Biological Systems, Biodiversity, and Stability of Plant Communities

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CHAPTER 12

SUGAR BEET PRODUCTIVITY FORMATION DEPENDING ON FOLIAR APPLICATION OF MICROELEMENTS

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ABSTRACT

It was analyzed the research results of sugar beet foliar application influence, at stated periods of vegetation, by various types and norms of microelements on the yield and root crops quality formation in the conditions of unstable moistening in the right bank of the Central Forest-Steppe Zone of Ukraine. It was revealed that the sugar beet yield formation, sugar content and sugar yield are significantly depends on plants foliar application in their respective phases of vegetation forms of microelements and norms of their application. Foliar application is conducting in closing leaves in a row phase and by the 30 days before harvesting by different microfertilizers at the norms of application from 3.0 to 7.0 L/ha was promote the macronutrients better absorption from the soil, which in turn influences on the final sugar beet productivity. The most effective is foliar application, which provides roots growth productivity and sugar yield. Foliar application is provides a significant increase not only roots productivity, but their sugar yield from hectare at conducting in a month before harvesting.

12.1 INTRODUCTION

The questions about plant organism relationship patterns and environment are open the unlimited possibilities for human on the growth and plants development influence in order to obtain the high and stable yields [1, 2]. The one of the ways to address on the production process is the using sugar beet foliar application of microelements. The foliar application effectiveness is depends on the types of micronutrients, norms of their consumption and timing of feeding. Micronutrients are accelerate the plants development and seed ripening, increase the plant resistance to adverse environmental conditions, as well as make them resistant against several bacterial and fungal diseases. It was established [3] that for the plants are most effectiveness the biologically activeness microelements in the form of chelates microfertilizers – kompleksons (chelated metal compounds). Foliar feeding can improve the rates of assimilation of nutrients from fertilizers; significantly reduce their doses without crop productivity reducing, to achieve a uniform distribution of micronutrients within a field area, to minimize the stress of pesticide treatments, to provide all the necessary elements of plant nutrition at critical periods of their development [4]. Through the leaves and stems is allows to optimize the norm and ratio between nutrients during the growing season. A lot of attention was paid in the Zarishnyak [4], Bulygin [3], etc. works for foliar application issues by the chelate forms of fertilizers. Earlier research works were established [3], that foliar feeding of sugar beet hybrids that created on cytoplasmic male sterility (CMS) basis within Reakom-R-beet microfertilizer is positively effected on plant growth and development, the leaf surface formation, mass of roots increase, dry matter accumulation, which ultimately leads to in yield of roots and sugar increases.

The goal of our researches was influence of new microfertilizers Reastim-humus-beet and Reakom-plus-beet study, in which the ratio of microelements is balanced, with taking into account their needs for sugar beet productivity and photosynthesis, respectively – on sugar beet yield. Microelements that are part of these micronutrients are in a biologically active form, so easily and quickly by plants absorbed. In the control variant micronutrients were not used. As the standard was used domestic microfertilizer Reakom-R-beet.

12.2 MATERIALS AND METHODOLOGY

Field experiments were performed during 2010–2012. It was directed on the effect of foliar application of sugar beet in the growing period by the different types of microelements and norms on the yield formation and quality of roots in the field conditions of Bila Tserkva National Agrarian University, which is located in the zone of unstable moistening.

Under programmed sugar beet yields of 70 t/ha was created the common background with the application of organic fertilizers and mineral fertilizers. At the same time was taken into account the nutrient reserves in the soil. For the problem of increasing the productivity of photosynthesis of sugar beet, respectively, – the yield of roots solving was conducted three-factor experiment which investigated the influence of the timing of foliar feeding application (factor A), types of micronutrients (factor B) and norms of their application (Factor C). In the experiments were use microfertilizers of Ukrainian production research and production center "Reakom": Reakom-R-beet (standard), Reastim-humus-beet and Reakom-plus-beet. Microelements were added in two terms: closing leaves in a row phase and one month before harvesting by different norms from 3.0 to 7.0 L/ha.

Determination of the pure productivity of photosynthesis, which is measured in grams of dry matter per m^2 of leaf area per one day (g dry matter/m^2 leaf surface per day) was determined by Nichiporovich method [5]. The components of the net productivity of photosynthesis are leaf surface area, which is measured in thousands of square meters of leaf area per hectare (thousands m^2/ha) and photosynthetic potential (mln $m^2 \times$ day/ha). This experience gives the opportunity to comprehensively assess the effectiveness of this agrotechnological technique.

