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Applying Biotechnology in Agriculture: Initial Performance Results of VolRC RAS Laboratory for Bioeconomics

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Abstract. The development of the agro-industrial complex is one of the state priorities in the context of ensuring food security in the Russian Federation. At the same time, the vector of development of ecological agriculture has recently become more pronounced (Strategy for Scientific and Technological Development of the Russian Federation No. 145, dated February 28, 2024; Strategy for the Development of Organic Production until 2030 No. 1788-r, dated July 4, 2023; FAO documents, etc.). Given that the Northwestern Federal District specializes in dairy farming, it is of particular importance to improve the system of cattle feeding, forage production and forage harvesting in the region. Enzymatic and probiotic preparations in animal feeding, microbial growth-stimulating preparations, and biopesticides represent an environmentally safe way to improve the agro-industrial complex. In modern geopolitical conditions, with a high level of sanctions pressure on Russia, the need to develop domestic biological products and their implementation is becoming more obvious. One of the tasks for Vologda Research Center of the Russian Academy of Sciences (VolRC RAS) in such conditions is to implement research projects related to ensuring economic growth and sustainable development of territories based on the use of biotechnology achievements. In this regard, in December 2018, a laboratory for bioeconomics and sustainable development was created at VolRC RAS. During the six years of the laboratory's existence, its team has carried out significant work on the development of this research area. The aim of the article is to analyze and summarize the experience of conducting research on the use of biological drugs that, when being used in the agro-industrial complex, can contribute to addressing the issue of food security. As part of the work, the laboratory's research results have been disseminated on the territory of the Vologda Region: the potential economic effect of using the technology on the entire dairy livestock of the Vologda Region can reach 1.1 billion rubles annually.

Key words: agriculture, laboratory for bioeconomics and sustainable development, agrobiotechnology, enzymatic and probiotic drugs, microorganisms, mycotoxins.

Introduction

Food security is one of the main directions of ensuring the national security of the Russian Federation in the long term, a factor in preserving its statehood and sovereignty, and an essential component of socio-economic policy[1]. The main directions of the state policy to ensure the country's food security include the development of agriculture, as well as the improvement of its scientific potential (Mel'nikov et al., 2021; Mukhametgaliev et al., 2021; Vartanova, 2023).

The role of science in modern economic conditions is to identify and work out measures to improve the agro-industrial complex, develop competitive scientific and technical products in accordance with the needs of agro-industrial production, and innovate based on scientific and technical achievements.

One of the ways to increase the efficiency of the agro-industrial complex is to use the achievements of biotechnology in agricultural production. It is possible to raise the productivity of animals and plants, the quality of feed and agricultural products, increase the use time of farm animals, and minimize the impact on the environment with the help of their rational use (Skryagin, Zabaikin, 2023; Temraleeva, 2024).

Dairy cattle breeding is the most important branch of the agro-industrial complex in the Northwestern Federal District of Russia. According to V.N. Surovtsev, it has comparative advantages

[1] On the approval of the Food Security Doctrine of the Russian Federation: Presidential Decree 20, dated January 21, 2020. Administration of the President of Russia. Available at: http://www.kremlin.ru/acts/bank/45106/page/1

in milk production in relation even to the Central Chernozem Economic Region with a higher agro-biological potential and to European countries, which is due to the wide possibilities of concentrating milk production and realizing economies of scale in dairy farming in the region (Surovtsev et al., 2016).

Numerous studies prove that cattle's productivity depends on the feeding system by 50–60%. However, it is the feed base that is one of the limiting factors in the development of cattle breeding in Russia. For instance, even in a significant part of advanced farms, the development rate of the feed base does not allow animals to fully realize their genetically programmed productive potential: the average content of exchangeable energy in feed from their own harvest rarely exceeds 9 MJ per kg of dry matter. At the same time, as A.L. Zinovenko notes, for a herd with a productivity of 6–7 thousand kg of milk per year, the exchange energy in feed should be at least 10 MJ, for a herd with a productivity of 8 thousand kg – 10.5–11.0 MJ (Zinovenko, 2015). In connection with the above, it is obvious that for the agro-industrial complex of the Northwestern Federal District of the RF, one of the priorities is the problem of increasing the production of high-quality feed and making it cheaper (Platonov et al., 2023a).

High intensity of modern agriculture has led to natural changes in animal husbandry and crop production, expressed in the overly intensive use of animals and water and soil resources. Currently, the transition to more environmentally friendly forms of agriculture is underway. Minimizing the use of various chemicals in crop production, avoiding feed antibiotics in animal husbandry, increasing the efficiency of coarse feed assimilation and reducing the proportion of compound feed in ruminants due to an increase in the nutritional value of harvested feed represent different aspects of environmentally friendly agriculture. The available advantages of biological preparations lead to an increased interest in them among agricultural producers (Petrov et al., 2022).

The use of microorganisms with various enzymatic activities and/or synthetic abilities is a global trend in modern agriculture. This trend can also be seen in the increased publication activity of researchers regarding the use of biological farming products. For example, on the PubMed portal, the query "biopreparations" found 52 publications over the ten-year period 1990–1999, 53 publications were in 2000–2009, 91 publications – in 2010–2019, and 111 publications – over the five-year period 2020-2024. In addition, experts from the Food and Agriculture Organization of the United Nations (FAO) have been carrying out technical work for a long time in the field of management of microorganisms and invertebrates for food production and agriculture, including their use in integrated plant protection programs. FAO experts also pay attention to the high retention of pesticides (40%) in food when used for plant protection (Maksimov et al., 2011).

