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Problems and prospects of sugar beet cultivation in Kazakhstan

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Abstract. Purpose - to ensure the food security of Kazakhstan, domestic sugar industry should aim at a significant reduction in import dependence and transition to self-sufficiency. The share of domestic sugar from sugar beet in Kazakhstan is 7%.
Design/methodology/approach - review indicating the main problems in the sugar beet production in Kazakhstan for the purpose of reimagining the domestic sugar beet industry to reduce dependence on sugar import. We analyzed the dynamics of sugar beet cultivation in Kazakhstan over the past 20 years and detected a sharp reduction in the sugar beet production.
Findings - we have identified 10 problems in sugar beet production in Kazakhstan and determined the necessary targeted solutions. We consider the main direction to be the development of scientific methodology for sugar beet production (breeding of new highly productive disease-resistant cultivars, improvement of sugar beet protection system, efficient crop rotation). The most notable problems included in this paper are small-scale marketability of sugar beet farms, infectious diseases of sugar beet, water supply shortages, use of outdated agricultural technologies, high cost of imported sugar beet seeds.
Originality/value - The present paper includes a full analysis of current problems in sugar beet production in Kazakhstan.

Key words: sugar beet production, diseases, food security, agrotechnical incompetence.

INTRODUCTION

Sugar beet is an alternative sugar crop accounting for about 30% of world sugar production (Ozguven & Adem, 2019). It is a biennial and short-duration crop with a lower water requirement than sugarcane. Historically, this crop was considered to be a European crop but now is cultivated in many other countries worldwide (around 57 sugar-producing countries) (Mulet, 2022). Sugar beet is generally considered a crop of temperate regions and requires vernalization for its flowering (Tobi et al., 2021). Today, this crop is successfully grown in subtropical countries during the winter season. The top fifteen sugar beet growing countries are Russian Federation, France, Germany, United States of America, Turkey, Poland, China, Egypt, Ukraine, United Kingdom, Iran, Belarus, Netherlands, Italy, and Belgium (Mulet, 2022).

Almaty, Zhetysu, and Zhambyl regions includes 14.5 thousand hectares of the fields for sugar beet cultivation, it is 99 per cent of all sugar beet sowing fields in the country. Where natural and climatic conditions are very favorable for its cultivation. Sugar beet is one of the most economically significant industrial crops for the south and south-east of Kazakhstan. The history of sugar beet cultivation began in 1932 under irrigation conditions in these regions (Maui et al., 2014).

To ensure the food security of Kazakhstan, the sugar industry is one of the key parts for the industrial development of the economy (Dautkanov & Dautkanova, 2022). Therefore, a comprehensive approach is required for the development of the sugar industry, aimed at a significant reduction in import dependence and the transition to self-sufficiency. On July 14, 2022, the President of the Republic of Kazakhstan, Kassym-Jomart Tokayev, at an expanded meeting of the Government of the Republic of Kazakhstan, instructed to increase the share of domestic sugar from sugar beet by six times by 2026: from 7% to 43%.

The Decree of the Government of the Republic of Kazakhstan dated September 22, 2022 No. 726 approved the Comprehensive Plan for the Development of the Sugar Industry in the Republic of Kazakhstan for 2022-2026. Within the framework of this plan state support measures would be available within the funds provided for in the national project for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021–2025 (Adilet. Agro-industrial complex, 2021; Adilet, 2022), through financial resources institutions - Baiterek JSC, Damu JSC, etc.. This would cover financing measures for the rational use of water resources and the development of irrigation networks within the framework of the Green Kazakhstan national project (Adilet. Green Kazakhstan, 2021; Adilet, 2022). The main needs for financing the development of the sugar beet industry in Kazakhstan are the purchase of seeds, fertilizers, plant protection products, agricultural machinery, and spring field work.

MATERIALS AND METHODS

Data analysis. This analysis included the changes in sugar beet field area size as well as yield between 1990 and 2021, taking into account the region and the year. Over the past 30 years, sugar beet cultivation area shrank by 300 per cent, and the crop yield by 310, with drastic reduction in 2013 and 2014. The crop productivity remained at the similar level: compared with 1990, it increased by 10 per cent (Stat.gov.kz, 2022).

