The effect of bacterial preparations on the growth, development and quality indicators of sugar beet yield

Rogat Minikayev and *Lilia* Gaffarova*

Kazan State Agrarian University, Kazan 420015, Russia

Abstract. Experimental samples of biological products based on endophytic microorganism strains were tested on sugar beet root plants. The studies were carried out at ZAI Agrofirm LLC, Zay District, the Republic of Tatarstan. The most effective preparations applied at the early stages (3–4 leaf phase) were RECB – 31 B (1.5 l/ha), RECB – 74 B (1.5 l/ha), RECB – 74 B (1.5 l/ha), RECB – 44 B (2.0 l/ha), RECB – 50 B (2.0 l/ha), and RECB – 74 B (2.0 l/ha). Biological preparations applied in the row closing leaf phase have an advantage over chemical preparations when applying RECB – 14 B (1.5 l/ha), RECB – 31 B (1.5 l/ha), RECB – 74 B (1.5 l/ha), RECB – 74 B (2.0 l/ha). At the late vegetation stages, experimental preparations increased the yield. A significant increase was observed when applying RECB – 95 B (1.5 l/ha).

1 Introduction

The intensive development of agricultural production, including plant protection products, contributed to a significant increase in sugar beet yields.

A promising direction in the ecologization of agriculture and agricultural technologies is the use of biological products. They can have immunostimulating and growth-regulating effects on plants [1–3].

In addition, chemical plant protection products do not always inhibit the spread of pathogens in agricultural crops, and biological products can be more effective against phytopathogens [4, 5].

The use of biological products on sugar beets, one of the economically significant crops of the Chernozem Region, will reduce the use of chemical plant protection products and implement the genetic potential of hybrids plants [2]. The aim of the study is to test prototypes of biological products based on endophytic microorganism strains to increase the crop yield and the sugar content.

2 Materials and methods

To conduct experimental studies, microorganisms of the following strains were isolated: Bacillus sp., Pseudomonas putida, Bacillus subtilis, Pseudomonas fluorescens. The following biological preparations were produced: RECB-50B (isolate of Bacillus sp.), RECB-14B (isolate of Pseudomonas putida), Streptomyces sp., Trichoderma viride, RECB-95B (isolate of Bacillus subtilis), RECB-44B isolate of Pseudomonas fluorescens, REC-31B (isolate Streptomyces sp.), RECB-74B (isolate Trichoderma viride).

These strains can reduce the growth of seed and soil infection, as well as to increase the resistance of agricultural plants to adverse environmental conditions. Bacillus sp. Strains produce substances acting against pathogens, Pseudomonas putida can secrete growth stimulants, contributing to the plant growth, and Trichoderma viride can be used to produce antibiotics, stimulate growth and weight of the root system which increases the crop yield [6–10].

Field experiments were carried out in 2018 in the conditions of the ZAY agricultural company in Zay district, Zakamye (the Republic of Tatarstan).

Meteorological conditions in 2018 reflected the climate features of the forest-steppe zone of the Republic of Tatarstan with its unstable moisture during the growing season and a sharp fluctuation in air temperature.

The average daily temperature varied from +13.3 – in May to + 21.7 – in July, the amount of precipitation was 221.8 mm.

The experiments were conducted on heavy loamy leached chernozem with the following agrochemical characteristics of the arable layer: pHB – 5.6; mobile phosphorus – 223 mg/kg; mobile potassium – 109 mg/kg; nitrate nitrogen – 3.2 mg/kg; mobile copper compounds – 0.11 mg/kg; mobile zinc compounds – 0.82 mg/kg; mobile cobalt compounds – 0.09 mg/kg; mobile manganese compounds – 2.07 mg/kg; mobile molybdenum compunds – 0.11 mg/kg; mobile boron compounds – 0.53 mg/kg.

Land was treated to a depth of 30 cm by the Horsch aggregate. Pelleted seeds of sugar beet obtained from the Bravissima KBC hybrid were sown by the 18-row Monopill seeder. The main N96P72K macro-fertilizers were applied. Plants were sprayed with herbicides.

