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Technological Qualities Improvement Of Sugar Beet Root Crops In Sugar Beet Top Dressing.

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ABSTRACT

The influence of foliage dressing with melafen, a new generation growth regulator, in a complex with non-reutilized trace elements (boron, zinc, manganese) on technological qualities of sugar beet root crops and sucrose losses in molasses has been studied. In the course of the experiments it was found that the yielding capacity increased. The content of molasses forming agents (potassium, sodium, alpha-amino nitrogen) decreased that led to the sucrose loss reduction and ultimately, the gross yield increase of purified sugar.
Keywords: sugar, beet root, top dressing, molasses

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INTRODUCTION

The value of root crops, first of all, depends on the sucrose amount in them. Sucrose is deposited and accumulated in sugar beet roots during the plant's life activity. The processes of outflow and accumulation are in interrelationship with the major physiological processes of a vegetating plant and depend on a set of environmental conditions, as well as on weather factors. The sugar content does not fully determine technological qualities of the sugar beet raw material, that is why the soluble part of non-sugars should also be taken into account. Depending on the chemical composition various qualitative and quantitative combinations of individual dry matter components can be in a root crop, different proportions between sucrose and non-sugars, the different composition of non-sugars. We consider that the chemical composition of root crops has influence on technological qualities when beet roots are processed at a factory, consequently, technological qualities exert influence on sucrose losses considerably.

The main factors of the yield increase and improvement of sugar beet root crops' technological qualities are weather conditions, mineral nutrition with macro and microelements (especially those which are not reutilized).

There are data in scientific literature which suggest that the application of microfertilizers as a top dressing material intensifies the leaf formation process, increases the length of their life and slows down the dying processes resulting in the yield increase of sugar beet [1, 2, 3, 4].

We found in our studies that the application of growth regulators raises the sucrose content, increases the purity of raw juice and improves the main technological qualities of sugar beet roots [5, 6, 7, 8, 9, 10].

The purpose of the study was to examine technologic qualities of root crops and sucrose losses in molasses in the process of top dressing with melafen, a new generation growth regulator together with non-reutilized trace elements (boron, zinc, manganese) in production conditions.

OBJECTS AND RESEARCH METHODS

The experiment was conducted in 2012-2015 in the Tsilninsky district of the Ulyanovsk region on the seedlings of the one stalk hybrid Manon produced by the company SESVanderHave.

Top dressing with trace elements and growth regulator was conducted twice in the vegetation period. First treatment was done in the phase of 5-6 true leaves, the mixture was prepared in a container, simultaneously with the second herbicide spraying, the second treatment was done in the root formation period. Melafen, a growth regulator was applied as a water solution in the concentration $1 \cdot 10^{-7}$%, trace elements as water solutions of their salts: boron (boric acid – H_3BO_3), zinc (zinc sulfate – $ZnSO_4$), manganese (manganese sulfate – $MnSO_4$) in concentrations 0,05%. The soil of the experimental plot is leached black soil with average thickness, average humus content and average clay loam. The humus content – 4,8-5,3%, phosphorus content – 115-160 mg/kg, potassium – 140-200 mg/kg.

The content of microelements in the fields fluctuates in the following range: boron – 0,1-0,18 (mean value – 0,14 mg/kg), manganese – 4,7-10,9 (mean value – 7 mg/kg), zinc – 0,4-0,6 (mean value – 0,47 mg/kg). In boron and zinc the soils are referred to very poor, in manganese to poor. The stand thickness was at the level of 99,3 thousands of plants on 1 ha. Weather conditions of the vegetation periods of 2012–2015 were different. 2013 was a favorable year in the rainfall amount and temperature conditions – very humid, especially in August and September, when the rainfall was 2,5 of a monthly rate, that is why the yield was higher but with a lower sucrose content. The year 2014 was less favorable at the beginning and the end of the vegetation because there was no precipitation.

High temperature in August-September contributed to a more intensive outflow of sucrose from the leaves, so in 2014 the sugar content of root crops was higher in comparison with 2012 and 2013. In 2015 in May-June the rainfall amount was less than a monthly norm and in July the precipitation amount was more than a monthly rate in 2 times. In August-September the rainfall amount was less than a monthly rate in 2 times. June and September of 2015 were warmer in contrast to the mean rate for many years.