Assessment of the main problems in sugar beet cultivation was based on the analyses of seed production, sugar beet diseases and technologies applied in field. The main weakness of seed production in Kazakhstan is that limited number of productive sugar beet seeds are available, and farmers purchase imported seeds, mainly from Europe. The most widespread and dangerous sugar beet diseases in Kazakhstan are rhizomania, black leg, powdery mildew, cercosporosis, peronosporosis and rot root. Crop rotations not based on recent scientific advances, insufficient use of water-saving technologies, more than 40% deterioration of the irrigation system - all damage Kazakhstan’s food security.

RESULTS AND DISCUSSION

Seed production. To increase sugar production, it is necessary to provide the manufacturer with high quality seeding material and highly productive technical means (Kostenko et al., 2019). The use of high-quality seeds in agriculture is crucial for the success of any crop, since its performance depends not only on the agronomic practices adopted but also on the source material, represented by high performing varieties adapted to the areas where they are grown, with desirable characteristics that will ensure high yield, and on the availability of high-quality seeds, with satisfactory germination and a reduced damping-off in adverse conditions (Romano, 2022). The quality of seeds is also determined by other characteristics such as the chemical composition or tolerance to certain diseases or pests. In the case of sugar beet, the goal of growers is to obtain a high sugar yield, which is also linked to the amount of root produced per hectare. Consequently, the highest germination ability and vigor are the key factors to ensure an early and high level of field emergence (Salimi & Boelt, 2019). Sugar beets are a temperate crop with potential for growing in tropical and subtropical climates. India is a good example, where numerous commercial cultivars for Indian agroclimatic conditions have been released, along with the development of agro-technologies pertaining to crop production, protection, and machinery (Kumar et al., 2022).

One of the fundamental problems in the development of sugar beet production in Kazakhstan is the weak material and technical base of seed production: sugar beet seeds of high reproduction are produced in limited volumes and sugar beet producers acquire the missing volumes mainly from Kyrgyzstan, Ukraine, and France (Master plan, 2009). This forms dependence on imported sugar beet seeds. Seeds of sugar beet varieties of foreign selection are often very expensive, of unknown origin, and of poor quality, which is often the reason for the low yield of sugar beet. This raises the question of the development of sugar beet growing in Kazakhstan using seed varieties of local selection (Master plan, 2009).

Import dependence on sugar beet seeds has developed, among other things, for the following reasons: imperfection of legislation in the field of protection of breeding achievements; insufficient amount of sugar beet seeds being submitted for the state testing of seed varieties; there are no seed farms specializing in sugar beets; insufficiently developed network of elite seed farms, etc. (Master plan, 2009).

Sugar beet improvement is primarily achieved by conventional means, but now modern techniques particularly genetic transformation has also been introduced in sugar beet breeding (Pattanayak et al., 2023). A protocol to produce synthetic sugar beet seed has been developed for prolonged storability, minimizing the cost of production, and to facilitate seed handling (Kaur et al., 2022). This may also be one of the ways to solve the problem of the dependence on imported seeds in Kazakhstan.

Sugar beet diseases. Globally, integrated disease management of sugar beet is a better option for controlling disease. Plant production through an integrated approach is a new economic method for producing high yield and healthy crop production (Ozguven & Yanar, 2022).

The spread of sugar beet diseases has caused a strong impact on sugar beet productivity due to which growers suffer huge economical losses (Ozguven & Yanar, 2022). As the climate is changing, the occurrence of new pathogens as well as species already occurring in the region is also causing more losses in productivity (Misra et al.,

2021). More than one pathogen can attack a variety at the same time, and even the type of pathogen may vary from fungal, bacterial, and mycoplasmal infection to viral infections (Mehmet Metin Ozguven &Yusuf Yanar, 2022).

The reduction in cultivated areas and gross harvest is caused by environmental, economic, and technical reasons, and one of the main reasons is the massive spread of various pests and diseases on sugar beet plantations. Specific conditions of the beet-growing zone in Kazakhstan, caused by the hot and dry climate, contribute to the development of harmful organisms in beet plantations, which include a variety of pathogens and diseases affecting the aerial organs of beet as well as its roots (Maui et al., 2015).