A plant analyzes and other observations were performed according to existing methods that have been used in domestic practice [6]. Experiment was laid by the method of split plots location repetitions systematically, consistently. Experiments repeated were fourfold. For research it was use hybrid seeds of domestic selection Ukrainian ChS 72.

The statistical data processing was performed on a personal computer by R. Fisher method [7].

12.3 RESULTS AND DISCUSSION

Sugar beet plants productivity is the result of all metabolic process in which was balanced the steps of organic matter forming and its expenditure on growth, development, breathing and other vital processes. Influence of individual agricultural methods research including foliar application and its impact on this important biological process is theoretical and practical significance.

Our researches have shown that during all sugar beet vegetation period, raw mass of roots and leaves growth were passed irregularly. In the first half of the growing season was happened quite intense growth of the assimilation apparatus that due to plant genetic features. From the biological point of view is warranted, as it leaves apparatus is synthesizes dry matter, which in the second half of vegetation more intensively accumulated in the sugar beet roots. At the end of vegetation the leaf surface area and leaf mass in the terms of a balanced fertilizer system are naturally decreases. Root mass was increased throughout the growing season.

On September 1st it is established that on the root mass and leaf mass increase have essentially influenced the types and norms of microelements using in the both terms of their application (Table 12.1).

On the I date of accounting – September 1, in the phase of leaves closing in a row, at the application norm of 3 L/ha of microfertilizer Reakom-plus-beet the leaf mass was 120.8 g, at the norm of 5 L/ha –163.2 g and the highest leaf mass was noted in the variant with microfertilizer application in the norm of 7 L/ha – 170.7. In all variants, the growth of leaves was significantly higher than on the control. At microelements application a month before harvesting were obtained similar results. The greatest value of leaves mass was also obtained in the variant with the microelements application of Reakom-plus-beet fertilizer at the norm of 7 L/ha – 185.4 g. Analogous results were obtained with the foliar application of Reastim-humus-beet microfertilizer. With the increase of the microelements norms using is increases the mass of leaves. Mass of leaves in the closing leaves in rows phase in the norm of 5 L/ha at the foliar feeding by Reakom-R-beet (standard) microfertilizer was 140.6 g, by Reastim-humus-beet – 156.5 g, Reakom-plus-beet microfertilizer – 163.2 g (SSD_{05} = 12.7 g) on September 1. Significant difference in a leaves mass gain is depending on types of micronutrients is not found.

On the second date of accounting – before harvesting (October 30) was set to decrease leaves mass gain in all variants, compared with the first date of accounting, which is related with the sugar beet biological features, i.e. a decrease in the assimilation apparatus functionality and a significant nutrients outflow from leaves to the roots. If at the first term of Reastim-humus-beet microelements application in the norms of 5 and 7 L/ha on September 1 the leaf mass gain was 156.5 and 163.1 g, then before harvesting it was 101.4 and 104.6 g, respectively. At Reakom-plus-beet and Reakom-R-beet (standard) microfertilizers application were obtained the similar results. It is worth to noting that at the foliar application in the second term (30 days before harvest) most effective was Reakom-plus-beet microfertilizer, which provided the roots mass gain at the all application norms compared with Reastim-humus-beet t micronutrient.

TABLE 12.1 The Dynamics of Sugar Beet Root and Leave Mass Increases Depending on the Timing, Types and Application Norms of Microelements in Feeding (Average of 2010–2012)

Type of microfertilizers (factor B)	Application norm, L/ha (factor C)	Mass of leaves, g		Mass of roots, g	
		September 1	before harvesting	September 1	before harvesting
Phase of closing leaves in a row (factor A)					
Without feeding (control)	-	126.3	57.8	301.9	342.5
Reakom-R-beet (standard)	5.0	140.6	73.7	340.9	382.3
Reastim-humus-beet	3.0	137.3	91.9	324.8	386.8
	5.0	156.5	101.4	357.0	414.7
	7.0	163.1	104.6	396.3	448.9
Reakom-plus-beet	3.0	129.8	85.8	339.6	421.9
	5.0	163.2	90.1	380.1	461.5
	7.0	170.7	131.1	418.9	482.6
A month before harvesting (factor A)					
Without feeding (control)	-	117.7	51.6	304.3	337.9
Reakom-R-beet (standard)	5.0	133.6	69.4	328.6	364.3
Reastim-humus-beet	3.0	124.0	88.4	330.6	409.9
	5.0	150.1	90.5	351.5	457.1
	7.0	164.7	125.3	409.0	477.1
Reakom-plus-beet	3.0	137.6	98.1	361.1	432.5
	5.0	164.4	103.2	387.4	470.2
	7.0	185.4	144.1	438.1	503.3
SSD_{05} factor A (term of application)		12.9	19.8	10.9	26.1
SSD_{05} factor B (type of microfertilizer)		12.7	18.2	15.1	21.2
SSD_{05} factor C (application norm)		3.3	6.7	5.8	8.4