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The sugar content of root crops was determined by the method of hot water digestion on a colorimetric flow-through sugarmeter AP-05 in the research laboratory of the department of «Biology, chemistry, technology of storage and produce processing» at Ulyanovsk State Agrarian University. The potassium and sodium content was determined with the use of a lab ionmeter I-160MI applying ion selective electrodes ELIS-121K and ELIS-212Na. To determine α-amino nitrogen the method offered by Stanek and Pavlas which was modified by Wininger and Kubadinov was used that was based on the measurement of optical density with the use of a spectrophotometerPE-5300 V.

Standard sugar losses when molasses was formed were calculated according to the Braunschweig's formula [11]:

$$SSL= 0{,}12 \cdot (K + Na) + 0{,}24 \cdot \alpha\text{-amino nitrogen} + 0{,}48, \quad (1)$$

where SSL – standard sugar losses, %; K – potassium content, mmol for 100 gr of the wet weight; Na – sodium content, mmol for 100 gr of the wet weight;α-amino nitrogen – the content of alfa-amino nitrogen, mmol for 100 gr of the wet weight.

The content of purified sugar was equal to the difference between sugar content and standard sugar losses in molasses [11]:

$$SPS = SC – SSL, \quad (2)$$

where CPS – content of purified sugar, %; SC – sugar content, %; SSL – standard sugar losses in molasses, %.

Gross sugar yield was determined as an equation of the yield and sugar content:

$$GSY = Y \cdot SC / 100,$$

where GSY – gross sugar yield, t/ha; Y – the yield of root crops, t/ha; SC – sugar content of root crops, %.
Gross yield of purified sugar was calculated according to the formula:

$$GYPS = Y \cdot PSC/ 100,$$

where GYPS – gross yield of purified sugar, t/ha; Y – the yield of root crops, t/ha; PSC – purified sugar content in root crops, %.

RESEARCH RESULTS

The results of the field experiments conducted in 2012-2015 are given in table 1.

Table 1: The yield of sugar beet, t/ha.

Variant	The year of studies				Average yield t/ha	Gain	
	2012	2013	2014	2015		t/ha	% in relation to control
Control	42,3	53,5	28,2	26,8	37,7	-	100
Melafen	44,9	55,3	29,9	29,1	39,8	2,1	105,6
Boron	46,8	58,5	32,0	30,0	41,8	4,1	110,9
Zinc	45,6	56,3	30,4	28,2	40,1	2,4	106,4
Manganese	45,9	57,7	31,5	27,1	40,6	2,9	107,7
Zinc + Manganese + Boron+ Melafen	54,7	68,4	34,0	32,6	47,4	9,7	125,7
LSD_{05}	0,56	1,39	0,61	0,52			

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Weather conditions in the years of the studies (2012-2015) in the rainfall amount and temperature regime were different – 2014 and 2015 were arid, that is why the yielding capacity in these years was significantly lower– in 1,5 times in comparison with more favorable years of 2012 and 2013.

The research results show that the use of our technology with two-time top dressing of agrophytocenosis of sugar beet raises the yielding capacity on average for 4 years by 9,7 t/ha (25,7%), with the yield in the control group of 37,7 t/ha.

Technologic qualities of root crops

While processing sugar beets at a sugar factory technological qualities have a significant effect on the magnitude of sugar losses. The index of sugar content does not completely identify technologic qualities of beet raw materials that is why it is also important to take the soluble part of non-sugars into account.

The main factor of the yield rise and improvement of technologic qualities of sugar beets is the mineral nutrition with macro- and microelements.

The application of growth regulators is an additional factor increasing the sucrose content that raises the purity of normal juice and improves major technological qualities of sugar beet.

Major indicators of technological qualities are: sucrose content, juice purity, hydrogen value (pH).

The research results show that in the experimental variant the sucrose content increased from 16,9 % to 18,4 % (table 2).

Table 2: The sugar content of root crops, in % for the wet weight.

Variant	The year of the study				Average sugar content
	2012	2013	2014	2015	
Control	16,5	15,6	17,2	18,1	16,9
Melafen	16,9	16,2	17,5	18,5	17,3
Boron	17,0	16,0	17,4	18,6	17,3
Zinc	16,6	15,8	17,2	18,3	17,0
Manganese	16,7	15,8	17,2	18,3	17,0
Zinc+ Manganese + Boron+ Melafen	18,1	17,6	18,6	19,3	18,4

More intensive sugar accumulation takes place irrespective of weather conditions in all the years of the study. Technological qualities, apart from the sucrose content, are the purity of normal juice and hydrogen index (pH) (tables 3, 4).

