, enabling the optimization of seed preparation technology for sowing. This research resulted in the creation of a specialized production line, including a mechanism for pre-treating the seed surface and a drum unit for coating the seeds with a protective coating with a rotating base, as well as a specialized seeder for precision sowing of sugar beet seeds. This seeder, equipped with a seed feed mechanism with an adjustable spring ejection device, reduces seed damage during sowing by up to 6% thanks to careful calibration of the planting unit according to the morphometric characteristics of the seeds [10].

Purpose of the study consisted of conducting an objective comparative analysis of various sugar beet hybrids in terms of yield and quality characteristics of root crops obtained when grown on leached chernozems.

Materials and methods. To study the cultivation efficiency of the Anaconda, Carioca, Bartavella, Mustang, and Pluton hybrids, field trials based on the Field Experiment Methodology [4] were conducted in 2023–2024 on the leached chernozems of JSC Rassvet (Ust-Labinsk District, Krasnodar Krai). Soil cultivation included plowing with a PLN-5-35 plow to a depth of 27 cm, with the addition of mineral fertilizers (N60P120K60). Sowing was carried out in the third ten-day period of April.

Research results. The duration of the period from the moment of sowing until the formation of all seedlings was about 18-19 days, with slight fluctuations depending on the individual varietal characteristics of the studied samples (Table 1).

Table 1. Duration of phase stages and total duration of the growing season of different varieties of sugar beet, days

Name samples	Sowing - full shoots	Full germination – 3rd pair of true leaves	3rd pair of true leaves – closure of leaves in the inter-rows	Closing of leaves in the inter-rows – harvesting	Growing season
Anaconda	19	32	43	87	162
Bartavella	18	29	40	86	155
Carioca	19	33	43	90	166
Mustang	18	29	38	84	151
Pluto	18	33	43	89	165

Source: compiled by the authors based on experimental data.

It should be emphasized that the duration of individual phenological stages varied significantly among the tested samples. For example, the third pair of true leaves appeared 1-6 days later in the Carioca and Pluton hybrids compared to other varieties. The longest growing season was observed for the Carioca hybrid—166 days—while the shortest—147 days—was observed for the Mustang hybrid.

It is important to note that in the first half of the growing season, the growth rate of sugar beets was determined primarily by the ambient temperature and soil moisture levels, but in the subsequent period of active growth of root crops and accumulation of sugar, the availability of nutrients in the area where the plant roots were located had a decisive influence [13].

Frequent dry summer conditions accompanied by depleted air and soil moisture, particularly pronounced in the Krasnodar Krai in 2024, accelerated the plant's development through all phases. As a result, leaf blades began to open and close the space between rows as early as September. However, none of the experimental samples achieved complete leaf closure within the row by harvest time.

It is known that an optimal number of functioning leaves and a sufficient lifespan of these leaves under favorable climatic conditions ensure a high level of photosynthesis intensity and, consequently, maximum crop yield [6]. Leaf formation in sugar beet plants is closely related to meteorological growing conditions [1]. The average number of leaves formed over the entire growing season was 19.1-20.1 leaves per plant. During the growing season, the Anaconda and Mustang hybrids demonstrated significantly greater foliage density compared to the Bartavella and Carioca hybrids.

Experiments indicate that the activation of new leaf formation occurred primarily in June and July, with the number of newly forming leaves exceeding the number of wilted leaves by 9.2-16.0%. Intensification of natural leaf aging and death was observed in the second half of the growing season, by the end of which the average number of remaining living leaves was 19.0-20.5, and the number of withered leaves was 11.5-13.1 per plant.

The life cycle of each individual leaf varied widely depending on the time of its emergence. After reaching a certain age, senescence of older leaves progressed, causing gradual tissue degradation and subsequent shedding. The natural dieback process began in late June, increasing in intensity until early September (the number of dead leaves on a single plant could range from 1.9 to 13.2).

The obtained experimental data demonstrate that the maximum leaf area for all the studied samples was reached in July, in the range of 27.7-39.7 thousand m²/ha. Subsequently, a steady decrease in the assimilation area was recorded, amounting to 23.7-33.5 thousand m²/ha by the beginning of August, and further decreasing by 1.9-2.2 times by the first of September. A trend similar to the formation of the leaf area in the change in photosynthetic potential is observed. From June to July, an intensive accumulation of photosynthetic potential occurs, reaching its maximum in mid-summer. After July, it begins to gradually decline [1]. Thus, in sugar beet hybrids, the photosynthetic potential in July is in the range of 746.3-1134 thousand m²/ha/day, and in August it decreases by approximately 1.2 times, to 578.4-789 thousand m²/ha/day, which is typical for all the hybrids studied.