So, the next important component in the production of sugar beet is the need to account for and ensure crop rotation, to prevent the mass spread of species of pathogens of fungal, bacterial, and viral origin. The most widespread and dangerous diseases including the most common and harmful are black leg, powdery mildew, cercosporosis, peronosporosis, rot roots, and rhizomania (Maui et al., 2015; Kukol et al., 2018).

Black leg is a complex disease that most often occurs in areas with easily saturated soils. Soils for sugar beet growing in Kazakhstan form a crust that prevents the penetration of air. As a result, young plants become weak and easily affected by various microorganisms living in the soil (Kukol et al., 2018; Bhadra et al., 2020; Majumdar et al., 2022).

Affected plants develop poorly, wither, and die. The cause of the disease can be adverse environmental conditions, poor seed quality, and damage by microorganisms. Often these factors are interrelated. Weak seedlings develop from bad seeds, and the formation of a crust on the soil surface and sharp temperature fluctuations further weaken the plants, reducing their resistance to microorganisms.

About 100 fungi and bacteria can participate in the development of black leg, of which the most common are fungi from the genus *Fusarium Link, Pythium debaryanum Hesse, Phoma betae Frank, Rhizoctonia solani Kuehn, Aphanomyces cochlioides Drechsler, Moniliopsis aderholdii Ruhl*, etc.

The most widespread and dangerous sugar beet disease in Kazakhstan is rhizomania (the causative agent of the disease is beet necrotic yellow vein virus). Its carrier is the soil fungus *Polymyxa betae Keskin*, in whose hyphae the virus persists for many years. It can infect plants starting from the period of beet seed germination. The mass of root crops of affected plants is 10–15 times less than that of healthy ones. In Kazakhstan, rhizomania occurs in all sugar beet growing areas, causing a decrease in the average yield of over 40% and a loss of sugar of up to 10.6%. Study of the morphology, physical, and biological properties of pathogens yielded the basic directions of practical measures to combat the disease (Maui et al., 2015). Growers are always interested in cultivating resistant varieties as this will reduce the investment needed for crop protection. In such types of genotypes, disease incidence is small and the damage caused by the pathogen also appears to be less on the plant. In rhizomania of sugar beet, the use of resistant cultivars can reduce infection to some extent in current sugar beet production in Kazakhstan (Ozguven & Yanar, 2022).

More than 50 species of insects and mites have been noted on sugar beet crops in Kazakhstan. The most widespread and common pests include winter and clover scoops (*Agrotis segetum and Mamestra trifilii Rott.*) bugs (beet, hemp, alfalfa), beet aphids,

fleas, leafhoppers, polyphagous soil pests, spider mites (Maui et al., 2014; Hejri et al., 2021; Stat.gov.kz, 2022; Zhao et al., 2022).

Diseased sugar beet crops are of less economic value as the quality of sucrose deteriorates and is of great concern to growers. Interaction between host, pathogen, and environment is necessary for the development of any disease. In order to protect plants from any disease, there is a need to manage all three factors. Proper disease surveillance, disease forecasting, and its identification are some of the primary management strategy steps. Integrated management strategies for diseases need to be accorded more importance and applied efficiently in obtaining healthy sugar beet crops. Integrated disease management involves the amalgamation of cultural, resistance, chemical, and biological control measures. By adapting to these strategies, growers could manage the significant losses they are facing due to disease infection in sugar beet crops (Baitha et al., 2022).

Agricultural technologies in sugar beet production. Determining the optimal agricultural technologies for sugar beet farms is, along with the issues of import substitution and the creation of highly productive and disease-resistant local varieties of sugar beet, one of the key parts in the development of the sugar beet industry in Kazakhstan. One of the pertinent agrotechnical measures is sowing. Proper sowing ensures optimal crop density which is important for achieving a high yield. The correct choice of assortment for a certain production area contributes to a larger and more stable production of cultivated plants, also, important take into account effective weed control (Bulgakov et al., 2019; Bulgakov et al., 2021; Bojović et al., 2022).