Root mass was also increased significantly with increasing consumption norms depending on microelements and their application norms. At the first term of Reakom-plus-beet microfertilizer application in the leaves closing in a row phase, at the norm of 3 L/ha, at the first of September, the root mass was 339.6 g, in the norms 5 and 7 L/ha – 380.1 and 418.9 g, respectively. At Reastim-humus-beet microfertilizer foliar feeding in norms of 3, 5 and 7 L/ha root mass were 324.8, 357.0 and 396.3, respectively. According to the root masses depending on the type of micronutrients, it was established that under the same application norm of preparations – 5 L/ha the higher mass of root – 380.1 g was obtained by Reakom-plus-beet microfertilizer foliar feeding or above on 23.1 g compared with Reastim-humus-beet microfertilizer and 39.2 g, compared with standard Reakom-R-beet (SSD_{05} = 21.2 g).

At the second term of micronutrient fertilizer application was observed a similar dependence on the root mass growth, depending on the term, type and application norms of micronutrients (SSD_{05} factor A = 26.1 g, factor B = 21.2 g factor C = 8.4 g). Roots mass in the variant with the standard was higher by 26.4 g, on the variants with the Reastim-humus-beet application by the different norms above 72–139.2 g, and on the variants with Reakom-plus-beet application in different norms above 94.6–165.4 compared to the control (without fertilization).

Thus, the raw mass of roots and leaves growth during of sugar beet growing season is undergo more intensive in variants with foliar feeding application of new Reakom-plus-beet t and Reastim-humus-beet microfertilizers. The growth trend of root raw mass in variants with foliar fertilizer with microelements was persisted during the harvest season. Significant influence on plant growth and development, both in the closing plants in a row phase, and before the harvest, had types of micronutrients, their norms and terms of application. With the application norms of micronutrients increasing from 3 to 7 L/ha was increased leaves and root wet mass. Under foliar application conducting during the second term (30 days before harvest) effectively was Reakom-plus-beet microfertilizer.

Dynamics of roots and leaf mass growth is inextricably linked with the intensity of photosynthetic processes transmission.

Photosynthesis process regulation i.e. its productivity increasing – is one of the most effective methods of influence on the sugar beet productivity, and for them – an important means of yield level increasing.

Researches have established that on the efficiency of sugar beet photosynthesis is significantly influence the timing of micronutrients foliar feeding, types and norms of their application. Observation of the growth and development of sugar beet plants assimilation surface on the first date of registration (September 1) when microelements is making in the closing leaves in a row phase was showed that leaf surface area depending on the term, types and norms of microelements application on average was ranged between 34.5 to 46.6 thousand m^2/ha (Table 12.2).

TABLE 12.2 Leaf Surface Area and Photosynthetic Productivity Depending on the Types, Norms and Terms of Microelements Applying in Feeding on September 1 (Average of 2010–2012)

Type of micro-fertilizers (factor B)	Application norm, L/ha (factor C)	Leaf surface area, thousand m^2/ha	Photosynthetic potential, million m^2 × days/ha	Pure photosynthesis productivity, g dry matter/m^2 of leaf area per day
Phase of closing leaves in a row (factor A)				
Without feeding (control)	-	34.5	1.03	5.48
Reakom-R-beet (standard)	5.0	38.4	1.15	5.67
Reastim-humus-beet	3.0	37.5	1.12	5.61
	5.0	42.7	1.28	5.96
	7.0	44.5	1.34	6.26
Reakom-plus-beet	3.0	35.5	1.06	5.88
	5.0	44.6	1.34	6.50
	7.0	46.6	1.40	6.61
A month before harvesting (factor A)				
Without feeding (control)	-	32.1	0.96	4.65
Reakom-R-beet (standard)	5.0	36.5	1.09	5.29
Reastim-humus-beet	3.0	33.9	1.02	5.54
	5.0	41.0	1.23	5.67
	7.0	45.0	1.35	5.73
Reakom-plus-beet	3.0	37.6	1.13	5.37
	5.0	44.9	1.35	5.97
	7.0	50.6	1.52	6.31

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On the control variant (without feeding), average for research years, the leaf surface area was 34.5 thousand m^2/ha and its higher value was obtained in the variant of Reakom-plus-beet application in the norm of 7 L/ha – 46.6 thousand m^2/ha, that is caused by optimal area of plant nutrition and the best leaf surface assimilation apparatus formation. The smallest value of the leaf surface index, relative to the control, was obtained in the areas with Reastim-humus-beet and Reakom-plus-beet micronutrients application in the norm of 3 L/ha, respectively, 37.5 and 35.5 thousand m^2/ha. That is, on leaf surface increasing a significant influence had as a form of micronutrients and the norm of application. On a variant with using for foliar feeding Reastim-humus-beet at the application norms of microelements increasing from 3 to 7 L/ha the leaf surface area was increased on 7.0 thousand m^2/ha, and on the plots with Reakom-plus-beet application the leaf area was increased on 11.1 thousand m^2/ha.