Throughout the growing season, the Mustang (2,757.4 thousand m²/ha/day) and Anaconda (2,673.5 thousand m²/ha/day) hybrids demonstrated maximum photosynthetic potential. Their results were significantly higher than those of other samples, exceeding them by 182.3-776.6 thousand m²/ha/day. Observations show that the concentration of dry matter in the leaves tends to increase until the beginning of August, reaching 54.1 g/plant for the Mustang hybrid, 50.2 g/plant for the Anaconda hybrid, 43.1 g/plant for the Bartavella hybrid, 36.1 g/plant for the Carioca hybrid, and 39.7 g/plant for the Pluton hybrid (Table 2). Subsequently, a steady decrease in the dry matter content in the leaves was recorded to levels of 28.3, 25.1, 20.7 and 17.2 g/plant, respectively, which is due to the natural process of aging and death of leaves associated with the movement of organic compounds to the roots.

Table 2. Dynamics of accumulation of dry biomass (g/plant) and net photosynthetic production (NPP, g/m² day) in sugar beet plants.

Determination date	Name of the hybrid				
	Anaconda	Bartavella	Carioca	Mustang	Pluton
as of June 1 sheet root vegetable plant	3.71 1.13 4.84	3.09 1.03 4.12	2.88 1.03 3.91	4.02 1.24 5.25	3.61 1.03 4.74
NPF, g/m² per day	6.4	6.3	6.0	6.5	6.3
on July 1 sheet root vegetable plant	30.90 26.68 57.68	28.84 22.66 51.50	21.42 18.23 39.65	35.74 31.31 67.05	29.97 25.54 56.65
NPF, g/m² per day	7.7	7.5	7.2	7.9	7.6
on August 1 sheet root vegetable plant	49.64 78.18 127.82	41.30 73.85 115.15	30.99 53.05 84.05	53.66 79.93 133.69	48.41 76.12 125.86
NPF, g/m² per day	4.7	4.6	4.6	4.7	4.7
on September 1st sheet root vegetable plant	25.85 117.32 143.17	21.32 108.36 128.65	17.72 76.32 94.04	29.15 127.10 156.25	26.88 114.23 141.52
NPF, g/m² per day	5.5	5.4	5.2	5.6	5.4

Source: compiled by the authors based on experimental data.

The accumulation of dry biomass in sugar beet tissues is a multifactorial dynamic process integrating the impact of environmental conditions and varietal characteristics of individual plant development [3, 12]. During the growing season, the dry matter content continuously increased both in the roots and leaves of sugar beet, with the accumulation rate in the root system being 1.3-1.9 times higher than in the aboveground green mass. The intensity of dry component accumulation in sugar beet roots under regional conditions reaches its highest level in July-August [1]. If at the beginning of July the dry matter content in roots was in the range of 18.23-31.31 g/plant, then by September 1 it had increased by 4.3-4.8 times, reaching a level of 76.32-127.10 g/plant.

The total dry biomass content at harvest showed that the maximum value was achieved by the hybrids Mustang (156.25 g/plant), Anaconda (143.17 g/plant) and Pluton (141.52 g/plant); the minimum level was recorded by the hybrid Carioca (94.04 g/plant), and the hybrid Bartavella occupied an intermediate position (128.65 g/plant).

It was established that during the growing season (from June 1 to September 1, subject to the application of mineral fertilizers at the rate of N60P120K60), the net productivity of photosynthesis varied as follows: for the Anaconda hybrid it was 5.90 g/m²/day, for the Bartavella hybrid – 5.95 g/m²/day, for the Carioca hybrid – 5.75 g/m²/day, for the Mustang hybrid – 6.17 g/m²/day, and for the Pluton hybrid – 6.00 g/m²/day. Peak photosynthesis rates occur during the initial stages of vegetation (beginning with 3-4 pairs of leaves), reaching 7.2-7.9 g/m²/day. Then, towards the final stage of development (the closure of leaves in row spacing), photosynthesis activity slows, dropping to 4.6-7.7 g/m²/day due to a decrease in the rate of vegetative mass growth. An interesting fact was experimentally established: by early September, photosynthesis rates increase slightly to 5.2-5.6 g/m²/day due to the growth of new sugar beet leaves before harvesting.

