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Orel City, Russian Federation • 23–24 March 2022

Editors • Sergey Knyazev, Ibrahim Kahramanoglu, Viktor Kukhar, Volkan Okatan and Mikhail Tsoy

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Sergey Knyazev
Russian Research Institute of Fruit Crops Breeding, Orel Region, Russian Federation

Ibrahim Kahramanoglu
European University of Lefke, Turkey, Mersin, Turkey

Viktor Kukhar
Ural State Agrarian University, Yekaterinburg, Russian Federation

Volkan Okatan
Eskisehir Osmangazi University, Turkey, Turkey

Mikhail Tsoy
Russian Research Institute of Fruit Crops Breeding, Orel Region, Russian Federation

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Editors

Sergey Knyazev
Russian Research Institute of Fruit Crops Breeding
Director
Zhilina Village
Orel Region, 302530
Russian Federation

Email: info@vniispk.ru

Ibrahim Kahramanoglu
European University of Lefke, Turkey
Department of Horticulture
Northern Cyprus TR-10
Mersin, 99010
Turkey

Email: ibrahimcy84@yahoo.com

Viktor Kukhar
Ural State Agrarian University
Department of Metal Technology and Machine Repair
Karl Liebknecht street building 42
Yekaterinburg, 620075
Russian Federation

Email: viktorurgau@mail.ru

Volkan Okatan
Eskisehir Osmangazi University, Turkey
Department of Horticulture
Eskişehir Osmangazi Üniversitesi Meşelik Kampüsü Büyükdere Mah.Prof.Dr. Nabi AVCI Bulvarı
26040
Turkey

Email: okatan.volkan@gmail.com

Mikhail Tsoy
Russian Research Institute of Fruit Crops Breeding
Senior research of laboratory
Zhilina Village
Orel Region, 302530
Russian Federation

Email: nauka@vniispk.ru

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Preface: International Scientific and Practical Conference «INNOVATIVE TECHNOLOGIES IN AGRICULTURE

On March 23-24, 2022, the International Scientific and Practical Conference "INNOVATIVE TECHNOLOGIES IN AGRICULTURE" (ITIA 2022) was held on the basis of the Russian Research Institute of Fruit Crop Breeding (VNIISPK) together with the Ural State Agrarian University with the support of specialists from the European University of Lefke (Turkey) and Eskişehir Osmangazi University (Turkey).

The event was dedicated to priority areas in the field of agriculture and in particular crop production: plant genetic resources, cultivars, technologies and methods, introduction, adaptation and biologization of agriculture.

Within the framework of the Conference, issues of sustainable agriculture were discussed, the main problems hindering innovative directions in the agricultural sector of the economy were identified, a number of modern approaches, including foreign ones, to solving strategically important tasks in the field of crop production were proposed. The conclusion was made about the need for an integrated approach to the regulation of innovation activity in the agro-industrial complex and the development of a system of measures aimed at increasing the innovative activity of agriculture. A number of agreements were reached to strengthen international cooperation in priority areas in the field of agriculture. Thanks to the joint fruitful work, the Scientific and Practical Conference was held at a high organizational and scientific level.

Positive feedback loop was received both from Russian and foreign specialists.

The organizers of the Conference express their gratitude to the participants, experts and moderators for their help and interest in the Conference. We hope for further fruitful work! See you at future conferences, symposiums and seminars!

Look forward to further fruitful cooperation!

Prof. Sergey Knyazev

Chairman of the organizing committee, editor of conference materials

Russian Research Institute of Fruit Crop Breeding, Russian Federation

Dr. Olga Panfilova

Dr. Mikhail Tsoy

Russian Research Institute of Fruit Crop Breeding, Russian Federation

Scientific and Technical Committee of Conference Materials

PhD Ibrahim Kahramanoglu

European University of Lefke, Turkey

PhD Volkan Okatan

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Eskisehir Osmangazi University, Turkey

Scientific and Technical Committee of Conference Materials

Dr. Viktor Kukhar

Ural State Agrarian University, Russian Federation

Scientific and Organizing Committee of Conference Materials

Bactericidal Hydrosols' Properties of Metal Nanoparticles and Their Oxides in Relation to Escherichia Coli

V.M. Bachinskaya[1, a)], A.A. Deltsov[1, b)], S.V. Akulova[2], Ya.N. Karasenkov [3, c)], E.K. Tarasova [4, d)] and E.A. Egorov [4, e)]

[1] *FSBEI HE Moscow State Academy of Veterinary Medicine and Biotechnology - MVA named after K.I. Skryabin, Moscow, Russia*
[2] *State Autonomous Cultural Institution "Moscow State Zoological Park", Moscow, Russia*
[3] *ROSDENT LLC, Moscow, Russia*
[4] *"Estetika" dental clinic, Moscow, Russia*

[a)] Corresponding author: bachinskaya1980@mail.ru
[b)] deltsov-81@mail.ru
[c)] rosdent@mail.ru
[d)] Ekaterina-t@yandex.ru
[e)] dagaz7@yandex.ru

Abstract. The article presents the results of in *vitro* studies of metal hydrosols conducted by the suspension method to determine antimicrobial activity against the gram-negative microorganism Escherichia coli, which is an indicator of bacteria in determining the disinfection quality. The studies were carried out in accordance with the current regulatory document GOST R 59072-2020. National Standard of the Russian Federation. Disinfectants. Suspension method for determining antimicrobial activity. The test culture of Escherichia coli was acquired in the laboratory of diagnostics and control of antibiotic resistance of the most clinically significant infectious diseases' animal pathogens of the Federal State Budgetary Institution of the Federal Research Center of Experimental Veterinary of the Russian Academy of Sciences. According to the results of the studies, the authors found that the studied metal hydrosols prevent the growth of E. coli on dense Endo and meat infusion agar media; the results were recorded after 24 and 48 hours of cultivation in a thermostat at a temperature of 37.0 °C. Except for the Ag + sodium citrate hydrosol (E 331), the growth of the culture from the 3rd to the 5th cultivation on the Endo medium was noted. The data obtained allow to recommend the above-mentioned metal hydrosols for use at veterinary supervision facilities as disinfectants.

INTRODUCTION

Providing the country with high-quality and safe products of animal origin in terms of veterinary and sanitary aspect is the main task of the government [1].

Food safety control is carried out based on the current regulatory documents TR CU 021/2011 "On food safety", international regulatory documents that toughen the control of food safety [2].

According to WHO, food poisoning is a major problem worldwide; it is transmitted through food that is contaminated with pathogenic and conditionally pathogenic microflora that is resistant to high and low temperatures [7]. In the USA, several million cases of food poisoning are registered annually [12; 9].

Microbial food poisoning accounts for about 90% of the total number of food poisoning of various etiologies [4].

The recommendations to processing enterprises at the places of sale indicate planned disinfection of equipment and the use of raw materials for the preparation of food that is safe in veterinary and sanitary terms.

One of the widespread microorganisms is E. coli; in natural conditions, it is the normal intestinal microflora of animals and humans. In the course of evolution, E. coli strains have become sources of intestinal infections and cause severe diseases [11; 10]. According to the research data of Kozlova S.V., 2019, Yurchenko A.A., 2021,

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Escherichia coli was detected in 43% of cases when slaughtering the cattle with injuries; 35.4% of them were detected in raw milk.

It is worth noting that due to the active development of nanotechnology, the use of nanoparticles currently finds a place in many areas including veterinary medicine. Having a proven bactericidal effect, metal nanoparticles, particularly in the form of hydrosols, are used to create new antimicrobial - especially antiseptic - agents, which can help in the fight against antibiotic resistance, which is actively spreading around the world. Studies have shown that, for instance, silver nanoparticles have bactericidal properties against gram-positive bacteria E. hirae and S. aureus, as well as gram-negative E. coli and S. typhimurium [3].

Based on the above, the authors believe that the issue of studying the resistance of Escherichia coli to metal hydrosols is relevant since livestock farms and processing enterprises should seek new antiseptic agents for proper disinfection.

MATERIALS AND METHODS

The experimental part of the work on the resistance study of metal hydrosols to Escherichia coli was carried out at the Department of Parasitology and Veterinary and Sanitary Examination of the FSBEI HE Moscow State Academy of Veterinary Medicine and Biotechnology - MVA named after K.I. Scriabin - within the framework of the research agreement No. 45-11 dated 08.11.2021. Experimental samples of metal hydrosols were presented by Biomedical Engineering Laboratory LLC, Russia. Escherichia coli strain was used in the research work; the strain number in the "All-Russian State Collection of pathogenic and vaccine strains of microorganisms-pathogens of infectious diseases of animals": B-1364. Date, source, and allocation place: June 2019, allocated from cattle, Moscow region. The culture was identified in: the laboratory of antibiotic resistance diagnostics and control of pathogens of the most clinically significant infectious animal diseases of the FSBEI Federal Research Center of Experimental Veterinary of the Russian Academy of Sciences. Conclusion on the pathogenicity group: all types of farm animals and birds are susceptible to this type of bacterial agent.

The authors conducted the study of Escherichia coli resistance to 6 antiseptics, which are based on hydrosols of metal nanoparticles and their oxides.

The **1st sample** contains the following as an active substance:

- Cu – 6.64 mg/l;

In **the 2nd sample**:

- TaO_4 – 8.55 mg/l;

In **the 3rd sample**:

- Fe_3O_4 – 4.94 mg/l;

In **the 4th sample**:

- TiO_2 – 3.4 mg/l;

In **the 5th sample**:

- Ag + sodium citrate (E 331) – 2.4 mg/l.

In **the 6th sample**:

- ZnO – 13.88 mg/l;

In addition to the silver-based antiseptic (sample 5), cetylpyridinium chloride (CPC) was present in all samples as an auxiliary substance - 0.07%.

The work adopted the methodology as per GOST R 59072-2020. National Standard of the Russian Federation. Disinfectants. Suspension method for determining antimicrobial activity. 4.5 cm of the tested metal hydrosols' solution presented in Table 1 of the corresponding concentration was placed in a sterile bacteriological tube, to which 0.5 cm of a suspension containing E. coli 1×10^9 microbial cells per 1 cm^3 was added and thoroughly mixed; the exposure was maintained for 30 and 60 minutes as the most optimal, which is an indicator of the high disinfectants' efficiency. Methols' hydrosols from E. coli suspension were transplanted into dense nutrient meat infusion agar (MIA) media and Endo medium; after that, they were thermostated at a temperature of 37.0 ° C for 24-48 hours.

TABLE 1. Study samples of metal hydrosols

No.	Samples	Concentration of metal hydrosols' nanoparticles and their oxides
1.	CuO + CPC - 0.07 %	Cu – 6.64 mg/l
2.	TaO_2 + CPC – 0.07 %	TaO_4 – 8.55 mg/l
3.	Fe_3O_4 + CPC – 0.07 %	Fe_3O_4 – 4.94 mg/l
4.	TiO_2 + CPC – 0.07 %	TiO_2 – 3.4 mg/l
5.	Ag + sodium citrate (E 331)	Ag + sodium citrate (E 331) – 2.4 mg/l
6.	ZnO + 0.07 % CPC	ZnO – 13.88 mg/l

RESEARCH RESULTS

Escherichia coli bacteria was used to determine the exposure of antimicrobial action of metal hydrosols; it is used as an indicator bacterium in determining the quality of disinfection against gram-negative pathogens of infectious diseases (salmonellosis, klebsiellosis, hafniosis, protein infection, brucellosis, etc.).

Disinfectants used in veterinary practice and food industry must meet the following requirements: be environmentally friendly, have low toxicity, have no unpleasant strong odor, maintain stability during storage and dissolve well in water; it should not damage the treated surfaces, while having an optimal price-quality ratio, which is important for the consumer [8]. The study results of metal hydrosols and E. coli suspension are presented in Table 2.

TABLE 2. Record of the growth results of test cultures with metal hydrosols on the MIA nutrient medium

No.	Test samples	Accounting time	1 100 % hydrosole	2 80 % hydrosole	3 60 % hydrosole	4 40 % hydrosole	5 20 % hydrosole
1.	CuO + CPC - 0.07 %	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
2.	TaO_2 + CPC – 0.07 %	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
3.	Fe_3O_4 + CPC – 0.07 %	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
4.	TiO_2 + CPC – 0.07 %	24 h	-	-		-	-
		48 h	-	-	-	-	-
5.	Ag + sodium citrate (E 331)	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
6.	ZnO + 0.07 % CPC	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
7.	Control of the MIA medium	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
8.	Culture control in MBP (without metal hydrosols' addition)	24 h	+	+	+	+	+
		48 h	+	+	+	+	+
9.	Culture control in saline solution (without metal hydrosols' addition)	24 h	+	+	+	+	+
		48 h	+	+	+	+	+

(+) – culture growth on the medium; (–) – no culture growth on the medium.

According to the studies' results, the authors found that the studied metal hydrosols prevent the growth of E. coli on a dense MIA medium; the results were considered after 24 and 48 hours of cultivation in a thermostat at a temperature of 37.0 °C.

TABLE 3. Record of the growth results of test cultures with metal hydrosols on the nutrient Endo medium

No.	Test samples	Accounting time	1 100 % hydrosole	2 80 % hydrosole	3 60 % hydrosole	4 40 % hydrosole	5 20 % hydrosole
	CuO + CPC - 0.07 %	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
2.	TaO_2 + CPC – 0.07 %	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
3.	Fe_3O_4 + CPC – 0.07 %	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
4.	TiO_2 + CPC – 0.07 %	24 h	-	-		-	-
		48 h	-	-	-	-	-
5.	Ag + sodium citrate (E 331)	24 h	-	-	+	+	+
		48 h	-	-	+	+	+
6.	ZnO + 0.07 % CPC	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
7.	Control of the Endo medium	24 h	-	-	-	-	-
		48 h	-	-	-	-	-
8.	Culture control in MBP (without metal hydrosols' addition)	24 h	+	+	+	+	+
		48 h	+	+	+	+	+
9.	Culture control in saline solution (without metal hydrosols' addition)	24 h	+	+	+	+	+
		48 h	+	+	+	+	+

(+) – culture growth on the medium; (–) – no culture growth on the medium.

According to the studies' results, it was found that the studied metal hydrosols prevent the growth of E. coli on a dense Endo medium; the results were considered after 24 and 48 hours of cultivation in a thermostat at a temperature of 37.0°C. The growth of the culture from the 3rd to the 5th cultivation was noted apart from the Ag + sodium citrate hydrosol (E 331).

The data obtained allow to recommend the above-mentioned metal hydrosols for use at veterinary supervision facilities as disinfectants.

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Cephalotrichum Asperulum - New Pathogen of Potato in Russia

Ivan Tuchkov, Rashit Tarakanov [a)], Fevzi Dzhalilov and Olga Beloshapkina

Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, 127434 Moscow, Russian Federation

[a)] Corresponding author: tarakanov.rashit@mail.ru

Abstract. The parasitic effect on the potato plant of fungi of the genus *Cephalotrichum*, referred to in the mass scientific literature as endophytic, has been proved as a priority. The pathogenicity of isolates on leaves and slices of tubers was checked. Micromorphological features of conidial sporulation and mycelium structures in pure culture are described. By PCR and sequencing, it was proved that the isolate is close to the genus *Cephalotrichum*, the species *C. asperulum*. The resulting sequence was deposited in GenBank (registration number ON364353).

INTRODUCTION

Russia, producing 28 about 20 million tons of potatoes annually, is among the top 5 countries with the largest potato production. Due to the intensification of crop production, there is a change in the pathocomplex affecting potatoes.

The emergence of new plant pathogens is probably due, among other things, to the 39 transition to parasitism of endophytic fungi [1]. Endophytic fungi inhabiting the internal tissues of living plants actually do them no harm. These fungi are mostly specialized biotrophs. However, it is likely that under certain conditions endophytic fungi can enter into a different relationship with the host plant, partially or completely transitioning to a parasitic lifestyle. [2]. In the course of studying the literature, we noted that recently cases of detection of the transition of endophytes to a parasitic type of nutrition have become more frequent.

The genus *Cephalotrichum* (Ascomycota, Pezizomycotina, Sordariomycetes, Hypocreomycetidae, Microascacales, Microascaceae) includes synnematous species of saprotrophic fungi with an extensive distribution, which are released mainly from air and soil, urban environments, and decaying plant residues, straw, manure, wood [3].

The aim of this study was to identify a new disease of potato tubers based on the morphological and molecular characteristics of the pathogen.

MATERIALS AND METHODS

Isolation and characterization of the pure culture

To assess the phytosanitary status of a batch of potatoes of cv. Zhukovsky ranniy stored in the basement at 2-4 °C in a private farm in Oryol region, tubers were selected and visually examined outside and inside at the cut. Subsequently, fragments of selected tubers with signs of damage in the form of local darkening of flesh were placed in a wet chamber. Pure culture was isolated by the limiting dilution method. Therefore, one simple of coremia was taken under a Carl Zeiss Stemi 508 stereo microscope and placed in amicrotube containing 1 ml of sterile water. The microtube was thoroughly mixed on a Cyclotemp-901 microcentrifuge-vortex (Russia) to obtain a mother liquor. Next, we performed ten-fold dilutions of the suspension in water. The procedure was repeated until the concentration of 10^3 CFU/mL was reached. 25 μL of the solution was transferred to Czapek medium with the antibiotic gentamicin (DalChimPharm,

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Khabarovsk, Russia) added at a concentration of 1 g/L and evenly distributed with a Drigalski spatula. The solution was incubated at 20 °C until germination of individual single spores. Single spores were transferred to Czapek medium for further cultivation. The morphological features of conidial spore structures of the fungus were described using a Carl Zeiss Primo Star optical microscope. Affiliation with the genus **Cephalotrichum** was determined using the Webster identifier [4] with subsequent correction for the latest taxonomy.

DNA purification and molecular genetic characterization

One representative potential isolate kolpna3 was isolated from diseased potato tubers and purified to single colonies by cultivating on Czapek medium at 20 °C for 7 days. The mycelium was washed from the medium with distilled water and prepared for DNA purification. Total genomic DNA was extracted using a CytoSorb DNA extraction kit (Syntol, Moscow, Russia) according to the manufacturer's protocol. DNA concentration was measured on a spectrophotometer NanoDrop OneC (Thermo Fisher Scientific; Waltham, Massachusetts, USA).

PCR was performed using a universal primer pair with the ITS1/ITS4 internal transcribable spacer (ITS) [5] using master-mix 5X MasDDTaqMIX-2025 (Dialat, Moscow, Russia). Amplification was performed in a T100 thermocycler (Bio-Rad Laboratories, California, USA).

Amplicon sequencing was performed at LLC «Syntol» (Moscow, Russia). The obtained sequences were assembled and analyzed using BioEdit v. 7.2.

The evolutionary history was deduced using the minimum-evolution method [6]. Evolutionary analysis was performed in MEGA 11.

Pathogenicity testing

The pathogenicity of the isolated fungus was tested according to the traditional methodology by inoculation [7] of individual leaves and tuber slices of potato of cv. Zhukovsky ranniy. potato plants were damaged with a sterile needle at to S1 phase and 50 µL of conidia suspension with a concentration of 10^5 conidia/mL was applied to the wound.

The control variant was also wounded, but 50 µL of sterile water was applied instead of a suspension of conidia. After inoculation, the plants were covered with a polyethylene bag and kept at 22 ± 2 °C with relative humidity of 95 to 100% and a light day of 16 hours. After 7 days, symptoms were observed. To confirm Koch's postulates, a second isolation into pure culture of *C. asperulum* from inoculated plant parts was performed, and then a morphological comparison of microstructures with the original isolate was carried out.

For tuber inoculation, potatoes were peeled, cut into 10-mm-thick slices, which were sterilized in 70% ethyl alcohol and aseptically dried for 5 min on a paper filter in Petri dishes. Then, under laminar flow cabinet conditions, one coremium from a 2-week- old isolate culture grown on Czapek medium was transferred to the middle of a potato slice, the cup was covered, and kept at 22 °C without access to light, periodically wetting the filter paper with sterile water. The diameter of the necrosis area was measured on day 7 using a caliper. In the experiments, 5 leaves were used in 2 repetitions and 4 slices of potato tubers in 4 repetitions.

Statistical processing of the analysed data was carried out using the method of variance analysis, with Statistica 12.0 (StatSoft, TIBCO, Palo Alto, CA, USA), comparing averages according to the Duncan criterion. Percentage data were converted to arcsines before processing. Plots were created with GraphPad Prism 9.2.0.

RESULTS AND DISCUSSION

Extraction and characterization of pure culture

Studies in this direction were initiated after the detection of darkened flesh of unknown etiology in a batch of stored potato tubers in the Oryol region (Figure 1A). The analyzed potatoes were harvested in the Kolpnyansky district of Oryol region (52.22°N, 156 37.00°E) in 2021.

After incubation of diseased tissue fragments in a wet chamber, fungal structures were visually detected on the surface of dying darkened tissue, which were subsequently identified as conidial sporulation of fungi, coremia (Figure 1B).

Morphological description of isolate structures was performed using an optical microscope (Figures 1C-1D). Mycelial hyphae are segmented, 2.17 to 2.96 µm wide, and septa are distinct.

Conidia unicellular, oval, oval-extended and narrowed at one end, less frequently globular, colorless, smoky gray in mass, 4.39-4.46 μm long, 3.02-3.05 μm wide; phialides at ends of conidiophores elongated and curved, 3.01-3.12 μm long and 2.12-2.14 μm width. The type of conidiogenesis is blastic. Conidiophores unbranched, up to 2830 μm long (on the PDA), aggregated in bundles, coremia, 42.0-42.3 μm wide. No structures of marsupial sporulation were found.

Based on the structure of conidiophores and conidia, the obtained fungal isolate was identified as a representative of the genus *Cephalotrichum*. Our data on the morphology of microstructures of the identified fungus of this genus differ slightly from those described in potato culture in Iran [8].

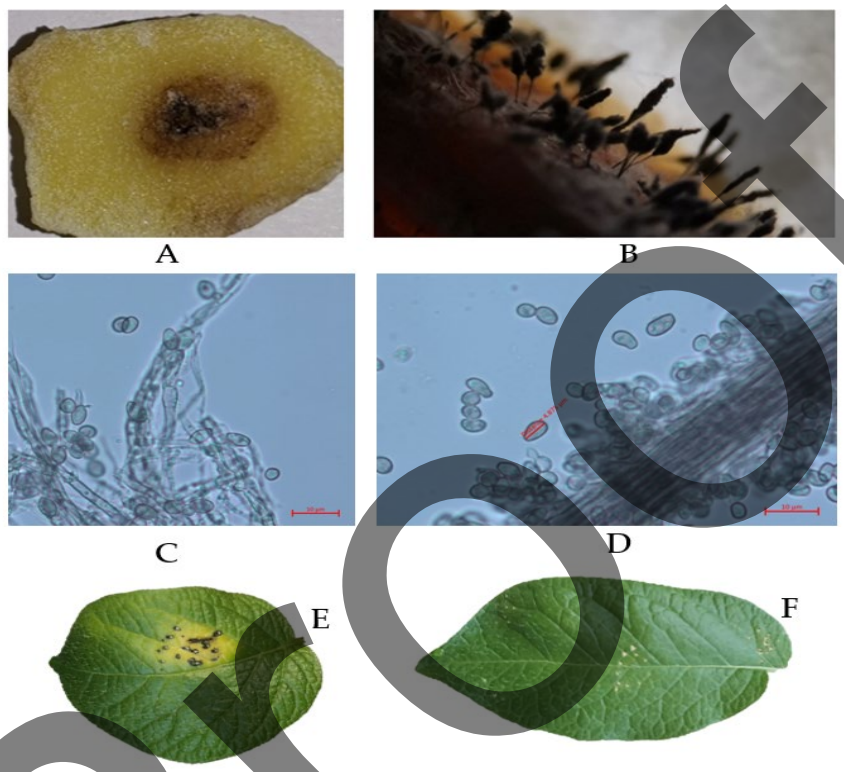

FIGURE 1. Morphological, cultural and pathogenic properties of *C. asperulum* kolpna3 isolate. Symptoms of lesions on potato tuber Zhukovsky ranniy (primary detection) (A-B). Morphological structure of microstructures of *C. asperulum* (C-D). Symptoms on potato leaves Zhukovsky ranniy 7 days after inoculation with *C. asperulum* (E) and sterile water (F) by wound inoculation with conidial suspension.

Pathogenicity testing

Three days after leaf inoculation, typical local chlorosis and black-brown necroses were observed at the needle prick site on potato leaves, while the control wounds remained asymptomatic (Figures 1E, 1F). Symptoms appeared on all wounds infected with conidia on potato leaves and tubers. The pathogen was repeatedly isolated in pure culture from diseased areas of inoculated plant organs and verified by pure culture isolation and sequencing using the above technique.

The isolate also showed pathogenicity when inoculated with a single coremia of potato slices. This was manifested in the form of brown necroses, which reached a diameter of 47 mm.

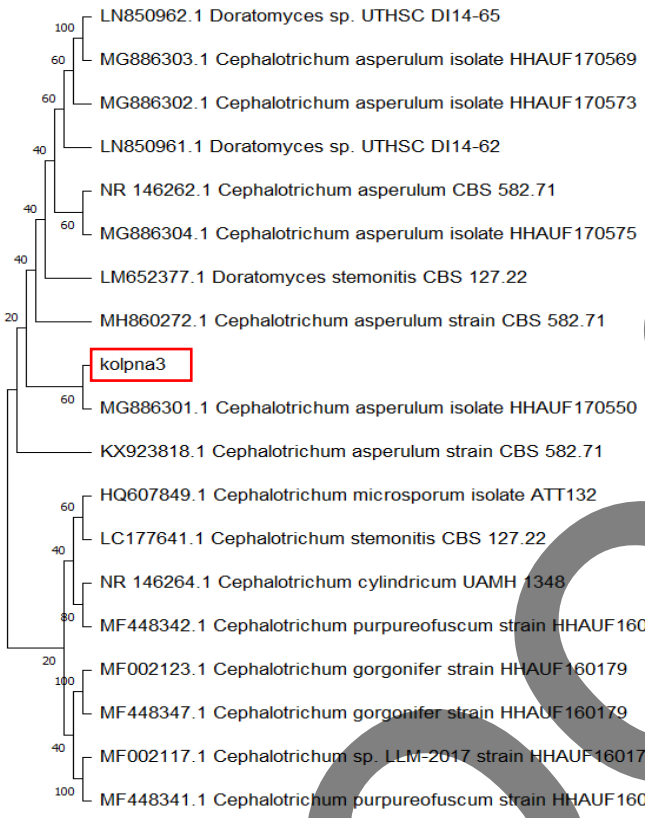

FIGURE 2. A phylogenetic tree created using internal transcribable spacer (ITS) gene sequences from *Cephalotrichum* species. The identified kolpna3 strain is highlighted with a red border. Evolutionary analysis and adjustment of the tree image was created in MEGA 11.

Molecular identification

A specific identification of the fungus isolate was performed by PCR using a universal primer pair for the ITS1/ITS4 internal transcribable spacer (ITS) gene. Sanger sequencing results showed that the length of the corresponding PCR product for the ITS gene was 560 b.p.

BLASTn search results showed that the ITS sequence of kolpna3 strain was most identical to the species *Cephalotrichum asperulum* of the genus *Cephalotrichum* (MG886301.1) with a genome identity of 99.33 %. A phylogenetic tree constructed on the basis of ITS gene sequences (Figure 4) showed that kolpna3 strain is the closest to isolate *C. asperulum* HHAUF170550. The resulting sequence was deposited in GenBank (accession number ON364353).

Thus, the isolated fungus causing local necroses and chlorotic areas on leaves and necroses in potato tuber flesh under artificial and natural infection was identified as *C. asperulum* (Wright et. Marchand) Sandoval-Denis et al.

When studying the weather conditions of the growing season of 2021, it was revealed that during the first and second decade of August, the amount of precipitation was 44% of the average monthly norm, and the air temperature rose to 34 °C. Most likely, it was these conditions that served as stress for the potato plant, as a result of which the nonspecific immunity was weakened. Our study can be compared with the results of scientists from Iran [8], where it was concluded that *C. asperulum* and *C. tenuissimum* spread in dry and hot climates. Due to the similarity of our results, it can be assumed that stress caused by lack of moisture and elevated air temperatures is the starting point for the transition of the fungus *C. asperulum* to parasitism. To obtain more accurate information on the background of which abiotic factors the endophytic fungus is transitioning to a parasitic lifestyle, of course, additional research is necessary.

CONCLUSIONS

As far as we can judge, there were no previous publications and reports on the pathogenesis of fungi of this species on potatoes in Russia. The established fact of pathogenicity of the studied fungus of the genus *Cephalotrichum* shows the need for further monitoring, clarification of its phylogenetic specialization, evaluation of the disease harmfulness on different potato varieties and development of protective measures to reduce damage.

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Biochemical Indicators of Primate Blood as a Result of the Inclusion of White Lupine in Diet Structures

N.V. Gaponov [1, 2, a)], O.P. Neverova [3], S.Yu. Harlap [3], A.V. Stepanov [3] and P.V. Sharavyev [3]

[1] *All-Russian Lupine Scientific Research Institute – Branch of the Federal Williams Research Center of Forage Production & Agroecology, 241524, p/o Michurinskiy, Berezovaya str., 2, Bryansk region, Russia*
[2] *FSBI Scientific «Research Institute of Medical Primatology», 354376, Krasnodar Territory, World st., 177, Sochi, Russia*
[3] *Ural State Agrarian University, 620075, Karl Liebknecht 42, Yekaterinburg, Russia*

[a)] Corresponding author: nv.1000@bk.ru

Abstract. Today, in addition to rodents, the non-human primates of the rhesus monkey (M. mulatta), which are valuable models in biomedical research, are at the disposal of scientists for experiments, in addition to rodents. Anatomical resemblance to humans makes it possible to successfully conduct studies of the digestive system, as well as to be used in preclinical and toxicological studies. In this regard, the study of white lupine in primates and its influence on their biochemical blood parameters, in order to extrapolate the results to humans, is an urgent task. In the present study, we established the effect of white lupine with an alkaloid content of 0.02% on the biochemical parameters of the blood of rhesus monkeys. We used the results of biochemical analysis of clinically healthy male M. mulatta at the age of 9 years and an average body weight of 10 kg. We studied both the main biochemical parameters (creatinine, urea, alkaline phosphatase, total protein, albumin, globulin, glucose and total bilirubin), and additional parameters (calcium and phosphorus concentration), the activity of a number of enzymes (ALT-Alanine aminotransferase, AST-spartate aminotransferase, GGT -Gamma-glutamyltransferase, LDH -lactate dehydrogenase), which are biochemical markers of damage to various systems and organs. The analysis of the research results as a result of the inclusion in the structure of the diet of white lupine with an alkaloidity of 0.02%, showed the absence of pathological abnormalities in the liver, heart muscle, skeletal muscles, pancreas and bile ducts. The studied indicators were within the reference values, which indicates a normal metabolism and the absence of inflammatory processes in the body.

INTRODUCTION

Intensive metabolism, especially anabolic processes in the body, are possible only with sufficient intake of protein-rich feeds balanced in all nutrients. It is difficult to satisfy the need for protein by increasing the production of full-fledged animal feed [1,2,3,4]. To successfully solve this problem, it is necessary to include vegetable proteins of leguminous crops such as white lupin in diet structures. The problem of plant protein deficiency in many countries of the world has caused increased interest in lupin. The need to import soybeans and protein dependence on the United States led to the search for ways out of the current situation. Different lupine types can be grown in more temperate climatic conditions than soy. This crop is less demanding to the soil due to the development of a powerful root system. Seeds of white lupine contain the same amount of protein as soy (35...40%), of similar quality. Lupin grain is not inferior in nutritional value to soy grain, and in some respects surpasses it, has excellent taste qualities. The prime cost of lupin grain makes it an increasingly popular alternative to soy. The dry matter of lupin grains contains 30- 46% of crude protein. In terms of amino acid composition, lupin protein surpasses cereals and many protein feeds.

The lupin advantages have been repeatedly noted by many scientists and practitioners. Lupin contains many - biologically active elements, which makes it possible to use it in the fight against diabetes 2 and cardiovascular diseases [5,6].

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All over the world, lupin is cultivated primarily as a source of feed and food protein. In our country today, lupin is used as a fodder and break crop. There is a certain problem with the introduction of this culture into food products. This is due to the fact that the crop is quite young, therefore it is not present in the list of food products both in SanPiN 2.3.2.1078-03 and in the adopted technical regulations.

The main reason that slows down the use of lupin grain in nutrition is the presence of alkaloids in it – anti-nutritional substances with toxic properties. These substances are a group of nitrogen-containing organic, primarily, heterocyclic compounds. Biologically active antialimental substances, alkaloids, trypsin and chymotrypsin inhibitors contained in lupine negatively affect the anabolism and catabolism processes, reduce body resistance to pathogenic factors [4,5,6]. Adaptive and protective properties of the body, as a result of white lupin inclusion in the structure of diets, can be assessed using a biochemical blood test. Blood is a liquid substance that creates the internal milieu necessary for the optimal functioning of the cytological and histological systems of the body [7]. The components contained in it are plastic substances that provide blood viscosity, create colloidal osmotic pressure, maintain acid-base equilibrium, provide transport and protective functions. The blood homeostasis balance is influenced by the type and age, technology of keeping and feeding primates.

In connection with the above, this work is of great scientific interest and practical importance for substantiating the feasibility of introducing white lupine grains with an alkaloid level of 0.02% into the composition of complete feeds for primates, such as M. mulatta as experimental models. Because phylogenetically primates are closer to humans than other laboratory animals, and therefore they are very convenient for modeling and studying biological processes in the body.

The purpose of the research was to study the hematological blood parameters of M. mulatta males when different amounts of white lupine grains with an alkalinity of 0.02% were included in the composition of complete feed.

MATERIALS AND METHODS

The experiment was carried out in the conditions of the FSBSI "Research Institute of Medical Primatology" Krasnodar Krai, city of Sochi. To carry out scientific experiment, 3 groups of human primates M. mulatta, 4 heads each, similar in appearance, origin, age, gender, were formed by the method of analogue pairs in accordance with generally accepted research methods [11;12;13]. The groups differed in feeding ration [14;15]. The animals were kept in individual cages. The experiment period was 35 days.

Animal experiments were performed in accordance with the requirements of the guidelines for the maintenance of laboratory animals [16;17], the Helsinki Declaration (2000) and the EU Directive 2010/63/EU. The study was approved by the Bioethical Commission of the FSBSI "SRI MP". The scheme of the experiment is presented in table 1.

TABLE 1. Experiment scheme

Groups	Amount of individuals	Feeding conditions
I Control	4	Complete feed (**CF**)
II Experimental	4	**CF – lupin content 10%**. Replaced with native lupin: soybean meal and sunflower meal by 50%
III Experimental	4	**CF – lupin content 20%.** Replaced with native lupin: soybean cake, sunflower and corn cake by 50%, fish meal, and milk powder by 50%

The control group received a complete balanced feed.

Primates of the 2-experimental group, with complete feed, consumed native white lupin in the amount of 10%.

In primates of the 3-experimental group, native white lupin was present in the structure of complete feed in the amount of 20%.

The alkaloid content in white lupin grain of the Dega variety was determined in the Laboratory of Plant Physiology of the All-Russia Scientific Lupin Research Institute - a branch of the FRC "V.R. Williams All-Russia Scientific Research Institute"

The inorganic part of the biochemical composition of the complete feed was determined using an X-ray fluorescence wave dispersion spectrometer "Spectroscan max GVM". Method of measuring the mass fraction of Mg, Al, Si, Zn, P, S, Cl, K, Ca, Ba, Ti, Cr, Mn, Fe, Ni, Br, Rb, Sr in powder samples of plant materials - by X-ray fluorescence method using X-ray devices for spectral analysis SPECTROSCAN MAX (M-049-RM/12, Russia). The remaining indicators were determined using the FOSS NIRS DS2500F spectral feed analyzer (USA).

The material for the study was venous blood and blood serum. Blood samples (2.5-3.0 ml) were taken from the ulnar or femoral vein on an empty stomach before the use of chlorella and 35 days after the end of the experiment. Whole blood was stabilized with a heparin solution. Hematological analysis was performed on an automatic analyzer CoulterAcT 5diffCP of the Beckman Coulter company (USA). The level of erythrocytes, leukocytes, platelets, hemoglobin concentration, hematocrit, average volume of erythrocytes, erythrocyte anisocytosis were determined. The erythrocyte sedimentation rate (ESR) was determined by the Panchenkov method. Blood serum was obtained from venous blood without anticoagulants in a centrifuge glass tube, which was maintained at a temperature of 15-20 °C until a clot forms. Decanting and centrifugation was performed with a thin glass rod (10 minutes at 1000-1500 g). The biochemical analysis (the content of total protein, glucose, total bilirubin, calcium, phosphorus) was performed with blood serum without hemolysis for 2-3 hours after receiving it using commercial kits from High Technology Inc (USA) on a semi-automatic BioChem SA analyzer (USA) in accordance with the manufacturer's instructions.

The obtained results were processed statistically in the GraphPad Prizm 8.0 program (USA) and expressed in the form of arithmetic averages and their standard errors. The statistical significance of the differences was determined using a one-factor variance analysis with subsequent a posteriori correction for multiple comparisons using the Tukey and Sidak method. The accepted level of statistical significance is $p<0.05$ [18]

RESULTS OF THE STUDY AND THEIR DISCUSSION

The white lupine grain contained 0.02% alkaloids, which allows for use in feeding. White lupin is known as a source of high nutritional value and feed protein. Thus, the studied samples of lupin grain of the Dega variety contained 13.8 MJ of metabolic energy, 35.85% of crude protein. The fiber and crude fat content averaged 14.62% and 4.01%, respectively.

The first control group received a complete balanced feed for 35 days, in which 34.10% was wheat. The share of soybean cake, sunflower, corn and corn gluten in the structure of complete feed accounted for 10.00% each. The sources of animal feed were fish flour in the amount of 6.00%, egg powder - 2.00% and dry milk 4.00%. The diet of the control group was balanced in terms of energy by the introduction of sunflower oil, an amount of 0.3% and sugar - 6%. The lack of calcium and phosphorus macronutrients is balanced by the introduction of tricalcium phosphate in the amount of 3% and a premix - 3.6%.

The feeding ration of the 2nd experimental group for a set of feeds was identical with the control one. Nevertheless, the studied legume crop white lupine in the amount of 10% was added to the structure of the diet of this group. As a result, high-protein feed of vegetable origin, soybean meal and sunflower meal, were replaced with lupin by 50%. The diet structure for the remaining feeds and additives was identical to the control group.

In the 3rd experimental group, high-protein feeds, both of vegetable and animal origin, were replaced with white lupin. As a result, white lupin was 20% in the structure, which replaced vegetable feed, soybean cake by 50%, sunflower cake by 50%, corn by 50% and wheat by 0.3%. Animal feed: fish meal and milk powder - by 50%. Since as a result of the lupin inclusion, the level of metabolic energy of the diet began to correspond to the norm, the content of vegetable oil in the diet decreased by 1.2%. For the rest of the component composition, the experimental diet corresponded to the control one.

Biochemical analysis is one of the most common laboratory studies in modern biomedicine, reflecting the functional state of the organs and body systems (liver, kidneys, pancreas, etc.). Biochemistry allows to assess the state of metabolic processes (protein, carbohydrate, fat, water-electrolyte metabolism, imbalance of macronutrients).

To assess the effect of the introduction of white lupine with alkaloid content of -0.02% in the diet on metabolism, we determined some biochemical parameters of blood serum. With norm-balanced primate feeding, the biochemical composition of the blood is quite constant. Insufficient or, conversely, excessive intake of macro- , micronutrients disrupts the nature of metabolic processes in tissues, which affects the biochemical composition of the blood.

Alkaline phosphatase (ALP) is a protein enzyme that is present in all tissues of the body and in an alkaline environment ensures normal metabolism at the cellular level. According to the data (Table 2), at the beginning and end (Table 3) of the experiment, the ALP indicators were within the reference values. Consequently, the inclusion of white lupin in the diet structure of male rhesus macaques did not affect the increase in alkaline phosphatase, which

indicates the absence of pathological changes in the hepatobiliary and osseous systems.

TABLE 2. Biochemical blood parameters at the beginning of the experiment, X±Sx

Indicators	Reference values [a]	Groups		
		I-Control	II-Experiment	III-Experiment
ALP (u/l)	42.1-1635.0	137.93±19.83	168.93±19.81	149.63±58.30
ALT (u/l)	1.0–29.0	28.58±0.34	25.79±6.60	30.61±21.2
AST (u/l)	12.0–55.0	37.85±6.49	50.22±11.33	55.00±12.20
GGT (u/l)	2.0–128.0	86.59±5.20	66.55±5.90	70.42±7.50
LDH (u/l)	59.0–287.0	198.33±15.50	286.20±38.2	164.80±15.1
Amylase (mmol/l)	98.0-570.0	441.87±15.94	540.13±98.0	403.80±81.0
Urea (mmol/l)	1.69 -3.76	3.74±0.71	3.40±0.56	3.48±0.57
Creatinine (umol/l)	53.04 -114.0	114.1±12.41	113.40±7.42	108.23±5.70
Glucose (mmol/l)	1.83-6.76	6.02±0.10	3.40±0.76**	6.70±0.01**
Bilirubin (umol/l)	1.71-11.97	7.57±1.60	8.35±1.59	8.57±2.46
Protein, (g/l)	39.0- 79.6	79.58±3.49	80.73±4.31	72.57±10.30
Albumin, (g/l)	39.0- 51.0	42.84±1.76	39.57±4.04	39.16±1.23
Globulins (g/l)	35.0- 41.0	36.74±1.50	41.16±2.71	33.41±1.01
Ca, (mmol/l)	1.75-2.45	2.35±0.29	4.11±0.61	3.79±0.13**
P, (mmol/l)	1.06-2.13	1.75±0.76	1.53±0.04	1.46±0.30

Note: the data is given in the form of an average value and a standard error, n=4 for all groups.
$p<0.01$**, $p<0.05$* compared to the control group.
[a] - reference data are given according to [19, 20, 21].
ALP - Alkaline phosphatase
ALT - Alanine transaminase
AST - Aspartate aminotransferase
GGT - Gamma glutamine transferase
LDH - Lactate dehydrogenase

Alanine aminotransferase (ALT) is an enzyme from the transaminase group. At the beginning of the experiment, in the 3-experimental group, an increase in the ALT level of blood serum was noted compared to the control group by 7.1%, $p>0.05$ (Table 2). The ALT level in primates in the remaining groups both at the beginning and at the end (Table 3) of the experiment was within the physiological norm, but at the end of the experiment, a decrease in enzyme activity in the blood serum of the experimental animals was found compared with the control group. In the 2nd experimental group by 47.23% and in the 3rd experimental group by 57.5% compared to the control, it may be associated with better use of amino acids in the biosynthesis process and a decrease in the intensity of their catabolism, as well as the beneficial effect of white lupin on the functional state of the liver. Thus, the analysis of the data on ALT, as a result of the inclusion of white lupin with an alkaloid content of 0.02% in the diet structure, indicates the absence of pathological abnormalities in the liver, heart muscle, skeletal muscles, pancreas, and bile ducts. The increased ALT level in blood serum in group 3 at the beginning of the experiment was probably transient and was not associated with the action of white lupin alkaloids in the diet of human primates.

TABLE 3. Biochemical blood parameters at the end of the experiment, X±Sx

Indicators	Reference values [a]	Groups		
		I-Control	II-Experiment	III-Experiment
ALP (u/l)	42.1-1635.0	205.3±12.25	281.7±34.2	209.5±47.1
ALT (u/l)	1.0–29.0	28.24±6.20	19,18±4.60	17.93±1.10*

Continuation of TABLE 3.

AST (u/l)	12.0–55.0	22.46±0.90	26.64±3.12	32.32±3.90
GGT (u/l)	2.0–128.0	74.19±2.26	91.77±14.22	83.87±15.4
LDH (u/l)	59.0–287.0	180.1±20.17	179.5±15.44	190.1±15.49
Amylase (mmol/l)	98.0-570.0	243.5±11.75	293.9±23.27	266.4±16.69
Urea (mmol/l)	1.69 -3.76	3.41±0.79	3.01±0.56	3.63±0.59
Creatinine (umol/l)	53.04 -114.0	112.5±10.79	113.2±5.31	113.6±7.13
Glucose (mmol/l)	1.83-6.76	6.50±0.11	5.12±0.21	6.60±0.09*
Bilirubin (umol/l)	1.71-11.97	5.32±1.14	5.44±3.02	3.35±0.40
Protein, (g/l)	39.0- 79.6	80.51±6.71	74.73±3.30*	77.59±3.04
Albumin, (g/l)	39.0- 51.0	38.52±2.98	35.06±0.63	35.66±3.90
Globulins (g/l)	35.0- 41.0	41.99±1.98	39.67±2.01	41.93±1.73
Ca, (mmol/l)	1.75-2.50	2.329±0.06	2.50±0.10	2.50±0.11
P, (mmol/l)	1.06-2.13	1,4623±0.07	1.69±0.06	1.89±0.23

Note: the data is given in the form of an average value and a standard error, n=4 for all groups.
p<0.01**, p<0.05* compared to the control group.
[a] - reference data are given according to [19;20;21].
ALP - Alkaline phosphatase
ALT - Alanine transaminase
AST - Aspartate aminotransferase
GGT - Gamma glutamine transferase
LDH - Lactate dehydrogenase

Aspartate Aminotransferase (AST) is an endogenous enzyme from the group of transferases, a subgroup of aminotransferases (transaminases) involved in amino acid metabolism. The level of the AST enzyme, both at the beginning and at the end of the experiment, was within the reference values in all groups. There is no increase in the intake of this enzyme into the blood. Which indicates good metabolism and blood supply to the liver. The absence of pathologies in organs and tissues, inflammatory processes in the liver, and, therefore, does not lead to hepatocytolysis.

Gamma glutamine transferase (GGT) is an enzyme involved in amino acid metabolism. The GGT enzyme level both at the beginning and at the end of the experiment in all groups was within the physiological norm. At the end of the experiment, the average GGT level in the 2-experimental group was 23.69% higher relative to the control group, and 13.04% higher in the 3-experimental group, but the differences did not reach statistical significance ($p>0.05$). The lack of this enzyme activity indicates non-accumulation of bile in the organs, healthy digestion and the absence of inflammatory processes in the vital organs of primates.

The study of the lactate dehydrogenase enzyme (LDH), which is involved in glucose metabolism, found that the LDH enzyme in all groups did not exceed the reference values both at the beginning and at the end of the experiment in all groups. At the end of the experiment, the average LDH value level in the 3rd experimental group was slightly higher than the control group by 5.50%, but this increase was within the physiological norm and these differences did not reach statistical significance ($p>0.05$). This indicates the absence of oncological processes and damage in body cells and tissues, as a result of the inclusion of white lupine with alkaloidness 0.02% in the diet structure.

The study of the pancreatic amylase enzyme found that its level, both at the beginning and at the end of the experiment in all groups, was within the normal range. The non-increased level of amylase indicates a normal metabolism and the absence of inflammatory processes in the body. The results obtained by amylase are confirmed by data on the AST enzyme, which indicate the absence of deviations in the gluconeogenesis processes.

Since 85% of urea is released during filtration of blood in the kidneys, our studies of urea concentration in the blood allowed to assess kidney function. Both at the beginning of the experiment and at its end, the urea level was within the physiological norm. The absence of uremia indicates a good metabolism in the kidneys and a balanced diet of primates, in particular in terms of protein.

The study of an important indicator of nitrogen-containing carboxylic acids- serum creatinine - involved in energy metabolism in muscle and nerve cells, allowed to judge the state of the body. At the beginning of the experiment, the creatinine level was within the reference values. At the end of the experiment, the average creatinine level in the 2-experimental group was 0.62% higher relative to the control group and 0.97% higher in the 3-experimental group, but these indicators were within the normal reference values. These indicators show the absence of a side effect of white lupin on the filtration and excretory function of the kidneys. Indicate the balance of the protein feeding diet.

To understand the overall picture of carbohydrate metabolism in the body, one of the basic biochemical parameters was studied, the glucose level in the blood. At the beginning of the experiment, the glucose level was statistically significantly within the physiological norm in all groups. At the end of the experiment, in the third experimental group, after the introduction of white lupine into the structure of the diet, the glucose level relative to the control group increased statistically significantly slightly ($p<0.05$) to the upper values of the norm, but was in the range of reference values. Symptoms of hypoglycemia and hyperglycemia were not detected. Therefore, it is possible to diagnose the absence of endocrine system diseases (glucoganoma, acromegalia, thyrotoxicosis, etc.). Absence of pathology in the liver and kidneys and disorders in the pancreas.

At the beginning of the experiment, the level of bilirubin, bile pigment formed from hemoglobin in liver cells, was within the reference values. At the end of the experiment, the average bilirubin level in the 2-experimental group was 2.20% higher than the control group, but it was within the normal range and the differences did not reach statistical significance ($p>0.05$). As a result, no signs of hyperbilirubinemia, which occurs in pathologies of the liver or gallbladder, were found. Accordingly, the excretion and conjugation of bilirubin is impaired. That is, the balance between its formation and excretion is not impaired.

To control the presence and degree of amino acid metabolism disorders, as well as diseases and pathological conditions, the total protein was studied. The level of blood protein in the primates of the control and 2-experimental groups at the beginning of the experiment was higher than the reference values. At the end of the experiment, a decrease in the level of total protein in the 2-experimental group was observed to the physiological norm with a statistical significance of $p<0.05$. The total protein in the 3-experimental group was both at the beginning and at the end of the experiment within the reference values. These results indicate the absence of liver diseases, kidney diseases (glomerulonephritis, amyloid disease, etc.). This indicates a balanced diet and good absorption of protein from the gastrointestinal tract. The content of albumin and globulin protein fractions, as well as total protein, indicate good synthetic liver and kidney function. Sufficient intake of protein from the diet.

To diagnose electrolyte disorders in the body, the calcium and phosphorus level in the blood was determined. The phosphorus and calcium exchange is closely related, therefore, for the normal assimilation of minerals, their certain ratio with each other is equal to 1:1-1.5 (V. I. Smolyar, 1991) [22;23]. The calcium and phosphorus level in the blood of primates of all three groups, at the beginning of the experiment, was within the reference values. By the end of the experiment, these indicators in the experimental groups and the control group had not changed statistically significantly. Thus, imbalance in calcium (hypocalcemia, hypercalcemia) and phosphorus (hypophosphatemia, hyperphosphaturia) metabolism were not detected.

CONCLUSION

The use of white lupine makes it possible to balance the protein feeding diets of primates without the additional use of other high-protein legumes. As a result of biochemical blood tests, it was found that the use of white lupine with an alkaloidness of 0.02% does not lead to pathological abnormalities in the body of primates. Consequently, the use of lupin as a protein supplement will allow to obtain amino acid-balanced feed and optimize their cost by reducing the content or completely eliminating animal protein. Lupin protein could be the basis for use in human food production. Considering the growing popularity of vegetarianism, the use of lupin protein for the creation of meat and fish analogues, sports protein nutrition seems promising.

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Dynamics of Daily Variability of the Amount of Fatty Acids with Different Saturation of Carbon Bonds and Their Trans-Isomers in the Milk of Black-and-White Cows

O.A. Bykova [a)], A.V. Stepanov, O.V. Kostyunina and O.A. Shevkunov

Ural State Agrarian University, Karl Liebknecht 42, Yekaterinburg, 620075 Russian Federation

[a)] Corresponding author: olbyk75@mail.ru

Abstract. In the breeding enterprise in the summer, studies were carried out on the content of fatty acids with different saturation of carbon bonds and their trans-isomers in milk obtained during morning and evening milking. In the course of the study, it was found that in the evening milk, the level of all groups of fatty acids is significantly higher than in the morning milk, the difference ranges from 42.9% to 75.0%. Saturated fatty acids predominate in milk in general during the day, as well as for different periods, their level is 69% of the total amount of fatty acids and their trans-isomers. The trans-isomer level is 2%. The high variability of the amount of milk fatty acids and their trans-isomers was established from 59.5% for polyunsaturated fatty acids to 93.3% for trans-isomers of fatty acids, which indicates a high variability of traits and, as a consequence, the possibility of carrying out breeding work according to these indicators.

INTRODUCTION

In recent years, the problem of rationing the content of trans-isomers of unsaturated fatty acids in animal products remains relevant all over the world, while Russian legislation practically does not regulate the content of trans-isomers of fatty acids dangerous to health [1-4].

Trans-isomers of fatty acids are spatial isomers of natural unsaturated fatty acids contained in animal fats. They are formed in small quantities in the rumen during the digestion of vegetable raw materials rich with unsaturated fatty acids and get into animal fats, including milk fat, and further into milk processing products with a high fat content: sour cream and butter. In cow milk, butter, and cheese, the TFA proportion ranges from 3.2 to 6.2% of the total amount of FA [5-8].

The effects of TFA on human health may vary depending on their type, structure, composition, and origin. Despite the widespread discussion of the adverse effects of industrial TFA on health, the impact of natural TFA on health is still questionable [9-10].

According to a number of foreign researchers, TFA at the level of metabolism can block the mechanisms of gene expression associated with lipid compounds [11,12,13].

Milk TFA is natural and can have many health benefits, including enhancing immune function, reducing body fat, and preventing or slowing the formation of tumors in certain types of cancer. This information requires further research, since it suggests that natural TFA are metabolized quite differently than industrially produced ones.

MATERIALS AND METHODS

The object of the study was the breeding stock of black-and-white cows of the breeding enterprise of the Sverdlovsk region of different ages (from 1 to 3 lactation). The research included milk samples taken by specialists of the farm in July 2022. The analysis was carried out at the Center for the collective use of scientific equipment "Bioresources and Bioengineering of Farm Animals" of the FSBSI FRC VAA n.a. L.K. Ernst using a multiparametric automatic milk analyzer CombiFoss 7. Based on the results obtained, the average values for each component were calculated

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and an experimental database of the following indicators was compiled: the content of saturated, monounsaturated, polyunsaturated fatty acids and trans-isomers of fatty acids.

The results of the study were processed biometrically according to the method of N.A. Plokhinsky (1970). Quality control of the received information on average daily observations for milk fat components was carried out using a PC program MS Excel.

RESULTS AND DISCUSSION

Milk fat is a complex consisting of a large number of fatty acid esters. The composition of cow milk undergoes significant changes both during lactation and during the day. At the same time, the content and dynamics of fatty acids content in milk fat composition has recently been of scientific interest. Changes in the amount of fatty acids in the cow milk of the breeding farm are presented in Table 1.

TABLE 1. Daily dynamics of the amount of fatty acids depending on the saturation of carbon bonds and their trans-isomers, g/100g.

Indicator	Morning		Evening		Average per day	
	$\overline{X} \pm S_{\overline{X}}$	Cv, %	$\overline{X} \pm S_{\overline{X}}$	Cv, %	$\overline{X} \pm S_{\overline{X}}$	Cv, %
Saturated fatty acids	1.38±0.18	95.9	2.24±0.27	84.2	1.81±0.22	85.8
Mono-unsaturated fatty acids	0.51±0.06	80.3	0.83±0.09	73.2	0.67±0.07	72.9
Poly-unsaturated fatty acids	0.07±0.006	58.8	0.10±0.01	63.3	0.09±0.01	59.5
Trans-isomers of fatty acids	0.04±0.006	97.7	0.07±0.01	96.6	0.06±0.01	93.3

The presented data (Table 1) on the change in the amount of fatty acids depending on the number of double bonds of the carbon atom show that for all groups of acids, their content in milk obtained during morning milking is significantly lower than in evening milk. The smallest amount was noted for the group of trans-isomers and poly-unsaturated fatty acids, saturated fatty acids were found in the largest amount in milk, mono-unsaturated acids occupied an intermediate position. A similar ratio of fatty acids and trans-isomers of fatty acids was found in evening milk. On average per day, the concentration of saturated fatty acids in milk fat exceeded the content of unsaturated fatty acids by 2.38 times, the proportion of trans-isomers of fatty acids from their total amount was 2.33%. At the same time, the level of saturated and mono-unsaturated fatty acids in morning milk exceeded the evening value by 31, poly-unsaturated – by 28%, trans-isomers of fatty acids – by 1.5 times.

Thus, in the milk of black-and-white cattle of the breeding enterprise, both during certain periods of milking and on average per day, a high amount of saturated fatty acids is noted.

Daily change in the amount of fatty acids depending on the saturation of carbon bonds and their trans-isomers is shown in Figure 1 more clearly.

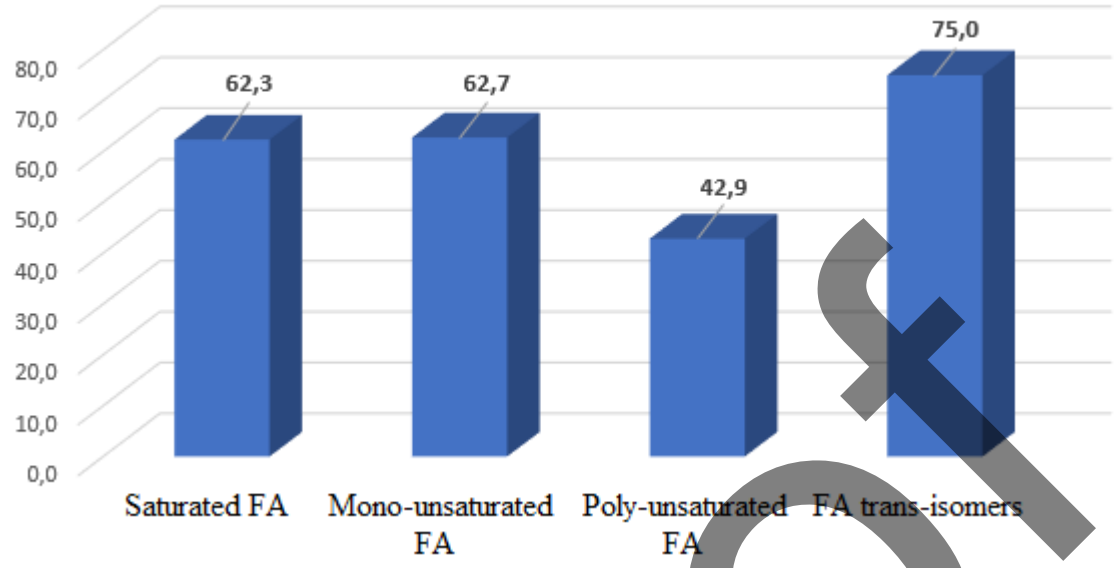

FIGURE 1. Dynamics of daily changes in milk fatty acids by saturation of carbon bonds and their trans-isomers, %

The difference in the daily change in the level of fatty acids and their trans-isomers does not give a complete picture of their dynamics between their content in morning and evening milk, but the calculation of relative dynamics gives a clear picture of the change. Thus, according to the data presented in Figure 1, it can be seen that, in general, the level of trans-isomers and fatty acids directly in evening milk is significantly higher compared to morning milk. The largest increase was recorded in trans-isomers and amounted to 75.0%. The content of saturated and mono-unsaturated fatty acids increased by almost the same amount during the day – 62.3 and 62.7%, respectively. The smallest change was noted for poly-unsaturated fatty acids – 42.9%.

Thus, during the summer period, the daily change in the amount of milk fatty acids and their trans-isomers occurs in a significant range – from 75.0% to 42.9%.

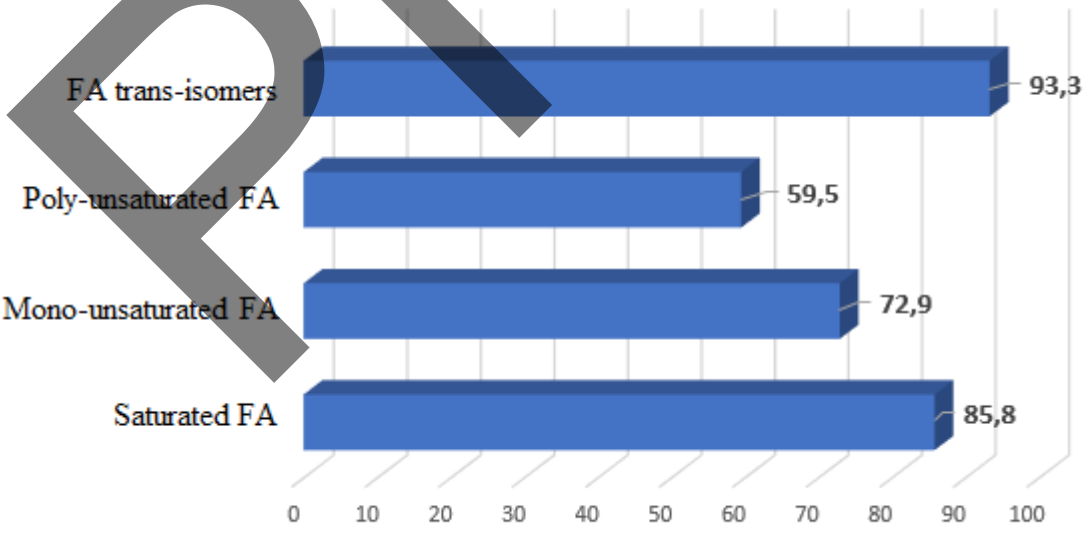

FIGURE 2. Variability coefficient of the average daily content of fatty acids and their isomers, %

The analysis of the variability of the average daily content of fatty acids in milk demonstrated a high value of the variation coefficient, which indicates a significant difference in the magnitude of this trait in the studied group of animals. The highest value of the variation coefficient was noted for the group of trans-isomers of fatty acids, this indicator was the lowest in the group of poly-unsaturated fatty acids, for saturated and mono-unsaturated fatty acids it occupied an intermediate value. It should be noted that the largest value of the coefficient was for the group of saturated fatty acids, characterized by the highest level of content in cow milk.

Based on the analysis of variability indicators, it can be said that the studied livestock of the breeding enterprise is characterized by high genetic diversity, which in turn is a prerequisite for further improvement of animals in terms of the number of trans-isomers and fatty acids in milk.

For groups of fatty acids and their trans-isomers, there was a high difference between the daily average values (Table 2). Thus, according to the studied indicators, the greatest superiority of the maximum values over the minimum values was found for trans-isomers of fatty acids – by 31.2 times, for unsaturated and mono-unsaturated fatty acids by 15.4 and 11.9 times, respectively. It should be noted that in the studied livestock there are animals in whose milk poly-unsaturated fatty acids are completely absent.

TABLE 2. Average daily fluctuations in the amount of trans-isomers and fatty acids in milk, g/100 g

Indicator	Minimum	Maximum	Difference
Saturated FA	0.602	9.307	8.705
Mono-unsaturated FA	0.259	3.076	2.817
Poly-unsaturated FA	0	0.369	0.369
FA trans-isomers	0.011	0.343	0.332

The daily dynamics of the distribution of fatty acids and their trans-isomers in the milk of the studied black-and-white cattle at different periods of the day is of particular scientific interest (Fig.3 and 4).

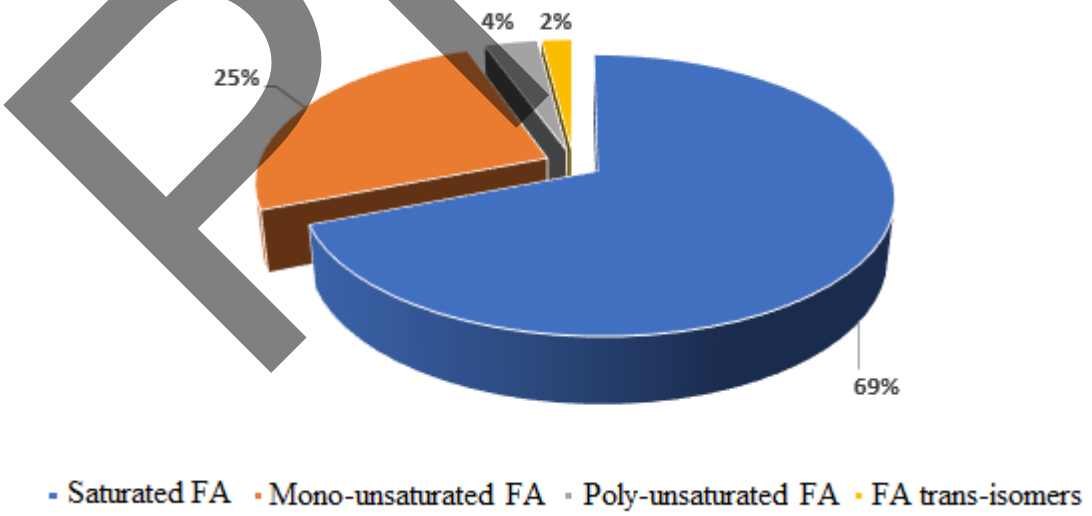

FIGURE 3. Distribution of fatty acids and their isomers in morning milk, %

Analysis of the ratio of fatty acids and their trans-isomers in milk obtained in the morning shows a high proportion of saturated fatty acids – 69%, the concentration of mono-unsaturated fatty acids was slightly lower, which was 25%. Poly-unsaturated fatty acids and transisomers of fatty acids account for only 4% and 2%, respectively.

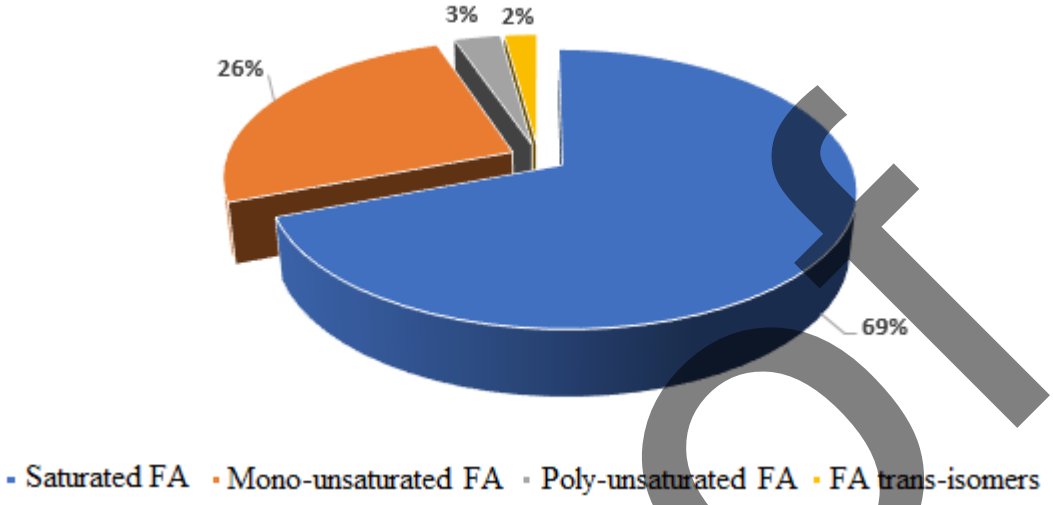

FIGURE 4. Distribution of fatty acids and their isomers in evening milk, %

In the milk of the studied herd of black-and-white cows obtained in the evening, the distribution of the proportions of fatty acids and their trans-isomers changed slightly. It is worth noting only an increase in the proportion of mono-unsaturated fatty acids by up to 26% (an increase of 1%) and a decrease by an corresponding value (up to 3%) in the proportion of poly-unsaturated fatty acids.

CONCLUSIONS

In the milk of black-and-white cattle of the breeding enterprise, both during certain periods of milking and on average per day, a high amount of saturated fatty acids is noted. Low content of poly-unsaturated fatty acids and their trans-isomers. During the summer, the daily change in the amount of fatty acids in cow milk and their trans-isomers occurs in a significant range – from 75.0% to 42.9%. The studied livestock of the breeding enterprise is characterized by a high genetic diversity in the content of fatty acids and trans-isomers of fatty acids, which in turn is a prerequisite for further improvement in terms of these traits.