In the current geopolitical situation and the strengthening of sanctions restrictions against Russia, the development of Russian production of biological drugs, as well as the expansion of their use in the agro-industrial complex, is of particular relevance. This will increase the productivity of agricultural crops and improve the characteristics of finished products, which is an important factor in strengthening the food independence of the state. It is worth noting that the significant dependence of the Russian agro-industrial complex on imported supplies, including seeds, pesticides and feed additives, has led to serious problems in the work of certain sectors of the agro-industrial sector (Eregina, Kuznetsova, 2024; Shelamova, 2023).

The list of studies has significantly expanded after the formation of Vologda Research Center of the Russian Academy of Sciences (VolRC RAS) in 2017 by joining the Northwestern Dairy Farming and Grassland Management Research Institute

(NWDFGMRI) as a separate subdivision. One of the key tasks of the center was the scientific and methodological support for improving the existing system of agricultural activities. For example, the Institute's staff investigated the role and methods of using promising varieties of leguminous crops, the widespread use of low-spread species and varieties of perennial grasses in pasture phytocenoses, effective agrotechnical techniques for creating agrophytocenoses of different maturation periods. Resource-saving technologies for creating highly productive agrophytocenoses of forage crops are presented, ensuring an increase in their productivity and nutritional value by 5–20% (Vakhrusheva et al., 2024). In addition, the effects of mineral fertilizers and a microbiological preparation based on the Gram-positive spore-forming bacterium *Bacillus subtilis* on the yield and nutritional value of spring rapeseed and pasture grasses were studied. It was noted that inoculation of seeds and modification of fertilizers with Bisolbi-T contribute to an increase in the yield of green mass (Pryadil'shchikova et al., 2024; Chernysheva et al., 2025). The Institute's researchers also studied the formation of standardized animal feeding systems, including the use of biological products (Gusarov, Obryaeva, 2023). A significant amount of the Institute's work is devoted to cattle breeding in the European North of Russia (Abramova et al., 2024). The research results served as the basis for the development of the database "Array of microsatellite profiles of the Holstein cattle of the Vologda Region", which contributes to the study of the frequency of occurrence of cattle alleles in the Holstein population of the Vologda Region and genetic diversity in the population[2].

[2] Selimyan M.O., Kozhevnikova T.V., Khenerina E.V., Murzaeva A.V., Surnacheva S.V. (2025). Certificate of State registration of the database 2025621624, Russian Federation. Array of microsatellite profiles of the Holstein cattle of the Vologda Region: Application: December 13, 2024: published: April 14, 2025.

The list of tasks of VolRC RAS expanded even further in December 2018, since the creation of the new youth Laboratory for Bioeconomics and Sustainable Development within the framework of the national project "Science and Universities". The laboratory was created with the aim of implementing research projects related to ensuring economic growth and sustainable development of territories based on the use of biotechnology achievements. Over the previous six years, the laboratory's scientists have made a significant qualitative step forward in the development of research, the results of which have shown the practical importance of biological preparations for agricultural producers, as well as other agricultural entities.

In this regard, the article aims to analyze and summarize the experience of the Laboratory for Bioeconomics and Sustainable Development of VolRC RAS in the use of biological preparations, the introduction of which in agriculture can contribute to solving the problem of the country's food security.

Taking into account the dairy specialization of the Vologda Region agro-industrial complex, the laboratory's research activities developed in three directions:

1) studying the issues concerning the spread of mycotoxins in the feed harvested in the region, as well as the factors influencing this (research began in 2023, the main contribution was made by the following laboratory staff: A.V. Platonov, I.V. Artamonov, D.E. Falaleeva, I.I. Rassokhina, S.V. Eregina);

2) studying the effect of biological preparations on the growth and productivity of fodder crops, as well as the search for promising bacterial strains for agriculture (research began in 2019, the main contribution was made by the following laboratory staff: A.V. Platonov, I.I. Rassokhina, L.V. Sukhareva, S.V. Eregina, M.M. Kuznetsova, A.S. Nikulina);

3) studying the effect of enzymatic probiotic drugs in cattle feeding (research began in 2019, the main contribution was made by the following laboratory staff: Yu.M. Smirnova, A.V. Platonov, A.S. Litonina, S.V. Surnacheva, N.V. Burtseva).

Laboratory tests were carried out at VolRC RAS using the equipment of the Common Use Center "Center for Agricultural Research and Biotechnology".