Improving the situation in the production of sugar beet in Kazakhstan requires understanding the relationships between the dependence on environmental and agronomic factors that significantly affect the sugar beet yield and quality. In order to improve the quality of sugar beet and to obtain maximum yield, it is necessary to select the most appropriate varieties, sowing time, sowing method, sowing density, sowing depth, fertilizer type and amount, and irrigation plan (Zicari et al., 2019).

Small-scale marketability of sugar beet farms in Kazakhstan does not allow: to organize science-based crop rotations, forming profitable inter-industry relations, lack of agricultural opportunities for the use of water-saving technologies, etc. If compared with European experience (in Serbia - Vojvodina) - sugar beet is grown mainly on larger agricultural farms, and the reason is using the specific mechanization of production technology and for achievement of better financial results on larger production surface areas and better use of favorable soil and agro-ecological conditions for sugar beet production (Vlahović et al., 2006).

The regions of sugar beet cultivation in the Republic of Kazakhstan are irrigated, so issues regarding the condition of the irrigation system and the use of water saving technologies are critical. The level of deterioration of the irrigation system is more than 40%, and therefore its reconstruction and restoration are paramount, it is also important to adopt water accounting and reduce water losses, and apply water-saving technologies (drip irrigation, etc.). The irrigation effect, rational consumption of water, the irrigation economy, and soil protection depend on the correct irrigation regime (Zicari et al., 2019).

Important environmental variables that determine the beginning of sugar beet growing processes are temperature, precipitation and soil moisture (Petkeviciene, 2009). The sugar beet plant is sensitive to water deficiency, especially when there is not enough rainfall at the time of germination and 3–4 weeks after emergence. In cases where precipitation is delayed and irrigation cannot be done adequately, it becomes difficult to

obtain the necessary plants for optimum efficiency, and yield loss may be equivalent to late planting (Żarski et al., 2020).

The situation with agricultural machinery should also be noted. It is in poor and worn condition and requires almost complete replacement. At the same time, it is practically impossible to acquire the necessary agricultural machinery, since farmers have low solvency and there is no way to obtain credit resources and guarantees from leasing companies.

Sugar beet cultivation. Over the past 20 years, there has been a sharp reduction in the area under sugar beet: by 3 times compared with 1990. It should be noted that there was a sharp increase in sugar beet crops in 1992 - up to 85.1 thousand hectares and a sharp reduction in crops in 2013 and 2014 by 2.7 and 1.2 thousand hectares, respectively. The reduction in crops as a whole began in 1997 (Fig. 1) (Maui et al., 2014; Stat.gov.kz, 2001; Stat.gov.kz, 2002; Stat.gov.kz, 2003; Stat.gov.kz, 2007; Stat.gov.kz, 2012; Stat.gov.kz, 2017; Stat.gov.kz, 2021).

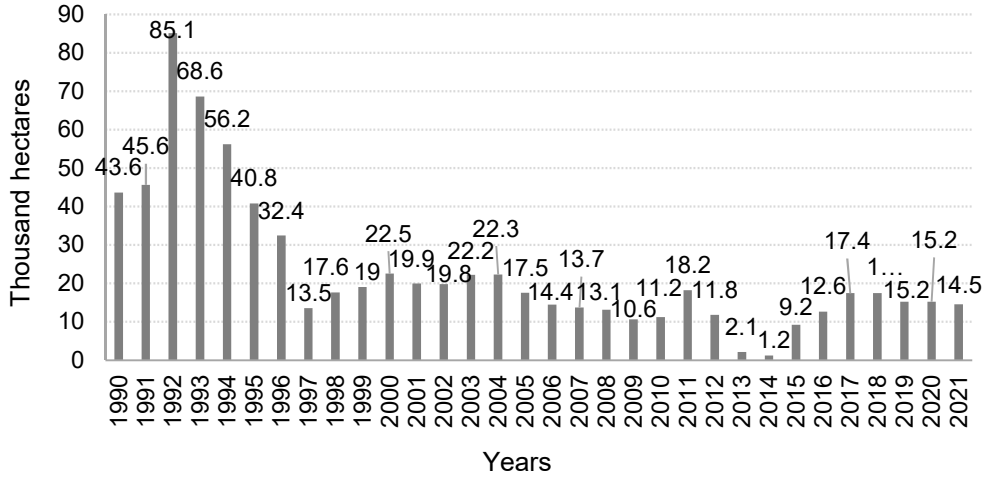

Figure 1. Dynamics of sown areas of sugar beet, thousand hectares.