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Antibiotic Susceptibility Characteristics of Opportunistic Gram-Positive Bacteria in Poultry Microbiocenosis

A.S. Krivonogova, I.M. Donnik, A.G. Isaeva [a)], E.A. Loginov, M.V. Petropavlovsky and E.N. Bespamyatnykh

Ural State Agrarian University, Karl Liebknecht 42, Yekaterinburg, 620075 Russian Federation

[a)] Corresponding author: isaeva.05@bk.ru

Abstract. Opportunistic pathogenic microflora inhabiting microbiocenoses associated with broiler chickens were studied. Gram-positive bacteria were studied in biomaterial from broiler chickens that were given the antibiotic avilamycin and a phytobiotic based on Brassica juncea, Linum usitatissimum, and Nigella sativa L. oils as an additive to the diet. The dynamics of the species composition of Staphylococcus spp., Enterococcus spp., phenotypic susceptibility to antibiotics vancomycin, ofloxacin, levomycetin, tobramycin were analyzed. Itwas found that the introduction of avilamycin into the diet of chickens led to a twofold decrease in the number of opportunistic cocci in the biomaterial from chickens. In the broiler biomaterial from the groups receiving phytobiotic, no antibiotic-resistant isolates of gram-positive cocci were detected, while the largest number of isolates were susceptible to antibiotics at a low value of the minimum suppressive concentration.

INTRODUCTION

The spread of antimicrobial resistance (AMR) in livestock and poultry microbiomes has now reached a critical level. The vast majority of agricultural enterprises are contaminated with resistance agents – microorganisms, geneticdeterminants, and AMR [1, 2, 3].

The emergence of resistant bacteria and the further spread of drug resistance in microbiomes was associated with the irrational use of antibiotics [4, 5]. The addition of antibiotics into the diet to stimulate growth and productivity, the violation of treatment regimens, the prophylactic use of antibiotics to reduce the incidence of livestock and low availability of laboratory antibioticsusceptibility testing (AST) in animal husbandry and poultry gradually led to the displacement of less adapted bacteria from microbiomes and their replacement in ecological niches with more resistant strains [2, 6, 7]. One of the most significant negative effects of the AMR spread, along with a decrease in the therapeutic effectiveness of antibiotics, is the contamination of humanmicrobiomes by AMR agents.

Bacterial resistance genes (ARGs) and non- pathogenic bacteria can be transmitted to humans through animal products - eggs, milk, meat that have not undergone antimicrobial treatment, as wellas, in contact with animals, their microbial products, and raw materials of animal origin [1, 2]. Thus, there are data on the detection of human opportunistic pathogens (E.coli, Enterobacter spp.) with genetic determinants of resistance, primarily detected in the microbiomes of farm animals and associated with extended-spectrum β-lactamases (ESBLs), [1, 8, 9, 10]. To a lesser extent, the spread ofARGs associated with non-pathogenic microorganisms and representatives of the normal microflora of humans and animals (Lactobacillus spp., Bifidobacterium, Bacillus licheniformis), which can also participate in the contamination of microbiomes with resistance determinants, has been studied [11, 12]. At the same time, the environment is important in the process of resistant bacteria emergence, their selection, maintenance, and distribution between adjacent ecological niches, causing contamination of previously untouched ecosystems [8, 13]. There is a lot of data on the mechanisms of distribution of individual resistance determinants (cmx, ctx-m, tet, bla, cfr, etc.) in animal microbiomes, while the authors note the stable nature of ARGs circulation, the risks of their

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migration along the food chain to humans, as well as trends towards interspecific distribution [9, 10, 14].

Since poultry is one of the most common types of meat consumed worldwide, and industrial poultry farming technologies are characterized by the use of a large number of antimicrobials for the prevention, treatment of diseases, and improvement of productivity, poultry microbiomes make a significant contribution to the formation and spread of AMR [3, 7, 15]

The existing mechanisms of horizontal gene transfer (HGT) and cross contamination of the organism with resistant bacteria are associated with the spread of ARGs in livestock and poultry enterprises [6, 7]. Transfer factors in this case can be not only technological lines, inventory, animals, and raw materials being moved, but also workers who are in direct contact with animals [6, 7].

The results of modeling conducted by van Bunnik et al. showed that currently the reduction in the use of antimicrobials in animal husbandry and poultry farming is no longer sufficient to contain AMR in humans [16]. Nevertheless, it is necessary to study the mechanisms of AMR spread in poultry enterprises, as well as the search for a replacement for antibiotics in poultry farming. One of the alternatives to preventive antibiotics is the use of phytobiotics that have antimicrobial and stimulating effects, but do not cause resistance in microorganisms.

MATERIALS AND METHODS

Opportunistic pathogenic microflora inhabiting microbiocenoses associated with broiler chickens were studied. 4 groups of 120 heads each were formed, which were in the same technological conditions in facilities isolated from each other to exclude the transfer of microorganisms between groups.

Chickens were raised from 1 day to slaughter on day 58. In groups #1 and #2, the antibiotic avilamycin A was introduced into the feed ("MaxusG-100, Eli Lilly and Company, USA). In groups #2 and #3, phytobiotic based on Brassica juncea, Linum usitatissimum and Nigella sativa L. oils were introduced into the diet for 21 days.

Microbiological studies of swabs from the cloaca of chickens and litter were carried out. Biomaterial samples were cultured on nutrient media according to standard microbiological methods. Identification of the grown colonies was carried out by the MALDI-TOF method (Vitek MS, BioMerieux, France). Susceptibility to antibiotics was determined by the method of minimal inhibitory concentration (MIC) according to the standard method (EUCAST), as well as using instructions for test systems. MIC for Enterococcus spp. was determined by the method of E-tests with vancomycin.

RESULTS AND DISCUSSION

Opportunistic pathogenic microflora inhabiting microbiocenoses associated with broiler chickens were studied.
During the experiment, 22 types of microorganisms were found in the swabs from the chicken cloaca, among which 11 were gram- positive (Figure 1). At the same time, staphylococci and enterococci accounted for 86%-100% of the gram-positive cultures detected in swabs. Staphylococci were most often detected in the biomaterial: S. epidermidis, S. succinus, S. xylosus, S. sciuri. At the same time, S. xylosus was most often detected (37.7%), S. aureus was least often detected (1.6% of the isolated Staphylococcus isolates) (Figure 2). The microbial load ranged from a single and poor growth to abundant. In addition, 21 Enterococcus isolates were found (Figure 3). More than half of the isolates were represented by E. gallinarum (52.4%), E. hirae was the least common (9.5% of the isolated enterococcal cultures). Streptococcus infantarius, Brevibacterium luteolum, Aerococcus viridans (the proportion of isolated strains less than 1%) were found in the samples.

During the experiment, 29 types of microorganisms were found in the samples of chicken litter, among which 11 species were gram- positive: they totaled 22.45% from obtained isolates. They also found 12 types of gram-negative bacteria, 6 types of yeast and mold fungi. Staphylococci and enterococci predominated – in total they accounted for 86%-92% of the gram-positive cultures detected in the samples (Figure 4). The microbial load is expressed in quantitative values and ranged from 10^2 CFU/gram to 10^8 CFU/gram.

It was found that in group 1, where chickens received feed containing an antimicrobial additive (avilamycin), single isolates of E. faecalis, E. gallinarum, and S. warneri were found in the swabs taken on day 1, which were not subsequently detected.

S. sciuri, S. succinus, and S. xylosus were detected in washes on days 13-56.

In the swabs from the chicken cloaca in group #2, which diet included both the antibiotic avilamycin and phytobiotic (Brassica juncea, Linum usitatissimum, Nigella sativa L.), only isolates of E. faecalis and E. hirae were

detected in the first three weeks in the swabs. Staphylococcus isolates were detected on days 24 and 37 (represented by S. xylosus). S. lentus was detected on day 56.

In the litter of experimental groups #1 and #2, which diet included an antibiotic, no isolates ofenterococci and staphylococci were detected. At thesame time, the total number of staphylococcus and enterococcus isolates in the biomaterial in groups#1 and #2 was 2.4 times less than in groups #3 and #4. This confirmed the avilamycin activity against these types of microorganisms.

In group #3, chickens received only aphytobiotic preparation as an additive. On the first day, only Enterococcus was present in the biomaterial. Staphylococci were detected from day 13.

At the same time, enterococci have not beendetected since this period. In group #4 (control), only feed was present in the diet without any additives. In this group, the vast majority of microorganisms were found, 36 isolates of Enterococcus and Staphylococcus were isolated in total. In the same group, the proportions of gram-positive bacteria and fungi were the highest among all four groups. The phenotypic susceptibility of Enterococcus spp. to vancomycin was determined. It was found that the proportion of vancomycin-sensitive isolateswas 54.5% with MIC of 1.0 mg/l - they were mainly represented by E. faecalis, E. hirae, and E. faecium. Isolates resistant to vancomycin (MIC higher than 4.0 mg/l) were represented by E. casseliflavus and E. gallinarum, characterized by natural resistance to vancomycin associated withthe chromosomally encoded operon vanC.

Staphylococcal isolates obtained from litter samples and swabs in all 4 groups were 98% susceptible to vancomycin at MIC 0.5-1.0 mg/l.

Studying of the phenotypic sensitivity of cocci isolated from the biomaterial of broiler chickens estimated that at the target value of the minimum inhibitory concentration, 94.4%, 85.7%, 97.2%, and 70.0% of the isolates were susceptible to ofloxacin, doxycycline, tobramycin, and levomycetin, respectively (Figure 5). The remaining isolates were susceptible to these antibiotics at higher values of MIC within the range of acceptable values, and were also evaluated as susceptible. The largest number of isolatessusceptible to the target MIC value was found in group #3, which received phytobiotic as an additive to the diet. The smallest number is in the control group #4.

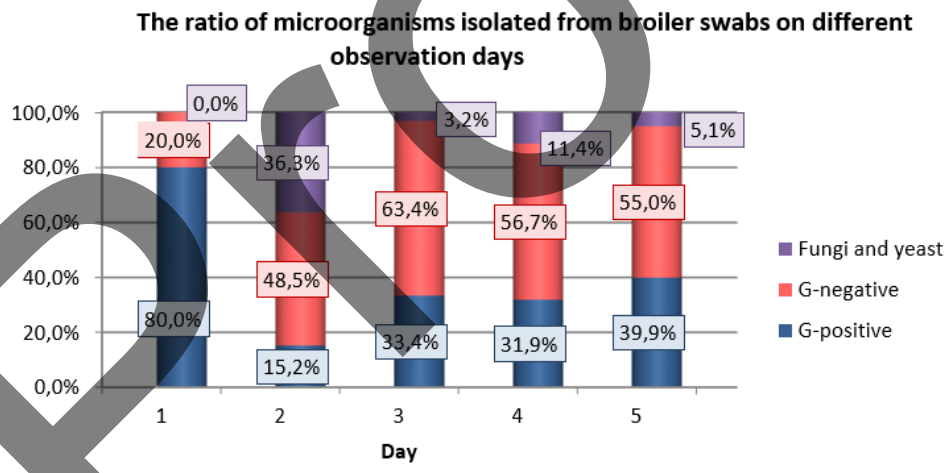

FIGURE 1. The ratio of microorganisms isolated from broiler cloaca swabs on different observation days.

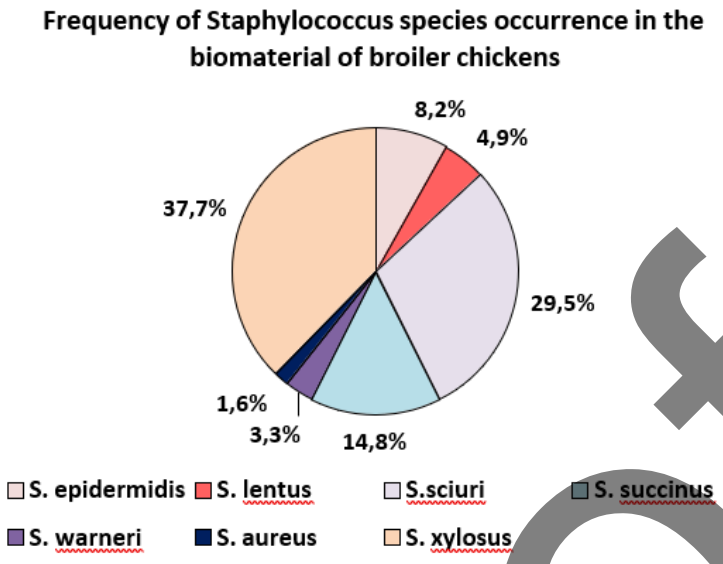

FIGURE 2. Frequency of Staphylococcus species occurrence in the biomaterial of broiler chickens.

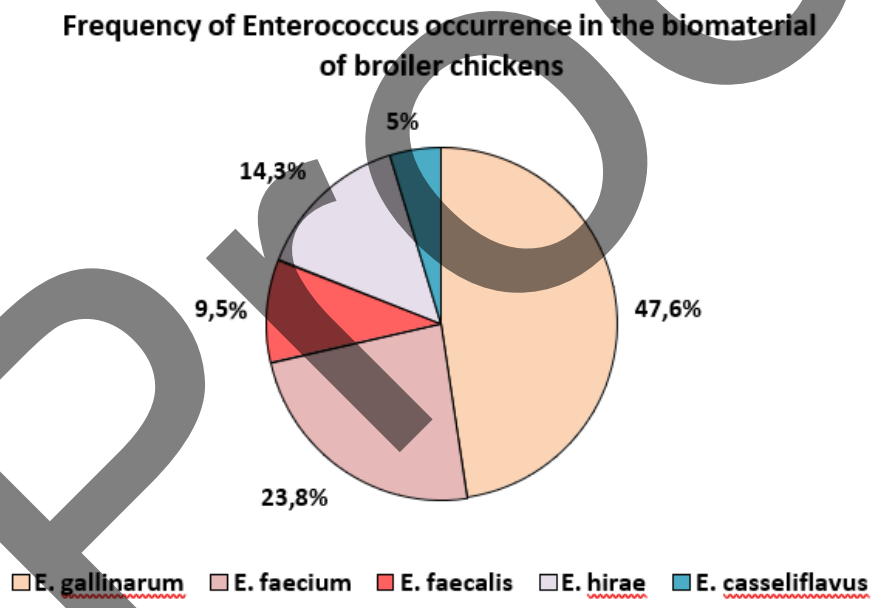

FIGURE 3. Frequency of Enterococcus occurrence in the biomaterial of broiler chickens.

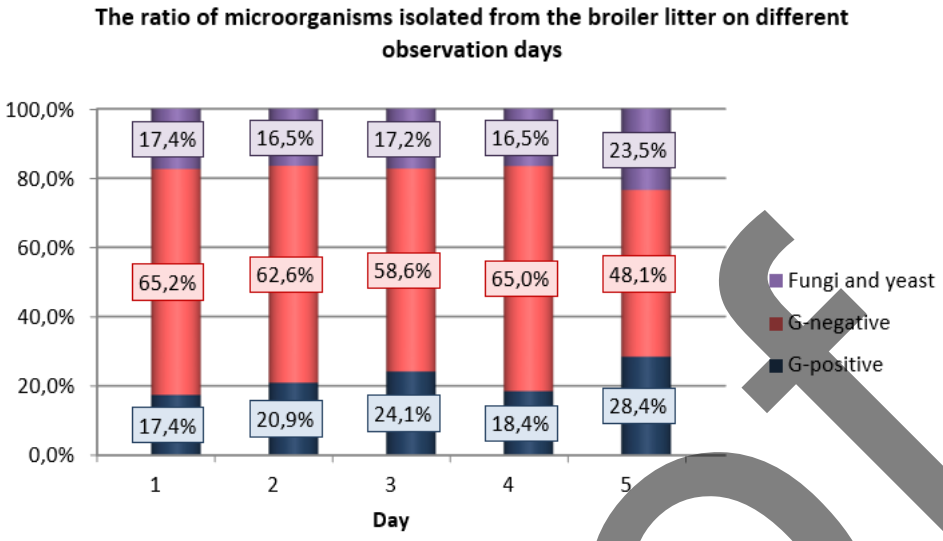

FIGURE 4. The ratio of microorganisms isolated from the broiler litter on different observation days.

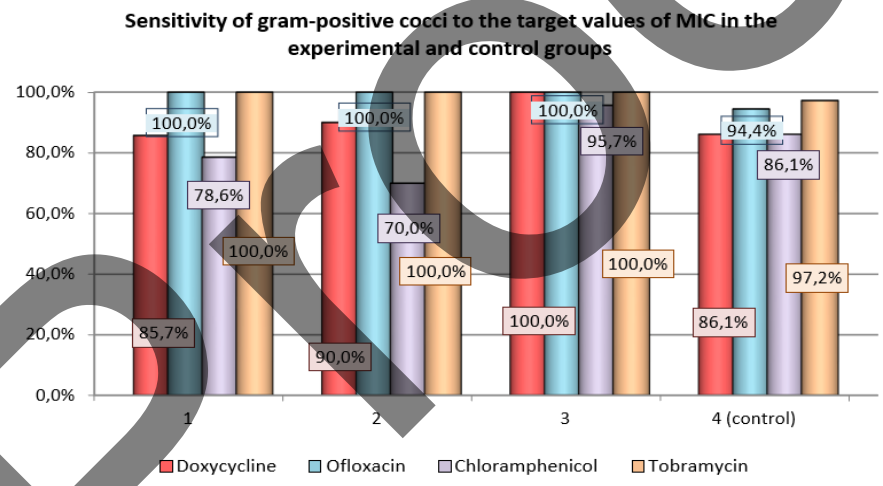

Figure 5. Susceptibility of gram-positive cocci to the target values of MIC in the experimental and control groups.

FIGURE 5. Susceptibility of gram-positive cocci to the target values of MIC in the experimental and controlgroups.

TABLE 1. Dynamics of the species composition of opportunistic cocci* and susceptibility to vancomycin.

	Microorganism, proportion of susceptible isolates, MIC**			
	Group 1	Group 2	Group 3	Group 4 (control)
Day				
1	S. warneri (MIC<0.5mg/l) E. faecalis (MIC<1.0 mg/l) **E. gallinarum** (MIC >4.0 mg/l – Resist.)	E. faecalis (MIC<1.0 mg/l) E. hirae (MIC<1.0 mg/l)	E. faecalis (MIC<1.0 mg/l) E. gallinarum (MIC<1.0 mg/l)	S. epidermidis (MIC<1.0 mg/l) **E. gallinarum** (MIC >4.0mg/l – Resist.)
13	S. sciuri (MIC<0.5mg/l) E. hirae (MIC<1.0 mg/l)	E. hirae (MIC<1.0 mg/l)	E. faecium (MIC<1.0 mg/l)	S. sciuri (MIC<1.0 mg/l) S. epidermidis (MIC<1.0mg/l) E. faecium (MIC<1.0 mg/l) **E. gallinarum** (MIC >4.0mg/l – Resist.)
24	S. sciuri (MIC<0.5mg/l) S. xylosus (MIC<0.5mg/l)	S. xylosus (MIC<0.5 mg/l)Str. infantarius (MIC<0.5 mg/l)	S. xylosus (MIC<0.5 mg/l) S. succinus (MIC<1.0 mg/l)	S. sciuri (MIC<1.0 mg/l) S. epidermidis (MIC<1.0mg/l) E. hirae (MIC<1.0 mg/l) S. xylosus (MIC<0.5 mg/l) **E. casseliflavus** (MIC >4.0mg/l – Resist.)
37	S. sciuri (MIC<0.5mg/l) S. xylosus (MIC<0.5mg/l)	S. xylosus (MIC<0.5 mg/l)	S. xylosus (MIC<0.5 mg/l) S. sciuri (MIC<1.0 mg/l)	S. sciuri (MIC<1.0 mg/l) S. epidermidis (MIC<1.0mg/l) S. xylosus (MIC<0.5 mg/l) S. succinus (MIC<1.0 mg/l)
56	S. sciuri (MIC<0.5mg/l) S. succinus (MIC<1.0mg/l) S. xylosus (MIC<0.5mg/l)	S. lentus (MIC<0.5 mg/l)	S. xylosus, (MIC<0.5 mg/l) S. sciuri (MIC<0.5 mg/l)	S. sciuri (MIC<1.0 mg/l) **S. epidermidis** (MIC>5.0mg/l – Resist.) S. xylosus (MIC<0.5 mg/l) S. aureus (MIC<1.0 mg/l)
Numb erof isolates	14	10	23	36

*Staphylococcus n=61, Enterococcus n=21, Streptococcus n=1
**permissible values of MIC 0.5-2 mg/l

CONCLUSION

Studies of the species composition and antibiotic susceptibility of oportunistic cocci of microbiocenoses associated with broiler chickensshowed that the predominant microorganisms in all 4 groups of chickens were Staphylococcus spp. and

Enterococcus spp. - they ranged from 86% to 100%of the obtained isolates of gram–positive bacteria. It was found that in the swabs from chicken cloaca and in the litter samples in experimental groups #1 and #2 treated with the antibiotic avilamycin, the number of these microorganisms in the samples

was 2.4 times less than in the biomaterial from groups #3 #4. Analysis of the phenotypic susceptibility of obtained isolates to ofloxacin, doxycycline, tobramycin, and levomycetin showed that the majority of isolates (more than 70%) were susceptible to the target values of the minimum inhibitory concentration of the antibiotic. The growth of the remaining isolates was inhibited at a higher MIC, but not exceeding the permissible value, that is, all isolates were evaluated as"susceptible". An analysis of the susceptibility of the detected isolates of Staphylococcus and Enterococcus to vancomycin showed that more than half of the detected enterococci were susceptible at the target value of MIC 1.0 mg/l. At the same time, E. casseliflavus and E. gallinarum isolates with chromosomal-mediated natural resistance to this antibiotic demonstrated resistance to vancomycin (MIC higher than 4.0 mg/l). Staphylococcal isolates isolated from litter samples and swabs in all 4 groups were 98% susceptible to vancomycin at MIC 0.5-1.0 mg/l.

Vancomycin-resistant strains were identified only in groups #1 and #4, which did not receive phytobiotic. At the same time, no antibiotic- resistant isolates of Staphylococcus spp. and Enterococcus spp. were detected in the biomaterial of broilers from groups #2 and #3 treated with phytobiotic. Also, broilers who received only a phytobiotic supplement were found to have the maximum number of isolates with good susceptibility to vancomycin, tobramycin, ofloxacin and levomycetin. In this group, the largest number of isolates were susceptible to antibiotics at a low value of the minimum inhibitory concentration. For a more detailed study of the phytobiotics effect on resistant strains of opportunistic cocci in microbiocenoses of broiler chickens, it is desirable to conduct similar studies over a longer time period.

ACKNOWLEDGEMENT

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Effects of Gibberellic Acid on the Regeneration of *Amelanchier* Medik. Cultivars *in Vitro*

Ekaterina Raeva-Bogoslovskaya [a)] and Olga Molkanova

Tsitsin Main Botanical Garden of Russian Academy of Sciences, 127276 Botanicheskaya street 4, Moscow, Russian Federation

[a)] Corresponding author: katyaraeva@rambler.ru

Abstract. *Amelanchier* Medik. is a promising for cultivation in Russia fruit crop with abiotic stress tolerance. Plants of this genus are deciduous shrubs or small trees with edible sweet fruits. The work is devoted to the improvement of the clonal micropropagation method of cultivars *Amelanchier*. A significant influence of the genotype on the number of microshoots (83%) and gibberellic acid (GA_3) on the height of microshoots (73%) was established. *A. alnifolia* 'Krasnoyarskaya' was characterized by the greatest number of microshoots (7.79 pcs.). The use of 1.0 mg/l GA_3 in combination with 1.0 mg/l 6-benzylaminopurine (BA) significantly affected the height of microshoots of *A. alnifolia* 'Thiessen' (28.9 mm) and *A. canadensis* 'Prince William' (27.3 mm). The addition of 1.0 mg/L GA_3 to 1.0 mg/L BA reduced the number of vitrified microshoots of 'Prince William'.

INTRODUCTION

Expanding the range of berry crops, that are resistant to various environmental factors, significantly improves the quality of human life. To solve this problem it is necessary to study rare plant species and introduce their promising cultivars into industrial production. One of such crops for Russia is the serviceberry (*Amelanchier* Medik.). The habitat of most species with economically valuable traits is located in North America and Canada where serviceberry has been grown as a fruit plant since the 19th century [1].

Serviceberry fruits are characterized by a rich biochemical composition. They are distinguished by the highest sugar content (10.0–13.5%) in comparison with chokeberry, ashberry, raspberries, hurtleberry and honeysuckle [2]. This implies the possibility of using products of serviceberry processing as a substitute for sugar in flour products [3]. Due to the high content of anthocyanin serviceberry is used as a natural food coloring. [4, 5]. The fruits have a harmonious taste so juices, wines, compotes, jams and marmalade are prepared from them [6, 7].

Serviceberry is used for medicinal purposes. The fruits can be used to produce natural multivitamin concentrates and therapeutic and prophylactic products [8]. Some researchers noted the high content of flavonols in the fruits of serviceberry in comparison with other berry crops. [9]. The antioxidant properties of alcoholic extracts of various parts of the plant have been identified [10].

Serviceberry is propagated by generative and vegetative methods [4, 6, 11, 12]. The use of seed propagation to obtain varietal seedlings of serviceberry is not suitable since the offspring differ from the mother plant. Of the vegetative propagation methods, grafting and cuttings are the most common, the implementation of which largely depends on the time of year and requires maintenance of scion and rootstock parent plants [6, 7]. Clonal micropropagation has an advantage over traditional methods of propagation [13]. Some cultures are characterized by shortened microshoots under in vitro conditions which reduces the efficiency of further rooting and adaptation [14, 15, 16]. The solution to this problem is the introduction of an additional elongation step or the addition of various growth regulators to the nutrient medium, one of which is gibberellic acid (GA_3).

There is a small number of works devoted to the use of gibberellic acid in plants of the genus *Amelanchier* in the scientific literature. K. Pruski and J. Hunková established the effectiveness of using a GA_3 solution in combination with 6-benzylaminopurine (BA) to overcome dormancy after the stage of adaptation in *A. alnifolia* plants [17, 18].

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The influence of gibberellic acid at the micropropagation stage was studied by V. A. Vysotsky by the case of *A. canadensis*. The addition of GA_3 to the nutrient medium did not affect the morphology of microshoots and the use at a concentration of more than 2.0 mg/l led to leaf chlorosis [12].

To date, the method of in vitro cultivation of the genus *Amelanchier* representatives requires improvement which makes research in this direction relevant.

The aim of the scientific work is to study the effect of gibberellic acid on the regeneration of serviceberry cultivars during clonal micropropagation.

RESEARCH OBJECTS AND METHODS

Various members of the genus *Amelanchier* are propagated and preserved in the Tsitsin Main Botanical Garden of Russian Academy of Sciences. The objects of study and their brief description are presented in the table 1.

TABLE 1. Economic features of serviceberry cultivars.

Species	*A. alnifolia*		*A. canadensis*
Cultivar	'Krasnoyarskaya'	'Thiessen'	'Prince William'
Height, m	4,0	3,5-4,0	2,5-3,0
Plant habitus	Sprawling shrub	Sprawling shrub	Compact shrub
Maturing term	End of July	Mid July	Mid July
Fruit size, mm	1,7	1,8	1,5
Fruit form	Pear-shaped	Spherical	Spherical
Fruit color	Blue-black	Violet blue	Purple
Fruit taste	Sweet with sourness	Sweet	Sweet

The cultivation of microshoots was carried out on Murashige-Skoog (1962) nutrient medium with the addition of growth regulators: 1.0 mg/l 6-benzylaminopurine (BA) and 1.0 mg/l BA in combination with 1 mg/l GA_3. The nutrient medium without the addition of GA_3 was used as a control. The experiments were carried out in 3 repetitions with 10 explants in each.

During cultivation the following conditions were maintained: lighting of 2000 lux, 16-h photoperiod, temperature 23-25°C. After 28 days the height of the microshoots was measured and the number of microshoots was counted.

The obtained data were processed according to the generally accepted methods of ANOVA statistical analysis [21] using Microsoft Office Excel 2010 software.

RESULTS AND DISCUSSION

The regenerative potential of a plant in vitro depends on many factors: the type of explant, genotype, mineral and hormonal composition of the nutrient medium, cultivation conditions, etc. The most effective way of clonal micropropagation of serviceberry cultivars is to stimulate the formation of adventitious microshoots which makes it important to study their morphometric parameters. In the course of statistical analysis the influence of factors on the number and height of microshoots of serviceberry cultivars was revealed (Fig. 1)

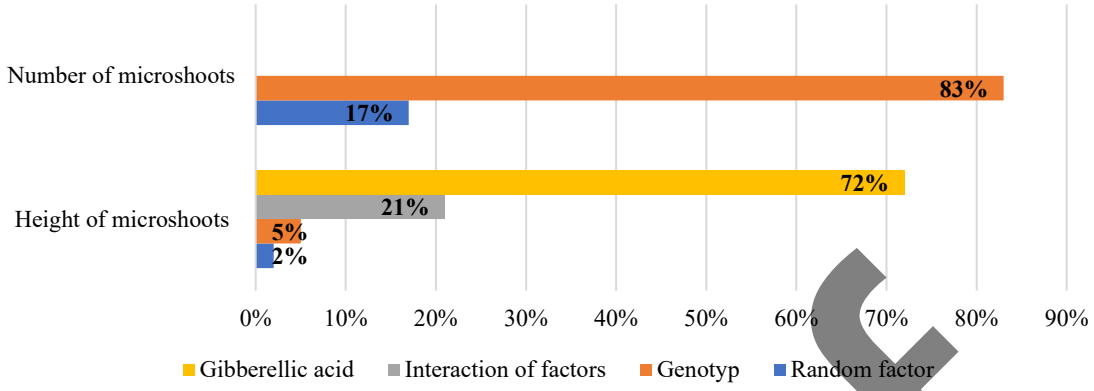

FIGURE 1. Influence of factors on morphometric parameters of serviceberry cultivars in vitro.

The plant genotype completely controlled the number of microshoots (83%), other factors did not significantly affect this indicator. In turn, the addition of 1.0 mg/l GA_3 to the nutrient medium had a significant effect on the height of microshoots of serviceberry cultivars (72%), the interaction of factors (22%) and the plant genotype (5%) had a lesser effect.

The number of microshoots is one of the indicators that characterizes the morphogenetic potential of a culture. The cultivars of serviceberry differed significantly in the number of microshoots (Fig. 2)

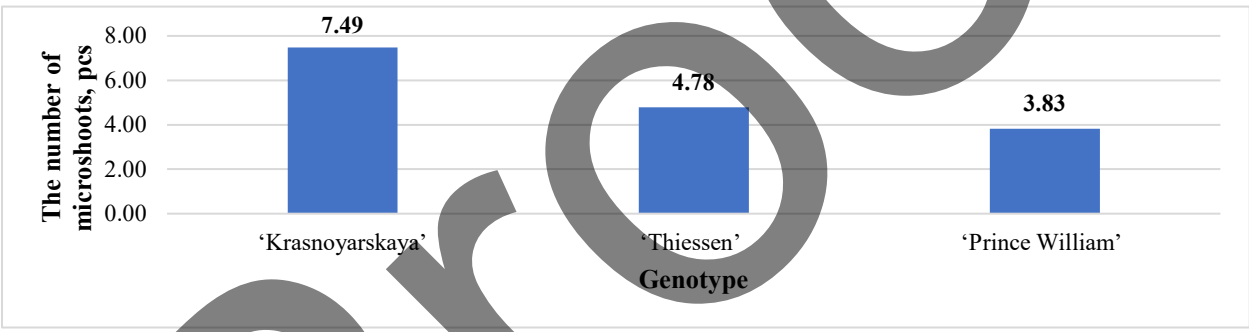

FIGURE 2. The number of microshoots of serviceberry cultivars depending on the genotype (LSD_{05} 1,82).

The number of microshoots in 'Krasnoyarskaya' cultivar (7.49 pcs.) was significantly higher than in other studied cultivars. Significant difference between cultivars of serviceberry 'Thiessen' (4.78 pcs.) and 'Prince William' (3.83 pcs.) was not found. This is consistent with studies by Boga A. where the addition of 1.0 mg/l GA_3 to 0.5 mg/l BA did not affect the number of microshoots of *Dalbergia latifolia* [19].

It should be noted that the explants differed to the number of newly formed microshoots and were conventionally divided into 3 groups: from 3 to 6 pcs; from 7 to 10 pcs; from 11 to 14 pcs. (tab.2).

TABLE 2. Ratio of explants of serviceberry cultivars with different numbers of adventitious microshoots, %.

Genotype	Number of microshoots per explant		
	3-6 pcs.	7-10 pcs.	11-14 pcs.
'Krasnoyarskaya'	43	41	16
'Thiessen'	82	18	
'Prince William'	100		

Serviceberry ‘Krasnoyarskaya’ differed to a greater extent in the number of microshoots: 43% of explants formed 3-6 pieces, 41% formed from 7 to 10 pieces, and 16% formed from 11 to 14 pcs. Explants of cultivar ‘Thiessen’ to a greater extent formed from 3 to 6 microshoots per explant (82%) and to a lesser extent from 7 to 10 microshoots per explant. (eighteen%). In the case of cultivar 'Prince William' all explants formed from 3 to 6 microshoots.

The height of microshoots is an important feature for rooting and the adaptation stage. The height of microshoots in most cultivars of serviceberry increased on a nutrient medium containing GA_3 (Fig. 2). This is consistent with studies by other authors, where the use of GA_3 in combination with BA contributed to an increase in the height of microshoots. [14, 15, 16].

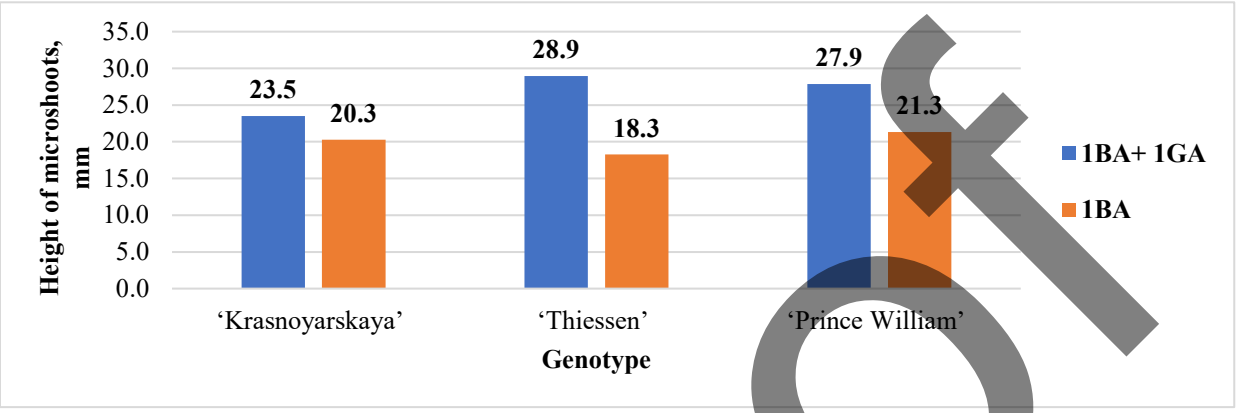

FIGURE 3. Influence of nutrient media with the addition of 1.0 mg/l GA3 and without GA3 on the height of microshoots of various representatives of the genus *Amelanchier* LSD_{05} 3,2.

The greatest difference in the use of gibberellic acid in the nutrient medium was noted in the cultivar ‘Thiessen’: the height of microshoots in comparison with the control variant was 57% higher. GA_3 contributed to a 31% increase in microshoot height in ‘Prince William’. The addition of GA_3 did not significantly affect the height of microshoots of the serviceberry cultivar 'Krasnoyarskaya'.

Microshoots of serviceberry cultivars differed in height, as a result three groups were distinguished: from 5 to 16 mm, from 17 to 18 mm, and from 29 to 41 mm (Fig. 4)

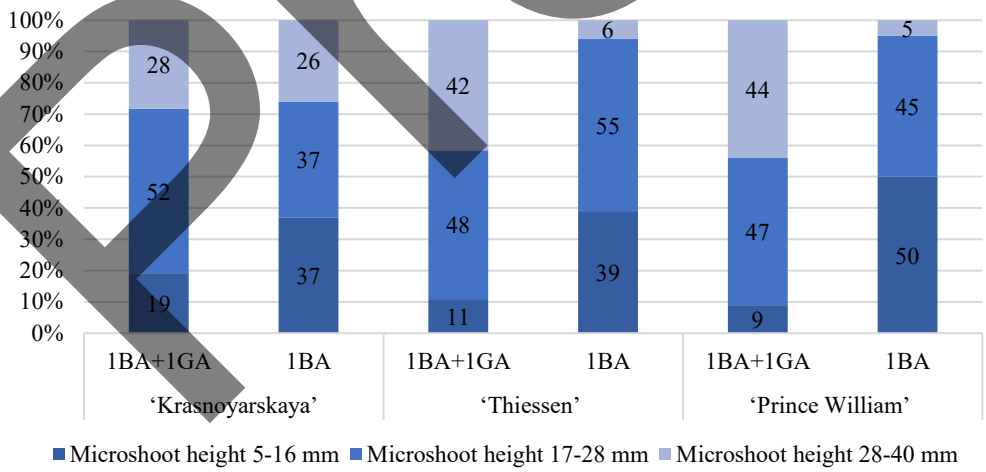

FIGURE 4. The ratio of microshoots of serviceberry cultivars by height on media with the addition of 1.0 mg/l GA_3 and without GA_3

The use of GA_3 contributed to an increase in the number of microshoots with a height of 17 to 28 mm in ‘Krasnoyarskaya’. The addition of gibberellic acid to the nutrient medium increased the number of microshoots from

28 to 41 mm in the serviceberry cultivars ‘Thiessen’ and ‘Prince William’. 'Prince William' and 'Thiessen' to a greater extent formed microshoots with a height of 5 to 16 mm on the control.

It should be noted that the nutrient medium without GA3 contributed to the formation of thickened microshoots as well as the rupture of microshoot tissues (Fig. 5)

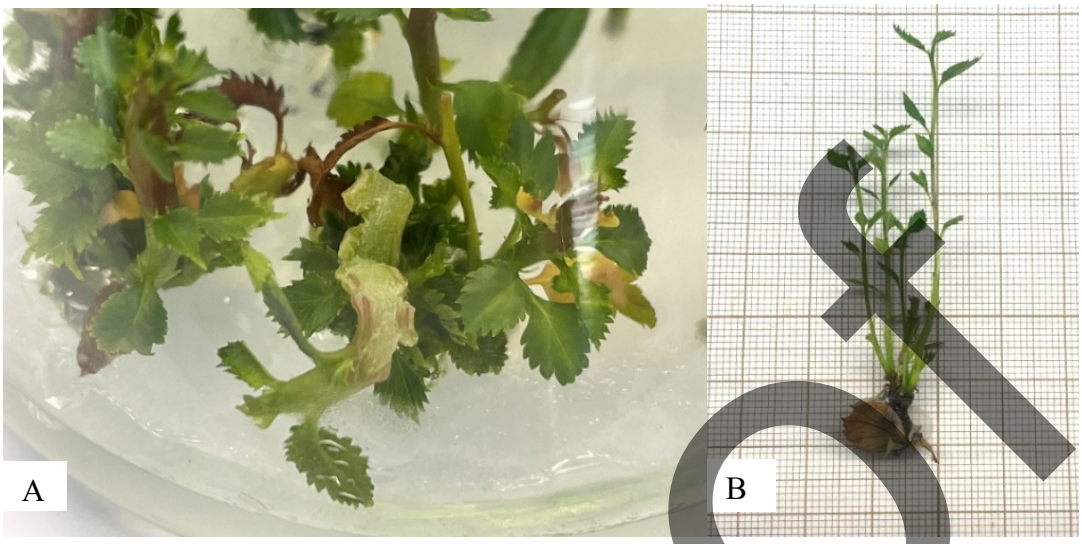

FIGURE 5. Microshoots of serviceberry ‘Prince William’ cultivar on a medium with: A – 1.0 mg/l BA; B - 1.0 mg/l BA + 1.0 mg/l GA_3

Vitrified microshoots grew more slowly and reached a height of more than 20 mm after 2 months while explants cultivated on a nutrient medium supplemented with 1.0 mg/l GA_3 were characterized by a height of more than 20 mm after 28 days of cultivation.

CONCLUSION

The significant influence of the genotype (83%) on the number of microshoots was found. The number of microshoots in ‘Krasnoyarskaya’ cultivar (7.49 pcs.) was significantly higher than in other studied cultivars (4.78 pcs. in ‘Thiessen’, 3.83 pcs. in ‘Prince William’). Explants of ‘Krasnoyarskaya’ were characterized by a different number of microshoots: 43% formed from 3 to 6 pcs., 41% formed from 7 to 10 pcs., and 16% formed from 11 to 14 pcs. Cultivars ‘Thiessen’ and ‘Prince William’ mostly formed 3-6 microshoots in vitro.

The average height of microshoots of different serviceberry cultivars was 34% higher on the nutrient medium with GA3 than on the control. The greatest difference in the use of gibberellin in the medium was noted in the cultivars ‘Thiessen’ (the height of microshoots increased by 57%) and ‘Prince William’ (the height of microshoots increased by 31%). The use of GA_3 contributed to an increase in the number of microshoots with a height of 17 to 28 mm in the cultivar ‘Krasnoyarskaya’. In the case of serviceberry cultivars ‘Thiessen’ and ‘Prince William’ the addition of gibberellic acid to the medium increased the number of microshoots from 28 to 41 mm. An increased water content of microshoots and rupture of explant tissues was noted in the cultivar ‘Prince William’ on a nutrient medium containing 1.0 mg/l BA. The addition of GA_3 at a concentration of 1.0 mg/l reduced the negative effect of BA on the tissues of the ‘Prince William’ explant.

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Detection of *Pseudomonas Savastanoi* pv. Glycinea in Soybean Seeds Using PCR Assay

Rashit Tarakanov[1, a)], Irina Ignatyeva[2] and Fevzi Dzhalilov[1]

[1] *Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, Department of Plant Protection, 127434 Moscow, Russian Federation*
[2] *All-Russian Plant Quarantine Centre, Laboratory of Bacteriology, 140150 Bykovo, Russian Federation*

[a)] Corresponding author: tarakanov.rashit@mail.ru

Abstract. This article shortly describes the application of classical PCR for the identification of *Pseudomonas savastanoi* pv. *glycinea* in soybean seeds. 2 methods of pathogen extraction in infected soybean seeds, 5 DNA isolation techniques, and 2 master-mixes have been studied. It can be seen that for highly sensitive diagnostics the implementation of the destruction of seeds in a homogenizer, DNA allocation by Proba-GS set, application of 5x MasDDTaqMIX-2025 master-mix, and 1 µL volume primers per reaction are required.

INTRODUCTION

One of the most economically notorious diseases of bacterial etiology of soybean is bacterial blight (path. *Pseudomonas savastanoi* pv. *glycinea*, (Coerper 1919) Gardan et al. 1992 (synonym - *Pseudomonas syringae* pv. *glycinea* (Coerper 1919) Young et al. 1978), further *P. s. glycinea*).

P. s. glycinea affects all parts of soybean, whereas, primary symptoms start to emerge on leaves of the top and the middle tiers, therefrom, the pathogen spreads throughout the plant, including newly forming beans. As a rule, in 5-15 days after the infection, the leaves have necrotic oil spots with chlorotic halo, which amalgamate and form necrosis zones on leaves. After the pathogen damage, prolificness might decrease up to 40%, sowing qualities of seeds can be worsened as well [2].

The spread of the bacteria to new territories due to the intensification of soybean production in the country is possible within the seed material which has the infection in a latent state; as a result, it can evoke epiphytoty of bacterial blight in favorable conditions.

A promising method for identifying bacteria in soybean seeds is the use of PCR with the detection of the *cfl* gene fragment (product size 650 bp), which encodes the thermoregulated coronafacate ligase gene. Coronatine ligase is a component of the synthesis of the phytotoxin coronatine, which is necessary for the initiation of pathogenesis in the plant. In this case, primers PsgFOR-1 ('5-GGC GCT CCC TCG CAC TT-3') and PsgREV-2 ('5-GGT ATT GGC GGG GGT GC-3') specific for the above gene [3] are used.

MATERIALS AND METHODS

Conditions for PCR

For amplification, a PCR mixture was prepared to comprise 5x Master Mix (5x MasDDTaqMIX-2025, Dialat LTD) - 5 µL; 1.0 µL of each primer at a concentration of 10 pM/µL; 5 ng DNA - 5 µL; water for PCR - 13 µL. The final volume of the mixture was 25 µL. Amplification conditions were as follows: preliminary denaturation at a temperature of 96 °C - 10 min; denaturation at 96°C - 30 s, primer annealing at 67°C - 2 min, elongation at 72°C - 30 s, 40 cycles; final elongation at 72 °C - 5 min.

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Determination of sensitivity and specificity

To determine the PCR sensitivity, a loop (diameter 2 mm) of a 3-day-old culture of the CFBP 2214 strain [4] grown on King B agar medium was suspended in a sterile 10 mM $MgCl_2$ solution and tenfold dilutions were made. 100 µL of the suspension from each dilution was plated in triplicate on King B medium and incubated for 72 h, followed by colony counting. In parallel, DNA was isolated from each dilution using the Proba-GS kit (Agrodiagnostica, Moscow, Russia) and analyzed according to the program presented earlier. The tests were carried out on «T100 Thermal Cycler Bio-RAD» (Applied Biosystems USA) and «Nyxtechnik» ATC 201 (Nyx Technik, Inc., USA) cyclers. Electrophoretic separation of amplicons was performed in 0.5x TBE buffer in the presence of ethidium bromide. Visualization was performed using the Gel DocXR+ (Bio-Rad) gel documentation system. The repetition of the experiment is twofold (one reaction per cycler).

To determine the specificity, we used the DNA of closely related and other species of endophytic and phytopathogenic bacteria stored in the bioresource collections of the All-Russian Center for Plant Quarantine (Bykovo, Russia) and the Department of Plant Protection of the Russian State Agrarian University-Moscow Timiryazev Agricultural Academy (Moscow, Russia). The DNA of the following bacteria was studied: *Pseudomonas congelans, Pseudomonas syringae* pv. *syringae, Xanthomonas campestris* pv. *campestris, Pectobacterium carotovorum* subsp. *odoriferum, Pectobacterium wasabiae, Pseudomonas fuscovaginae, Pseudomonas* sp. *(isolated from carrot), Pseudomonas* sp. (isolated from pea), *Pseudomonas azotoformans, Pseudomonas syringae, Pseudomonas hibiscicola, Curtobacterium flaccumfaciens* pv. *flacumfaciens, Curtobacterium flaccumfaciens* pv. *oortii, Curtobacterium flaccumfaciens* pv. *poinsettiae, Pseudomonas savastanoi* pv. *phaseolicola, Pseudomonas savastanoi* pv. *phaseolicola, Pseudomonas savastanoi* pv. *glycinea, Xanthomonas axonopodis* pv. *phaseoli, Clavibacter michiganensis* subsp. *nebraskensis, Clavibacter michiganensis* subsp. *michiganensis, Pseudomonas fluorescens, Pseudomonas syringae* pv. *aptata, Pseudomonas syringae* pv. *syringae (Pseudomonas holci), Pseudomonas syringae* pv. *tomato, Pseudomonas graminis, Xanthomonas* sp. (isolated from clover), *Pseudomonas* sp. (isolated from pea), *Pseudomonas sp.* (isolated from maize), *Pseudomonas sp. (isolated from soybean), Pseudomonas syringae pv. syringae, Pseudomonas* sp. (isolated from fruit trees), *Pseudomonas* sp. (isolated from dry bean), *Pseudomonas corrugata, Pseudomonas baetica, Pseudomonas* sp. (isolated from fruit trees), *Pseudomonas nitroreducens, Pseudomonas syringae* pv. *maculicola, Pseudomonas* sp. (isolated from fruit trees). PCR conditions were similar to those mentioned above.

Artificial infection of seeds

Seeds of soybean cv. Kasatka were infected according to the protocol of Rooney et. al. [5] with modifications. For this, a three-day culture of strain CFBP 2214 was grown at a temperature of 18°C in an agar medium. The bacteria were resuspended in sterile 10 mM $MgCl_2$ and adjusted the concentration to OD_{600}~0.2, which corresponded to 10^4 CFU/mL. Seeds were poured into a sterile flask and filled with a bacterial suspension until the seeds are completely submerged. In one case (to create surface infections), the seeds were left for 1 h in solution and subsequently dried for 24 h on paper towels. To create an internal infection flask with seeds and the bacterial suspension was placed in a vacuum chamber at -10^5 Pa for 10 min. The processed seeds were dried for 24 h on paper towels to remove redundant liquid.

Determining the optimal method for extracting the pathogen from seeds

To establish the optimal method for extracting the pathogen from seeds, the following procedure were used: 1) shaking the seeds with the buffer on a shaker and 2) destroying the seeds in the buffer, recommended for the extraction of *Curtobacterium flaccumfaciens* pv. *flaccumfaciens* in bean seeds [6]. For the first method, 200 g of artificially infected seeds of soybeans with internal and external infection were placed in a flask, filled with 300 mL of SPS buffer, and placed on a shaker at +4°C for 12 h at 180 rpm. With the second method, the seeds were filled with buffer and placed for 12 h at +4°C. After swelling the seeds were transferred to plastic bags and destroyed in the BagMixer 400R homogenizer for 300 s. In both cases, it was further filtered employing sterile cotton filters, the suspension was centrifuged at 8000 rpm at +4°C, the supernatant was removed and the pellet was resuspended in 1.5 mL SPS buffer, centrifuged at 13000 rpm, and removed the supernatant. From the obtained extracts seeds, DNA was isolated using the Proba-GS kit according to the instructions manufacturer and carried out the PCR reaction according to the conditions given earlier.

Master mix selection

To determine the optimal pair "DNA extraction method-master-mix" from seed extract with internal infection and extraction with a homogenizer, DNA was isolated by five different kits and methods. As variants, 3 commercial kits were used (Proba GS (LLC "AgroDiagnostics"), Fitosorb and Cytosorb (LLC "Synthol")) and 2 methods (heating in NaOH (called «thermal» and modified SDS-CTAB method (mSDS-CTAB)). In the case of commercial kits, the manufacturer's instructions were followed.

For the method with heating in NaOH (thermal), NaOH was added to the extract to a concentration of 50 mM and placed in a solid state thermal bath at 96°C for 10 min [7]. In the case of the modified SDS-CTAB method, the protocol [8] was followed. In analysis used 2 master mixes: 5x Master Mix (5x MasDDTaqMIX-2025, Dialat LTD) and 5x ScreenMix-HS ("Evrogen"). Thus, in experience 10 variants were analyzed (2 master mixes x 5 DNA extraction methods). Selection of the volume of primers was carried out by varying them from 0.5 to 2 μL per reaction.

Determining the optimal method for DNA extraction at different pathogen locations

In the experiment, seed extracts with internal and external infection were isolated DNA with 5 different kits and methods described in section 2.5. Thus, the number of experimental options was 20 (5 methods of selection x 4 options of localization and extraction of the pathogen). After DNA isolation, PCR was performed under the previously described conditions.

Obtaining results and statistical processing

Analysis of graphic images of electrophoresis results obtained was carried out using the IMAGE J2 program (National Institute of Health, USA) according to the protocol [9]. Statistical processing of the analyzed data was implemented through analysis of variance using Statistica 12.0 (StatSoft, TIBCO, Palo Alto, CA, USA), comparing the mean values according to Duncan's new multiple range test (MRT) and by using the Kruskal-Wallis test applying Dunn's Multiple Comparison Test. Graphical presentation of results and partial statistical analysis were performed using GraphPad Prism 9.2.0 software. (GraphPad Software, San Diego, CA, USA).

RESULTS AND DISCUSSION

Determination of sensitivity and specificity

Our PCR-based study using commercial amplification mix 5x MasDDTaqMIX-2025 (Dialat Ltd) showed that the analytical sensitivity was 2 x 10^3 CFU/mL (Figure 1).

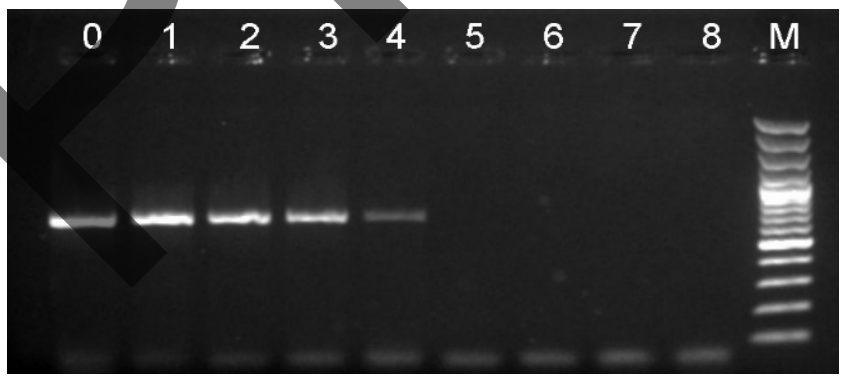


FIGURE 1. Electrophoregram of PCR products with primers PsgFOR-1 and PsgREV2-1, where 0 - 10^7 CFU/mL, 1 - 10^6 CFU/mL, 2 - 10^5 CFU/mL, 3 - 10^4 CFU/mL, 4 - 10^3 CFU/mL, 5 - 10^2 CFU/mL, 6 - 10^1 CFU/mL, 7 - 10^0 CFU/mL, 8 - negative control, M - 100+ bp DNA Ladder (Evrogen) Molecular Weight Marker.

When testing the analytical specificity, no cross-reactions of the primers with other phytopathogens were noted. In some strains, non-specific products were marked, the dimensions of which did not match the length (of the product)

of the target organism. With one strain (*Pseudomonas syringae* pv. *tomato*) product similar in size to the size of the amplicon of the pathogen under study, however, given that this strain infects tomato, its presence on soybean seed samples is unlikely, which is consistent with the results of the work of foreign colleagues [10]. Thus, the analytical sensitivity was 97.4% out of 37 tested closely related and other bacteria.

Determining the optimal method for extracting the pathogen from seeds

Considering that the pathogen might be found on the surface and under the seed shell, it is necessary to carry out extraction both by flushing from the surface of the seeds and by destroying the seeds in the buffer. For this reason, it was necessary to determine the best method to achieve maximum amplicon peak area, for internal and superficial infections.

The results show that the maximum peak area of the amplicon was achieved with external infection, both with flushing and with the destruction of seeds, the peak area was 416.9 and 390.7, respectively (Figure 2). With internal infection, the peak area decreased and averaged 245.0 and 85.5 at seed destruction and washout, correspondingly. Therefore, as a pathogen extraction method from infected seeds, seed destruction must be applied.

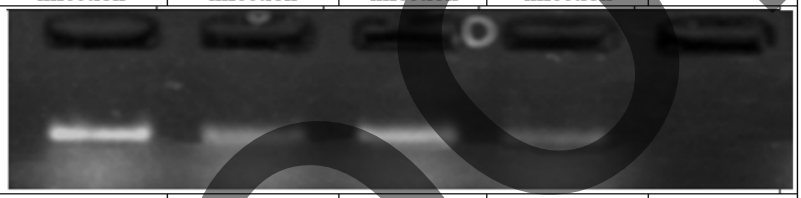
Variant	seed destruction - external infection	seed destruction - internal infection	flushing in a shaker - external infection	flushing in a shaker - internal infection	Negative control (no DNA)
Image of bands on gel for electrophoresis					
Area	416.9 ±27.0	245.0 ±18.5	390.7 ±24.3	85.0±11.0	1.1±0.3
Histogram in the IMAGE J2 program					

FIGURE 2. Graphical representation of the results of electrophoresis obtained by processing in the IMAGE J2 program on variants of localization of infection and methods for extracting the pathogen from seeds.

Master mix selection

An experiment using DNA isolated by five different methods and two master mixes shows that the peak area was maximum (645.0) when extracting DNA using the Proba-GS kit and using the 5x MasDDTaqMIX-2025 master mix (Figure 3A).

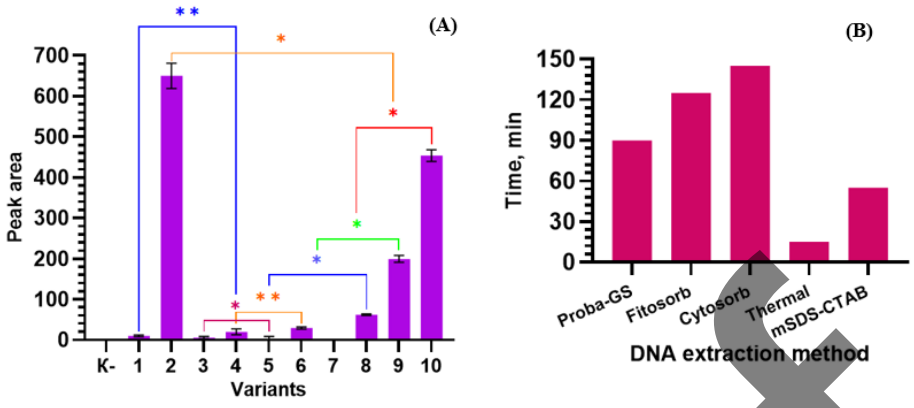


FIGURE 3. Peak area values depending on the DNA extraction methods and master mix. Error bars show the standard deviation in triplicate. K - negative control (ddH2O). Note: 1-2 - Proba-GS, 3-4 - Phytosorb, 5-6 - Cytosorb, 7-8 - Thermal, 9-10 – mSDS-CTAB (**A**). Even options - 5x MasDDTaqMIX-2025, odd - 5x ScreenMix-HS. Statistical differences were assessed using the Kruskal-Wallis test using Dunn's multiple comparison test. * - no differences, ** - differences at $p < 0.05$. Time is taken to isolate DNA from 3 soybean seed samples by different methods (**B**).

It was found that in the variants using the 5x ScreenMix-HS master mix and different methods of DNA isolation, either no amplicon was formed or the peak area was very low. Therefore, for further studies, it is necessary to isolate DNA using the Proba-GS kit and use the 5x MasDDTaqMIX-2025 master mix. At the same time, the shortest time required for DNA extraction from soybean seed extract is spent when using the Proba-GS kit (Figure 3B). Primer volume selection showed that the highest peak area was achieved when using the 5x MasDDTaqMIX-2025 master mix in combination with 1.0 and 2.0 µL of primer per reaction (Figure 4).

Considering that the peak area did not differ statistically in these two variants, it is recommended to use a primer in the amount of 1.0 µL per reaction.

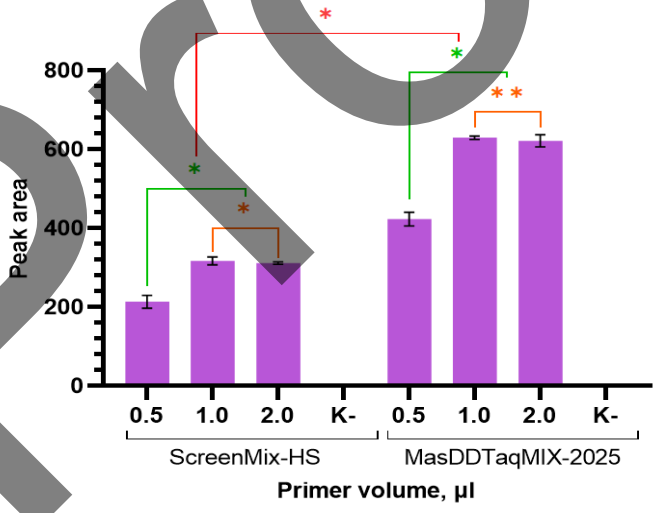


FIGURE 4. Peak area values depending on the amount of primer and the master mix variant. Error bars show the standard deviation in triplicate. Statistical differences were assessed using the Kruskal-Wallis test using Dunn's multiple comparison test. * - no differences, ** - differences at $p < 0.05$.

Determination of the optimal diagnostic scheme depending on the extraction method, the localization of infection and the method of DNA isolation

It was found that in the variants using the 5x ScreenMix-HS master mix and different methods of DNA isolation, either no amplicon was formed or the peak area was very low. Therefore, for further studies, it is necessary to isolate

DNA using the Proba-GS kit and use the 5x MasDDTaqMIX-2025 master mix. At the same time, the shortest time required for DNA extraction from soybean seed extract is spent when using the Proba-GS kit (Figure 3B). Primer volume selection showed that the highest peak area was achieved when using the 5x MasDDTaqMIX-2025 master mix in combination with 1.0 and 2.0 µL of primer per reaction (Figure 4).

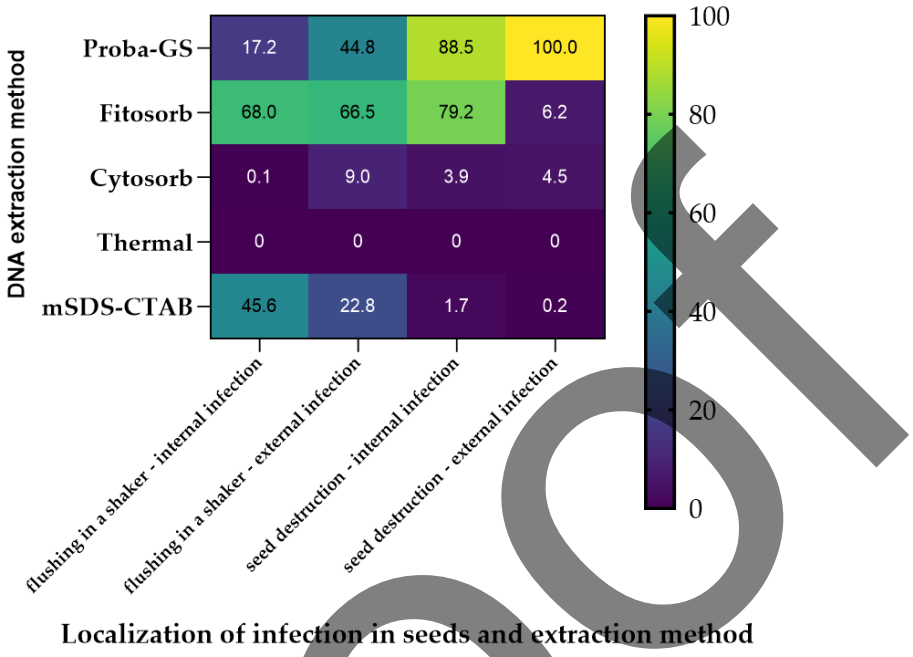


FIGURE 5. Values of signal intensity values (percentage of the maximum area value) depending on the method of DNA isolation, localization of infection, and extraction method. Right: bar showing signal intensity values versus color.

CONCLUSIONS

As a result of research using two master mixes, two infection locations on seeds, two extraction methods, and five isolation methods DNA found that accurate and highly sensitive diagnostics of soybean seeds in the presence of bacterial blight of soybeans is optimal for the destruction of seeds in a homogenizer in SPS buffer and DNA extraction with the GS-Probe kit. In the reaction mixture for PCR, it is recommended to use the master mix 5x MasDDTaqMIX-2025 and 1.0 µL each primer. The sensitivity of this diagnostic scheme was 10^3 CFU/mL, which is quite enough to determine the infection of soybean seeds with bacterial blight.

FUNDING

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The Effect of Ultrasonic Vibrations on the Activation of the Vital Functions of Barley Seeds

Mikhail Volkhonov[1, a)], Maksim Belyakov[1, b)] and Viktor Kukhar[2, c)]

[1] *Kostroma State Agricultural Academy, Kostroma Region, Kostroma District, Karavaevo, 156530, Russia*
[2] *Ural State Agrarian University, Yekaterinburg, Russia*

[a)] Corresponding author: vms72@mail.ru
[b)] m-belyakov-94@mail.ru
[c)] viktorurgau@mail.ru

Abstract. The main reason for lower yields of grain crops is the poor quality of seeds. It is possible to increase the yield of grain by 35–40% through the activation of their vital function before sowing. Nowadays, there is no common methodology for assessing the effectiveness of one or another technique for activating the vital function of seeds around the world. The following criteria are used: viability, germination readiness, the length of sprouts and roots, the number of germinated seeds, etc., which complicates the comparability of the effectiveness of the known techniques for activating the vital function of seeds. A method of pre-sowing ultrasonic seed treatment has been developed that provides for the processing of seeds by ultrasonic vibrations in a bath of water with an ultrasonic vibration frequency of 20–60 kHz and radiation power up to 240 watts for 30–180 seconds, followed by drying when preparing seeds for sowing in the field or without drying when processing for malt. In the optimal mode of barley ultrasound treatment, the frequency of ultrasonic vibrations is 60 kHz, the radiation power is 240 W, and the exposure time is 180 seconds. In this mode, there is a maximum increase in the length of barley seed sprouts compared to control samples —by 1.73 cm, which is 108%.

INTRODUCTION

The primary task for agriculture is to increase the production of food and feed grains [1].

The principal reason for the low yield of grain crops is the insufficiently high quality of seeds. According to the State Seed Inspection of the Russian Federation, for example, no more than 20% of high-quality seeds are sown in Russia, and up to 34.9% of substandard seeds [2]. It is possible to reduce seeding rates by improving seed quality and, as a result, downsize seed crops and get an additional 1.7 to 1.9 million tons of grain, which is comparable to the total volume of seeds sown in the Russian Federation [3].

The activation of a seed's vital function may improve its quality. In the process of activating the vital function of seeds before sowing, seeds draw on their energy reserves, contributing to an increase in yield of up to 35–40%. For now, there are many techniques for the preparation and pre-sowing treatment of seeds aimed at increasing the activation of their vital functions during germination. Such techniques include treatment with electrostatic fields of various ranges. Moreover, these include the use of biological and chemical activators, for instance, with the help of Agromix with increased laboratory viability and germination readiness of spring barley [4], or the use of sodium selenate to detect laboratory viability of soybean seeds [5], the use of electromagnetic waves with ultraviolet and infrared radiation, the use of ultrasound, and others. However, the search results in various literary sources do not give a general systematization by which the effectiveness of various methods can be evaluated. One of the key reasons for the difficulty of assessing the effectiveness of a wide range of criteria, which include viability, germination readiness, the length of sprouts and roots, the number of germinated seeds, etc. There is no single way to assess the methodology [6].

The use of acoustic energy is one of the prospective techniques for the pre-sowing treatment of seeds. According to researchers [7], ultrasonic treatment of dry wheat seeds with a radiation power of 360 W for 5 minutes results in an increase in the number of germinated seeds by 36% compared to control samples. Nowadays, the effect of the

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frequency of ultrasonic vibrations and the characteristics of ultrasonic treatment on improving the quality of seeds has not been adequately studied.

The aim of the research is to increase the activation of the vital functions of seeds.

Research tasks:

– to develop a way to activate the vital function of barley seeds;

– to investigate the effect of ultrasonic vibrations, power, and processing time on the length of barley seed sprouts and to identify the best seed treatment methods.

THE OBJECT, METHODOLOGY AND RESULTS OF THE STUDY

To activate the vital functions of the embryo inside the seed, accelerate the metabolic process, increase crop yields, and reduce the time of malting, a technique for activating the vital functions of seeds has been designed. It includes the treatment of seeds with ultrasonic vibrations in a bath of water with an ultrasonic vibration frequency of 20–60 kHz and radiation power up to 240 watts for 30–180 seconds, followed by drying when preparing seeds for sowing in the field or without drying when processing for malt. The treatment mode is adjusted depending on the type of crop.

To identify the optimal activation modes of the vital functions of barley seeds, an information model of the effect of the frequency of ultrasonic vibrations, radiation power, and exposure time on the length of barley seed sprouts was created (Fig. 1).

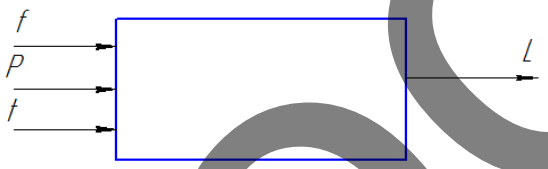

FIGURE 1. Information model of vital function activation of barley seeds by ultrasound.

The frequency of ultrasonic vibrations (f, kHz), the radiation power (P, W), and the time of ultrasonic exposure (t, sec) were taken as input factors.

The response function was the length (L, cm) of the barley seed sprouts.

A block diagram of laboratory research was developed under the obtained model (fig.2).

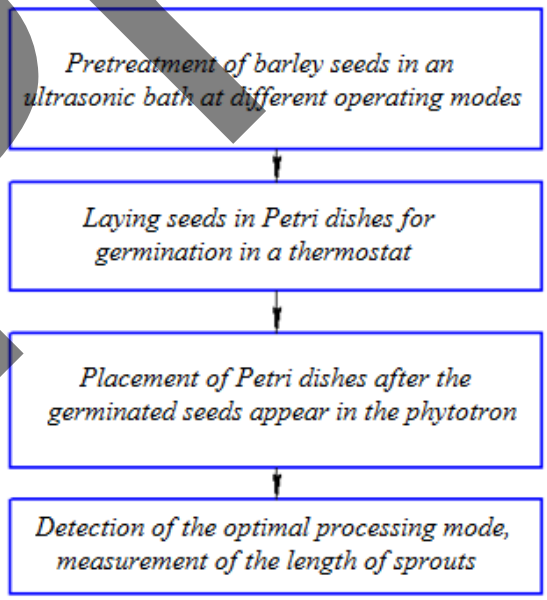

FIGURE 2. A block diagram of laboratory tests.