Studying the issues concerning the spread of mycotoxins in the forages harvested in the region, as well as the factors influencing this

The implementation of this laboratory area was initiated as part of the work on the RSF project (23-26-00163). The assessment of the content of various groups of toxins in harvested feed was carried out in accordance with GOST 31653-2012 on the AIFR-01 UNIPLAN enzyme immunoassay analyzer (Picon, Russia), using standard MULTISCREEN® test systems manufactured by Komprodservice (Belarus) and R-Biopharm (Germany). During the research, samples in which their content was less than the lower detection limit of the test systems were considered to be free of mycotoxins. The maximum accepted concentration (MAC) levels, which are reflected in the veterinary and sanitary requirements of the Customs Union (approved by the decision of the Eurasian Economic Community of the CIS countries 317, dated June 18, 2010), regulate the content of mycotoxins in feeds such as wheat, barley, oats, corn, etc., ignoring juicy and coarse feeds. The values of the MAC level for the above cultures do not have significant differences, therefore, some in their work were guided by these standards: the amount of aflatoxins (according to aflatoxin B1, taking into account the fact that the main part of this amount is aflatoxin B1) is 5 micrograms/kg, ochratoxin–A is 5 micrograms/kg, toxin T-2 – 60 mcg/kg, zearalenone – 500 mcg/kg, DON – 1,000 mcg/kg (Platonov et al., 2024b).

In total, 404 samples of feed harvested by farms of the Vologda Region were examined for mycotoxin content in 2023–2024. The samples are represented by hay (28 pieces), haylage (18 pieces), grain (12 pieces), grain (18 pieces), green mass (38 pieces), silage (30 pieces) and silos of various compositions (257 pieces): legume, grain, corn and mixed grass silage. 318 samples of feed, ochratoxin-A – 308, zearalenone – 246, disoxynivalenol (DON) – 238, and T-2 toxin – 178 were analyzed for the amount of aflatoxins. A comprehensive determination of 4–5 toxins was carried out in 234 samples of harvested feed.

The research results presented that 99% of the studied samples were infected with mycotoxins to some extent, while all the analyzed samples were infected with aflatoxins and zearalenone, 97% with ochratoxin–A and less than a third of the samples with DON, and a significant part of the samples were contaminated with two or more mycotoxins. The samples of grain, green mass and haylage contained mycotoxins below the MAC level, in the hay samples the predominant contaminant was T-2 toxin, the content of which is 9 times higher than the MAC level. According to the results of analyses of silos of different composition, we found that the most infected were legumes and cereal monospecies silos: the excess of the maximum permissible concentration in the amount of aflatoxins averaged 4.1–4.2 times, for ochratoxin-A – 1.1–1.3 times. Monitoring of the mycotoxin content showed that the content of a number of mycotoxins in the samples of grain and legume silage increases with increasing shelf life. For instance, the amount of aflatoxins three to four weeks after harvesting was 3.27 mcg/kg, after 4 months – 5.74 mcg/kg, after 10 months – 22.31 mcg/kg. A similar trend was observed in the determination of zearalenone. The content of ochratoxin-A, on the contrary, decreased slightly. Silage, silage and haylage were

the most susceptible to mycotoxin contamination, where the mycotoxin content often exceeded the maximum permissible concentration. At the same time, the botanical composition of the silos did not significantly contribute to the spread of mycotoxins. Aflatoxin and ochratoxin-A turned out to be the most dangerous in terms of distribution and quantitative content (Platonov et al., 2024a; Platonov et al., 2024b).

The results obtained in the work give an idea of the breadth of the problem and the need for timely analysis of feed for mycotoxin content. Agricultural enterprises should implement practices/measures to avoid the possibility of contamination of feed, food raw materials and livestock products with mycotoxins, as well as implement measures to reduce the negative effects on the animal body when using contaminated feed.

One of the possible ways to reduce the level of contamination of feed with toxins is the use of biological preparations in the cultivation of biomass, its silage, as well as in animal feeding (Kuchinsky et al., 2023). These issues are addressed in the research of the Laboratory for Bioeconomics and Sustainable Development.

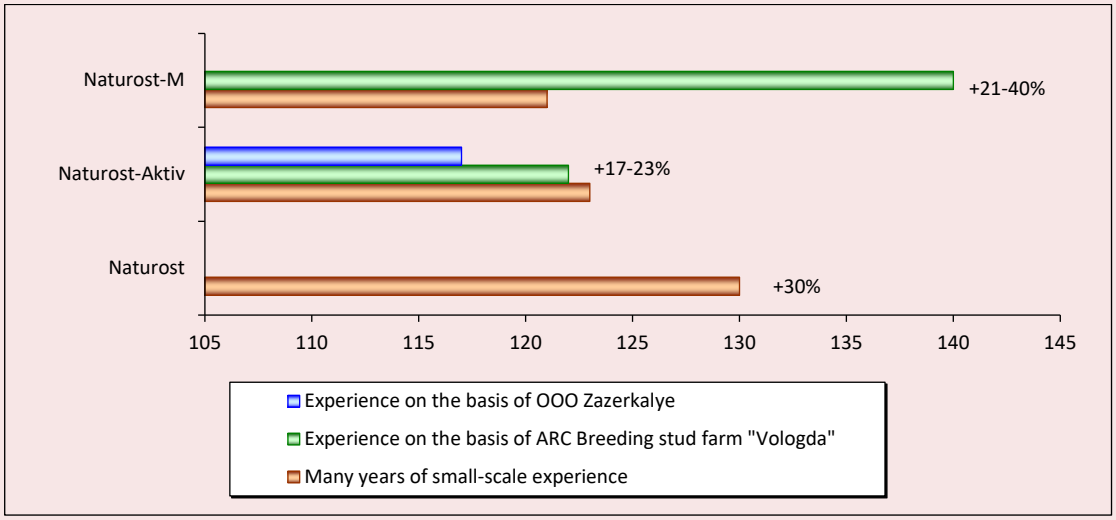
Studying the effect of biological preparations and suspensions of strains of promising microorganisms on the growth and productivity of crops