The gross harvest of sugar beet also reduced by 3.1 times compared to 1990. There was a sharp increase in the gross harvest to 1,160.1 thousand tons in 1992. In 2013 and 2014, this had fallen to 64.6 and 23.9 thousand tons, respectively (Maui et al., 2014; Stat.gov.kz, 2001; Stat.gov.kz, 2002; Stat.gov.kz, 2003; Stat.gov.kz, 2007; Stat.gov.kz, 2012; Stat.gov.kz, 2017; Stat.gov.kz, 2021). The crop yield of sugar beet as a whole retained its level. Compared with 1990, there is an increase in crop yield by 1.1 times. A sharp reduction in crop yields was revealed in 1994 - up to 77 centners per hectare (Fig. 2) (Maui et al., 2014; Stat.gov.kz, 2001; Stat.gov.kz, 2002; Stat.gov.kz, 2003; Stat.gov.kz, 2007; Stat.gov.kz, 2012; Stat.gov.kz, 2017; Stat.gov.kz, 2021). The sugar content of the roots ranges from 15–19% (Kazakh Research Institute of Agriculture and Crop Production, 2022).

The main zone of sugar beet growing in Kazakhstan is located in the foothills of the North Tien Shan Mountains, including Dzhungarskiy, Zailiyskiy, and Kyrgyz Alatau. Sugar beet is cultivated here only under irrigation. The climate of the irrigated

agricultural area is sharply continental. The average annual temperature is 7–10 °C. The maximum temperature reaches 40 °C, the minimum -30 °C. The number of days with temperatures above 10 °C varies from 173 to 191 (Maui et al., 2015).

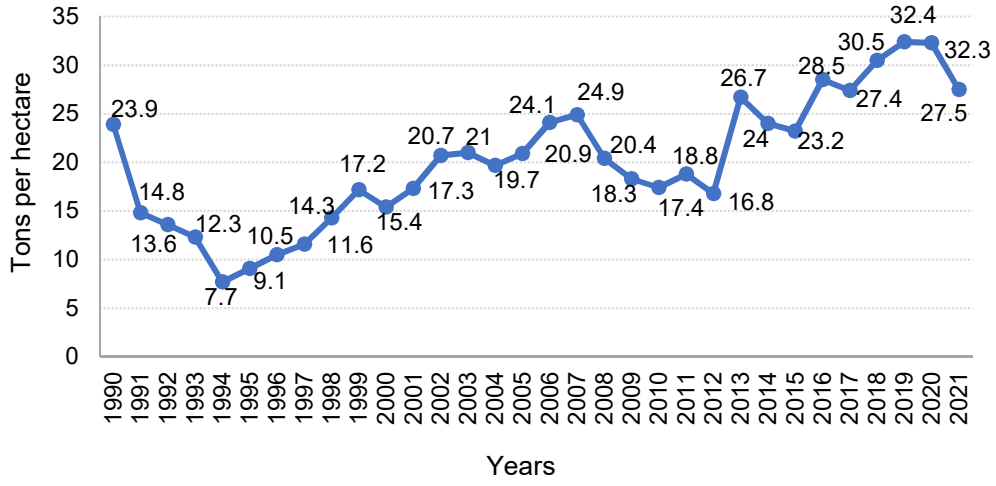

Figure 2. Dynamics of sugar beet yield, tons per hectare.

The average annual rainfall in sugar beet growing areas is 200–400 mm. According to the hydrothermal coefficient, the climate of the irrigated zones is desert and semi-desert types. The weather conditions during the research period were quite suitable for the cultivation of sugar beet, as we can see from the analysis of temperature conditions, 16 out of 23 years of research have been above normal and 7 below normal.