The designed technique for pre-sowing treatment of seeds 3 (Fig. 3) with ultrasonic vibrations was implemented in a bath 1 with water 2. The bath below is equipped with ultrasonic transmitters 4. The frequency of ultrasonic vibrations was changed using a controller connected to a pulse former on an ultrasonic generator (fig. 4). The radiation power was altered by changing the number of transmitters connected to the generator.

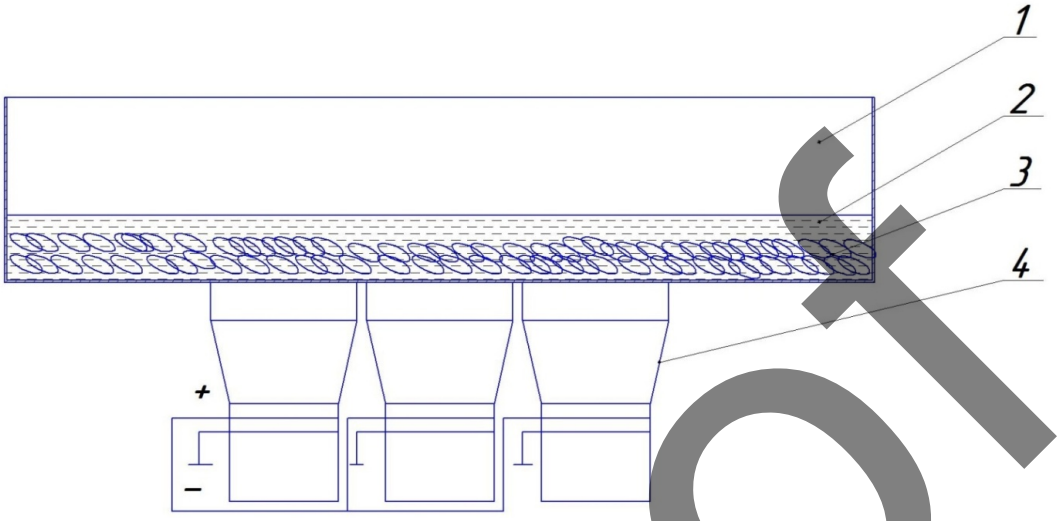

FIGURE 3. A bath with ultrasonic transmitters. 1 – a bath; 2-water; 3-seeds; 4-ultrasonic transmitters.

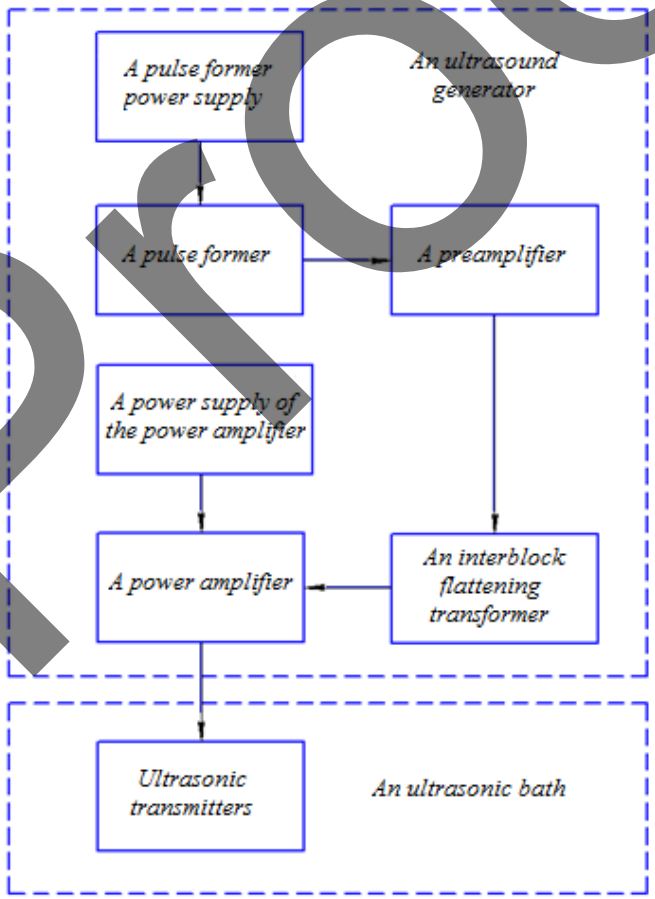

FIGURE 4. An ultrasonic device for pre-sowing seed treatment.

In the developed device, barley seeds were treated according to the following technique: In each experiment, 100 seeds were immersed in an ultrasonic bath of water for 30 to 180 seconds at an ultrasonic vibration frequency of 20-60 kHz and a radiation power of 120-360 W. After that, the barley seeds were germinated in Petri dishes. On the 7th day, the sprouts were measured. The results of the measurements are shown in the table.

Under the research performed, a mathematical analysis was made with the calculation of the average values, the error of the average σ, %, definition of criteria at a 5 percent significance level, and the determination of the least significant difference HCP_{05} at a five percent significance level depending on the treatment mode (tab). Each test was performed four times.

TABLE 1. The effect of ultrasonic treatment on the length of barley seed sprouts.

Frequency, f, kHz.	**Power, P, W.**	**Time, t, sec.**	**Length of sprouts, L, cm.**	**Error of the average σ, %.**	**$t_{act}>t_{05}$**	**$d>HCP_{05}$**
60	360	105	1.05	8.57	6>1.97	0.54>0.18
60	120	105	2.99	5.98	11.6>1.97	1.4>0.24
20	360	105	1.82	15.28	1.53<1.97	0.23>0.29
20	120	105	2.09	7.65	4.54>1.97	0.5>0.22
40	240	105	2.59	5.4	3.03>1.97	1>0.65
60	240	180	3.32	5.56	14.41>1.97	1.73>0.23
60	240	30	3.16	4	15.7>1.97	1.57>0.19
20	240	180	1.98	7.6	3.54>1.97	0.39>0.22
20	240	30	1.37	12.3	2>1.97	0.22=0.22
40	240	105	2.49	7.4	7.5>1.97	0.9>0.23
40	360	180	1.89	7	3>1.97	0.3>0.19
40	360	30	1.48	6	1.22<1.97	0.11<0.18
40	120	180	3.2	4.8	14.63>1.97	1.61>0.22
40	120	30	3.07	5.51	13.45>1.97	1.48>0.22
40	240	105	2.92	6.4	11.08>1.97	1.33>0.23
	Control		1.59	10.7		

Statistical processing of experimental research data was performed using STATGRAPHICS® Centurion XV.

A mathematical model was developed from the multivariate logistic regression analysis performed to determine the influence of the frequency of ultrasonic vibrations f, radiation power P, and radiation time t on the length of the barley seed sprouts L:

$$L = -0{,}37891 - 2{,}20968 \cdot f^2 - 0{,}00002 \cdot P^2 + 0{,}00002 \cdot t^2 - 4{,}81267 \cdot f + 0{,}01294 \cdot P + 0{,}00029 \cdot t - \\ -0{,}00017 \cdot f \cdot P - 0{,}00008 \cdot f \cdot t. \quad (1)$$

From the variance analysis of the regression equation, it follows that the model is informationally capable since the coefficient of determination of the parameter L is 78.32% and the resulting model explains 78.32% of the change in L. The model is significant. There is a statistically significant relationship between variables at the level of 95%.

Under the regression equation (1), the dependences of the length of the sprouts on the radiation power, radiation time, and frequency of ultrasonic vibrations were constructed (figs. 5, 6, and 7).

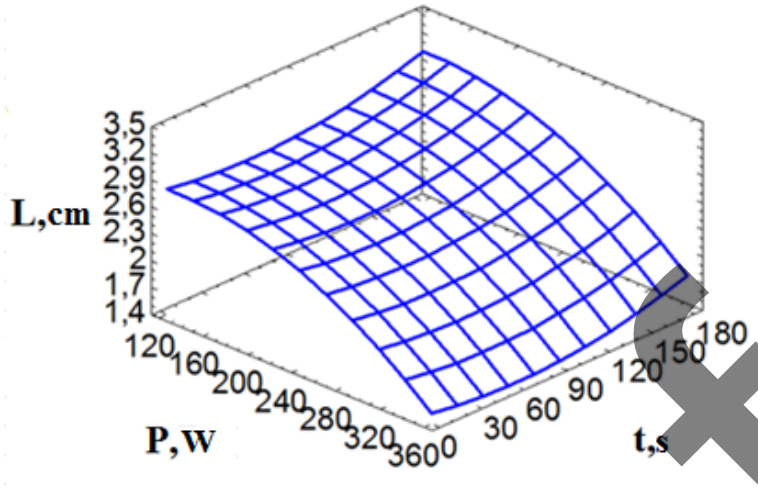

FIGURE 5. The dependence of the length of barley seed sprouts on the radiation power and the time of ultrasonic exposure.

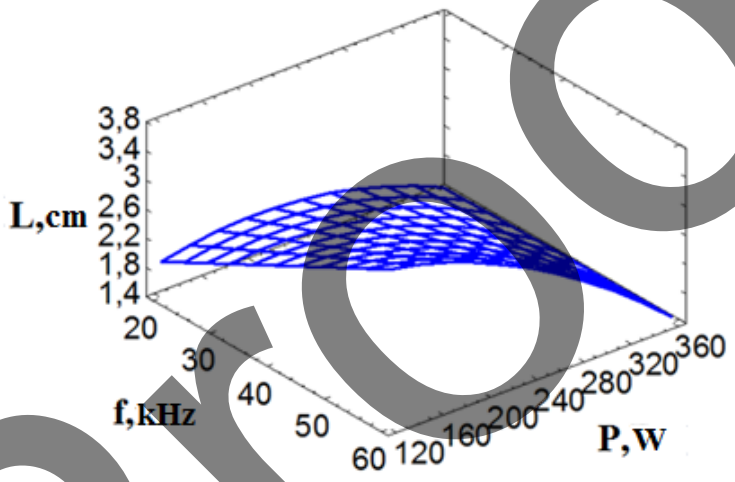

FIGURE 6. Dependence of the length of barley seed sprouts on the frequency of ultrasonic vibrations and radiation power.

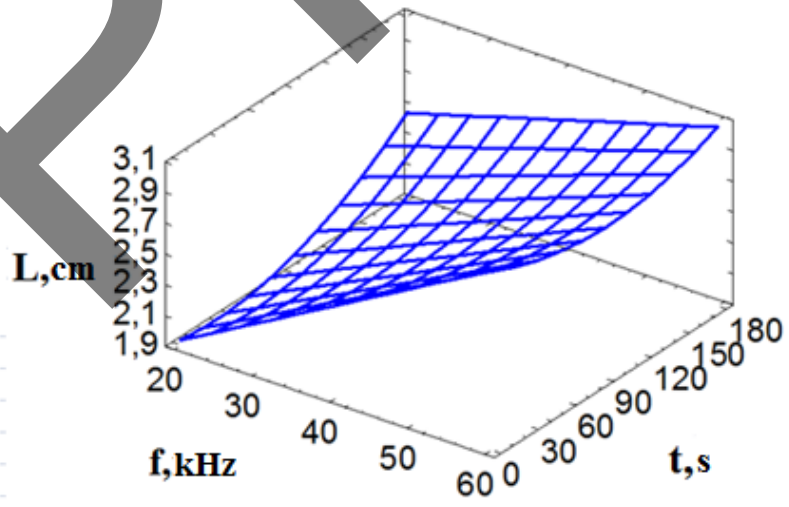

FIGURE 7. The dependence of the length of the sprouts on the frequency of ultrasonic vibrations and the time of ultrasonic exposure.

Activation of the vital function of barley seeds (Figs. 5-7, Table) rises with an increase in the frequency of ultrasound up to 60 Hz, the radiation power up to 240 watts, and significantly depends on the exposure time at lower ultrasound frequencies.

An adverse effect is the maximum suppression of vital functions by ultrasound. It is observed in the operating mode with a radiation power of 360 W, a frequency of ultrasonic vibrations of 60 kHz, and a processing time of 105 seconds. In this mode, the length of barley sprouts was reduced by 34% compared to the control.

The maximum efficiency of ultrasonic action on the length of barley seed sprouts is observed at a frequency of ultrasonic vibrations of 60 kHz, a radiation power of 240 W, and an irradiation time of 180 seconds. In this mode, there is a maximum growth in the length of barley seed sprouts compared to control samples—by 1.73 cm, which is 108%.

A comparison of the actual value of t with the theoretical one (Table) for a mode of operation with a frequency of ultrasonic vibrations of 60 kHz, a radiation power of 240 W, and an exposure time of 180 seconds shows that the 14.41>1.97 difference is significant at the 5% significance level. Consequently, the condition $t_{act} > t_{05}$ is fulfilled. In this regard, the null hypothesis regarding the absence of significant differences between the averages is rejected. The condition of the difference between the averages $d > HCP_{05}$ is also fulfilled, which is 1,73 > 0,23. Therefore, the difference between the averages falls into the critical area of significant differences. The null hypothesis is disproved. The difference is significant.

CONCLUSION

1. A technique for pre-sowing ultrasonic seed treatment has been developed. It provides for the treatment of seeds with ultrasonic vibrations in a bath of water with an ultrasonic vibration frequency of 20–60 kHz and radiation power up to 240 watts from 30 to 180 seconds, followed by drying when preparing seeds for sowing in the field or without drying when processing for malt.

2. In the optimal treatment mode of barley with ultrasound, the frequency of ultrasonic vibrations is 60 kHz, the radiation power is 240 W, and the exposure time is 180 seconds. In this mode, there is a maximum growth in the length of barley seed sprouts compared to control samples—by 1.73 cm, which is 108%.

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The use of Biofungicides to Increase the Induced Soil Suppressiveness in Intensive Fruit Plantations

Kh.M. Nazranov[1, a)], A.N. Esaulko[2, b)], B.B. Beslaneev[1, c)], I.Kh. Thamokova[3, d)], K.Z. Kasheva[3, d)] and T.S. Aisanov[2, e)]

[1] *Kabardino-Balkarian State Agrarian University, Nalchik, Russia*
[2] *Stavropol State Agrarian University, Stavropol, Russia*
[3] *Agro-industrial Complex LLC, Nalchik, Russia*

[a)] Nazranov777@mail.ru
[b)] AEsaulko@yandex.ru
[c)] Corresponding author: Beslaneev@mail.ru
[d)] AgroConsult.LDI@yandex.ru
[e)] Aysanov_Timur@mail.ru

Abstract. Studies were conducted in intensive apple tree plantations in the foothill zone of the CBD in 2020–2022 on the use of biological plant protection agents against pathogens of radical and root rot, tracheomycosis diseases and mycotic drying. The influence of biological preparations on the dynamics of phytopathogenic fungi population density and the soil ability to self-purify - suppressiveness - has been studied. The option with no fungicides application was compared with the option using a chemical fungicide, the option with using an integrated protection system, as well as with using biological fungicides exclusively. The integrated protection system using chemical and biological fungicides has been found the most effective due to the complex effect of a chemical active substance on soil pathogens that sharply reduces the amount of pathogen, followed by the settlement of beneficial microflora in the so-called "vacated niche" of the soil microbiota. This method also significantly increased soil suppressiveness. Based on the conducted research, an integrated protection system using biological products for the prevention and treatment of radical and root rot of fruit plantations has been developed.

INTRODUCTION

The first main requirement for agricultural production is obtaining high-quality competitive products [1]. In modern conditions, it is possible to achieve such a result only through the iterative use of chemicals used to combat various pests and diseases of agricultural crops. Despite the relative decrease in modern pesticides' toxicity to humans and the environment compared with those used earlier, their repeated application still has a negative impact on the environment, especially against the background of an increased treatments' number to maximize the effect. A number of researchers have noted that pathogenic organisms develop tolerance to the chemicals used over time; their use becomes less effective against the background of destroying natural pathogen antagonists by pesticides [2].

Due to the above, modern protection of fruit trees in the orchards should be provided as a complex that includes the minimum required amount of chemical protection with a gradual increase in the share of biological agents and methods' usage. Biological preparations contribute to the improvement of the soil microbiota. The use of integrated plant protection systems will hinder the resistance development in pathogens, reduce the environmental contamination risk of agrobiocenosis and final agricultural products [3, 4].

When laying an intensive garden, a wide range of variety-rootstock combinations and various soil and climatic conditions requires the development of individual technologies, nutrition systems, and garden protection. Root rot of fruit crops is a serious problem for horticulture in the North Caucasus and the south of Russia as a whole, especially in nurseries and young gardens [5]. The problem of reducing soil suppressiveness (the ability to self-purify) in

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intensive gardens is one of the main reasons for the high damage degree by phytopathogenic (fusarium) fungi [6]. At the present stage, the main task of gardeners is the introduction of innovative technologies where induced suppressiveness will play a decisive role in reducing the morbidity of fruit plants.

As part of the scientific research, the Kabardino-Balkarian State Agrarian University together with the Stavropol State Agrarian University on the basis of the "Center for Laboratory Diagnostics and Tests in the Agro-Industrial Complex" LLC Russia, Kabardino-Balkaria, Nalchik, have conducted studies in the foothill zone of the KBD on the use of biological fertilizers, biostimulators, and biological plant protection products.

Among the diseases in modern intensive apple plantations, phytopathogens – pathogens of root and basal rot, tracheomycosis diseases and mycotic drying (fungi of the genus *Fusarium*, *Phytophtora*, *Pythium*, etc.) have become widespread.

Interest in the study of these phytopathogens is primarily due to that the damage percentage to gardens on rootstocks M9, MM106, SK2, being the most used in the Kabardino-Balkarian Republic and the entire North Caucasus, is increasing every year. Although for the first time, these diseases were discovered in the conditions of the Kabardino-Balkarian Republic relatively recently – in 2012-2013.

When affected by late blight, the bark acquires a bluish-purple hue, there is peeling and dying of the bark and necrotic damage to the grafting site and the basal neck – constriction. Rapid seedlings' drying by the type of tracheomycosis wilts occurs with partial or complete constriction, tissues' blockage of the conductive rootstock vessels, which leads to blocking the flow of organomineral substances and water to the graft. In trees with traits of tracheomycosis wilting, active growth of shoots is noted with development inhibition or drying of the graft part (Figure 1).

FIGURE 1. Lesion of Gala variety trees with M9 rootstock by tracheomycosis diseases, 2020 Strong growth of shoots is one of the traits of root rot damage.

Favorable conditions for the rapid diseases' spread are a relatively warm humid winter with a predominance of positive temperatures, a rainy spring with a temperature optimum of $+18^0$C and high relative humidity, heavy alkaline soils characteristic of the Kabardino-Balkarian Republic. The stability of the rootstock and the variety, the plot preparation before garden planting, elimination and reduction of stress factors effects that sharply reduce the immunity of trees are also important. Having variability and high adaptability, these phytopathogens are difficult to eradicate, despite the use of chemical means to combat them.

Despite the current trend in the development of environmentally friendly agriculture, plant protection is mainly based on the use of chemical pesticides. Thus, chemical active substances effective against root and basal rot have been experimentally determined (aluminum ethylphosphite, Mancozeb, mefenoxam, dimethomorph, benomyl). These substances are highly effective, yet they have a number of disadvantages: accumulation of toxic residues in the environment, lack of selective action, formation of resistant pathogen races. In addition, the use of systemic chemicals in protection technology is limited in fruit-bearing gardens.

Biological control using microorganisms is a promising alternative to pesticides, which helps to reduce the chemical load on perennial plantings. Information on the actual microorganisms' interactions in natural habitats is extremely limited. It has been established that the introduction of bacterial and fungal populations into the soil biocenosis is stabilized at a sufficiently high level, and the survival of a particular mechanism is influenced by the chemical soil composition, the level of introducer's application and the stage of microbial succession, the application period.

Therefore, to increase soil suppressiveness, it is important to introduce biological methods of plant protection that have a wide range of phytoprotective and growth-stimulating effects that are not toxic to warm-blooded species. Compared to chemical analogues, microbial biopreparations have a number of advantages: selective action against a number of pathogens, environmental safety.

Bacteria of the genus ***Bacillus*** and fungi of the genus ***Trichoderma*** are among the most promising for introduction into the soil biota to regulate the density of phytopathogenic populations, as well as colonization of tree microbiota. The application technology of *Bacillus subtilis* and *Trichoderma harzianum* depends on the phase of plant development, temperature regime, soil moisture, and other factors. Maximum efficiency is achieved with repeated use during the growing season from the moment of active sap ascent start.

CHARACTERISTICS OF BIOLOGICAL PREPARATIONS

A biological preparation based on *Bacillus subtilis* causes lysis of Fusarium graminearum *conidia;* formation of protoplasts in Fusarium solani *conidia;* suppresses the growth of Phytophthora infestans *zoospores;* suppresses the formation of growth tubes and consequently, the formation of fungi mycelium of the genus *Fusarium*, *Phytophthora* and *Pythium* sp.

The inhibitory effect of bacteria on phytopathogenic fungi is carried out due to the following factors:

- formation of an enzyme complex capable of lysing the cell walls of fungi;
- synthesis of antibiotic substances;
- competition in the consumption of nutrients.

A biological preparation based on *Trichoderma harzianum* suppresses phytopathogens by type of:

- direct parasitism (entwines pathogens' hyphae with mycelium while disrupting their cellular structure and metabolism; uses foreign mycelium as a nutrient medium while destroying them);
- competition for the substrate (soil);
- isolation of enzymes, antibiotics, and other biologically active substances.

Research objectives:

1. Development of an integrated protection system with the use of biological products for the prevention and treatment of radical and root rot of fruit plantations;
2. To study the effect of *Bacillus subtilis* antagonist microbe and *Trichoderma harzianum* suppressor fungus on the dynamics of population density of the main phytopathogenic fungi – pathogens of radical and root rot.
3. Conclusion on the condition of trees and soil on the results of systematic long-term biopreparations' application (in 2020 - 2022).

MATERIALS AND METHODS

Field experiments to study the effectiveness of selected strains of biological preparations created on the basis of *Bacillus subtilis* and *Trichoderma harzianum* and laboratory studies were conducted during the growing seasons of 2020 – 2022 on the basis of the horticultural farm of Fruitlight LLC, Nalchik, Kabardino-Balkarian Republic in intensive apple plantations of 2017 planting on the M9 rootstock. The total area of the garden - 14 hectares. The garden is divided into 4 cells. Cell No.1 - Fuji variety, cells No. 2–4 - Gala variety.

This horticultural business was chosen after a route phytopathological examination. According to the results of a preliminary plantings' inspection, a conclusion was made on the established agricultural background: the trees showed traits of disease damage by root and basal rot, there was tree drying.

The protection system against leaf diseases and major pests is a generally accepted practice on the farm.

Additionally, an agrochemical analysis of the garden soil was carried out. Study results: soils – slightly alkaline and alkaline – pH of water extract – 7.6 – 8.3, humus content according to Tyurin – low – 2.5%, phosphorus and potassium content according to Machigin – average – P_2O_5 30.5mg/kg of soil and K_2O – 255.0mg/kg of soil. The mechanical soil composition is heavy loamy, the structure is granular cloddy.

The object of research was soil samples taken from the rhizosphere zone of trees.

Beneficial and pathogenic microflora was determined by the following laboratory research methods: microscopic analysis; microbiological analysis; flotation method (express test: the level of phytopathogens excess relative to the harmfulness threshold was assessed).

Microorganisms' planting on solid nutrient media (PGA for bacteria and Chapek medium for fungi) were carried out by dilution methodsas per G.I. Yezhov (1981) [7]. To isolate strains of microorganisms, 1g of air-dry soil was filled with 5ml of sterile water and shaken on a shaker for 30 minutes. After solid particles settled, an aqueous suspension of microbial cells was dispersed with an inoculation loop onto the surface of the corresponding agarized nutrient media in Petri dishes. One loop was planted into 2 cups. After incubation in a thermostat at 25 – 28^{0}C for 2-3 days for bacteria and 5-7 days for fungi, the grown colonies of microorganisms were replanted. Chapek medium with starch or sucrose was used for fungi; for bacteria - PGA (potato-glucose agar) or MIA (meat infusion agar).

The identification of micromycetes to genus was carried out by cultural and morphological characteristics using determinants; the species identity was established in accordance with the taxonomic system of N.M. Pidoplichko (1977) [8].

The soil suppressiveness was assessed by the presence of fungi of *Trichoderma* genus in it and the ratio of pathogenic microflora to the total amount of all detected microflora.

In the experimental work on the pure culture isolation from a soil suspension of beneficial and pathogenic microflora, nutrient media containing hydrocarbon and complex organic compounds easily assimilated by microorganisms (potato-glucose agar PGA, Chapek medium) were used.

The fungicidal activity of *Bacillus subtilis* was tested by the socket method and by the counter cultures method. *The socket method* - for it, phytopathogenic fungi *Fusarium* sp. were planted on Petri dishes with agarized potato-sucrose medium. Sockets with 8 mm diameter were cut out in agar-agar with a drill, 150 µl of suspension liquid of the claimed strain's isolated pure culture was introduced into them. The fungicidal action effectiveness of the claimed strain was determined by the diameter of no test cultures growth zone.

The fungicidal activity of *Trichoderma harzianum* was detected in vitro by the interrelation type of the phytopathogen *Fusarium* sp. and fungi of the genus *Trichoderma* sp. The experiment used the *method of counter colonies.* The essence of the method consists in the conditional division of a Petri dish into equal parts; the pathogen fungus is planted on one half (on the right), on the other – fungus of the *Trichoderma* genus. On the 5th–7th day, the indicators of phytopathogen inhibition by fungus of the *Trichoderma* genus were calculated.

Several experimental options were selected for comparison (Table 1). The control was the experimental option with no use of chemical and biological fungicides against root and basal rot – option 1. As an option of using chemical protection, a fungicide with the active substance ethylphosphite aluminum active against the pathocomplex under study – Efatol – option 2 - was used. The preparation was applied using a drip irrigation system based on aluminum ethylphosphite a.s. in the "end of flowering" phase twice with an interval of 14 days. Biological fungicides based on *Bacillus subtilis* and *Trichoderma harzianum* strains were used under the drip irrigation system in the "walnut" and "fruit growth" phases both in combination after using a chemical fungicide – option 3, and as the only fungicides against root and basal rot – option 4.

TABLE 1. Compared experimental options.

Experimental option	Phenological phase of application	Used preparation	Application rate, kg/ha	Application frequency
1. No use of fungicides against root and basal rot	-	-	-	-
2. Aluminum ethylphosphite	"end of flowering"	Aluminum ethylphosphite (Ethafol)	2.5	twice with an interval of 14 days

Continuation of TABLE 1.

3. Aluminum ethylphosphite + *Bacillus subtilis + Trichoderma harzianum*	**"end of flowering"**	**Ethylphosphite aluminum**	**2.5**	**twice with an interval of 14 days**
	"walnut"	*Bacillus subtilis* + fulvic acids	2.5 + 2.0	single
	"fruit growth"	*Trichoderma harzianum*	2.5	single
4. Bacillus subtilis + Trichoderma harzianum	"walnut"	*Bacillus subtilis* + fulvic acids	2.5 +2.0	single
	"fruit growth"	*Trichoderma harzianum*	3.0	single

Before the experiment's establishment, soil was sampled in the garden from the rhizosphere three zone at several points to a depth of 15-20 cm with an agrochemical drill, followed by the isolation of an average sample. Repeated selection was made 20 days after the introduction of biological preparations to study changes in the species composition of the microbiota.

RESULTS AND DISCUSSION

The complex of laboratory studies has established the species composition of soil pathogens on the garden plot with a total area of 14 ha (Table 2). Phytopathogens provoking root and basal rot – the target objects of the antagonist strains used by the authors - are highlighted in bold. The assessment of soil suppressiveness was determined by the content of native fungi of the genus *Trichoderma* sp.

TABLE 2. The results of phytopathological analysis before experiments' establishment, 2020.

Disease	Pathogen	Pathogenic microflora		Suppressive microflora	
		Average values, CFU/g titer	%	Average values, CFU/g titer	%
Verticillosis	*Verticillium dahliae*	0	0	Colonies of the soil suppressor *Trichoderma* sp.0,3x10 ^{3}	4.1
Fusarium root rot	***Fusarium* sp.**	1,1x10^{3}	18.8		
Late blight root rot	***Phytophtora* sp.**	0,3x10^{3}	5.9		
Pythium root rot	***Pythium* sp.**	0.8x10^{3}	13.7		
Spur blight	*Monilinia fructigena*	0	0		
Apple-tree cancer	*Sphaeropsis malorum*	0	0		
European cancer	*Nectria galligena*	0	0		
Anthracnose	*Gleosporium* sp.	0	0		
Alternaria blight	*Alternaria* sp.	1.3x10^{3}	22.2		
Gray rot	*Botrytis cinerea*	0.6x10^{3}	14.7		
Nectrium necrosis	*Nectria* sp.	0	0		
Trichoteciosis	*Trichotecium roseum.*	0	0		
Black Rot	*Rhizopus* sp.	0	0		
Penicillous rot	*Penicillium* sp.	1.2x10^{3}	20.6		
		7.1x10^{3}	95.9	0,3x10^{3}	4.1%
Total amount:			100%		

Assessment of soil suppressiveness: this soil sample is characterized as weakly suppressive.

Dynamics of population density, frequency of occurrence and isolation of *Fusarium* sp., *Phytophtora* sp., *Pythium* sp. were studied; these are the target objects that occur singly or in a pathocomplex in gardens after

conducting a series of model experiments for 3 full growing seasons. The analyses were carried out in spring – with the beginning of active sap ascent, in summer – during heavy rains, in autumn – during harvest (Table 3).

Studies have shown that the initial phytopathogens' population density affected the dynamics of their development both in experimental options and in control without introducing antagonists.

It should be noted that the following factors also contributed to good colonization and a high response to the use of chemical and biological agents: maintaining a high agricultural background, combating weeds – additional reserves of infections, balanced macro- and micro-nutrition of plants, timely watering, avoiding mechanical damage to plants, frost damage and sunburn of perennial wood through well-planned post-harvest treatments.

TABLE 3. Phytopathogens' population density depending on the experimental options, CFU/g.

Experimental options	Vegetation period	Fusarium root rot *Fusarium* sp.	Late blight rot *Phytophtora* sp.	Pythium root rot *Pythium* sp.
1. No use of fungicides against root and basal rot (control)	*2020*	$1.2*10^3$	$0.3*10^3$	$0.8*10^3$
	2021	$1.1*10^3$	$0.3*10^3$	$0.9*10^3$
	2022	$1.1*10^3$	$0.4*10^3$	$0.9*10^3$
2. Aluminum ethylphosphite	*2020*	$1.2*10^3$	$0.3*10^3$	$0.9*10^3$
	2021	$1.0*10^3$	$0.2*10^3$	$0.7*10^3$
	2022	$1.1*10^3$	$0.2*10^3$	$0.8*10^3$
3. Aluminum ethylphosphite + *Bacillus subtilis* + *Trichoderma harzianum*	*2020*	$1.2*10^3$	$0.3*10^3$	$0.9*10^3$
	2021	$0.8*10^3$	$0.2*10^3$	$0.8*10^3$
	2022	$0.8*10^3$	$0.1*10^3$	$0.7*10^3$
4. *Bacillus subtilis* + *Trichoderma harzianum*	*2020*	$1.3*10^3$	$0.2*10^3$	$0.8*10^3$
	2021	$1.0*10^3$	$0.3*10^3$	$0.7*10^3$
	2022	$0.9*10^3$	$0.2*10^3$	$0.7*10^3$

The inhibitory effect of antagonists was noted in all experimental options. Let us note the most pronounced changes in the number for the period from 2020 to 2022 for each option:

Option 1 (control): natural decrease in *Fusarium* sp. from $1.2x10^3$ to $1.1x10^3$ CFU/g;

Option 2: excellent dynamics in *Pythium* sp. – from $0.9x10^3$ to $0.8x10^3$, *Phytophtora* sp. – from $0.3x10^3$ to $0.2x10^3$;

Option 3: excellent dynamics in *Fusarium* sp. from $1.2x10^3$ to $0.8x10^3$, *Phytophtora* sp. - from $0.3x10^3$ to $0.1x10^3$, *Pythium* sp. - from $0.9x10^3$ to $0.7x10^3$;

Option 4: excellent dynamics in *Fusarium* sp. in the last year: from $1.3x10^3$ to $0.9x10^3$,

Phytophtora sp. – from $0.3x10^3$ to $0.2x10^3$, *Pythium* sp. from $0.8x10^3$ to $0.7x10^3$;

Compared to 2020, the soil suppressiveness increased from 4.1% to 4.8 by 2022 – 5.9% in areas with used biofungicides based *on Trichoderma* sp. (Table 4).

TABLE 4. Changes in soil suppressiveness during the research.

Experimental options	Suppressive microflora – colonies of the soil suppressor *Trichoderma* sp.			
	2020		2022	
	Average values, CFU/g titer	%	Average values, CFU/g titer	%
1. No use of fungicides against root and basal rot (control)	$0.30x10^3$	4.1	$0.31*10^3$	4.2
2. Aluminum ethylphosphite	$0.30x10^3$	4.1	$0.29*10^3$	3.9
3. Aluminum ethylphosphite + *Bacillus subtilis* + *Trichoderma harzianum*	$0.30x10^3$	4.1	$0.35*10^3$	4.8
4. *Bacillus subtilis* + *Trichoderma harzianum*	$0.30x10^3$	4.1	$0.43*10^3$	5.9

Additionally, laboratory studies were conducted to identify the effectiveness of the selected biological strains against the main pathogenic complex. Several ways of regulating soil phytopathogens and manifestations of antibiotic activity of *Trichoderma harzianum* have been studied:

- *method of direct parasitizing;*
- *competition for the substrate (soil);*
- *isolation of enzymes, antibiotics, and other biologically active substances.*

Several interrelation types of the *Fusarium* sp phytopathogen and fungus of the Trichoderma genus have been identified *in vitro* by the method of counter cultures. The method's essence is in conditional division of a Petri Dish into equal parts: the pathogen fungus is planted on one half (on the right), on the other – fungus of the Trichoderma genus. Indicators of phytopathogen inhibition are calculated on the 5th–7th day.

Photo 2 shows the manifestation of direct parasitism and antibiotic activity of *Trichoderma harzianum* (half a Petri dish) against *Fusarium* sp. (the opposite half of the dish). The growth suppression zone was already formed on the 4th day after planting; Fig. shows the 8th day after planting. With direct parasitism, *Trichoderma harzianum* entwines the pathogens' hyphae with mycelium, while disrupting their cellular structure and metabolism; it uses *Fusarium*sp. mycelium as a nutrient medium while destroying them.

Photo 3 shows the manifestation of direct parasitism and entwining of *Trichoderma harzianum Fusarium* sp. conidium by mycelium under the microscope. This in vitro model experiment is defined as territorial antagonism (fouling of pathogen colonies with fungus of the Trichoderma genus; as a rule, the pathogen lags behind in growth), as well as oppression due to release of enzymes, antibiotics, and other biological substances.

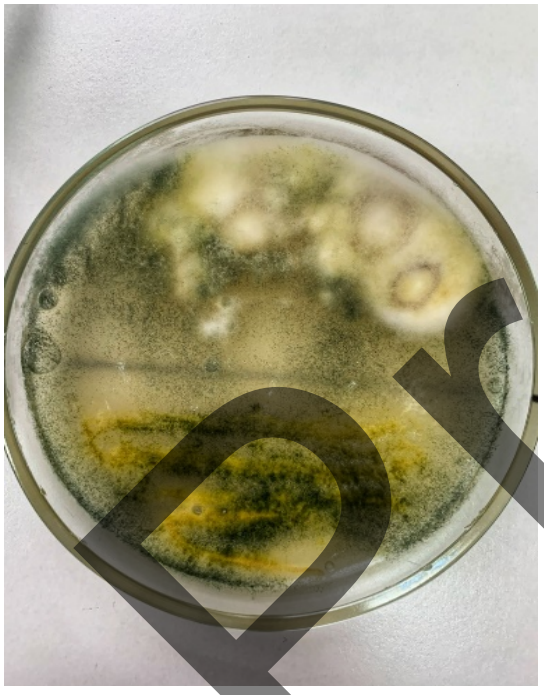

FIGURE 2. Antibiotic activity of biofungicide to fungi of the Fusarium genus, 8 days after planting.

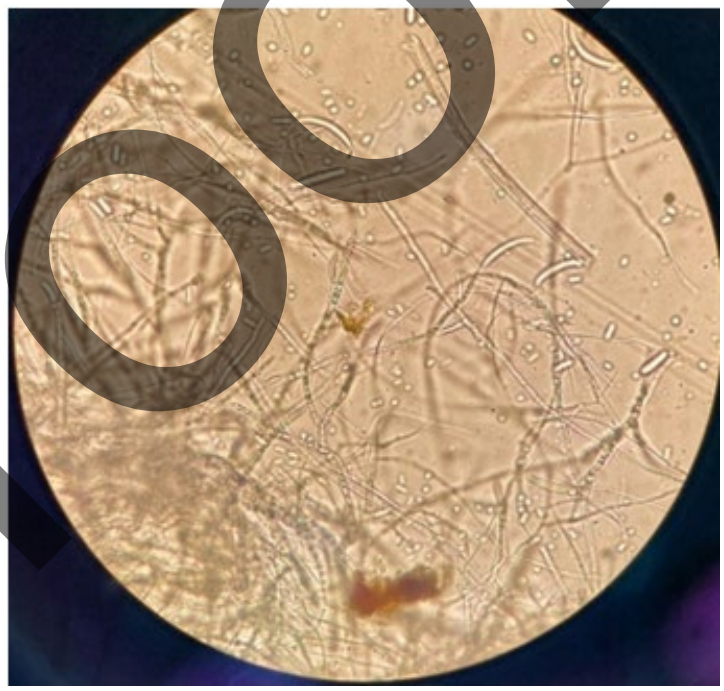

FIGURE 3. Direct parasitism and entwining of Fusarium sp. conidium with mycelium.

CONCLUSIONS

In the course of the conducted studies, it was found that populations' introduction of bacteria and fungi into the soil biocenosis for the period of 2020 – 2022 on the basis of the experimental site of horticulture proceeded at a high level. Chemical soil composition, introduction level of introducents and the stage of microbial succession, application period contributed to the survival, reproduction, and development of beneficial microflora.

The research results indicate the ability of biological preparations' strains to effectively control the populations' density of soil-dwelling phytopathogens, which determines the biological effectiveness of strains in suppressing root rot.

The antagonistic effect of biological preparations on the growth and development of pathogenic microorganisms' associations has been established. The strains showed the highest antagonistic activity against Fusarium sp. and Alternaria sp., medium – to Pythium sp. (by the diameter of the colony growth inhibition zones).

The data obtained indicate that the use of chemical fungicides alone has no selective effect and has a short-term influence on phytopathogenic fungi. This can lead to repeated infections under favorable conditions for pathogens and weak soil suppressiveness.

The integrated protection system using chemical and biological fungicides had the greatest effectiveness due to the complex effect of the chemical active substance on the soil pathocomplex sharply reducing its amount, followed by the settlement of beneficial microflora in the so–called "vacated niche" of the soil microbiota to increase the soil ability to self-purify (suppressiveness).

Biopreparations based on the studied strains can be used as separate fungicides for preventive purposes against root diseases in fruit plantations and to increase soil suppressiveness, as well as in an integrated protection system. Biological agents affect pathogens throughout the entire growing season; however, with epiphytotic root diseases, it is more effective to use them in combination with chemical fungicides in compliance with the order of plant protection means' application.

The results obtained during laboratory analyses to study the antagonistic activity of Trichoderma harzianum serve as a prologue for the development of biological plant protection products.

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Formulation and Quality Evaluation of Partially Prepared Dough Using Protein Plant Raw Materials

Elena Bychkova[1, a)], Ekaterina Podgorbunskikh[2], Vladimir Buchtoyarov[2], Lada Rozhdestvenskaya[3] and Polina Kudachyova[3]

[1]*Faculty of Biotechnologies (BioTech), ITMO University, 191002, St. Petersburg, Russia*
[2]*Laboratory of Mechanochemistry, Institute of Solid State Chemistry and Mechanochemistry SB RAS, 18 Kutateladze, 630090 Novosibirsk, Russia*
[3]*Department of Business, Novosibirsk State Technical University, 20 Prospekt K. Marksa, 630073 Novosibirsk, Russia*

[a)] Corresponding author: bychkova.nstu@gmail.com

Abstract. The article presents the stages of yeast sponge-and-dough formulation with the use of mechanochemical treatment of pea grains. There is an increase in the yield of water-soluble substances due to additional treatment of plant raw materials. The addition of pea hydrolysate makes it possible to optimize the yeast dough formulation.

INTRODUCTION

Current global trends in vegetable and animal protein consumption incline world society toward the prevalence of consumption of foods enriched with plant protein [1, 2]. This is due to several predominant aspects. Obtaining plant protein is more cost-effective, environmentally friendly, and potentially carries a higher nutritional value component. When consuming food of animal origin in addition to protein the human body receives cholesterol and saturated fatty acids, which have a negative impact on human health. By eating foods with plant protein, a person additionally receives a complex of vitamins, minerals and dietary fiber. The problem of vegetable protein consumption is associated with its inadequate amino acid composition and anti-nutritional properties, which reduce the digestibility of protein by up to 80%. Therefore, there is a need for a comprehensive scientific approach to the formulation of food products using plant proteins, where the main key emphases will be balancing the composition of amino acids and leveling the anti-nutritional properties of the food system [3].

Globally, the COVID-19 pandemic has also had a direct impact on food systems by changing the balance of supply and demand for food resources, due on the one hand to reduced purchasing power and on the other to a dramatic change in food production, distribution and marketing capacity [4-7]. In mature countries, these changes are of varying depth and nature, but almost everywhere there has been a decline in agricultural production and food availability. At the same time, the livestock sector, which accounts for about 40% of the value of global agricultural production, suffered most severely in agriculture [8, 9]. Worldwide, farm animals provide about 13% of the caloric content of the diet and 28% of the protein requirement through meat, milk and eggs [10]. But combined with the closure of meat and milk processing plants over the 2019-20 period, there has been a significant loss of production capacity and livestock products. The situation was exacerbated by upheaval in the protein supply chain. Like most other agricultural businesses, livestock systems and their supply chains have experienced numerous logistical failures.

Pandemic-induced shortages of protein products, meat in particular, have turned into great opportunities for the plant protein sector. For example, meat shortages at the beginning of the pandemic led to an increase in consumer demand for plant-based meat in the United States, and a 200% sales increase of meat substitutes [11]. Production of alternative proteins involves less reliance on labor and lack of staff, unlike red meat, which is relatively labor-

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intensive. The rapid spread of the COVID-19 pandemic has led to a shift in priorities toward alternative proteins due to health and environmental concerns. Coronavirus infection, as demonstrated by numerous studies, has a serious impact on the development and exacerbation of comorbidities, such as diabetes [12, 13] hypertension [14], and heart disease [15]. In this case, an alternative protein diet can help reduce the impact of the virus on people at high-risk group due to the large amount of macronutrients, trace elements and antioxidants present in the diet. Thus, COVID-19 has begun to accelerate the development of alternative proteins and over the past two years this industry has seen unprecedented demand from manufacturers as well as consumers, especially for certain types of products such as meat analog and plant milk, which has provoked the active formation of production and distribution channels.

There are many challenges facing today's food and agriculture industry that require immediate action, such as: feeding a growing global population; mitigating and adapting to climate change, reducing pollution, waste and loss of biodiversity; and ensuring that people stay healthy. The expected growth of the world's population in the coming decades will put enormous pressure on the food system, especially for protein.

Therefore, agronomists, nutritionists, and food scientists have begun to explore ways to increase the supply of protein. To create a new generation of healthier and more sustainable foods, four basic components are fundamental: new raw materials; principles of structural design to create innovative products; developments in environmentally friendly packaging; and customized food production that takes a personalized approach.

MATERIALS AND METHODS

Pea seeds (I grade, GOST 6201-68, EKO-PAK Ltd, Novosibirsk region, Russia) and a complex enzyme preparation "Feedbest VGPro" (Sibbiopharm Ltd., Berdsk, Russia) were used as materials for the study. The biocatalytic activity on model substrates is as follows: xylanase up to 10000 units/g, β-glucanase up to 3500 units/g, pectinase up to 5000 units/g, and proteolytic up to 120 units/g. Mechanical treatment of pea seeds was performed according to the method [16] in two stages: the first stage was pre-crushing on a cutting mill to particle size less than 2 mm; the second stage was mechanical treatment together with an enzyme agent on a roller mill RM-20 (designed and made at the Institute of Solid State Chemistry and Mechanochemistry, Novosibirsk, Russia, power 5.5 kW, raw material feed rate 8 kg/h). This mode of mechanical treatment makes it possible to disorder the ultrastructure of the plant material while preserving the catalytic activity of the enzyme [16]. Subsequent enzymatic hydrolysis of mechanically processed pea biomass was carried out for 5 hours at 50 °C and stirring at 120 rpm.

The method of exhaustive extraction in a Soxhlet extractor for 24 hours was used to determine water-soluble substances. The content of reducing sugars was determined according to the described method [17].

RESULTS AND DISCUSSION

The effectiveness of a scientific idea depends on an integrated approach to its implementation. The organization of the scientific part of the formulation and production of a new food product, based on a methodological approach of quality formation, will ensure a high efficiency of the result. On the basis of already available data and the researches spent before, basic principles for creation of foodstuffs with use of hydrolysates of plant raw materials which observance will allow to create a foodstuff with the confirmed safety, economic availability and positive action on an organism are allocated. The following principles have been singled out: the principle of naturalness, safety, stability; the principle of efficiency, scientific validity and accessibility.

During the design of a new food product with the inclusion of liquid hydrolysate, the choice of a food base is important. At this stage it is necessary to control and take into account the following parameters:

1. Justification for the choice of the source raw material;
2. Influence of hydrolysate on consumer quality indicators of the final food product;
3. Convenience of adding plant hydrolysate to a food product;
4. Terms, conditions of storage and rules of realization to the consumer of the finished food product;
5. Nutritional and biological value of the final product;
6. Economic feasibility of development.

The main stages of development of a food product using hydrolysates are shown in Figure 1.

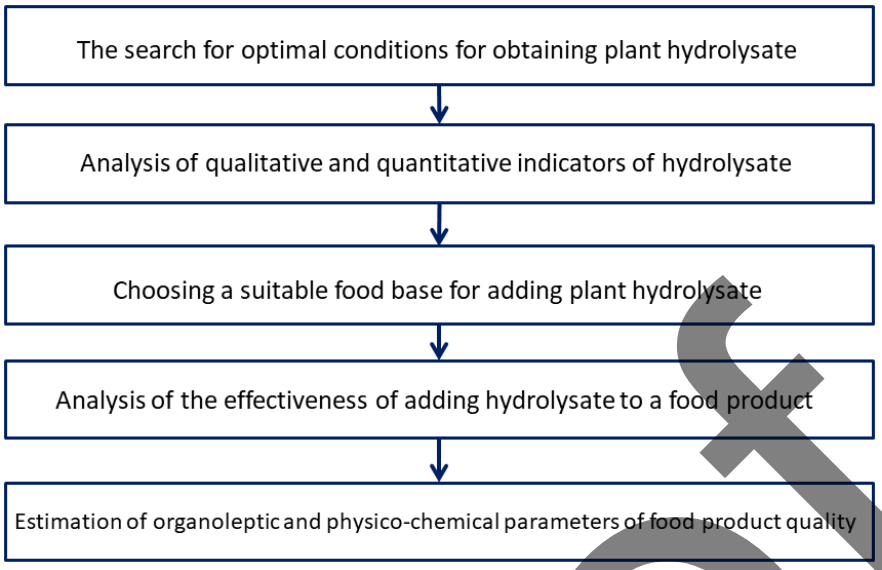

FIGURE 1. The main stages of the formulation of a food product with plant hydrolysates.

The purpose of this work was to consider the effectiveness of adding pea hydrolysate to yeast dough. Yeast dough is a multicomponent system in which many physical and chemical processes take place during kneading, fermentation, proofing and heat treatment. Since the dynamics of physical and chemical processes in yeast dough depends on the activity of yeast, it is interesting to study the effect of pea hydrolysate on the intensification of the stage of fermentation in dough.

According to Figure 1, the initial stage of development is the selection of optimal conditions for obtaining pea hydrolysate. Modern approaches to the processing of plant raw materials allow us to obtain an effective result of the yield of valuable components. Pea grains were subjected to ultrafine mechanical grinding with enzymatic agent on a roller mill RM-20. It was found that mechanochemical treatment of pea grains together with an enzyme can increase the yield of water-soluble substances by 3.4 times compared with the original plant raw materials [18]. At the milling stage, pea flour with a particle size of the order of 40-50 microns was obtained. Then, water was added to the dry fraction and the stage of enzymatic hydrolysis at 50°C was carried out. The main conditions for obtaining pea hydrolysate: concentration of the enzymatic agent - 2 %; optimum time of enzymatic hydrolysis - 5 hours. The data were obtained from studies on the accumulation of total water-soluble substances and reducing carbohydrates in the dynamics by hours [19]. Ready pea hydrolysate is a liquid system of uniform consistency, sandy color, smell and taste peculiar to peas.

Prepared for use pea hydrolysate was injected into yeast sponge-and-dough (Step 3, Figure 1). It is important to consider the subtleties of the technological process of dough preparation, which consists of several stages:

- Step 1 – Preparation of the sponge. Yeast is diluted in milk whey at 30 °C and filtered. The resulting mixture is mixed with sifted wheat flour and sugar. Pea hydrolysate is introduced into the stew. Place the sponge for fermentation in the proving chamber for 2 hours at a temperature of 32 °C.

- Step 2 – Preparation of the dough. In the wheat flour add all the prepared sponge and additional ingredients according to the recipe. Then the resulting mixture is put into the dough mixer bowl and thoroughly kneaded for 10 minutes. At the end of the kneading, oil of vegetable origin is added. Since the dough contains pea flour, the amount of wheat flour was reduced. To preserve the quality of the dough and finished products additional intensive mechanical processing of the dough was carried out.

- Step 3 – The ready dough was placed in proving chamber at 35°C for 40 minutes. Then the dough is kneaded and portioned.

The mathematical modeling method was used to derive a pattern of influence of the amount of yeast and pea hydrolysate on the dry insoluble residue of the dough.

Regression equation of the relationship between the three indicators (amount of yeast, hydrolysate and dry insoluble residue) was derived (Equation 1):

$$Z = 14.9994 - 0.8883*x - 0.0605*y, \quad (1)$$

where x is the amount of yeast, g;
y - amount of hydrolysate, g;
z - amount of dry insoluble residue, g.

The use of this equation in the technological process will make it possible to control the fermentative hydrolysis process, helping to set the most optimal fermentation duration to obtain a finished hydrolysate with a given amount of water-soluble substances.

Experimentally established that the threshold values of the components of yeast and hydrolyzate, which can be introduced into the sponge, 2 and 33 grams, respectively (for the yield of sponge 50 g). At these concentrations of components are not violated organoleptic quality indicators. Prepared for use dough has a smooth surface, slightly sour, tasteless and odorless; color is white with a yellowish hue. The consistency is homogeneous elastic mass without lumps and traces of unmixed.

CONCLUSIONS

Based on the totality of the results obtained, we can conclude that mechanochemical treatment of plant raw materials intensifies the subsequent process of hydrolytic disintegration of polymeric molecules and consequently increases the yield of water-soluble substances. Such a comprehensive approach can serve as an important aspect in the context of the development of resource-saving technological solutions, as well as in the formulation of foods for people with varying degrees of allergic reactions.

The introduction of pea hydrolysate and yeast into the dough can reduce the amount of dry insoluble residue, in other words, has the effect of increasing the amount of easily digestible substances and optimizing the quantity of components applied.

ACKNOWLEDGMENT

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Dependence of Physico-Chemical Characteristics of Leached Chernozem's Soil Fertility on Fertilizers and Ameliorator Used

Elena S. Gasanova [a)], Konstantin E. Stekolnikov, Anna N. Kozhokina, Angelina V. Malyavskaya

Voronezh State Agrarian University named after Emperor Peter I, Voronezh, Russia

[a)] Corresponding author: upravlenieopm@mail.ru

Abstract. The paper presents the study results on the effect of using fertilizers and ameliorator on the physico-chemical properties of soils, as well as the content of total and labile humus. The surveys were carried out under the conditions of long-term stationary experiment of the Department of Agrochemistry, Soil Science and Agroecology of FSBEI HE Voronezh State Agrarian University on leached chernozem. In the course of the experiments, it was revealed that fertilizers and ameliorator change the indicators of soil acidity. Mineral fertilizers lead to soil acidification. It was found that the sum of exchange bases in the studied samples of the arable layer varied from 24.08 to 27.08 mg-equ/100 g of soil, which is typical for the soils of the CCR. The maximum content of exchange calcium in the arable layer is noted on the option with the joint introduction of defecate, manure and solid mineral fertilizers (24.31 mg-equ/100 g of soil); the minimum values are noted on the options with the introduction of mineral fertilizers against manure background (19 mg-equ/100 g of soil). The cation-exchange capacity (CEC) in the arable layer of the analyzed soil samples is characterized as high (29.2-31.6 mg-equ/100 g of soil). According to the humus content, soils belong to the medium-humic category (4.31-4.46%) except for the option using mineral fertilizers against liming background (3.96%). The amount of mobile humus forms increases when using mineral fertilizers (up to 41.66 and 53.08%, depending on the dose of fertilizers applied). It was determined that the use of ameliorator leads to the accumulation of mature non-mobile humus in the soil. When determining the correlation value, it was found that there is a close interrelation between the content of humus, labile humic substances, and hydrolytic acidity, as well as the sum of exchange bases and the content of exchange calcium.

INTRODUCTION

In modern soil chemistry, various methods, and approaches to studying humus condition are proposed. Most of them are aimed at in-depth characterization of the chemical structure of humic acids, study the agronomic significance of individual components of soil organic matter. Currently, approaches allowing to identify the most agronomically valuable humus components that consistently correlate with the level of fertility and productivity of arable land and are also sensitive to the conditions of agricultural technology are particularly relevant in agrochemistry.

When conducting an agronomic assessment of soil quality, it is advisable to divide organic matter into two groups. The first group is represented by mineralization-resistant conservative compounds. It includes highly condensed humic acids (humA), humic acids associated with calcium cations (HA-2), organo-mineral complexes humA, non-hydrolyzable residue (humin), lignin and its derivatives. Qualitative and quantitative characteristics of these organic matter components are determined by the type of soil-forming process. These compounds have existed in soils for hundreds and thousands of years, are poorly mineralized and characterize typical soil indicators. These substances do not participate in plant nutrition; however, they form favorable thermal, water, air, and other soil regimes.

The second group of organic substances is represented by mobile components that are easily mineralized. It is the substances of this group that are an affordable energy and nutrient substrate for microorganisms and plants. Easi-

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ly degradable organic matter (EDOM) is the closest reserve of micro- and macronutrient nutrition of plants, largely determining the content and dynamics of mobile forms of these elements in the soil [2,3]. They are involved in the process of soil structuring. In addition, EDOM performs a protective function. With a high EDOM content, the mineralization intensity of conservative organic compounds decreases, the rate of biodehumification decreases. EDOM components determine the course of biological and geological cycles of substances, participating in migration processes of chemical elements, differentiation of the soil profile, as well as in the formation of new organo-mineral complexes.

According to various authors [1, 10], the second group of organic substances includes non-specific organic compounds, root secretions, products of microbial metabolism, newly formed humus compounds and humA loosely connected to the soil's mineral matrix.

Determination results of ecologically and agronomically significant humus components are important for the development of systems for regulating soil fertility to increase their productivity, as well as for the development of a system for monitoring the humus state of chernozem soils.

The aim of the work was to study the effect of organic-mineral-lime fertilizer systems on agrochemical indicators, humus content and leached chernozem's EDOM.

EXPERIMENTAL METHODOLOGY

The research was carried out in a long-term stationary field experiment with fertilizers laid on the territory of the ESTC "Agrotechnology" of the Voronezh State Agrarian University named after Emperor Peter I. Soil samples of leached low-humic medium-thick heavy loamy chernozem on cover loams of 0-100 cm in increments of 20 cm were used as objects of research. Seven options were taken for the research: 1. No fertilizers (control); 2. 40 t/ha of manure – (background) - aftereffect; 3. Background + NPK; 5. Background + 2 NPK; 12. Background + NPK + defecate (aftereffect); 13. Background + defecate (aftereffect); 15. NPK + defecate (aftereffect). The work was carried out during 2019-2021.

The following parameters were determined in soil samples: humus content as per Tyurin's method with a photocolometric termination (GOST 4647-76); pH as per CSRIASA method; hydrolytic acidity according to Kappen in the CSRIASA modification. The composition of exchange bases (Ca^{2+}+Mg^{2+}) was determined by the trilometric method.

Labile humus substances (LHS) extracted with 0.1 n NaOH were studied at a soil :solution ratio of 1:20, extraction time - 17-20 hours. It is this extractant that is recommended for soils with close to neutral medium reaction.

RESULTS AND DISCUSSION

The study results are presented in Table 1 in Figures 1-5. Figure 1 shows the results of determining soil acidity in the studied soil samples.

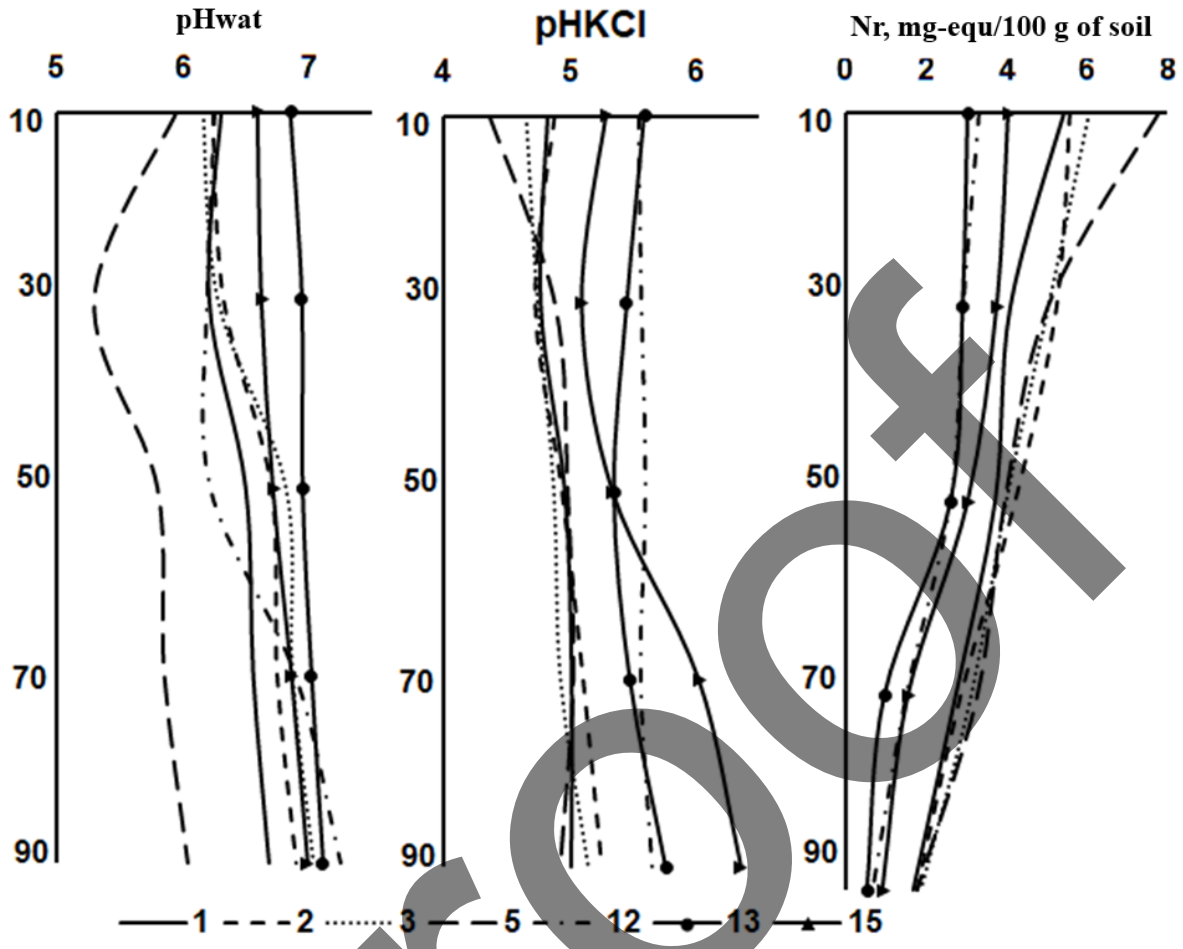

FIGURE 1. Indicators of actual and potential acidity of soil samples in analyzed options.
1. No fertilizers (control); 2. 40 t/ha of manure – (background); 3. Background + NPK; 5. Background + 2 NPK; 12. Background + NPK + defecate; 13. Background + defecate; 15. NPK + defecate.

Analyzing the data of the actual (pH_{wat}) and exchange (pH_{KCl}) acidity, it was found that the minimum values are noted in the option with high doses of mineral fertilizers against manure background (option 5). According to the soil classification as per acidity degree by Kidin V.V., the soils of options with the introduction of a double dose of mineral fertilizers against organic background are highly acidic. The control, background and option introducing a single dose of macronutrients (options 1, 2, 3) attribute to medium acidic type, limed options (options 12, 13, 15) are characterized as close to neutral. This indicates a high reclamation effect of defecate aftereffect and the acidifying effect of mineral fertilizers. Hydrolytic acidity is determined to establish the need for liming, calculating lime doses, as well as to adjust the use of phosphorus fertilizers. In accordance with the soil gradation, control and background options are strongly acidic; options using mineral fertilizers against manure background (3 and 5) are very strongly acidic, limed options are slightly acidic. Thus, it was established that the station's soils have a need for liming and the reclamation defecate aftereffect is already insufficient.

Figure 2 shows the curves of the profile distribution of the most important SAC characteristics – the sum of the exchange bases, the content of the exchange calcium and the capacity of the cation exchange.

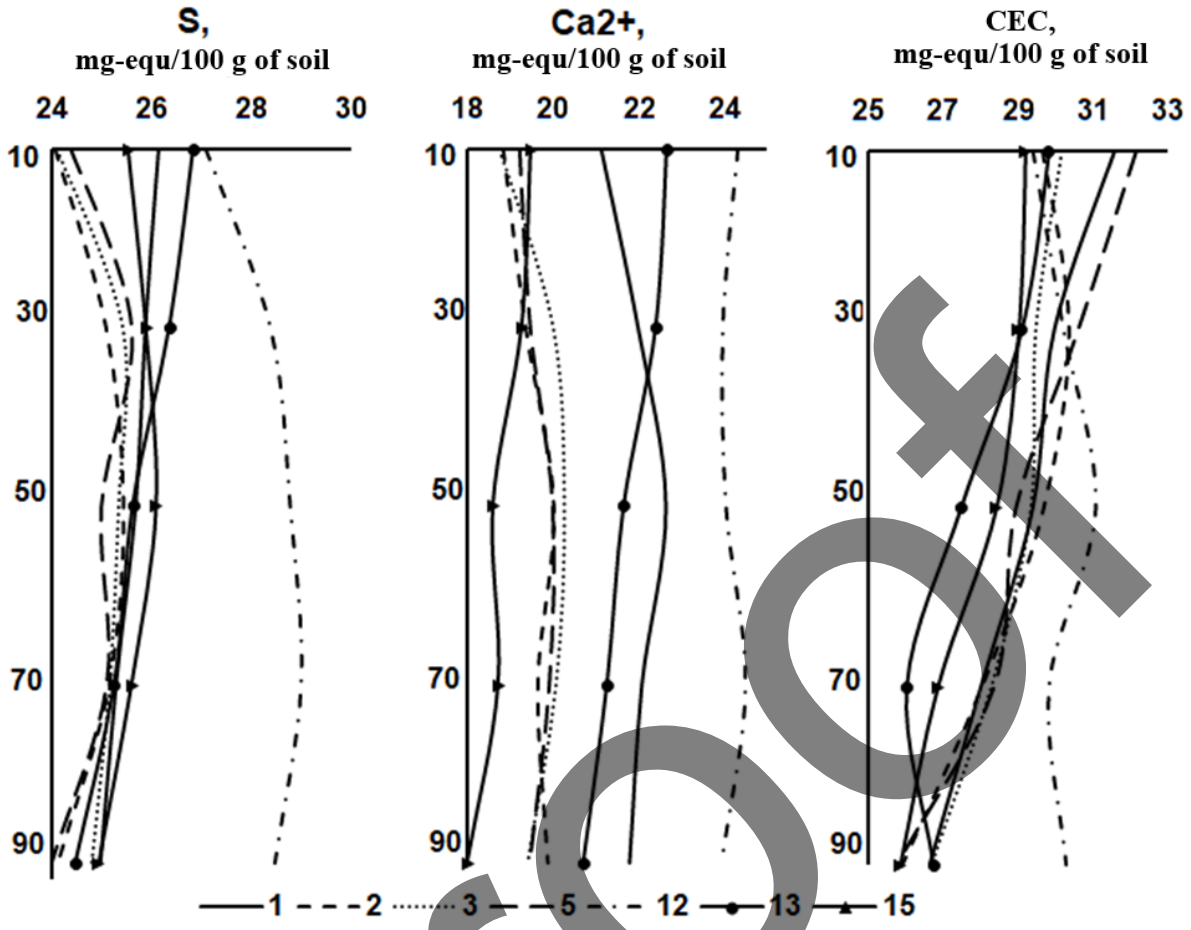

FIGURE 2. Characteristics of the soil-absorbing complex in analyzed soil options
1. No fertilizers (control); 2. 40 t/ha of manure – (background); 3. Background + NPK; 5. Background + 2 NPK; 12. Background + NPK + defecate; 13. Background + defecate; 15. NPK + defecate.

The sum of exchange bases in arable layer's samples varies from 24.08 to 27.08 mg-equ/100 g of soil, which is characteristic of the turf soil formation process occurring on rocks with a high content of calcium carbonate. Several types of substance distribution can be identified on the graph by the profile; for example, a uniformly decreasing type is noted in the control and option 13, on options 2, 3 and 15 - progressive eluvial one with the accumulation of exchange cations in the middle part of the profile. Option 12 shows a smooth uniformly accumulative profile with slight eluviation in the lower part of the profile. The option with introducing high doses of mineral fertilizers against manure background is characterized by an S-shaped distribution type of exchange cations along the soil profile.

The content of exchange calcium ranges from 18.78 to 24.45 mg-equ/100 g of soil. On options 1, 2, 3, 5, 12, 15, there is a gradual increase in values towards the middle of the profile (from 18.74 to 24.48 mg-equ/100 g of soil) and then a decrease (from 18.02 to 23.93 mg-equ/100 g of soil), which is characteristic of the progressive-eluvial-illuvial profile. The option's profile using defecate against organic background (option 13) is uniformly decreasing in nature. The maximum content of exchange calcium in the arable layer is noted on the option with the joint introduction of defecate, manure and solid mineral fertilizers (24.31 mg-equ/100 g of soil); the minimum values are noted on the options with the introduction of mineral fertilizers against manure background (options 3 and 5, 18.78 and 19.24 mg-equ/100 g of soil, respectively).

The cation exchange capacity is the most important characteristic of the cation exchange ability of soils and is determined by the total amount of cations that are exchange-retained in the soil. CEC in the arable layer is characterized as high (29.2-31.6 mg-equ/100 g of soil). With depth, CEC values decrease to average values (25.9-26.7 mg-equ/100 g of soil) due to a decrease in the exchange cations of hydrogen and aluminum. Apart from option 12, a uniformly decreasing type of distribution over the soil profile is noted in all options. In the option with the joint ap-

plication of fertilizers and ameliorator, a slight increase in the CEC in the middle and lower parts of the profile was revealed.

