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**СИБИРСКИЙ ВЕСТНИК
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SIBIRSKII VESTNIK SEL'SKOKHOZYAISTVENNOI NAUKI

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ПАМЯТИ УЧЕНОГО

IN COMMEMORATION OF SCIENTIST

Василий Захарович Ямов

Vasily Zakharovich Yamov



ДИФФЕРЕНЦИРОВАННАЯ СИСТЕМА ОБРАБОТКИ ПОЧВЫ В ЛЕСОСТЕПНОЙ ЗОНЕ СРЕДНЕГО ПОВОЛЖЬЯ

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Представлена оценка агроэкономической эффективности различных систем обработки почвы под горчицу, возделываемую в зернопаровом севообороте со следующим чередованием культур: чистый пар – озимая пшеница – яровая пшеница – горчица. Эксперименты заложены в полевом опыте в лесостепной зоне Среднего Поволжья в 2019–2021 гг. Почва опытного участка – чернозем слабовыщелоченный среднетяжелосуглинистый. Пахотный горизонт характеризуется следующими агрохимическими показателями: содержание гумуса от 5,8 до 6,1%, обеспеченность подвижным фосфором высокая (226 мг/кг), калием средняя (92 мг/кг), реакция почвенного раствора близкая к нейтральной (рН 6,6). Объект исследования – горчица сорта Рапсодия, предмет исследования – системы обработки почвы. Установлена целесообразность замены ежегодной классической вспашки на дифференцированную в севообороте обработку, основанную на чередовании глубокой вспашки и поверхностной дисковой обработки. Она положительно влияет на процесс формирования агрофизических, биологических и агрохимических свойств почвы, способствует сохранению запасов продуктивной влаги, помогает снизить засоренность посевов. Данная обработка приводит к достоверному росту урожайности на 0,11 т/га, позволяет получить продукцию с наивысшей рентабельностью 199% (в среднем по фону) и наибольшим энергетическим коэффициентом 1,33, что на 71 и 22% выше, чем на варианте с ежегодной отвальной обработкой. Отмечено, что применяемые минеральные удобрения в дозе $N_{30}P_{30}K_{30}$ не дали должного эффекта. Отсутствие роста урожайности привело к формированию отрицательных экономических показателей при внесении минеральных удобрений на всех изучаемых вариантах, за исключением дифференцированной в севообороте обработки. В данном варианте отмечено максимальное увеличение урожайности на 0,25 т/га и стоимости валовой продукции на 7500 р./га, что на 1521 р./га выше возросших производственных затрат. На варианте с ежегодной отвальной обработкой внесение удобрений сопровождалось снижением чистого дохода и уровня рентабельности на 965 р./га и 75% относительно неудообренного фона, что свидетельствует об убыточности применения удобрений.

Ключевые слова: горчица, обработка почвы, плотность сложения, запасы продуктивной влаги, урожайность, рентабельность

DIFFERENTIATED TILLAGE SYSTEM IN THE FOREST- STEPPE ZONE OF THE MIDDLE VOLGA REGION

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Evaluation of agro-economic efficiency of different tillage systems for mustard, cultivated in a grain fallow rotation with the following alternation of crops: complete fallow - winter wheat - spring