Table 3: Purity of normal juice of sugar beets, cond.u.*.

Variant	The year of the study				Average purity
	2012	2013	2014	2015	
Control	85,8	83,3	87,1	86,5	85,7
Melafen	86,2	84,5	88,9	87,3	86,7
Boron	85,9	84,0	88,9	87,1	86,5
Zinc	85,7	83,6	87,8	86,6	86,0
Manganese	85,8	83,7	87,9	86,7	86,0
Zinc + Manganese + Boron + Meafen	88,2	85,9	91,2	91,4	89,2

*Conditional unit – a unit that shows the number of sucrose parts contained in 100 parts of sugar beet juice, the rest parts are composed of pectin, fiber, invert sugar and non-sugars.

Table 4: Hydrogen index (pH) of normal juice.

Variant	The years of the study				Mean value
	2012	2013	2014	2015	
Control	6,1	6,5	6,3	6,5	6,4
Melafen	6,7	6,6	6,4	6,6	6,6
Boron	6,6	6,3	6,3	6,6	6,5
Zinc	6,1	6,0	6,1	6,5	6,2
Manganese	6,3	6,2	6,1	6,4	6,3
Zinc + Manganese + Boron + Melafen	6,8	6,8	6,5	6,9	6,8

The data (table 3) demonstrate that the purity of normal juice increases for 4 years on average by 3,5 cond.u. The most stable index is the hydrogen index (table 4).

The content of potassium in root crops which is one of the molasses-forming agents is referred to important technologic qualities. The higher this index is, the lower the quality of beet raw materials is. In our experiments the potassium content (table 5) decreased from 5,46 mmol for 100 gr. of the wet weight of root crops in the control group to 3,60 mmol in the experimental group.

Table 5: The content of potassium in sugar beets, mmol for 100 gr. of the wet weight.

Variant	The year of the study				Average content
	2012	2013	2014	2015	
Control	5,53	5,57	5,48	5,25	5,46
Melafen	4,64	4,69	4,59	4,37	4,58
Boron	5,38	5,43	5,33	5,11	5,31
Zinc	5,36	5,41	5,32	5,09	5,29
Manganese	5,24	5,30	5,20	4,98	5,18
Zinc + Manganese + Boron + Melafen	3,68	3,71	3,62	3,40	3,60

Sodium is also a molasses forming agent, the content of which impedes the extraction of crystallized sugar [12]. The research results (table 6) showed that the sodium content in all the years in the control group was 1,55 mmol for 100 gr. of the wet weight, in the experimental group – 0,69 mmol.

Table 6: The content of sodium in sugar beets, mmol for 100 gr. of the wet weight.

Variant	The year of the study				Average content
	2012	2013	2014	2015	
Control	1,51	1,64	1,57	1,48	1,55
Melafen	0,83	0,94	0,86	0,79	0,86
Boron	1,40	1,52	1,44	1,35	1,43
Zinc	1,20	1,31	1,23	1,16	1,23
Manganese	1,25	1,38	1,31	1,22	1,29
Zinc + Manganese + Boron + Melafen	0,66	0,77	0,70	0,62	0,69

The most harmful molasses forming agent among nitrogenous compounds is α–amino nitrogen that plays a negative role in the process of sugar extracting [13].

Table 7: The content of α–amino nitrogen in sugar beets, mmol for 100 gr. of the beet wet weight.

Variant	The year of the study				Average content
	2012	2013	2014	2015	
Control	5,8211	5,9281	5,7676	5,5002	5,7543
Melafen	5,5002	5,5002	4,9652	4,0559	5,0054
Boron	5,6071	5,5002	5,3932	5,0722	5,3932
Zinc	5,6606	5,6606	5,3932	4,6443	5,3397
Manganese	5,7141	5,6071	5,3397	4,2164	5,2193
Zinc + Manganese + Boron + Melafen	5,3932	5,3932	4,7513	2,2907	4,4571

On average, for the years of the study the greatest content of α–amino nitrogen in sugar beets decreases from 5,75 mmol for 100 gr. of the wet weight in the control group to 4,46 mmol in the variant with combined application of microelements and melafen (table 7).