It is of interest to study the profile distribution of the total content of humus and mobile humus substances in soil samples of different fertilization levels (Fig. 3). It was found that humus content in the 0-20 cm layer ranges from 4.31-4.46% except for the option using mineral fertilizers against liming background (3.96%). Soils belong to the medium-humic category. Humus content decreases with depth; the profile is progressively accumulative, except for organic background options with a single dose of mineral fertilizers and with defecate together with a single dose of mineral fertilizers, where it is accumulative-eluvial-illuvial. The profile of LHS distribution varies greatly through experimental options; yet in general, it also has a progressive accumulative nature.

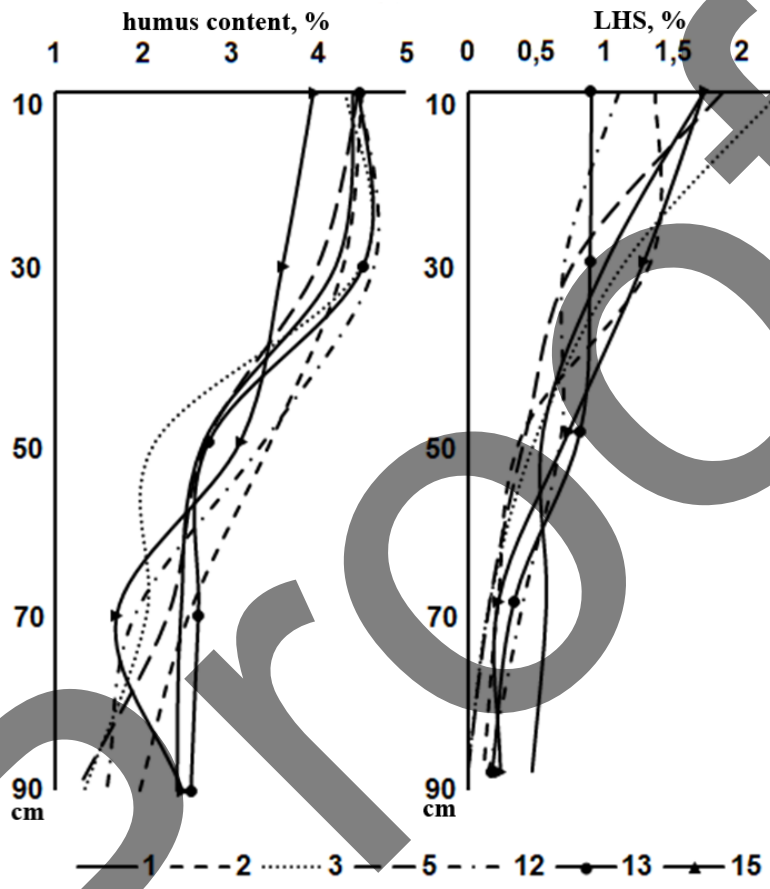

FIGURE 3. Profile distribution of humus and labile humus substances (LHS) in the analyzed soil samples.
1. No fertilizers (control); 2. 40 t/ha of manure – (background); 3. Background + NPK; 5. Background + 2 NPK; 12. Background + NPK + defecate; 13. Background + defecate; 15. NPK + defecate.

For a more accurate idea of the content of mobile fractions in humus composition, let us calculate their ratio to the total humus (Fig. 4).

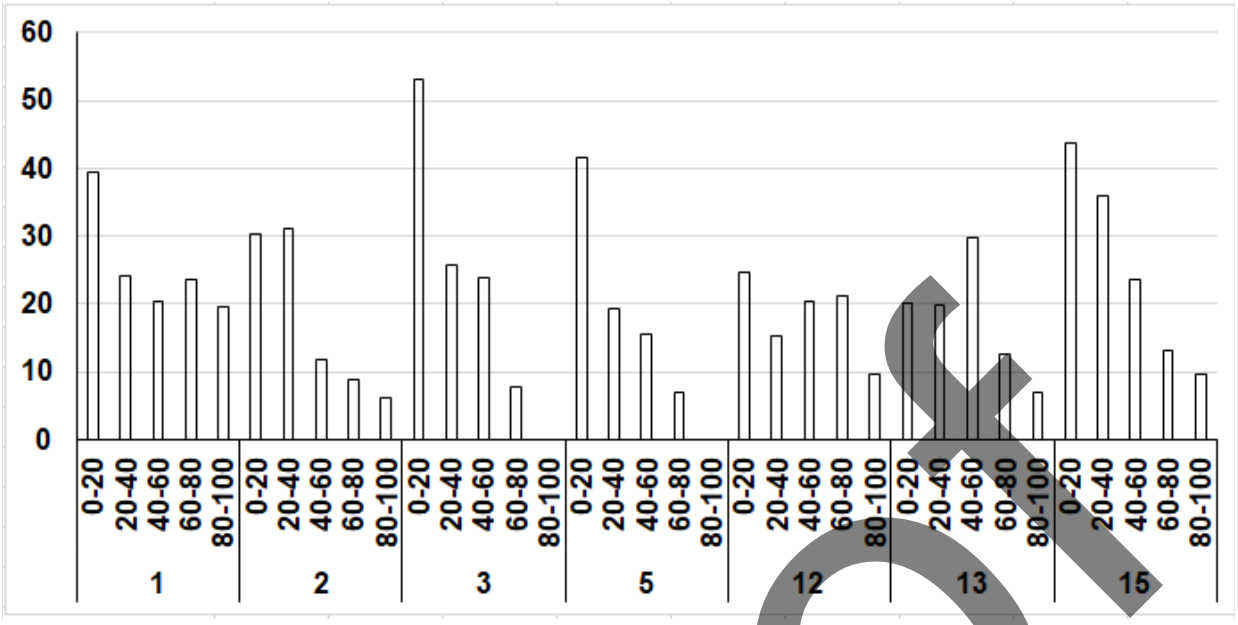

FIGURE 4. Ratio of mobile forms of organic matter to the content of humus in soils, %. 1. No fertilizers (control); 2. 40 t/ha of manure – (background); 3. Background + NPK; 5. Background + 2 NPK; 12. Background + NPK + defecate; 13. Background + defecate; 15. NPK + defecate.

It was found that the maximum amount of mobile forms in humus composition was noted in the options using mineral fertilizers against organic background (53.08% and 41.66%, option 3 and 5, respectively), which indicates an increase in humus mobility during the application of mineral fertilizers and subsequent acidification. The minimum values were noted on limed options against organic background (24.63% and 20.16% for options 12 and 13, respectively). It is natural to reduce the content of active humus down the soil profile in all options of the study.

It is known that the parameters of the soil humus state depend on the physicochemical properties [5,6]. It is of interest to determine the correlation coefficient between some soil properties and the content of total humus, as well as labile humus substances. It was revealed that the closest interrelation with humus and LHS is characteristic of such indicators as the content of exchange calcium and the sum of exchange bases. Table 1 shows the calculated correlation coefficients. This is explained by that calcium cations of the soil-absorbing complex play an important role in fixing humus substances in the soil profile [1,4].

TABLE 1. Correlation coefficients

Option	R Hum-Ca	R Hum-S	R LHS-Ca	R LHS-S
1	0.58	0.88	0.78	0.83
2	0.71	0.05	0.84	0.17
3	0.31	0.21	0.64	0.61
5	0.44	0.40	0.64	0.04
12	0.12	0.60	0.23	0.73
13	0.92	0.90	0.92	0.90
15	0.68	0.33	0.88	0.36

The calculation results of correlation coefficients are most clearly shown in Figure 5.

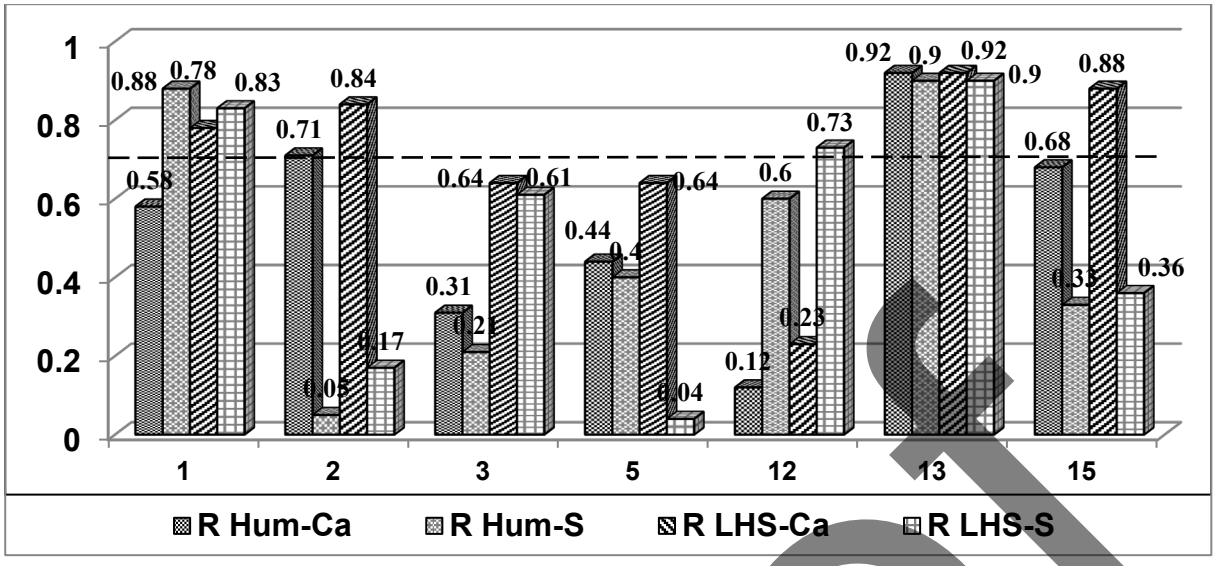

FIGURE 5. Correlation of humus state indicators with physico-chemical properties. 1. No fertilizers (control); 2. 40 t/ha of manure – (background); 3. Background + NPK; 5. Background + 2 NPK; 12. Background + NPK + defecate; 13. Background + defecate; 15. NPK + defecate.

The dotted line shows the level r > 0.7 of corresponding close connection. As follows from the data in Table 1 and Figure 5, the closest interrelation between the humus state indicators and the physico-chemical properties of the studied soil is observed in the option with defecate against organic background, where the value of r varies between 0.90-0.92. The control option revealed a close interrelation of all humus state indicators with the physico-chemical properties of the studied soil, except for R Hum-Ca. On the option with organic background, a close interrelation was revealed only for humus and LHS with calcium. In options with an organomineral fertilizer system, a close interrelation of humus state indicators with physico-chemical properties was not revealed; it is mainly medium or weak. In option 12, a close LHS interrelation with the sum of exchange bases was revealed; it is close for LHS with calcium in the option with defecate against organic background.

The closest interrelation (r 0.8) for all options was traced between the content of mobile humus and the value of hydrolytic acidity (Fig. 6). A linear interrelation between these indicators has been established: the amount of labile humic substances increases with an increase in hydrolytic acidity. This is also confirmed by literal data [7,9,11].

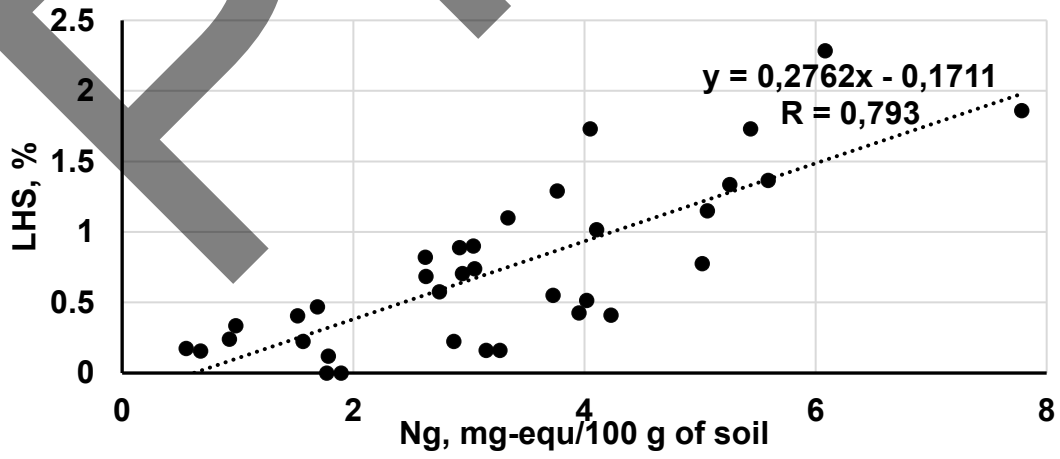

FIGURE 6. Dependence of LHS amount on hydrolytic acidity.

Thus, introduction of mineral and organic solid fertilizers, as well as liming, change the total content of humus and the amount of its labile fractions. The introduction of defecate (waste of sugar beet production) leads to the accumulation of mature non-mobile humus (calcium mulle characteristic of chernozem soils).

CONCLUSIONS

1. It was established that the use of organic-mineral-lime fertilizer system changes many indicators of soil fertility. According to the values of the actual and exchange soil acidity, the options introducing a double dose of mineral fertilizers against organic background are highly acidic. The control, background and single macronutrient dose options are medium acid; the limed options are characterized as close to neutral. In accordance with the value of the hydrolytic acidity, the station's soil requires liming.
2. When studying SAC characteristics, it was revealed that the sum of exchange bases in the analyzed samples of the arable layer varied from 24.08 to 27.08 mg-equ/100 g of soil, which is characteristic of chernozem zone soils. The maximum content of exchange calcium in the arable layer is noted on the option with the joint introduction of defecate, manure and solid mineral fertilizers (24.31 mg-equ/100 g of soil); the minimum values are noted on the options with the introduction of mineral fertilizers against manure background (19 mg-equ/100 g of soil). The cation-exchange capacity (CEC) in the arable layer of the analyzed soil samples is characterized as high (29.2-31.6 mg-equ/100 g of soil).
3. It was found that humus content in the 0-20 cm layer ranges from 4.31-4.46% except for the option using mineral fertilizers against liming background (3.96%). Soils belong to the medium-humic category. The maximum amount of mobile forms in humus composition was noted in the options using mineral fertilizers against organic background (53.08% and 41.66%, option 3 and 5, respectively), which indicates an increase in humus mobility during mineral fertilizers' application and subsequent acidification.
4. When calculating the correlation coefficients between the content of humus and LHS, it was revealed that a close interrelation between humus and LHS is characteristic of such indicators as the content of exchange calcium and the sum of exchange bases only in the option with defecate against organic background. It was revealed that there is a close interrelation between the amount of labile humic substances and the amount of hydrolytic acidity.
5. It has been established that introduction of mineral and organic solid fertilizers (as well as liming) changes the physico-chemical properties, the total content of humus and the amount of its labile fractions. Liming leads to an improvement in many soil fertility indicators, particularly to the accumulation of mature non-mobile humus.

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Growth Stimulants' Effects on Productivity and Quality Indicators of Apple Fruits in the Central Part of the North Caucasus

Kh.M. Nazranov [1, a)], V.N. Sitnikov [2, b)], A.N. Esaulko [2, c)], B.B. Beslaneev [1, d)], T.S. Aisanov [2, e)]

[1] *FSBEI HE Kabardino-Balkarian State Agrarian University, Nalchik, Russia*
[2] *FSBEI HE Stavropol State Agrarian University, Stavropol, Russia*

[a)] Nazranov777@mail.ru
[b)] Rector@stgau.ru
[c)] AEsaulko@yandex.ru
[d)] Corresponding author: Beslaneev@mail.ru
[e)] Aysanov_timur@mail.ru

Abstract. The use of high-tech organochelate preparations, concentrated ballast-free humic fertilizers based on natural plant raw materials enhanced with chelates of trace elements and fulvic acids at the present stage of horticulture development is becoming increasingly widespread. The development of optimal regimen for their use in combination with microbiological preparations on apple trees of various varieties and in various soil and climatic conditions is a mandatory element in the technology of their cultivation. The efficiency of mineral nutrition elements' fixation by trees increases when using growth stimulants in intensive gardening on apple trees. The use of these preparations on Idared variety apple trees leads to a significant increase in productivity indicators and commercial qualities of fruits due to photosynthetic activity stimulation; as a result, it leads to an increase in the economic efficiency of the orchard.

INTRODUCTION

The relevance of the chosen research topic is due to the economic realities of the modern world. The problems of reducing the chemical load, optimizing the mineral nutrition system, adapting the orchard to unfavorable climatic conditions, reducing the cost of fruit products in our country are long overdue issues, the solution of which is the primary task of horticultural organizations in the country [1].

The main ways to increase the productivity and quality of fruit growing are the issues of developing regulations to use many regulators and growth stimulators of a new generation in various soil and climatic conditions, followed by their organic introduction into the fertilizing system.

One of the main ways to solve many urgent agrotechnological problems is to adapt the maximum number of variety-rootstock combinations to diverse soil and climatic conditions [2]. Growth stimulators play an essential role in solving one of the main tasks of modern fruit growing – obtaining large and high-quality apple yields [3].

Despite that the range of growth stimulants recommended for horticultural use is quite large, this list needs to be improved over time in terms of functional and technological parameters of use for newly introduced varieties and cultivation conditions [4].

The main task in the field of developing regulations for growth stimulants' use is to increase adaptability to changing conditions of biotic and abiotic factors that could stimulate the growth and development of intensive apple orchards. At the same time, it is important to emphasize that the primary importance is given to improving the quality parameters of fruits [5].

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These studies are a reflection of a new direction - the use of humates with living microorganisms or products of their metabolism. The use of the unique abilities of humic preparations capable of intensifying the metabolic processes of plant cells have different phytoregulatory activity in different varieties and under various conditions of use; therefore, this research seems to be very relevant in conditions of intensive gardening [1, 2, 3].

The scientific novelty of this work is that for the first time, a regulation for using growth stimulants of domestic producers in combination with microbiological preparations was developed for the technological system of intensive gardening in the conditions of the Central part of the North Caucasus.

Research objectives:

1. To establish the influence of growth stimulants on the productivity and quality indicators of apple fruits in the conditions of the Central part of the North Caucasus.
2. Development of scientific recommendations on the regulation of using growth stimulants in the cultivation of Idared variety apple trees in various intensive gardening conditions in the Central part of the North Caucasus.

The objectives of the study were to determine the characteristics of growth and development of Idared apple trees in an intensive orchard, as well as to develop optimal regulations for using growth stimulants in combination with microbiological preparations.

CONDITIONS AND METHODS OF RESEARCH

The research was carried out in the plantations of Idared variety apple trees. The experiment included fruit-bearing trees of an intensive unsupported garden laid in 2012 in the forest-mountainous fruit zone of the Kabardino-Balkarian Republic at an altitude of 550 - 650 meters above sea level. The planting scheme was 4×3m, which amounted to 833 trees/ha, rootstock - MM106. The crowns were formed according to the "Russian spindle" system. The row spacing maintenance system - sodding. Experimental options were placed in the orchard by randomization. 10 trees were processed per each option. The soil of the experimental orchard is dark gray forest residually calcareous soil. Capacity of the humus profile (A+B) in the characterized soils had an average of 65 cm; the reaction of the soil solution was weakly acidic (pH = 5.8), the humus content was low (3,1 – 4,6%) [6].

During the research year, the crown structure was recorded and analyzed, the average shoot length, the number of growth shoots and lambourds per 1m bough were determined, "K" coefficient was calculated.

The main experimental records and observations were carried out in accordance with the "Program and methodology of variety studies of fruit, berry, and nut crops". The fruit yield was accounted by the weight method, the commercial qualities of fruits were evaluated according to GOST 21920-76. The economic efficiency evaluation of fruit production was carried out considering all types of costs, as well as cash gains from the sale of fruit products. Mathematical processing of the research results was carried out by the dispersion method according to B.A. Dospekhov [7].

TABLE 1. Experimental schemes in determining the effectiveness of growth stimulants on Idared variety apple trees, 2022.

Experimental options	**The norms for preparations' application according to the apple trees' phenological phases**			
	"rosebud"	**"hazel"**	**"walnut"**	**"fruit growth"**
1. Control (water treatment)	-	-	-	-
2. Lignohumate AM+ Trichodermin	0.5 kg/ha	0.5 kg/ha	0.5 kg/ha	0.5 kg/ha
3. Humate+7 + Trichodermin	0.2 l/ha	0.2 l/ha	0.2 l/ha	0.2 l/ha
4. Argolan Aqua + Trichodermin	2.5 l/ha	2.5 l/ha	2.5 l/ha	2.5 l/ha
5. Organomix for fruits and berries, Organomix Bor	0.5 l/ha + 0.6 l/ha	0.5 l/ha + 0.6 l/ha	0.5 l/ha + 0.6 l/ha	0.5 l/ha + 0.6 l/ha
6. Organomix for fruits and berries, Organomix Bor, Organostim	0.5 l/ha + 0.6 l/ha + 0.5 l/ha	0.5 l/ha + 0.6 l/ha + 0.5 l/ha	0.5 l/ha + 0.6 l/ha + 0.5 l/ha	0.5 l/ha + 0.6 l/ha + 0.5 l/ha
7. O-RISE (COMPLEX)	0.5 l/ha	0.5 l/ha	0.5 l/ha	0.5 l/ha

RESEARCH RESULTS

The use of growth stimulants had a certain positive effect on the structure of apple branches. There was a significant increase in the number of lambourds per 1m bough already in the 1st phase of preparations' application. The greatest result in terms of the "K" coefficient was achieved by the options of preparations' use before the rosebud phase in O-RISE (COMPLEX) 6.1 and by the option of the joint use of Organomix fruits and berries (0.5 l/ha), Organomix Bor (0.5 l /ha), Organostim (0.6 l/ha) 5.9.

In terms of this indicator, Lignohumate AM, Argolan Aqua, Humate+7 and Organomix fruits and berries, Organomix Bor had approximately the same indicator value at the level of 4.6.

The ratio of generative formations to growth ones ("K" coefficient) when using humic preparations + Trichodermin and Organomix fruits and berries, Organomix Bor - increased from 41 to 47% to control. The complex application of Organomix fruits and berries, Organomix Bor, Organostim and O-RISE (COMPLEX) gave an 84% and 91% increase, respectively.

TABLE 2. Structure of an Idared apple tree branch when treated with preparations (number of organs per 1 m of bough, pcs.), 2021.

Treatment time	Name of preparations (options)	Accretion number in the form of growth shoots (pcs.)	Number of accreted twigs in the form of lambourds, hastulas, brindilles (pcs.)	"K" – ratio of generative formations to growth	"K" in % to control
Before the "rosebud" phase	1.Control (water treatment)	10.5	33.2	3.2	100
	2.Lignohumate AM+ Trichodermin	11.2	51.5	4.6	143
	3. Humate +7+ Trichodermin	11.1	52.1	4.7	147
	4. Argolan Aqua+ Trichodermin	11.5	52.1	4.5	141
	5.Organomix fruits and berries, Organomix Bor	11.3	52.0	4.6	144
	6.Organomix fruits and berries, Organomix Bor, Organostim	11.2	66.1	5.9	184
	7.O-RISE (COMPLEX)	11.0	67.2	6.1	191

The study results revealed that the use of all growth stimulators in the "hazel" or "walnut" phase also contributed to an increase in the generative formations' number compared to the control, yet the "K" coefficient decreased by an average of 1.3 times compared to the treatment period before the rosebud phase (Table 3).

TABLE 3. Structure of an Idared apple tree branch when treated with preparations (number of organs per 1 m of bough, pcs.), 2021

Treatment time	Preparation name	Accretion number in the form of growth shoots (pcs.)	Number of accreted twigs in the form of lambourds, hastulas, brindilles (pcs.)	"K" – ratio of generative formations to growth	"K" in % to control
After flowering in "hazel" or "walnut" phase	Organomix fruits and berries, Organomix Bor, Organostim	13.1	59.0	4.5	140.6

In the "walnut" phase, complex application of Organomix fruits and berries, Organomix and Bor, Organostim led to an increase in the number of growth shoots by an average of 1.9 pcs., and the number of generative formations decreased by 7.1 pcs. compared to the treatment with these preparations before the "rosebud" phase. This pattern was observed in all treatment options after the "rosebud" phase for all preparations.

An increase in the percentage of useful sets when using preparations led to a significant increase in yield in all experimental options. The most significant effect on the increase (29.7 t/ha) was the use of O-RISE (COMPLEX) in technology. The tree productivity increased by 40% in this experimental option. A significant increase in the number of fruits and the average weight of fruits by 12 g caused a significant increase in yield in this experimental option. The largest increase in the average fruit weight was noted in the 4th experimental option and amounted to 146.4g, which was 16.9g more than the control option. At the same time, the number of fruits per tree was less than in the 3rd option using Humate + 7 + Trichodermin, where the average weight of apples was noted at the same level. An increase in the number of fruits in this option did not lead to an increase in the total weight of fruits per one tree and according increase in yield.

In a number of experimental options, the yield increased due to an increase in the number of fruits. In other options, the increase in yield was due to a significant increase in the average fruit weight (Table 4). Thus, in the 6th and 7th options using Organomix fruits and berries, Organomix Bor, Organostim and O-RISE (COMPLEX), an increase in the "K" coefficient led to a significant increase in the number of fruits. At the same time, the mass of fruits was at the level of average indicators. There was a significant increase in the average weight in options using Humate+7 and Argolan Aqua – 11 and 13% higher than the control (larger fruits (143-146g) were formed), yet the productivity of plantings was lower due to that the number of apples per one tree decreased.

TABLE 4. Yield of Idared variety apple trees with 4-fold treatment with growth stimulants, t/ha.

Experimental Option No.	Preparation name	Average weight of fruit, g	Productivity of 1 tree, kg	Yield, t/ha	% to control
1	Control (water treatment)	129.5	25.4	21.2	100
2	Lignohumate AM+ Trichodermin	138.0	30.3	25.3	119.3
3	Humate+7 + Trichodermin	143.6	30.8	25.7	121.2
4	Argolan Aqua + Trichodermin	146.4	32.8	27.4	129.2
5	Organomix fruits and berries, Organomix Bor	138.6	32.4	27.0	127.4
6	Organomix fruits and berries, Organomix Bor, Organostim	139.8	33.5	27.9	131.6
7	O-RISE (COMPLEX)	141.5	35.6	29.7	140.0
	LSD_{05}			1.23	

So, when using the tested growth stimulants, there is an increase in productivity per unit area both by increasing the number of fruits and by increasing the average weight of apples. At the same time, it should be noted that as a rule, fruits with a lower mass are formed in plantings in the specific climatic conditions of the mountainous zone than in plantings in the plain zone. In these experiments using growth stimulants, the average weight of apples was at the level of indicators of plain orchards (Figure 1).

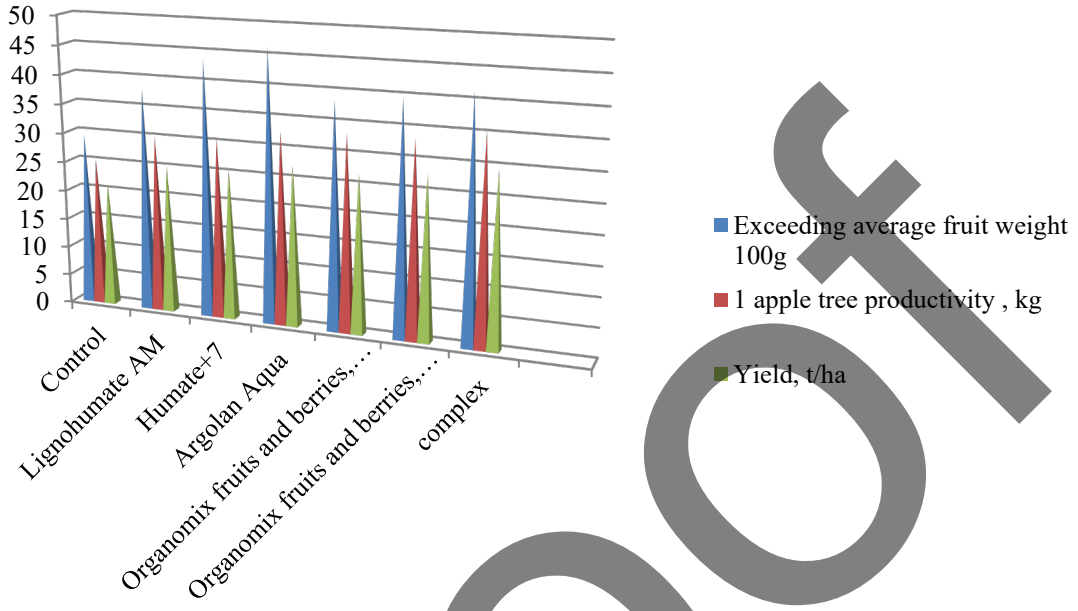

FIGURE 1. Productivity indicators of Idared variety apples.

Treatment of trees with growth stimulants leads to a significant increase in the quality indicators of fruits. 4-fold preparations' use increases the fruit yield of top and first grades in the best option by 23% (Table 5). A significant improvement in the commercial quality of Idared variety apple fruits was obtained by treating trees with stimulants Argolan Aqua+ Trichodermin, Organomix fruits and berries, Organomix Bor, Organostim, O-RISE (COMPLEX) - more than 95% of apples were of high commercial quality.

In the experimental option using Lignohumate AM + Trichodermin, the fruit yield of top commercial grade was 85%, which was also 9% higher than the indicator of the control option. As for the standard part of the fruit harvest, the ratio of grades 1 and 2 in the control was about the same. When using O-RISE (COMPLEX), only 1% of apples were of a non-standard category. The fruits of the 3rd commercial grade were absent in the options of treatment with growth stimulants Argalon Aqua and Organomix fruits and berries, Organomix Bor, Organostim. When treated with other stimulants, their number did not exceed 2%.

TABLE 5. The effect of treatments with growth stimulants on the commercial qualities of Idared variety apple fruits

Experimental	Preparation name	Commercial grades, %			
		top	first	second	third
1	Control (water treatment)	31	45	13	11
2	Lignohumate AM + Trichodermin	67	18	13	2
3	Humate +7+ Trichodermin	70	18	10	2
4	Argolan Aqua + Trichodermin	72	24	4	0
5	Organomix fruits and berries, Organomix Bor	63	27	9	1

Continuation of TABLE 5.

6	Organomix fruits and berries, Organomix Bor, Organostim	72	27	1	-
7	O-RISE (COMPLEX)	73	26	-	1

Determining the economic feasibility of using various growth stimulants is an important part of the study. It is known that making a profit from the sale of apples is possible only with a certain yield of standard fruits; as a result, an increase in the quality indicators of fruits contributes to economic efficiency.

The use of plant growth stimulators in the technology of growing fruit crops can provide a significant increase in the economic efficiency of gardening due to that additional costs of using this agricultural technique are small. This is due to the insignificant introduction rates of stimulants and their compatibility with most chemical preparations for plant protection, so that additional costs for separate preparation's introduction are not required.

The use of phytoregulators increases adaptability to the prevailing climatic conditions of the year, increases the immune properties of plants, which in turn leads to a reduction in the number of treatments per tree.

In the experiment, the greatest net profit from growing Idared variety apples was achieved in the 7th option using O-RISE (COMPLEX), where this indicator amounted to 578.6 thousand rubles/ha. This result was obtained by increasing the yield with high quality indicators of fruits. But at the same time, the profitability here was slightly lower than that of the Argolan Aqua option where the highest indicator was achieved – 132.8%. In this option, the cost of a unit of production was 14.9 thousand rubles/t. The use of domestic humic preparations + Trichodermin was much cheaper.

The efficiency of mineral nutrition elements' fixation by trees increases when using growth stimulants in intensive gardening on apple trees. Thus, the combination of humates with mineral fertilizers is a guarantee of their effective fixation by the plant. In addition to increasing productivity, the stimulating role of preparations in the phytosynthetic activity of Idared variety apple plants in the mountainous zone of the KBR can significantly improve the commercial qualities of fruits and thereby increase the economic efficiency of the orchard.

TABLE 6. The influence of using growth stimulants on the economic indicators of Idared variety apples' production

Indicators	**Measurement unit**	**commercial grades**	**Experimental options**						
			1	**2**	**3**	**4**	**5**	**6**	**7**
Yield (standard fruits)	t/ha	top+first	16.3	21.5	22.6	26.3	24.3	27.6	29.4
		second	2.8	3.3	2.6	1.1	2.4	0.3	0
		third	2.3	0.5	0.5	0	0.3	0	0.3
		total	**21.4**	**25.3**	**25.7**	**27.4**	**27**	**27.9**	**29.7**
Selling price of 1T of fruit	thousand rubles	top+first				35			
		second				25			
		third				8			
Cost of product from 1 ha	thousand rubles	top+first	570.5	752.5	791.0	920.5	850.5	966.0	1 029,0
		second	70.0	82.5	65.0	27.5	60.0	7.5	0.0
		third	18.4	4.0	4.0	0.0	2.4	0.0	2.4
		total	**658.9**	**839.0**	**860.0**	**948.0**	**912.9**	**973.5**	**1 031.4**
Costs per 1 ha	thousand rubles	-	384.8	402.8	404.0	407.2	436.8	448.2	452.8
Cost of 1T of fruits	thousand rubles	-	18.0	15.9	15.7	14.9	16.2	16.1	15.2
Net income from 1 ha	thousand rubles	-	274.1	436.2	456.0	540.8	476.1	525.3	578.6

Continuation of TABLE 6.

Profitability level	%	-	71.2%	108.3%	112.9%	132.8%	109.0%	117.2%	127.8%

CONCLUSIONS

The efficiency of mineral nutrition elements' fixation by trees increases when using growth stimulants in intensive gardening on apple trees. Thus, the combination of humates with mineral fertilizers serves as a guarantee of their effective fixation by fruit trees.

Growth stimulators have a positive effect on the branch structure of Idared apple trees in the forest-mountain fruit zone. The most noticeable effect on increasing the yield of trees (by 40%) was the use of the O-RISE (COMPLEX) preparation.

The complex use of Organomix fruits and berries, Organomix Bor, Organostim and O-RISE (COMPLEX) significantly increases the marketability of apple fruits.

In addition to increasing productivity, the stimulating role of preparations in the phytosynthetic activity of Idared variety apple trees can significantly improve the commercial qualities of fruits and thereby, increase the economic efficiency of the orchard. The highest profitability was achieved in the 4th option using Argolan Aqua + Trichodermin – 365.6%.

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Trends in Change and the Current State of the Effectiveness of Land Reclamation Measures in Agriculture

Bakhodir Sultanov [1], Timur Nurimbetov [4], Sarsengaliy Bayjanov [4], Berdiyar Seyilbekov [5], Akmal Durmanov [1, 2, 3, a)]

[1] *Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME)-National Research University, 100000, Kari Niyaziy str., 39, Tashkent, Uzbekistan*
[2] *International Center for Food and Agriculture Strategic Development and Research under the Ministry of Agriculture of the Republic of Uzbekistan, Tashkent, Uzbekistan*
[3] *Branch of the Astrakhan State Technical University in the Tashkent region of the Republic of Uzbekistan, Tashkent, Uzbekistan*
[4] *Karakalpak state university, Nukus, Uzbekistan*
[5] *Karakalpakstan Institute of Agriculture and Agrotechnologies, Nukus, Uzbekistan*

[a)] Corresponding author: akmal.durmanov.1977@mail.ru

Abstract. Aim research is the development of proposals and practical recommendations aimed at improving the scientific and methodological base for assessing and increasing the effectiveness of land reclamation measures in agriculture. The object of the study is agricultural users of land and water resources in agricultural production, farms and dekhkan farms, as well as WUAs and entities engaged in water management. According to a monographic study of the ameliorative state of lands, the highest indicator is in the Namangan region and the lowest in the Republic of Karakalpakstan. The subject of the study is the conditions, factors that affect the effectiveness of land reclamation measures in agriculture and organizational and economic relations that arise in the course of their interaction. The results of the study are substantiated scientific and practical aspects of the effectiveness of land reclamation measures related to natural and climatic factors, including bioclimatic potential, photooptical radiation (PAR), biomass and plant formation processes under the influence of photosynthesis, proposals have been developed to improve the mechanisms of economic incentives for effective use of land and water resources in agriculture.

INTRODUCTION

The growth of the world's population and the intensification of globalization processes give rise to the need for a proportional increase in the volume of production of material goods and products necessary for people's consumption and improving the quality from an environmental point of view. According to the calculations of the Department of Social and Environmental Affairs, the world population by 2100 will be 10.9 billion people [1], namely, compared to 2019, it will increase by 40%. According to the analysis, in most cases, this problem appeared due to extensive factors, namely, due to the increase in agricultural sown areas. But it is worth noting that the total area of all limited sown areas is projected at 1,500 million hectares. In this regard, we can say that humanity has almost completely used all the reserves of suitable sown areas for agricultural production. For this reason, in order to prevent the development of new lands, in order to avoid the risk of ecological collapse, there is a need to ensure inter-farm compliance and organization of reproduction based on the efficient use of crop areas through innovative solutions in the use of natural resources.

Global climate change has a negative impact on human interests, and in some cases leads to socio-economic tension. In particular, an average temperature increases of 0.7 degrees [2] in the middle of the 19th century in the early years of the 20th century had a negative impact on crop yields, especially limiting the possibility of ensuring

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food security, in economically slowly developing countries. Naturally, the impact of these problems on the sustainable development of the agricultural sector, especially its central part - the agricultural network, is subject to natural factors, unlike other systems and sectors of the real economy. Prevention of these investigated global problems, first of all, requires the creation of Agro-adapted agricultural production based on intensive factors and innovative developments [3,4].

One of the factors of the intensification of agricultural production is the role of melioration, which is the primary and basic basis for the efficiency of the industry, firstly, because the lack of melioration limits the sector's potential to ensure its efficiency, and secondly, this leads to the production of products that do not meet regulatory requirements for quantity and quality [5]. Therefore, broad measures are being taken in the republic to improve the reclamation state of lands [6]. However, the current status of land reclamation, the legal and regulatory framework for improving the efficiency of land reclamation activities, and the incomplete relationship between actors prevent the creation of adequate conditions for achieving the goals set out in the Strategy for Sustainable Agricultural Development until 2030 [19, 20]. Therefore, the improvement of methods for assessing and calculating the economic efficiency of land reclamation measures and the financial resources spent on them, its impact on the growth of incomes of agricultural enterprises [7,8], sources of financing of land reclamation measures, the development of scientifically based proposals and guidelines for determining the strategic directions of its development in the near future is one of the most urgent today's tasks.

MATERIALS AND METHODS

In the process of research, the methods of statistical analysis, monographic observation, induction and deduction, abstract thinking, economic and mathematical modeling, expert and rating evaluation are widely used.

RESULTS AND DISCUSSION

Studies show that over the years of independence in the republic, the use of land and water resources in agriculture:
a) The size of the land fund has not changed significantly in terms of composition and quantity. During these years, the area of arable land has increased by almost 30 percent in terms of the area of arable land, which has been on a downward trend since 2005.

- In the structure of agricultural crops, the area under cereals increased almost four times, and the area under cereals increased 6 times. Accordingly, the area under cotton decreased by 26.4%, and fodder crops - by almost 4 times;

– The main source of water resources in irrigated agriculture in the country are border areas. The use of water resources in neighboring countries tends to reduce annual water consumption as a result of the transition to an energy resource regime, the prioritization of intensive agricultural production in terms of food security and global climate change [9, 17];

– As a result, the population growth rate is higher than the growth rate of irrigated land, as a result, the share of irrigated land per capita in the country tends to decrease [10, 18].

b) c from the point of view of oragination-quantitative analysis, according to the implementation of the Program for the improvement of the reclamation state of lands, has a relatively positive trend. That is, solonchaks decreased by 10.8%, and solonchaks increased by 17.2%. However, the water table has increased by 22.8 percent from 0-1 meters. Also, the level of mineralization of groundwater with a dangerous level of 3-5 g / l decreased by 24.7%;

- however, the bonus point for irrigated arable land in the country has decreased by 5 points over the years, in particular, the land valuation by 61-80 points has decreased by 6.6 points, and the share of sown areas with better soil fertility by 81-100 points by 7 .1 points;

- a decrease in republican bonus points due to the use of agricultural machinery, in particular, the movement of units across the sown area also has a negative character.

In other words, it has a direct effect on soil compaction, which contributes to a decrease in its fertility. This was also confirmed by the results of a monographic survey conducted on the Ilhomjon farm. Eshondadaevich in Mingbulak district of Namangan region. In this farm, in 2018, cereals were sown using traditional crops on 79.6 hectares and on the rest of the resource-saving technologies.

As a result of these measures, the cost of equipment for processing and sowing one hectare of land using traditional methods is 587,000 UZS, the reserve is 484,000 UZS, the fuel consumption is 70 liters, the reserve is 30 liters, 125-150 kg instead of 250 kg. The average cost of fuel was 103,000 UZS, while the average fuel consumption was 41 liters or 189,000 UZS and seeds 250,000 UZS (Table-1).

TABLE 1. Economic and environmental efficiency of using resource-saving and traditional technologies on irrigated lands when growing grain (*per 1 hectare)* (2018)

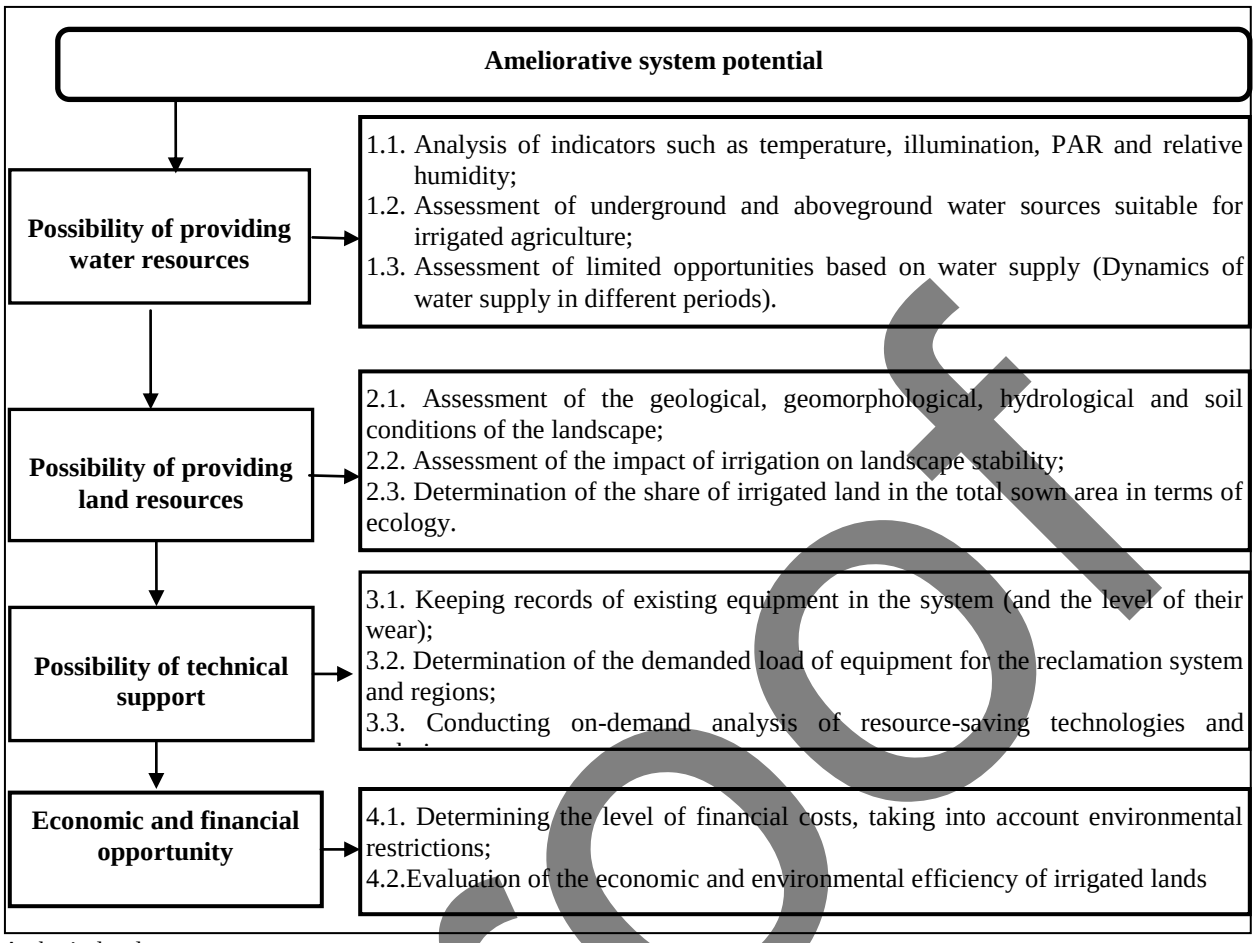
No.	Indicators	Traditional technological map	Resource-saving technologies	Difference + , -
one	Productivity, c/ha	54.0	61.2	+7.2
2	Gross output, ton	5.4	6.12	+0.72
3	The number of movement of equipment on the sown area, total times	18	13	-5
4	Change in soil density from the movement of machinery across the sown area (average cost), g/cm^3	1.45	1.31	-0.14
5	Increasing yields by reducing soil density, centner/ha	-	7.2	+7.2
6	Costs per 1 hectare, you sum	4679	4408	-271
7	Income received, thousand UZS	6089	6879	+790
8	Earned profit, thousand UZS	1410	2471	+1061
9	Profitability, %	30.1	56.0	+25.9

Developed on the basis of data from the farm "Ilkhomjon Eshonnilayevich" of the Mingbulak district of the Namangan region.

Predominantly, the density of the soil was 1.45 g/cm3, and in the resource saving method it was 1.31 g/cm3 due to a 5-fold reduction in the number of high gravity fields. The yield per hectare was 61.2 centners per hectare due to reduced soil compaction.

That is why it is necessary to prevent soil compaction, apply resource-saving irrigation methods that reduce soil intensity, switch to technologies that significantly reduce the number of agricultural machineries and also reduce the number of effective and complex agricultural methods [11, 12] to prevent soil compaction. Efficient land management in order to adopt advanced technologies and prevent soil compaction Arid areas can also be used to improve soil fertility.

It is well known that the effective organization of land reclamation measures will directly restore the operation of any land reclamation systems [13, 14]. Therefore, although it is important to assess the existing capacity of reclamation systems [15, 16], we believe that the algorithm for estimating reclamation capacity can be formed as follows (Figure-2).



Author's development.

FIGURE 1. Algorithm for assessing the reclamation potential of the region, taking into account environmental restrictions.

Thus, the potential of reclamation systems should be assessed based on the ability to use the land, water and climatic conditions of the region, taking into account geoecological restrictions. Therefore, when assessing the potential of existing reclamation systems in the country, the combination of all of the above factors will provide a scientifically based solution to the problem [15].

Financing the operation and maintenance of irrigation and reclamation potential on the basis of the "residual" until 1990-2007. led to problems with the wear of the collector-drainage system, channels and hydraulic structures. This led to a sharp decline in the productivity of irrigated lands. This will not have a negative impact on the potential of existing reclamation systems, since the development of reclamation in agriculture depends not only on natural factors, but also on the potential of existing reclamation systems. Thus, the potential of reclamation systems in the republic is somewhat lower than the required optimal condition (2-table).

TABLE 2. Indicators and state of meliorative potential of the Republic of Uzbekistan.

No.	Indicators	Current state	Demanded optimal state
one	Land Use Factor(LRF)	0.6 0 -0.80 _	Over 90 %
2	Irrigation system efficiency	0.60 _ _	Over 80%
3	Share of salinized areas of different levels of the total area, %	Above 45.0 % _	0
4	Level from 1.0 to 3.0 meters of groundwater to the total area, %	8.8	Below 3

Continuation of TABLE 2.

5	Share of area with mineralization level from 1.0 to 3.0 g/l of groundwater to the total area, %	78.4	Below 10
6	GTI performance , %	40-60	100
7	The state of water supply during the growing season,%	10-75	100
8	The ratio of water measuring facilities per 100 hectares of area, pcs	1-2	5-7
9	Dispatch service and irrigation system automation level, %	Below 10	80-100

Author's development.

The data in the table show that improving the efficiency of land use and the efficiency of the irrigation network requires, first of all, a reduction in the proportion of water losses in existing irrigation systems. This is due to the fact that the efficiency of the irrigation network is below the optimal demand, which is 60%. This loss is connected, first of all, with the fact that the canals are sandy and there is an unauthorized diversion of water from irrigated areas [20].

It is also related to the price mismatch between agricultural and industrial products and energy resources. Price inequality and financial instability on farms drastically reduce the flow of investment needed to maintain and increase the reclamation potential in the country.

CONCLUSION

In conclusion, it should be said that hydraulic structures, collector drainage networks and inadequate use of financial resources for irrigation and reclamation measures in general have a negative impact on the occurrence of the mentioned adverse phenomena. The analysis shows that the main reasons for this are:

- inadequate mechanism of organizational and economic relations between agricultural enterprises and water management organizations that carry out land reclamation activities;

- an imperfect system of efficient and rational use of material and financial resources for land reclamation activities, that is, the lack of a methodology for directing these funds to the implementation of certain types of activities;

– low administrative or material responsibility for improving financial resources for land reclamation activities and low interest rates for positive results or lack of a regulatory framework for their regulation;

– lack of a land referral mechanism to improve land reclamation, not only with the water management authorities, but also with the Ministry of Agriculture and government agencies responsible for monitoring and monitoring the use of land resources.

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Ammonium Nitrogen Regimen of Leached Chernozem in Stationary Experiment with Fertilizers and Defecate

V.B. Pimenov [a], E.S. Gasanova [b], K.E. Stekolnikov [c], N.V. Stekolnikova [d] and P.T. Brekhov [e]

Voronezh State Agrarian University named after Emperor Peter I, Voronezh, Russia

[a] vladpimenov387@mail.ru
[b] Corresponding author: upravlenieopm@mail.ru
[c] soil@aqgrochem.vsau.ru
[d] stekolnikova-nv@mail.ru
[e] brehovp@mail.ru

Abstract. The regimen of ammonium nitrogen of leached low-humic moderately deep heavy loam chernozem was studied in 2019-2022 in a stationary experiment with fertilizers and defecate of the Department of Agrochemistry, Soil Science and Agroecology of the Voronezh State Agrarian University. The experiment was established in four-fold repetition, plot area - 200 m^2. Alternation of crops in crop rotation – fallow, winter wheat, sugar beet, vetch-oats mixture, winter wheat, barley. The analysis of soil samples was performed using ion-selective electrodes made by Volta in water-saturated pastes at a soil:solution ratio of 1:0.5. Exchange ammonium was determined by photocolorimetric method with Nesler reagent. It has been established that organic and organomineral fertilizer systems contribute to an increase in the water-soluble content and exchange-absorbed forms of ammonium nitrogen; the content of the latter in the studied soil is significantly higher. The use of ameliorator reduces the content of water-soluble and exchange-absorbed ammonium, yet it stabilizes all types of soil acidity. The distribution pattern of NH_4^+ is predominantly eluvial-illuvial and is practically the same for both the water-soluble and the exchange form. The correlation of exchange-absorbed ammonium content with the acidity of the soil was determined. On the control and fertilized options, the interrelation of exchange-absorbed ammonium content with the pH value of the aqueous and salt extract was negative, medium and close; on the options with defecate - positive, medium and close; with the value of hydrolytic acidity in the control and fertilized options - mainly medium and close, in the options with defecate - ranges from medium to close in separate years.

INTRODUCTION

Unlike nitric nitrogen, ammonium nitrogen is not mobile enough in soils due to its fixation by the soil adsorption complex (SAC). In minerals with mobile crystal lattice (illite, montmorillonite, vermiculite, etc.), it is fixed in the inter-pack space and becomes practically inaccessible to plants. Ammonium compounds are partially fixed irreversibly. Usually, non-exchange fixed ammonium nitrogen in soils is 2-4 times more than its exchange and water-soluble forms. Ammonium nitrogen in arable soils is present in the absorbed or exchanged state and is easily displaced by potassium or sodium cations [1, 2, 3]. Therefore, its determination is carried out in a salt extract with a soil:solution ratio of 1:5, that is, with a soil moisture of 500%, which does not correspond to natural humidity at all and gives overestimated results.

Since late 20th century, ion-selective electrodes have been widely used in research. Their use in the analysis - and mainly in the diagnosis of the agricultural crops' supply with nutrients - is a promising direction in agrochemistry and soil science. The determination is carried out both in suspensions in laboratory conditions and in field studies. Only soil moisture limits the use of ion-selective electrodes in field studies. The lower humidity limit is about 15% for soils with heavy granulometric composition [4, 5, 6, 7]. It is essential to control the nitrogen cycle for normal functioning and development of plants. Otherwise, there will be traits of nitrogen deficiency manifested in weak plant branching, delayed ripening, increased fragility of shoots. Nitrogen controls the synthesis of proteins and enzymes in the plant body, thereby affecting all metabolic processes [8, 9, 10, 11].

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It is of interest to study the regimen of ammonium nitrogen using the traditional photometric method with Nesler reagent and ionometric method using an ion-selective electrode, which was the aim of this research.

EXPERIMENTAL METHODOLOGY

Studies of the ammonium nitrogen regimen were carried out in a stationary experiment with fertilizers and ameliorators laid on the territory of the Voronezh State Agrarian University on leached low-humic moderately deep heavy loam chernozem in 1987 with an area of 12 hectares. The experiment was carried out in four-fold repetition, plot area - 200 m^2. The experimental scheme includes 15 options. The following experimental options were selected for research: 1 – control, 2 – organic background, 40 t/ha of cattle manure, 3 – background+$N_{60}P_{60}K_{60}$, 5 – background+ $N_{120}P_{120}K_{120}$, 13 – background+ defecate, 15 – defecate+$N_{60}P_{60}K_{60}$. Cattle manure (N - 0.5%, P – 0.25%, K – 0.6%) was introduced in bear fallow; fertilizers were applied annually according to the experimental scheme; defecate was introduced three times at the beginning of the first (1987) and third (1999) rotation. In the fourth (2005) crop rotation, defecate was introduced at a dose of 22 t/ha in options 13 and 15. Defecate composition: $CaCO_3$ – 46.50%, P_2O_5 – 0.48%, K_2O – 0.48%, total nitrogen – 0.35%. Ammonium nitrate, double superphosphate, and potassium chloride were used in the experiment.

Within the experiment, a six-field crop rotation was mastered with the following crops: fallow, winter wheat, sugar beet, vetch-oats mixture, winter wheat, barley.

The method of saturated soil paste has been widely used in the USA. The essence of the method is that the least amount of water is added to the soil [9]. The studies were performed using ion-selective electrodes made by Volta in water-saturated pastes with a soil:solution ratio of 1:0.5 [5]. The ammonium exchange was determined by the photocolorimetric method with the Nesler reagent [4].

Soil samples were taken up to 1 m depth in 20 cm increments.

RESEARCH RESULTS

The results of the research are presented in Figures 1-5. For the regime of mineral nitrogen, the precipitation regime of the active growing season (AGS) and hydrothermal conditions (HTC) are important.

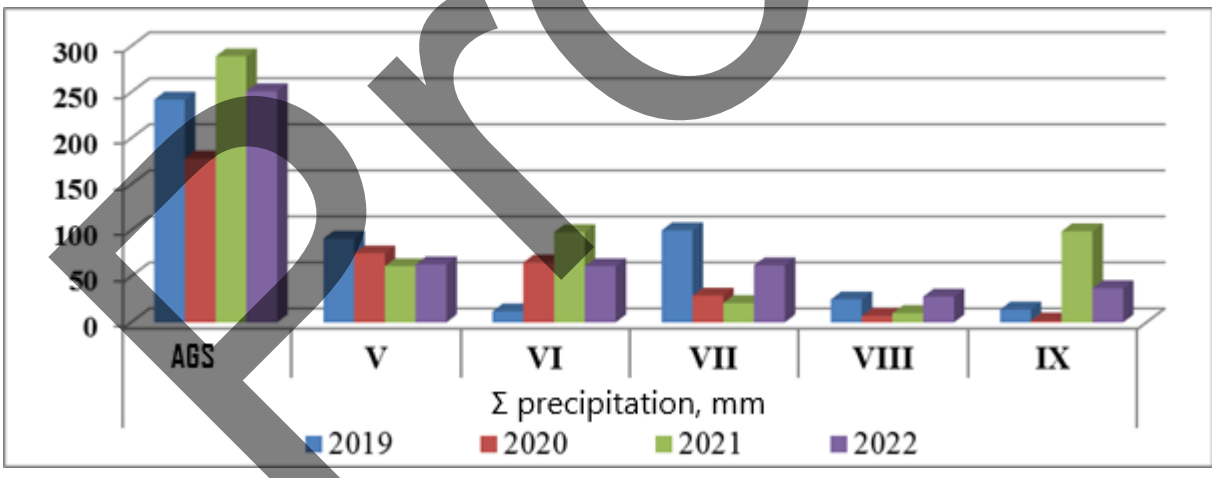


FIGURE 1. Precipitation regime of the active growing season (AGS).

Over the years of observations, vegetation periods were characterized by moisture shortage, especially in 2022. On average, precipitation amount per AGS ranged from 178 - which is significantly lower than normal - to 289 mm (Fig. 1). Σ

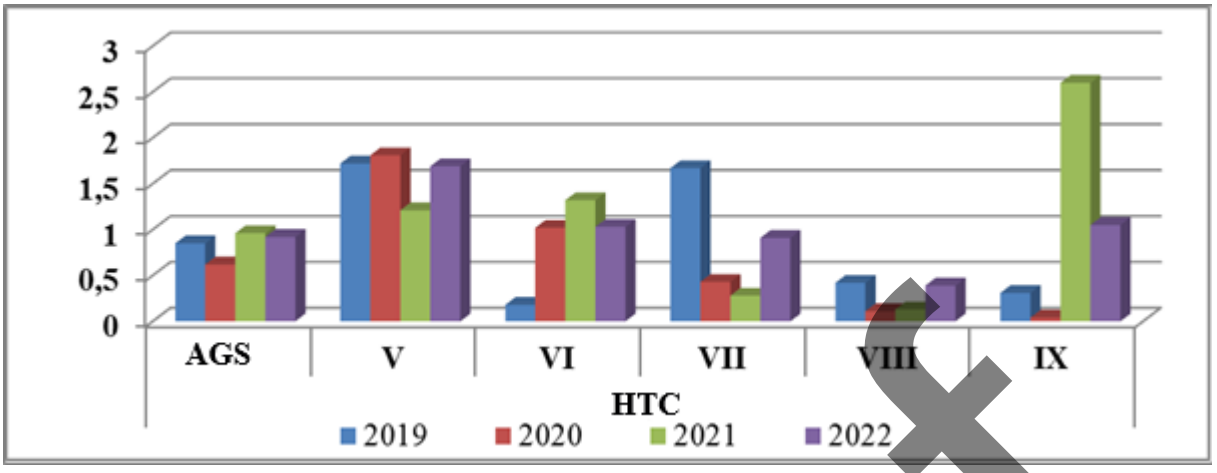
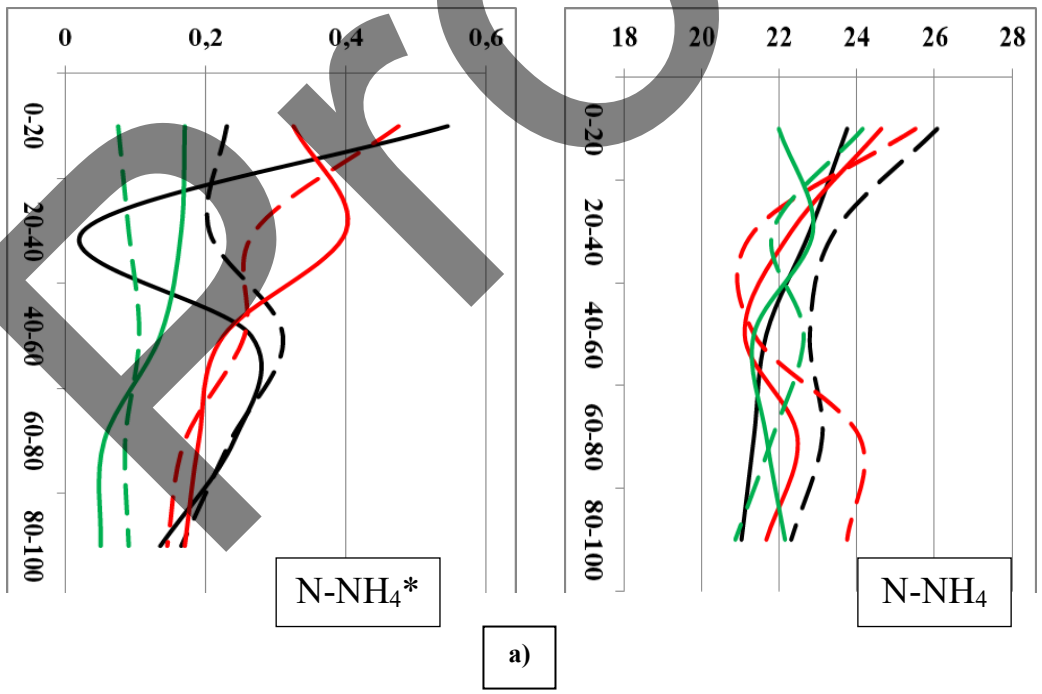
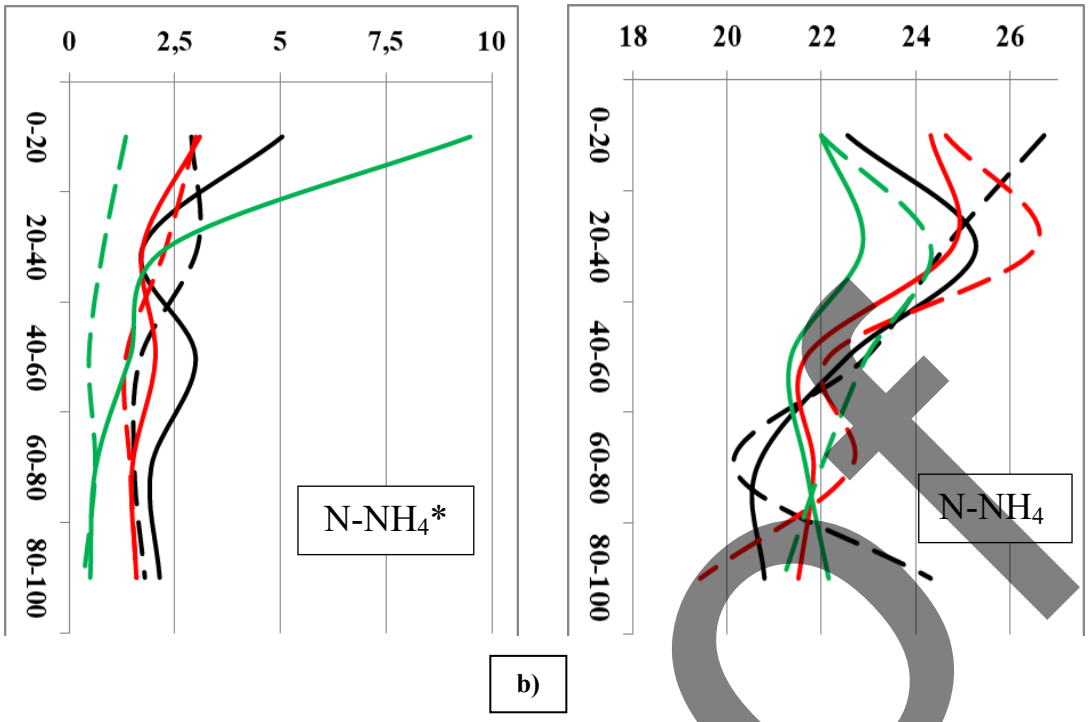


FIGURE 2. Hydrothermal conditions (HTC) of the active growing season (AGS).

Precipitation distribution was extremely uneven. Most of it fell in early spring, the minimum fell in August. The lack of precipitation and high air temperature led to low HTC value on average for AGS. It was below one for the entire period of observations, which is not typical for the forest-steppe zone of the Central Chernozem region. The average value of the HTC per AGS ranged from 0.62 to 0.96. However, excessive moisture was formed in May and June with the exception of June 2019 with a sharp shortage of HTC precipitation of 0.18. 2022 can be distinguished in terms of the hydrothermal regime, the growing season of which was the most favorable because the lack of moisture was observed only in July – HTC 0.39 (Fig. 2). This affected the regime of mineral nitrogen in the studied soil. Cultivated crops undoubtedly influenced the regime of mineral nitrogen. Over the years of observations, sugar beet, vetch-oats mixture, winter wheat and barley were consistently placed on field No. 1.

The effect of fertilizer and defecate systems on the content and distribution pattern of ammonium nitrogen along the profile is shown in Figure 3.

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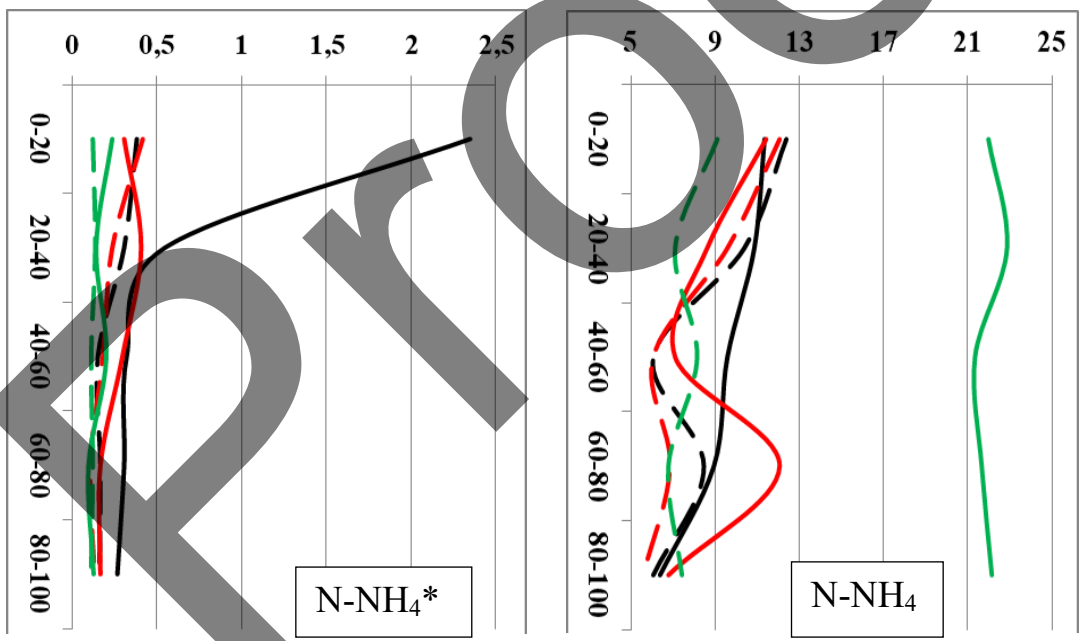
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c)

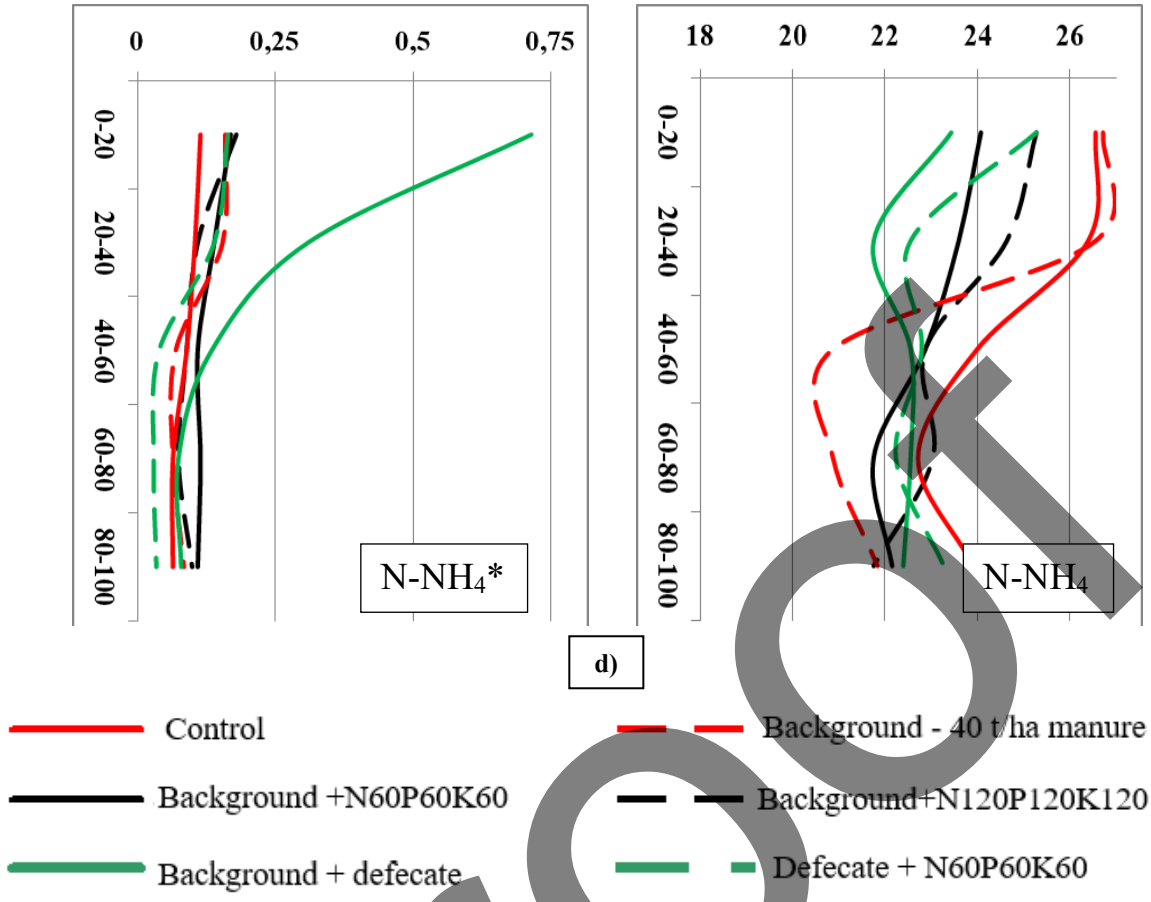

FIGURE 3. Effect of fertilizer and defecate systems on the content and distribution pattern of ammonium nitrogen in leached chernozem, mg/kg of soil ($N\text{-}NH_4$* – in saturated soil paste).
a) 2019; b) 2020; c) 2021; d) 2022.