As part of the research, we used the following experimental preparations to stimulate plant growth and increase plant productivity: Naturost (based on the bacteria *B. subtilis* 111), Naturost-M (based on *B. megaterium* B–4801) and Naturost-Aktiv (based on *Lactobacillus buchneri* 600). During the production of the preparations, the bacteria were cultivated on a nutrient medium that included beet molasses (2%) and mineral salts, with sodium nitrate as the nitrogen source. In 1 ml of the preparation, the content of live bacteria of the initial strain was at least 1×10^8 CFU. The evaluation of the effect of these experimental preparations was carried out by setting up laboratory, small-scale (2019–2023) and production (4 experiments for the period 2020–2023) field experiments. In small-scale field experiments, biologics were introduced by pre–soaking seeds on the day of sowing for 1–2 hours (1 ml of the preparation/1 liter of water), re-application by spraying vegetative organs with a solution of the drug in the same concentration (in cereals – during the tillering phase, in forage grasses – a month after germination/after 3 weeks after mowing). In production conditions, pre-sowing treatment of grain seeds with a mordant was carried out together with a biological preparation of 1 liter/100 liter of the working solution, the second application to the tillering phase together with foliar top dressing of 1–2 l/ha (consumption of the working solution was 200–250 l/ha), in experiments with forage grasses, the preparation was applied in the same concentrations during foliar top dressing after mowing the groundcover crop or after overwintering.

The evaluation of the effect of experimental preparations on forage grasses in the framework of small-scale field experiments was carried out with ryegrass (Platonov et al., 2021), clover-thistle grass mixture (Platonov, Rassokhina, 2023; Platonov et al., 2023c; Rassokhina et al., 2023c), and pea grass mixture (Platonov et al., 2024c). Production experiments of experimental preparations were carried out with a clover-thymophage herb mixture on the basis of farms of OOO Zazerkalye (Platonov et al., 2023c) and Agricultural Production Cooperative (APC) Breeding Stud Farm "Vologdsky" (Platonov, Rassokhina, 2023).

The works of I.I. Rassokhina and co-authors show that under the influence of the studied microbial preparations, the yield of green and dry mass of clover-thymus grass mixture increased by 17–33 and 21–30%, while an increase in metabolic energy to 8% and the content of feed units to 17% was observed (Rassokhina et al., 2023). The effect of the preparation Naturost-M on the productivity and nutritional value of the clover-

Figure 1. Increase in the mass of the dry matter of clover-thymophage herb mixture under the action of experimental microbial preparations (2020–2023)



Source: (Platonov et al., 2023s; Rassokhina et al., 2023).

thymus grass mixture was confirmed in production experience in the fields of the APC Breeding Stud Farm "Vologdsky": the green mass of the grass mixture increased by 36% when the preparation Naturost-M was applied, the dry mass increased by 40%, the protein content in the dry mass increased by 36%. (Platonov, Rassokhina, 2023). The results of studying the effect of the preparation Naturost-Aktiv have also been confirmed in the conditions of a real economy (OOO Zazerkalye). It was shown that the green mass collection increased by 10–17% when the drug was applied, the dry mass by 9–22%, and the nutritional value of the total content of feed units per 1 kg of biomass by 6% (*Fig. 1*).

In addition to the effect of the studied microbial preparations on a long-term clover-thymus grass mixture, field small-scale studies have shown the effect of Naturost series preparations on the pea grass mixture: the biomass of the pea grass mixture increased to 26%. There was a slight growth in the nutritional value of both the grass itself and the silage harvested from it (Platonov et al., 2024c). A similar effect of the preparations was revealed on annual ryegrass: an increase in the productivity of the green mass of ryegrass to 41% and the preservation of nutrients in the resulting silage was found. The yield of feed units and exchange energy in the silage mass of ryegrass of the experimental variants exceeded the control by up to 53 and up to 43%, respectively (Platonov et al., 2021).

Evaluation of the effect of experimental drugs on grain crops in the framework of small-scale field experiments (*Tab. 1*) was carried out on Sonnet barley (Platonov et al., 2023b; Platonov et al., 2024d; Rassokhina, Platonov, 2023a), Lev oats (Platonov et al., 2022; Rassokhina et al., 2024) and Yakov (Platonov et al., 2022; Platonov et al., 2023), as well as wheat of Darya variety (Rassokhina et al., 2024). Production experience with test preparations based on Sonnet spring barley was delivered in 2020 to the fields of the IAPC (Integrated Agricultural Production Center) Collective Farm "Peredovoi" (Rassokhina, Platonov, 2023a) and in 2022 to APC (Collective Farm) "Plemzavod Prigorodny" (Platonov et al., 2024d).