The allocation of plots was consistent, the experiments repeated thrice. Spraying with biological

* Corresponding author: gaffarovalylya@mail.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

products was carried out once in different phases of sugar beet development (3–4 leaves, closing leaves in rows, closing leaves in inter-rows). Preparations were applied in different dosages: 1.5; 2.0 l/ha. The generally accepted methods and relevant GOSTs were used during the experiments. Sugar content was determined using a SU-4 polarimeter-saccharimeter in the laboratory of Zay Sugar LLC. The results were processed by the methods of variance and correlation-regression analyzes [11].

3 Results

The results of the experimental studies are presented in Table 1.

Table 1. The crop yield, 2018

No	Option	Yield of root crops, t/ha	Increase to chemical preparation, t/ha
Spraying in the phase of 3–4 leaves			
1	RECB – 14 B (1.5 l/ha)	33.14±0.6	–8.05
2	RECB – 31 B (1.5 l/ha)	53.32±2.47	12.13
3	RECB – 44 B (1.5l/ha)	31.96±0.98	–9.23
4	RECB – 50 B (1.5 l/ha)	37.46±1.40	–3.73
5	RECB – 95 B (1.5 l/ha)	28.85± 0.57	–12.34
6	RECB – 74 B (1.5 l/ha)	52.02± 4.19	10.83
7	RECB – 14 B (2.0 l/ha)	38.46± 1.34	–2.73
8	RECB – 31 B (2.0 l/ha)	61.80± 4.10	20.61
9	RECB – 44 B (2.0 l/ha)	72.91± 4.17	31.72
10	RECB – 50 B (2.0 l/ha)	58.70± 1.92	17.51
11	RECB – 95 B (2.0 l/ha)	46.26± 1.43	5.07
12	RECB – 74 B (2.0 l/ha)	48.48± 2.33	7.29
13	Chemical preparation	41.19± 3.08	–
	$LSD_{0.5}$	7.12	
Spraying in the phase of closing leaves in rows			
1	RECB – 14 B (1.5 l/ha)	62.32± 2.57	14.0
2	RECB – 31 B (1.5 l/ha)	63.39± 2.59	15.07
3	RECB – 44 B (1.5l/ha)	34.68± 1.23	–13.64
4	RECB – 50 B (1.5 l/ha)	45.15± 1.0	–3.17
5	RECB – 95 B (1.5 l/ha)	53.0 ± 0.16	4.68
6	RECB – 74 B (1.5 l/ha)	63.46 ± 3.13	15.14
7	RECB – 14 B (2.0 l/ha)	53.19 ± 0.89	4.87
8	RECB – 31 B (2.0 l/ha)	45.31 ± 1.23	–3.01
9	RECB – 44 B (2.0 l/ha)	34.3± 0.40	–14.02
10	RECB – 50 B (2.0 l/ha)	46.17 ± 2.07	–2.15
11	RECB – 95 B (2.0 l/ha)	52.57± 1.4	4.25
12	RECB – 74 B (2.0 l/ha)	65.1 ± 3.42	16.78
13	Chemical preparation	48.32 ± 1.78	–
	$LSD_{0.5}$	8.56	
Spraying in the phase of closing leaves in the aisles			
1	RECB – 14 B (1.5 l/ha)	23.64 ± 1.34	–32.09
2	RECB – 31 B (1.5 l/ha)	30.20± 1.27	–25.49
3	RECB – 44 B (1.5l/ha)	55.30 ± 2.01	–0.39*
4	RECB – 50 B (1.5 l/ha)	24.71 ± 0.89	–30.98
5	RECB – 95 B (1.5 l/ha)	65.37 ± 3.52	+9.68
6	RECB – 74 B (1.5 l/ha)	38.07 ± 0.62	–16.99
7	RECB – 14 B (2.0 l/ha)	20.37 ± 0.34	–35.32
8	RECB – 31 B (2.0 l/ha)	52.35± 9.28	–3.34
9	RECB – 44 B (2.0 l/ha)	54.76 ± 1.68	–0.93
10	RECB – 50 B (2.0 l/ha)	46.70 ± 1.21	–8.99
11	RECB – 95 B (2.0 l/ha)	57.41 ± 2.71	1.72
12	RECB – 74 B (2.0 l/ha)	33.21 ± 1.72	–22.48
13	Chemical preparation	55.69 ± 1.48	–
	$LSD_{0.5}$	7.47	

The yield of sugar beet root crops changed as follows: when spraying in the 3-4 leaf phase, the largest reliable increase was obtained in the options: RECB – 31 B (1.5 l/ha), RECB – 74 B (1.5 l/ha), RECB – 74 B (1.5 l/ha), RECB – 44 B (2.0 l/ha), RECB – 50 B (2.0 l/ha), RECB – 74 B (2.0 l/ha) – it ranged from 7.29 to 31.72 t/ha.