As it follows from the data obtained by the authors, the content of ammonium nitrogen determined in saturated pastes by an ion-selective electrode is significantly lower than that of exchange ammonium. This is quite natural since ammonium ion is determined in the soil solution in the first case, and in the soil, ammonium predominates in the exchange state [12, 13]. In the arable layer of the studied soil, the content of water-soluble ammonium varies throughout the years of observations on the experimental options within a wide range of 0.08-9.5 mg kg/soil. The minimum ammonium content was observed in 2019 – 0.08-0.715 mg/kg (Fig. 3 a); the maximum was observed in 2020 – 0.35-9.50 mg/kg of soil (Fig. 3 b). The ammonium content in the arable layer of the studied soil varies significantly among experimental options. As a rule, its content is higher in fertilized options than in control and the option with defecate together with a single dose of mineral fertilizers (Fig. 3a, b, c, d). The NH_4^+ content is affected by the reaction of the soil solution. Its change is shown in Figure 4.

FIGURE 4. Change in the pH value of the water extract under the long-term use influence of fertilizer and defecate systems.

A general pattern is observed for all study years. The soil solution reaction increases in options with defecate; it decreases in fertilized options, especially in the organomineral fertilizer system, which indicates a pronounced acidification effect under the influence of fertilizers. Fertilizers containing nitrogen in the form of NH_4^+ are capable of

acidifying the soil solution near the granule as a result of H^+ ions release by the roots to preserve the electrical balance [14, 15].

As noted above, the content of exchange ammonium is much higher than its content in the soil solution. The content of exchange-absorbed ammonium is influenced by the exchange acidity (Fig. 5).

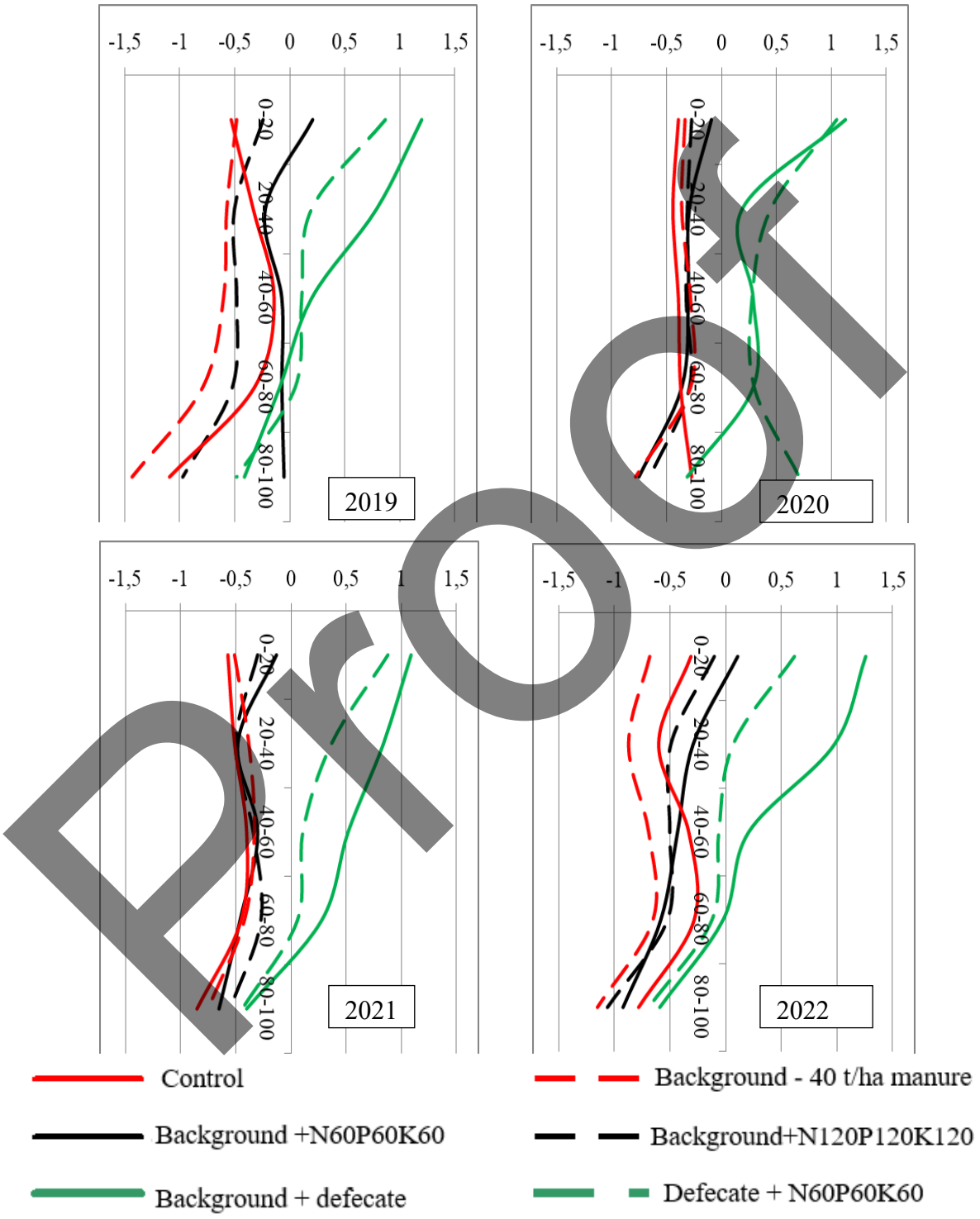

FIGURE 5. Change in the pH value of salt extraction under the long-term use influence of fertilizer and defecate systems.

For all the years of observations, there was a general trend in the change of metabolic acidity. As it follows from the data in Figure 5, there is a steady increase in the pH of the salt extract in the options with defecate; there is an equally pronounced decrease in fertilized and control options, which indicates a significant increase in the exchange acidity, especially in the options of organomineral fertilizer system. Soil acidification contributes to the accumulation of ammonium nitrogen in the soil. This is confirmed by the data obtained by the authors.

The content of exchange ammonium in the arable layer varies mainly in a narrow range – 22-27 mg/kg of soil. The exception was 2021: the content of ammonium nitrogen in the arable layer varies in the range of 9-21 mg/kg of soil.

As a rule, the content of exchange ammonium in fertilized options is higher than on options with defecate. If limed options are considered, then the content of exchange ammonium in the option with defecate together with a single dose of mineral fertilizers is higher than in the option with defecate against organic background. The reason is simple: we observe the aftereffect of defecate and mineral fertilizers are introduced annually according to the experimental scheme. The lower content of exchange ammonium in the options with defecate is due to the competition of Ca^{2+} and NH_4^+ cations.

The distribution nature of NH_4^+ along the profile is almost the same for both the water-soluble and the exchange form. It is predominantly eluvial-illuvial, which is due to the profile differentiation of leached chernozem.

The content of exchange ammonium is influenced by all types of acidity. The authors calculated the correlation coefficients of exchange ammonium content with the pH of aqueous, salt extract, and hydrolytic acidity. The data are shown in Table 1 and Figures 6-8.

As follows from the data in Table 1 and Figure 6, a negative medium and close interrelation was revealed between the content of exchange-absorbed ammonium and the pH value of the aqueous extract on the control and fertilized options for all observation years – r -0.52-0.95; on options with defecate, it varied from medium negative – r -0.40-0.58 to a close negative – r -0.90, and close – r 0.73.

A weak negative interrelation – r -0.32-0.38 and a close negative interrelation – r -0.76-0.94 was revealed between the content of exchange-absorbed ammonium and the pH value of the salt extract on fertilized options.

In the option with defecate against organic background, the interrelation of exchange-absorbed ammonium content with the pH of the salt extract varied from medium to close – r 0.56-0.96 and medium negative – r -0.57.

In the option with defecate together with a single dose of mineral fertilizers, the interrelation of exchange-absorbed ammonium with salt extract pH in 2020 and 2021 varies from a close negative – r -0.79 - to medium negative – r -0.36. In 2019 and 2022, it was medium and close – r 0.57 and 0.88.

TABLE 1. Correlation coefficients of exchange ammonium content with pH of aqueous, salt extract, and hydrolytic acidity.

r NH_4/pHwat						
Years	Control	Organic background	Background+ NPK60	Background+ NPK120	Background +defec.	Defec.+ NPK60
2019	-0.95	-0.73	-0.61	0.01	-0.58	-0.016
2020	-0.61	0.52	-0.95	-0.85	0.10	-0.90
2021	-0.92	-0.86	-0.30	-0.92	0.73	0.43
2022	-0.84	-0.76	-0.91	-0.88	-0.40	0.19
r NH_4/pHsal						
Years	Control	Organic background	Background+ NPK60	Background+ NPK120	Background +defec.	Defec.+ NPK60
2019	-0.76	-0.38	-0.84	-0.33	0.56	0.57
2020	-0.86	-0.34	-0.77	-0.86	-0.57	-0.79
2021	-0.94	-0.74	-0.43	-0.93	0.96	-0.36
2022	-0.32	0.81	-0.91	-0.86	0.22	0.88
r NH_4/Ng						
Years	Control	Organic background	Background+ NPK60	Background+ NPK120	Background +defec.	Defec.+ NPK60
2019	0.92	0.52	0.69	-0.15	-0.16	0.51
2020	0.81	0.66	0.91	0.88	0.22	0.78
2021	0.97	0.81	0.31	0.94	0.57	0.07
2022	0.59	0.80	0.32	0.45	0.05	-0.04

The interrelation of exchange-absorbed ammonium with the pH value of aqueous and salt extracts is most clearly shown in Figures 6 and 7.

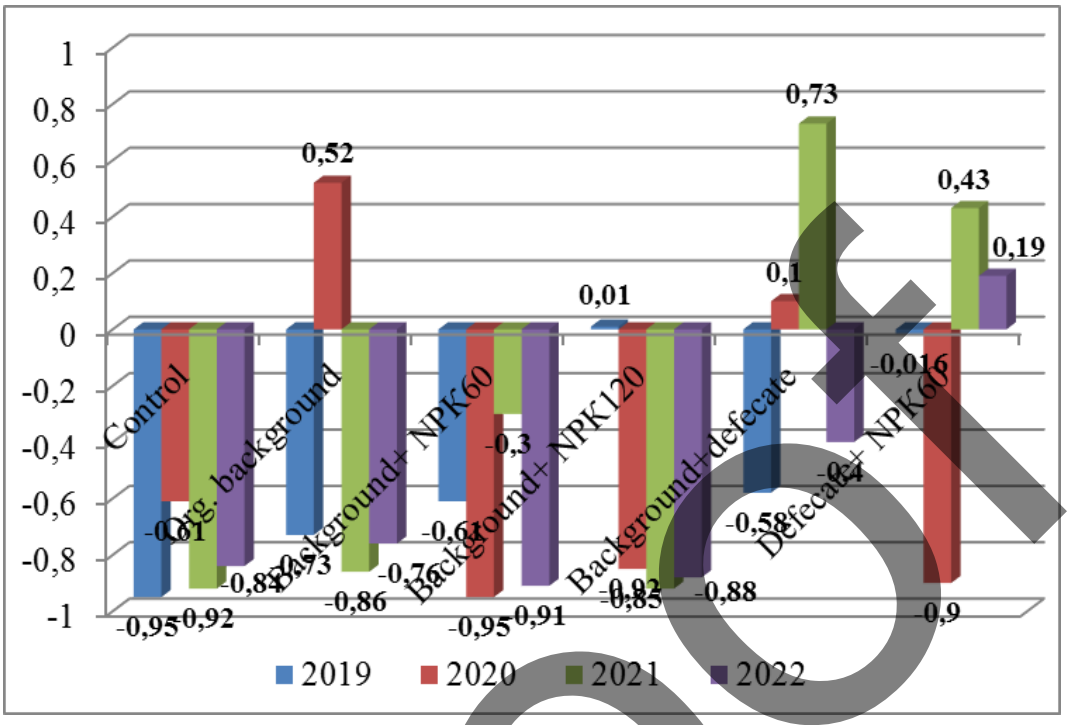

FIGURE 6. Correlation coefficients of exchange ammonium with aqueous extract pH.

As follows from the data in Figure 6, the closest interrelation of exchange-absorbed ammonium with the pH value of the aqueous extract was observed in the control option and the organomineral fertilizer system with a double dose of mineral fertilizers.

Figure 7 shows the correlation coefficients of exchange-absorbed ammonium content with the pH value of the salt extract. As in the case of this value's correlation with water extract pH, the closest interrelation was observed in the control and the organomineral fertilizer system options. A completely different dependence is observed in options with defecate; as per organic background, it was predominantly positive medium and close – r-0.66 and 0.96, it was negative medium only in 2020 r-0.57. This is due to the competition between Ca^{2+} and NH_4^+ cations.

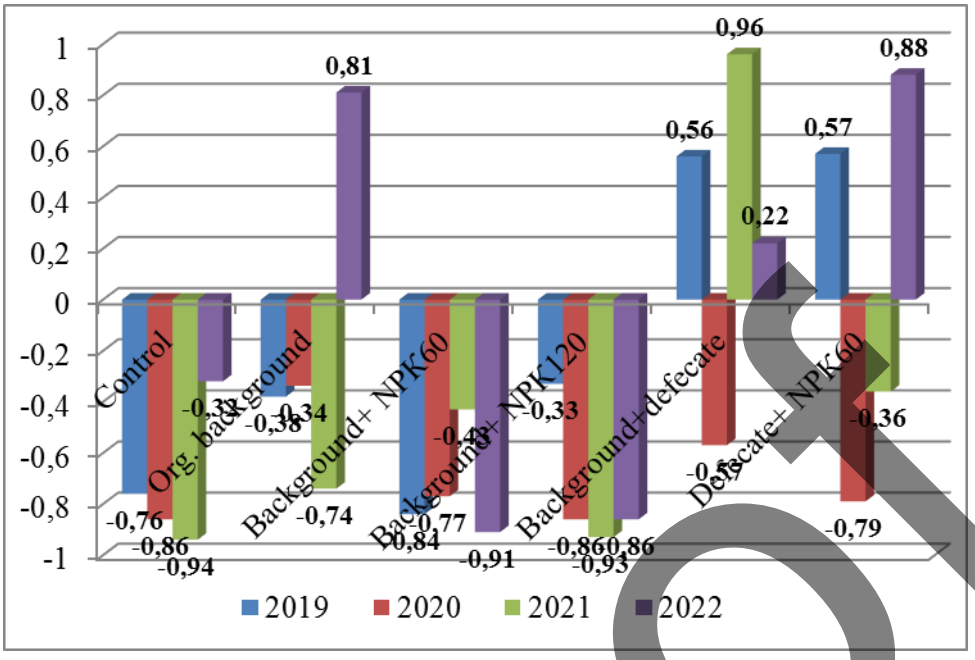

FIGURE 7. Correlation coefficients of exchange ammonium with salt extract pH.

In the option with joint introduction of defecate and a single dose of mineral fertilizers in 2019 and 2022 - positive medium and close, respectively; in 2020 and 2021 - negative close and medium, respectively.

The interrelation of exchange-absorbed ammonium content with the value of hydrolytic acidity in the control and fertilized options was mainly medium and close – r-0.31-0.69 and close – r-0.81-0.97 (Fig. 8).

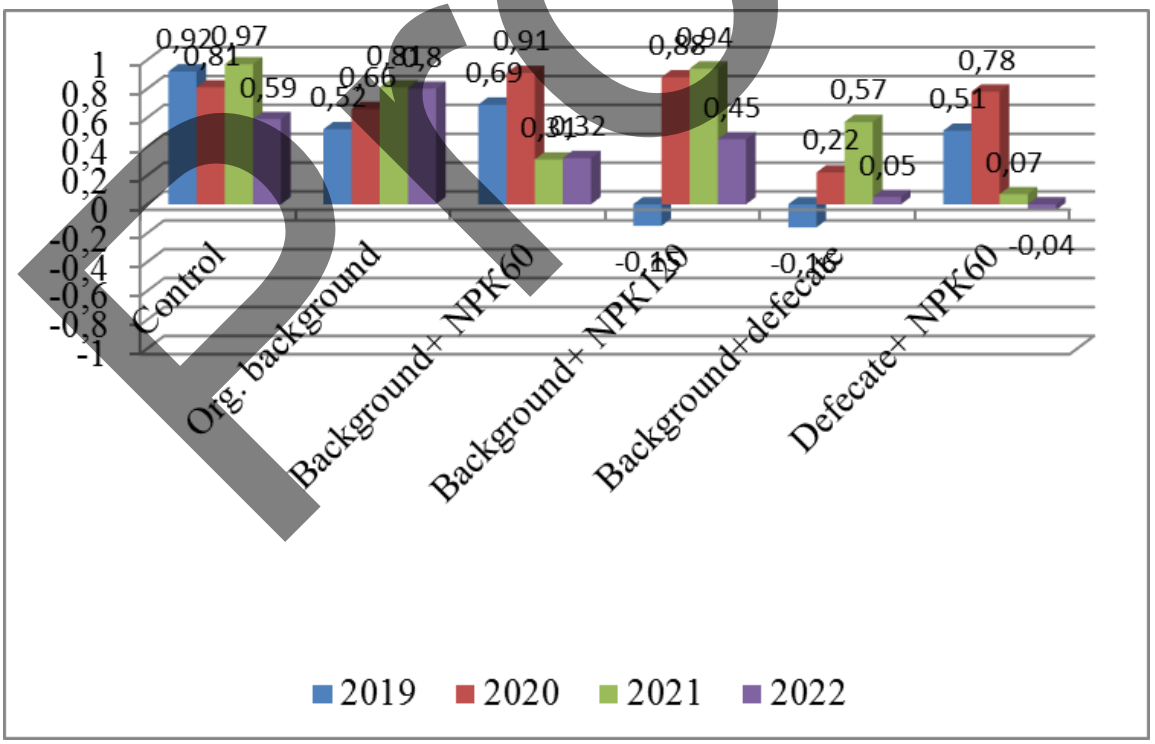

FIGURE 8. Correlation coefficients of exchange ammonium with hydrolytic acidity.

The interrelation of exchange-absorbed ammonium content with the value of hydrolytic acidity in the option with defecate against organic background was absent or medium in 2021 - r-0.57. In the option with defecate together with a single dose of mineral fertilizers (in 2019 and 2020) -medium and close, r-0.51 and 0.78, respectively.

CONCLUSIONS

1. It was established that the content of the water-soluble ammonium nitrogen form was much lower than the metabolically absorbed one. Organic and organomineral fertilizer systems contribute to an increase in the content of these nitrogen forms in the studied soil.

2. Defecate reduces the content of both water-soluble and exchange-absorbed ammonium. However, the defecate effectively conditions all types of acidity and maintains it at an optimal level even in the aftereffect.

3. The distribution nature of NH_4^+ along the profile is almost the same for both the water-soluble and the exchange form. It is predominantly eluvial-illuvial, which is due to the profile differentiation of leached chernozem.

4. The interrelation between the content of exchange-absorbed ammonium with the pH value of water, salt extract and the value of hydrolytic acidity was revealed.

In the control and fertilized options, the interrelation of exchange-absorbed ammonium content with the pH value of the aqueous and salt extract is predominantly negative medium and close over all years of observations; in the options with defecate - positive medium and close.

5. The interrelation of exchange-absorbed ammonium content with the value of hydrolytic acidity in the control and fertilized options was mainly medium and close. The interrelation of this indicator in options with defecate was lower and ranged from medium to close – r-0.51-0.57, in some years - 0.78.

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Issues of Digital Transformation of Agriculture

V.E. Torikov [1] , V.A. Pogonyshev [1, a)], D.A. Pogonysheva [2], N.A. Ivanova [2] and T.V. Bychkova [1]

[1] *FSBEI HE Bryansk State Agrarian University, Bryansk, Russia*
[2] *FSBEI HE Bryansk State University named after Academician I.G. Petrovsky", Bryansk, Russia*

[a)] Corresponding author: pog@bgsha.com

Abstract. The article examines the trends of digital transformation of agriculture. It was shown that the introduction of such digital agricultural solutions as "Smart farm", "Smart field", "Smart herd", "Smart greenhouse", "Smart warehouse", "Smart agri-office", etc. is envisaged in the agricultural sector in the near future. The features of digital modernization of agriculture in the Bryansk region were noted. It was established that smart farming technologies are currently being introduced in the region based on the use of geoinformation systems, satellite systems, equipment monitoring systems; digital solutions are being introduced in animal husbandry. The relevance, main directions, and characteristics of consulting services for the development of agricultural business were substantiated. The main factors of supply and demand in agricultural consulting have been established. The risks of agricultural consulting have been identified.

INTRODUCTION

According to the UN forecasts on the growth of the world's population, the countries of the world need to increase the level of food production by more than 70%. Providing economic and food security, agriculture forms the agri-food market, labor and settlement potential. The functioning of agriculture as a complex dynamic socio-ecological-economic system is influenced by the interaction of people, machinery, living organisms, and the distribution of agricultural objects. Transforming the interrelations and interaction of subsystems, digital solutions in the digital space ensure rational use of natural resources, sustainability of agricultural business development. In the context of the industry's digitalization, there is a rapid increase in demand for consulting services, the level of which is influenced by exogenous and endogenous factors. In the context of the "Consulting 4.0" trend formation, agri-consultants determine promising directions for the development of agricultural business together with clients, based on the analysis of the internal and external environment.

MATERIALS AND METHODS

In the course of the research, the issues of digital transformation of agriculture were considered, statistical data were used. Based on the application of general scientific methods, the assessment of digital development state of the agricultural industry was given, the prospects for its modernization were substantiated.

RESULTS AND DISCUSSION

Giving a FoodNet forecast to the prospects of the food market, The Agency for Strategic Initiatives notes that by 2035, rural producers will occupy about 5% of the world market in such segments as "new sources of raw materials", "smart" agriculture, affordable organic, and personalized nutrition. The USA, Germany, Japan, China, and France have been implementing precision farming technologies for over twenty years. For example, US farmers use digital solutions to analyze soil conditions, to assess crop yields, for spot fertilization, etc. More than 80% of agricultural machinery in Germany has built-in smart systems.

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Russia has about 10% of the global arable land fund, while up to 40% of them are located in the zone of risk farming. In recent years, Russia has achieved high levels of food security in key areas. Despite the difficult conditions, the grain harvest in 2020 amounted to over 131 million tons in net weight; the problem of providing food to the population is being successfully solved, the country's position in international markets is being strengthened. About 900 items of products are supplied to 157 countries, 70 million tons of products have been sold abroad, more than 30 billion USD has been earned. By the end of 2020, exports of agricultural products exceeded imports for the first time. Russia ranks 19th in the rating of global food exporters. Work to open new markets is in progress. [5]. There are real opportunities for crop yields and animal productivity growth in the country. However, due to the low mechanization level of agricultural work, fertilizers' insufficiency, a large number of peasant (farmer) enterprises having insufficient financial resources for the introduction of agricultural innovations, and staff shortage, there is a lag behind the leading countries in terms of labor productivity [1-4].

The Ministry of Agriculture of Russia has developed the Digital Agriculture platform to digitalize the interaction of all participants in the agricultural market, including the provision of digital consulting services. It is expected that in the next decade, more than 75% of organizations in Russia will use such agricultural innovations as "Smart farm", "Smart field", "Smart greenhouse", "Smart herd", "Smart warehouse", "Smart agri-office" based on the introduction of technologies, methods, models, algorithms. The use of geo information systems allows to create a digital model of the agricultural landscape, plan and control the quality of agrotechnical measures, monitor the condition of crops, predict crop yields, monitor the operation of agricultural machinery. Precision agriculture in Russia is supported by suppliers of navigation equipment and software (Agrophysical Institute, "Agroshturman", "Agronout", "Agrosoft", "Agrocom", "Trimble", "Farm Works", etc.). According to expert estimates, digitalization of agriculture will reduce production losses by up to 40%. Among the most promising agrotechnological solutions, experts include agrobiotechnology, digital logistics, e-commerce, bioenergy and biomaterials, robotics. Digitalization of the industry will make it possible to implement rational use of natural resources, resource-saving agriculture, improve management efficiency, create opportunities to ensure the sustainability of organizations' development, involve workers in new professions in production [7-9].

Researchers note that in recent years, both in Russia and in the Bryansk region, despite external and internal challenges, agriculture has maintained the necessary level of population's consumption of the main product types and their export. Thus, the region has made a breakthrough in potato growing, increased the production of grain crops, revived animal husbandry in large agricultural holdings. Agricultural enterprises use more than 1800 thousand hectares of farmland. The industry includes over 650 organizations, more than 200 thousand personal subsidiary farms, employs over 30 thousand people. In the structure of the region's rural population, more than 50% is the employable population, but the proportion of retirement-age people is large (Figure 1).

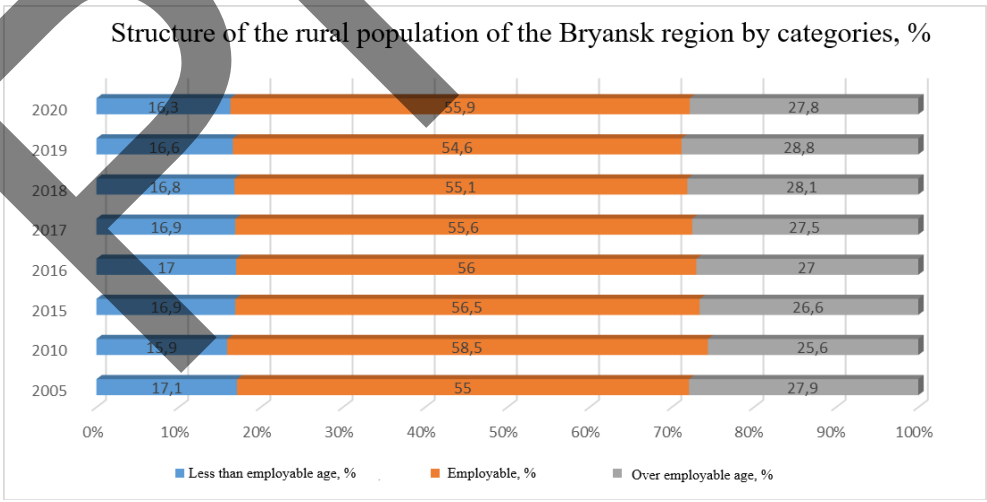

FIGURE 1. The structure of the rural population of the Bryansk region by category, % (compiled by the authors).

In the structure of the gross regional product, the contribution of agriculture approached 30%. The region is among the top five in terms of grain yield. High results of agricultural labor have been achieved in peasant (farmer)

enterprises and households of the population. In recent years, the structure of products by farm category has changed significantly (Figure 2).

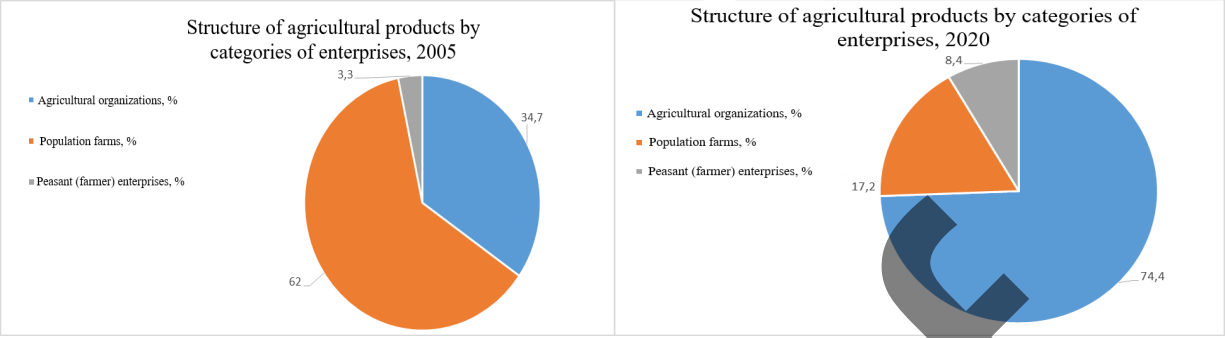

FIGURE 2. Structure of agricultural products by categories of enterprises (compiled by the authors).

Resource-saving technologies are being introduced in the region; the agricultural machinery fleet is being updated. Thus, the share of resource-saving technologies in grain farming exceeds 90%; it is about 40% in potato growing. Technical and technological modernization of the industry provides for the use of foreign brands in addition to domestic agricultural machinery. Precision farming technologies based on satellite systems, GIS, equipment monitoring systems, digital technologies in animal husbandry, etc. are being introduced in the region. Rural producers are implementing the results of research by scientists of the Bryansk State Agrarian University. Modern infrastructure, high-speed Internet connection, digital platforms as services supporting smart industry planning, smart contracts, mass implementation of digital agricultural solutions in economic entities are needed to solve the problems of agribusiness, eliminate digital inequality, and ensure access to digital services for the rural population. An important problem is the lack of knowledge on the availability of certain digital solutions, agricultural innovations. By actualizing the transfer of business processes into the online environment and reducing the cost of transactions, digitalization of agriculture opens up promising sources of income for market entities, launching products and services much faster in digital format for successful entry into local and global markets. Economic entities must constantly introduce technological innovations to maintain competitive positions in agribusiness.

Quite often, it is difficult for economic entities to make substantiated management decisions when adapting to the dynamics of agricultural markets' development. The main reasons for inviting experts are either the presence of serious problems in the organization's activities or lack of time to solve them. The production and application of knowledge is the most important resource for the digital transformation of the agricultural sector. Information and knowledge in the field of agriculture are transmitted by expert consultants to economic entities on a contractual basis. The methodology issues for the development of the consulting services market are presented in the works of M.I. Goncharov, E.A. Utkin, et al. Practical aspects of this market's development were studied by Markham C., Holmes E., et al. The rating agency "Expert RA" includes strategic, legal, financial, tax, production, marketing consulting, information technology, HR consulting, etc. in the sectors of the consulting market.

TABLE 1. Factors of supply and demand of consulting services in agribusiness*.

Supply	Demand
Exogenous (political, economic, socio-cultural, technological)	
Development of intellectual activity institutions, regulatory and control institutions, infrastructure institutions	
Formation of the innovation system in Russia	Formation of innovative corporate culture in market subjects of agriculture
Scientific and technological progress	Formation of the need of agricultural sector's economic entities for industry knowledge, the ability to perceive consulting services
Endogenous	
Ability to generate innovative approaches to agribusiness development based on digitalization of key business processes	Ability to apply digital agri-innovations

Continuation of TABLE 1.

Adaptation of services to the peculiarities of rural producers	Consumer trust in consulting service providers
Formation of transparency of agri-consulting market participants	Awareness of consumers on the range of services in agri-consulting
Pricing	The solvency level of potential agricultural sector's customers

*compiled by the authors

Based on the performed research, the characteristics of consulting services in digital agriculture are considered intangibility, mobility, individuality, inseparability from the source, scientific and intellectual intensity, interdisciplinarity, risk and uncertainty, confidentiality, etc. The peculiarity of consulting in the agricultural sector is primarily associated with the presence of natural and biological factors that determine socio-eco-economic, organizational, technical and technological specifics. The authors believe that the level of demand and supply of services in the industry is influenced by exogenous and endogenous factors of the digital space (Table 1).

The forms of consulting services' organization in agriculture are diverse. In addition to the services that are structural units of the Ministry, there are regional and local administrations and departments; services created on the basis of agricultural universities, research institutes, industry colleges and specialized schools; cooperative organizations; commercial organizations, etc. In recent years, the Ministry has focused on the creation of an info-communication system for the exchange of data between market participants, market management, the creation of a remote land monitoring system, multidimensional support for rural producers. Automation and digitalization have become the main trends in improving the consulting business [6, 10] (Figure 3).

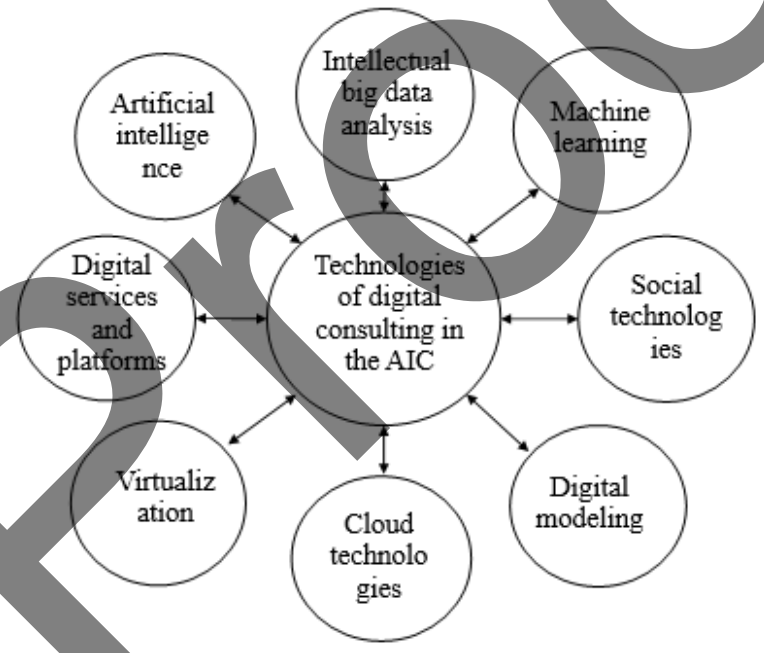

FIGURE 3. Digital consulting technologies in the AIC (compiled by the authors).

The main tasks of the "Federal Center for Agricultural Consulting of the Agro-industrial Complex" of the federal state budgetary educational institution of additional professional education "Russian Academy of Personnel Support of the AIC" include methodological support for the development of consulting, assistance to economic entities and the population, educational institutions, retraining and advanced training of teachers, managers, consultants; assistance in the sustainable development of the industry and rural settlements. Recently, the Open Agrarian University "Land of Knowledge" has been created in Russia as a digital educational platform providing access to the database of applied knowledge in the industry, which has an innovative format for improving the skills of the

population. Experts from 23 leading agricultural universities and 4 research institutes take part in the provision of remote services. In the Bryansk region, the state budgetary institution "Center of Competence of the AIC of the Bryansk region" provides information and consulting services as a legal entity in the region to industrial economic entities of all forms of ownership. On the basis of the Bryansk State Agrarian University, a regional educational and methodological information and consulting center has been established to support the development of economic entities.

In the course of the research, the authors found that the activity of a digital consulting company in the agricultural sector is associated with entrepreneurial risks. Subjective, objective, external and internal risks in digital consulting were identified. In addition, there are property, trade, production, information, financial, and investment risks in agri-business consulting. The authors believe that it is advisable to use risk management methodology in a digital consulting company.

CONCLUSIONS

The use of digital technologies in agriculture makes it possible to create effective soil-agrotechnical and organizational conditions for the growth of labor productivity, rational use of natural resources, environmental protection, food security provision, and improving the standard of living of the population. Digital consulting acts as a trend of digital transformation of agricultural business, feeling the dependence of demand for services on the state of the digital environment. Developing the competitive advantages of organizations, consulting companies are obliged to manage entrepreneurial risks.

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Encouraging the use of Water-Saving Technologies

Tulkin Farmanov[1], Bahtiyar Khasanov[3], Farida Yusupova[1], Samandar Gapparov[2], Akmal Durmanov [1, 3, 4, a)]

[1]*International Center for Food and Agriculture Strategic Development and Research under the Ministry of Agriculture of the Republic of Uzbekistan, Tashkent, Uzbekistan*
[2]*Scientific Research Institute of Irrigation and Water Problems, Tashkent, Uzbekistan.*
[3]*Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME)-National Research University, Tashkent, Uzbekistan*
[4]*Branch of the Astrakhan State Technical University in the Tashkent region of the Republic of Uzbekistan, Tashkent, Uzbekistan*

[a)] Corresponding author: akmal.durmanov.1977@mail.ru

Abstract. The article examines the economic tools to support the use of water-saving technologies. The purpose of the study is to develop scientifically based proposals and practical recommendations for improving the state system of economic support for the use of water-saving technologies in agriculture. It has been substantiated that the implementation of water-saving technologies on a leasing basis, for example, of economic benefits and various preferences, can significantly reduce budgetary allocations for financing the introduction of drip irrigation technology. Calculations have shown that the provision of drip irrigation technology in leasing and the establishment of a lease payment rate not exceeding 50% of the Central Bank refinancing rate, an advance payment not exceeding 15-20% with a maturity of up to 5 years, will save agricultural producers up to 12-15 % of funds in comparison with a commercial loan, and will reduce the collateral amount by 55-60%.

INTRODUCTION

The development of world agriculture, first of all, depends on the availability of water resources. The current critical situation on earth in the field of water, which is already called "blue gold" today, requires the rational use of water resources in the agricultural sector, the improvement of the farming system, which ensures a decrease in water use, the introduction of modern water-saving technologies. Since, according to experts, by 2040 the world's population will reach nine billion people, while fresh water supplies will be able to cover only 70 percent of humanity's needs [9].

In addition, global climate change, chronically recurring droughts and dry years necessitate maintaining the hydrological balance at the regional and global levels. Since, the latest estimates of specialists indicate that climate change on our planet will increase water scarcity by 20 percent and lead to a deterioration in the lives of 2 to 5 billion people in more than 45 countries of the world [3].

Currently, a shortage of water resources is felt in all Central Asian states, but the Republic of Uzbekistan is the most vulnerable in this regard, since it has the highest demand for water in the region to meet the socio-economic and environmental needs of the growing population and natural ecosystems, and ensure sustainable development in general [1].

It is important to note that only 9.6 percent of the total flow of transboundary rivers in the Aral Sea basin is formed on the territory of Uzbekistan. More than 80 percent of the water used enters Uzbekistan from the territory of neighboring countries [7]. In other words, Uzbekistan is dependent on its neighbors for water resources. In addition, dry years are often observed in the Aral Sea basin. If before the 2000s, dry years were repeated every 6-8 years, then recently they have been observed in every 2-3 years [14].

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In this regard, large-scale reforms are being carried out in Uzbekistan aimed at efficient use of water resources, radical modernization of the water management system, as well as the introduction of innovative technologies in the agricultural sector. For example, when agricultural producers introduce water-saving irrigation technologies, subsidies are provided at the expense of the State budget to cover part of their costs [10]. It should also be noted that agricultural producers who have introduced water-saving irrigation technologies are exempt from the single land tax for a period of 5 years [10]. Nevertheless, "state stimulation of the further expansion of the introduction of water-saving technologies for irrigation of agricultural crops, as well as attracting foreign investments and grants to this area" is defined as one of the priority directions of the Concept for the Development of the Water Economy of the Republic of Uzbekistan. It should be noted that in 2021-2023 it is planned to increase the area of [13] implementation of water-saving irrigation technologies from 308 thousand hectares to 1.1 million hectares, including drip irrigation technologies - from 121 thousand hectares to 822 thousand hectares [12].

From this point of view, the further widespread introduction of drip irrigation and other water-saving technologies in agriculture through the improvement of economic mechanisms determines the relevance and demand for research in this direction.

MATERIALS AND METHODS

The methodological and theoretical basis of the study is the scientific works of domestic and foreign economists on the problems of economic stimulation of the use of drip irrigation and other water-saving technologies in agriculture in the context of an increasing shortage of water resources, adopted state programs and legislative acts, decrees and resolutions of the President of the Republic of Uzbekistan, as well as data official sites. The initial information for the analysis of the area of implementation of water-saving technologies in agriculture was the statistical and reporting materials of the Ministry of Water Resources of the Republic.

When solving the set tasks, abstract-logical, economic-statistical, sociological survey and other research methods were used in the work.

A sociological survey was conducted among managers and workers of farms in Andijan, Tashkent, Jizzakh and Kashkadarya regions. These regions were chosen because they are located in different zones: Andijan region - the eastern zone, Tashkent, Jizzakh region - the central zone, Kashkadarya region [30] - the southern zone of the republic, which have different levels of water supply and the degree of application of water-saving technologies.

A sociological survey was conducted among 60 managers and workers of farms in the Andijan region, 82 in the Tashkent region, 81 in the Jizzakh region, as well as 60 heads and workers of farms in the Kashkadarya region, who were randomly selected [16].

Results. Analysis of the data of the Ministry of Water Resources of the Republic of Uzbekistan showed that over the past 7 years, drip irrigation technology was introduced on an area of 77461 hectares, irrigation with portable flexible hoses on 245062 hectares, and irrigation along furrows screened with plastic wrap - 70819 hectares (Fig. 1).

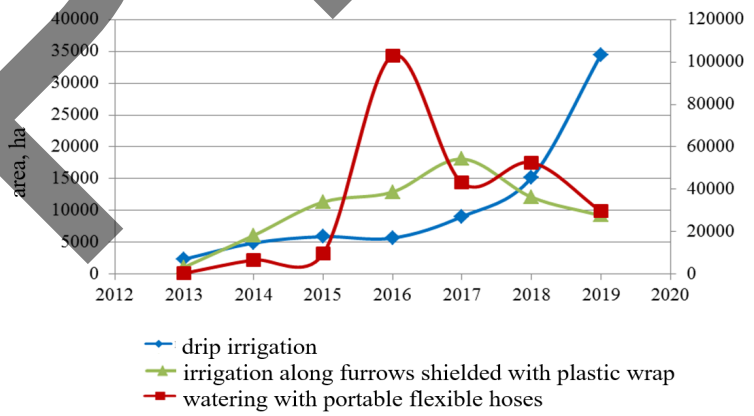

FIGURE 1. Dynamics of the area of implementation of water-saving technologies in the republic for 2013-2019.

In addition, in 2020, water-saving irrigation technologies were additionally introduced on an area of 133,000 hectares of land. The results of the analysis of statistical data show a positive trend in the introduction of drip irrigation technology in agriculture, which is primarily [31] associated with the creation by the state of favorable conditions for agricultural producers in the acquisition and application of drip irrigation technology. However, it should be noted that the area of implementation of water-saving technologies is only 7.3 percent of the total irrigated area. The results of a sociological survey conducted to determine the availability of water resources and the degree of application of drip irrigation technologies and other water-saving technologies by agricultural producers in the field showed that economic entities experience a shortage of water resources during the growing season, and only 44 percent of the respondents in the Andijan region, 6 percent in the Tashkent region , 30 percent - in the Jizzakh region and 25 percent - in the Kashkadarya region use water-saving technologies in the cultivation of agricultural crops (Fig. 2).

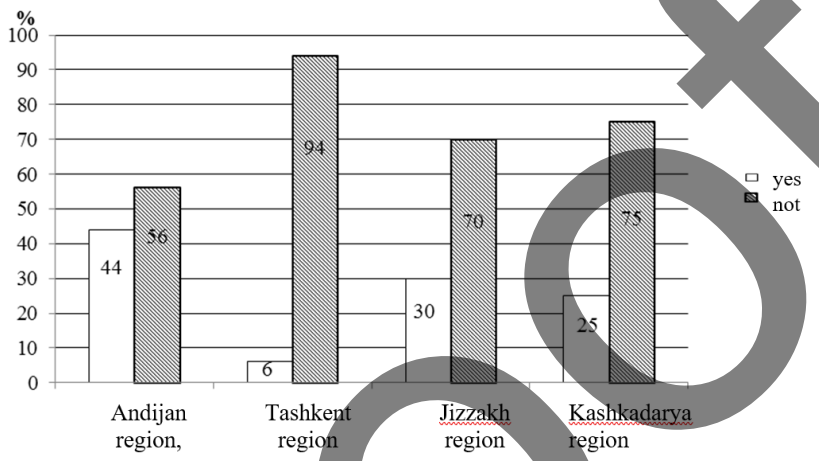

FIGURE 2. Results of the survey of respondents to the question: "Do you use water-saving technologies (drip irrigation, flexible hoses, etc.)?"

According to the interviewed respondents, the low degree of implementation of water-saving technologies is associated with the high cost of equipment and the lack of financial resources of economic entities during the period of acquiring water-saving technologies.

In addition, 79 percent of the interviewed respondents in the Andijan region, 65 percent in the Tashkent region, 84 percent in the Jizzakh region and 92 percent in the Kashkadarya region noted that they would like to use water-saving technologies in the cultivation of agricultural crops (Fig. 3).

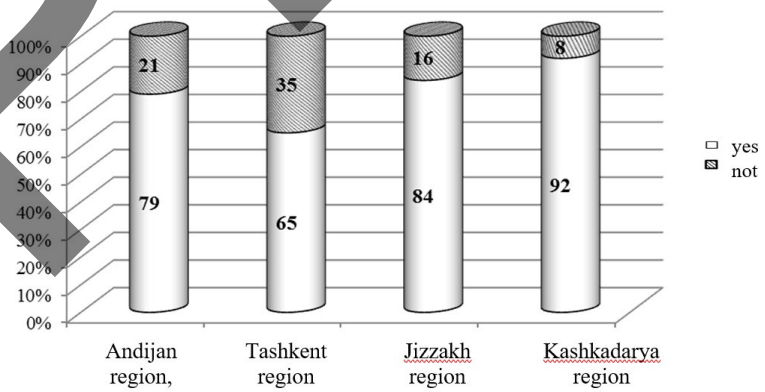

FIGURE 3. Results of the survey of respondents to the question: "Would you like to apply water-saving technologies?"

The results of the survey, shown in Fig. 4 indicate that farmers need government support in purchasing drip irrigation technology and innovative water-saving technologies. In particular, in the Andijan region - 31 percent, in the Kashkadarya region - 29 percent and in the Jizzakh region, 24 percent of the respondents noted that they need

state support. And for the sustainable introduction of drip irrigation technology [32], according to the survey participants, it is necessary to lease technology (in Andijan region - 28 percent, Jizzakh region - 37 percent, Tashkent region - 45 percent) and through a soft loan (in Andijan region - 34 percent, Tashkent region - 40 percent, Kashkadarya region – 60 percent) (Fig. 4).

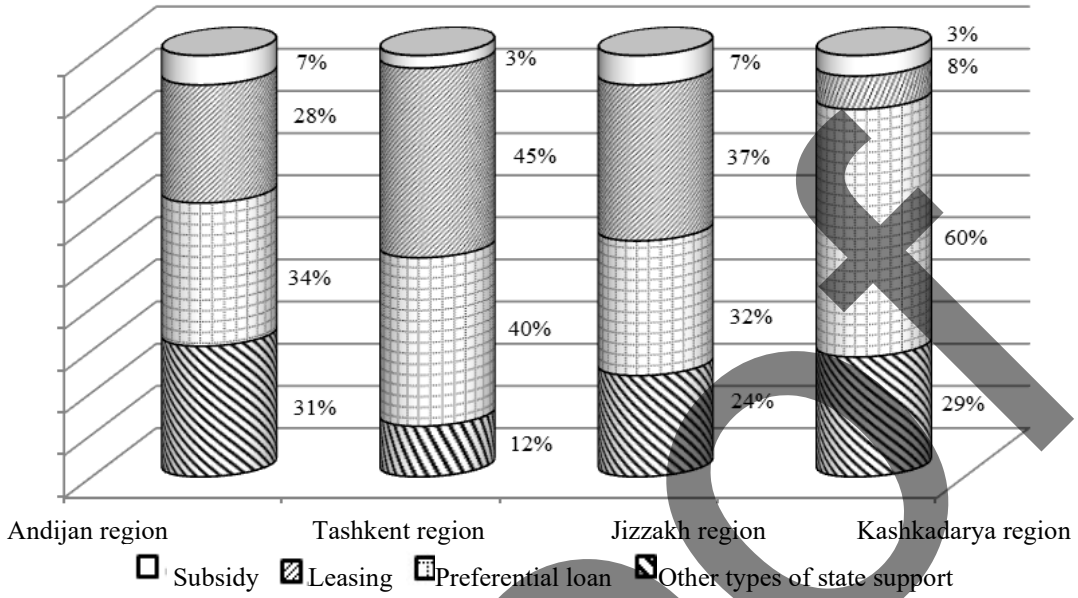

FIGURE 4. Results of the survey of respondents to the question: "What do you think needs to be done for the sustainable introduction of drip irrigation technology?"

A study of economic literature shows that state targeted off-budget funds are a form of education and expenditure of funds created separately from budgets of a targeted nature and intended to finance national and local activities [5, 6].

Extra-budgetary funds provide additional funds for the priority sector of the economy - agriculture, and also guarantee timely financing of such expenditures, which in no case can be cut even if a budget deficit is formed. Considering the above-mentioned features and positive results of the creation of the Fund for Land Reclamation Improvement of Irrigated Lands [33], the experience of recent years in the creation of extra-budgetary funds under the branch ministries and departments, as well as the fact that the large-scale application of drip irrigation technology and other water-saving technologies requires large capital investments. To stimulate the production and implementation of water-saving technologies on a systematic basis and their targeted targeted financing, it is advisable to create a state targeted off-budget Fund for the development of the introduction of water-saving technologies [1] in agriculture under the relevant ministry (Fig. 5).

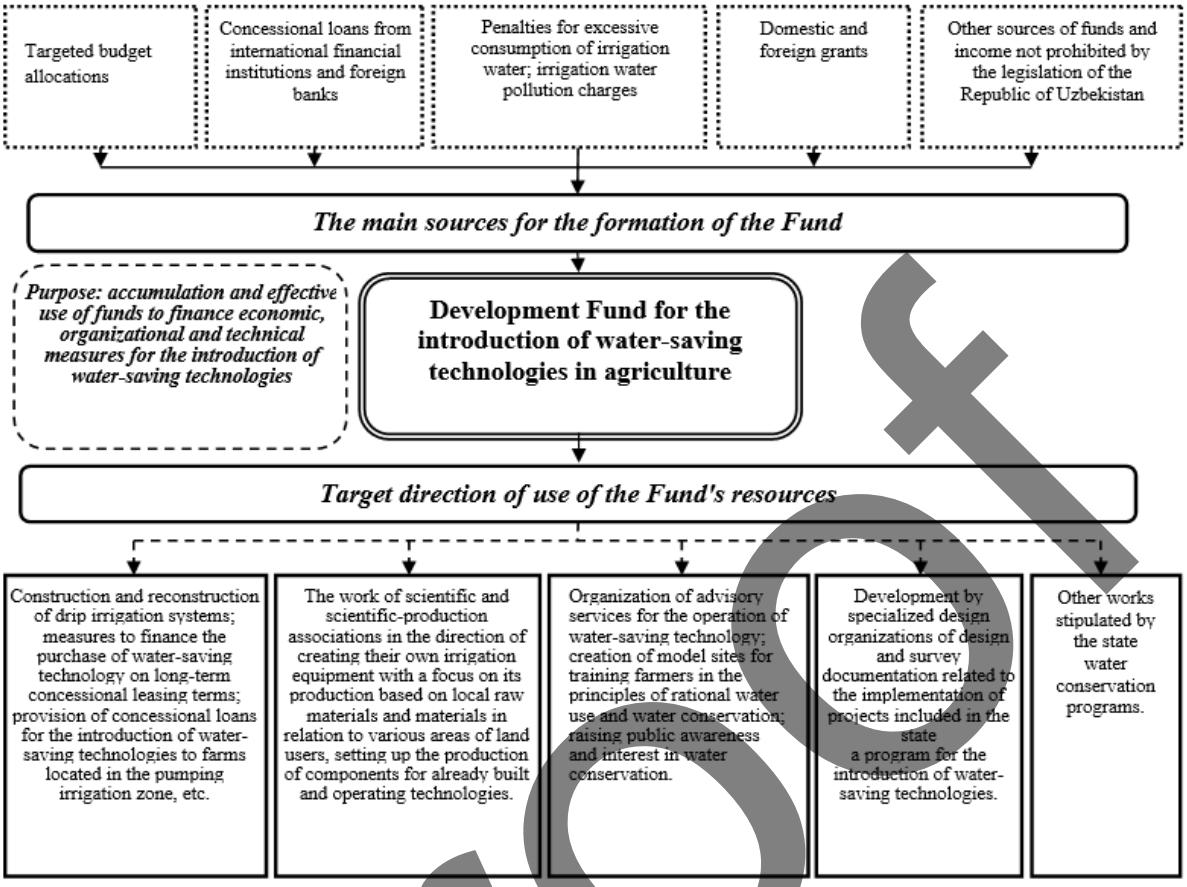

FIGURE 5. Mechanism for the formation and spending of the fund development of the introduction of water-saving technologies in agriculture.

Operational management is carried out by a specially created administrative apparatus, which has the appropriate rights and responsibilities.

The creation of the Fund will allow spending all the planned funds on the introduction of drip irrigation and other water-saving technologies without any restrictions.

The main sources of the formation of the Fund's resources can be considered the following: targeted budget allocations (for the formation of a public-private partnership mechanism in this direction), concessional loans from international financial institutions [1] and foreign banks (World Bank, Asian Development Bank, Islamic Bank, etc.), domestic and foreign grants (UNDP, FAO, ICARDA, USAID, KOICA, as well as grant funds allocated in Uzbekistan for innovation projects, etc.), penalties for overspending of irrigation water, payments for water pollution in irrigation systems, as well as other sources of funds and income not prohibited by the legislation of the Republic of Uzbekistan.

To fulfill the above tasks, the Foundation must establish close economic and legal relations with the leading ministries and departments of the Republic by signing a Memorandum of Cooperation.

The creation of the Fund will promptly eliminate the organizational, financial, legal and other problems that agricultural producers face on a daily basis in the application of water-saving technologies in their activities.

For the effective functioning of the Fund, it is advisable at the initial stage (at least 5 years) to provide the following benefits:

- to exempt from all types of taxes, fees, duties and mandatory contributions to state trust funds;
- to exempt from payment of value added tax contractors performing work and services within the framework of State programs at the expense of the Fund.

In addition, cooperation with the WB, ADB, the GEF project on the Central Asian Initiative, as well as interaction with UNDP at the level of potential donor programs will be an important aspect of the work of the new Fund, guaranteeing the concentration of funds [15].

In order to disseminate knowledge about the rational use of water resources among the population, improve the qualifications of agricultural producers in the operation of drip irrigation systems and the use of innovative agricultural technologies, raise funds for the implementation of these projects, the Fund provides for active cooperation with various ministries and departments, local authorities in the field. as well as enterprises for the production of drip irrigation systems.

In the future, in conditions of large-scale application of water-saving technologies, a gradual transition of this Fund to self-financing is envisaged, i.e. all kinds of consulting services will be provided to agricultural producers on a paid basis, and the Fund will become self-sustaining.

The creation of the Fund for the Development of the Implementation of Water-Saving Technologies in Agriculture will make it possible to efficiently and purposefully use budgetary funds, grants and loans from international financial institutions for the production, implementation and leasing of water-saving technologies in farms, etc.

As you know, another of the modern, promising and effective financial instruments that allows farms to acquire and renew their fixed assets, increase the competitiveness of their products, and reduce tax and operational costs of investment management is leasing. Given the lack of financial resources of entities producing agricultural products and the high cost of water-saving technologies, in our opinion, it is advisable to introduce the practice of leasing technologies.

The advantage of leasing is due to the fact that its implementation does not require a one-time mobilization of financial resources in the amount of the full cost of the acquired asset. This is especially important when the investment needs of an agricultural producer associated with the use of complex, expensive equipment currently exceed its financial capabilities.

In this regard, given the growing shortage of water resources, the relevance of the introduction of drip irrigation, it is also advisable to set the rate of lease payments not exceeding 50 percent of the refinancing rate of the Central Bank and an advance payment not exceeding 15-20 percent.

In the course of the study, the experience of the Republic of Kazakhstan was studied, which also suffers from a shortage of water resources, and also has a simplified scheme for acquiring drip irrigation technology and other water-saving technologies in leasing, based on market principles [25].

Table 1 shows an approximate calculation of the comparative efficiency of acquiring drip irrigation technology using its own funds, a soft loan from the Fund, a loan from commercial banks and leasing (presented in 4 prepayment options).

TABLE 1. Indicators of the comparative efficiency of own funds, leasing and credit when purchasing drip irrigation technology.
((notional cost of drip irrigation technology - 25,000,000 soums / ha) (cotton area - 50 hectares))

№	Name indicators	Method of acquiring drip irrigation technology			
		at own expense	at the expense of the Fund's preferential loan	at the expense of a loan from JSCB "Agrobank"	on lease (suggested option)
1.	Cost of equipment	1 250 000 000	1 250 000 000	1 250 000 000	1 250 000 000
2.	Annual interest rate of loan / lease	-	6	14	7
3.	Loan / lease term, months	-	до 36	до 60	до 60
4.	Processing time, working days	x	15	x	x
5.	Insurance policy, sum (3%)	-	37500000	-	30 000 000
6.	Collateral (movable or immovable property),%	-	125% of the loan amount (equipment can be used the subject of a pledge in the amount equal to 80% of its value)	at least 125% of the loan amount	125% of the amount remaining after the prepaid advance payment (equipment can serve as a collateral in the amount equal to 50% of its value)

Continuation of TABLE 1.

7.	Grace period, months		-	6	-	-
8.	Prepayment, %		0	0	0	20
9.	Annual payments, sum	prepayment				250 000 000
		1 year	1 250 000 000	280 729 167	408 958 333	264 750 000
		2 year	0	467 708 333	373 958 333	250 750 000
		3 year	0	442 708 333	338 958 333	236 750 000
		4 year	0	211 979 167	303 958 333	222 750 000
		5 year	0	0	268 958 333	208 750 000
10.	Total amount, sum		1 250 000 000	1 440 625 000	1 694 791 666	1 463 750 000
11.	Difference with the cost of equipment, sum		0	190 625 000	444 791 666	213 750 000

Source: Calculated by the author based on data from http://www.uzmml.uz/ru/site/calculator, https://agrobank.uz/ru/

DISCUSSION

According to our calculations, the provision of drip irrigation technology to farms, dehkan farms and other agricultural producers in leasing, as well as the establishment of a lease payment rate not exceeding 50 percent of the Central Bank refinancing rate, an advance payment not exceeding 15-20 percent with a maturity of up to 5 years will save agricultural producers up to 12-15 percent of financial resources in comparison with a commercial loan, and will reduce the amount of collateral by 55-60 percent. This, in turn, will ensure the stable development of the use of drip irrigation technology in agriculture [27, 28].

According to the calculation results, the debt repayment period for the acquisition of a drip irrigation system on lease by farms specializing in cotton and grain growing, due to their specificity, should be set for a period of at least 60-96 months.

Due to the high profitability of farms focused on the production of fruits and vegetables, viticulture and melons, the maturity period should be set approximately 36-60 months.

The above scheme for acquiring drip irrigation technology and advanced water-saving technology on a lease basis will create a solid foundation for stimulating the sustainable introduction of advanced irrigation technologies by agricultural producers in arid and non-irrigated zones.

CONCLUSION

The creation of a leasing company for the implementation on a leasing basis of water-saving technologies, the encouragement of leasing activities and the use for this, for example, of economic benefits and various preferences, can significantly reduce budget allocations for financing the introduction of drip irrigation technology, and will also help to reduce water costs, prevent degradation soil and increasing the productivity of agricultural crops of farms and dekhkan farms, etc. When setting the lease payment rate not exceeding 50 percent of the Central Bank refinancing rate, an advance payment not exceeding 15-20 percent with a maturity of up to 5 years will save agricultural producers up to 12-15 percent of financial resources compared to a commercial loan, and will reduce the amount of the collateral by 55-60 percent.

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The Study of the Risks of Implementing Artificial Intelligence Technologies and Robotics in Agriculture

E.G. Skvortsova[1, a)], Y.V. Leonova[2, b)], E.A. Skvortsov[3, c)]

[1] *Ural State Agrarian University, Ekaterinburg, K. Liebknecht, 42, Russia*
[2] *Guest Lecturer at GBS campus, Dubai Knowledge Park, P.O.Box 500651, DUBAI, United Arab Emirates*
[3] *Ural State Economic University, Ekaterinburg, St. March 8, Russia*

[a)] Corresponding author: Uralmash91@list.ru
[b)] yana.leonova2020@gmail.com
[c)] 9089267986@mail.ru

Abstract. The implementation of artificial intelligence technologies and robotics in agriculture is taking place in rapidly changing and ever-increasing risks that are not well studied. The study aims to assess the risks of implementing artificial intelligence technologies and robotics in agriculture according to the degree of validity. As research methods, a survey of agricultural experts was used (by the example of the Sverdlovsk region). Reasonable risks include the lack of own financial resources for the implementation of artificial intelligence and robotics technologies (4.5 points), difficulties in hiring workers capable of mastering these technologies (4.3 points), increasing dependence on foreign suppliers of equipment, components, software under sanctions (4.2 points), insufficient level of state support (3.8 points). Unreasonable risks include insufficient development of infrastructure (3.4), resistance of workers to the implementation of these technologies (2.9 points), a possible fall in incomes of the rural population under the conditions of mass unemployment when these technologies are implemented (2.4 points). The results of the study will make it possible to develop adequate public policy measures to reduce emerging risks.

INTRODUCTION

Nowadays, agriculture is developing within various challenges and stresses. One of the most significant stressful events is the COVID-19 pandemic and the associated restrictions on labor movement [1]. Some scientists from Wales note that the coronavirus pandemic has exposed the food and beverage industry at significant risks, as they are considered priority sectors in this country [2]. These changes have had a significant impact on food producers and destroyed the existed stable supply chains for consumers. Food and agricultural producers have met a shortage of harvest workers due to international travel restrictions. Under these conditions, farmers are implementing labor-saving technologies, including robotics and artificial intelligence. With mass digitalization, there are concerns about the capabilities of agricultural systems to cope with shocks and stresses and to deal with them.

MATERIALS AND METHODS

Agriculture is developing within rapidly changing and ever-increasing risks. They concern social, economic, financial and personnel risks that are influenced by the rapid development of digital technologies, including robotics and artificial intelligence.

The study aims to assess the risks of implementing artificial intelligence technologies and robotics in agriculture according to the degree of validity.

The research objectives include the following:

– to identify the main risks of implementing artificial intelligence technologies and robotics in agriculture;

– to conduct an expert assessment of the risks of implementing artificial intelligence technologies and robotics in

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agriculture;

– to distinguish risk groups for implementing artificial intelligence technologies and robotics in agriculture according to the degree of validity.

The study of the risks of implementing artificial intelligence technologies and robotics in agriculture took two stages. The first one summarizes the scientific literature on the risks of using these technologies in agriculture. Manual screening of the most cited publications at the scientific base of the RSCI was performed. As a result of this analysis, the most common risks and concerns associated with the implementation of artificial intelligence technologies and robotics in the industry were identified. The second stage involves assessments of the risks of using artificial intelligence technologies and robotics in agriculture, the experts were the heads of agricultural organizations in the Sverdlovsk region, as well as representatives of the academic community specializing on studying the problems of the agricultural sector of the economy (Figure 1).

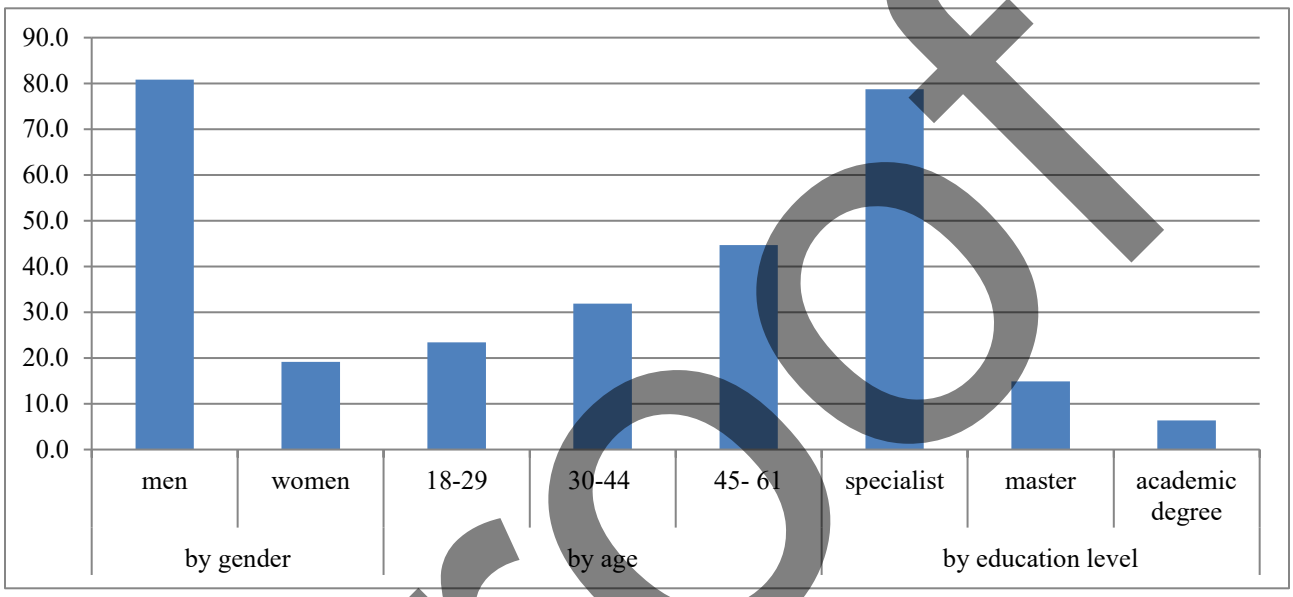

FIGURE 1. Characteristics of the expert group, %.

As Figure 1 shows, the largest proportion among the experts were men (80.9%), due to their predominance among the heads of agricultural organizations in the Middle Urals. Experts aged 45-61 (44.7%) make up the largest share, the middle age category is represented by people aged 30-44 (31.9%), the smallest share (23.4%) is made up of young people aged 18-29 years. The largest share in terms of the education level is made up of specialists (78.7%) who received education before the entry of the Russian Federation into the Bologna process for unification of education standards, but 14.9% have a master's degree. It should be noted that all experts (6.4%) from the academic community (employees of universities, research institutes) involved in the study have a degree.

As research methods, the experts were asked to fill in a questionnaire. The first part of the questionnaire proposed to answer standard questions about characteristics of a surveyed expert. The second part of the questionnaire proposed to give points for each of the previously identified risks. Thus, 5 points corresponds to the assessment of "very high risks", 4 points - "high risks", 3 points - "medium risks", 2 points - "below average risks", 1 point - "minimum risks". The conditional index corresponds to the average assessment of this risk, which is calculated by software.

RESULTS AND DISCUSSION

The problem of studying the risks of implementing artificial intelligence technologies and robotics in agriculture is an urgent scientific problem that has not been sufficiently studied. It is becoming more and more important in the context of rapid digitalization of various sectors of the economy, including such a conservative industry as agriculture. A group of experts was involved to assess the risks of implementing artificial intelligence technologies and robotics in agriculture in terms of the degree of validity. The results of the survey can be seen in Figure 2.