wheat - mustard is presented. The experiments were made in a field experiment in the forest-steppe zone of the Middle Volga region in 2019-2021. The soil of the experimental plot is slightly leached medium-powered heavy loamy chernozem. Tillage horizon is characterized by the following agrochemical parameters: humus content of 5.8 to 6.1%, the provision of mobile phosphorus is high (226 mg/kg), the potassium is medium (92 mg/kg), the reaction of the soil solution is close to neutral (pH 6.6). The object of the study is the mustard variety Rhapsody, the subject of the study is soil tillage systems. The expediency of replacing the annual classic plowing with a differentiated treatment in the rotation, based on the alternation of deep plowing and surface disc cultivation is established. It positively affects the process of formation of agrophysical, biological and agrochemical properties of soil, contributes to the conservation of productive moisture reserves, and helps to reduce weed infestation of crops. This treatment leads to a significant increase in the yield by 0.11 t/ha, allows for the highest yields of 199% (on average for the backgrounds) and the highest energy factor of 1.33, which is 71 and 22% higher than on the option with the annual mouldboard plowing. It was noted that the used mineral fertilizers at a dose of $N_{30}P_{30}K_{30}$ did not produce the desired effect. Lack of yield growth led to the formation of negative economic indicators when making mineral fertilizers in all the variants studied, with the exception of differentiated treatment in the rotation. In this variant, the maximum increase in the yield by 0.25 t/ha and the cost of gross output by 7500 rubles/ha, which is 1521 rubles/ha higher than the increased production costs is noted. In the option with annual mouldboard plowing fertilization was accompanied by a decrease in the net income and profitability levels by 965 rubles/ha and 75% relative to the non-fertilized background, indicating that the unprofitable use of fertilizers.

Keywords: mustard, tillage, bulk density, productive moisture reserves, yield, profitability

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Автор заявляет об отсутствии конфликта интересов.

Conflict of interest

The author declares no conflict of interest.

INTRODUCTION

Tillage affects all properties of the soil and regulates most factors of plant life. Its incorrect application can cause great damage to the soil [1-3]. The choice of tillage system has always been the most controversial and relevant in the process of agronomic practice. Various opinions on the necessity of deep and active loosening, especially with a layer turnover, nowadays lead in practice to minimization of tillage with reduction of depth and number of tillings [4-8]. However, the transition from plowing to long-term application of loosening and especially to surface or minimum tillage generates negative phenomena. These include: increased weed infestation of crops, decreased water permeability of the top layer, etc. All this can lead to a

decrease in crop yields [9-11]. In this regard, the most coordinated system of tillage is differentiated, consisting of various combinations of mouldboard and non-mouldboard methods [12, 13]. The problems of increased weeding of fields and deterioration of agrophysical soil properties after abandoning intensive mechanical intervention are solved by periodic use of plowing for the most demanding crops [14-16].

The great diversity of soil cover has not allowed so far to give an accurate agro-economic characteristic of different methods and depth of main tillage used in agricultural production. Therefore, the development of resource-saving tillage systems that ensure the optimization of soil properties, soil regimes, phytosanitary state and fertility reproduction is relevant.

The purpose of the research is the comparative agrotechnological and economic evaluation of tillage systems on the chernozems of the Middle Volga region.

MATERIAL AND METHODS

The research was conducted in a field experiment at the Ulyanovsk Research Institute of Agriculture - branch of the Samara Federal Research Center of the Russian Academy of Sciences (Ulyanovsk NIISKh - branch of the Samara Research Center RAS) in 2019-2021. The research objects were white mustard Rhapsody and leached chernozem. The soil of the experimental plot was medium-low leached heavy loam chernozem with the following agrochemical parameters: humus content from 5.8 to 6.1%, very high mobile phosphorus content (226 mg/kg), medium potassium content (92 mg/kg), the reaction of the soil solution is close to neutral (pH 6.6).

The subject of the research is six tillage systems (factor *A*):

- mouldboard (control): plowing at 20-22 cm PLN-4-35;
- differentiated multidepth: alternation of plowing at 25-27 cm PLN-4-35 and discing at 6-8 cm;
- without basic fall tillage, in spring - shallow mulching treatment: at 10-12 cm APK-3;
- ridge-coultisse tillage: OP-3C at 13-15 cm;
- discing: BDMu at 6-8 cm;
- flat cutter: KPSH-3 at 13-15 cm.

The main tillage methods were applied systematically from 2015 for each variant.

Efficiency of different systems of main tillage was studied on two backgrounds (factor *B*):

- without fertilizers (control);
- background (N₃₀P₃₀K₃₀).

Azophoska (nitrogen-phosphorus-potassium fertilizer) brand N: P: K - 15: 15: 15 was used as mineral fertilizer, which was introduced by surface spreading method under pre-sowing cultivation.