Table 1. Grain addition of experimental crops using experimental preparations (small-scale experiments), %

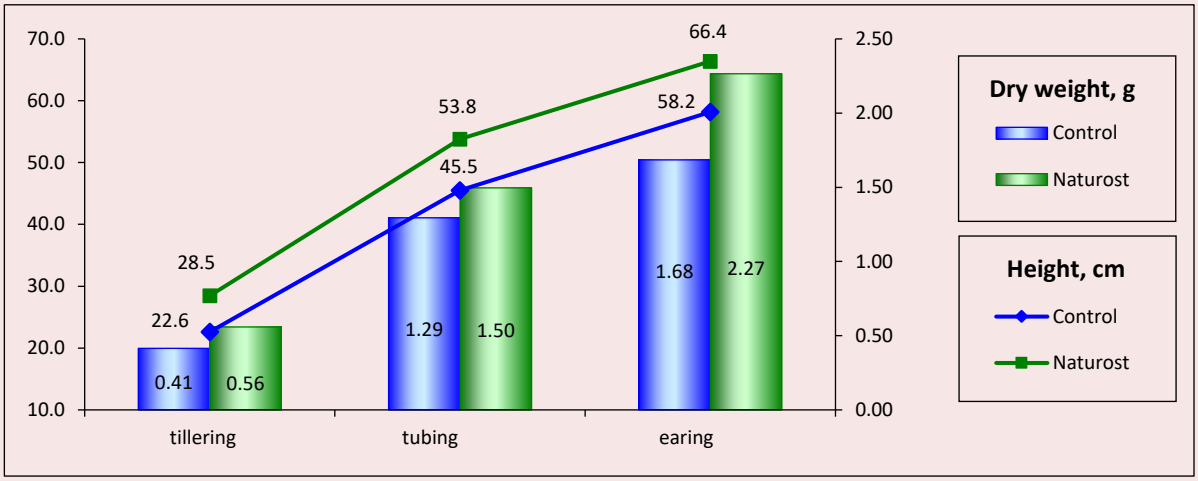
Preparation	Barley of Sonnet variety	Oat of Lev variety	Oat of Yakov variety	Wheat of Daria variety
Naturost	+ 7–19	+ 6–29	+ 14–35	+ 5–6
Naturost-Aktiv	+ 8–26	+ 13–29	+ 2–25	+ 9
Naturost-M	+ 7–9	+ 15–17	+ 12–31	+ 5–10
Source: results of our own research.				

The research of A.V. Platonov and co-authors proved that the preparation Naturost within the framework of three-year small-scale field experiments contributed to an increase in the growth and productive parameters of barley: dry weight increased by 29–33%, chlorophyll content – by 3–16%, grain productivity – by 7–19%. The 2022 production experience confirmed the results obtained earlier, an increase in plant height was detected when applying Naturost by 14–26%, raw and dry weight by 14–46% (*Fig. 2*), grain productivity by 14% (Platonov et al., 2024d).

The results of studying the effect of the preparation Naturost-M on the growth and productivity of barley indicate that the area of the assimilation surface of barley raised by 15%, and the content of photosynthetic pigments increased by 10–36%, which suggests a greater energy supply of experimental plants compared with the control. This assumption is consistent with the indicators of dry weight (increases by 3–19%) and grain productivity (by 7–9%, see Tab. 1) (Platonov et al., 2023b).

The effect of the preparation Naturost-Aktiv led to growth in the yield of Sonnet barley by 8–26%. In addition, the application of the preparation Naturost-Aktiv increased the area of a single barley leaf to 16%, the content of chlorophylls – by 18–49%, carotenoids – by 13–17%, dry weight – by 12–65%. The results of the growth-stimulating effect of the preparation were confirmed in real farming conditions: the grain productivity of barley exceeded the control by 14% (Rassokhina, Platonov, 2023a).

Figure 2. Dynamics of growth parameters of barley in production experience on the basis of APC (Collective farm) "Plemzavod Prigorodny" (2022)



Source: (Platonov et al., 2024d).

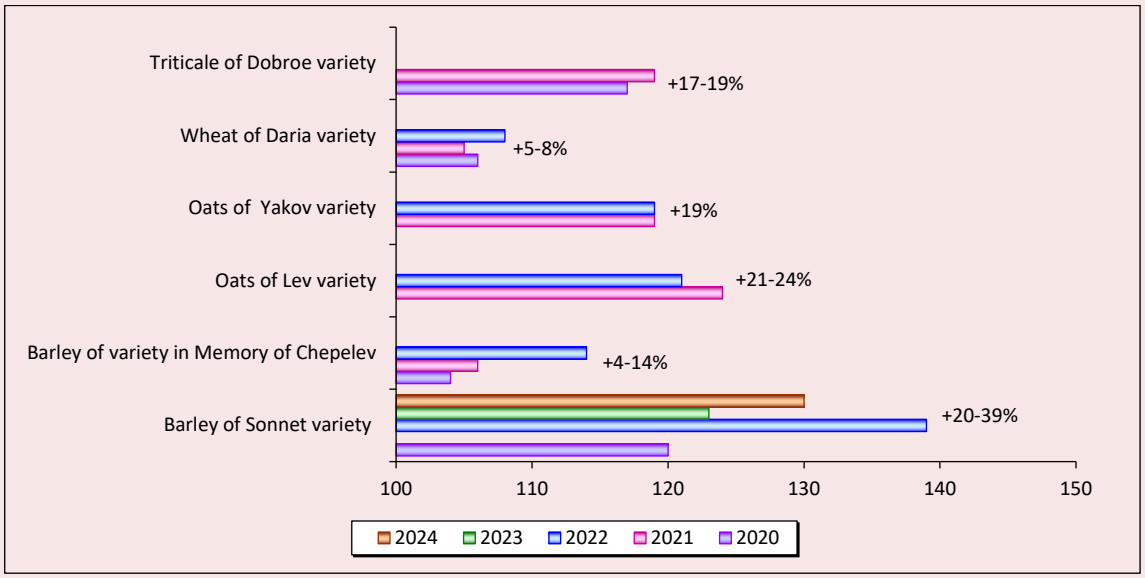
The leaf surface area of Yakov oats when applying Naturost and Naturost-M preparations exceeded the control by 12–40 and 15–33%, the dry weight by 9–59 and 9–58%, respectively. Activation of the growth of experimental variants contributed to an increase in the final grain productivity of oats by 20–25% (Platonov et al., 2023). The effect of these preparations has also been demonstrated on oats of Lev variety: during the tubing phase, the differences in dry weight are 38-59%, and in raw weight – 41–66%. In terms of grain yield, the differences between the experimental variants relative to the control reach 6–29% and 15–17% (see Tab. 1) according to the preparations Naturost and Naturost-M (Platonov et al., 2022). The preparation Naturost-Aktiv significantly increased the dry weight of Lev oats by 16–48%, and the wet weight by 18–37%. Grain productivity of oats exceeded the control by 13–29% (Rassokhina et al., 2024).