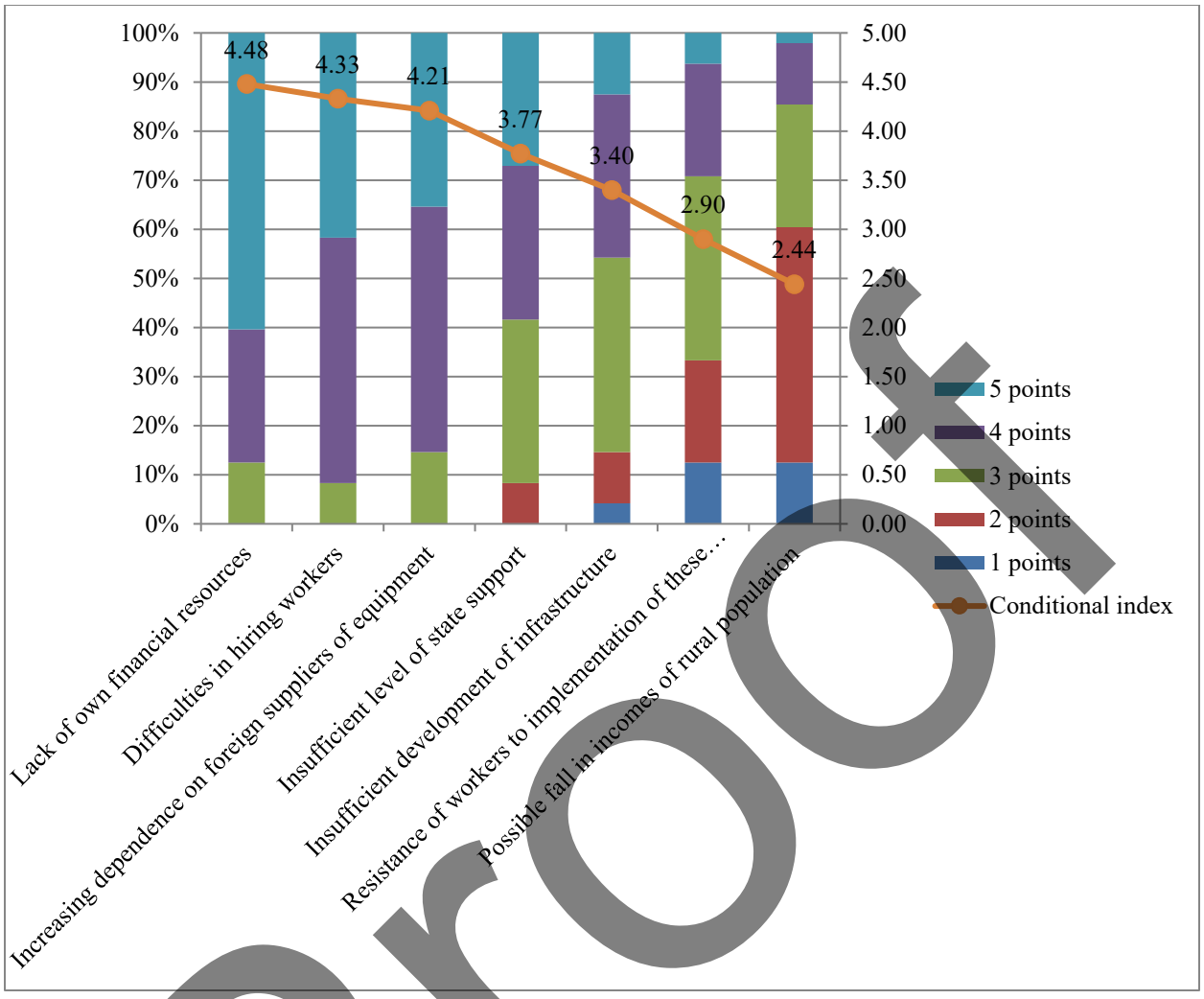

FIGURE 2. Risks of implementing artificial intelligence technologies and robotics in agriculture by a degree of manifestation.

According to the experts, the greatest risks of implementing artificial intelligence technologies and robotics in agriculture are associated with the insufficient amount of own financial resources. The fact is that farmers, not without reasons, associate the implementation of artificial intelligence technologies and robotics with significant investments. And a significant part of agricultural organizations in the Sverdlovsk region stops their activities with a loss, and in 2016-2021 24.4% of farmers stopped their activities for economic reasons (Table 1).

TABLE 1. Financial results of the activity of agricultural organizations of the Sverdlovsk region.

Indicator	2016	2017	2018	2019	2020	2021	2021 to 2016, %
Number of organizations with profit, pcs.	271	260	246	233	204	205	75.6
Profit before taxation, thousand rubles	4604	3773	4764	3831	4669	5889	127.9
Subsidies from the budgets of all levels, thousand rubles	3565	3280	3564	3471	3454	3924	110.1
Net profit, thousand rubles	4452	3710	4613	3713	4571	5699	128.0
Share of agricultural organizations operating with profit, %	82.0	80.4	82.1	84.4	83.3	80.0	-2.0 (percentage points)

Continuation of TABLE 1.

Net profit per organization, thousand rubles	16.4	14.3	18.8	15.9	22.4	27.8	169.2
Subsidies from the budgets of all levels per organization, thousand rubles	13.15	12.62	14.49	14.90	16.93	19.14	145.5

Despite the fact that during the studied period profit before taxation increased by 27.9%, and net profit by 28.0%, a share of agricultural organizations operating with a profit decreased by 2 percentage points. And only 27.8 thousand rubles of profit falls per one organization. Even considering the fact that it grew by 69.2% per organization, its value is very doubtful for starting large investment projects. Under these conditions, the fears of the experts look very reasonable. As can be seen from Figure 2, more than 60% of the experts gave 5 points to this risk, and the conditional index is 4.48 points.

One of the most significant risks of implementing artificial intelligence and robotics in agriculture is hiring workers who are able to master these technologies. According to the survey data, more than 41% of the surveyed experts gave the highest rating, and another half rated this risk as 4 points, while the conditional index was 4.33 points. The fact is that even the implementation of modern digital technologies does not mean complete exclusion of a person from the production process, especially in such an industry as agriculture. There is a need to maintain this equipment, to interact and interpret the results. For example, at present, artificial intelligence technologies are widespread, which make it possible to predict the productivity and behavior of animals [3,4] depending on various factors. The use of these technologies requires certain skills in interacting with software products. Another example would be the widespread use of robotics in milking and feeding [5]. However, the use of these robots requires appropriate services, replacement of consumables and components, etc. It leads to the need to hire specialists who can perform these types of work. And at rural areas the task of hiring such workers becomes a much greater problem than in the urban areas, primarily due to the limited supply of labor resources in the countryside.

In the context of sanctions restrictions [6] many experts noted increasing dependence on suppliers of equipment, components, and software as one of the risks of implementing artificial intelligence and robotics technologies. It should be noted the assessments of these risks, which make up 35.4% as “very high risks”, another 50.0% of assessments are “high risks”, and the conditional index was 4.21 points. Indeed, all the robotics used in the agriculture of the Russian Federation is imported, which causes particular fears of farmers about the prospects for further maintenance of robots and software updates, including management decision support programs (artificial intelligence). For example, the most popular milking robots DeLaval and Lely are Swedish and Dutch-made, respectively. A significant part of the software, ERP-systems for agriculture is also foreign-made. The possibility of stopping the supply of equipment and software updates makes farmers' fears reasonable.

One of the risks of implementing artificial intelligence technologies and robotics in agriculture is the level of state support in the form of subsidies. This is because robotics remains quite expensive for most farmers. And the return on investment for purchasing of this equipment is possible only if a part of the costs is subsidized from the budgets of various levels - federal, subject of the federation, municipal. State support for farmers exists all over the world, but in many countries of the European Union it is indirect and often higher than in the Russian Federation. Currently, Russia provides various measures of state support [7]. These include the provision of preferential loans to agricultural producers (at a rate of 10% per annum). Other measures are compensation of part of the costs of paying commission fees, limiting acquiring commissions, and credit holidays for farmers. The most effective support measure is the compensation of part of the capital costs for purchasing of equipment of 40-80% by its various types. And according to the respondents, there is a certain risk that such support may be reduced or not provided if the documents for the provision of subsidies are filled with errors. Thus, 27.1% of the experts indicated a "very high risk" of reducing state support, and another 31.3% indicated a "high risk", the conditional index was 3.77 points. However, as our analysis shows (Table 1), the volume of subsidies for the studied period increased by 10.1%, while in 2021, 45.5% more subsidies were allocated to one organization from budgets of all levels than in 2016.

The availability of the necessary infrastructure is one of the conditions for implementing artificial intelligence and robotics technologies in agriculture. First of all, this concerns the Internet at outer rural areas, including broadband access. This allows the exchange of information between stationary equipment (computers or robots) on the farm and service points located remotely in district or regional centers. This allows remote diagnosing the wear of components and assemblies, timely performing preventive repairs, and updating software. An important infrastructure object is the availability of roads in rural areas, especially paved ones. If a failure takes place, a robot maintenance technician should be able to come to the farm and fix the problem within a short time (the EU standard

is up to 2 hours). If it takes a long time, it can result in serious downtime and disruption of the production process, which will cause significant losses for farmers. The lack of the necessary infrastructure may rise doubts on the feasibility of implementing a project to introduce robotics or artificial intelligence. According to experts, these risks can be assessed as "very high" in 12.5% of cases, "high" in 33.3%, the conditional index is 3.4 points.

One of the risks of implementing new technologies is the possible resistance of employees to innovations. This comes from the fear of workers to lose their jobs. Also, the implementation of new equipment means the need to improve qualifications and skills, which is not always possible or irritates employees. The implementation of artificial intelligence technologies and robotics in agriculture fully meets these reasonable concerns of workers. At the same time, resistance can take various forms, from active as damages of new equipment to passive observation of the process. According to experts, these risks can be assessed as "very high" in 12.5% of cases, "high" in 33.3%, the conditional index is 3.4 points.

There are a number of assessments that indicate that the massive implementation of artificial intelligence and robotics technologies can displace a person from the economy and, as a result, decrease household incomes. Thus, according to some estimates, the further use of these technologies will replace of about 50% or more of modern jobs with robots [8] and then reduce significantly jobs in the middle class [9]. However, the results of other studies revealed a positive impact of robotization and the use of artificial intelligence on employment in the high-tech sector and only a slight decrease in employment in traditional sectors of the economy [10]. According to the expert group, a possible fall in income of the rural population in the context of implementing artificial intelligence and robotics technologies is assessed as insignificant. Thus, 47.9% of the experts noted this risk as “below average” rating 2 points, and the conditional index was 2.44 points.

CONCLUSION

The implementation of artificial intelligence technologies and robotics requires large investments, which is associated with reasonable risks, as a significant part of farmers has limited financial resources. The implementation of digital technologies leads to the need to hire specialists who can perform maintenance and interact with this equipment. And the task of hiring such workers becomes a much greater problem at the rural areas, primarily due to the limited supply of labor resources in the countryside. In the context of sanctions restrictions and the possibility of stopping the supply of equipment and updating software, it makes farmers' fears quite reasonable, as almost all equipment is foreign-made.

According to the expert group, the implementation of artificial intelligence technologies and robotics, a possible fall in income of the rural population, due to the displacement of a person from production and mass unemployment, does not cause concern. The risks of availability of infrastructure also do not cause significant concern for experts. Apparently, the rural areas (in the Sverdlovsk region) have the necessary infrastructure, including paved roads and the Internet. It should be noted that, according to the experts, the possible resistance of workers to innovations is low.

Thus, it is possible to identify two groups of risks of implementing artificial intelligence technologies and robotics in agriculture according to the degree of validity. Reasonable risks are risks that have the conditional index of more than 3.5 points. They include a lack of own financial resources, difficulties in hiring workers, increasing dependence on suppliers of equipment, components, software, and an insufficient level of state support. Unreasonable risks are risks which have the conditional index of expert assessments below 3.5 points. They include insufficient development of infrastructure, resistance of workers to the implementation of these technologies, and a possible fall in incomes of the rural population.

ACKNOWLEDGMENTS

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The Organizational-and-Economic Mechanism for Reproduction of Labor Resources Capable of Mastering Robotics in Agriculture

A.N. Semin [1], E.A. Skvortsov [1, a)], N.K. Pryadilina [2]

[1] *Department of Competition Law and Antimonopoly Regulation, Ural State Economic University, 620144, st.March 8 / Narodnaya Volya, 62/45, Ekaterinburg, Russian Federation*
[2] *Ural State Forest Engineering University, 620100, Siberian tract, 37, Ekaterinburg, Russian Federation*

[a)] Corresponding author: 9089267986@mail.ru

Abstract. Russia's agriculture is experiencing a shortage of workers due to the negative demographic situation, the low attractiveness of the industry and the COVID pandemic, which poses risks to sustainable development. To reduce the personnel shortage, farmers use robotics, but its implementation is slow, due to poor skills of workers to interact with robots. The main goal of the study is to develop a model of the organizational-and-economic mechanism for formation of agricultural labor resources in the context of the use of cyber-physical systems, including robotics. A model of the organizational- and-economic mechanism has been developed, its main elements are: target; organizational-economic; motivational; personnel training and retraining. The goals for achieving the number of employees interacting with cyber-physical systems, in particular with robots, have been adjusted - up to 3% in 2023 and 8% in 2024. The total investments in robotization of the industry will be 3,863 million rubles, including 76.6 million rubles in employee training. The implementation of the elements of the organizational-and-economic mechanism will ensure the conditions for formation of labor resources in accordance with the state program on digitalization of agriculture.

INTRODUCTION

Agriculture is one of the most important sectors of the economy, as it provides the world's population with food. According to various estimates, the population of the Earth may reach 12.6 billion by 2100 [1, 4], and the demand for agricultural products will increase by 60% [1]. Traditional farming systems will not be able to meet the ever-increasing demand for food, and therefore the digitalization of the economy is a response to the challenges of our time. The need to use robotics and artificial intelligence technologies is also caused with the increasing intensity of agriculture, which is associated with an increase in population and a general increase in living standards in the world. The introduction of new digital technologies will result in significant transformation of labor relations in the agrarian sector of the economy.

According to the International Labor Organization (ILO), a share of agricultural workers in the total labor force had fallen from 81.0% to 48.2% in developing countries and from 35.0% to 4.2% in developed countries by 2014. The shortage of people working on farms is becoming persistent everywhere. In the Asia-Pacific region, especially in Japan, the number of people working on farms decreased from 2.2 million in 2004 to 1.7 million in 2014 [2]. A significant reduction in the labor force of about 12.8% is also observed in the European agricultural sector. This decline in the labor force is due to the fact that young people do not become farmers, they find it unattractive, and the lack of qualified personnel encourages the introduction of agricultural automation technologies. These problems have been escalated with the spread of the COVID epidemic and the associated restrictions on labor movement [3]. The COVID pandemic has clearly shown the growing dependence of the industry on the supply of labor force and has become a real challenge for the sustainability of agricultural production [4, 5].

In these conditions, farmers are increasingly using robotics and artificial intelligence technologies to reduce the shortage of workers. Milking robots are one of the most successful and important innovations in the dairy farming

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system. According to the International Federation of Robotics, milking robots take up to 85% of the total number of robots used in the industry. Average sales of milking robots grew by about 9.4% in 2016-2017. Nearly 20,000 dairy farms have installed robots in Western Europe, Canada, the USA, China and Japan. Such factors as increased frequency of milking and high labor flexibility are driving the market for milking robots.

METHODOLOGY

Some scientists have developed models for predicting the need for labor force, the use of which makes it possible to satisfy the need for personnel [6,7]. The use of multiple regression and econometric methods in these models to predict labor demand depends on a number of key variables such as employment and a wage level. These models are quite complex and include several processes for estimating key variables that can change dramatically and thus affect the accuracy of forecasting. An alternative to the above-mentioned approaches is the labor multiplier method, which allows establishing the relationship between the volume of agricultural production and the need for labor.

One of the limitations for introduction of robotics in agricultural organizations of the Sverdlovsk region is the characteristics of cattle and the suitability of facilities for installation of robots. So, for the use of milking robotics, it is necessary that the teats of the udder of cows are suitable for machine milking (cylindrical and of sufficient length). At the same time, the facilities for keeping cattle should be suitable for loose housing and with hard flooring. Let's assume that 20% of the cattle population is suitable for robotic milking, and the housing facilities have conditions for the use of a robot feed trimmer. In this case, the service rate for one milking robot is 60 cows, and for a feed trimming robot is 400 cows.

Data from the Ministry of Agriculture of the Sverdlovsk Region and Rosstat were used to develop an organizational-and-economic mechanism for the reproduction of labor resources capable of mastering robotics in agriculture. The state program «Digital Agriculture» [8] (2019), developed by the Ministry of Agriculture of Russia, is used as a guideline for the level of digitalization in agriculture. It indicates that «a share of specialists at agricultural enterprises who have undergone retraining and have competencies in the field of the digital economy to work with digital products should be 50%» in 2024. Another legal document is the «Concept for «the Scientific and Technological Development of Digital Agriculture «Digital Agriculture» [9] (dated January 12, 2017). It uses "job positions associated with information technologies, data processing and cyber-physical systems (the Internet of Things) at rural areas" as a target indicator, which should be at least 20% in 2024.

The main postulate will be the assumption that all categories of workers must interact with cyber-physical systems. This should apply equally to managers, specialists and workers in material production, including in animal husbandry. The main goal of the study is to develop a model of the organizational-and-economic mechanism for formation of agricultural labor resources in the context of the use of robotics.

In accordance with the mentioned goal, the following research tasks can be outlined:

– to perform an analysis of the number of agricultural workers directly interacting with cyber-physical systems (robots, the Internet of things, artificial intelligence) (by the example of the Sverdlovsk region);

– to determine the composition of the main elements (blocks) of the organizational-and-mechanism for formation of agricultural labor resources in the context of robotization;

– to carry out an analysis of feasibility of the goals of scientific and technological development of digital agriculture;

– to perform an analysis of the number of employees and a volume of necessary investments needed to achieve the goals.

To achieve the aims and tasks of the study, general economic methods were used, including methods of an economic-and-statistical analysis, as well as other methods of scientific research, generalization and processing of information, due to the specific tasks of this scientific work.

RESULT

The slow pace of social development of rural areas should be noted, which determine the deterioration of the socio-demographic situation. There is an outflow of the employable population to large cities, especially young people, which results in a shortage of qualified personnel in agriculture in the Sverdlovsk region. If on January 1, 2017, 665.4 thousand people (15.4% of the total regional population) lived in rural areas, then on January 1, 2021, the rural population decreased to 639.3 thousand people (or 14.9%). 0Basically, there is an outflow of the employable population from rural areas: in 2016, the labor force of the rural population was 286.6 thousand people, in 2020 it

decreased to 260.1 people (91%). The unemployment rate of the rural population is in 1.5 times higher than the one of the urban population.

It seems appropriate to consider the structure of workers employed in agriculture (Figure 1).

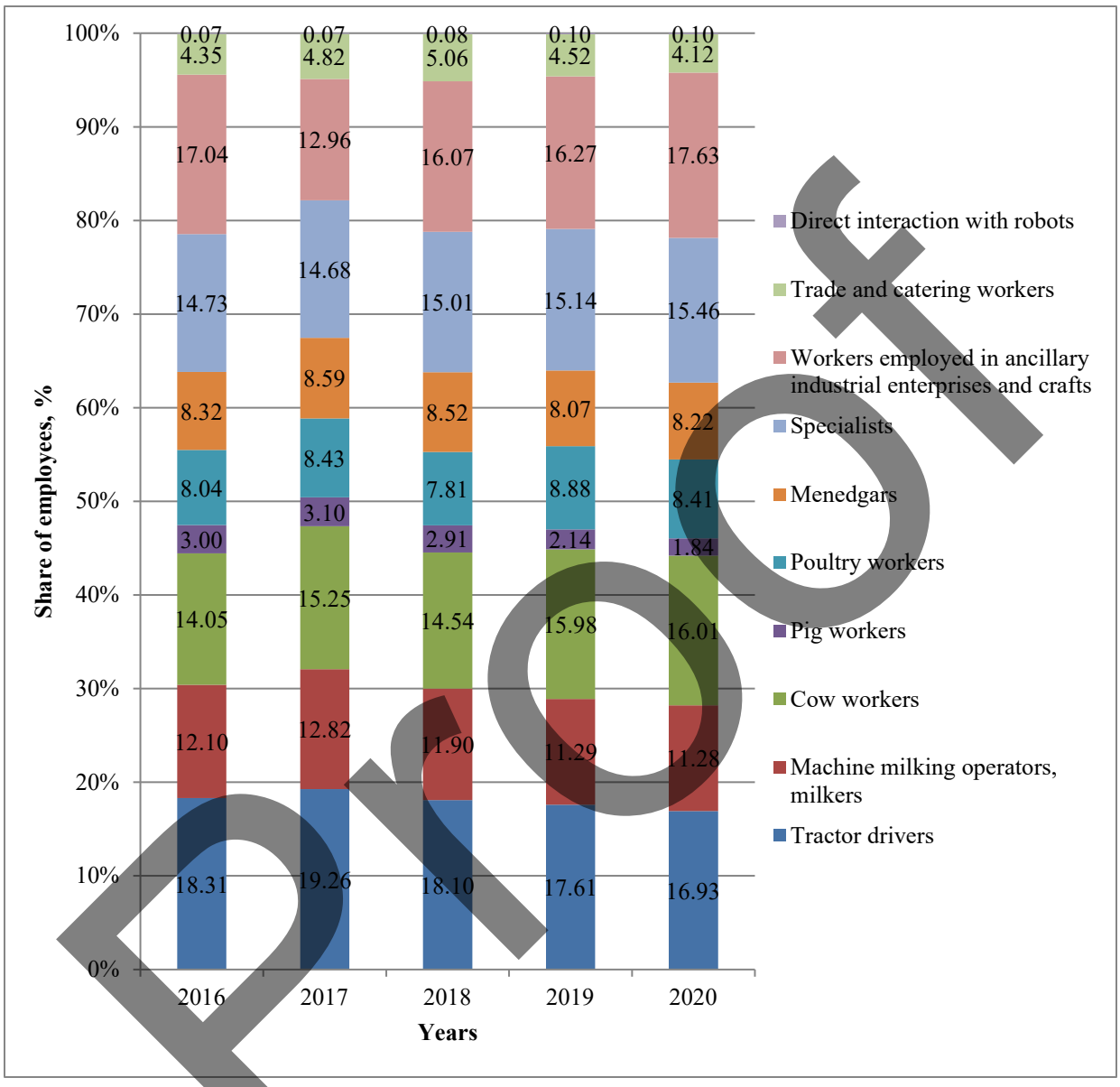

FIGURE 1. The structure of workers employed in agriculture in the Sverdlovsk region, people.

As the figure shows, the structure of employment of agricultural workers in the Sverdlovsk region can be characterized as traditional. The largest share in it is occupied by workers employed in auxiliary industrial enterprises and crafts (17.6%), tractor drivers (16.9%) and various specialists (15.5%), which include veterinarians, agronomists, accountants and other employees. The priority direction of agricultural production in the Sverdlovsk region is dairy farming, its products is about 35% of the total volume of marketable agricultural products and the main production of most agricultural organizations (farmers). So, a share of workers serving cattle (16.0%) and milkers (11.3%) is quite high. At the same time, a share of workers directly interacting with robots is low and only 0.1% in 2020. This is significantly lower than it was planned in the Concept of «The Scientific and Technological Development of Digital Agriculture «Digital Agriculture» (20% by 2024).

TABLE 1. The number of workers in animal husbandry and their share to interact with robots.

Indicator	2016	2017	2018	2019	2020
Machine milking operators, milkers	2160	2158	2050	1934	1917
Cow workers	2509	2567	2504	2737	2721
Total in animal husbandry	4669	4725	4554	4671	4638
Workers directly interacting with robots	12	12	14	17	17
A share of workers interacting with robots	0.26	0.25	0.31	0.36	0.37

The low pace of robotization of agriculture should be noted. During the analyzed period, the number of animal husbandry workers directly interacting with robots was 17 people, or 0.37% of the total number of employees in the industry. At the same time, operators of robotic milking and technicians of robot maintenance often perform operations for 3-4 units of robotics, and their working day can be up to 12 hours a day. This indirectly indicates a shortage of workers with skills in interacting with robots, that necessitates training.

The shortage of qualified personnel in agriculture, a low proportion of workers interacting with cyber-physical systems (robots, artificial intelligence) encourages the development of an appropriate organizational-and-economic mechanism for formation of labor resources. The key element (block) of this mechanism is a target block, which concerns achievable goals for the reproduction of labor resources (Figure 2).

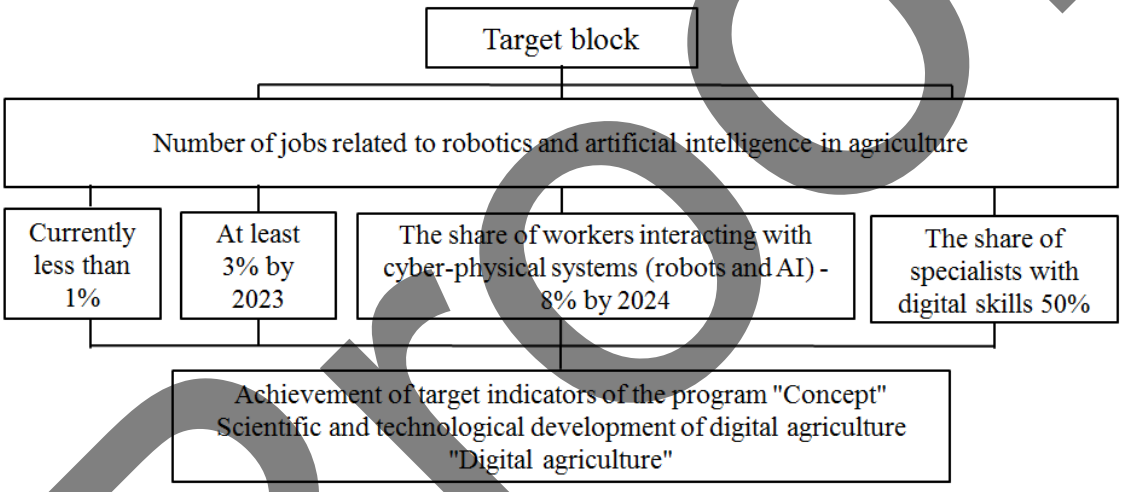

FIGURE 2. A target block of the organizational-and-economic mechanism for the reproduction of labor resources.

In accordance with the performed analysis, at present a share of workers interacting with cyber-physical systems is less than 1% of the total number of employees in animal husbandry (Table 1). These data make doubtful the possibility of achieving the goals of the Concept of "The scientific and technological development of digital agriculture «Digital Agriculture», according to which the number of employees interacting with cyber-physical systems should be 20% by 2024. The most realistic goals may be those to achieve the number of workers interacting with robots up to 3% in 2023 and 8% in 2024. This also encourages changes in the personnel training system (Figure 3).

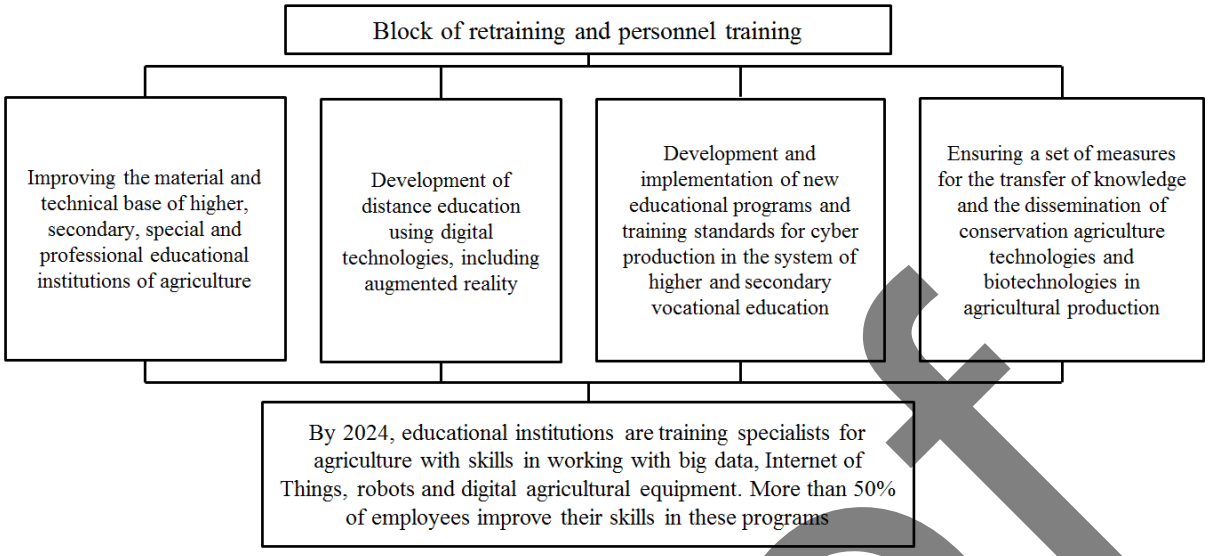

FIGURE 3. A block of personnel training and retraining.

An important component of the block of personnel training and retraining is the improvement of the material-and-technical base of higher, secondary, special and vocational educational institutions that train workers for agriculture with skills of interacting with robots and other cyber-physical systems. One of the elements of the material base of educational institutions is their technical equipment.

The availability of numerous stands that simulate the work of robots, computer equipment and software, and the appropriate infrastructure that allows processing large volumes of data is of great importance. However, the technical base of many educational institutions in Russia does not meet the modern level of production. While agricultural organizations are introducing advanced technologies, including robotics, educational institutions are conducting the educational process on outdated technologies. Modernization of outdated educational and laboratory equipment is not carried out intensively enough. Many elective engineering courses at agricultural universities do not have classrooms and laboratories with modern equipment, CNC technologies, computer equipment that allows modeling and using high-performance software. Educational institutions are mainly equipped with machine tools, that are out of service at machine-building plants.

The most important component of the organizational-and-economic mechanism for the reproduction of labor resources is availability of investments (Figure 4).

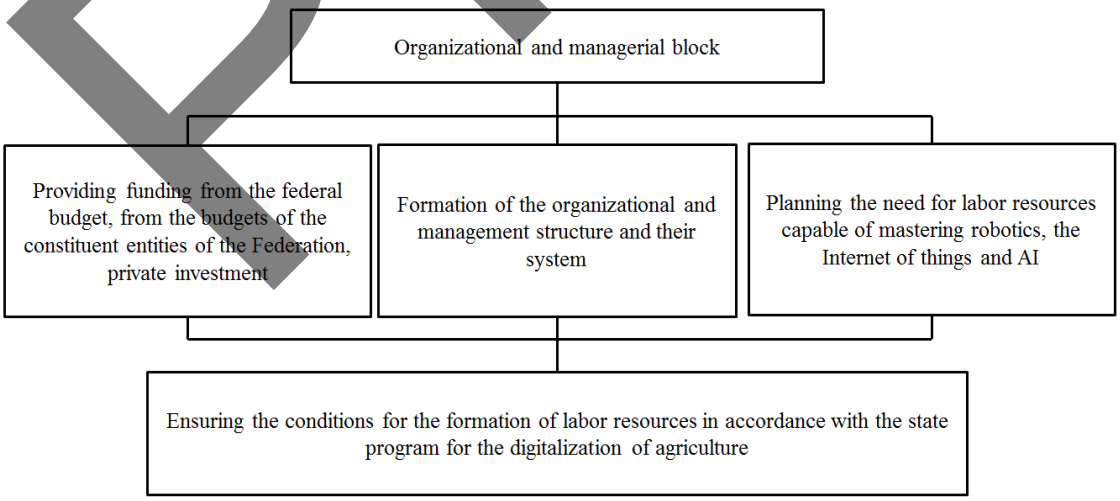

FIGURE 4. An organizational-management block.

The organizational-and-management block considers funding of required changes, which include private and public investments. An important element of this block is planning the need for labor resources capable of mastering robotics (Table 2).

TABLE 2. Calculation of investments on robotization of the industry and employee training (on the example of the Sverdlovsk region)

Indicators	2022	2023	2024	Total
Investments in robotization of milking, thousand rubles	565346	878560	2262291	3706197
Investments in introduction of robotic feed trimmers, thousand rubles	9600	19768	50902	80269
Necessity to train workers, pers.	60	48	199	306
Total costs for employee training, thousand rubles	14917	11906	49728	76551
Total investment in robotization of the industry, thousand rubles	589863	910233	2362921	3863018
Share of animal husbandry workers interacting with robots, people	1.82	3.0	8.0	8.0

According to the analysis data, as well as the planned goals on robotization up to 8% in 2024 (Figure 2), investments of 3,706 million rubles will be required for the purchase of milking robots and 80.3 million rubles for the purchase of feed trimmers robots. The service of this equipment will require to train 306 workers by 2024. At the same time, the cost of employees training will be 76.6 million rubles. The implementation of the elements of the organizational-and-management block will ensure the conditions for formation of labor resources in accordance with the state program on digitalization of agriculture.

The motivation block is a set of elements aimed at increasing the motivation of the population to realize their labor potential in agriculture (Figure 5).

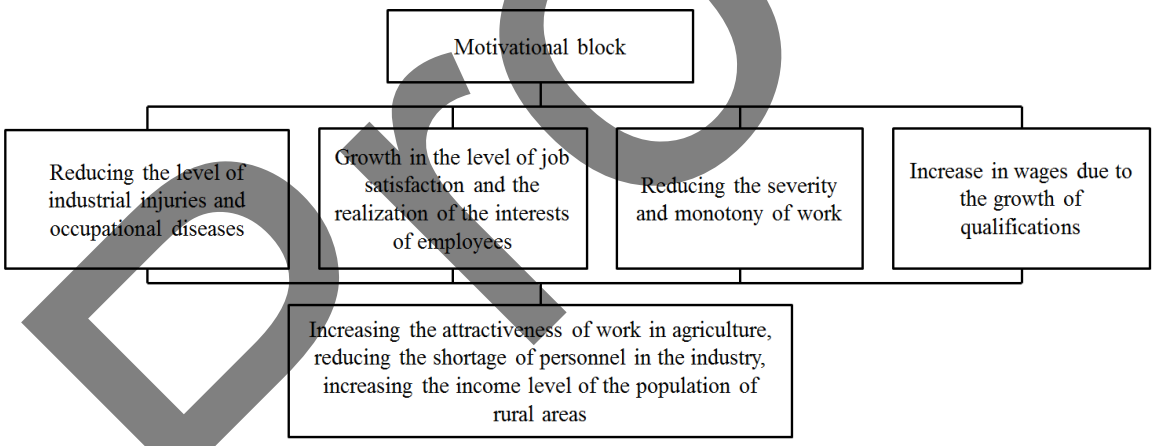

FIGURE 5. A motivational block.

First of all, the motivation to work in agriculture can increase as a result of a decrease in labor heaviness [10], as monotonous and heavy work can be performed by robots. Their use will also reduce work injuries and increase the level of job satisfaction, as well as raise wages by increasing the qualifications of workers. Finally, this will make it possible to increase the attractiveness of work in agriculture, reduce the shortage of personnel in the industry, and increase the income level of the population at rural areas.

CONCLUSION

One of the main indicators of the Concept of «The scientific and technological development of digital agriculture «Digital Agriculture» [11] (dated January 12, 2017) is «a share of job positions associated with information technologies, data processing and cyber-physical systems (the Internet of things) at rural areas», which should be at

least 20% in 2024. However, at present the number of animal husbandry workers directly interacting with robots is 0.37% of the total number, or 0.1 of all employees in agriculture. This allows making a conclusion that the pace of implementation of cyber-physical systems, including robotics and artificial intelligence technologies, can be characterized as insufficient. It should be noted that the achievement of these indicators of the concept is not an end in itself, but their achievement will reduce the shortage of workers in the industry and achieve the goals of sustainable development of agriculture.

The need to reduce uncertainty and risks associated with the introduction of cyber-physical systems and robotization of the industry has resulted in development of a mechanism aimed at improving the formation of agricultural labor resources. To develop this mechanism there was a postulate that all categories of workers, including those in material production, including animal husbandry, must interact with cyber-physical systems. The main elements (blocks) of this mechanism are: target; organizational-economic; motivational; personnel training and retraining.

The goals on achievement the number of employees interacting with cyber-physical systems were adjusted, in particular with robots up to 3% in 2023 and 8% in 2024. The total volume of investments in robotization of the industry is 3863 million rubles, including 76.6 million rubles for the training of employees. The implementation of the elements of the organizational-and-management block will ensure the conditions for formation of labor resources in accordance with the state program on digitalization of agriculture.

CONFLICT OF INTERESTS

The authors confirm that the revealed information does not contain a conflict of interest.

ACKNOWLEDGMENTS

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Ballasting Features of the 4K4a Scheme Tractors with High Engine Power and Drawbar Category and the 4K4b Layout Scheme Tractors

Grigory A. Iovlev [1, a)], Mavses K. Sahakyan [1, b)], Mamed L. Yusupov [1, c)], Irina I. Goldina [1 ,d)] and Artem A. Sadov [1 ,e)]

[1] *Ural State Agrarian University, Yekaterinburg, Russia*

[a)] Corresponding author: gri-iovlev@yandex.ru
[b)] samokar@mail.ru
[c)] mamed.yusupov.2014@mail.ru
[d)] ir.goldina@mail.ru
[e)] artemsadov@yandex.ru

Abstract. Many tractors with engine power indicators over 206 kW have power/weight ratio indicators in the range of 1.23 kW/kN – 1.54 kW/kN and belong to tractors of traction concept, are capable of performing all types of mechanized work and transport work without installing additional ballast weights. At the same time, tractors with the specified engine power parameters have a power/weight ratio R = (1.6-2.77) kW/kN and they need to use ballast weights to realize their operational properties. Such tractors include Case IH Magnum 290, Massey Fergusson 8732, Fendt Vario 1050, etc. When using ballast weights, it is essential to consider the requirements for tractor controllability. This requirement is not compulsory for tractors of the 4K4b layout scheme, yet there is a requirement for the distribution of operational weight along the tractor axes when performing agricultural work with various types of machines. Representatives of tractors with the 4K4b layout scheme are: John Deer 9370R, New Holland T9060, John Deer 9520R with respective power/weight ratios – 1.6 kW/kN, 1.67 kW/kN, 2.03 kW/kN. In the study, the authors will consider the possibilities of improving the operational properties of the Massey Fergusson 8732 tractor with power/weight ratios of R = 2.48 kW/kN, the New Holland T9060 tractor with power/weight ratio of R = 1.67 kW/kN.

INTRODUCTION

Tractors with high engine power (over 206 kW) of the 4K4a layout scheme are normally truck tractors, i.e. tractors of the traction concept [1] with power/weight ratios of R = (1.23-1.54) kW/kN. Such tractors include Massey Fergusson 8730, New Holland T9030, Massey Fergusson 8737, and other tractors. Tractors with the presented power/weight ratios have an operational weight and engine power capable of performing all types of mechanized work and transport work without installing additional ballast weights. At the same time, many tractors of the 4K4a layout scheme have power/weight ratios of R = (1.6-2.77) kW/kN and belong to tractors of traction and energy concept [1], i.e. to perform mechanized and transport work; these tractors need ballast weights to increase the operating mass of the tractor. Such tractors include Case IH Magnum 290, Massey Fergusson 8732, Fendt Vario 1050, etc.

When determining the optimal proportion of ballast weights providing optimal performance properties for modern tractors with the 4K4a scheme, it is vital to consider the requirements of controllability (the load on the front axle must be at least 0.2 m_O (operating weight) and the requirements for the maximum permissible load on the axes – for the front axle (0.35-0.45) $m_O < m^F_{max}$(maximum permissible load on the front axle); for the rear axle (0.55-0.65) $m_O < m^R_{max}$(maximum permissible load on the rear axle).

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Tractors with a 4K4b layout scheme with different ratios of operational weight distribution between the axes have no requirement for controllability, yet there are more strict requirements for the load on the rear axle from the point of view of ensuring maximum tractor traction when using various agricultural machines and tractor trailers. The load on one wheel is very important for 4K4b tractors; therefore, the use of dual wheels on all axles - and sometimes 3 wheels - is provided for tractors with an articulated frame.

Recommended ratios of operational weight distribution along the axes for the tractor layout scheme 4K4b:

1. Agricultural machines with high tractive resistance – 55% front axle, 45% rear axle.
2. Mounted agricultural machines – 60% front axle, 40% rear axle.
3. Agricultural machines, tractor trailers with large vertical loads on the trailer device – 65% front axle, 35% rear axle.

Characteristic representatives of tractors with a 4K4b layout scheme are: John Deer 9370R, New Holland T9060, John Deer 9520R with respective power/weight ratios – 1.6 kW/kN, 1.67 kW/kN, 2.03 kW/kN.

MATERIALS AND METHODS

In the study, the authors will consider the possibilities of improving the operational properties of the Massey Fergusson 8732 tractor with power/weight ratios of R = 2.48 kW/kN, the New Holland T9060 tractor with power/weight ratio of R = 1.67 kW/kN (Fig. 1,2).

FIGURE 1. Tractor Massey Fergusson 8732.

FIGURE 2. New Holland T9060 Tractor.

For ballasting the Massey Fergusson 8732 tractor, front weights with a mass of 1500 kg and 2300 kg can be used, wheel weights – 3 rings of 250 kg, 2 rings of 750 kg per wheel. The maximum number of rings on the rear wheels can be used in the following combination: 2 rings of 750 kg + 2 rings of 250 kg per wheel. For the New Holland T9060 tractor – a bracket for weights on the front half-frame weighing 294 kg plus up to 18 weights of 45 kg (9 loads per side); a frame for weights on the rear half-frame weighing 468 kg plus up to 14 loads of 45 kg; wheel weights – up to 2 loads weighing 227 kg and one load weighing 454 kg per wheel.

From the presented data, it is possible to deduce the interrelation between the mass of ballast weights and the operational mass of tractors. Thus, the Massey Fergusson 8732 tractor with an operational mass of 10300 kg had a total weight of ballasting weights of 12,800 kg, i.e. the ballasting coefficient k_b (the ratio of ballast weights' mass to the operational weight of the tractor) [1] was more than one, $k_b = 1.24$. This indicates a high power/weight ratio of the tractor, R = 2.48 kW/kN. The New Holland T9060 tractor with an operational weight of 23980 kg had a total ballast weights' mass of 5834 kg or 24.3%. The conclusion on the dependence of ballast weights' mass on the operational mass of the tractor will be made after determining the optimal proportion of ballast weights affecting the maximum increase in operational properties.

The following options for additional tractors' loading will be taken to determine the optimal proportion of ballasting weights.

Massey Fergusson 8732. Option 1 – no additional load; option 2 – front weight of 1500 kg; option 3 – front weight of 1500 kg + 2 rings of 250 kg on the rear wheels (one ring per wheel); option 4 – front weight 1500 kg + 4 rings of

250 kg on the rear wheels (two rings per wheel); option 5 – front weight 1500 kg + 2 rings of 750 kg on the rear wheels (one ring per wheel); option 6 – front weight 2300 kg + 2 rings of 250 kg on the rear wheels (one ring per wheel); option 7 – front weight 2300 kg + 4 rings of 250 kg on the rear wheels (two rings per wheel); option 8 – front weight 2300 kg + 2 rings of 750 kg on the rear wheels (one ring per wheel); option 9 – front weight 2300 kg + 4 rings of 750 kg on the rear wheels (two rings per wheel); option 10 – front weight 2300 kg + 4 rings of 750 kg on the rear wheels (two rings per wheel) + 2 rings of 250 kg (one ring per wheel); option 11 – front weight 2300 kg + 4 rings of 750 kg on the rear wheels (two rings per wheel) + 4 rings of 250 kg (two rings per wheel).

New Holland T9060. Option 1 – no additional weight; option 2 – mounting bracket for weights on the front half-frame 294 kg; option 3 – bracket for weights on the front half-frame 294 kg + frame for weights on the rear half-frame 468 kg; option 4 – bracket for weights on the front half-frame 294 kg + 8 weights (4 for each side) + frame for weights on the rear half-frame 468 kg; option 5 – bracket for weights on the front half-frame 294 kg + 8 weights (4 for each side) + frame for weights on the rear half-frame 468 kg + 3 weights; option 6 – bracket for weights on the front half-frame 294 kg + 10 weights (5 for each side) + frame for weights on the rear half-frame 468 kg + 3 weights; option 7 – bracket for weights on the front half-frame 294 kg + 10 weights (5 for each side) + frame for weights on the rear half-frame 468 kg + 6 weights ; option 8 – bracket for weights on the front half-frame 294 kg + 12 weights (6 for each side) + frame for weights on the rear half-frame 468 kg + 6 weights; option 9 – bracket for weights on the front half-frame 294 kg + 12 weights (6 for each side) + frame for weights on the rear half-frame 468 kg + 8 weights; option 10 – bracket for weights on the front half-frame 294 kg + 14 weights (7 for each side) + frame for weights on the rear half-frame 468 kg + 8 weights; option 11 – bracket for weights on the front half-frame 294 kg + 14 weights (7 for each side) + frame for weights on the rear half-frame 468 kg + 10 weights; option 12 – bracket for weights on the front half-frame 294 kg + 16 weights (8 for each side) + frame for weights on the rear half-frame 468 kg + 10 weights; option 13 – bracket for weights on the front half-frame 294 kg + 16 weights (8 for each side) + frame for weights on the rear h–lf-frame 468 kg + 12 weights; option 14 – bracket for weights on the front half-frame 294 kg + 18 weights (9 for each side) + frame for weights on the rear half-frame 468 kg + 12 weights; option 15 – bracket for weights on the front –alf-frame 294 kg + 18 weights (9 for each side) + frame for weights on the rear half-frame 468 kg + 14 weights.

These ballasting options provide for the use of front and rear ballast weights excluding wheel weights. The use of wheel weights can add over 40 different options using wheel weights of 227 kg, 454 kg, or a combination of 227 kg + 454 kg. In this study, the authors apply the use of ballast weights of 227 kg per wheel in options 1-5, in options 6-10 – 454 kg, options 11-15 – 227 + 454 = 681 kg.

RESULTS AND DISCUSSION

The distribution of weight (load) along the axes and the total weight of Massey Fergusson 8732 tractor is presented in Table 1.

TABLE 1. Weight distribution on the axles of Massey Fergusson 8732 tractor.

Option No.	Weight characteristics, kg				
	Front axle		Rear axle		Total operational weight
	Value	Share of the total load	Value	Share of the total load	
Option 1	3860	37.5	6440	62.5	10300
Option 2	*5360*	*45.4*	*6440*	*54.6*	*11800*
Option 3	*5360*	*43.6*	*6940*	*56.4*	*12300*
Option 4	5360	41.9	7440	58.1	12800
Option 5	5360	40.3	7940	59.7	13300
Option 6	*6160*	*47.0*	*6940*	*53.0*	*13100*
Option 7	*6160*	*45.3*	*7440*	*54.7*	*13600*
Option 8	*6160*	*43.7*	*7940*	*56.3*	*14100*
Option 9	6160	39.5	9440	60.5	15600
Option 10	6160	38.3	9940	61.7	16100
Option 11	6160	37.1	10440	62.9	16600

From the calculations presented in Table 1, it can be seen that with additional loading options 2, 3, 6-8, Massey Fergusson 8732 tractor is preferable to be used with mounted agricultural tools and with large vertical loads on the drag-bar.

To determine the ballasting effect on the operational properties of the tractor, i.e. on productivity and fuel consumption, the authors calculate the nominal tractive effort for different additional loading options; the calculation data is presented in Table 2. Table 2 also shows the change in power/weight ratios depending on the options for loading ballast weights.

The rated tractive force on a hook (nominal tractive effort) is determined by the formula: $P_{H\,N} = Am_O$, where A is the coefficient for tractors with 4 drive axles and operational weight of over 2600 kg (25.5 kN)

$A = 3{,}92\times10^{-3}$.

For the MF 8732 tractor in option 1 $P_{H\,N} = \frac{3{,}92\times101}{1000} = 39.6$ kN.

TABLE 2. Rated tractive effort, power/weight ratios of the Massey Fergusson 8732 tractor with various loading options.

Option No.	Indicators		
	m_O, kN	$P_{H\,N}$, kN	O, kW/kN
1	101.0	39.6	2.48
2	115.7	45.3	2.16
3	120.6	47.3	2.07
4	125.5	49.2	1.99
5	130.4	51.1	1.92
6	128.5	50.4	1.95
7	133.4	52.3	1.87
8	138.3	54.2	1.81
9	153.0	60.0	1.63
10	157.9	61.9	1.58
11	162.8	63.8	1.54

The nominal tractive effort using ballast weights increased by 61.1%. According to power/weight ratios, the MF 8732 tractor ballasted as per option No. 11 is in the range of truck tractors; determination on how this affects the operational properties will be given after corresponding calculations.

For clarity, the dynamics of changes in operational mass, nominal tractive effort, power/weight ratio depending on the mass of ballast weights for the Massey Fergusson 8732 tractor are presented in Fig. 3.

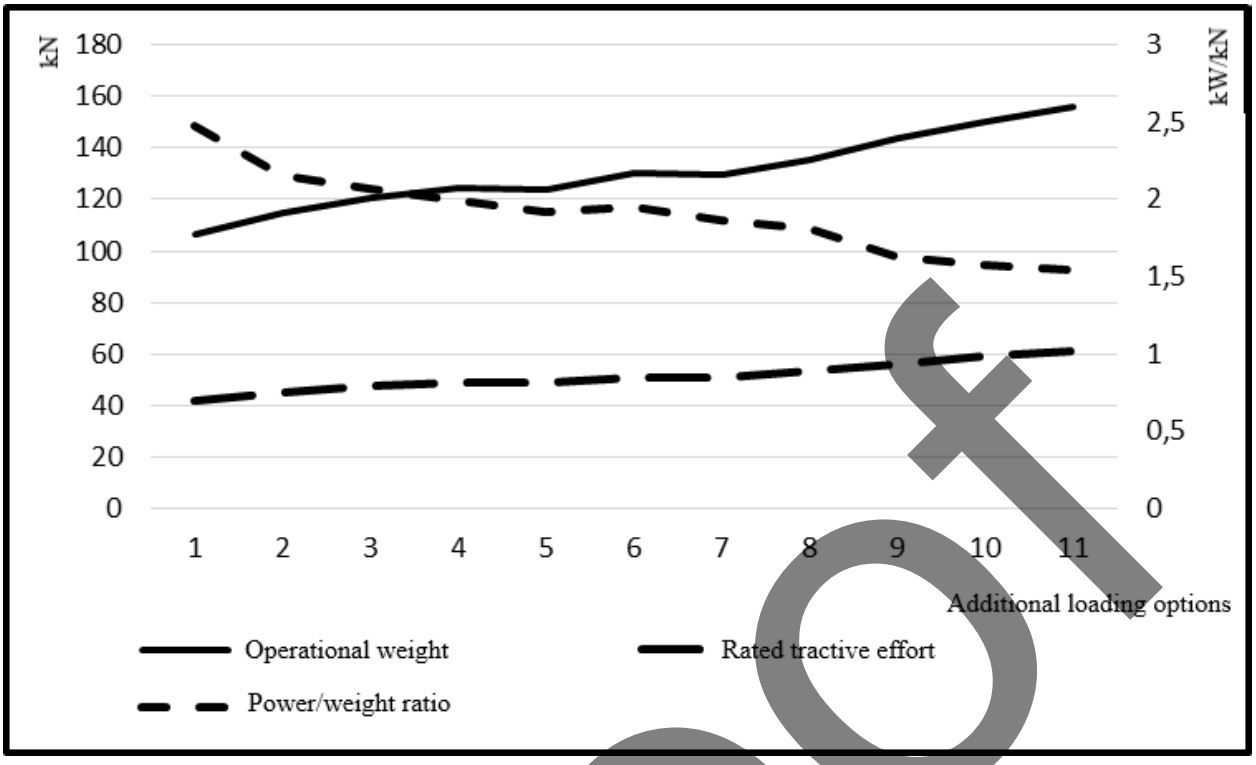

FIGURE 3. Dynamics of changes in operational mass, nominal tractive effort, power/weight ratio depending on the additional loading option.

To assess the impact of ballasting on operational properties, i.e. on the performance of the machine-tractor units (MTU) and fuel consumption, the authors present calculations on MTU formation for performing cultivation technological operation.

Initial data for calculations: specific resistance – 1.7 kN/m, rolling resistance coefficient – 0.15, traction margin – 7.5%. When calculating, it is necessary to choose the highest possible speeds in accordance with agrotechnical requirements.

The nominal traction forces for different loading options at different operating speeds are presented in Table 3.

TABLE 3. Nominal tractive efforts for various additional loads' options.

Operating speed, km/h	Rated tractive effort, kN										
4	39.6	45.3	47.3	49.2	51.1	50.4	52.3	54.2	60.0	61.9	63.8
6	36.2	41.4	43.2	45.0	46.7	46.1	47.8	49.6	54.9	56.6	58.3
8	32.8	37.5	39.2	40.8	42.3	41.8	43.3	44.9	49.7	51.3	52.9
10	29.4	33.7	35.1	36.5	38.0	37.4	38.9	40.3	44.6	46.0	47.4
12	26.0	29.8	31.1	32.3	33.6	33.1	34.4	35.6	39.4	40.7	42.0
14	22.6	25.9	27.0	28.1	29.2	28.8	29.9	31.0	34.3	35.4	36.5

The unit's traction resistance is determined by the formula: $R_a = R_m + R_f$

where R_m is the traction resistance of the agricultural machine, kN;

R_f is the rolling resistance of the agricultural machine, kN.

For cultivator KPM-14 $R_a = 14 \times 1.7 + 0.15 \times 45.4 = 23.8 + 6.81 = 30.6$ kN.

The tractive resistance corresponds to a tractive effort of 32.8 kN at an operating speed of up to 8 km/h with a margin of tractive effort.

Hourly productivity is determined by the formula:

$$W_H = eB_P V_P = e\,\xi_V \xi_V \tau V_a V_T \quad (1)$$

where e is a coefficient that considers the units of the untit's speed measurement. e = 0.1.

B_P – the working width of the unit grip, m; $B_P = \xi_B B_a$, where ξ_B - the coefficient of use of the grip width considers the difference between the working width of the grip from the design value: $\xi_B = \frac{B_P}{B_a}$. With surface processing ξ_B = 0.95-0.96.

V_P is the operating speed of the unit; $V_P = \xi_V V_T$, where ξ_V is the speed utilization factor: $\xi_V = \frac{V_P}{V_T}$. ξ_V = 0.81 for tractors class 3-4 ton-force; ξ_V = 0.83 for tractors of class 5 ton-force and above;

τ - shift time utilization factor: $\tau = \frac{T_P}{T_{shift}}$. With good work organization and normal operating conditions, τ = 0.7-0.8.

W_H = 0.1 ×0.955 ×14 ×0.81 ×8 ×0.75 = 6.5 ha/h

Calculation of fuel consumption.

$$g_{HA} = \frac{G_{F.C}+G_{B.W}+G_{F.CR}+G_{F.IDL}}{W_h} \quad (2)$$

where $G_{F.C}$, $G_{B.W}$, $G_{F.CR}$, $G_{F.IDL}$ – average hourly fuel consumption during the shift, kg/h - when performing basic (clean) work, idling on turns, crossings and during engine idling (during stops of the unit with the engine running). The average hourly fuel consumption is taken according to reference data or calculated using the specific fuel consumption per 1 EF h.p. and the degree of engine load.

$g_{HA} = \frac{34,6\times0,75+18,9\times0,25}{6,5} = \frac{25,95+4,72}{6,5}$ = 4.72 kg/ha

The calculation results of the ballasting effect on the performance of the machine-tractor unit (MTU) and fuel consumption are presented in Table 4.

TABLE 4. The ballasting effect on the MTU performance and unit's fuel consumption with Massey Fergusson 8732 tractor.

Option No.	Agricultural machine brand	Hourly productivity, ha/h	Specific fuel consumption, kg/ha
1	Cultivator KPM-14	6.5	4.72
2	Cultivator KPM-14	8.12	4.32
3	Cultivator KPM-14	8.32	4.4
4	Cultivator KPM-14	8.32	4.58
5	Cultivator KPM-14	9.99	3.96
6	Cultivator KPM-14	9.99	3.9
7	Cultivator KPM-14	9.99	4.06
8	Cultivator KPM-14	9.99	4.21
9	**Cultivator KPM-14**	**11.6**	**4.0**
10	Cultivator KPM-14	11.6	4.13
11	Cultivator KPM-14	11.6	4.26

Using the index method and taking loading option 1 as the basic one, let us determine the optimal additional loading option with ballast weights of the Massey Fergusson 8732 tractor.

Option 1 – 1 + 1 = 2 points; option 2 – 1.25 + 1.09 = 2.34 points; option 3 - 1.28 + 0.93 = 2.21 points; option 4 – 1.28 + 1.07 = 2.35 points; option 5 – 1.54 + 1.19 = 2.73 points; option 6 – 1.54 + 1.21 = 2.75 points; option 7 – 1.54 + 1.16 = 2.7 points; option 8 – 1.54 + 1.12 = 2.66 points; **option 9 – 1.78 + 1.18 = 2.96 points;** option 10 – 1.78 + 1.14 = 2.92 points; option 11 – 1.78 + 1.11 = 2.89 points.

The best option for Massey Fergusson 8732 tractor's additional loading with ballast weights will be front weights of 2,300 kg + 4 rings of 750 kg on the rear wheels (two rings per wheel).

Let us make similar calculations for the New Holland T9060 tractor. The calculation data on weight distribution along the tractor axes excluding wheel weights are presented in Table 5. Options of wheel weights can be used depending on the type of technological operation and the type of agricultural machine. So, to use the New Holland T9060 tractor on the technological operation 'cultivation', let us provide for the use of wheel weights combination of 227 kg and 454 kg per wheel. The distribution of weight along the tractor's axes taking into account wheel weights is presented in Table 6.

TABLE 5. Weight distribution on the axles of the New Holland T9060 tractor excluding wheel weights

Option No.	Weight characteristics, kg							
	Front axle			Rear axle			Total operational weight	Permissible wheel load (brand, quantity)
	Value	Share of total load, %	Load on 1 wheel	Value	Share of total load, %	Load on 1 wheel		
Option 1	14390	60	3597	9590	40	2397	23980	5000*
Option 2	14684	60.5	3671	9590	39.5	2397	24274	5000*
Option 3	14684	59.3	3671	10058	40.7	2514	24742	5000*
Option 4	15044	59.9	3761	10058	40.1	2514	25102	5000*
Option 5	15044	59.6	3761	10193	40.4	2548	25237	5000*
Option 6	15134	59.7	3783	10193	40.3	2548	25327	5000*
Option 7	15134	59.4	3783	10328	40.6	2582	25462	5000*
Option 8	15224	59.6	3806	10328	40.4	2582	25552	5000*
Option 9	15224	59.4	3806	10418	40.6	2604	25642	5000*
Option 10	15314	59.5	3828	10418	40.5	2604	25732	5000*
Option 11	15314	59.3	3828	10508	40.7	2627	25822	5000*
Option 12	15404	59.4	3851	10508	40.6	2627	25912	5000*
Option 13	15404	59.2	3851	10598	40.8	2649	26002	5000*
Option 14	15494	59.4	3873	10598	40.6	2649	26092	5000*
Option 15	15494	59.2	3873	10688	40.8	2672	26182	5000*

* For dual wheels of model 710/70 R42

To determine the ballasting effect on the operational properties of the tractor, its productivity and fuel consumption, let us calculate the nominal traction forces for different additional loading options; the calculation data is presented in Table 7. In Table 7 one can find the change in power/weight ratios depending on the options for additional loading with ballast weights.

TABLE 6. Weight distribution on the axles of the New Holland T9060 tractor considering wheel weights.

Option No.	Weight characteristics, kg							
	Front axle			Rear axle			Total operational weight	Permissible wheel load (brand, quantity)
	Value	Share of total load, %	Load on 1 wheel	Value	Share of total load, %	Load on 1 wheel		
Option 1	14390	56.0	3597	11312	44.0	2828	25702	5000*
Option 2	14390	54.7	3597	11915	45.3	2855	26305	5000*
Option 3	14684	55.2	3671	11915	44.8	2855	26599	5000*
Option 4	14684	54.9	3671	12050	45.1	3012	26734	5000*
Option 5	15044	55.5	3761	12050	44.5	3012	27094	5000*
Option 6	15044	55.3	3761	12140	44.7	3035	27184	5000*
Option 7	15134	55.5	3783	12140	44.5	3035	27274	5000*
Option 8	15134	55.3	3783	12230	44.7	3057	27364	5000*

Continuation of TABLE 6.

Option 9	15224	55.4	3806	12230	44.6	3057	27454	5000*
Option 10	15224	55.3	3806	12320	44.7	3080	27544	5000*
Option 11	15314	55.4	3828	12320	44.6	3080	27634	5000*
Option 12	15314	55.2	3828	12410	44.8	3102	27724	5000*
Option 13	15404	55.4	3851	12410	44.6	3102	27814	5000*
Option 14	15494	55.5	3873	12410	44.5	3102	27904	5000*

* For dual wheels of model 710/70 R42

TABLE 7. Rated tractive effort, power/weight ratios of the New Holland T9060 tractor with various additional loading options.

Option No.	Indicators		
	m_O, kN	$P_{H\,N}$, kN	O, kW/kN
1	252.0	98.8	1.56
2	258.0	101.1	1.52
3	260.8	102.2	1.51
4	262.2	102.8	1.5
5	265.7	104.1	1.48
6	266.6	104.5	1.48
7	267.5	104.9	1.47
8	268.3	105.2	1.47
9	269.2	105.5	1.46
10	270.1	105.9	1.46
11	271.0	106.2	1.45
12	271.9	106.6	1.45
13	272.8	106.9	1.44
14	273.6	107.2	1.44

The nominal tractive effort using ballast weights increased by 8.5%. In terms of power/weight ratio, the New Holland T9060 tractor is practically in the range of truck tractors with the exception of the first option (wheel weights of 227 kg + 454 kg on the rear wheels were used); determination on how this affects the operational properties will be given after corresponding calculations.

For clarity, the dynamics of changes in operational mass, nominal tractive effort, power/weight ratio depending on the mass of ballast weights for the New Holland T9060 tractor are presented in Fig. 4.

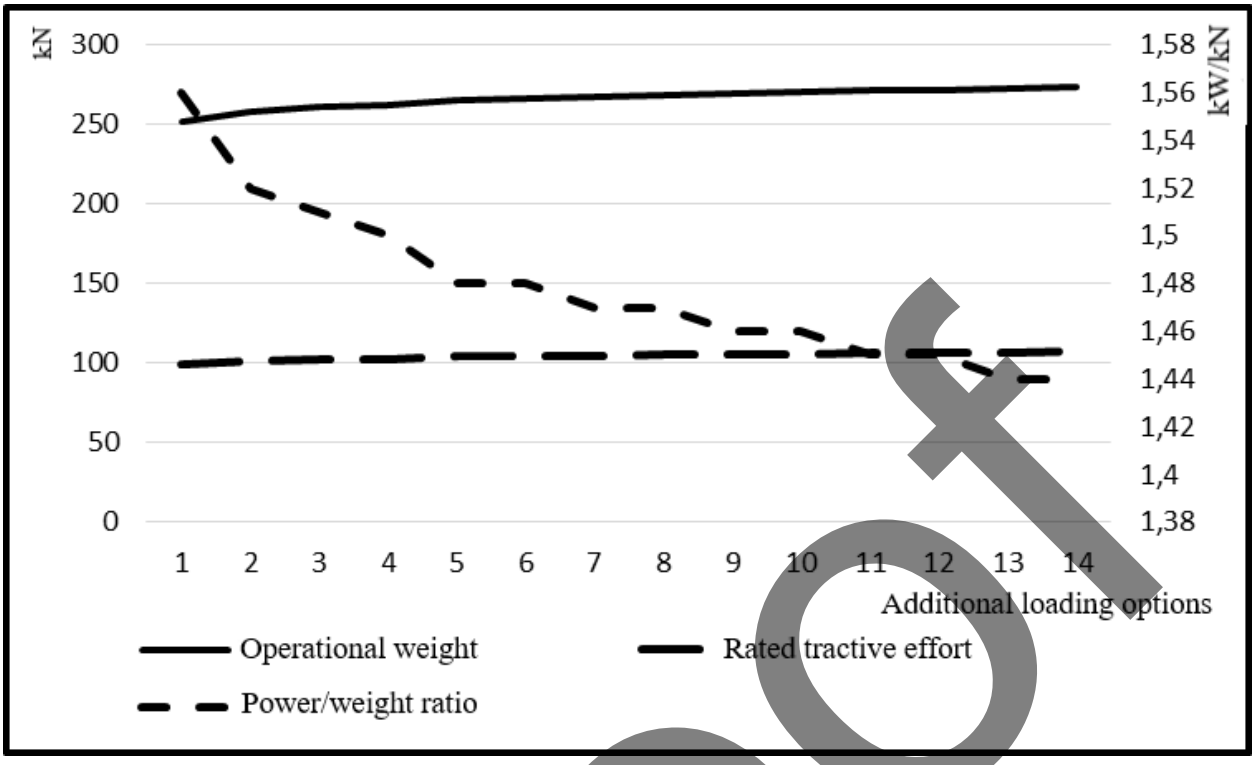

FIGURE 4. Dynamics of changes in operational mass, nominal tractive effort, power/weight ratio depending on the additional loading option.

The nominal traction forces for different loading options and at different operating speeds are presented in Tables 8, 9.

TABLE 8. Nominal tractive power for various additional loads' options (1-7 options).

Operating speed, km/h	Rated tractive effort, kN						
4.0	98.8	101.1	102.2	102.8	104.1	104.5	104.9
4.8	95.4	97.6	98.7	99.3	100.0	100.9	101.3
5.8	91.2	93.3	94.3	94.9	96.1	96.4	96.8
6.9	86.5	88.5	89.5	90.0	91.2	91.5	91.8
8.0	81.9	83.8	84.7	85.2	86.3	86.6	86.9
8.9	78.1	79.9	80.7	81.2	82.2	82.5	82.8
9.7	74.7	76.4	77.2	77.7	78.7	79.0	79.2
10.6	70.9	72.5	73.3	73.7	74.7	74.9	75.2
11.6	66.6	68.2	68.9	69.3	70.2	70.4	70.7
12.9	61.1	62.6	63.2	63.5	64.4	64.6	64.8
14.0	56.5	57.8	58.4	58.7	59.5	59.7	59.9

TABLE 9. Nominal traction forces for various additional loading options (options 8-14).

Operating speed, km/h	Rated tractive effort, kN						
4.0	105.2	105.5	105.9	106.2	106.6	106.9	107.2
4.8	101.6	101.9	102.2	102.6	102.9	103.2	103.5
5.8	97.1	97.4	97.7	98.0	98.4	98.7	98.9
6.9	92.1	92.4	92.7	93.0	93.3	93.6	93.9
8.0	87.2	87.4	87.7	88.0	88.3	88.6	88.8

Continuation of TABLE 9.

8.9	83.1	83.3	83.6	83.9	84.2	84.5	84.7
9.7	79.5	79.7	80.0	80.3	80.5	80.8	81.0
10.6	75.4	75.7	75.9	76.2	76.4	76.7	76.9
11.6	70.9	71.1	71.4	71.6	71.9	72.1	72.3
12.9	65.1	65.3	65.5	65.7	65.9	66.1	66.3
14.0	60.1	60.3	60.5	60.7	60.9	61.1	61.3

Traction resistance for cultivator KPM-24 $R_a = 24 \times 1{,}7 + 0{,}15 \times 79.24 = 40{,}8+11{,}9 = 52{,}7$ kN.

The traction resistance corresponds to a traction force of 61.1 kN at speeds up to 12.9 km/h with a traction margin.

$W_H = 0.1 \times 0.955 \times 24 \times 0.83 \times 12.9 \times 0.75 = 18.4$ ha/h

$g_{HA} = \frac{58{,}3 \times 0{,}75 + 31{,}8 \times 0{,}25}{18{,}4} = \frac{43{,}7+7{,}95}{18{,}4} = 2.81$ kg/ha

The calculation results are presented in Table 10.

TABLE 10. The effect of ballasting on the MTU performance and the fuel consumption with the New Holland T9060 tractor.

