Development of the beet sugar subcomplex of the regional agro-industrial complex

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Abstract. In the present research, we have studied the beet sugar sub-complex at the regional level. Using the scenario method, the cultivated areas indicators of the beet-growing districts of the sugar plant Raevsakhar LLC in the short term have been predicted, that allows us to take into account and adjust the planned indicators due to changing economic conditions and the likelihood of risks. The gross yield of cultivated and harvested areas of sugar beet in raw material areas has been calculated. We have identified the reserve for increasing the gross yield of sugar beet by reducing the area of crop death in the raw material areas of the plant to 117 000 c. Directions for activating the work of the beet-sugar sub-complex of the region with the further development of agricultural firms, the use of intensive cultivation technologies and the involvement of additional farms in the cultivation of sugar beet have been proposed.

1 Introduction

The agroindustrial complex combines various sectors of the national economy and consists of non-food and food segments. The latter, in its turn, includes food sub-complexes, where the sugar product sub-complex takes a special place. Sugar production occurs over a short period of time, and the production volume is related to the slow growth and storage of sugar beet. One of the key aspects of the powerful and effective development of the agro-industrial complex is to ensure equality and balance between production and processing of agricultural products, as well as their storage and marketing [1, 2].

The sugar product sub-complex is a group of enterprises and organizations connected in a systemic, economic and technical way, whose activities are aimed at meeting the needs of the country's residents in the essential food product – sugar [3]. Sugar business is economically attractive, so solving the problems of growing competition is an urgent task related to ensuring the availability of food in Russia and stability in the food sugar market. Sugar is very important, and sugar industry in Russia has a great influence on the formation of economic sectors. Besides, the growth, development and competition of the beet sugar sub-complex can save and increase the creation of hundreds of jobs and give an additional impetus to the development of industries and related sectors of the national economy [4].

The purpose of this research is to analyze the state of sugar beet production in the region, as well as beet-growing areas of sugar factories in the Republic of Bashkortostan.

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2 Materials and methods

The materials included regulatory and reference materials, data from the Federal State Statistics Service of the Russian Federation and the Republic of Bashkortostan, the Ministry of Agriculture of the Russian Federation and the Republic of Bashkortostan, the Ministry of Trade and Economic Development of the Russian Federation.

3 Research results

Let us analyze the main indicators of sugar beet production in the country in comparison with the data from the Republic of Bashkortostan. Both in the country and in the republic from 2019 to 2023 there is a decrease in the cultivated and harvested areas by 19% and 2%, respectively. Sugar beet consumes a lot of nutrients and water from the soil during the growing season. Therefore, the best condition for beet is an increased moisture content. There is also a positive trend in the indicators characterizing sugar beet, so there is a yield increase by 22,3% and 3,0%. In its turn, this had an impact on production – an increase in the sugar beet gross harvest in the republic by 0,9%, and a slight decrease in the country in general. In the agricultural enterprises of the region 134 kg of active substance of mineral fertilizers were applied per hectare of the cultivated area for sugar beet crops in 2019, and 232 kg of active substance of mineral fertilizers for the harvest in 2023, that is increased by 73,1% , i.e. the application of organic fertilizers increased 7 times. Generally, the use of mineral fertilizers does not change in the counrty, but organic fertilizers are reduced by 22.7% [5].

In the modern world, technologies and mechanization play an important role in all sectors of agriculture. The number of beet harvesting machines per 1000 hectares of sugar beet crops in the Russian Federation and the Republic of Bashkortostan has not changed in 5-year dynamics. There is an increase in cultivated area per beet harvesting machine in the country and our region by 10,7% and 5,7%, respectively [6, 7, 8].

Sugar cost changes are influenced by the presence of factories in the region, supply, sales volume and competition. Sugar production is characterized by seasonality. In dynamics there is an increase in the price of sugar in the Republic of Bashkortostan from 43,11 rub/kg in 2019 to 59,42 rub/kg in 2023. However, the consumer price index revealed a slight decline in December 2023 (by 1. 2) compared to 2021. The increase in prices is explained by inflationary cost measures in the Russian economy, affecting both food and non-food products [9].

There are two sugar factories on the territory of Bashkortostan: Raevsky and Chishmy. Chishmy sugar factory in Bashkiria was founded in 1971 and is considered one of the largest sugar factories in the republic. Raevsky sugar factory is considered the youngest. Raevsky sugar factory processes 3.200 tons of beet, 700 tons of raw beet per day. The main factor holding back the production of Raevsakhar LLC is the insufficiency of the natural product – raw materials. This shows the importance of the economically justified formation of zones for sugar factories. Therefore, the organization of production and the use of land in these areas is very important [10, 11].

Calculating the forecast values sugar beets by 2024 according to the developed formula, taking into account all the main parameters necessary for predicted figures of farm products [12]:

$$VP = a + b * S_k \tag{1}$$

where VP – stands for forecast values sugar beets;

a and b are coefficients that characterize the relationship between the variables under study;

Sk is forecast values of sugar beets cultivated lands under crops in the k-th forecast period.