According to the research results on the variants with the application of various types of micronutrients with different norms, on the first of September the photosynthetic potential was average and was within 1.03–1.40 million m^2 days/ha. So, on the variant with the application of Reakom-R-beet (standard) micronutrient in the norm of 5 L/ha the index of photosynthetic potential was 1.15 million m^2 days/ha, which is on 0.12 million m^2 days/ha higher than on the control variant (without application).

High indicators of photosynthetic potential were obtained in variants with Reastim-humus-beet and Reakom-plus-beet microfertilizers application in the norms of 5 and 7 L/ha. In comparison with the application norm of 3 L/ha these indicators were increased on 0.06–0.34 million m^2 days/ha.

Reakom-R-beet, Reastim-humus-beet and Reakom-plus-beet microfertilizers foliar feeding application amid a general background of fertilizer is establishing appropriate conditions for the photosynthetic process intensity increasing, especially pure photosynthetic productivity. The most favorable were areas in which the feeding was carried out in closing leaves in a row phase with the norm of micronutrients application of 5 and 7 L/ha. At Reakom-R-beet application in the recommended norm of 5 L/ha for the production the pure photosynthetic productivity was 5.67 g of dry matter/m^2 leaf area per day, at Reastim-humus-beet application in the norms of 5–5.96 and 7 L/ha – 6.26 g dry matter/m^2 leaf area per day, respectively. After Reakom-plus-beet application in the norms of 5 and 7 L/ha, the pure photosynthetic productivity was 6.50 and 6.61 g dry matter/m^2 leaf area per day, respectively. Given that in these variants there was a high photosynthetic potential (1.15–1.40 million m^2 days/ha) and has created a favorable physiological background for productive work of each plant cell by the expense of micronutrients application, it were created the necessary conditions for a high level of photosynthesis process passing.

On September 1, at the second period of micronutrients application were also determined the indicators of photosynthesis productivity. It should be noted that the indicators of leaf surface area in all variants were almost in a par, as in the variants after the first term of micronutrients foliar feeding were in the range of 32.1 to 50.6 thousand m^2/ha. Photosynthetic potential value (0.96–1.52 million m^2 days/ha) and pure photosynthetic productivity (4.65–6.31 g dry matter/m^2 leaf area per day) were lower in comparison with the first period of micronutrient application.

Summing up it should be noted that foliar feeding application in closing leaves in a row phase is delivers the productivity of photosynthesis increasing, particularly in variants where used Reakom-R-beet microfertilizer at application norm of 5 L/ha, Reastim-humus-beet at application norms of 5 and 7 L/ha and the Reakom-plus-beet at the same norms, which resulted the high indicators of leaf area from 38.4 to 46.6 thousand m^2/ha, the photosynthetic potential of 1.15 to 1.40 million m^2 days/ha and pure photosynthetic productivity from 5.67 to 6.61 g dry matter/m^2 leaf area per day, and this in turn is impact on sugar beet final productivity. On pure photosynthetic indicators productivity it is possible to predict the sugar beet productivity depending on the norms and types micronutrient application in feeding.

Assimilation surface of sugar beet plants growth and development observation in the second registration date (October 30) at the microelements application in closing leaves in a row phase was showed that leaf surface area depending on the term, types and application norms of microelements, on average, ranged from 15.8 to 35.8 thousand m^2/ha that at 10.8–18.7 thousand m^2/ha less in comparison with the similar period on the first date of registration – the first of September (Table 12.3). This is related to the sugar beet biological features because in the autumn at the harvest time, leaf mass does not develop, but on the contrary, begins to die and most share of nutrients goes from the leaves to the roots.