Option No.	Agricultural machine brand	Hourly productivity, ha/h	Specific fuel consumption, kg/ha
1	Cultivator KPM-24	18.4	2.81
2	**Cultivator KPM-24**	**20.0**	**2.65**
3	Cultivator KPM-24	20.0	2.67
4	Cultivator KPM-24	20.0	2.69
5	Cultivator KPM-24	20.0	2.72
6	Cultivator KPM-24	20.0	2.73
7	Cultivator KPM-24	20.0	2.74
8	Cultivator KPM-24	20.0	2.75
9	Cultivator KPM-24	20.0	2.76
10	Cultivator KPM-24	20.0	2.77
11	Cultivator KPM-24	20.0	2.78
12	Cultivator KPM-24	20.0	2.79
13	Cultivator KPM-24	20.0	2.79
14	Cultivator KPM-24	20.0	2.81

Let us take additional loading option as the basic one. Using the index method, the optimal additional loading option with ballast weights of the New Holland T9060 tractor will be determined.

Option 1 – 1 + 1 = 2 points; **option 2 – 1.09 + 1.06 = 2.15 points**; option 3 - 1.09 + 1.05 = 2.14 points; option 4 – 1.09 + 1.04 = 2.13 points; option 5 – 1.09 + 1.03 = 2.12 points; option 6 – 1.09 + 1.03 = 2.12 points; option 7 – 1.09 + 1.02 = 2.11 points; option 8 – 1.09 + 1.02 = 2.11 points; option 9 – 1.09 + 1.02 = 2.11 points; option 10 – 1.09 + 1.01 = 2.1 points; option 11 – 1.09 + 1.01 = 2.1 points; option 12 - 1.09 + 1.01 = 2.1 points; option 13 – 1.09 + 1.01 = 2.1 points; option 14 – 1.09 + 1 = 2.09 points.

The best option for loading the New Holland T9060 tractor with ballast weights will be loading with wheel weights on the rear wheels (227 + 454)×2 = 1362 kg; other loading options lead only to an increase in fuel consumption with given operating weight (Table 10). This suggests that the New Holland T9060 tractor with its technical characteristics refers to tractors of the draught concept, and the installation of ballast weights does not lead to an improvement in operational properties.

Many researchers are engaged in improving draught properties of tractors; let's look at some of them.

In their work "Efficiency comparison of using ballast weights and transport and technological modules to improve tractor draught properties", Shutenko V.V., Perevozchikova N.V., Hort D.O. [2] consider the use of a transport and technological module (TTM) as one of the methods of improving traction properties. A comparative analysis on using ballasting and the transport and technological module showed that with an equal increase in tractive effort, fuel consumption when ballasting increased by 28%, when using TTM - by 3.3%, propulsor pressure on soil remained constant when using TTM, when using ballasting - increased by 38.5%. As a result of the research, the authors came to the conclusion that "the use of a tractor with TTM is more efficient than a tractor loaded with ballast weights."

In the article "Improving the operational properties of wheeled 4K4 agricultural tractors" [3], Zhuravlev S.Yu. assessed the possibility of increasing the efficiency of using machine-tractor units in tillage operations by applying

rational parameters and characteristics of the tractor considering the use of ballast weights. Traction properties of tractors with single and twin wheels at different weight values were considered. The author believes that "one of the most effective methods of ensuring optimal values of tractor draught characteristics is the choice of the most rational value of the tractor's operational mass m_O with the installation of twin (2K) or single (1K) wheels. Ballasting of wheeled 4K4 tractors can provide rational values of traction forces P_h and operating speeds' intervals V_{gi} when performing various tillage operations. "

In the work "Improving the technological parameters of a wheeled tractor as part of a machine-tractor unit using methods of rational weight correction" [4], Slepenkov A.E., Kulinchenko S.N., Schitov S.V., Samuilo V.V., Kuznetsov E.E. consider increasing the technological parameters of a wheeled tractor in terms of improving its traction properties through the trailing weight regulator, which contributes to the redistribution of part of the trailing weight between the power vehicle (tractor) and the agricultural tool.

In the article "Operational studies of changes in traction and energy indicators of tractors using twin tires", Revenko V.Yu., Rusanov A.V., Kryukovskaya N.S. conclude that traction and energy indicators of tractors increase when using twin tires - in both 4k4a and 4K4b layout schemes, traction efficiency increases, the specific fuel consumption is reduced. The authors note that "The use of twin tires reduces the tractor's pressure on the soil by increasing the total area of tire contact with the soil, as well as slightly increasing the tangential traction force developed by spade bugs."

The authors published the following articles on the subject of this study: Analysis and comparison of operational properties of Belarus tractors and tractors of leading foreign companies [6], Realization of operational properties by agricultural tractors of foreign production [7], Ballasting and operational properties of tractors [8], Improvement of operational properties of agricultural tractors [9], Ballasting as a way to improve the operational properties of tractors [10], Operational properties, ballasting, productivity of machine-tractor units [11].

CONCLUSION

Tractors with high engine power, operating weight (over 206 kW and 100 kN) need other approaches to increase the operational weight of the tractor, especially for tractors with a 4K4b layout scheme with no controllability requirements, yet there are more strict requirements for the load on the rear axle in terms of ensuring maximum traction when applying various agricultural machines and tractor trailers, as well as requirements for the load on one wheel; therefore, the use of dual wheels on all axles is provided for tractors with an articulated frame. This study also determined that the New Holland T9060 tractor can only be operated on twin wheels (in this case - when performing a technological operation 'cultivation' on agricultural tires 710/70 R42).

In this study, the possibility of improving the operational properties of Massey Fergusson 8732 tractors with power/weight ratio of R = 2.48 kW/kN and the New Holland T9060 tractor with an index of R = 1.67 kW/kN is considered. Additional loading options were proposed, tractive forces were calculated in accordance with additional loading options. Based on the calculations of productivity and ballasting effect on productivity, the conclusion on the optimal loading option was made. For the Massey Fergusson 8732 tractor, the optimal additional loading amounted to 5,300 kg or 51.5% of the operating weight. In addition, with the options of additional loading in options2, 3, 6-8, it is recommended to operate with mounted agricultural tools, agricultural machines and other equipment with large vertical loads on the drag-bar.

For the New Holland T9060 tractor with an operating weight of 23,800 kg, the effect of ballast weights on operational properties is minimal; the best performance indicators are obtained when using two wheel weights of 227 kg and 454 kg per rear wheel amounting to 1,362 kg per tractor, or only 5.7% of the tractor's operating weight.

Based on the research data and calculations, it can be concluded that in order to improve the operational properties of tractors with a high power/weight ratio (Massey Fergusson 8732, R = 2.48 kW/kN), it is essential to use the maximum amount of ballast weights considering the distribution along the axes. There is no need for ballast weights for tractors with an articulated frame and a 4K4b layout scheme due to sufficient operational mass to create an appropriate tractive effort. This is a preliminary conclusion; the final conclusion can be made after further research with tractors of similar drawbar categories and layouts.

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Innovative Processes in the Agricultural Sector: Features and Prospects

L.A. Molchanova [1, a)], O.S. Akupiyan [2, b)], D.P. Kravchenko [2, c)], Z.Ch. Pak [2, d)] and N.I. Chovgan [2, e)]

[1] *Russian Academy of Entrepreneurship, Moscow, Russia*
[2] *Belgorod State Agrarian University. V.Ya. Gorina, Belgorod, Russia*

[a)] Corresponding author: milan7777@rambler.ru
[b)] ol-ga71@mail.ru
[c)] dimkra54@yandex.ru
[d)] zinpak@yandex.ru
[e)] natalyushka-14@yandex.ru

Abstract. The use of new technologies in modern economic conditions is the basis for effective financial and economic activity of enterprises in all spheres of the economy. The introduction of innovations in the agricultural sector of the economy increases the level of food security of the state. In addition, the development of new plant varieties, animal breeds, approaches to the optimal use of resource potential, updating of equipment and technologies, etc. is the key to the competitiveness of agricultural producers, which is an urgent issue for Russia at this stage. Activation of innovative development of domestic agriculture is one of the priority directions of strategic development and economic growth of the state. The article substantiates the essence, signs and problems of innovation implementation in the domestic agricultural sector. The features of innovative processes of the agricultural sector in modern conditions are formulated. The main constraining factors of innovation activity of its subjects are: the attitude of a modern entrepreneur to innovation processes and awareness of their role in ensuring success, the lack of full-fledged state support for innovation and the imperfection of the legislative framework in the Russian Federation. Promising directions for increasing the level of innovative development of domestic agricultural producers have been identified.

INTRODUCTION

The agricultural sector of Russia is endowed with significant opportunities for development when suitable soil and climatic conditions and high-quality land resources contribute to obtaining high yields of agricultural crops, in an amount sufficient to meet domestic needs and the formation of export potential for the sale of products on international markets.

As practice shows, the most priority tasks of strategic management according to modern sectoral features of the domestic economy is the formation and implementation of a process of harmonious innovative development that can ensure efficient and maximally efficient industrial production, especially in the agricultural sector. The strategic focus on the implementation of innovative shifts in the agricultural sector indicates the end of the era of spontaneous, chaotic market transformations, which were carried out under the influence of short-term internal and external factors. The innovative type of long-term development strategies at the present stage has gone beyond theoretical scientific concepts, and appears to be the main driving force for achieving competitive advantages in the domestic and global agricultural markets.

The relevance of determining the role of innovation in the economic system occupies one of the leading places. Innovation is the main factor of long-term economic development. The widespread introduction of innovations in

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all areas of the enterprises' activities ensures their successful functioning and provides competitive advantages. A meaningful analysis of scientific research shows that the foundations of the theory were developed on innovation issues, at the origins of which stood J. Schumpeter in the early twentieth century. Many foreign scientists, including P. Drucker, J. Galbraith, J. Bell, M. Castells considered the "innovative" economy as the basic concept of post-industrial society.

Leading Russian scientists and specialists conducted research on the prospects for the development of the agro-industrial complex, the feasibility of innovation, the problems of innovation in Russia, the impact of the regulatory framework on innovation. In particular, these issues are reflected in the works of domestic scientists, including I.G. Ushachev, I.S. Sandu, A.I. Altukhov, who proposed to introduce new methods of updating the material and technical base into the domestic sector of the agro-industrial complex.

Fundamental studies of Russian scientists S.Y. Glazyev, N.A. Voronov, V.V. Golbert, Zh.M. Kozlova, E.O. Naumenko and others are devoted to the study and generalization of various trends in the development of innovations, including in the agricultural sector.

However, the low level of innovative activity of enterprises of agricultural and industrial production indicates the insufficiency of the implementation of the results of scientific research into economic practice, therefore, the issues of strategic priorities for the development of business entities on an innovative basis need further justification and improvement.

MATERIALS AND METHODS

The purpose of the article is to substantiate the strategic aspects of innovative development of agricultural and industrial enterprises, as well as the conceptual foundations for the formation and implementation of a strategy for their harmonious innovative development.

The theoretical and methodological basis of the research is a dialectical method of cognition and a systematic approach to substantiating the process of the concept of innovative development of the agricultural sector of the Russian economy. To implement the tasks set in the research process, techniques and methods were used, the main ones among which are: monographic - in the process of studying the promising experience of the development of innovative infrastructure; statistical and economic - for collecting and processing statistical data of scientific potential, innovative activity of enterprises, information on the functioning of infrastructure facilities on the market; analytical - for a systematic analysis of the current state of development of innovative infrastructure of agricultural enterprises; tabular, graphic - for visual presentation of research materials and improving the quality of perception of scientific developments; comparison - to compare economic phenomena within different time periods in order to establish causal relationships, to conduct a comparative analysis of the development of domestic innovation infrastructure and the infrastructure of the leading countries of the world.

RESULTS

The study of problems in the agricultural sector is impossible without clarifying the etymology and essence of innovations in it, so let's consider what content and features different authors fill this category with (Table 1)

Based on the analysis presented in Table 1, the main components and signs of agricultural innovations at the present stage are: positive impact / effect (quantitative and qualitative) on the environment, results of activities; innovations (new knowledge, breeding, new species of plants, animals, etc.), consistency, sustainability [1].

TABLE 1. Basic components and signs of innovation in the agricultural sector.

Author	*Signs*
E.S. Ilyushina, V.Y. Konyukhov [8]	Consistency, positive (qualitative and quantitative) impact on the environment
A.P. Sokolova, L.Y. Boginovich [15]	Participants of the innovation process: man, machine (equipment, tools), environment
G.N. Litvinenko, A.A. Esekkueva [10]	Innovations are the result of labor, new knowledge, increased efficiency, sustainability, consistency of the agro-industrial complex
L.M. Kornilova E.A. Ivanov [9]	Innovations – new varieties of plants, breeds and species of animals, birds, etc.; new technologies, increasing production efficiency

Continuation of TABLE 1.

A.I. Bogachev [4]	Progressive methods of farming, accounting for accumulated potential
The San Jose Declaration [17]	A catalyst for growth and change, solving agricultural problems, adapting to climate change, improving food security and the quality of life of all residents

**Compiled by the authors*

In our opinion, the most systematic and strategic definition of innovations in the agro-industrial complex is the presence in them of a sign of a catalyst for growth and change, the ability to solve agricultural problems, ensure adaptation to climate change, improve food security and the quality of life of the population [14].

However, despite the various approaches to determining the essence of agricultural innovations, these processes have certain specifics, which is due to both the level of development of the country and the industry. In particular, it is advisable to include specific components of agricultural innovations:

- long process of innovation development;
- innovations are, as a rule, of an improving nature;
- living organisms are being investigated;
- the leading role is played by research institutions;
- there is a direct dependence on the natural zone and climate;
- dispersal of agricultural production over a large area;
- a variety of agricultural products and products of its processing, as well as a significant difference in their production technologies;
- there is a big difference in the production periods of certain types of agricultural products [2].

If we consider the development of the innovative component of the agar sector enterprises, then in this case the strategy is a set of actions and methods of managing the innovative activities of business entities that ensure their competitive advantages on an innovative basis [7].

In turn, the choice of a specific strategy for innovative development is determined by the influence of a combination of factors of the external and internal environment of the functioning of a business entity, priority directions of the state's innovation policy, the actual state of development of scientific, technical and human resources potential in the country's economy. Along with this, innovative processes are aimed at solving socio-economic issues based on the use of modern achievements of science and technology, determined by the set and structure of functional elements of strategies. Scientific research of theoretical and methodological aspects of the policy of innovative development in domestic and foreign practice allowed us to identify the main components of the strategy of innovative development of enterprises in the agricultural sector:

1) goals and main objectives of the strategy of innovative development;
2) innovative policy of development of a separate branch of production and its elements;
3) priority directions of ensuring the implementation of innovation policy;
4) structural changes in the field of institutional management;
5) the available resource and production potential of the enterprise;
6) realization of innovative potential [5].

DISCUSSION

It should be noted that a reasonably chosen and, accordingly, content-filled innovation strategy is the key to the long-term successful development of the enterprise and a means of ensuring its competitiveness.

This should be served by a clear typologization and detailed decomposition of the strategy of innovative development of business entities according to their various elements, which determine their place in the strategic set of the enterprise [12].

The conducted research makes it possible to propose a concept for the formation and implementation of an innovative Development Strategy for agricultural enterprises, which provides for the possibility of choosing the optimal option for the development of business entities on an innovative basis, taking into account their resource capabilities, and the direction of implementing a long-term innovation policy with a favorable investment and innovation environment (Fig. 1).

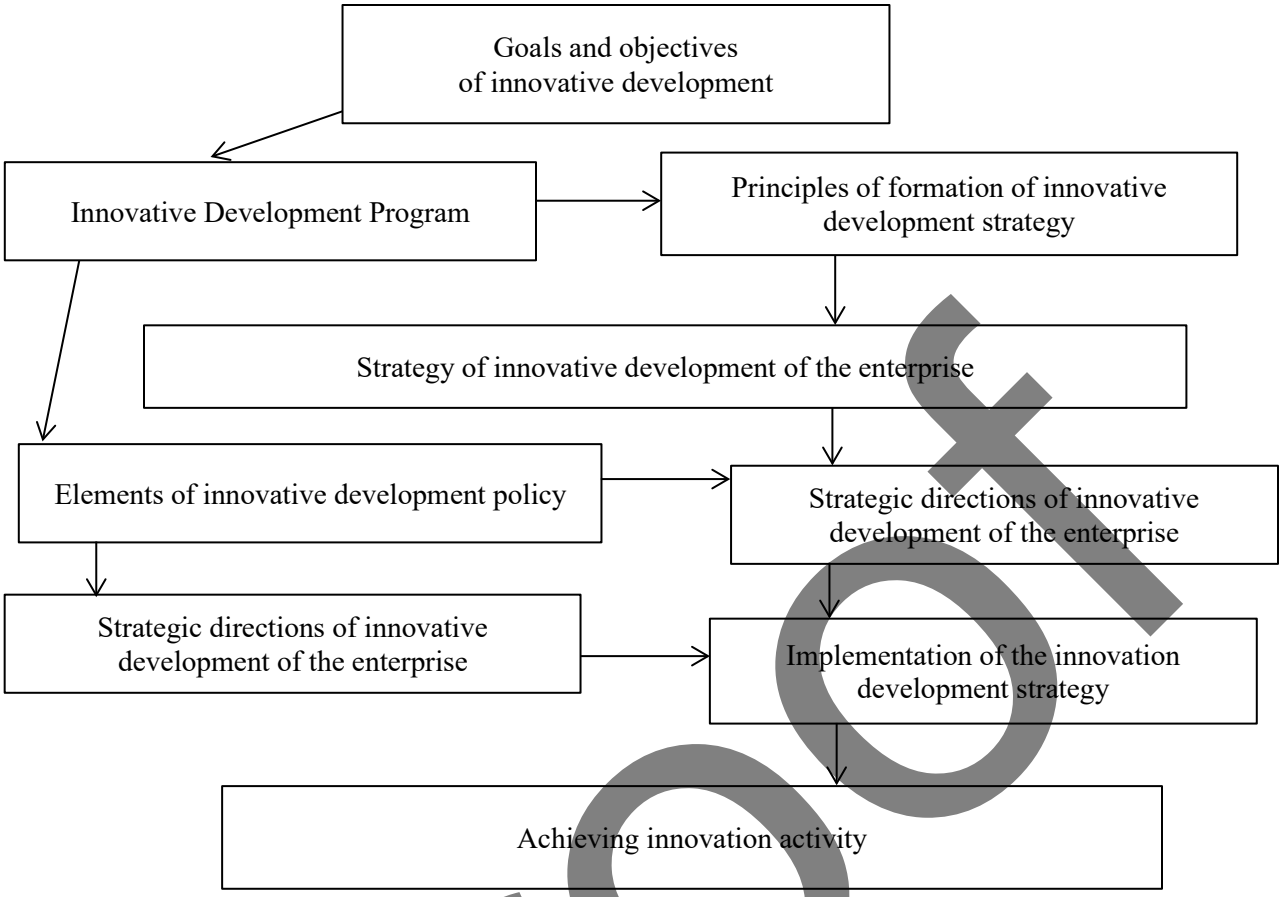

FIGURE 1. The concept of formation and implementation of the strategy of innovative development of enterprises of the agricultural sector (developed by the authors)

The innovative goals of the enterprise are related to its mission, strategic vision, innovation lifecycle, and serve as a guideline for innovation activities for planned periods. These include the development and implementation of scientific research at the enterprise, production, updating, improving the quality and technical level of innovative products, solving socio-economic problems of enterprise development and a number of others [11].

The principles of forming the strategy of innovative development of economic entities, which can be applied to enterprises of the agricultural sector, are:

1. Identification of priority directions of innovative development.
2. Monitoring changes in the market environment and studying its impact on the innovative development of enterprises.
3. Research and forecasting of market conditions of enterprises of branches of the domestic economy, as well as their main economic performance indicators.
4. Analysis of the current strategy for the development of enterprises and its possible changes in relation to innovative internal reserves [6].

Regarding the strategic directions of innovative development of agricultural enterprises, we note that they can be distinguished within individual industries, such as seed production and breeding, production and processing of agricultural and industrial products, etc.

The development and functioning of the strategy of innovative development of individual enterprises has a great impact on the results of their activities, the evaluation of which is advisable to carry out using the methods of the strategic management system, which will encourage enterprises to rationally use their own resource potential to ensure an increase in their efficiency at all stages of development, including innovation. In such methods, it is advisable to apply economic criteria that will provide an objective assessment of entrepreneurial activity [13].

Achieving the strategic goals of an economic entity in the future already today needs solutions to attract the necessary resources. The formation of a strategy for the harmonious innovative development of an enterprise is the

identification of strategic opportunities and resources in their best combination that can increase the competitiveness of an economic entity, the determination of reserves of potential resources on an innovative basis. Determining the strategy for the formation of a harmonious innovative development of the enterprise, it is necessary to take into account new trends and directions of scientific and technological progress in agriculture, economic and environmental requirements, features of the modern material, technical, organizational and technological base of the domestic agricultural sector.

These conditions correspond to the principles of sustainable socio-economic development, and their consideration in the process of implementing the model of innovative development of the agrarian economy will ensure a harmonious combination of the economic recovery of the country and the industry with the simultaneous improvement of socio-environmental conditions of society.

Thus, the development and implementation of the concept and strategy of innovative development of the agricultural sector of the economy should take into account a number of aspects of the methodological direction that will ensure their adequacy to the conditions and effectiveness, in particular:

1) primitiveness of ideological innovations that will form an innovatively thinking society;

2) rational combination of economic and socio-ecological effects from the implementation of the model of innovative development of the agricultural sector of the economy;

3) directions/stages of the model implementation;

4) the need for further restructuring of agricultural enterprises in the direction of their consolidation and integration;

5) reorientation of Russia from a raw country to a country that supplies safe and environmentally friendly products to foreign markets [16].

At the same time, the implementation of the concept requires further research on the development of a methodology, the structure of which is aimed at ensuring the effect of the introduction of various types of innovations at various hierarchical levels.

So, the strategy of innovative development of enterprises as an effective management tool makes it possible to take into account changes in the environment in favor of the economic entity, contributes to the generation of changes, optimization of their management within the enterprise to improve its financial and economic condition. The innovation strategy is designed to ensure that the greatest effect is obtained from the existing potential of (innovative) enterprises. First of all, such a strategy should be focused on the development of basic innovations that make it possible to move to new product and technological structures of production.

In modern conditions of global competition, the transition of enterprises of any organizational and legal form and the agricultural production industry to an innovative development model is quite important, since the main objectives of the implementation of the innovation development strategy are to increase the competitiveness of agricultural and industrial production, improve the performance indicators of such enterprises and increase the value of their business, ensuring food security of the country, increasing the export of agricultural products. products by the enterprises themselves and the peculiarities of their management.

Summing up, it should be noted that innovations in the agricultural sector are the development of new products, tools and technologies with which a modern manufacturer will be able to find more rational ways of using natural resources to achieve the most efficient production of agricultural products. The active introduction of such innovations can be a significant step towards environmental sustainability in the regional and global dimension.

Nevertheless, domestic innovation activity in the agricultural sector remains at a low level, the percentage of penetration of high technologies is about 10-12 (China 18%, Brazil 15%) [18].

The indicated indicators of innovation activity in the agricultural sector are due to a number of constraining factors. Most often , among the problems are:

- inconsistency of the coordination and management system in market conditions;
- imperfection of the legislative framework and inefficient management of innovations at the state level.

All of them are connected with state support of innovative activities in the agricultural sector. In addition, they point to the lack of specialists in the field of innovation, the increased risk of innovation and the lack of a financial mechanism for innovation. Agribusiness representatives should be aware of the need to adapt to changes, increase their own awareness of the latest technologies and take concrete steps to increase efficiency in order to enter new markets and increase profits.

CONCLUSION

Currently, domestic agricultural enterprises have great potential to work in competitive markets as equal partners of the world leaders of the agro-industrial complex. First of all, the availability of resources and climatic conditions are among the success factors. However, the rapid development of technology dictates new business conditions for strengthening and improving their positions through the introduction of innovations.

Innovative approaches to the development of the agricultural sector are a significant catalyst for the growth of the national economy as a whole and a means of solving various socio-economic and global challenges.

Taking into account the results of the analysis, we note once again that agricultural innovations should have such characteristics as a positive impact on the environment and an effect on results; be a systemic catalyst for growth and change, ensure adaptation to climate change, improve food security, the quality of life of the population, etc.

The main constraining factors of innovative activity of the subjects of the agricultural sector are the attitude of a modern entrepreneur to innovation processes and awareness of their role in ensuring success, as well as the low level of state support for innovation and the imperfection of the legislative framework for its provision in Russia.

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Methodology for Calculating Maximum Income in the Greenhouse Economy

Akmal Durmanov[1, 2, 5, a)], Azamat Tabayev[1], Tokhir Turmanov[4], Gozzal Aliyeva[6], Saidakmal Kasimov[3], Dilobar Ruzieva[3]

[1]*Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME)-National Research University, Tashkent, Uzbekistan*
[2]*Branch of the Astrakhan State Technical University in the Tashkent region of the Republic of Uzbekistan, Tashkent, Uzbekistan*
[3]*Tashkent State Economic University, Tashkent, Uzbekistan*
[4]*Tashkent State Pedagogical University, Tashkent, Uzbekistan*
[5]*International Center for Food and Agriculture Strategic Development and Research under the Ministry of Agriculture of the Republic of Uzbekistan Tashkent, Uzbekistan*
[6]*Karakalpakstan Institute of Agriculture and Agrotechnologies, Nukus, Uzbekistan*

[a)] Corresponding author: akmal.durmanov.1977@mail.ru

Abstract. With the transition to market relations in conditions of free pricing, a rapid rise in prices for material and energy resources began. All this made it difficult to use greenhouses. The main problem in the production of off-season vegetables is their high cost due to significant energy costs. The share of energy costs reaches 60% in the structure of the cost of greenhouse vegetable production. The primary task of greenhouse vegetable growing is to eliminate seasonality in the production of vegetables and provide the population with vegetables at scientifically sound standards and affordable prices. A prerequisite for solving this problem is to increase the efficiency of greenhouse vegetable growing, which implies an increase in vegetable production and a reduction in their cost. The main goal of the study is to develop effective directions and economic mechanisms for increasing the efficiency of greenhouse vegetable production, primarily through the use of advanced energy and resource-saving technologies. When performing the research work, statistical, monographic, calculation-constructive and economic-mathematical methods of research with the use of computers were used. The economic analysis was carried out by the following methods: comparison of actual and normative (planned) indicators; index, to determine the rate of growth or increase in indicators; graphic, for visual representation of the scale, dynamics, with the texture of all processes; correlation, multidimensional analysis of changes in generalized indicators under the influence of various factors.

INTRODUCTION

After the intensive development of closed pound vegetable growing in the 80s, the industry is currently in a recession. The production of products in most greenhouse complexes is unprofitable. In order to preserve the existing potential and ensure the further development of the industry in the current economic conditions, it is necessary to improve the directions increasing the efficiency of greenhouse vegetable growing [1,2]. When planning and implementing measures to improve the efficiency of vegetable production in greenhouses in modern conditions, it is necessary to take into account the features of greenhouse vegetable growing, which predetermine the features of assessing economic efficiency [3,4].

The use of modern substrates for jumping out of vegetable crops suggests that land, as the main means of production, for greenhouse vegetable growing is not decisive. Consequently, for greenhouse vegetable growing, specific performance indicators per 1, we are deprived of economic content, their it is more expedient to determine per 1 kg of vegetable products [5].

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The presence of artificial lighting and heating has a huge impact on increasing the productivity of vegetable crops in greenhouses.

Consequently, the determination of the indicators of the specific consumption of energy resources in the study of the production efficiency of off-season vegetables is mandatory.

In greenhouse vegetable growing at the present time, due to the development of new technologies, the growing season of vegetable crops has significantly expanded [6]. The speed of the production process in different periods of the growing season will be different, which must be taken into account when analyzing the efficiency of vegetable production,

The collection and sale of off-season vegetable products are stretched over time, which is why the selling prices for vegetables at the beginning and at the end of the period of nakedness differ significantly. In this situation, the use of seasonal indicators of the efficiency of vegetable production will give a clearer picture of the results of the enterprise.

The sectoral feature of greenhouse vegetable growing determines the search for ways to increase economic efficiency. A large number of factors affect the efficiency of the production of greenhouse vegetables. However, the results of the study of the state of indoor vegetable growing showed that in modern conditions, two factors should be singled out, which will significantly increase the economic efficiency of production: the introduction of intensive technologies for growing vegetables in greenhouses; rational use of energy resources in greenhouse vegetable growing.

Literature review

The theoretical and practical aspects of the development of hydroponics, the issues of specialization and concentration of agricultural production, cost management and the formation of the organizational and economic mechanism of vegetable and horticultural economies were studied by agronomic economists [7]. For instance, Abdullaev & Zuev (2002) devoted their publication to vegetable growing in protected soil [8]. Regional allocation of green houses and their advantages in Uzbekistan are their main contribution emphasizing the importance of the work. Buzdalov (2009) focused on the aspect of forecasting consumer demand for vegetable products of closed ground [9]. The author's findings are essential in the area of mathematical modeling of greenhouse vegetable crops and demand for it in the market. Chazova (2015) approached the forecasting of cycles and crises in overall agricultural products [10]. However, the author produced a generalized forecasting model for agricultural products. Umarov, Durmanov (2019), Nurimbetov (2021), Sharapova (2016), highlighted the issues of innovative irrigation in green houses located in Tashkent Region of Uzbekistan [11,12,13,14]. Silaeva (2015), A. Skachkova (2013), A. Svetlakov (2017) Therefore a need for a particular approach for greenhouse farming is observed through the literature review [15,16,17]. Significant contributions to the area of sustainable development of public production were made by such scientists as, M. Li (2017), V. Nabokov and K. Nekrasov (2017), M. Porter (2006) [18,19,20]. Their findings were used in this research as a basis for mathematical calculations.

METHODOLOGY

Currently, there are no generally accepted methods to predict the development of agricultural production in organizations with satisfactory reliability [21].

It should also be noted that the strengthening of the economic freedom of participants in the reproductive innovation process at the regional level forms a probabilistic picture of organizational and economic processes occurring in different sectors, and forces the use of a scenario approach and multivariate alternative ways of finding solutions [22].

To solve this problem, it is proposed to use the methods of multivariate statistical analysis and economic and mathematical modeling. The changes taking place in the modern economy lead to the creation of new and improved systems that allow analyzing the dynamics of the development of a regional organization and using large volumes of relevant information and economic and mathematical modeling [23].

The methodology of the organizational and economic mechanism for sustainable development of the greenhouse market is based on an integrated and systematic approach [24]. An integrated approach takes into account a set of market factors affecting the management of sustainable development of the greenhouse market. The systematic approach is applied in the study as a general methodological basis [25]. It provides an objective reflection of the systemic properties of the functioning of the greenhouse market players and takes into account a complex of

interrelated elements, taking into account the peculiarities of local agriculture, the variability of external and internal factors, the level of state support to meet the requirements. social needs formed by enterprises in the context of constant changes in the elements of the market environment [26].

The inconstancy of the external environment, limited resources, the presence of highly profitable and unprofitable industries in greenhouse farms located in the same natural and economic conditions, do not allow us to determine the only most effective methodological approach [27].

The general theoretical and methodological basis of the research is formed by scientific publications on the problems of the development of the agro-industrial complex and agriculture, in particular the market of greenhouse vegetable crops; analysis of intra-industry competition and increasing the competitiveness of enterprises in modern economic conditions [28].

The study used methods widely used in economic sciences: general scientific (dialectical method, analysis and synthesis, comparisons and analogies, graphic method) [29]; special (economic and mathematical, systemic, statistical and economic, comparative analysis, mathematical modeling and experimental methods).

The information base of the study is made up of official statistical data of the Ministry of Agriculture of the Republic of Uzbekistan; state statistics; normative legal norms of the republican and municipal, regional levels; reference materials of specialized publications on the topic; data received from participants in the greenhouse market, own research; scientific internet data [30, 31].

RESULTS

Our methodology allows us to optimally assign the area of crops with a known deficit of fuel, energy and labor resources, as well as to increase the productivity of irrigation and irrigation water, taking into account the climatic conditions of farms, as well as the biological characteristics of crops.

This problem is solved using the proposed computer model, which is based on the following system of equations:

$G_{\max} = \sum_{i=1}^{N} (P_i - C_i) Y_i F_{iopt}$ - the maximum income from the cultivation of agricultural prospect of induction, sum where P is the value of agricultural products, sum / kg; C - the cost of cultivation agriculture of -agricultural products, UZS / c; U - crop productivity, kg / ha; F - area under.

Restriction of fuel and energy resources is expressed cl e following way:

$$\sum_{i=1}^{N} Q_{iopt} F_{iopt} = K_{\lim} \sum_{i=1}^{N} Q'_{inor} F'_i$$

Here Q_{iopt}, Q'_{norm} - optimized and biologically optimal thermal energy neo b walk for cultivating crop, J; F_{iopt}, F'_{norm} - Adapt and Rowan and planned area crops ha; By $_{\lim}$ –limiting the conductive factor, based on the availability of energy resources.

Limitation in the area:

$$F = \sum_{n=1}^{N} F_i;$$

where the F - total area of Hothouse and greenhouse agriculture under the Agricultural e cult have, ha; The F_i - Square of the area under crops (tomato, cucumber, bell pepper, lemons, Cloud b nickname and roses).

$$\begin{cases} F_{1opt} = f_1 F; \quad Q_1 = w_1 Q; \quad q_1 = \dfrac{Q_1}{F_{1opt}}; \quad Y_1 = Y_{1\max} \cdot \left[1 - \dfrac{q_1}{q_{1opt}}\right]^2 \cdot \prod_{j=1}^{13} k_j; \\ F_{2opt} = f_2 F; \quad Q_2 = w_2 Q; \quad q_2 = \dfrac{Q_2}{F_{2opt}}; \quad Y_2 = Y_{2\max} \cdot \left[1 - \dfrac{q_2}{q_{2opt}}\right]^2 \cdot \prod_{j=1}^{13} k_j; \\ \ldots\ldots\ldots\ldots \\ F_{Nopt} = f_1 F; \quad Q_N = w_N Q; \quad q_N = \dfrac{Q_N}{F_{Nopt}}; \quad Y_N = Y_{N\max} \cdot \left[1 - \dfrac{q_N}{q_{Nopt}}\right]^2 \cdot \prod_{j=1}^{13} k_j \end{cases} \quad (1)$$

is: f_i, w_i - fraction culture area to the total area, and thermal end apology to general minutes limited minutes of heat.

When evaluating the productivity of plants used approximate e m -empirical dependence of the ultimate productivity of the main factors of any and development of plant-based agriculture (Law indispensable for STI and equivalency factors [32, 33]; the law of the optimum, which states that the greatest productivity occurs when all the factors are in optimal range). It is recommended to use a multiplicative form of a productivity of dependence, which allows you to determine the yield of villages s rural culture in a given year based on the actual condition farmland and farming systems, as well as dependent on the STI on soil moisture and changes in the factors and conditions of plant life (in d, thermal, chemical, food and other land modes)

$Y_{N\max}$ - potential crop yield with optimal combinations of all environmental factors, kg / ha. The potential crop yield is determined by the formula (2);

$$Y_{N\max} = \frac{10 \cdot FAR \cdot \eta}{\lambda \cdot \chi \cdot (100 - \nu)} \quad (2)$$

FAR - the amount of photosynthetic active radiation during the growing season MJ / ha;

TABLE 1. The dependence of the total arrival of PAR (billion. KJ / ha) by wide by s mo t Nosta

Areas	Parish PAR
Surkhandarya	17.2-1 8.2
Kashkadarya	16.4-17.1
Bukhara, Navoi	15.6-16.3
Tashkent, Sirdarya, Jizzakh	14.9-15.5
Ferghana, Andijan, Namangan	14.1-14.8
Khorezm	13.8-14.0
Republic of Karakalpakstan	13.4 -13.7

η - coefficient of useful use of the PAR.

By A.A. Nipochorovichu coefficient useful PAR d e divisible into four groups:

1-group - usually observed 0.5-1.5%; 2-group - good - 1.53%; 3-group - record-breaking - 3.5-5.0%; 4-group - theoretically possible 6.0-8.0%

λ - caloric content of a unit of dry organic matter, MJ / t;

TABLE 2. Calorie content of 1 kg of dry biomass of crops, kJ, average.

Culture	Plant organs			
	Whole plant	Main products	By-products	Root system
Tomato	4540	4420	4350	4240
Cucumbers	4500	4620	4330	3960
Bell pepper	4800	4900	4600	4430
Lemon	4700	4800	4400	4180
Strawberry	3900	3900	3900	3700
Roses	5200	5200	5200	4430

χ - *the* ratio of the masses of the main and by-products; - moisture content in agricultural products.

TABLE 3. Values χ, ν, for some crops.

No.	Crops	% Values	V values
1.	Tomato	11.8	94
2.	Cucumbers	10,2	9 5
3.	Bell pepper	14.1	74

Continuation of TABLE 3.

4.	Lemon	8.2	85
5.	Strawberry	13.8	9 4
6.	Roses	12.7	21

K_1 - coefficient taking into account the deviation of the moisture content of the root layer of the soil from the optimal value for a particular crop;

$$K_1 = \sum_{a=1}^{n} \tau_a \beta_a \tag{3}$$

τ_a - the contribution of a – second phase in the formation of crop yields; β_a - Coe p coefficient, which depends on the value of moisture reserves .

$$\beta_a = \left(\frac{W}{W_{opt}}\right)^{\gamma \cdot W_{opt}} \cdot \left(\frac{1-W}{1-W_{opt}}\right)^{\gamma \cdot (1-W_{opt})} \tag{4}$$

W – available moisture reserves;

$$W = \frac{\omega - \beta_a}{m - \beta_a} \tag{5}$$

ω - soil moisture, in fractions of the volume; - OT - wilting point, in the village of Lakh by volume; m - is the porosity.

W_{opt} - optimum moisture reserves

$$W_{opt} = \frac{\omega_{opt} - \beta_a}{m - \beta_a} \tag{6}$$

ω_{opt} - optimal moisture content of the root layer of the soil.

TABLE 4. The parameter values W_{opt} and γ for various agricultural plants.

Culture	Phase Numbers *					On average for the growing season
	1	2	3	4	5	
Tomato	0.55	0.48	0.54	0.43	0.61	0.54
	5.1	5.5	5.6	5.9	5.3	5.6
Cucumbers	0.49	0.54	0.45	-	-	0.51
	5,4	5.7	5.2			5,4
Bell pepper	0.67	0.70	0.65	-	-	0.67
	5.7	5,4	5.9			5.7
Lemon	0.65	0.70	0.65	-	-	0.67
	5.7	4.7	5.7			5.3
Strawberry	0.62	0.64	0.67	0.56	-	0.62
	3.2	5.8	5.6	6.0		5.6

The numerator shows the values W_{opt}, the denominator - γ.

K_2 - coefficient taking into account the uniformity of moistening of agricultural lands of various irrigation;

$$K_2 = 0{,}985\sqrt[4]{\left(K_2 \cdot e^{1-K_2}\right)^3} \quad (7)$$

$K_2 = 1 - \frac{h_{\max} - h_{\min}}{h_{кс}}$ - watering efficiency coefficient. Values for various irrigation techniques are adopted according to the irrigation technique used or the technical parameters of the machines used (for example, this indicator is shown in the certificates of sprinkler machines). $h_{\max}$, $h_{\min}$ - maximum and minimum values for the depth of humidification, м; $h_{кс}$ - depth of the root system.

$K_2 = 0{,}88 - 0{,}95$ - with the introduction of a drip system;

$K_2 = 0{,}92 - 0{,}95$ - shielding of irrigation furrow with a plastic film;

$K_2 = 0{,}8 - 0{,}9$ - with laser field planning;

K_3 - coefficient taking into account the possibility of changing the yield due to soil alkalization and reducing irrigation quality water depends on the content of adsorbed Na ions, Ca, Mg in soil absorption to m plexus at the end of the billing period, salinity and moisture IU x die soil and groundwater and is determined by the results of the forecast of the water-salt regime of soils;

TABLE 5. Coefficients characterizing the degree of salinization and salinization of soils.

The content of toxic salts,%	Coefficient characterizing the degree of salinization of soils	Value SAR	Coefficient characterizing the degree of salinization of soils
0.1	0.99	2	1,0
0.2	0.78	4	0.8
0.3	0.4	6	0.5
0.4	0.1	8	0.3
-	-	10	0.2

TABLE 6. The condition of crops depending on the degree of salinization of soils.

Soil salinity	The state of agricultural plants
Virtually non-saline	Good growth and development (attacks virtually no harvest Normal s ny)
Lightly salted	Weak inhibition (attacks plants and decrease ur on zhaya 10-20%)
Saline	Average inhibition (decrease of plants and attacks ur about zhaya 20-50%)
Highly saline	Strong inhibition (attacks plants and decrease ur on zhaya 50-80%)
Salt marshes	Single plants survive (almost no crop)

When using saline soils, an alternative approach to the selection of optimal solutions is important. In this regard, the different resistance of agricultural plants should be borne in mind.

K_4 - coefficient reflecting disparity actually contains a Nia mineral nutrients in the soil optimal;

The composition and scope of the necessary agrochemical measures include the introduction of organic and mineral fertilizers into the soil. This fact is taken into account when determining land productivity through the coefficient K_4, the value of which is determined by the dependence:

$$K_4 = 0{,}2 + \mu\sqrt{D_{NPK}} \quad (8)$$

μ - coefficient depending on the reaction of the soil solution; - dose of mineral fertilizers (NPK), kg / ha. D_{NPK}

When determining the doses of mineral fertilizers are taken into account: shortage of nutrients; potential crop yields; removal of nitrogen, phosphorus and potassium with the main products and their entry into the soil with crop residues, straw and siderite;

TABLE 7. Coefficient μ depending on the reaction of the soil solution.

Indicators	Soil solution reaction (pH)				
	four	5	6	7	8
Coefficient μ	0.15	0.50	0.90	1.0	0.9
Mineral Fertilizer Efficiency					
The moisture content of the root layer,% PPV	20	40	60	80	100
The effectiveness of NPK, %	35	60	100	80	30
pH	4	5	6	7	8
The effectiveness of NPK, %	75	91	100	100	0

K_5 - coefficient reflecting the deviation of the thermal regime root e inhabited the soil layer from the optimum value;

$$K_5 = 1 - \frac{\delta \cdot T}{T - T_0} \quad (9)$$

where T - - the amount of biologically active daily temperatures Air at ha (over $10\ ^0$C) during the growing period (starting from the optimal sowing date); $\delta \cdot T$ - lost amounts of biologically active temperatures as a result of delay with sowing (or planting) dates;

T_0 - the minimum amount of average daily biologically active temperatures required for plant maturation.

TABLE 8. Minimum amounts of daily average biologically active air temperatures.

Culture	Value
Tomato	3060
Cucumbers	2710
Bell pepper	2890
Lemon	3870
Strawberry	2540
Roses	2080

K_6 - coefficient taking into account the effect of soil salinization on the value of crop yields;

TABLE 9. The values of the coefficient K6 depending on the content of toxic salts in the soil [21].

The salt content, %	0	0.1	0.2	0.3	0.4
The value of the coefficient K_6	1,0	0.95	0.70	0.40	0.10

TABLE 10. Salinity of 0-100 cm saline soil, according to FAO Coefficient of assessment of the effect of the level on crop yield.

Type of cultivation	**ECe, dS/m**					
	2	**4**	**6**	**8**	**12**	**16**
Tomato	100	86	67	48	10	0
Bulgarian pepper	93	65	37	8	0	0
Klupnoy	86	58	30	1	0	0
Perfume	95	76	57	38	0	0
The lemon tree	91	55	20	0	0	0

Note: soil salinity is estimated by the conductivity of saturated soil extract

K_7 - coefficient taking into account the depth of the groundwater level;

TABLE 11. The values of the coefficient K_7 depending on the relative magnitude of the amplitude of fluctuations in the level of groundwater [8].

The relative magnitude of the amplitude of groundwater level fluctuations, m	0	0.2	0.4	0.6
The values of the coefficient K_7	1.0	0.92	0.82	0.7

K_8 - coefficient taking into account the reaction of the soil solution in the year *t of the* calculation period;

TABLE 12. The values of the coefficient K_8 depending on the reaction soil pH.

Soil pH	4.0	4.5	5.0	5.5	6.0	7.0
The values of the coefficient K_8	0.75	0.85	0.91	0.96	1.0	1.0

K_9 - coefficient taking into account the content of heavy metals in the soil in the year *t of the* calculation period;

TABLE 13. K_9 values for various soils and pollution.

Cd, mg / kg	Productivity		Pb, mg / kg	Productivity		Zn, mg / kg	Productivity	
	Sod-podzolic soils	Chernozem soils		Sod-podzolic soils	Chernozem soils		Sod-podzolic soils	Chernozem soils
2.5	1.0	1.0	125	1.0	1.0	125	1.0	1.0
5	0.95	1.0	250	1.0	1.0	250	0.65	1.0
10	0.65	1.0	500	0.95	1.0	500	0.50	1.0
20	0.50	0.90	1000	0.50	1.0	1000	0	0.85
50	0.35	0.75	2000	0.10	0.85	2000	0	0.60
100	0	0.45	-	-	-	-	-	-

T_{10} - correction factor for climatic conditions.

TABLE 14. Value $K_{10.}$

Climatic zones	Ci	C-II	C-I	C-II	Yu-I	Yu-II
K 10	0.83	0.92	0.96	1.0	1.04	1.08

The concept of the theoretical and methodological model of the greenhouse farming market is developed, based on the introduction of innovative technologies, taking into account state regulation that influences the main market parameters and includes strategic directions for increasing the effectiveness of greenhouse vegetable cultivation based on product quality differentiation (highly competitive, medium-competitive and low-competitive), aimed at increasing the sustainable development of the market, taking into account its segmentation and consumer preferences [34, 35]. Trends are determined and forecast scenarios for the development of the greenhouse vegetable market are developed (basic, compromise, intensive ones), depending on the level of state support and incentive mechanisms on the basis of an analysis of the actual indices of its capacity, which allow determining the level of self-sufficiency and import substitution, taking into account the cluster-territorial approach, realization of a set of organizational and economic measures that increase the performance efficiency of greenhouse vegetable farming.

CONCLUSIONS

The applied econometric approach accurately reflects the dynamics of the greenhouse cucumber price. Also the approach can be used for preliminary forecasting of the average price for other greenhouse vegetable crops, at least for the nearest calendar period. The calculated correlation coefficient (k = 0.93) between the actual data and the simulated trend, taking into account the seasonal and random components, indicates a sufficiently high degree of adequacy. For a more accurate price forecast for greenhouse vegetables, it is necessary to consider the qualitative composition of costly and other external factors for the theoretical construction of the response function. Modeling the pricing of domestic greenhouse products will make it possible to increase the predictability of the demand for greenhouse vegetables and to achieve certain uniformity in their production and sales, producing a stable profit.

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Multilevel Dynamic-Stochastic Model for Optimizing the Production of Agricultural Products Under Risk Conditions

Ya.M. Ivanyo and S.A. Petrova [a)]

Irkutsk State Agricultural University named after A.A. Ezhevsky, Irkutsk region, Irkutsk district, Molodezhny, 664038, Russia

[a)] Corresponding author: sofia.1987@bk.ru

Abstract. The article presents the developed multilevel dynamic-stochastic model, which allows predicting production and economic indicators according to adequate trends in the form of linear and nonlinear functions, as well as evaluating extreme events using probabilistic distribution laws. According to the proposed algorithm, three sequences are distinguished in the time series of the indicator under consideration. The entire range of values describes the average trend of the indicator variability. The sequences of peaks and troughs characterize favorable and unfavorable cases of obtaining agricultural products. After determining significant trends for three levels, the parametric programming problem is used to obtain optimal plans for different conditions of the agricultural producer's activity with a parameter in the form of time. The values of the time series, which are below the trend of the lower levels and above the trend of the upper levels, are classified as extreme events, estimated using probabilistic laws. At the same time, the optimal solutions obtained reflect planning taking into account probabilistic events. Multilevel models of parametric programming are applied to an agricultural enterprise and a municipal district. Their feature is the ability to assess various situations in the future, taking into account risks.

INTRODUCTION

To solve the problem of optimizing agricultural production under the conditions of risks associated with climatic and biological adverse events, a multilevel problem of parametric programming based on the works [1 - 3] is proposed. The solution of this problem makes it possible to obtain optimal plans for the production of agricultural products, corresponding to the maximum possible income in certain average, favorable and unfavorable external conditions. Meanwhile, extreme hydrometeorological phenomena and unfavorable biological factors associated with plant and animal diseases, pest invasion, and epidemics of farm animals significantly affect the activities of agricultural producers [4 - 7]. In these cases, for planning agricultural production, it is necessary to use mathematical programming problems, taking into account risks, which are probabilistic estimates.

Thus, the aim of the work is to describe the developed methodology for dynamic and probabilistic optimization of agricultural production under averaged, favorable and unfavorable conditions using multilevel trends, parametric programming models and applied stochastic extremal problems. To achieve the goal, the following tasks were solved:

- determination of multilevel trends in time series of production and economic indicators and identification of abnormal levels with their probabilistic assessment;
- building parametric programming models using multilevel trends and stochastic extreme problems to optimize the production of agricultural products in average, favorable, unfavorable conditions, as well as taking into account high risks;
- implementation of the proposed methodology for one of the municipal districts of the Irkutsk region.

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MATERIALS AND METHODS

In preparing this article, the works of various authors on modeling various indicators characterizing agricultural production [1, 2, 4, 8, 9] were used. In addition, the results of assessing the impact of various climatic and biological phenomena on the activities of agricultural producers were analyzed [4 - 7]. According to the proposed methodology, the time series of the production and economic indicator can be divided into three sequences according to the algorithm proposed in [10. 11]. The first one is the original time series. The second and third sequences describe the upper and lower levels of the time series - peak and trough values.

Points above and below the trends of the upper and lower levels of the series represent extreme events, reflecting highly favorable and very unfavorable conditions. This series structure can be described by the formula:

$$y_t = \overline{y}_t \pm \Delta y_t \pm \Delta d_t, \quad (1)$$

where y_t is a level of the series, $\overline{y}_t$ are trend levels of the entire series; Δy_t are modulo differences between the levels of the averaged and upper (lower) trends; Δd_t are modulo differences between the event values and the trend values of the upper (lower) levels.

Formula (1) is valid provided that the trends for the levels of the entire series and sequences of upper and lower values are accurate and significant according to the coefficient of determination (R^2>0.50), Fisher's *F*-test and Student's *t*-statistics.

When developing a methodology for optimizing the production of agricultural products, methods of probability theory and mathematical statistics and methods of mathematical programming under uncertainty were used. The methodology was tested on the basis of long-term data on agricultural production in the Cheremkhovo municipal district.

MAIN RESULTS AND DISCUSSION

An analysis of a large number of long-term time series characterizing the yield of agricultural crops and the productivity of farm animals shows that with increasing time, they as rule to increase, and labor costs for the production of agricultural products decrease [1, 2, 4, 5]. At the same time, this growth has wave-like form, since production and economic indicators are strongly influenced by extreme hydrometeorological and biological phenomena.

Since time can be used as a parameter, it is possible with a certain accuracy to assess the future situations of the activity of an agricultural producer, taking into account risks. This result is consistent with modeling the production of volumes of agricultural products in adverse conditions. Obviously, the difference in values, for example, the yield obtained under average and unfavorable conditions ($-\Delta y_t$), is a predictable level of losses for an agricultural producer. The value $+\Delta y_t$ is an additional product obtained under favorable production conditions.

Table 1 shows multilevel yield trends for wheat, oats and potatoes according to the Cheremkhovo district, located in the Irkutsk region. The asymptotic and logistic growth models with saturation were used as analytical functions [1, 3]. According to the coefficient of determination ($R^2 > 0.50$), Fisher's F-test and Student's t-statistics, the trends are adequate. In addition to the types of models, Table 1 shows forecast values for 2022 and 2024.

In some cases, the points are located above and below the trends of the sequences of the upper and lower levels of the time series. The differences between these events and the trend values characterizing the upper and lower levels of the series ($\pm \Delta d_t$) are probabilistic estimates.

To describe them, it is proposed to use the Pearson type III distribution [12, 13]:

$$p(y) = \frac{\gamma^{\gamma}}{\Gamma(\gamma)(\overline{y} - l)} \left(\frac{y - l}{\overline{y} - l} \right)^{\gamma - 1} e^{-\gamma \left(\frac{y - l}{\overline{y} - l} \right)}, \quad (2)$$

where $\overline{y}$ is the mean, γ and l are the distribution parameters associated with the coefficients of variation C_v and skewness C_s.

TABLE 1. Asymptotic and logistic models and their statistical parameters for a long-term series of wheat, oat and potato yields in the Cheremkhovo district for 1996 - 2020 and forecast values for 2022 and 2024.

Levels	Regression equation	R^2	Fisher's F-test	|Student's t-statistics|	Forecast	
					2022	2024
			Wheat yield, c/ha			
Whole range	$y=31.2/(1+e^{-0.0959t})$	0.64	45.2	6.72	29.1	29.4
Lower	$y=23.5/(1+e^{-0.152t})$	0.72	15.6	3.95	23.1	23.2
Upper	$y=31.2/(1+e^{-0.180t})$	0.86	37.0	6.08	30.9	31.0
			Oat yield, c/ha			
Whole range	$y=29.6-19.7e^{-0.0906t}$	0.69	55.6	7.52	27.9	28.2
Lower	$y=24.7-9.9e^{-0.106t}$	0.67	14.4	3.80	24.1	24.2
Upper	$y=29.6-12e^{-0.115t}$	0.77	23.1	4.81	29.1	29.2
			Potato yield, c/ha			
Whole range	$y=194.1/(1+e^{-0.120t})$	0.53	27.9	5.29	186.8	188.3
Lower	$y=166.3/(1+e^{-0.182t})$	0.77	26.3	5.13	165.1	165.5
Upper	$y=194.1/(1+e^{-0.175t})$	0.51	7.35	2.71	192.4	192.9

On the basis of the given distribution law, the probabilities of rare events for crop yields under favorable and unfavorable conditions were obtained (Table 2).

TABLE 2. Rare crop yield events and their probabilistic assessment in accordance with the Pearson type III distribution according to the data of the Cheremkhovo district for 1996–2020.

Crop	Wheat	Oats	Barley	Potatoes	Cabbage	Carrot
Year	2015	2015	2015	2007	2015	2000
Low yield, c/ha	16.0	13.1	14.7	135.1	234.7	104.3
Probability	0.0134	0.0167	0.0110	0.0337	0.0205	0.0210
Year	2014	2008	2004	1997	2007	1997
High yield, c/ha	31.0	27.9	27.5	193.0	490.5	225.3
Probability	0.0241	0.00640	0.030	0.0150	0.00950	0.00954

The results obtained with the help of multilevel trends (Table 1) and the probability distribution law (Table 2) can be used for parametric and stochastic programming problems to optimize the production of agricultural products in various conditions.

Let us present a multilevel model of parametric programming with probabilistic estimates for the crop industry, using the results of [1, 2, 4]. The value of the objective function is determined by the maximum income:

$$\sum_{i\in I} c_i^l x_i - \sum_{s\in S}\sum_{i\in I} d_{si}^{l(p)} x_i \to \max. \tag{3}$$

The following conditions of the problem are identified:
limitation of production resources

$$\sum_{i\in I} a_{iz} x_i + \sum_{s\in s}\sum_{i\in I} b_{siz}^{l(p)} x_i \le A_z \ \ (z\in Z); \tag{4}$$

limited size of the crop industry

$$\underline{n}_r \le \sum_{i\in I_r} (1+\alpha_i) x_i \le \overline{n}_r \ (r\in R); \tag{5}$$

production of final products of a given volume

$$\sum_{i\in I} y_{qi}^{l}(t)x_i - \sum_{s\in S}\sum_{i\in I} w_{si}^{l(p)}x_i \geq V_q \quad (q \in Q); \tag{6}$$

a certain amount of applied fertilizers and plant protection products

$$\sum_{i\in I} u_{mi}x_i + \sum_{s\in S}\sum_{i\in I} k_{si}^{l(p)}x_i \leq U_m \quad (m \in M); \tag{7}$$

non-negativity of variables

$$x_i \geq 0, \tag{8}$$

where x_i is the desired variable, the area of arable land i; c_i^l is the income per 1 ha of i-crop for the sequence of levels l; $d_{si}^{l(p)}$ are losses per unit area as a result of the impact on production of products of extreme event s on crop i for the sequence of levels l, p is the probability, a_{lz} is the consumption of resource z per unit area of crop i or forage type; A_z is the presence of a z-kind resource; $b_{siz}^{l(p)}$ are additional production resources z to recover losses as a result of the impact of an extreme event s on culture i for a sequence of levels l, V_q is the guaranteed volume of production of the type q; $\overline{n}_r, \underline{n}_r$ is the maximum and minimum possible area of cultures of group r; $y_{qi}^{l}(t)$ is the output of q-type commercial products per unit area of culture i for a sequence of levels l; α_i is a coefficient that takes into account the area of seed crops for crop i; u_{mi} is the consumption of fertilizers of type m and means of protection per unit area of crop i or type of fodder land; U_m is the required volume of fertilizers of type m, $w_{si}^{l(p)}$ are losses in the production of crop i as a result of the influence of an extreme event s on it for a sequence of levels l, $k_{si}^{l(p)}$ are additional volumes of fertilizers and plant protection products applied as a result of the influence of an extreme event s on crop i for a sequence of levels l.

In model (3) - (8), the left side of the constraint (6) depends on the parameter t, which is time. In this case, the function $y_{qi}^{l}(t)$ can be described as a linear and non-linear expression. In particular, for different situations, the marketable output indicator most often takes the following form:

$$y_{qi}^{l}(t) = y_{qi}^{l(\max)}/(1+e^{-a_{qi}^{l}t}), \tag{9}$$

$$y_{qi}^{l}(t) = y_{qi}^{l(\max)} - (y_{qi}^{l(\max)} - y_{qi}^{l(\min)})e^{-\alpha_{qi}^{l}t}, \tag{10}$$

$$y_{qi}^{l}(t) = y_{qi}^{l(0)}t^{a_{qi}^{l}}, \tag{11}$$

where $y_{qi}^{l(\max)}$, $y_{qi}^{l(\min)}$ are the upper and lower bounds for the output of the type product q per unit area of culture i for the sequence of levels l; α_{qi}^{l} are the coefficients of expressions (9), (10) and (11), $y_{qi}^{l(0)}$ is a parameter of expression (9).

The algorithm for implementing the model (3) - (8), taking into account one or another expression (9) - (11), consists in the following sequence of operations. First, the coefficients are determined for the unknown objective function and the left parts of the constraints, as well as the right parts of the conditions. Secondly, three sequences with lower, upper and all levels are distinguished from the rows of marketable output, for which adequate trends are built according to (9), (10) or (11). Other functions may be used. Thirdly, the problem of parametric programming is solved for three levels of output of marketable products. Fourth, for values located below the trend characterizing the sequence of lower levels, their probabilities are estimated taking into account an adequate distribution law. A mathematical programming problem is solved, the optimal solution of which corresponds to the probabilities of anomalous levels or events. Fifth, for values located above the trend characterizing the sequence of upper levels, their probabilities are estimated taking into account an adequate distribution law. A mathematical programming problem is solved, the optimal solution of which corresponds to the probabilities of anomalous levels. Table 3 shows the simulation results according to (3) - (11).

In accordance with the optimal solutions obtained in the Cheremkhovo district, agricultural producers in the aggregate can receive more than 2.16 billion rubles of income. At the same time, losses on average correspond to the level of 18%. Meanwhile, in the most difficult situation in some years, the damage can reach about 47%, and in very

favorable conditions for the activities of agricultural producers, you can get about 5% of additional income. Some negative production volumes of oats and carrots, obtained under very favorable conditions, relative to the average values, are due to the fact that the largest value Δd_t in general case does not always correspond to the maximum of the time series. This follows from the physical meaning of the indicator Δd_t, which is considered as the difference between the value of the time series and the trend level of the sequence of upper values.

TABLE 3. Optimal solutions of parametric programming problems for the middle and lower levels of the series and linear programming problems with probabilistic rare events according to the Cheremkhovo district.

Row levels	Year	Wheat	Barley	Oats	Potatoes	Cabbage	Carrots	Objective function, thousand rubles
		x_1, ton	x_2, ton	x_3, ton	x_4, ton	x_5, ton	x_6, ton	
Medium	2022	73471.7	40431.5	19900.0	2241.60	8986.00	933.90	2164145.0
Lower		58322.9	35538.8	17006.7	1981.2	6946	852.9	1778594.6
Losses		15148.8	5098.4	2681.6	260.4	2040	81	17.8 %
Medium	2024	74229.1	40787.1	19900	2259.6	9116	936.3	2184517.8
Lower		58575.4	35988.6	17077.3	1986	6966	854.4	1789348.8
Losses		15653.8	4798.5	2822.7	273.6	2150	81.9	18.1 %
Rare negative events		40396.8	19786.2	10213.6	1621.2	4694	312.9	1150118.6
Losses		33074.9	20850.9	9474.7	620.4	4292	621	46.9 %
Rare positive events		78268.8	42140.2	19107	2316	9810	675.9	2265535.8
Additional income		4797.1	1503	-581.3	74.4	824	-258	4.69 %

Let us pay attention to the features of the application of the proposed algorithm for optimizing the production of agricultural products. First, the time series of production and economic indicators of the activities of agricultural producers should have significant trends at three levels. Therefore, it is necessary that the number of values of the original series correspond to at least 21. Secondly, the number of events (anomalous levels) largely depends on the type of trend. Third, cycles between peaks and troughs vary greatly in the series of production and economic indicators, and, meanwhile, losses or additional production volumes are not observed every year. This factor requires further research.

CONCLUSION

The proposed algorithm is based on a formula in which the empirical values of the series consist of three terms: the trend levels of the original sequence, the difference between the trend levels of the original sequence and the trend levels of sequences of upper and lower values, the difference between anomalous levels and trend levels of upper (lower) values. According to the proposed algorithm, it is possible to optimize the production of agricultural products and obtain damage values for the short, medium and long term. The average risks are estimated as the difference between the optimal plans and income corresponding to the trends of the sequences of the entire series and the lower levels. For anomalous levels, a stochastic optimization problem is solved taking into account extreme events. An algorithm for optimizing the production of agricultural products based on multilevel trends, parametric and stochastic programming models was implemented using the example of one of the municipal districts of the Irkutsk region.

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Digitalization of Agriculture as a Factor of Sustainable Economic Growth of the Agrarian Sector in Russia

Rishat A. Migunov [a)], Anastasia A. Syutkina [b)], Elena S. Kolomeeva [c)], Vladislav I. Gornostaev [d)], Ekaterina V. Enkina [e)]

Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, Moscow, Russia

[a)] Corresponding author: migunovrishat@mail.ru
[b)] a.sytkina@rgau-msha.ru
[c)] elena_dorov@mail.ru
[d)] vgornostaev@rgau-msha.ru
[e)] romashka18.12@mail.ru

Abstract. The article aims to identify the features of the institutional environment formation of agriculture and show that digitalization is a specific factor of sustainable economic growth of agriculture at the present stage of economic development. The study is based on the dialectical method aimed at identifying cause-effect relationships between the economic growth of domestic agriculture and the factors that influence it. The study shows that at the present stage of the institutional environment development of domestic agriculture, one of the main factors of agriculture sustainability is the process of digital technology development. The study's originality lies in identifying specific factors of sustainable economic growth of agriculture in Russia at the present stage of economic development.

INTRODUCTION

A high degree of volatility and heterogeneous growth across agribusiness sub-sectors characterize the current economic development of agriculture. At the same time, heterogeneous agricultural development and sustainability factors have a multidirectional and often ambiguous impact at different stages of the agri-food market condition development. Under such circumstances, studying the impact of agricultural economic growth factors, especially its sustainability, on the development of the agrarian sector is particularly acute today.

It is also essential to assess the impact of various advances in science and technology on the economic growth of the agrarian sector. Although there is a significant amount of research in this area, further comprehensive research is needed to identify the impact of digitalization processes on the agrarian sector's economic growth and its sustainability at different stages of the agri-food market condition development.

MATERIALS AND METHOD

Researchers of various branches of economic theory (classical political economy, neoclassical economic theory, and institutionalism) carried out the study of economic growth factors, its sustainability, and its interrelation with the historical and cyclical development [1, 3, 4, 5, 7, 10, 14].

Despite a wide range of studies, many questions on the study of specific factors for sustainable economic growth in agriculture, especially at the current stage of development of the agrarian sector, remain under-researched, which has determined the search directions in the research.

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RESULTS

Identifying economic growth factors in agriculture and its sustainability requires us to dwell on the specifics of the industry, where economic growth is more than an increase in the final product. S. Kuznets, the classical scholar of economic theory, defines economic growth as "a long-term increase in the ability to provide the population with more and more diverse goods, based on technical progress and the necessary institutional and ideological changes" [5]. Russian classical scholars of economic theory generally support this statement [16; 17]. It should be noted that all definitions do not equate gross domestic product growth and economic growth. Economic growth can be defined as such an increase of gross domestic product when qualitative improvements occur, such as:

- increasing labor productivity;
- increasing competitiveness of domestic products on the world market;
- increasing share of high-tech industries in gross domestic product;
- increasing quality and standard of living of the population, etc. [6].

Russian agricultural economists primarily understand economic growth in agriculture as "economic growth based on the development of industrial productive forces, accompanied by the formation of the division of labor in agriculture" [13]. At the same time, the growth of agricultural gross domestic product can be considered economic growth when:

- the economic sustainability of agricultural enterprises increases;
- the financial opportunities for the expanded reproductive performance in the agrarian sector are improving;
- development of agricultural enterprises is based on innovations;
- there are environmental constraints of the agrarian sector development;
- social well-being of rural areas is ensured (formulated according to [18]).

Thus, economic growth in agriculture is a process of increasing the actual gross domestic product based on increasing and improving the economic strength quality of the agrarian sector.

A set of institutions and institutional mechanisms with the corresponding institutional structure represent the institutional environment that ensures the functioning of the economy, including the agrarian sector, according to certain rules. Its development is influenced by various specific factors that shape the structure and influence economic growth and its sustainability in modern Russian agriculture.

If categorized, agricultural economic growth factors can be classified into three broad groups.

1. Production factors include natural, biological, organizational and economic, technological, scientific and technical, and environmental factors.
2. Socio-economic factors include the lag of rural development from the city regarding living standards and conditions, low level of access to budgetary guarantees and social services, and performance motivation of rural population.
3. Socio-physiological factors include the structure of the population's nutrition and food quality (formulated according to [9, 19]).

Summarizing Russian and foreign experience, it is possible to give the following working definition of sustainable economic growth in agriculture: an increase in agricultural gross domestic product based on the proximity of the current economic growth to the trend and the observed positive long-term trend of the agrarian sector development.

Sustainable economic growth in agriculture is possible only if the degree of development of the institutional environment and the stage of the agri-food market condition development are correctly taken into account. Market institutions in modern economic systems are responsible for the agrarian sector’s economic growth, and the complementary institutions of state regulation are in charge of its sustainability.

Market institutions in the agrarian sector are institutions of entrepreneurship, market exchange, competition, based on the pervasive development of the private property and feedback through increased corporate profitability. At the present stage of the agri-food market condition development, market institutions cannot ensure long-term positive agricultural development dynamics. Such conditions require expanding and introducing new complementary institutions of state regulation of the agrarian sector.

The complementary institutions of state regulation of the agrarian sector influence both the economic growth rate of the sector (the institution of preferential taxation of agricultural producers and the institution of their financial and credit support) and the sustainability of this growth:

1. Institutions of direct subsidization of economic agents in rural areas.
2. Political market institutions.

3. Institutions for stabilizing the agri-food market condition.
4. Institutions of demand support at agri-food market.
5. Institutions of innovative development of the agrarian sector.

The latest group of institutions aims at obtaining new results of the scientific and technological search and new agro-technologies that are the basis for innovative growth of the agrarian sector, ensuring its sustainable growth. This group deserves special attention in the study. In Russia, the long-term effectiveness of these institutions manifests in the transition to " high-yield and environmentally friendly agri- and aquaculture, development and implementation of various chemical and biological protection systems, efficient storage and processing of agricultural raw materials, and production of safe, quality, and functional foodstuff" (Decree of the RF Government No. 708 of 04.09.1992).