Coefficients a and b are calculated using the formulas:

$$b = \frac{\sum_{i=1}^{n} S_i * VP_i - n * \overline{S * VP}}{\sum_{i=1}^{n} S_i^2 - n * \overline{S^2}} \quad (2)$$

$$a = \overline{VP} - b * \overline{S} \quad (3)$$

where n is the number of the measured values;

$\overline{VP}$ – the average value of sugar beets;

$\overline{S}$ – the average value of cultivated lands under crops sugar beets.

Let us calculate the forecast values of sugar beets shown in table 1, contributing to the expansion of markets. To calculate the a and b coefficients for sugar beets, the average values cultivated lands for previous years were used from the statistical collection:

$b_{\text{sugar beet}}$ = (689864.0 + 839520.0+ 656052.0)) – 2181267.7) / (7484.5 – 7460.1) = (2185436.0 – 2181267.7) / 24.4 = 4168.3 / 24.4 = 170.6

$a_{\text{sugar beet}}$ = 14580.7 – 170.6 * 47.1 = 6546.8

The calculation of the correlation coefficient determines the close relationship between the indicators taken into account and the accuracy of the forecast:

$$r = \frac{\sum_{i=1}^{n} S_i * VP_i - n * \overline{S * VP}}{\sqrt{(\sum_{i=1}^{n} S_i^2 - n * \overline{S^2}) * (\sum_{i=1}^{n} VP_i^2 - n * \overline{VP^2})}}, \quad (4)$$

Let us calculate the correlation coefficient and find its level:

$$r_{sugarbeet} = \frac{(2185436.0 - 2181267.7)}{\sqrt{(7484.5 - 7460.1) * (640631044.0 - 637787521.3)}} = \frac{4168.3}{8334.1} = 0.50$$

The correlation coefficients obtained revealed a strong relationship between the considered indicators.

The area of The correlation coefficients obtained revealed a strong relationship between the considered indicators. sugar beets cultivated lands under crops by 2024 was predicted using the function "Forecast" in Excel. The values $\overline{S}$ for sugar beet (Alsheevo district) – 5259.0 ha.

Forecast values of sugar beet were divided into a short-term period. It helps to consider and adjust the planned indicators while implementing this method due to changing economic conditions and the likelihood of risks.

Forecast values for sugar beet production were as follows:

$VP_{\text{(Alsheevo district)}}$ = 6546.8 + 170.6 * 5259.0 = 1799.9 thousand tons

The scenario method implies various options to implement internal potential under

external economic conditions (table 1).

Distribution of sugar beet cultivated areas among beet-growing areas of sugar factories in the Republic of Bashkortostan in 2024 allows us to draw the following conclusions. The main share of the sugar beet sown area is occupied by Blagovar district, its part is 23.5%, followed by Alsheevo district – 21.8% and Buzdyak district – 17.1%. The sizes of the sugar beet cultivated area in the beet-growing areas of Raevsakhar LLC in the overall structure is small and occupies 25.9% (14.226 ha). Proper organization of sugar beet production is impossible without concentration and specialization of beet sowing to plants in farms without maintaining and creating a special cycle of sugar beet crops and taking into account economic, institutional, biological and agro-technical factors.

Beet yield is one of the main indicators used in beet farms. The volume of sales of raw materials, cost, profit margin, profitability, the company's income, its solvency and other financial indicators depend on it (Table 1).

Table 1. Yield and gross harvest of sugar beet in the raw material zones in 2024

District	Cultivated area, ha	Harvested area, ha	Yield, c/ha	Gross harvest, thousand centners
Alsheevo district	5259.0	5207.3	264.8	1378.9
Aurgazy district	1535.0	1534.6	337.8	518.4
Bakaly district	50.0	50.0	450.0	22.5
Blagovar district	5657.0	5657.6	310.5	1756.7
Buzdyak district	6107.0	6107.3	365.5	2232.2
Gafuri district	1490.0	1490.0	389.2	579.9
Davlekanovo district	3579.0	3578.5	294.9	1055.3
Ermekeevo district	1618.0	1555.0	280.0	435.4
Ilishevo district	184.0	184.0	226.6	41.7
Karmaskaly district	251.0	251.1	285.9	71.8
Kushnarenkovo district	3329.0	3328.6	338.7	1127.4
Meleuz district	704.0	704.1	388.3	273.4
Miyaki district	896.0	895.9	302.7	271.2
Stelitamak district	85.0	84.8	284.1	24.1
Tuymazy district	250.0	250.0	257.2	64.3
Ufa district	581.0	581.0	480.4	279.1
Chekmagush district	4817.0	4549.6	332.4	1512.3
Chishmy district	6956.0	6955.1	354.5	2465.6
Sharan district	918.0	918.1	263.8	242.2
Total for the republic	44385.0	44008.0	327.0	14390.6

The average yield of sugar beet in the raw material zones of sugar factories is 327 c/ha. The highest yields was obtained in the districts of Ufa – 480 c/ha, Bakaly – 450 c/ha, Gafuri – 389 c/ha and Meleuz – 388 c/ha. The analysis of sugar beet yield showed that in some farms of Alsheevo, Sterlitamak, Tuymazy and Ilishevo districts, the available reserves of its increase were not used. Agronomic measures were carried out untimely, namely: organic and mineral fertilizers were applied in insufficient volumes, violations of crop rotation in crop turnovers, timing of cultivated ares preparation, necessary care of crops and harvesting were allowed [8, 9]. An important reserve for increasing sugar beet production is reducing the area of crop death. The crop death is a direct loss for the farm. In 2023 the death crop area in beet-growing areas amounted to 382 hectares.