Sugar losses in the control variant were 2,70% (fig. 1). They were connected with a high content of molasses forming substances, potassium and α–amino nitrogen especially. With foliage application of microelements and a growth regulator standard losses of sugar in molasses lowered to 2,06% (table 8).

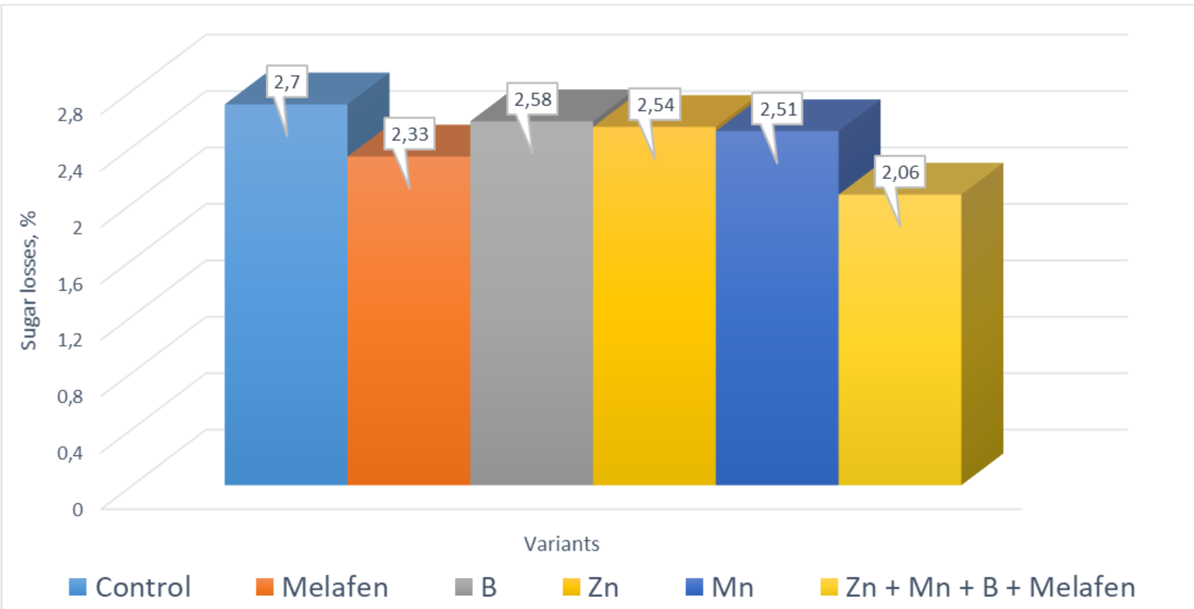

Fig. 1. Mean values of standard sugar losses in molasses for 2012-2015.

The content of purified sugar in sugar beets was in indirect dependence with standard sugar losses in molasses. The content in the control group was 14,15%, in the experiment with combined application of preparations - 16,34% (fig. 2).