On the control variant (without feeding) the leaf surface area, in average of research years, was 15.8 thousand m^2/ha and its higher value was obtained in the variant with Reakom-plus-beet micronutrient in norm of 7 L/ha application – 35.8 thousand m^2/ha, that due to the optimal area of plant nutrition and the best assimilation apparatus of leaf surface formation. The smallest value of leaf surface area, concerning the control was in the areas with Reastim-humus-beet and Reakom-plus-beet micronutrients application in norm of 3 L/ha was obtained of 25.1 and 23.4 thousand m^2/ha, respectively. That is, on the leaf surface area increase was affected as the timing of foliar feeding type of micronutrients and their norms of application. In an variant with using Reastim-humus-beet micronutrient for foliar feeding with increasing application norms of microelements from 3 to 7 L/ha the leaf surface area was increased to 3.5 thousand m^2/ha, and in the plots with Reakom-plus-beet micronutrient application leaf surface area was increased to 12.4 thousand m^2/ha.

According to the research results in variants with the application of various types of micronutrients with different norms of application, at 30 October the photosynthetic potential was unsatisfactory and average, and was in the range from 0.47 to 1.07 million m^2 days/ha. On the variant with the Reakom-R-beet micronutrient (standard) application in the norm of 5 L/ha the photosynthetic potential indicator was 0.60 million m^2 days/ha, which is on 0.13 million m^2 days/ha more, than on control variant (without feeding).

TABLE 12.3 Leaf Surface Area and Photosynthetic Productivity Depending on the Types, Norms and Terms of Microelements Applying in Feeding on October 30 (Average of 2010–2012)

Type of microelements (factor B)	Application norm, L/ha (factor C)	Leaf surface area, thousand m^2/ha	Photosynthetic potential, million m^2 days/ha	Pure photosynthesis productivity, g dry matter/m^2 of leaf area per day
Phase of closing leaves in a row (factor A)				
Without feeding (control)	-	15.8	0.47	2.78
Reakom-R-beet (standard)	5.0	20.1	0.60	4.40
Reastim-humus-beet	3.0	25.1	0.75	4.34
	5.0	27.7	0.83	4.46
	7.0	28.6	0.86	4.57
Reakom-plus-beet	3.0	23.4	0.70	4.35
	5.0	24.6	0.74	4.48
	7.0	35.8	1.07	4.82
A month before harvesting (factor A)				
Without feeding (control)	-	14.1	0.42	2.56
Reakom-R-beet (standard)	5.0	19.0	0.57	4.36
Reastim-humus-beet	3.0	24.1	0.72	4.19
	5.0	24.7	0.74	4.36
	7.0	34.2	1.03	4.81
Reakom-plus-beet	3.0	26.8	0.80	4.57
	5.0	28.2	0.85	4.70
	7.0	39.3	1.18	4.95

The high indicators of photosynthetic potential were obtained in variants with Reastim-humus-beet and Reakom-plus-beet microfertilizers application in norms of 5 and 7 L/ha. In comparison with the norm of 3 L/ha application these indicators were increased on 0.03–0.37 million m^2 days/ha.

Application of Reakom-R-beet, Reastim-humus-beet and Reakom-plus-beet microfertilizers in foliar feeding amid a general background of fertilizer, at application the microelements in both terms is establishing the appropriate conditions of photosynthetic process intensity increasing, especially its pure productivity. However, in

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comparison with the first registration date these indicators were slightly lower that caused by physiological and biological features of sugar beet. The most favorable were plots on which the feeding is carried out in a clamping leaf in row phase with the flow norm of microelements of 5 and 7 L/ha. After Reakom-R-beet application in the recommended norm for the production of 5 L/ha the pure photosynthetic productivity was 4.40 g of dry leaf surface matter/m^2 leaf surface per day, Reastim-humus-beet in the norms of 5 and 7 L/ha – 4.34 and 4.57 g dry matter/m^2 leaf surface per day, and for Reakom-plus-beet application in this norm, – 4.35 and 4.82 g dry leaf surface matter/m^2 per day, respectively.

On October 30th, at the second term of microelements entering were also determined the photosynthetic productivity indicators and studying the influence of microelements on this process. It should be noted that the indicators of leaf surface area in all variants with Reakom-R-beet in the norm of 5 L/ha, Reastim-humus-beet in the norms of 5 and 7 L/ha and Reakom-plus-beet in the same norms application were almost at the level as in the variants for the first period make of microelements application in feeding and ranges from 19.0 to 39.3 thousand m^2/ha. The highest value of photosynthetic potential was obtained in the variant with Reakom-plus-beet in norm 7 L/ha application – 1.18 million m^2 per day/ha, which is on 0.11 million m^2 per day/ha, more than by the first term of micronutrients application. At the second period of Reakom-plus-beet microfertilizer making at application norms of 3 and 7 L/ha was also received high pure photosynthetic productivity (4.57 and 4.95 g dry matter/m^2 leaf surface per day), compared with the first period of microelements application in feeding.