Pre-sowing tillage consisted of early spring harrowing in April and pre-sowing cultivation. Sowing was carried out in the I ten-day period of May by a disk seeder SZ-5,4 by continuous seeding method with a row spacing of 15

cm, seeding rate of 1.5-2.0 million germinated seeds/ha at a depth of 3-4 cm. Adjustment of the depth of seeding into the soil in all the studied variants was carried out by changing the depth of the coulter stroke with the help of the depth control screw, located on the bottom of the seeder. The minimum penetration (about 4 cm) was achieved with the screw completely unscrewed, while the hydraulic cylinder rod was completely retracted.

The location of plots in the experiment was systematic, the size of variants for the main soil treatment was 500 m², the size of the sowing area of the plot was 250 m² (10 × 25), the recording area was 125 m² (5 × 25). Fourfold repetition was used.

Tillage systems were studied in a cereal fallow rotation with the following crop rotation: 1 - complete fallow; 2 - winter wheat; 3 - spring wheat; 4 - mustard; 5 - winter wheat; 6 - barley.

Observations, determinations and recordings were made according to generally accepted methods. Counting of weed infestation was carried out on 0,25 m² areas by 8 pieces on the first and third replications in three terms, the method of recording - quantitative-weight, the indicators were converted to 1 m². The recording was carried out in the period of appearance of mass shoots in the middle of the crop vegetation and before harvesting. Soil moisture was determined by a drying method. Samples were taken in two non-adjacent replications of two boreholes in layers 10 cm deep up to 1 m in spring and in autumn after harvesting. The samples taken were placed in weighting bottles, weighed, and dried at 140 °C for 6 h. The moisture content in the soil was calculated as a percentage of absolutely dry soil and in millimeters of productive moisture. Soil density was determined by the cutting-ring method, by sampling with undisturbed complexity (g/cm³) in the first and third replications, the samples were taken in the middle of the crop vegetation in the soil layers 0-10, 10-20 and 20-30 cm. The structural and aggregate composition of the soil was determined before harvesting according to the method of N.I. Savinov. Soil was fractionated on sieves in air-dry state (dry sieving). The average sample (2.5 kg) was divided into

fractions: 10, 10-7, 7-5, 5-3, 3-2, 2-1, 1.0-0.5, 0.5-0.25, and 0.25 mm. Each fraction was collected, weighed separately, and its percentage was calculated. The fraction less than 0.25 mm was calculated from the difference between the soil taken for analysis and the sum of fractions greater than 0.25 mm. The entire sample taken for analysis was taken as 100%.

N-NO₃ content was determined by disulfo-phenol method according to Grandval-Lajoux method (GOST 26951-86) in the soil samples taken in arable layer with Malkov's drill at the following dates: in spring (sowing-sprouting), at flowering and before harvesting in the soil layers 0-10, 10-20 and 20-30 cm.

Biological activity of the soil was determined by the linen cloth method - "applications" according to Vostrov and Petrova during the incubation period (sowing - harvesting) in triple replication on the layers 0-10, 10-20, 20-30 cm (application size 8 × 8 cm). Yield of crops was recorded by threshing the entire mass from the accounting plot with SK-5 combine. The recording data were adjusted to 100% purity and 8% moisture content (GOST 10856). Statistical processing of experimental data was carried out by methods of variance and correlation analysis using Agros, Microsoft Office Excel, Statistica.

The economic efficiency of various technologies of main tillage and plant protection systems was analyzed by the calculation-normative method and conducted according to the methodological recommendations of the

Ministry of Agriculture of the Russian Federation. The energy assessment of cultivation was carried out in accordance with the methodology for the energy assessment of crop rotations and crop growing technologies (E.N. Bazarov, E.V. Glinka, 1983).

RESULTS AND DISCUSSION

The results showed that differential tillage was superior to other compared types of basic tillage in all parameters. It formed the optimal compaction density for growth and development of mustard plants before sowing 1.07 g/cm³ (see Table 1). The treatment created favorable conditions for the formation of agronomically valuable structure, the content of which increased by 2.1% compared with the traditional annual plowing, increased the microbiological activity and the provision of nitrate form of nitrogen in the arable soil layer by 5.4 and 20.0%, provided better conditions of moisture accumulation and storage during the entire vegetation of mustard (see figure).