The effectiveness of the preparation Naturost-M has also been demonstrated on soft wheat in the region. The dry mass accumulation rate of the experimental version exceeded the control by 17–55% in 2020, by 9–21% in 2021 and by 6–22% in 2022. The grain productivity of wheat in the framework of field experiments reached 28.3–34.5 c/ha, the preparation Naturost-M increased this indicator by 5–10% (Rassokhina et al., 2024).

In addition to studying the effect of ready-made experimental preparations on the growth and productivity of crops, the laboratory has been studying a suspension of a promising strain of *Pseudomonas* sp. GEOT18 since 2020. The bacteria *Pseudomonas* sp. GEOT18 were isolated from the internal tissues of stem tuberoids of generative individuals *Dactylorhiza incarnata* (L.) Soó in the Laboratory for Molecular Genetics and Biotechnology of P.G. Demidov Yaroslavl State University. The strain was identified by molecular genetic analysis of the nucleotide sequence of the 16S rRNA gene fragment, and the resulting sequence was deposited in the GenBank database (MT180656). A suspension of the *Pseudomonas* sp. GEOT18 strain was obtained on LB medium under constant stirring conditions at a temperature of 24 ° C for 16–18 hours. Plants were treated with a suspension of the strain twice: before sowing (seed inoculation for 30 minutes) and in the tillering phase (spraying the phyllosphere until fine dew drops appear). For the treatment of plants in the control variant, water was used according to the same scheme (Rassokhina, Marakaev, 2023; Rassokhina, Platonov, 2023b).

Laboratory experiments using water and soil culture methods on Lev oats have shown the possibility of suspension to activate plant growth already at the first stages of vegetation (Rassokhina et al., 2020), and field experiments in 2020–2024 have confirmed the effectiveness of using suspension as a growth stimulator for grain crops: oats, barley (Rassokhina, Marakaev, 2023; Rassokhina, Platonov, 2023b), wheat (Rassokhina, Platonov, 2021) and triticale (Rassokhina et al., 2022). It has been shown that in the 2020 experiment, treatment with a suspension of *Pseudomonas* sp. GEOT18 strain causes a growth in dry weight (up to 53%) and assimilation surface area (up to 21%) in barley, while an increase in pigment content is observed in Sonnet barley plants throughout the growing season. As a result, the grain productivity of Sonnet barley increases by 20% relative to the control (Rassokhina, Marakaev, 2023). At the same time, the differences between the experimental and control versions of Sonnet barley in the 2022 studies become even more pronounced throughout the growing season, with the difference in grain productivity reaching 46% (Rassokhina, Platonov, 2023b). In barley, as in other crops, regardless of the conditions of the growing season, grain productivity increased when using a suspension of *Pseudomonas* sp. GEOT18 strain (*Fig. 3*).

Figure 3. Grain productivity of crops under the action of suspension of Pseudomonas sp. GEOT18 strain, % relative to control



Source: results of our own research.

Currently, the laboratory's research in this area is deepening and is limited to the search for promising bacterial strains from various parts of local plants from the point of view of agricultural production. The agricultural production development by environmentally sound methods is one of the priority areas of activity in Russia, which is reflected in current regulatory documents: the Strategy of Scientific and Technological Development of the Russian Federation (approved by Presidential Decree 145, dated February 28, 2024) and the Strategy for the Development of Organic Production until 2030 (RF Government Resolution 1788-r, dated July 4, 2023).

Studying the effect of enzymatic probiotic drugs in cattle feeding

Scientific and economic experiments to study the effects of probiotic preparations were conducted in the livestock farms in the Vologda Region: AO Plemzavod Rodina (Vologdsky District), IAPC Collective Farm Peredovoy (Vologdsky District), APC Andoga Collective Farm (Kaduysky District), OOO Zarya (Chagodoshchensky District), OOO Zazerkalye (Gryazovetsky District). As part of the laboratory's research, the effect of probiotic drugs for feeding cattle was studied: Cellobacterin+, Rumit, Rumit-V.