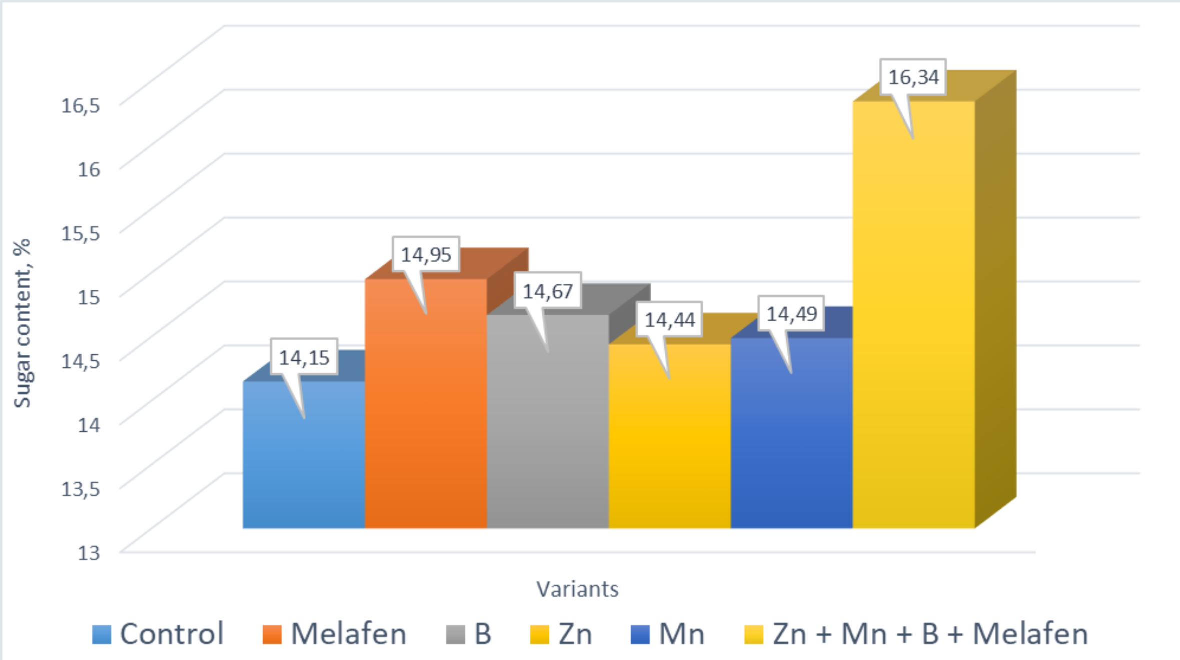

Fig 2. Mean values of purified sugar content for 2012-2015.

Table 8: Sugar beet yield values.

Variant	The year of the study				Mean value
	2012	2013	2014	2015	
Standard sugar losses, %					
Control	2,72	2,77	2,71	2,61	2,70
Melafen	2,46	2,48	2,33	2,07	2,33
Boron	2,64	2,63	2,59	2,47	2,58
Zinc	2,63	2,64	2,56	2,34	2,54
Manganese	2,63	2,63	2,54	2,24	2,51
Zinc + Manganese + Boron + Melafen	2,30	2,31	2,14	1,51	2,06
Purified sugar content, %					
Control	13,78	12,83	14,49	15,49	14,15
Melafen	14,44	13,72	15,17	16,43	14,95
Boron	14,36	13,37	14,81	16,13	14,67
Zinc	13,97	13,16	14,64	15,96	14,44
Manganese	14,07	13,17	14,66	16,06	14,49
Zinc + Manganese + Boron + Melafen	15,80	15,29	16,46	17,79	16,34
Gross yield of sugar, t/ha					
Control	7,0	8,3	4,9	4,9	6,4
Melafen	7,6	9,0	5,2	5,4	6,9
Boron	8,0	9,4	5,6	5,6	7,2
Zinc	7,6	8,9	5,2	5,2	6,8
Manganese	7,7	9,1	5,4	5,0	6,9
Zinc + Manganese +	9,9	12,0	6,3	6,3	8,7

Boron + Melafen					
Gross yield of purified sugar, t/ha					
Control	5,8	6,9	4,1	4,2	5,3
Melafen	6,5	7,6	4,5	4,8	5,9
Boron	6,7	7,8	4,7	4,8	6,1
Zinc	6,4	7,4	4,5	4,5	5,8
Manganese	6,5	7,6	4,6	4,4	5,9
Zinc + Manganese + Boron + Melafen	8,6	10,5	5,6	5,8	7,7

The gross yield of sugar is one of the integral indexes of sugar beet productivity. While applying top dressing with microelements and a growth regulator the sugar yield started rising and reached a maximum value (8,7 t/ha) when they are applied together (fig. 3).