The long development of new agricultural technologies and their manufacturing application implies the active involvement of state institutions in innovation policy, especially for developments that can be characterized as public goods (selection and breeding centers, agricultural R&D and education, etc.).

At the present stage of agricultural development, digital technologies can significantly impact the economic growth rate and its sustainability. This happens because digital technologies can spread horizontally among companies, interacting to create new technologies, and the resulting products become much cheaper.

Study of the development stages of digital technologies in the domestic agro-industrial sector (before 1966 – predigital; 1967-1980 – automation; 1981-1990 – electronization; 1991-2005 – informatization; 2006-present – digitalization) shows that the historical development of technologies in Russian agriculture has not had a direct impact on the rate of economic development of the sector. The decisive influence is primarily institutional.

In Russia, a comprehensive study showing the utilization capacity of digital technologies 4.0 in the domestic agrarian sector based on the FAO methodology has been conducted so far [11]. The study's general conclusion is that the transition of Russian agriculture to digital technologies will increase the prospective agricultural products by 1.58 times at the same agricultural input.

Arranging quality institutions of innovative development of the agrarian sector, aimed at the introduction of digital technologies 4.0 in the domestic agrarian sector, will achieve the following positive economic effects:

- increasing sales of high-tech products;
- increasing productivity through hybrid intelligence technologies and automation of production;
- increasing exports of products with high added value; creating high productivity jobs;
- increasing revenues of domestic businesses from sales of new digital products and solutions;
- increasing share of products and services with high added value in the revenues of Russian companies, and, accordingly, increasing tax and customs revenues to the Russian budget.

The development of digital technologies will lead to positive social effects:

- increasing real well-being of the population by reducing the cost of infrastructure use and related products and services;
- improving health and increasing life expectancy;
- developing current trends in science and education;
- developing a generation of advanced specialists and scientists;
- accelerating and improving scientific, technological, industrial, and trade cooperation with foreign countries.

Thus, the development of digital technologies at the present stage of agrarian sector development becomes one of the most important factors of sustainable economic growth of the sector in the long term.

CONCLUSION

The study shows the leading institutions that influence the agrarian sector’s economic growth and its sustainability.

The authors revealed specific factors of the domestic agrarian sector’s economic growth and its sustainability.

They emphasized that the digitalization of domestic agriculture is a specific factor for sustainable economic growth in the long term.

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On the Digitalization of the Russian Agricultural Economy: Condition, Development Forecast

B.A. Voronin, Ya.V. Voronina, O.G. Loretts, E.M. Kot, A.V. Ruchkin and V.S. Kukhar [a)]

Ural State Agrarian University, Yekaterinburg, Russia

[a)] Corresponding author: viktorurgau@mail.ru

Abstract. Currently, researchers associate the positive and cost-effective functioning and development of Russian agriculture and the entire agro-industrial complex with the digitalization of the agrarian economy, which offers the intellectualization of agricultural activities based on the use of nano-technologies, biotechnologies and information technologies. The definition of the concept of "intellectualization" is interpreted in many scientific publications in different ways. In the Large Explanatory Dictionary of the Russian language intellectualization is the strengthening of the role of intelligence, the increase of the intellectual level (in this case, agriculture and agricultural production). The Russian Encyclopedic Dictionary defines intelligence as cognition, understanding, the ability to think, rational cognition. The concept of "intelligence" in the Newest dictionary of foreign words and expressions is defined as the mind, reason, intellectual ability of a person. Intellectualization of production and economic activity is the core direction of the agrarian economy in the conditions of the modern period of development of Russian agriculture and the agro-industrial complex. In practice, the direction of intellectualization of agricultural activity is the development of "smart" agriculture based on the implementation of the project "Digital Agriculture". As part of digitalization in Russian agriculture, the following design solutions will be developed and implemented: "smart" field, "smart" farm, "smart" greenhouse, "smart" warehouse, "smart" processing, "smart" herd, "smart" agricultural office, "smart" land use, "smart" garden, "smart" agricultural enterprise and other projects of "smart" agriculture. This article provides information on the use of digital technologies in agriculture and agro-industrial production.

INTRODUCTION

The topic of this scientific article is relevant, since new concepts and categories of digitalization for the Russian economy, including the agricultural sector, are being investigated. Problems related to the study of the topic of digitalization are reflected in scientific publications of Ural scientists: B.A. Voronin, A.N. Mitin – "Management of digitalization processes" [1-5], B.A. Voronin, I.P. Chupina, Ya.V. Voronina – "Digitalization as a modern mechanism of learning in educational institutions" [6], A.N. Semin, A.N. Mitin, B.A. Voronin, Ya.V. Voronina – "Study of prospects for the development of high–precision digital technologies in the management of domestic agriculture" [7], B.A. Voronin, O.G. Loretz, A.N. Mitin, I.P. Chupina, Ya.V. Voronina – "On the issue of digitalization of Russian agriculture (review of information materials)" [8], B.A. Voronin, A.N. Mitin, O.A. Pichugin – "Management of digitalization processes of agriculture in Russia" [9], B.A. Voronin, I.P. Chupina, Ya.V. Voronina - "Digitalization in education as a necessary element of training a modern specialist" [10].

Scientific papers on the topic of digitalization are available in educational and research institutions throughout the Russian Federation. Naturally, a lot of research on this problem is carried out abroad. Since the topic of digitalization is new in the system of social and economic relations, and the practice is only being developed, only approaches to the introduction of digitalization in various sectors of the economy and the public sphere of Russia are observed in scientific publications. Taking into account these circumstances, the development of the topic of digitalization of the agrarian economy is appropriate. The scientific novelty of the research lies in the fact that the

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state and forecast of the formation and development of digitalization in agriculture and agro-industrial production are analyzed.

The purpose of this study is to consider the process of digitalization of Russian agriculture that has begun and the complex of relations that arise during the transition to digital, robotic and other intelligent technologies in the agricultural economy.

The objectives of the study are to study the process of introducing digitalization technologies and projects into agriculture and agro-industrial production and issues of organizational and legal support for this activity. The theoretical significance of this work is characterized by the introduction into economics of new directions of development of the agrarian economy based on digitalization and other intellectual technologies that were previously absent in the Russian agricultural sector.

The practical significance of this work is due to the fact that the materials can be used in the system of further development of regulatory legal regulation in the field of digitalization of the agrarian economy.

METHODS

Research methods: analysis, synthesis, generalization, forecast, economic and legal. The authors give a forecast of the further development of agriculture, taking into account the use of artificial intelligence, potential legal gaps and directions of development of legislation, analyze potential economic opportunities and costs. Based on the results of secondary research (a survey of managers of agricultural enterprises), the main economic positive shifts in the financial and economic activities of organizations due to the digitalization of production processes have been identified.

RESEARCH RESULTS

Decree No. 204 of 7 May 2018 of the President of the Russian Federation "On National goals and Strategic objectives of the Development of the Russian Federation for the period up to 2024" [4] and Decree of the President of the Russian Federation No. 474 of 21.07.2020 "On National Development Goals of the Russian Federation for the period up to 2030" are the legal basis for the development of digitalization in the Russian Federation [12].

In these decrees, the President of the Russian Federation set the task of transforming priority sectors of the economy and social sphere, including agriculture, through the introduction of digital technologies and platform solutions, which will mean the transition to the digital way of the Russian economy.

Other regulatory acts regulating relations on the introduction of the digital way of life have also been adopted. Among such legal acts are:

The program "Digital Economy of the Russian Federation", approved by the Decree of the Russian Federation No. 1632-r dated 28 July 2017 [13].

Regulation on the management system for the implementation of the national program "Digital Economy of the Russian Federation", approved by the Decree of the Government of the Russian Federation No. 234-r dated 2 March 2019 [14]. This Provision defines that the function of the federal executive authority responsible for the implementation of the national program "Digital Economy of the Russian Federation" is carried out by the Ministry of Digital Development, Communications and Mass Communications of the Russian Federation; the functions of the project office for the implementation of the Program are carried out by the autonomous non-profit organization Analytical Center under the Government of the Russian Federation; the functions of the federal executive authority responsible for the implementation of the federal projects "Regulatory Regulation of the Digital Environment" and "Personnel for the Digital Economy" are carried out by the Ministry of Economic Development of the Russian Federation; The functions of the federal executive authority responsible for the implementation of the federal projects "Digital Technologies", "Digital Public Administration", "Information Infrastructure", "Information Security" are carried out by the Ministry of Digital Development, Communications and Mass Communications of the Russian Federation.

The Strategy for the Development of the Information Society in the Russian Federation for 2017-2030, approved by Decree of the President of the Russian Federation No. 203 of 9 May 2017, should be added to the above legal acts [15]. And other legal documents have been developed at the level of the Russian Federation and its constituent entities at the present time.

In particular, in 2017, the Departmental project "Digital Agriculture" was adopted by the Ministry of Agriculture of Russia [16]. The project implementation period is 2019-2021. The goal of the project is the digital transformation

of agriculture through the introduction of digital technologies and platform solutions to ensure a technological breakthrough in the agro-industrial complex and achieve a 2-fold increase in labor productivity at "digital" agricultural enterprises by 2021.

In 2019, the Ministry of Agriculture of the Russian Federation prepared an information publication reflecting the problems of digital transformation of agriculture in Russia [17]. In this publication, it is noted that solving the problems that hinder the digitalization of agriculture is part of the nationwide task of integrated rural development. This task includes the need to develop (taking into account the spatial development of the country) a scheme for the placement and specialization of agro-industrial production, which as a basis should have a multi-level integrated information space based on modern digital technologies. Such problems include:

- Lack of financial resources for the implementation of information and communication technologies (ICT) in the majority of agricultural producers. A bipolar economy has emerged in the agricultural sector, where highly profitable farms with wide access to efficient technologies are concentrated on one pole, and farms working on the verge of payback using outdated technologies are concentrated on the other.
- Lack of qualified personnel. According to the Ministry of Agriculture of Russia, there are half as many IT specialists working in agriculture in our country than in countries with a traditionally developed sphere of the agro-industrial complex. According to experts, about 90 thousand IT specialists are needed by the Russian agricultural sector.
- Insufficient development of digital infrastructure in rural areas, especially in rural outback. Radical changes are taking place in this area, but the digital divide persists between urban and rural areas.
- Imperfection of legal regulation of the development of information technologies in the agro-industrial complex. The development of the system of state information support in the field of agriculture is regulated by the article 17 of the same name of the Federal Law of 29 December 2006 No. 264-FL "On the Development of Agriculture", but the article requires revision.

Kuban State Agrarian University named after I.T. Trubilin in 2018 conducted a survey of agricultural enterprises of the region in the direction of "Digital Agriculture" [18]. The survey allows us to draw the following conclusions, according to experts:

- The digital economy will be a new technological basis for the social and economic sphere of the Russian Federation – yes (90% of experts believe);
- Digital agriculture will contribute to the production of agricultural products in an end-to-end digital environment "from field to counter" – yes (80%);
- Digital agriculture will create conditions for the transition to industry with the minimization of intermediaries and trade margins – yes (73%);
- The volume of reporting will decrease with the use of digital technologies in the agro-industrial complex – yes (50%);
- Digitalization of production processes and support of commodity flows will create the possibility of systematic accumulation of trade lots for the export of agricultural products – yes (70%);
- Digital inventory and monitoring of land will increase the level of control over the state and use of agricultural land – yes (92%);
- Digitalization of agricultural production as a whole will increase the efficiency of industry management – yes (97%);
- Digitalization will improve the quality of life in rural areas – yes (46%);
- Digitalization will help reduce the impact of agriculture on climate change – no (46%);
- Digitalization will allow to involve workers of new professions in agricultural production – yes (95%);
- Is it necessary to stimulate the introduction of digital technologies through state support of agricultural producers – yes (95%);
- The use of new generation technologies can increase the productivity of world agriculture by an average of 70% by 2050 – I find it difficult to answer (48%);
- Competencies for digital agriculture are currently in demand by the market – yes (73%);
- Do agricultural universities need departments for digitalization of agriculture – yes (83%);
- Currently, there are no educational technologies for training specialists for digital agriculture – yes (76%);
- There are no highly qualified teachers in agricultural universities to train specialists in this area – yes (74%).

The above information is typical today for many regions of the country, since the digitalization of agriculture is just getting introduced in the agricultural sector of the economy.

CONCLUSION

Intellectualization of the agricultural economy, taking into account the formation and development of digitalization of robotization, information technologies and other projects and platforms, objectively ensures the transition of Russian agriculture and agro-industrial production to a new technological digital way.

The results of the introduction of digitalization in agriculture are still largely based on forecasts of future indicators of improving agricultural activity, given that the empirical base is still being formed.

As for the legal regulation of the implementation of digitalization in agriculture, the existing departmental project "Digital Agriculture" by legal force cannot effectively provide a solution to the problem of digitalization in a particular sector of the economy without the participation of other ministries and departments responsible for the implementation of the digital economy program in the country.

In this regard, it is advisable to adopt a federal law "On the digitalization of the economy of the Russian Federation", in which it is necessary to highlight a section on the assistance of state executive authorities in the development of digitalization of agriculture.

Since the Federal Law "On the Development of Agriculture" No. 264-FL of 29 December 2006 is the main law in the system of agricultural legislation, it is obvious that it is necessary to include a section on the digitalization of agriculture as a strategic direction for organizing agricultural activities in modern conditions.

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Efficiency of Seed Production and Sale as a Factor of Accelerated Development of the System of Seed Production and Breeding in Russia

Zinaida P. Medelyaeva [a)], Svetlana A. Golikova and Natalia P. Shilova

Voronezh State Agrarian University named after Emperor Peter the Great, Voronezh, Russia

[a)] Corresponding author: medelaeva@mail.ru

Abstract. The system of seed production and breeding in Russia is currently below the appropriate level. Seed-producing organizations provide agricultural producers with domestically grown seeds only for grain crops (more than 95%). The figures are much lower for grain maize, sunflower, soybean, and rapeseed (about 50%), and very low for sugar beet (not more than 5%). Seed breeding and production are links in one chain, and the efficiency of the whole system will be determined by the efficiency of functioning of its elements. This article formulates the principles of functioning of the seed production system that allow it to function efficiently in modern conditions. These principles include consistency, resource concentration, continuity, competitiveness, balance, adaptability, and economic feasibility. The principle of economic feasibility determines many others, e.g. the possibility of continuous seed production, the possibility of breeding new varieties, and the ability of seed organizations to compete in the national and foreign markets. To assess the efficiency of seed production and breeding system at various levels and for various economic entities, it is proposed to use qualitative and quantitative indicators. The analysis was conducted to evaluate the current state of seed production and breeding system. Its results show that this system is inefficient at the level of the country and regions, which is confirmed by qualitative and quantitative indicators. At the same time, a fairly high efficiency of seed production is observed in seed-producing organizations engaged in the production and sale of seeds of grain crops.

INTRODUCTION

The system of seed production is based on scientific, methodological, technological, organizational and economic principles that allow it to be market-adaptive, integrated into the global seed market and competitive, and to develop in the form of a unified scientific and production complex in three key directions:

1) agrobiological (improving the technologies for the production of high-quality seeds);

2) ecological (determining the optimal soil and climatic zones for the placement of seed production and using non-genetically modified seeds);

3) organizational and economic (improving the structure of the seed production system and economic relations between producers and buyers of seeds).

MATERIALS AND METHODS

The object of research was represented by agricultural producers of the Central Chernozem Region engaged in creation of berry fields and fruit production.

The study used a systematic approach, including such methods as the monographic method, methods of comparison, program-targeted method, and dynamic analysis.

Generalization and systematization of the principles for the organization and functioning of the seed production system from literary sources allowed formulating the principles that make the system function efficiently in modern conditions. The following principles can be defined as fundamental:

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- principle of consistency (ensuring the interconnection of all elements within the system);
- principle of resource concentration (a limited amount of resources is concentrated in the priority areas of development of the seed production system);
- principle of continuity (orientation towards ensuring the continuity of reproduction of all elements of the system);
- principle of competitiveness (varieties and hybrids introduced into the market should be competitive compared to the seed material already in use);
- principle of balance (maintaining the optimal proportions between the supply of seed material of parental forms, superelite, elite and seeds of various reproductions);
- principle of adaptability (new varieties and hybrids should be adapted to the conditions of specific natural and climatic zones of their cultivation);
- principle of economic feasibility (the cost of creating varieties and hybrids should provide an adequate increase in the efficiency of their use) (see Figure 1).

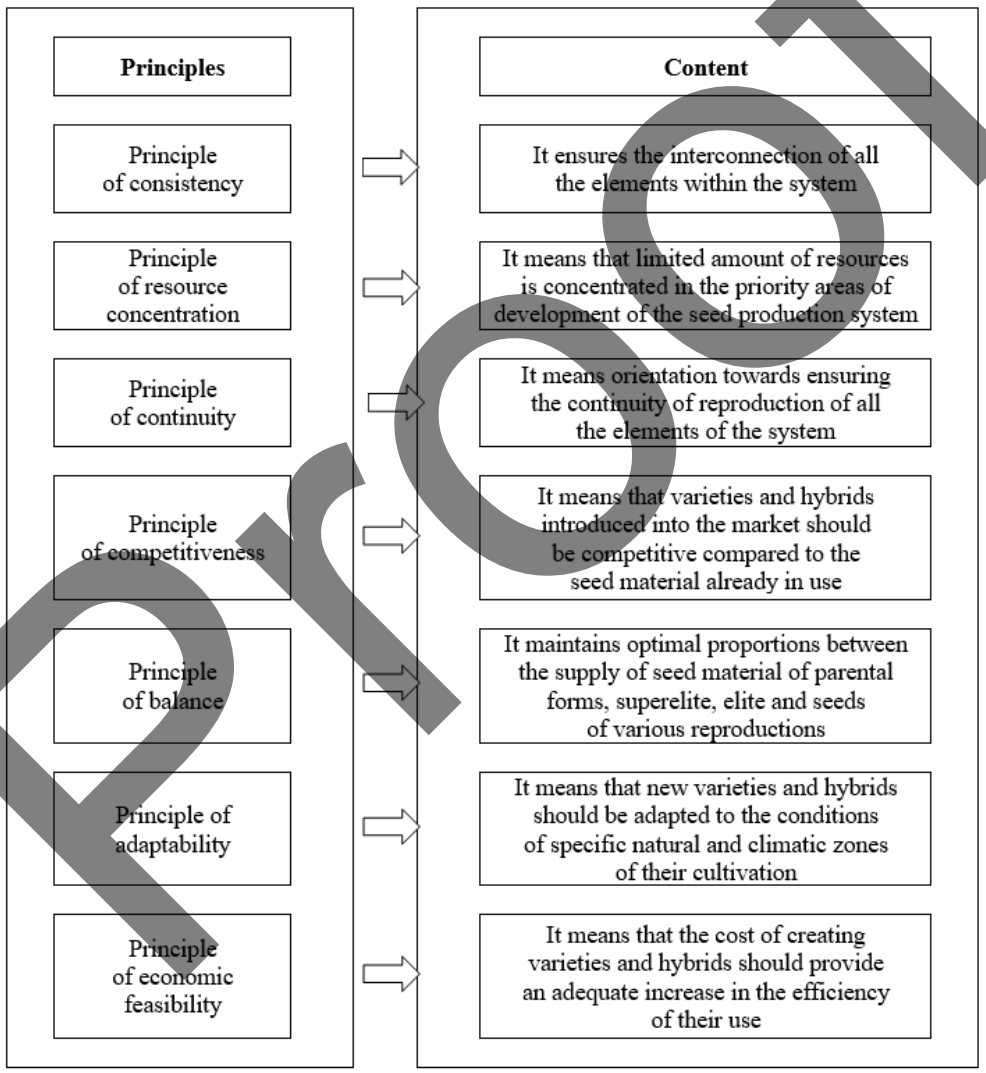

FIGURE 1. Basic principles of the seed production system organization and functioning
Reference source: compiled by the authors [1].

One of the most important principles of functioning of the seed production system is the principle of economic feasibility, which determines many others: e.g. the possibility of continuous seed production, the possibility of

breeding new varieties adapted to the conditions of specific natural and climatic zones, and the ability of varieties and hybrids to compete in the national and foreign markets [1].

The efficiency of the seed production system should be considered at different hierarchical levels and from the point of view of different interests, which sometimes do not coincide. It is also necessary to take into account the interests of the state, the creators of varieties, seed producers, and industrial consumers of seeds. To assess the efficiency of the seed production system, it is advisable to use a system of indicators that will differ for each level and set of economic entities. In addition, quantitative indicators are more acceptable at one level, while qualitative indicators would be more acceptable at another level. Based on the results of the analysis performed the authors substantiated the qualitative and quantitative indicators, which, to a certain extent, characterize the seed production system in Russia.

In our opinion, alongside with quantitative indicators, the analysis of efficiency of the seed production system at the country level should take into account the qualitative indicators, which in most cases are leading. It is the qualitative indicators that subsequently determine the changes in quantitative indicators in one direction or another. For instance, a decrease in the consumer satisfaction index for domestically grown seeds leads to an increase in the share of use of imported seeds with an increase in their sales. This can be reflected in an increase in the dollar value of seed imports at the country level, or an increase in the cost of seeds in the cost of production at the level of agricultural producers. The growth of the satisfaction index of state-supported seed enterprises is reflected in the quality of seed material, the volume of seed production, their sales, and competitiveness of domestically grown seeds. The growth of the index of satisfaction of breeding institutions in the legal support of royalty collection contributes to an increase in the number of domestic varieties and hybrids in the state register, etc [1. 2. 3].

Qualitative indicators allow determining the cause, while quantitative indicators are already the result of certain faults in legislation, state regulation, and allocation of budgetary funds. Timely monitoring of qualitative indicators predetermines the deterioration or, conversely, improves the quantitative indicators. Quantitative indicators can be represented as

- natural (production volumes, sales volumes, number of registered varieties, etc.);
- cost (gross output value, net income amount, etc.);
- absolute (state support amount, profit amount, etc.);
- relative indicators (growth rates, increment rates, indices, profitability, etc.).

Usually, to assess qualitative indicators, researches resort to the help of experts (expert assessments of specialists, conduct questionnaires, oral surveys, establish feedback (consumer reviews) and other research methods. In addition, various ordinal scales are used to measure qualitative and quantitative indicators.

Assessing the efficiency of seed production and breeding system at various levels and for various economic entities, it is proposed to use the following qualitative and quantitative indicators (see Table 1).

It is also necessary to note the interrelation between the elements of reproduction depends on:

- natural and climatic conditions;
- the use of labor and material resources;
- the allocation of funds for other programs that determine the volume of production (amelioration, gypsum treatment, etc.);
- intensification of production, etc.

However, most indicators are specific and reflect the efficiency of development of seed production system.

Most seed breeding and producing centers based on state institutions are being built at the expense of budgetary funds. The efficiency of these projects can be determined using the well-known method of discounting costs and cash flows by the time they are spent and received. When evaluating such projects, it is important to determine not only commercial, but also other types of efficiency, such as economic, social, and budgetary that are manifested through the creation of skilled jobs, tax revenues to the budgets of various levels, and most importantly, through the country's food independence [3].

RESULTS AND DISCUSSION

We have attempted to determine the qualitative and quantitative indicators that characterize the efficiency of the seed production system at the level of the country, its individual regions and seed producing organizations (see Table 2).

TABLE 1. Indicators for assessing the efficiency of the seed production system at various levels

Indicators	Characteristics of Indicators
	At the level of country and regions
Qualitative	Index of satisfaction with domestically grown seeds
	Index of satisfaction with state support
	Index of satisfaction with legal support of royalty collection
Quantitative	Share of domestically grown seeds in the volume of seed fund
	Share of imported seeds in sowing
	Production of products per 1 ton of seeds
	Share of cost of seeds in the cost of production of crop products
	Volume of state support within Federal Research and Development Programs relative to the number of registered domestic varieties and hybrids in the state register of breeding achievements
	Rates of growth of seed breeding and growing centers being created
	Share of zoned varieties and hybrids
	Share of elite seeds in the sown area
	At the level of seed breeding institution
Qualitative	Index of satisfaction of agricultural producers with varieties and hybrids of the breeding institution
	Level of satisfaction of demand for seeds in nearby regions
Quantitative	Number of registered varieties and hybrids in the state register of breeding achievements
	Growth rate of royalties being received
	Revenue per 1 ruble of state support
	Level of profitability
	At the level of seed producing enterprise
Qualitative	Index of satisfaction of agricultural producers with seeds
	Index of satisfaction of agricultural producers with service packages provided for purchased seeds
Quantitative	Growth rates of volumes of sold seeds of various quality
	Cost of 1 centner of seeds of various quality
	Growth rate of revenue from seed sales
	Revenue per 1 hectare of land
	Profitability of production activities
	At the level of agricultural producers
Qualitative	Index of satisfaction of agricultural producers with the choice of varieties and hybrids
	Index of satisfaction of agricultural producers with the provided state support
Quantitative	Growth rates of crop production when using new varieties
	Economic efficiency of introducing new varieties
	Profitability of production activities

Source: compiled by the authors.

TABLE 2. Assessment of efficiency of the seed production system at the level of the country and regions as of 2020

Indicators	Russia	Oblasts		
		Belgorod	Voronezh	Lipetsk
Share of domestically produced seeds in the volume of seed fund, %	62.7	n/a	n/a	n/a
Share of imported seeds for sowing, %:				
grain crops	4.5	4.8	5.6	4.3
sugar beet	90.0	100.0	99.0	100.0
maize	46.0	80.0	92.0	78.0
Production of spring grains and leguminous crops per 1 ton of seeds, t	8.2	28.2	16.0	22.2
Share of cost of seeds in the cost of grain production, %	9.2	17.6*	11.9	17.6*
Cost of seeds per 1 centner, rubles	111	128*	82	128*
Number of granted patents for breeding achievements, total:	796			
Russian	630	n/a	n/a	n/a
foreign	166			
Number of seed breeding and producing centers being created, % (2020-2025)	15	3	2	1
Share of conditioned crops in spring grain and leguminous crops, %	97.3	100.0	100.0	100.0
Share of elite seeds in the sown area of spring grain and leguminous crops, %	13.7	3.8	10.4	3.3

* - average for the Central Federal District; ** - 2021.
Source: generalization and calculations of the authors based on [3, 4, 5, 6, 7, 8, 9].

The conducted research shows that the qualitative indicators characterizing the efficiency of the seed production system at the country level remain at a low level, which is manifested through non-competitiveness of domestically grown seeds for industrial crops and maize and through the aging of material and technical base, migration of qualified specialists to private organizations, and violation of legislation in terms of seeds use. Quantitative indicators are in line with the qualitative ones, and as previously noted, the target figures for the provision of domestically grown seeds determined by the Doctrine and Federal Research and Development Programs are still unachievable. The cost of seeds import is increasing, the share of cost of seeds in the cost of production is high, the number of registered domestic varieties and hybrids in the state register of breeding achievements is much less than foreign ones, etc. Despite the constant search for more effective state regulation in the form of subsidies [10], the allocated funds do not interest seed breeding and producing organizations in expanding their activities [11].

It should be noted that at present there is no complete official data for calculating the economic efficiency of seed breeding and production at the regional level.

Considering the efficiency of seed production for individual agricultural crops and seed-producing institutions, alongside with low figures positive aspects can be noted. They are associated with the emergence of new varieties and their ability to be zoned in many regions of the country, unlike the varieties of foreign breeding. Such seeds are offered at a lower cost.

We have analyzed the economic efficiency of grain maize production in agricultural enterprises of Krasnodar Krai.

TABLE 3. Economic efficiency of grain maize cultivation in agricultural organizations of Krasnodar Krai.

Indicators	Average for periods, years:	
	2013-2015	2016-2018
Yield, c/ha	58.2	57.6
Material and monetary costs per 1 ha, rubles/ha	26,847	32,931

Continuation of TABLE 3.

Cost of 1 ton, rubles	**4,609**	**5,764**
Selling price of 1 ton, rubles	6,800	8,169
Net income per 1 ha, rubles	12,756	14,151
Profitability level, %	48	43

Source: [12].

Seed production in the agricultural organizations of Voronezh Oblast functions differently. For instance, Scientific and Production Commercial Firm Agrotech-Garant Berezovsky sells seeds of grain and industrial crops, which are purchased by this enterprise and tested in the fields of farms that are part of Agrotech-Garant group of companies. Independent experiments are carried out in the fields of the enterprise, cultivation technology is being improved, protection products are being selected, etc. The enterprise sells the seeds of the first reproduction obtained in its own fields from elite seeds. Scientific and Production Commercial Firm Agrotech-Garant Berezovsky sells hybrids of seeds of sugar beet, sunflower and maize from global producers such as SESVanderHave, Limagrain, MAS Seeds, Euralis Semences and Caussade Semences.

Other enterprises (e.g. CJSC Agrofirma Pavlovskaya Niva, CJSC Zemlyanskoye) have developed their own seed breeding and production for many grain crops. CJSC Agrofirma Pavlovskaya Niva is a seed producing enterprise and a member of the National Union of Plant Breeders and Seed Producers of Russia. This enterprise has its own breeding and seed producing center and a State Variety Test Plot, which allow producing and selling of up to 6 thousand centners of winter crop seeds and up to 10 thousand centners of spring crop seeds. The seed producing plant commissioned in 2012 is equipped with modern equipment by Gimbria (Denmark). A large amount of source material is purchased from breeders. For some varieties (there are already 10 of them) the enterprise is the originator (Snigurka winter wheat, Astarna, Ataman peas, Usatiy Kormovoy peas, etc.). More than 60 new varieties of winter wheat are tested every year. The enterprise participates in breeding programs of both domestic and foreign breeding centers, selecting from their material the samples that show the best results in the conditions of the Central Chernozem Region. Joint developments are carried out with the Republican Unitary Enterprise "Scientific and Practical Center of the National Academy of Sciences of Belarus for Agriculture" and Federal State Budgetary Scientific Institution Vladimir Research Institute of Agriculture. In addition to the farms in the Central Chernozem Region, seeds are sold to Penza Oblast, Mordovia, Crimea and other regions with positive customer feedback. The enterprise also offers professional agronomic support and sells the necessary means of protection. Seed treatment services are provided upon prior request.

As noted above, seed producing enterprises in the region are mainly engaged in the production and sale of seeds of grain crops, offering seeds of various categories for sale (see Table 4).

The indicators characterizing the efficiency of seed production in these enterprises are presented in Table 5.

TABLE 4. Varietal composition and categories of winter wheat seeds for sale in CJSC Zemlyanskoye, CJSC Agrofirma Pavlovskaya Niva and SPCF Agrotech-Garant Berezovsky.

Name of variety	CJSC Zemlyanskoye	CJSC Agrofirma Pavlovskaya Niva	SPCF Agrotech-Garant Berezovsky
Bezostaya 100	Second reproduction	Elite, first reproduction	Elite, first reproduction, second reproduction
Grom	Elite, first reproduction	Elite, first reproduction	Elite, second reproduction
Gubernator Dona	Elite	first reproduction	
Inna	Elite		
Moskovskaya 40	Elite		
Severodonetskaya Yubileynaya	Elite, first reproduction		First reproduction, Second reproduction
Skipetr	Elite, first reproduction	Elite, first reproduction	
Alekseich		Elite, first reproduction	Elite, first reproduction, second reproduction
Vela			Elite
Lipetskaya Zvezda			Second reproduction
Tarasovskaya 70			Elite, first reproduction

Continuation of TABLE 4.

Timiryazevskaya 150	**Elite**

Source: according to the data provided by specialists of agronomic service of enterprises.

TABLE 5. Efficiency of winter wheat seeds production and sales, 2016-2020.

Indicators	CJSC Zemlyanskoye	CJSC Agrofirma Pavlovskaya Niva	SPCF Agrotech-Garant Berezovsky
	2016		
Yield, c/ha	35.6	41.1	33.5
Revenue per 1 ha, thousand rubles	2.8	8.5	9.8
Profitability, %	5.9	18.6	23.6
	2017		
Yield, c/ha	33.7	48.5	30.6
Revenue per 1 ha, thousand rubles	2.9	88.2	10.1
Profitability, %	6.1	22.4	29.8
	2018		
Yield, c/ha	53.0	39.9	47.5
Revenue per 1 ha, thousand rubles	17.8	13.4	36.4
Profitability, %	37.5	35.6	56.2
	2019		
Yield, c/ha	55.5	44.1	42.0
Revenue per 1 ha, thousand rubles	28.8	10.7	15.4
Profitability, %	72.7	42.9	25.4
	2020		
Yield, c/ha	69.0	47.7	66.3
Revenue per 1 ha, thousand rubles	43.5	31.9	36.1
Profitability, %	88.6	66.3	44.4

Source: calculations of the authors based on annual reports of agricultural enterprises of Voronezh Oblast.

CONCLUSION

The performed analysis showed high efficiency of production and sale of seeds in seed producing organizations of Voronezh Oblast. Approximately the same profitability, which allows for expanded production, is observed in the seed producing enterprises of Lipetsk and Belgorod Oblasts. Unfortunately, this situation is typical only for seed production of grain crops, while there are no examples of efficient seed production of industrial crops. The operating seed producing enterprises mainly provide seeds to agricultural producers in the region, without increasing supplies to other regions of the country, not speaking about entering foreign markets.

The efficiency of use of new varieties and hybrids at the level of agricultural producers is high, since new varieties are more resistant to drought, frost and lodging, which allows obtaining high results under these unfavorable conditions.

In order to increase the efficiency of the seed production and breeding system, it is necessary to strengthen the organizational, economic and legal support for its development [13]. Many provisions are laid down in the Federal Scientific and Technical Program for the Development of Agriculture for 2017-2025 and the Science national project. Some of them are currently being implemented, which will increase the efficiency of seed production in Russia.

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The Formation and Development of Priority Exports of Organic Products of Agro-Industrial Complex of the Urals Region

David R. Krichker [a] and Olga A. Ruschitskaya

Ural State Agrarian University, Yekaterinburg, Russia

[a] Corresponding author: vetkek@mail.ru

Abstract. The purpose of the article. Analysis of the prospects for forming and expanding the geography and nomenclature of exports of organic agricultural products from the Ural-Siberian region. Methods. To solve the tasks set in the article, justification and argumentation of theoretical provisions and practical recommendations, general scientific and specific research methods were used: methods of comparative, abstract-logical, factor analysis and synthesis, methods of expert evaluations, modeling and forecasting, economic and statistical methods. The logical basis of the analysis is the comparative-legal method, the method of economic-legal analysis, the method of analogy, the method of modeling and analytical methods of research. Commodity and country analysis of agro-industrial exports from Russia over the past few years on the basis of data from the Federal Customs Service of Russia. The grouping by the main countries-importers of agricultural products from Russia, where the top three are the European Union, Turkey and China, and from the Ural region, where the top three look differently: Kazakhstan, Uzbekistan and China. The growth of the share of organic products in the global food market was studied. Scientific novelty of the work lies in the analysis of the significant growth in the volume of the organic market outside the traditional area of consumption in Europe and the United States at the expense of emerging economies in Asia (primarily China) and the features and differences in regulatory and legal regulation of organic food in China, compared with the European Union and the United States. Recommendations for agricultural producers of the Ural macro-region on the choice of commodity nomenclature of agro-export and logistics technologies and directions of product supply are formulated. The practical results of the work consist in substantiating the thesis that the development of new export markets and modern logistics technologies will allow exporters of traditional and organic agricultural products of the Urals region to significantly increase the volume and profitability of their production. The article substantiates the need for exporters of the Urals region to use the Trans-Caspian routes of the International Transport Corridor "North-South" and logistics technologies of "agroexpress trains" and container trains to obtain competitive advantages over suppliers of Southern Russia and the Far East, located closer to the ports and border crossings.

INTRODUCTION

The relevance of the topic of the research is determined by the fact that in the conditions of increasing foreign economic and foreign policy pressure on Russia, the domestic agro-industrial complex faces such strategic tasks as ensuring food security, sustainability of development of the country as a whole and its remote regions, as well as increasing the export of Russian agricultural products to world markets by increasing the efficiency of production, logistics and sales of products. And the solution of these tasks becomes fundamentally important for the stable and progressive development of the country for many years to come.

Multibillion-dollar investments in agricultural production in the last 10 years in the Russian Federation [2], on the one hand, and the stagnating incomes of the majority of the population [3], on the other hand, led the largest Russian producers of agricultural products and food to the classic crisis of overproduction [1] and to the need either to reduce the prices and profitability of their products, or to seek new markets for them. In this regard, at the state level the task of the industry to ensure food security of the country, after its successful solution for the main food groups [1], was replaced by the task of expanding exports of Russian agro-industrial complex products, solving both the problem of

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maintaining the level of profitability of new production facilities and preserving jobs at them, and the problem of diversifying the range of export from the Russian Federation to reduce dependence of its economy and budget income on hydrocarbon export.

In recent years the Russian Federation has successfully achieved the food security targets set by the State Program in almost all key areas: grain, vegetable oil, sugar, meat and meat products. As a result, the topic of international division of labor in the world agricultural and food market and Russia's participation in it comes to the forefront of the industry's work.

The present article will be devoted to the analysis and parsing of product niches for Russian agro-export in the world market and the prospects of foreign economic activity of agricultural and agro-industrial companies and enterprises of the Ural macro-region. Let us dwell in more detail on the analysis of the situation on the specific market of organic food.

The relevance of the topic of the study is also due to the need for comprehensive development of new directions and mechanisms to qualitatively improve the efficiency of production and marketing of products in the Russian agriculture, aimed at the successful solution of the tasks set as to provide organically clean food at affordable prices for the entire population of Russia and the food security of the country, and to achieve indicators of agroexport and increase the share of Russia in world agricultural markets.

The scientific novelty of the article includes the following results.

1. The substantiation of the thesis that the development of new external regional markets and export directions and modern logistics technologies will allow exporters of traditional and organic agricultural products of the Ural-Siberian macro-region to significantly increase the volume and profitability of their products.

2. Justification of the economic efficiency of using modern mechanisms of state support for exports and alternative financial instruments in the settlement of export-import operations in new markets and supply directions, in the conditions of sanctions restrictions.

3. Analysis of the growth of volumes of foreign markets of organic products outside the traditional area of its consumption in Europe and the USA, at the expense of developing economies in Asia (primarily China), and the peculiarities and differences in the legal regulation of production and sale of organic food in China, compared with the European Union and the United States. Practical recommendations for agricultural producers of the Ural-Siberian macro-region, planning to enter the world market of organic products.

4. Justification of the need for exporters of the Ural-Siberian macro-region to use the Trans-Caspian route of the International transport corridor "North-South" and new logistics technologies of Russian railroads: "agroexpresses" and container trains (including for bulk and liquid cargo), not yet developed by competitors - traditional suppliers of agricultural products from Russia, and carriers to obtain competitive advantages over suppliers of southern Russia and the Far East.

The practical significance of the scientific results of this study consists in the development of recommendations for producers on the use of new export directions, instruments of its state support, new financial and monetary mechanisms and logistics technologies for export-import deliveries of agricultural products.

METHODS

The theoretical and methodological basis of the article is based on the works and studies of domestic and foreign academic economists devoted to cross-border commodity flows of agro-industrial products and the growing popularity of organic agriculture products. The information base of the research is statistical data of the Federal Customs Service, the Ural Customs Administration, the Analytical Department of the Russian Export Center, the Institute for System Research in the Agricultural Sector of the National Academy of Sciences of Belarus, materials of scientific and practical conferences, periodic and special publications on the topics under consideration.

The United Nations (UN) 2030 Agenda and its 17 Sustainable Development Goals are designed to ensure a better and more sustainable future for all. These goals address the global challenges facing the global community, including the eradication of hunger and poverty and the restoration and sustainable use of natural resources. The goals bring together all three dimensions of sustainable development--the economic, social, and environmental--with closely interlinked objectives.

Sustainable agriculture, with the goal of increasing food production and employment in poor countries, is central to the UN's 2030 Agenda. Its links to food security, economic growth, employment and poverty eradication, environmental protection and natural resource management, and nutrition and health are reflected in most development goals.

World agricultural and food trade has changed significantly over the past 20-30 years. In real terms, it has more than doubled between 1995 and 2018, from $680 billion in 1995 to $1.5 billion in 2018. In real terms, it more than doubled between 1995 and 2018, from US$680 billion in 1995 to US$1.5 trillion in 2018 (in constant prices). In 2018 (at 2015 prices). Food trade averaged 7.5% of total trade over this period. This growing trend peaked with the 2007-2008 food price crisis and was abruptly interrupted by the 2008 financial crisis and subsequent global recession. Although trade recovered after 2-3 years and commodity prices rose again, the global economic slowdown had a significant impact on both trade and commodity prices. Emerging economies such as India and China have been particularly affected. Since 2014, the decline in agri-food trade in value terms has been mainly due to falling commodity prices and exchange rate fluctuations, and from 2016 to 2018, the growth rate has partially recovered. And in 2019-2021, growth continued amid the coronavirus pandemic.

At the same time, experts estimate that the new pandemic and its impact on the global economy is expected to have a major impact on trade. The WTO estimates that the COVID-19 pandemic, disrupting economic activity, will cause the volume of global trade in goods to fall by 13-32%. But at the same time, the volume of world food trade will continue to grow [6].

RESULTS

State support for Russian producers and exporters

The main directions of socio-economic development of the Russian Federation for the next ten years are formulated in the well-known Decrees of the President of the Russian Federation V.V. Putin's well-known Decrees No. 204 "On the goals and strategic objectives of the development of the Russian Federation for the period up to 2024" and No. 474 "On the national development goals of the Russian Federation for the period up to 2030".

One of the national projects under the Presidential Decrees was the project "International Cooperation and Export", which includes the federal project "Export of Agricultural Products". According to these documents and the new passport of the project, by 2030 the export of Russian agricultural products should increase to $45 billion. In particular, grain exports are planned to increase 1.5 times to $11.4 billion, fat and oil products - 2.8 times to $8.6 billion, food and processing industry products - 2.5 times to $8.6 billion, fish and seafood - 1.9 times to $8.5 billion, meat and dairy products - 4.7 times to $2.8 billion [5].

It is noteworthy that, since 2016, the foreign exchange earnings of the Russian Federation from the export of agricultural products have steadily exceeded the earnings from the export of arms. It should also be borne in mind that, according to the commodity nomenclature of the Foreign Economic Activity, the products of the agro-industrial complex are not classified as raw material exports.

According to the data of the Russian Export Center, Table 1 shows the dynamics of growth of exports of the agroindustrial complex from Russia from 9.3bn dollars in 2010 to 30.6bn dollars in 2020.

By the end of 2021, Russia again became a net exporter of products of agro-industrial complex. Shipments abroad exceeded a record $37.7 billion, compared to $30.6 billion in 2020. In physical terms, shipments amounted to 71.1 million tons. The average price of exported products rose from $384 to $552, or 44%. Industry analysts attributed such growth to a sharp increase in world prices of all agricultural and food products.

The EU became the main buyer of Russian agro-industrial complex's products (after customs statistics consolidated all buyer-countries of the EU). Export there increased by 41% to $4.7 bln. Turkey came second with 38% growth in purchases to $4.3 bln. The EU share in the total supplies was 17%. Turkey was slightly behind with a share of 16.6%. China reduced imports by 12% to $3.55 billion and came in third, the country's share in exports was 10.5%. Kazakhstan ($2.8 billion) and South Korea ($2.5 billion) were also among the biggest buyers in 2021.

A reservation is needed here that since 2021 the customs statistics of Russian exports do not include Kazakhstan (formerly the top three importers of Russian agro-industrial products) and other countries of the Eurasian Economic Union, since the circulation of products within the common EurAsEC market is free (duty-free) and the data are taken from other sources.

TABLE 1. Export of food from Russia.

year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
amount, $ bln	9.3	13.3	16.7	16.2	18.7	16.2	17	20.6	24.8	24.6	30.6	37.7

Commodity structure of agro-exports from Russia

The dynamics of agro-export from Russia over the past decade can be assessed according to the Federal Customs Service. Export of foodstuffs and agricultural raw materials has increased 2.6 times since 2011, while other growing sectors of the Russian economy have shown a maximum increase of 20% (e.g. machine-building and timber segments). But purely raw materials exports of mining industry and fuel and energy commodities halved in 10 years, metal exports decreased by 1.2 times, chemistry - by 20%. [7] Thus the task of reducing the dependence of federal budget revenues on oil and gas exports is being fulfilled.

Today, exports are primarily those types of food products that Russian agrarians produce in volumes exceeding domestic demand. These are grains (wheat, barley, oats, etc.), sugar, vegetable oil, potatoes, as well as poultry and pork.

At the moment the main products of Russian exports are grain, 6 percent of the world market, fish and vegetable oil, about 3 percent each, and meat, 1 percent. In the last 1-2 years the biggest growth was shown by the supplies of sugar and confectionery products - nearly twofold, meat and edible meat offal - by 45%, cereals, ready-made meat and fish products, fruit and nuts - by one third.

Russian pork and poultry have good prospects on the world food market. In 10 years pork production in Russia has grown by 326% and poultry meat - by 183,1%.

The structure of exports of agro-industrial products in 2020, remained without major changes. Cereals still account for the largest share of shipments in value terms - 34% (in 2019 - 31%). Fish products and seafood are also in second place in terms of shipments, although this category now accounts for 17% versus 21% in 2019. The share of fat and oil products is unchanged at 16%. Goods of food industry and agricultural raw materials processing in the total structure in 2020 reached 15% (in 2019 - 16%), other agro-industrial products - 14% (13%). The meat segment increased its share to 3% from 2%.

In the structure of shipments to foreign markets in 2021 dominated cereals - 43 million tons worth $ 11.4 billion. A year earlier shipments were 48.9 million tons worth $ 10.2 billion. The driver was the segment of fats and oils: its export increased by 48% to $ 7.28 billion, although in terms of volume supplies decreased from 8 million to 7.6 million tons. Shipments of fish and seafood increased by 37% to $7.3 billion, meat and dairy products by 31% to $1.6 billion, food and processing products by 15% to $5.2 billion, and other agricultural products by 12% to $4.9 billion. [7]

These positive results are, among other things, a consequence of the government's efforts to open the borders of Southeast Asian countries to Russian meat. The main growth in Russian meat exports came from countries such as China, Saudi Arabia, and Belarus.

Country structure of agro-exports

According to the Federal Customs Service of Russia, Russian agro-industrial products were exported to 149 countries in 2020. China remains the largest buyer of Russian food products in 2020, its imports amounted to 2.2 million tons worth $1.9 billion, a 35% increase over the same period in 2019. As a result, China's share of Russia's total agro-export increased to 15% compared to 13% in 2019. Already since 2018. China ranks first in the world in imports of soybeans, beef, frozen fish, second in imports of rapeseed, rapeseed and sunflower oil, crustaceans, third in imports of oats and pork, and fourth in imports of soybean oil. [18] Although the supply of Russian agro-food products to China has increased markedly (up to $4 billion in 2020), Russia ranks only ninth in this market. Despite the difference in the forecasts of industry experts, there is no doubt that the Chinese market is very attractive for Russian suppliers of agri-food products, given the annual increase in demand over the next decade from 1.5% to 6% for certain commodity items. [8]

Turkey ($1.5 billion, +42%) is in second place among importers of Russian agricultural products, while Kazakhstan ($974 million, +20%) is in third place. Vegetable oils and grain crops were the growth drivers, as well as significant growth was recorded in the export of meat and sugar.

Country structure of agro-exports from Russia in 2020:

TABLE 2. Country structure of agroexport

Country	*Share, %*
China	*15*

Continuation of TABLE 2.

Turkey	***10***
Kazakhstan	*6.8*
Egypt	*6.4*
South Korea	*5.7*
Belarus	*4.7*
Netherlands	*3.4*
Ukraine	*2.5*
Azerbaijan	*2.3*
Saudi Arabia	*2.3*

A lot of articles have been written on the topic of supplies of the main crop of Russian export - wheat, and since the Urals region is rather a net importer of grain crops, we will not dwell on it in this article.

For the agro-industrial complex of the Urals region, first of all, exports of meat, dairy and fat and oil products, including those produced according to organic standards, according to the recently adopted federal law, are of interest, and it looks as follows.

Exports of meat products in 2020 showed the highest growth rate among the major categories of food products. For the year, the physical volume increased by 53% and amounted to 525 thousand tons. In monetary terms, shipments reached $887 million, 49% higher than in 2019.

According to the FCS, poultry meat shipments increased by 40% to 296 thousand tons in physical terms and by 31% to $429 million in value terms, mainly due to an almost tenfold increase (in 2 years) in sales to China.

Pork exported more than 200 thousand tons (+87%), worth $336 million (+91%), beef - 16 thousand tons (2.7 times more), worth $88 million (3.1 times more). These figures were partly the result of the outbreak of African swine fever in China, when 700 million pigs had to be destroyed as part of the fight against the epizootic.

China remains the largest importer of Russian meat. Supplies of poultry meat to this country, which began in February 2019, by the end of 2020 increased 2.3 times to 146 thousand tons worth $265 million (1.8 times more). In the same year, exports to the Chinese market of Russian beef began, the shipped volume was 8.7 thousand tons worth $ 48 million, or more than 50% of all Russian exports of cattle meat. [8]

Several Russian companies have begun exporting poultry meat to Saudi Arabia, Kuwait, and have increased shipments to the UAE, although the share of these countries in total volume is still small. However, there are good prospects for growth in the supply of meat and dairy products to the markets of these countries.

The first place in purchases of Russian oil and fats is also held by China, which increased imports by 1.8 times to 1.1 billion dollars. Sunflower oil accounted for more than a half of it ($565 million, 771 thousand tons), rapeseed oil - 23% ($253 million, 282 thousand tons), soybean oil - 22% ($244 million, 328 thousand tons). For all three types of oils China is the leader among importers. In addition, Russia began to supply China with soybean meal and sunflower meal (14 million dollars, 31 thousand tons, respectively).

The second position is held by Turkey, which increased its purchases by 26% to $553 million. During the year, the country supplied 645 thousand tons of sunflower oil worth $456 million (+34%), 493 thousand tons of meal and cake worth $97 million (-2.2%), and 126 tons of margarine worth $102 thousand (no deliveries in 2019).

Also in the top 3 importing countries is India, which increased imports of Russian oil and fats products by 2.2 times to $364 million. Sunflower oil accounted for more than 90% of the volume, with purchases doubling to $333 million (460,000 tons). [9]

An important factor for export development in the future, according to industry experts, will be to solve the issue of Russian meat and dairy products supplies by rail to China, especially to its northern, northwestern and central provinces. Russian transportation and logistics companies have already presented their proposals for new routes and transportation technologies for export to China on the fields of the four Russian-Chinese EXPOs. These include accelerated container trains and "AgroExpress" trains, which will deliver products in refrigerated containers and flexitanks from Moscow Region to China in 7-10 days. [10] These trains pass through Yekaterinburg, Tyumen, Omsk, and Novosibirsk, where it is possible to hitch additional platforms with containers to the train. In this case, if at the

beginning of the route expedited transportation technology requires the formation of a train - at least 10 platforms with two 20-foot or one 40-foot containers, the subsequent stations on the route can be added and one platform, which greatly simplifies the start of shipments for export for small and medium businesses in the Urals and Siberia. The project "Eurasian Agroexpress" launched by JSC "Russian Railways Logistics" together with the major railway operators in China and Central Asia provides a digital system of agro logistics, continuity of cold chain and preservation of quality of food products during transportation in the space from Brest (Belarus) and Moscow to Beijing and Chengdu (PRC) and to the capitals of all Central Asian countries and Iran in the near future. The digital agro-logistics system and accompanying agreements of the EAEU and SCO countries make it possible to minimize the time of passing border stations and customs procedures, including through the use of a single digital bill of lading and the transfer of most of the control and inspection procedures to the initial and final stations of the AgroExpress routes, which allows the delivery of agricultural products in 10-14 days, many times faster than by sea transport through the Suez Canal or other traditional routes.

Prospects for exports of organic agricultural products from Russia

Separate attention deserves the world market for organic products, today - one of the fastest growing in the world. From 2000 to 2019, it grew more than sevenfold (from $18 billion to $129 billion), showing maximum growth in 2018-2019 of more than 16% per year. Grand View Research predicts the market will continue its growth at a rate of 10-12% per year and reach about $212-230 billion in 2025. Experts say that by 2025, the market for organic products could be 3 to 5% of the global food market. Historically, the largest national markets are the U.S. ($ 44.7 billion per year), Germany - $ 12 billion and France - $ 11.3 billion.

Most experts believe that the growth of the world population (according to the UN, 8.6 billion people will inhabit the planet by 2030 and almost 10 billion by 2050), and the average level of welfare (expected growth of GDP per capita - an average of 40-50% by 2030-2035 years) is inevitable. These factors alone are powerful drivers of increased demand for food around the world (by 2050 it will grow by 60-70% compared to 2000). At the same time, demand itself is highly heterogeneous. In particular, experts highlight the fast-growing niches of functional and eco-products (mainly in the rich countries of the West): according to estimates of the Institute of Statistical Studies and Economics of Higher School of Economics, the market for functional products by 2020 will be $ 305 billion with an annual growth rate of about 8.5%. Unless, of course, the situation in developed countries will not be affected by the coronavirus pandemic, the effects of economic sanctions against Russia and the unfolding against this background of the economic crisis of the American-centric model of world economic development.

The basic principles of organic agriculture are fixed in the Codex Alimentarius standard "Guidelines for the production, processing, labeling and sale of organic food" (GL 32-1999), developed by the UN Food and Agriculture Organization (FAO) and the World Health Organization (WHO) to unify requirements for organic products at the international level, the promotion of organic production and international trade. Legislatively organic agriculture is regulated in 103 countries around the world, and the number of states with legislation on organic farming, livestock and food production continues to grow.

As part of the creation of a system of organic production in the EAEC countries, corresponding to international requirements in the current period, the provisions of the CIS interstate standard GOST 33980-2016 "Organic products. Rules of production, processing, labeling and sales" are considered for inclusion in the family of IFOAM standards. In this regard, of particular importance is the application of international experience in the EAEU countries to form the requirements for organic agriculture and the organization of follow-up control of compliance with such requirements by producers. This will greatly facilitate the access of organic products produced in the EAEU to the premium international markets, primarily in Western Europe and China.

The main resource for the production of natural products is agricultural land, uncontaminated by excessive amounts of fertilizers and toxic chemicals. According to the Research Institute of Organic Agriculture (Research Institute of Organic Agriculture (FiBL) - an independent international research organization) [16], about 1% of all agricultural land in the world received organic certification. The largest areas of such land are concentrated in Australia (17.2 million hectares according to the latest data, while the vast majority of them - pastures for free grazing cattle and cattle), and the largest share of organic land from all agricultural areas in the EU has Austria - 19.4% (where also a high proportion of alpine mountain pastures for meat and dairy cattle).

70% of all organic land is used for livestock grazing, it is this type of use sets a high rate of organic certification and it is associated with a threefold gap Australia from standing in second place in the area of organic land in Argentina. Livestock grazing is the main type of land use after organic certification - it is growing twice as fast as the

others. Transferring pasture to organic management is the easiest solution with minimal risk for farmers to sell "red meat" (beef, lamb, venison, etc.) at a higher markup. The conversion of arable land and, moreover, perennial crops to "organic" involves a much more balanced decision from the farmer, because it requires a more serious expenditure of time and finances.

For Russia, Australia's experience in organic certification of pastures may be quite relevant, given the huge areas of fallow land in the Non-Black Soil region, the Urals, the Far East and Siberia, and the lag from the standards of food security, just in the production of "red meat" (beef and lamb).

In Russia, as of 2020 the area of agricultural land officially certified for organic production, is about 250 thousand hectares, or about 0.2% of all cultivated land (mostly arable land). According to recent data, Russia ranks 3rd in the world in terms of growth of certified organic farmland. But based on international estimates of the amount of unused agricultural land, Russia could easily take first place if it puts the certification of agricultural land for organic production on a regular basis.

In Russia, the Law on Organic Products was not passed until August 3, 2018 and went into effect on January 1, 2020. Despite this, from 2010-2014 the Russian market showed a fairly intense growth - on average 10% per year, but the crisis in 2014 and a number of indirect factors led to the fact that 2015 - 2016 the market has reduced the growth rate to about 4% per year. From 2017-2019 the situation has recovered, now there is a steady growth of 8-10% annually.

In the early 2000s the Russian market amounted to 16 million euros (100% of production was imported), today the country has reached the figure of 192 million euros (20% of which is domestic production). In spite of good relative indexes of growth, in absolute terms Russia's share in the world market is only 0.17%. At the same time, Russia, given the natural conditions, low environmental pollution, development of transport infrastructure, availability of pasture lands has significant potential and prospects for the implementation of organic agricultural production system.

The relatively rapid growth of conversion of land in Russia for organics is associated with active demand, but is still far from saturation - more than 80% of organic products are imported. Russia has great potential for the rapid introduction of new organic land: on its territory there are more than 28 million hectares of fallow cropland, which do not require a 3-year transition period for certification. Most of the producers are large agricultural holdings - the average area of land under one farm is ~7.8 thousand hectares. The organic segment in Russia has a high export potential, already now every third producer is an exporter. [17]

Since the domestic market for organic products is formed in Russia slowly, due to low incomes of the population, it is the export of organic products, will steadily increase its production and ensure its producers a decent level of profitability.

Particular attention, in this regard, deserves the experience of China in the regulation of production and sale of organic products. In China a completely new approach to the market of organic products; as a result, the National Organic Standard of China has become much stricter, more detailed and demanding in comparison with the regulations of the EU and the United States. In March 2012, the updated National Organic Standard of the PRC (GB/T 19630-2011) came into force and is still in force today. By the nature of regulatory documents in China has been taken to protect its own domestic markets. According to the "Organic Certification Management Method", imported organic products must comply with Chinese laws, administrative and industry regulations, as well as the National Organic Standard. Products that are not certified according to China's regulations and requirements cannot be marked with special signs on the packaging. In the domestic market, national certification has become mandatory, otherwise advertising information is considered misleading by the authorities. The growth rate of sales of organic products on the huge domestic market in China shows the highest results in the world, with an annual increase of more than 1 billion euros since 2012. [18] The level of interstate relations between Russia and China and the current vector of their development suggest that the issues of mutual recognition of national documents on the certification of organic products can be resolved as soon as possible. [20, 21] The political will for this is there, it remains to adopt the appropriate legal documents, including in terms of Russian bylaws to the law on the certification of organic production.

Scientists of the Ural State Agrarian University since 2012 have published numerous articles and scientific papers on the introduction of organic production in Russia and its regulatory and legal support. [11, 19] Finally, there comes a period of practical implementation of the scientific ideas and recommendations put forward by scientists.

Currently, total exports of organic products from Russia in value terms is about 1.5 billion rubles, or just over $ 20 million. These figures are an expert estimate, due to the fact that there are no official statistics in this sector, as there are no OKVED codes for organic products. [16]

Although in the period 2026-2030. Russia, according to experts, can achieve figures of 15 billion euros and more [16]. But in the coming years, large producers of organic products will have to focus on export markets. And since, as

a result of economic sanctions announced by European countries and the U.S., their markets will be closed to Russian suppliers, the priority areas of supply are China, India and the Middle East.

DISCUSSION AND CONCLUSION

Features of transport logistics of the Ural region

We traditionally say that the Sverdlovsk region occupies a unique transport and geographic location at the junction of regional and global Eurasian continental transport links. Within the region there is one of the largest railway junctions in Russia, the Yekaterinburg railway junction, located on the main course of the Trans-Siberian Railway and the International Transport Corridor "West-East".

But when we consider the main cargo flows from Russia for export, it turns out that for the Azov-Black Sea and Baltic sea ports (through which in recent years the bulk of food export shipments went) the shippers-exporters of the Urals region are further away than most other suppliers of agricultural products from the Central Black Earth region, the Russian South and the Volga region and their transportation costs will be higher. A possible exception is shipments in the container train Ekaterinburg - Helsinki (on a firm schedule via the border crossing of Buslovskaya station of the October railroad), if the final consignee is in the Baltics or Scandinavia.

Now consider the situation in another popular destination - China, South Korea, Vietnam, and Southeast Asia. Unfortunately, the situation is much the same - for all border crossings from Russia to China east of Krasnoyarsk (Naushki, Zabaikalsk, Leninsk) or seaports of Primorye the transport delivery distance for cargo from the Urals region will be 1-2 thousand km longer than for Siberian exporters of agricultural products (Altai Krai, Omsk, Novosibirsk, Kemerovo Oblast), not to mention suppliers of our Far East. (In addition, it should be borne in mind that almost all the volumes of the announced by JSC "Russian Railways" increase in the capacity of the BAM and Trans-Siberian Railway to 182 million tons by 2024 are already ready to take their products coal exporters from Eastern Siberia and the Far East and suppliers of agricultural products should not count on a significant increase in traffic in the direction of the Far Eastern ports and border crossings.

FIGURE 1. Eurasia Major international transport corridors

The only possible exception for exporters of the Urals region in the eastern direction is sending products through border crossings between China and Kazakhstan at Dostyk and Khorgos stations (these are directions from Yekaterinburg and Tyumen through Chelyabinsk, Kurgan, Kustanai, Petropavlovsk and Astana), where modern

transport and logistics centers have been created and China subsidizes railway tariffs through its territory to deliver products to the central provinces of China [12]. Although here, too, exporters from South Siberia will have a distance advantage of almost 1,000 km compared to the Urals region.

Exporters should keep in mind that there is already a lack of border capacity here as well. Kazakhstani authorities are actively working to expand the capacity of existing terminals. Thus, the dry port Khorgos Gateway in Kazakhstan in 2022 put into operation a new complex of tracks with a width of 1435 mm (Chinese standard). Thanks to the new tracks, the terminal's throughput capacity has increased from 9-10 trains per day to 19-20 trains per day. Similarly, Kazakhstan has significantly increased the throughput capacity of the Dostyk rail port since 2021. In May 2022, the second phase of a new transshipment station at the Dostyk rail "dry port" was commissioned, and the annual transshipment volume increased from 160,000 to 320,000 TEUs.

The conclusion is that the Urals producers of agro-industrial complex products should count on profits only from highly profitable food products with deep processing of agricultural raw materials, where the share of transportation costs in the product price is not critical for the end buyer. The advantages of accelerated container trains (including those for bulk and liquid cargo) and "Agroexpress trains" (including refrigerated containers for transportation of perishable goods), formed by RZD-Logistics, TransContainer and other federal carrier operators in major logistics centers and transport hubs (including Yekaterinburg, Tyumen and Chelyabinsk) will help reduce exporters' transportation costs. The delivery time for such transportation is approximately three times shorter and the cost is up to four times shorter due to the technology of container trains following a fixed schedule. By the way, Urals exporters will have one more advantage on the Agroexpress trains from Central Russia and the Volga Region to China - if at least 10 platforms with two 20-foot containers on each should be set up at the initial point of the route, the subsequent sorting stations will have the technological possibility of adding one platform to the train, which greatly simplifies entry into the export supply system for small and medium-sized producers of agricultural products.

Finally, a new direction of export of Russian agro-industrial complex products (which was loudly announced at the meeting of the heads of the Caspian states as one of the answers to the anti-Russian economic sanctions of the West in the sphere of freight logistics) is the international transport corridor "North-South" from St. Petersburg and Moscow to Iran, Pakistan, India and the United Arab Emirates. Although most articles about the "North-South" ITC, as a rule, refer to the Volga-Caspian Sea-Iran water route (with restrictions on winter navigation and depths in the Volga fairway and the port of Astrakhan), in fact, this corridor is represented by at least two more railroad routes: "Western (or Caucasian)": through Samara - Volgograd - Astrakhan - Makhachkala - Baku stations to Astara station (Azerbaijan Railway) with transshipment to road transport in Iran (the railway bridge and the connecting section of the Astara - Resht railway on the Iranian side are under construction), and "Eastern (or Trans-Caspian)": via Yekaterinburg - Chelyabinsk - Kartaly - Orsk - Makat (Kazakhstan) - Beineu - Bereket (Turkmenistan) stations to Etrek and Amirabad (Iran) with transition to Iranian railway gauge (1435 mm) and with the possibility of further transportation to Pakistan and India via Bender-Abbas or Gwadar ports, or (in 2-3 years perspective) Chabahar port that is under construction. [13] (See figure 2) The technology of replacing wheelsets under wagons from the Russian (1520 mm) to the European (1435 mm) gauge has long been tried out at the border crossings in Belarus, Poland, Slovakia, and does not require the mandatory transfer of containers or cargo from one train to another. This variant of the change of gauge for Russian platforms and wagons will make it possible to solve the problem of the rolling stock shortage on the Iranian side in the shortest possible time. It will also be relevant for railroad workers that the proposed route does not pass through the Trans-Siberian Railway and makes it possible to bypass its bottlenecks in Yekaterinburg, Tyumen, and Chelyabinsk. In the future, it may be necessary to strengthen tracks and railway stations along this route and create full-fledged transport and logistics centers at border crossings, following the example of China and Kazakhstan at Dostyk and Khorgos stations.

In the structure of food imports to Russia by country (goods from the group "Products of plant origin") in the first place is Ecuador (11%), the second place is Turkey (10%), the third is China (8.6%). Thus, the Iranian supplies can form an alternative to the Turkish and Chinese imports of consumer goods and exotic fruits. In other words, there is a counter freight base, which can form the basis for a new shorter and more profitable for the Urals and Siberian exporters and importers "Trans-Caspian" route of ITC "North-South". Taking into account American sanctions against Iran and Russia and the already existing trade balance of export-import of Iran and Russia with third countries, it is possible to organize mutual settlements both in rubles and in Chinese yuan or Indian rupees.

Compared with the traditional route through the Suez Canal, the time and cost savings on the new route could be 30-40%. According to experts the delivery time from Moscow to Mumbai (India) will be reduced by approximately 20 days. The first test train showed the result of 30 days - 32 forty-foot containers with cargo arrived from Finland to India along the route of the international transport corridor ITC "North-South". It took 18 days to reach the destination, while the other 12 waited in the port for the ship. (This was reported by rzd-partner.ru in August 2021.) Experts believe

that the annual turnover of the North-South corridor will reach 20-30 million tons. In June 2021 Russia and India reached an agreement on supplying up to 40 million tons of anthracite and coking coal a year. The shortest route from Kuzbass to India will be transit via Kazakhstan, Turkmenistan and Iran (Novokuznetsk - Barnaul - Kulunda - Almaty - Tashkent - Mary - Turkmenabad - Serakhs - Bender-Abbas direction). (See Figures 1, 2) That is, the "Trans-Caspian" route of the ITC "North-South" can get a stable cargo base of the main product of railway transportation - coal.

FIGURE 2. Iranian railways in operation and under construction.

The new railway routes of the North-South ITC give the Urals and Siberian suppliers direct access to huge consumer markets: Iran - population of 80 million people, Pakistan - 215 million people, finally, India - 1.5 billion people. In addition to these countries, through the ports of Bandar Abbas, Chabahar and Gwadar it is also possible to supply by sea by the shortest route to the United Arab Emirates, Qatar, Saudi Arabia, East African countries, which are already active buyers of Russian food products. [14, 15]

In recent years, along traditional sea routes (around all of Europe and through the Suez Canal), there are shipments from Russia of vegetable oils to Iran (2019 - 539.1 thousand tons) and India (200.5 thousand tons), grain and meat to Saudi Arabia, and mineral fertilizers to Southeast Asia (India in 2018 - 1,494 thousand tons, Sri Lanka). In other words, there is already an established cargo base, which can form the basis for a new shorter and more profitable for the Urals exporters "Trans-Caspian" route of the North-South ITC. It only remains for the Urals transporters (working with their Kazakhstani and Turkmen colleagues) and exporters to finally find each other.

In terms of promoting the export of organic agricultural products of the Ural-Siberian region, the authors believe that it is also preferable to make promising plans to develop the markets of China, India and the Middle East, where this market niche is in a phase of active growth and is only gaining momentum. [23, 24] While in Europe and the U.S. this market segment has already formed and enjoys great protectionist support from the government, foreign competitors are not expected there; government support measures are aimed at their own farmers and protect their market niche from large agricultural holdings and foreign suppliers. Moreover, the next US and EU sanctions will be added to export restrictions in the Western direction, which, it seems, will last for a long time. And the food markets of China and India are so large-scale that any projected volumes of Russian organic products today will remain in the premium segment of the consumer market for many years to come and account for a fraction of a percent of food imports into these countries.

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