The Rumit preparation is an association of bacteria isolated from reindeer rumen (*Rangifer tarandus*) (genera Bacillus, Bacteroides, Porphyromonas, Pseudomonas, etc.) applied to sunflower meal in an amount of 2×10^7 CFU/g and dried to obtain a dry concentrate in powder form. The results of laboratory studies made it possible to identify the most promising strain from the bacterial association, *Bacillus velezensis*. The staff of OOO Biotrof has established that this strain promotes the decomposition of cellulose, has antagonistic properties against a number of pathogenic microorganisms, and is not devoid of the ability to biodegrade mycotoxins. The preparation Rumit-V is based on a strain of *B. velezensi*, which is applied

to sunflower meal in an amount of 2×10^7 CFU/g. At the initial stages of the study, the widely known probiotic Cellobacterin+ was used in a comparative aspect, which is represented by the *Enterococcus faecium* 1-35 strain applied to sunflower meal in an amount of at least 10^6 CFU/g.

Studying the effect of enzymatic probiotic preparations on the health and productivity of cattle was carried out as part of experiments on the Russian Black Pied cattle (Litonina et al., 2020; Smirnova, Platonov, 2020; Smirnova et al., 2023b; Smirnova et al., 2023c; Platonov et al., 2024e; Surnacheva et al., 2024) and the Ayrshire (Smirnova et al., 2023a) breeds. In addition, studies were conducted on calves during breastfeeding (Litonina et al., 2022; Smirnova et al., 2022).

The results of the evaluation of the effect of the preparations Rumit and Cellobacterin + on the basis of OOO Zazerkalye are shown in the works (Litonina et al., 2020; Smirnova, Platonov, 2020). It is worth noting that these preparations raised the base fat content by 7–11 and 5%, respectively, the milk fat yield by 5–11 and 4–5%, the milk protein yield by 6–10 and 2–8%, which allowed for additional profit per day of 24.50–77.95 and 15.44–29.51 rubles, respectively, for the preparations Rumit and Cellobacterin+ (*Tab. 2*).

The research of Yu.M. Smirnova and co-authors noted that the use of the probiotic Rumit in feeding cows of the Ayrshire breed (experience on the basis of OOO Zarya) raises the activity of the scar microflora by 28%, increases the total protein content in the blood by 14%, reduces urea by 19% and bilirubin by 21%. As a result, the use of probiotics increased the dairy productivity of the Ayrshire cows by 7%. As a result, the cost of energy feed units for production decreased by 5%. The additional profit from the sale of milk in the experimental group amounted to 37.32 rubles per head per day (Smirnova et al., 2023a).

As follows from the data obtained, the preparation Rumit proved to be more effective in comparison with the preparation Cellobacterin +, and therefore research and modernization of this preparation continued. Its improved form is Rumit-V, the production of which turned out to be more profitable. The effectiveness of the new form of the drug was studied on the basis of OOO Zazerkalye (*Tab. 3*).

We can see that the basic fat content when feeding the preparation Rumit-V increases by 5% relative to the control (the preparation Rumit is 1% higher than the control), the milk fat yield is 8% (7%), the milk protein yield is 2% (1%). The

Table 2. Results of studying preparations Cellobacterin+ and Rumit in scientific and production experiments on dairy cows

Indicator	IAPC Collective Farm Peredovoi			AO Plemzavod Rodina		
	Control	Rumit	Cellobacterin+	Control	Rumit	Cellobacterin+
Above the base fat content, kg	31.8 ± 1.1	35.4 ± 1.4*	33.3 ± 1.5	30.9 ± 1.9	33.2 ± 1.1	32.4 ± 2.0
Gross milk fat yield, kg	84.4 ± 3.1	94.0 ± 3.7*	88.7 ± 4.0	79.8 ± 4.80	83.6 ± 3.33	82.6 ± 5.03
Gross milk protein yield, kg	74.4 ± 2.3	82.1 ± 3.0*	80.6 ± 3.4	74.9 ± 4.74	79.1 ± 5.52	76.6 ± 4.17
Gross income for the period of experience, kg [a]	2481	2764	2609	2346	2458	2429
The cost of additional milk, rubles [b]	-	7960.78	3600.64	-	3150.56	2334.79
Additional profit per day, rubles	-	77.95	29.51	-	24.50	15.44

Note: * – The difference with the control is statistically significant at $p<0.05$; [a] – calculated based on the amount of milk of the basic fat content; [b] – the average selling price of milk is 28.13 rubles.
Source: (Litonina et al., 2020; Smirnova, Platonov, 2020).