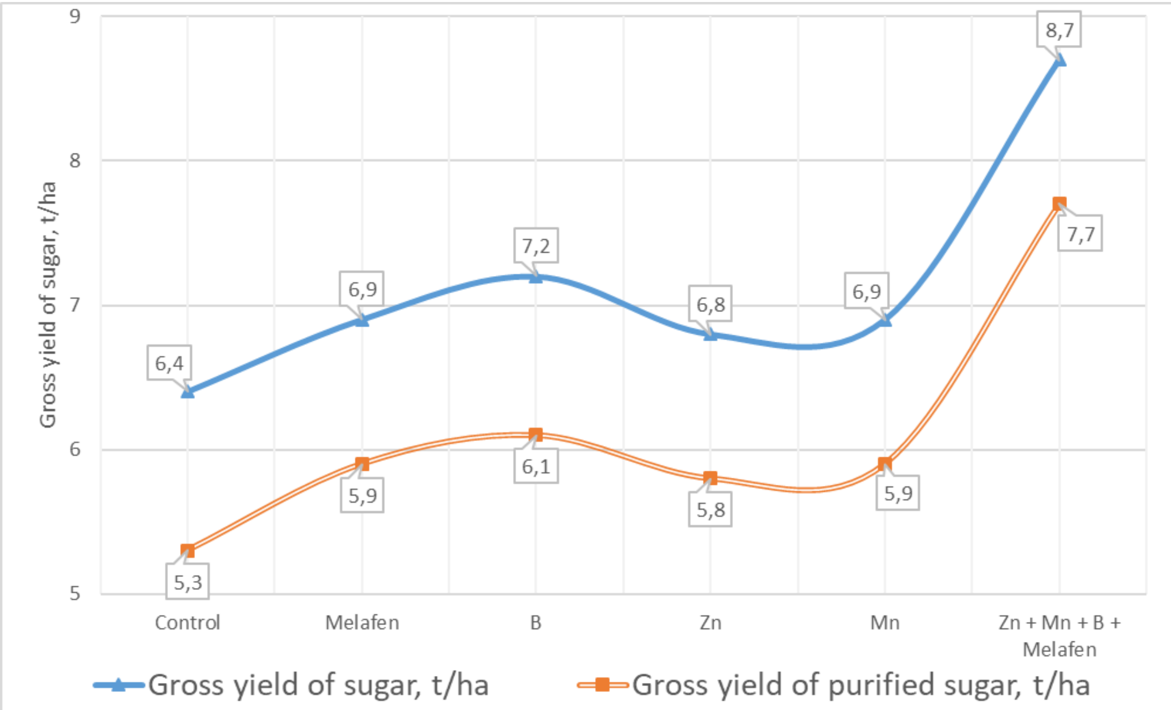

Fig. 3. Gross yield mean values of sugar and gross yield mean values of purified sugar for 2012-2015.

The gross yield of purified sugar is the final volume obtained after sugar beet processing at a sugar factory [14]. On average, in the variant with application of boron, zinc, manganese and melafen 7,7 t/ha of purified sugar was produced, in comparison with the control group – 5,3 t/ha (fig. 3).

CONCLUSION

Thus the studies showed that the yield of sugar beets increased with the use of microelements and a growth regulator in top dressing. In the joint application of the used factors (Zn + Mn + B + Melafen) this value is substantially higher than the other variants. At the same time top dressing reduces the content of potassium, sodium and α-amino nitrogen in beet roots. Standard losses of sugar in molasses also decline with application of microelements and growth regulator, mainly at the expense of a low content of potassium and α-amino nitrogen. The gross yield of sugar in a variant with the joint application of non-reutilized microelements and melafen was higher than in the control group. The yield assessment according to the purified sugar gross yield showed that the variant with application of boron, zinc, manganese and melafen exceeds the control group considerably. The results obtained allow us to make a conclusion about a productive cultivation of sugar beet with two-fold top dressing of boric acid solutions, zinc and manganese sulfates and melafen.

CONCLUSIONS

The application of the technology developed for sugar beet cultivation enables us to make the following conclusions:

- Under the action of melafen and non-reutilized microelements sucrose biosynthesis becomes intensified, the drought resistance increases in unfavorable years.
- While applying the preparation for treating vegetating plants the yielding capacity of sugar beet rose by 5,8-14,9 t/ha, on average for 4 years by 9,7 t/ha that amounts to 25,7% in relation to the level in the control group of plants.
- The application of this cultivation technology made it possible to increase the sugar content up to 1,5 %, to improve the purity of normal juice on average by 3,5 conditional units.
- The results of the experiments conducted showed that the content of such molasses forming agents as potassium and sodium declined by 1,86 and 0,86 mmol respectively for 100 gr of the beet wet weight.
- Under the influence of our technology the decline of harmful α-amino nitrogen is observed on average for the years of studies by 1,2972 mmol for 100 gr. of the beet wet weight. Thus favorable conditions are created to raise the amount of extracted sucrose.
- The gross yield of purified sugar in the experimental group amounted to 7,7 t/ha, in comparison with the control group – 5,3 t/ha.

Gratitude

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