Also due to the alternation of modes of mouldboard and non-mouldboard disc treatments at different depths there was a decrease in the potential stock of weed seeds and improved phytosanitary condition in the agro-ecosystem. The development of weeds in mustard crops in terms of total number of weeds was reduced by 7%, in terms of their air-dry mass - by 17% in comparison with the subsurface tillage. This is very important, as when choosing systems of

Табл. 1. Изменение свойств почвы в зависимости от ее обработки

Table 1. Changes in the soil properties depending on its processing

Treatment option	Soil layer 0-30 cm			
	Density, g ³ /cm	Structure, fraction 10.0-0.25 mm, %	Biological activity, %	N-NO ₃ , mg/100 g of soil
1. Moldboard at 20-22 cm	1,09	77,1	41,0	4,41
2. Differentiated	1,07	79,2	46,4	5,30
3. Mulching at 10-12 cm (in spring)	1,24	76,3	34,6	2,23
4. Ridge-coultisse at 13-15 cm	1,17	78,5	37,2	4,55
5. Discing at 6–8 cm	1,25	79,3	35,8	3,01
6. Flat cutter at 13–15 cm	1,13	79,4	40,7	3,06
LSD _{0,05} (AB factors)	0,05	1,36	2,05	0,23

main tillage, the increase of their anti-weed efficiency plays a decisive role and is one of the main objectives in agriculture.

The variants with flat-cut, ridge-coultisse and surface tillage with disc harrow were characterized by higher weed infestation compared to the mouldboard tillage. On these variants the increase in the total number and mass of weeds on average was respectively 45-57-42 and 34-20-28% relative to the control.

The level of mustard seed oil productivity varied significantly both by years of research and by variants of experience. The maximum crop productivity was formed on the variants with disc and differentiated tillage respectively 1.08-1.09 t/ha, which exceeded the yield indicator on the control by 0.10-0.11 t/ha. At the same time, all ploughless tillage on the value of the mustard seed yield was not inferior to the control (mouldboard tillage on 20-22 cm), except for shallow spring tillage, where the yield was lower by 0.18 t/ha (at $NSR_{0,05} AB = 0.049$ t/ha).

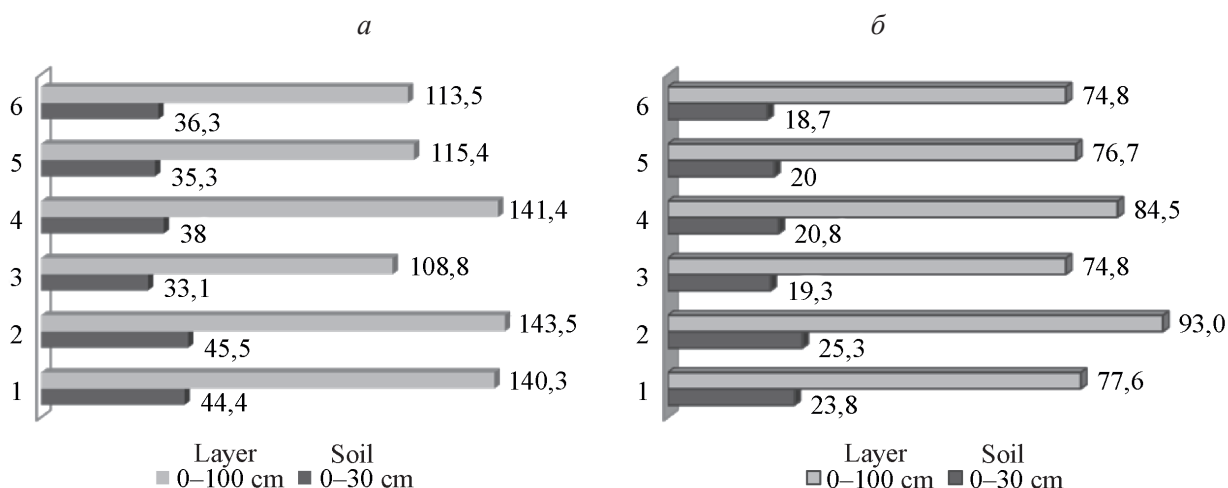
As is known, the basic elements of plant nutrition have a significant influence on the biochemical and physiological processes occurring in plants throughout the growing season, and, consequently, on the size and quality of the crop. The effectiveness of the fertilizers used is determined by the level of nutrients in the soil,

moisture conditions, temperature regimes and biological characteristics of mustard varieties.