Table 3. Results of studying the preparations Rumit and Rumit-V in scientific and production experience on dairy cows on the basis of OOO Zazerkalye

Indicator	Control	Rumit	Rumit -V
Above the base fat content, kg	31,3 ± 0,7	31,6 ± 1,0	33,0 ± 0,4*
Gross milk fat yield, kg	32,9 ± 1,5	35,2 ± 2,9	35,6 ± 0,5
Gross milk protein yield, kg	32,7 ± 1,1	32,9 ± 1,3	33,4 ± 0,1
Gross income for the period of experience, kg [a]	2881 ± 127	2906 ± 122	3032 ±1 31
The cost of additional milk, rubles [b]	-	6167,92	7566,46
Additional profit per day, rubles	-	56,03	71,57

Note: * – The difference with the control is statistically significant at $p < 0.05$; [a] – calculated based on the amount of milk of the basic fat content; [b] – the average selling price of milk is 28.13 rubles.
Source: (Smirnova et al., 2023; Platonov et al., 2024e; Surnacheva et al., 2024).

observed increase in productivity when feeding the preparation Rumit-V allowed receiving an additional 71.57 rubles per day, when using the preparation Rumit – 56.03 rubles per day. We also noted that the inclusion of Rumit and Rumit-V feed additives in animal diets contributed to an increase in the density of the infusion fauna by 68% and 3 times, respectively, compared with the control group (Platonov et al., 2024e; Surnacheva et al., 2024). The research also revealed that cows fed Rumit had a 45% increase in the density of ciliates in the rumen (Smirnova et al., 2023b). In addition, we found that the probiotics studied led to the stimulation of eating behavior: cows ate 13–26% longer, chewing time increased by 9–14% (Smirnova et al., 2023c).

The effectiveness of the probiotic Rumit has also been proven in studies on the Russian Black Pied cattle calves aged 1.5–2 months on the basis of the APC Andoga Collective Farm (Kaduisky district): when feeding a probiotic in the amount of 15 g/head/day, there is a gross increase in animal weight to 74.2 kg, which reduces feed costs per unit of production by 4% (Litonin et al., 2022). The research also noted that in calves of the experimental group, the blood content of total protein increased by 8%, glucose – by 22%, urea content decreased by 13%, bilirubin and cholesterol – by 6 and 12%, respectively (Smirnova et al., 2022).

Thus, the scientific results obtained by the Laboratory for Bioeconomics and Sustainable Development demonstrate the effectiveness of the use of biological preparations in feeding cattle (both dairy cows of different breeds and calves), in activating plant growth processes, increasing productivity and quality of feed harvested by agricultural enterprises. The importance of mycotoxicological analysis of feed harvested by farms in the region has also been proven.

To assess the economic effect for the region from the use of the investigated developments (new preparations Rumit and Rumit-V), calculations were carried out based on the results of experiments on the basis of four livestock farms in the Vologda Region. We revealed that in 90 days, the additional profit in the group of cows receiving the probiotic Rumit for the main diet amounted to 2205.0–7015.5 rubles per head, and in the group using Rumit-V – 6441.3 rubles per head. Thus, the additional profit per head per lactation will amount to 7428.5–23 777.8 rubles (*Tab. 4*).

Table 4. Economic effect of the use of biological products Rumit and Rumit-V by agricultural enterprises

Indicator	Preparation Rumit				Preparation Rumit-V	Average data
	IAPC Collective Farm Peredovoi	AO Plemzavod Rodina	OOO Zarya	OOO Zazerkalye		
Additional profit per day, rubles per head	77.95	24.50	37.61	56.03	71.57	53.53
Annual economic effect, thousand rubles per head	23.78	7.48	11.47	17.09	21.83	16.33
Note: the total duration of lactation is 305 days per year; the calculation was based on the prices of the research year. Source: results of our own research.						

Table 5. Potential economic effect for the region from the introduction by agricultural enterprises of the results of the production experiments

Indicator	Effect from one head	Vologodsky District	Vologda Region
Size of the milking herd, units	1	17,387	69,507
Annual economic effect, thousand rubles	16.33	283929.71	1135049.31
Note: the average data for two drugs is taken, the total duration of lactation is 305 days per year. According to: Agriculture, hunting and forestry (2025). Vologdastat: Federal State Statistics Service. Available at: https://35.rosstat.gov.ru/sel%27skoe%20hozyajstvo (accessed: 20.04.2025).			

Table 5 demonstrates the results of scaling up the laboratory's experience in the use of enzymatic probiotic preparations Rumit and Rumit-V in the Vologda Region. At the same time, the potential economic effect of using the technology on the entire dairy livestock of the Vologda Region can reach 1.1 billion rubles annually.

Conclusion

Thus, technological solutions by the Laboratory for Laboratory for Bioeconomics and Sustainable Development of VolRC RAS through the introduction of preparations of microbial origin into agricultural production (both in the feeding system and feed production) can increase the efficiency of the Vologda Region agro-industrial complex. This, in turn, will have an impact on ensuring Russia's food security.

In summary, we should say that the laboratory is at the stage of formation. The research team is faced with the task of identifying a key research area, as well as forming its own research profile. Based on the existing state tasks, as well as the capabilities of the infrastructure of VolRC RAS and the staff, it seems advisable to move toward creating our own microbial preparations for agricultural production in the region. The implementation of this direction will make it possible to provide agricultural producers with biological preparations that will prove to be the most effective in the conditions of the Vologda Region. To achieve such an ambitious goal, the laboratory staff has already begun exploratory research, which boils down to isolating, studying and selecting biotechnologically promising bacterial strains from various parts of native plants. A separate branch of the search will focus on the ability of bacteria to destroy mycotoxins.

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