The data is summarizing, it should be noted that the foliar feeding use a month before harvest was ensured the photosynthetic productivity growth, particularly in variants where was the studied the effectiveness of Reakom-R-beet micronutrients at application norm of 5 L/ha, Reastim-humus-beet at application norms of 5 and 7 L/ha and the Reakom-plus-beet at the same norms of application. Sugar beet foliar feeding by micronutrients of various types, and norms in different periods is enhances the intensity of the photosynthesis process passage.

The higher norms of micronutrients use for sugar beet foliar feeding in closing leaves in a row phase is provide a photosynthetic productivity increase. On the first date of registration the leaf surface area in closing leaves in a row phase was increased on 3–16%, a month before harvest – on 5–37%: on the second date of registration in in closing leaves in a row phase at 21–56% and per month before harvest at 26–64%. On the first date of the registration photosynthetic potential in closing leaves in a row phase was increased on 3–26%, a month before harvest on 6–37%, on the second date of registration in closing leaves in a row phase – on 20–55%, a month before harvest on 25–63%. On the first date of the registration pure photosynthetic productivity in closing leaves in a row phase was increased on 2–17%, a month before harvest – on 12–26%, in the second date of registration p in closing leaves in a row phase on 36–42%, a month before harvest on 39–48%.

Before sugar beet sowing and after harvesting was performed the determination of macronutrients in soil in variants, where spent the foliar feeding by various types of microfertilizers. The results were showed that hydrolyzable nitrogen (N), movable phosphorus compounds, and potassium (K_2O) amount was decreased (Table 12.4), which earlier results is confirms that microelements are facilitate the absorption of nutrients of plants from the soil [5].

TABLE 12.4 Content of Nutrition Elements in Soil (mg/kg of soil), Depending on the Timing, Types and Application Norms of Microelements in Sugar Beet Feeding (Average of 2010–2012)

Type of microelements (factor B)	**Application norm, L/ha (factor C)**	**In the period of sowing**			**In the period of harvest**		
		N	**P_2O_5**	**K_2O**	**N**	**P_2O_5**	**K_2O**
Phase of closing leaves in a row (factor A)							
Without feeding (control)	-	335.3	305.0	282.7	234.7	197.9	76.3
Reakom-R-beet (standard)	5.0	335.3	305.0	282.7	201.2	195.0	70.2
	3.0	335.3	305.0	282.7	227.7	194.5	74.9
Reastim-humus-beet	5.0	335.3	305.0	282.7	200.0	191.9	72.6
	7.0	335.3	305.0	282.7	191.2	188.6	72.2
	3.0	335.3	305.0	282.7	229.4	194.8	74.6
Reakom-plus-beet	5.0	335.3	305.0	282.7	201.4	193.0	73.3
	7.0	335.3	305.0	282.7	192.5	189.1	70.8
A month before harvesting (factor A)							
Without feeding (control)	-	335.3	305.0	282.7	234.7	197.9	76.3
Reakom-R-beet (standard)	5.0	335.3	305.0	282.7	202.2	196.6	72.0
	3.0	335.3	305.0	282.7	229.0	196.8	74.6
Reastim-humus-beet	5.0	335.3	305.0	282.7	201.2	193.4	72.4
	7.0	335.3	305.0	282.7	194.2	190.3	71.5
	3.0	335.3	305.0	282.7	229.6	197.5	74.4
Reakom-plus-beet	5.0	335.3	305.0	282.7	200.7	194.1	71.5
	7.0	335.3	305.0	282.7	192.7	188.6	70.6

Decrease in the content of macroelements in soil was observed both in foliar feeding in the closing leaves in a row phase, and a one-month before harvest. At the same time, there was a not significant difference on this indicator, depending on the timing of foliar application.

At application norms of microelements from 5.0 to 7.0 L/ha as in the closing leaves in a row phase, and 30 days before harvest in all variants were significantly decreased the content of hydrolyzable nitrogen, movable phosphorus compounds and potassium in the soil after sugar beet harvesting, compared with variants where foliar fertilizer was performed with application norm of 3.0 L/ha. The effect of microelements various types on the macroelements assimilation by plants, the efficiency of them was almost the same. After the first term of micronutrients application in foliar feeding, at the Reakom-R-beet microfertilizer in closing leaves in a row phase at a norm of 5 L/ha the hydrolyzable nitrogen in the soil was left 201.2 mg/kg, movable phosphorus compounds – 195.0 mg/kg soil and potassium – 70.2 mg/kg. At Reastim-humus-beet microfertilizer application in the same norm after sugar beet harvesting, the content of hydrolyzable nitrogen was 200 mg/kg, movable phosphorus compounds – 191.9 mg/kg and potassium – 72.6 mg/kg in the soil, at Reakom-plus-beet microfertilizer in the soil was hydrolyzable nitrogen of 201.4 mg/kg, movable phosphorus compounds – 193.0 mg/kg and potassium – 73.3 mg/kg, respectively.