Application of mineral fertilizers under pre-sowing cultivation on different variants of the main cultivation had ambiguous effect on the yield. Fertilizer application gave a reliable increase in the yield of the studied crop. The average yield of mustard on the natural background of fertility was 0.90 t/ha. When applying $N_{30}P_{30}K_{30}$ productivity increased relative to the natural background by 0.19 t/ha (see Table 2).

The greatest responsiveness in the collection of seeds from fertilizers was noted on the variant with differential treatment, where the increase was 0.25 t/ha relative to the unfertilized background of the appropriate treatment and 0.33 t/ha in comparison with the unfertilized version of the plowing. On the control with $N_{30}P_{30}K_{30}$ application the crop yield increased by 0,18 t/ha. On the remaining variants the effectiveness of the application of mineral fertilizers was 0,13-0,22 t/ha with respect to natural background.

The best economic performance was achieved in the technology based on differentiated in rotation tillage, which allowed to significantly reduce labor, energy and material costs of basic tillage and still get a higher yield than when using plowing. The total cost of mus-



Влияние способов обработки почвы на запасы продуктивной влаги в посевах горчицы, 2019–2021 гг., мм:

a – весной; *б* – в уборку; 1–6 – варианты обработки (см. табл. 1)

Influence of tillage methods on the reserves of productive moisture in mustard crops, 2019-2021, mm

a - in spring; *б* - during harvesting; 1-6 - treatment options (see Table 1)

tard seed production at the annual mouldboard treatment averaged 12,875 rubles/ha, the cost of 1 ton of seeds - 11,913 rubles, in the variant with differentiated treatment these indicators were lower by 15-25%, respectively. The conventional net income and profitability on the mouldboard tillage were 16,524 rubles/ha and 128%, on the variant with differentiated tillage these indicators were higher by 32 and 71%. Variants of ridge-coultisse, flat-cut and surface treatment with disc harrow were inferior to differential treatment in terms of efficiency, but had better performance than the control. They provided the reduction of production costs in comparison with the mouldboard cultivation by 12-13-15% that allowed to decrease the cost of the obtained production by 15-16-24% and increase the profitability of production by 39-66%. With the same selling price, the cost of production is in direct dependence on the value of the yield. Reducing the mustard yield in the variant with shallow spring tillage led to a decrease in profits from one hectare of arable land. In this regard, the cost of seed oil increased by 6%, and the profitability of their production decreased by 17% compared with the control.

Due to the low productive moisture in the soil, mineral fertilizers did not give the proper effect. The use of mineral fertilizers allowed to increase the yield of seeds per unit area on aver-

age by only 0.19 t/ha for the variants of treatment, which increased the cost of production by 21% compared with unfertilized background. At the same time, the cost of production on the fertilized background increased by 77%, so the level of profitability in this option was lower by 105% compared with the unfertilized background. On average for the background $N_{30}P_{30}K_{30}$ yield increase from the use of fertilizers was 0.95 kg of seed oil per kilogram of fertilizer and did not recoup the cash expenditures spent on the purchase and application of fertilizers.

Since on different treatment variants fertilizers provided unequal additional yield increase, they differed in the recoupment of the unit of fertilizers applied with additional yield increase received. The greatest responsiveness in the collection of seeds from fertilizers, noted on the option with differentiated treatment, provided the maximum yield increase from the use of fertilizers in the amount of 1.25 kg of seeds for every kilogram of fertilizer. This recouped the cash expenditures spent on the purchase and application of fertilizers, respectively, by 126% against the control, where the recoupment did not exceed 90%.