When spraying plants in the leaf closing phase in rows, an increase in the crop productivity was obtained in the options: RECB – 14 B (1.5 l/ha), RECB – 31 B (1.5 l/ha), RECB – 74 B (1, 5 l/ha), RECB – 74 B (2.0 l/ha) – from 14.0 to 16.78 t/ha.

The treatment of plants with biological preparations in later phases (closing leaves in inter-rows) revealed the effect of RECB – 95 B (1.5 l/ha) with increased the yield by 9.68 t/ha.

In the agricultural production of sugar beets, the yield and sugar content are crucial.

The results of identification of sugar content are presented in Table 2.

Table 2. Sugar content in sugar beet root crops and the yield, 2018

№	Option	Sugar content, %	Increase to chemical preparation,%	Sugar yield t/ha	Increase to chemical preparation, t/ha
Spraying in the phase of 3–4 leaves					
1	RECB – 14 B (1.5 l/ha)	18.24	0.49	6.04	–1.27
2	RECB – 31 B (1.5 l/ha)	18.3	0.55	9.76	2.45
3	RECB – 44 B (1.5l/ha)	17.36	–0.39	5.55	1.76
4	RECB – 50 B (1.5 l/ha)	18.69	0.94	7.0	–0.31
5	RECB – 95 B (1.5 l/ha)	18.02	0.27	5.2	–2.11
6	RECB – 74 B (1.5 l/ha)	19.45	1.7	10.12	2.81
7	RECB – 14 B (2.0 l/ha)	16.86	–0.89	6.48	–0.83
8	RECB – 31 B (2.0 l/ha)	17.31	–0.44	10.7	3.39
9	RECB – 44 B (2.0 l/ha)	17.17	–0.58	12.59	5.28
10	RECB –50 B (2.0 l/ha)	18.29	0.54	10.74	3.43
11	RECB – 95 B (2.0 l/ha)	18.28	0.53	8.46	1.15
12	RECB – 74 B (2.0 l/ha)	15.56	–2.19	7.54	–0.23
13	Chemical preparation	17.75	–	7.31	–
Spraying in the phase of closing leaves in rows					
1	RECB – 14 B (1.5 l/ha)	17.67	0.3	11.01	2.62
2	RECB – 31 B (1.5 l/ha)	17.66	0.4	11.19	2.80
3	RECB – 44 B (1.5l/ha)	19.03	1.66	6.6	–1.79
4	RECB – 50 B (1.5 l/ha)	18.48	1.11	8.34	0.05
5	RECB – 95 B (1.5 l/ha)	17.25	–0.12	9.14	0.75
6	RECB – 74 B (1.5 l/ha)	17.15	–0.22	10.88	2.49
7	RECB – 14 B (2.0 l/ha)	18.81	1.44	10.0	1.61
8	RECB – 31 B (2.0 l/ha)	17.52	0.15	7.94	–0.45
9	RECB – 44 B (2.0 l/ha)	17.39	0.02	5.96	–2.43
10	RECB –50 B (2.0 l/ha)	17.58	0.21	8.12	–0.27
11	RECB – 95 B (2.0 l/ha)	17.83	0.46	9.37	0.98
12	RECB – 74 B (2.0 l/ha)	17.71	0.34	11.53	3.14
13	Chemical preparation	17.37	–	8.39	–
Spraying in the phase of closing leaves in the aisles					
1	RECB – 14 B (1.5 l/ha)	16.92	–1.02	4.0	–6.0
2	RECB – 31 B (1.5 l/ha)	17.84	–0.1	5.39	–5.61
3	RECB – 44 B (1.5l/ha)	17.96	0.02	9.93	–0.07
4	RECB – 50 B (1.5 l/ha)	18.16	0.22	4.49	–5.51
5	RECB – 95 B (1.5 l/ha)	18.04	0.10	11.79	1.79
6	RECB – 74 B (1.5 l/ha)	18.11	0.17	7.0	–3.0
7	RECB – 14 B (2.0 l/ha)	18.32	0.38	3.73	–6.27
8	RECB – 31 B (2.0 l/ha)	16.97	–0.97	8.88	–1.12
9	RECB – 44 B (2.0 l/ha)	17.38	–0.56	9.52	–0.48
10	RECB – 50 B (2.0 l/ha)	18.95	1.01	8.85	–1.15
11	RECB – 95 B (2.0 l/ha)	18.40	0.46	10.56	0.56
12	RECB – 74 B (2.0 l/ha)	18.08	0.14	7.09	–2.91
13	Chemical preparation	17.94	–	10.0	–