Important element of sugar beet production are soils suitable for its production. Soils of sugar beet growing areas in Kazakhstan are piedmont light brown, gray, and meadow-gray (Maui et al., 2015).

79% of sown areas of sugar beet belong to small farms, 20% - to industrial farms, and 1% are used for personal needs. According to the survey of individual entrepreneurs, agricultural enterprises and farms, the crop productivity of sugar beet grown by privately owned farms was the highest (38.3 tons per hectare), in agricultural enterprises - 28.1 tons per hectare (Stat.gov.kz, 2022).

Main problems in the production of sugar beet. There are a number of main problems in the production of sugar beet in Kazakhstan and the low provision of the domestic market with domestic sugar production (Table 1).

Increasing the efficiency of sugar beet production is possible by the integration of small farms. Through such integration, it will be possible to observe a science-based crop rotation for the production of sugar beet, which will protect from the spread of diseases. Also, it will allow observing optimal agricultural technologies for the production of sugar beet, meet the need for and volume of necessary agricultural equipment, and credit resources for this. Therefore, it will increase the solvency of farms and improve the standard of living of the agriculture population.

Table 1. Main problems in the production of sugar beet in Kazakhstan

The problem	More detailed
Fixed prices for beets	Reduces the interest of farmers (5–6% profitability); provide an opportunity for farmers to sell sugar beet of their choice based on their own benefit, etc.
Small-scale marketability of sugar beet farms	Many farms less than 100 hectares that cannot organize science based crop rotations, there is no possibility of forming profitable inter-industry relations, lack of agricultural opportunities for the use of water-saving technologies and financial opportunities for leasing operations, etc.
Infectious diseases of sugar beet	The most common and harmful are black leg, powdery mildew, cercosporosis, peronosporosis, rot roots, rhizomania, etc.
Problems of water supply	Deterioration of irrigation systems by more than 40%, the need for cleaning and reconstruction of irrigation canals, rational use of water resources, and reduction of water loss, etc.
Lack of biostimulation of plant growth	Rational use of agricultural technologies
Use of outdated agricultural technologies	Introduction of modern optimal agricultural technologies in the production of sugar beet, reducing losses at all stages; drafting an optimal technological map for the production of sugar beet for each region
High cost of imported sugar beet seeds	Expensive, of unknown origin and of poor quality imported seeds, which is often the reason for the low yield of sugar beet.
The need to expand the network of seed farms for the production of sugar beet seeds	Improve legislation in the field of protection of breeding achievements of sugar beet varieties, insufficiently developed network of elite seed farms, insufficient amount of sugar beet seeds entering the state variety testing facility, etc.
Development and implementation of water-saving technologies	Use water-saving technologies on all farms producing sugar beet.
A high percentage of depreciation of agricultural machinery	A lack of harvesting equipment, which leads to large crop losses during harvesting, many farms require a complete replacement of agricultural machinery, low solvency of farmers, weak transport and logistics infrastructure, etc.
Standards for the acceptance of products of sugar factories	Outdated standards for sugar beet acceptance by sugar factories.

Measures to improve the situation. Accordingly, for the further successful development of sugar beet production in Kazakhstan, it is important to determine the necessary targeted measures to solve those problems (Fig. 3). It is necessary to provide:

1. scientific support for the development of sugar beet (breeding of new highly productive, disease-resistant seed varieties and improvement of the sugar beet protection system);

2. strengthening state support measures for sugar beet production: capital investments for the development of waste lands of former large sugar beet farms, providing tax preferences, providing measures to reimburse sugar beet producers for part of the costs of purchasing seeds and growing sugar beet by increasing subsidy standards;

3. observance of agrotechnical technologies for the cultivation, harvesting and transportation of sugar beets, the application of fertilizers and plant protection products, the high-quality performance of all field work, science-based crop rotation;