Costs of total man-made energy in the cultivation of mustard on the variants of the experiment varied on average by background from 35

Табл. 2. Изменение урожайности горчицы в зависимости от способов обработки почвы, и внесения удобрений (2019–2021 гг.), т/га

Table 2. Change in the yield of mustard depending on the methods of tillage and fertilization (2019–2021), t/ha

Treatment option	Background		Average for the option
	$N_0P_0K_0$	$N_{30}P_{30}K_{30}$	
Moldboard at 20-22 cm	0,89	1,07	0,98
Differentiated	0,97	1,22	1,09
Mulching at 10-12 cm (in spring)	0,69	0,91	0,80
Ridge-coultisse at 13-15 cm	0,95	1,08	1,01
Discing at 6–8 cm	1,01	1,15	1,08
Flat cutter at 13–15 cm	0,90	1,10	1,00
Average	0,90	1,09	–
LSD _{0,05} A – 0,035 (treatments) B – 0,020 (fertilizers) AB – 0,049			

320 MJ/ha (in the variant of surface treatment with a disc harrow) to 38 600 MJ/ha (by plowing). The difference between these variants was 3280 MJ/ha, or 9%. The maximum amount of biogenic energy accumulated in the economically valuable part of the crop was noted in the variant with differentiated treatment (47,143 MJ/ha). Differences in the accumulation of biogenic energy between the annual plowing and no-tillage treatments were in the range of 3-10%. Shallow spring tillage, despite the lower energy inputs for the cultivation technology, reduced the energy efficiency compared with the mouldboard tillage, which is explained by the under-accumulation in the energy accumulation of the obtained products by 18%.

The coefficient of energy efficiency of mustard cultivation taking into account the cost of technogenic energy for the variants of the experiment varied from 0.95 to 1.33. The highest values were obtained on the variant with disc and differentiated tillage, which exceeded its performance in comparison with the mouldboard tillage by 21-22%. The difference between moldboard, ridge-coulture and flat-cut was 10% in favor of the latter.

CONCLUSION

According to the research results, the most favorable conditions for growth and development of mustard were noted on the background of differentiated in the rotation tillage with elements of minimization (application after deep mouldboard tillage under winter wheat, surface disc tillage - under spring wheat and mustard). Its use has provided not only a sufficient accumulation of productive moisture, improved agro-physical properties and increased biological activity of the soil, but also a low degree of crop infestation, which contributed to the highest crop yield and the best economic and bioenergetic indicators. The greatest responsiveness in the collection of seeds from fertilizers, noted on the variant with differentiated treatment, provided the maximum increase in yield from the use of fertilizers in the amount of 1.25 kg of seeds for each kilogram of fertilizer. In this variant recouperment of cash expenditures

for the purchase and application of fertilizers was 126% against the control, where it did not exceed 90%.

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ИНФОРМАЦИЯ ОБ АВТОРЕ

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РЕЗУЛЬТАТЫ СИМБИОТИЧЕСКОЙ СЕЛЕКЦИИ ЛЮЦЕРНЫ

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Представлены результаты исследований эффективности симбиоза сортов люцерны, созданных разными способами. Выявлены некоторые особенности растительно-ризобиальных взаимодействий. При выращивании люцерны на слабокислой и близкой к нейтральной почве (рН 5,1–6,0) наиболее высокие прибавки урожайности по сухому веществу обеспечивала предпосевная инокуляция штаммом СХМ 412б, на сильно- и среднекислой почве (рН 4,1–5,0) – штаммом СХМ 404б. В год посева эффективность симбиоза составляла не менее 25%, снижение урожайности до уровня контроля происходило в течение 3–4 лет пользования. Штамм СХМ 404б обладает уникальной способностью повышать семенную продуктивность сортов в разных условиях выращивания на 23–56%, другие штаммы – на 3–32%. Установлено, что продуктивность сорто-микробных систем в основном определяется штаммом клубеньковых бактерий (влияние инокуляции 60–62%). Не выявлено связи между урожайностью надземной биомассы и содержанием в ней сырого протеина. Коэффициенты корреляции, полученные в разных полевых опытах, составили $-0,41 \pm 0,34$ – $0,26 \pm 0,39$. Предпосевная инокуляция высокоактивными штаммами ризобий семян люцерны изменчивой сортов Селена, Агния, Таисия, созданных с использованием методов сопряженной симбиотической селекции, повысила урожайность в год посева на 26–35% по сухому веществу и на 44–56% по семенам. Урожайность сортов Вега 87, Луговая 67, Пастбищная 88, Находка, созданных традиционными методами, возрастала на 3–20% по сухому веществу и на 23–29% по семенам. Предпосевная инокуляция активными штаммами ризобий сортов люцерны, созданных симбиотическими методами селекции, повысила урожайность в первый год пользования на 46–128% на участках, где люцерну прежде не выращивали, и на 32–35% в севообороте с высоким насыщением посевами люцерны.