The raw material zone of Raevsakhar LLC is represented by the following beet-growing

districts: Alsheevo, Blagovar, Buzdyak, Davlekanovo, Ermekeevo, Miyaki, Tuymazy, Chekmagush. An important reserve for increasing sugar beet production is reducing the area of crop death. The crop death is a direct loss for the farm. In 2024 the death crop area in beet-growing areas amounted to 382 hectares.

Table 2. Forecast of sown areas and yields in raw material zones of Raevsakhar LLC

District	Cultivated area, ha	Harvested area, ha	Yield, c/ha	Gross harvest, thousand centners
Alsheevo district	5259.0	5207.3	264.8	1378.9
Blagovar district	5657.0	5657.6	310.5	1756.7
Buzdyak district	6107.0	6107.3	365.5	2232.2
Davlekanovo district	3579.0	3578.5	294.9	1055.3
Ermekeevo district	1618.0	1555.0	280.0	435.4
Miyaki district	896.0	895.9	302.7	271.2
Tuymazy district	250.0	250.0	257.2	64.3
Chekmagush district	4817.0	4549.6	332.4	1512.3
Total for the raw material areas of the plant	28183.0	27801.2	313.2	8706.3

The greatest crop losses occurs in areas with high yields. For example, in the districts of Chekmagush – 267 ha with a yield of 332 c/ha, Yermekeevo – 63 ha with a yield of 280 c/ha, etc. The growth of processing capacities should be associated with an increase in the technological quality of the beet produced, as well as with changes in the technique and technology of the sugar industry, especially with regard to increasing the extraction of sugar and reduction of beet mass losses in the post-harvest period. An integrated approach to solving the problem of the new development of sugar beet production, especially in ensuring the quality of seeds, will help to increase the share of elite production of hybrids of Russian selection [13-15].

The reserve for increasing the sugar beet gross harvest by reducing the area of crop death is presented in Table 3.

Table 3. Reserve for increasing the gross harvest of sugar beet by reducing the area of crop death in the raw material areas of the plant

Indicator	Values
Average yield in the raw material areas of the plant, c/h	313.2
Cultivated area, ha	28183.0
Harvested area, ha	27801.2
Crop death area, ha	381.8
Gross harvest from harvested area, thousand centners	8707.3
Gross harvest from sown area, thousand centners	8826.9
Potential losses of sugar beet, thousand centners	119.6

The harvested area differs significantly from the cultivated area, due to this there is a sugar beet loss of almost 117 000 c. Thus, only through the concentration and specialization of raw material zones and the plant, maintaining special crop rotations to maximize the gross harvest of sugar beet and taking into account financial, economic, organizational and agrotechnical measures, it is possible to rationally organize sugar beet production.

4 Conclusion

One of many food sub-complexes of the agro-industrial complex is sugar beet. It comprises modern technologies from sugar beet cultivation, its complex processing to the sale of sugar. Both in the country and in the republic there is a decrease in the cultivated and harvested area by 19% and 2%, respectively. There is also a positive trend in the indicators characterizing sugar beet, so there is an increase in yield by 22,3% and 3,0%. In turn, this had an impact on production – an increase in the sugar beet gross harvest in the republic by 0,9%, and a slight decrease in the country in general. The Republic of Bashkortostan ranks 3rd in the Volga Federal District, its share is 4,5%. In 2022 in the raw material areas of Raevsakhar LLC the harvested area differs significantly from the cultivated area, due to this sugar beet loss is by 117000 c. In order to avoid this, it is necessary to intensify work in the following directions: further development of agricultural firms, use of intensive cultivation technologies, and involvement of additional farms in beet cultivation in order to harvest beet in sufficient quantities with a 50% share of agricultural firms in the future.

The obtained data on the development of the beet-sugar sub-complex allows us to identify important trends in its development and distinguish between industries and regions of the sub-complex. The growth of the beet-sugar sub-complex is possible on the basis of updating the production technology in joint activities:

- agricultural enterprises engaged in beet cultivation should strive to improve the technology of beet cultivation in factories, use elite varieties, reduce material and labor costs, improve the quality and yield of root crops per hectare of area;
- sugar plants should take measures to solve the problems of sugar beet production, introduce new technological lines ensuring the output of products when using their resources and reduce damage to the environment;
- trade organizations should strive to obtain funds for purchase, storage and sale of sugar and reduce the cost of sales of each product unit sold;
- some industries, providing the sugar beet complex with means of production, need to direct their efforts to technical equipment and re-equipment of enterprises and improvement of technical skills.

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