Sugar beet yield is a complex process, combining the individual productivity of individual plants and the plant density per unit of field area at harvest time. Therefore, achieving high quantitative results is only possible by maintaining a balance between maximum plant productivity and optimal plant density. Quantitative yield indicators are presented in Table 3.

Table 3. Yield of sugar beet roots depending on varietal characteristics, t/ha.

Name of the hybrid	Yield by replicates, t/ha					Sugar content, % date of determination			Sugar harvesting, t/ha
	I	II	III	IV	average	1.07	1.08	1.09	
Anaconda	37.32	36.15	34.85	35.22	35.89	11.2	14.5	17.0	6.10
Bartavella	31.24	31.57	30.76	30.64	31.05	11.9	14.3	17.4	5.40
Carioca	30.07	30.30	29.59	29.47	29.86	10.8	13.9	17.5	5.23
Mustang	37.11	37.77	36.74	35.70	36.83	11.6	14.8	17.0	6.26
Pluton	31.59	32.63	30.76	31.24	31.56	11.3	14.2	17.2	5.43
HSR05					1.71				

Source: compiled by the authors based on experimental data.

Scientific research showed that among the tested sugar beet hybrids, the Mustang and Anaconda varieties demonstrated the highest average yields, at 36.83 and 35.89 t/ha, respectively. The Pluton and Bartavella hybrids had slightly lower productivity, reaching 31.56 and 31.05 t/ha, respectively. The Carioca hybrid had the lowest yield, averaging 29.86 t/ha, significantly lower than other varieties by 1.19-6.97 t/ha, or 3.98-23.3%.

One of the defining quality parameters is sugar content, which is the relative sugar content in root crops. Measurements conducted as part of the experiment recorded a consistent increase in sugar content: in early July, this indicator varied in the range of 10.8-11.9%; by August, it had risen to 13.9-14.5%, and by September, it had reached maximum values of 17.0-17.5%. This trend indicates a direct positive correlation between the degree of plant maturity and the concentration of sugars in root formations, which is due to the intensification of the movement of carbohydrates from vegetative organs to the root system during natural ontogenesis. The presented data allow us to conclude that the maximum volume of sugar collected per hectare – 6.26 t/ha – was achieved by the Mustang hybrid, which combined the highest root crop yield (36.83 t/ha) with optimal sugar content (17.0%).

To calculate the economic efficiency of sugar beet cultivation, an average market price of 4,500 rubles/t was used. Therefore, it seems appropriate to conduct a comparative analysis of economic indicators demonstrating the production efficiency of various sugar beet hybrids in the central region of Krasnodar Krai (Table 4).

Table 4. Economic efficiency of growing sugar beet hybrids

Indicator	Option				
	Anaconda	Bartavella	Carioca	Mustang	Pluton
Yield, t/ha	35.89	31.05	29.86	36.83	31.56
Sugar content, %	17.0	17.4	17.5	17.0	17.2
Selling price, RUB/t	4500	4500	4500	4500	4500
Cost of sold products, RUB/ha	161505	139725	134370	165735	142020
Production and sales costs, RUB/ha	93800	93800	93800	93800	93800
Profit from product sales, RUB/ha	67705	45925	40570	71935	48220
Profitability level products, %	72.2	49.0	43.3	76.7	51.4

Source: compiled by the authors based on experimental data.

According to the results presented in the table, the highest yield of sugar beet roots, recorded for the Mustang hybrid (36.83 t/ha with a sugar content of 17.0%), made it possible to achieve a conditional net income of 71,935 rubles/ha, while ensuring the highest production profitability ratio of 76.7%. Production costs for all compared options remained unchanged and amounted to 93,800 rubles/ha. Similar figures were obtained for the Anakonda hybrid: conditional net income of 67,705 rubles/ha, profitability level of 72.2%. The minimum profitability level (43.3%) in the experiment was obtained for the Carioca hybrid, which is due to low root crop productivity indicators compared to other hybrids.

Conclusion. Expanding sugar beet production is possible not only by increasing the area under cultivation but also through the targeted selection of highly productive hybrids characterized by increased adaptability to adverse environmental factors, such as biotic and abiotic stresses, corresponding to the specific climatic conditions of the central part of the Krasnodar Krai. In regions with unstable moisture levels and on leached chernozem soils, the cultivation of Mustang and Anakonda sugar beet hybrids is recommended. These hybrids provide stable yields of 35 to 37 tons per hectare and higher, provided optimal mineral nutrition is provided.

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