Ключевые слова: люцерна, штаммы, клубеньковые бактерии, симбиоз, сопряженная селекция, урожайность

RESULTS OF SYMBIOTIC BREEDING OF ALFALFA

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The results of the studies on the effectiveness of alfalfa symbiosis varieties created by different methods are presented. Some peculiarities of plant-rhizobial interactions are identified. When alfalfa was grown in low- and near-neutral soils (pH 5.1-6.0), the highest increase in dry matter yield was achieved by pre-sowing inoculation with the CXM 412b strain, and on strongly and moderately acidic soils (pH 4.1-5.0) by the CXM 404b strain. In the year of sowing, the efficiency of symbiosis was at least 25%, and the yield reduction to the control level occurred during 3-4 years of use. Strain CXM 404b has the unique ability to increase the seed productivity of different varieties under different growing conditions by 23-56%, other strains - by 3-32%. It was found that the productivity of variety microbial systems is mainly determined by the strain of nodule bacteria (the effect of inoculation was

60-62%). No relationship between the yield of the aboveground biomass and its crude protein content was found. The correlation coefficients obtained in the different field experiments were -0.41 ± 0.34 to 0.26 ± 0.39 . Pre-sowing inoculation with highly active rhizobia strains of alfalfa variegated seeds of Selena, Agnia, Taisia, created using the methods of conjugate symbiotic breeding, increased the yield in the year of sowing by 26-35% in dry matter and by 44-56% in seeds. The yield of Vega 87, Lugovaya 67, Pastbishnaya 88, and Nakhodka varieties created by traditional methods increased by 3-20% in dry matter and by 23-29% in seeds. Pre-sowing inoculation with active rhizobia strains of alfalfa cultivars created by symbiotic breeding methods increased the yield in the first year of use by 46-128% in plots where alfalfa was not grown before and by 32-35% in the crop rotation with high alfalfa crop saturation.

Keywords: alfalfa, strains, nodule bacteria, symbiosis, conjugate breeding, yield

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Conflict of interest

The author declares no conflict of interest.

INTRODUCTION

Since 1990, a new stage of alfalfa breeding began at the Federal Williams Research Center of Forage Production & Agroecology: creation of new generation varieties capable of ensuring sustainably high dry matter and seed yields through the use of renewable resources of alfalfa-rhizobial symbiosis. The beginning of this research was the result of theoretical and experimental work of a number of domestic and foreign scientists¹⁻⁵. In view of this work, the Federal Williams Research Center of Forage Production & Agroecology proposed the "Method of alfalfa breeding"⁶. Then this method was optimized and the "Biotechnology of conjugate symbiotic breeding" was developed [1]. Using new methods of breeding, alfalfa varieties Selena (2007), Agnia (2012), Taisia

(2015) with high nitrogen-fixing capacity, yield and adaptability due to the use of renewable resources of plant-microbe symbiosis were created. Varieties of this type are necessary to create ecologically sustainable agrophytocenoses, high productivity of which is achieved with minimal use of agrochemicals [2, 3].