In variants with Reastim-humus-beet and Reakom-plus-beet microelements at application norm of 7.0 L/ha was also observed the content decrease of microelements in the soil compared with the norm of application 5.0 L/ha. In the variant, with Reastim-humus-beet application in feeding the hydrolyzable nitrogen content decreased on 8.8 mg/kg, movable phosphorus compounds – 3.3 mg/kg and potassium – on 0.4 mg/kg. In the variant with Reakom-plus-beet application the hydrolyzable nitrogen content was decreased on 8.9 mg/kg, movable phosphorus compounds – on 3.9 mg/kg and potassium – 2.5 mg/kg. The similar results were obtained by the balance of hydrolyzable nitrogen, movable phosphorus compounds and potassium and on the second term of application (one month before harvest) micronutrients in feeding.

An important indicator is characterizing the effectiveness of microelements and the level of productivity in the technology of sugar beet growing. The sugar beet yields, sugar content and sugar yield formation is significantly depends on the foliar feeding plants application in their respective phases of vegetation, forms of microelements and their application norm (Table 12.5).

TABLE 12.5 Sugar Beet Productivity Depending on the Timing, Types and Application Norms of Microelements in Feeding (Average of 2010–2012)

Type of microelements (factor B)	Application norm, L/ha (factor C)	Plants density before harvest, thousand/ha	Yield, t/ha	Sugar content, %	Sugar yield, t/ha
Phase of closing leaves in a row (factor A)					
Without feeding (control)	-	97.8	46.3	15.3	7.1
Reakom-R-beet (standard)	5.0	102.5	51.8	14.8	7.7
	3.0	102.4	49.5	14.4	7.1
Reastim-humus-beet	5.0	102.4	52.3	14.5	7.6
	7.0	102.5	56.5	14.5	8.2
	3.0	101.9	48.5	14.2	6.9
Reakom-plus-beet	5.0	102.2	53.2	14.4	7.7
	7.0	103.4	58.0	14.3	8.3
A month before harvesting (factor A)					
Without feeding (control)	-	98.7	47.4	15.4	7.3
Reakom-R-beet (standard)	5.0	102.9	52.6	14.7	7.7
	3.0	102.5	49.7	14.3	7.1
Reastim-humus-beet	5.0	103.4	56.3	14.5	8.2
	7.0	104.4	64.6	14.2	9.2
	3.0	104.9	54.4	14.7	8.0
Reakom-plus-beet	5.0	105.6	63.9	14.4	9.2
	7.0	107.3	71.2	14.4	10.3
SSD_{05} factor A (term of application)		1.1	1.9	0.1	0.3
SSD_{05} factor B (type of microfertilizer)		0.9	2.7	2.2	2.5
SSD_{05} factor C (application norm)		3.3	3.4	0.7	0.3

It is proved that sugar beet productivity was influenced on the terms of microelements application in fertilizer, micronutrients types and application norm. At in the second term of foliar feeding (one month before harvest) of Reastim-humus-beet microfertilizer in the application norm of 5 L/ha, the yield of roots was 56.3 t/ha or was higher on 4.0 t/ha, compared the first period. The similar results were obtained according to increasing norms up to 7 L/ha and Reakom-plus-beet microfertilizer foliar feeding, regardless of the application norm of micronutrient. According to the types of micronutrients, at the first term of foliar feeding was observed a tendency the yield of root crops to increase or decrease, and by the second term was established a significant increase at Reakom-plus-beet microfertilizer application, compared with other microfertilizers. On the sugar beet yield was more significantly affected the application norms of micronutrients. With application norms increasing of Reastim-humus-beet microfertilizer in the first period with the application from 3 to 7 L/ha the yield of root was increased from 49.5 to 56.5 t/ha (SSD_{05} = 3.4 t/ha). Similar results were obtained with Reakom-plus-beet micronutrient using.

The highest sugar beet productivity was received by Reakom-plus-beet microelement foliar feeding a month before harvest at the application norm of 7 L/ha. At almost the same density of evenly spaced plants in a row (coefficient of variation was 3.6%) on the high agricultural background, foliar application was obtained the high yields of root – 71.2 t/ha. High yield of roots has secured the yield of sugar more than 10 tons/ha at their sugar content of 14.4%.