During the period of early treatment with biological products (3-4 leaf phase), when applying RECB – 50 B (1.5 l/ha) and RECB – 74 B (1.5 l/ha), the highest sugar content was observed: an increase was 0.94 and 1.7, respectively.

The treatment of crops in the leaf closing phases in rows increased the sugar content when applying RECB – 44 B (1.5 l/ha), RECB – 50 B (1.5 l/ha), RECB – 14 B (2.0 l/ha). It was higher by 1.01–1.66 %.

In the phase of inter-row closing leaves, RECB – 50 B (2.0 l/ha) showed an increase in the sugar content by 1.01 %.

A significant increase in the yield influenced the sugar content; this indicator had the same dynamics. The total yield of sugar varied from 3.73 to 12.59 t/ha.

Thus, biological products have the greatest biological effectiveness with a single treatment in the phase of 3–4 leaves with an increase in the yield from 7.29 to 31.72 t/ha.

The highest sugar yield was observed when applying RECB – 44 B (2.0 l/ha) – 12.6 t/ha.

4 Conclusion

The research results showed that the biological products are promising and can be recommended for applying in different phenological phases.

Acknowledgement

The project is financially supported by the Ministry of Education and Science of the Russian Federation under the federal target program “Research and Development in Priority Directions for the Development of the Russian Science and Technology Complex for 2014–2020”, agreement number 14.610.21.0017, unique project identification number – RFMEFI61017X0017.

References

1. E.V. Zolnikova, A.N. Postnikov, *The influence of growth regulators on the yield of fodder beets*, Agricult., **5**, 25–27 (2016)
2. N.V. Besedin, N.V. Zaitseva, I.V. Ishkov, *The effect of biological products on the yield and quality of sugar beet root crops*, Bull. of Kursk State Agricult. Acad., **9**, 114–120 (2016)
3. N.V. Bezler, *Agrobiological aspects of the use of physiologically active substances and biological products in sugar beet crops* (Ramon, 2008)
4. P.N. Fatina, *The use of microbiological preparations in agriculture*, Herald of the State Techn. Univer., **4(39)**, 133–136 (2007)
5. O.D. Sidorenko, *Prospects for the use of biological preparations based on microorganisms*, Izvestia of TSHA, **6**, 707 (2012)
6. D.G. Baubekova, *Development of a multifunctional biological product based on genus bacillus for the protection of agricultural products*, in *XVIII Int. sci.-pract. Conf. “Natural and mathematical sciences in the modern world,”* **5(17)** (SibAK, Novosibirsk, 2014)
7. H.D. Wells, D.K. Bell, C.A. Jaworski, *Efficacy of Trichoderma harzianum as a biocontrol, Sclerot. rolfsii*, Phytopathol., **62**, 442 (1972)
8. M.N. Schroth, J.G. Hancock, *Disease – Suppressive Soil and Root-Colonizing Bacteria*, Sci., **216**, 1376–1381 (1982)
9. L.P. Trenozhnikova, A.S. Balgimbaev, G.D. Ultanbekova, R.Sh. Galimbaeva, *Antifungal activity against pathogens of crops and the study of the antibiotic strain Streptomyces sp. K-541 isolated from extreme ecosystems of Kazakhstan*, Agricult. Biol., **1** (2018)
10. M.V. Shternshis, F.S.-U. Dzhalilov, I.V. Andreeva, O.G. Tomilova, *Biological plant protection* (KolosS, Moscow, 2004)
11. B.A. Armor, *The methodology of a field experiment (with statistical processing of research results*) (Demand Book, Moscow, 2012)