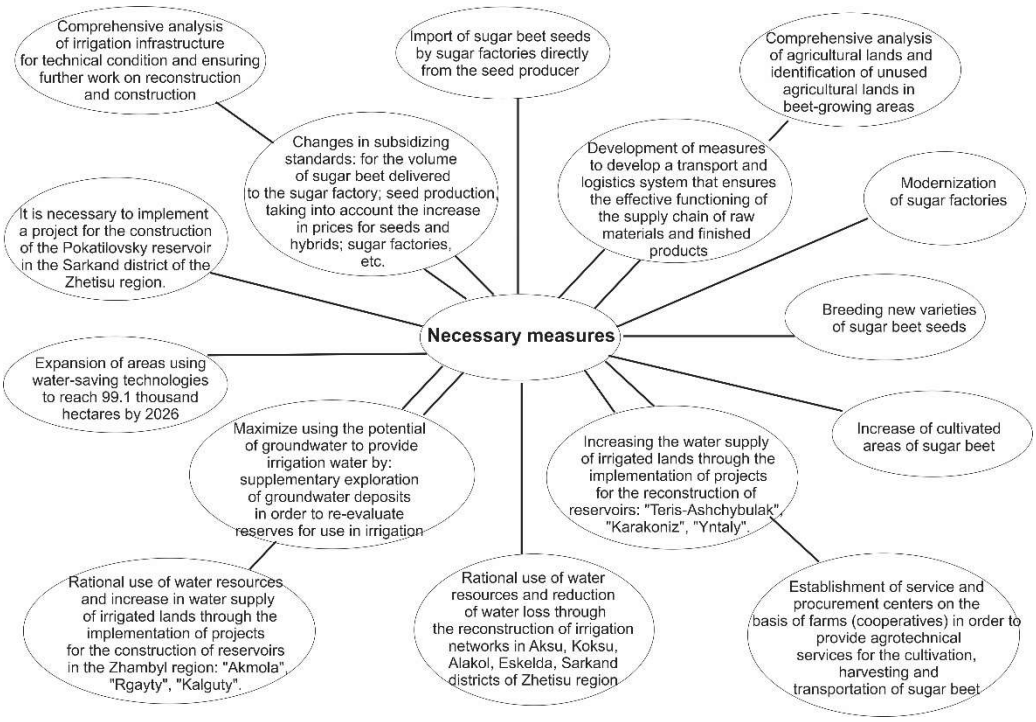

Figure 3. More targeted necessary measures.

4. to promote the activities of the Association of Beet and Sugar Producers, in order to protect the interests of sugar beet producers;

5. increase in the volume of leasing for the supply of agricultural machinery, equipment for the production and processing of sugar beet, lending for the purchase of agricultural machinery for the cultivation and harvesting of sugar beet with its further leasing to farmers;

6. organization and expansion of the network of elite seed development and seed-growing farms for growing sugar beet seeds of high quality;

7. improvement of normative legal documents in the field of seed production and breeding achievements;

8. infrastructure provision through the construction, reconstruction and restoration of irrigation networks with the involvement of funds from the state budget, international financial institutions, and development institutions, the use of water-saving technologies;

9. the introduction of over 10 thousand hectares of new irrigated lands;

10. use of sugar beet varieties approved for sowing in the Republic of Kazakhstan and included in the state register of breeding achievements;

11. creating conditions to reduce the cost of sugar beet seeds.

CONCLUSIONS

The high cost and low profitability of sugar beet production compared to other agricultural crops is brought about by small-scale farming, and lack of water resources, taking into account the fact that beet-growing areas in Kazakhstan are irrigated areas, a

high degree of deterioration of irrigation networks, the high cost of imported sugar beet seeds and often their inconsistency with growing conditions in Kazakhstan and low quality and, accordingly, low crop yields and resistance to diseases. The high level of depreciation of agricultural equipment used in the cultivation and harvesting of sugar beet, violation of the culture of cultivation of sugar beet and agrotechnical technologies, and much more led to the fact that the production of sugar beet in Kazakhstan has become a stagnating and unpopular destination. This caused, among other things, a huge crisis in the sugar industry and a high sugar shortage in the country in 2022, which is a direct threat to the food security of Kazakhstan. It is necessary to apply all recommended measures to eliminate this situation.

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