Foliar feeding conducting by Reakom-plus-beet microfertilizer in closing leaves in a row phase also was ensured the high productivity of sugar beet, but it was slightly lower than in micronutrients application a month before harvest at the all norms of application. Foliar application conducting in time a month before harvest by various types of microelements, with application norms of 5 and 7 L/ha was increase the yield of roots. If in the application norm of 5 L/ha in the closing leaves in a row phase of Reakom-plus-beet microfertilizer the root yield was 53.2 t/ha, their sugar content – 14.4%, at the feeding of this microfertilizer in the same norm a month before harvest, the yield was increased – on 10.7 t/ha, and the sugar content was remained at the level of 14.4%, a significant impact on the sugar content had the type of microelements (SSD_{05} factor B = 2.2%).

The similar relationship was established and with foliar feeding of sugar beet complex of Reastim – Humus – beet chelated micronutrients in the norms of 5 and 7 L/ha. But the productivity of sugar beet was lower than when using Reakom-plus-beet micronutrients. On the control – without foliar feeding at the same high agricultural background at the microelements application in closing leaves in a row phase the yield of roots was significantly lower and amounted of 46.3 t/ha, but the sugar content was higher – 15.3%, sugar yield in this case was – 7.1 t/ha.

After the first term of micronutrient application the high sugar yield was obtained in the variant with Reakom-plus-beet micronutrient using in norm of 7 L/ha – 8.3 t/ha, while in the variant with Reastim-humus-beet using on 0.1 t/ha less. After the second term of microfertilizers application the high sugar yield was received in the variant with Reakom-plus-beet micronutrient using in norm of 7 L/ha and was 10.3 t/ha. In the variant with Reastim-humus-beet using it was on 1.1 t/ha below. This suggests that a significant influence on the yield of sugar per 1 ha index has the form of micronutrient (SSD_{05} factor B = 2.5 t/ha). Other factors influence that has been studied – was negligible.

New chelate micronutrients Reakom-plus-beet and Reastim-humus-beet using on the high agricultural background was provided a significant increase in sugar beet productivity, not only in comparison with the control, where foliar feeding was not performed, and in the variant with Reakom-R-beet (standard) chelated micronutrient using. This is explained by the composition of microelements that positively influence on the growth and development of plants and the accumulation of organic mass. For example Reakom-plus-beet microfertilizer is a liquid concentrated solution based on ultramicro and micronutrients in chelate form, which also contains two different natures of chelating agent. Due to this microelements are part of fertilizer more stable and biologically active and Reastim-humus-beet microfertilizer is a balanced composition of humic substances and chelates microelements and considering of sugar beet requirement [8].

12.4 CONCLUSIONS

1. During the growing season raw mass of roots and leaves of sugar beet is intensive increase in variants with using of Reakom-plus-beet and Reastim-humus-beet new microfertilizers in foliar feeding. The growth trend of root raw mass was in variants with foliar feeding of microelements and persisted during the harvest season.
2. Significant influence on the growth and development of plants in closing leaves in a row phase, and a month before harvest had the types of micronutrients, their norms and terms of application. With norms of micronutrients from 3 to 7 L/ha increasing is increases raw mass of leaves and roots. At foliar feeding holding during the second term (30 days before harvest) was effective Reakom-plus-beet microfertilizer.
3. Foliar feeding using, a month before harvest, is delivers productivity of photosynthesis increased, particularly in variants where was studied the effectiveness of Reakom-R-beet at application norm of 5 L/ha, Reastim-humus-beet and Reakom-plus-beet micronutrients at application norms of 5 and 7 L/ha.
4. Sugar beet foliar feeding of various types and norms in different periods is enhances of the passage of the process of photosynthesis intensity.
5. Foliar feeding in the closing leaves in a row phase and 30 days before harvest by different microfertilizers at application norms of 3.0 to 7.0 L/ha is promotes better absorption of macronutrients from the soil, which in turn influence on the final productivity of sugar beet.
6. New chelate micronutrients Reakom-plus-beet and Reastim-humus-beet using in the high agricultural background was provided a significant increase in sugar beet productivity, not only in comparison with the control, where foliar feeding was not performed, and in the variant with chelated micronutrient Reakom-R-beet (standard) using.

7. The most effective is foliar feeding by Reakom-plus-beet chelated micronutrient during the second term in the norm of 7 L/ha, which provides productivity gains of roots – 18.6 t/ha and yield of sugar 2.6 t/ha compared with foliar feeding of Reakom-R-beet (standard) microfertilizer.
8. Foliar feeding conducting a month before harvest is provides a significant increase not only of roots productivity, but their yield of sugar per hectare.

KEYWORDS

- **microfertilizers**
- **photosynthetic potential**
- **sugar**

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