Studies using ¹⁵N isotope showed that highly complementary plant-microbe systems are able to accumulate 140-210 kg/ha of bound nitrogen in the field during the season. The coefficient of symbiotic nitrogen fixation reaches 0.88, the average yield increase is 25% [4]. It is possible to increase the yield of the varieties due to plant-microbe symbiosis using pre-sowing inoculation with nitrogen-fixing biological preparations. For example, alfalfa hay yield increased by 1.2 t/ha in the Tomsk region

¹Barnes D.K., Heichel G.H., Vance C.P. A multiple-trait breeding program for improving the symbiosis for N₂ fixation between *Medicago sativa* L. and *Rhizobium meliloti* // *Plant and Soil*. 1984. Vol. 82. P. 303–312.

²Phillips D.A., Teuber L.R. Plant genetics of symbiotic nitrogen fixation // *Biological Nitrogen Fixation*. New York, 1992. P. 625–647.

³Provorov N.A., Simarov B.V. Genetic variation of alfalfa, sweet clover and fenugreek for the activity of symbiosis with *Rhizobium meliloti* // *Plant Breeding*. 1990. Vol. 105. P. 300–310.

⁴Provorov N.A., Saimnazarov U.B., Tanriverdiev T.A., Simarov B.V. The contributions of plant and bacterial genotypes in the growth and nitrogen accumulation of inoculated alfalfa // *Plant and soil*. 1994. Vol. 164. P. 213–219.

⁵Provorov N.A. Relationship between symbiotic and combined nitrogen assimilation in leguminous plants: genetic and breeding aspects // *Russian Journal of Plant Physiology*. 1996. T. 43. N 1. С. 111–118.

⁶Patent 2077190 C1 Method of alfalfa breeding (Russian Federation) / G.V. Stepanova; application. 25.07.94; publ. 20.04.97; Bul. no. 11.

[5]. In the Moscow and Leningrad regions, pre-sowing inoculation of different alfalfa varieties with rhizobia strains A5, A6, A8 increased the yield by 27-36% in dry matter and by 7-109% in seeds [6, 7]. The yield of 73 alfalfa-rhizobia pairs was analyzed in the system of the Geographical Network for biopreparation evaluation at the All-Russian Research Institute for Agricultural Microbiology (St. Petersburg). It was found that inoculation with active rhizobia strains increased the yield of the varieties created by traditional methods by 6-84%, created by the methods of conjugate symbiotic breeding - by 33-198% [8].

High efficiency of symbiosis was noted when growing legume crops on new soils [9], as well as when there is a high "specificity of partner interaction" [5]. High "partner specificity" can be achieved only by conjugate selection of plants and microorganisms. Microorganisms, actively interacting with the plant, optimize the endogenous hormonal balance of plants, nitrogen and phosphorus nutrition, activate the mechanisms of systemic resistance to stress. Resistance to soil salinity and acidification, temperature shock and phytopathogens increases [9, 10].

The purpose of the study was to compare the symbiosis efficiency of alfalfa varieties created by different methods and to identify some features of plant-rhizobial interactions.

The research objectives are:

- to study the efficiency of alfalfa varieties symbiosis, created by traditional breeding methods with active rhizobia strains when grown in different soil conditions;
- identify the effect of inoculation on the accumulation of dry matter and nitrogen (protein);
- develop a method of conjugate symbiotic breeding and use it to create varieties of the variegated alfalfa.

MATERIAL AND METHODS

Field experiments were carried out in the experimental field of the Federal Williams Research Center of Forage Production & Agroecology located 30 km north of Moscow. Soil of the experimental plots was sod-podzolic medium-loamy, pH 4.99-5.91, humus content by Tyurin 1.62-2.10%, total nitrogen 0.161-0.174%, labile phosphorus 194.9-289.3 mg/kg soil, exchangeable potassium 107.7-184.1 mg/kg. Varieties of variegated alfalfa (*Medicago varia*, Mart.) selected by V.R. Williams All-Russian Research Institute of Plant Breeding were used in the work, created by traditional breeding methods: Vega 87, Lada, Pastbishnaya 88, Nakhodka, as well as Selena, Agnia, Taisia, created using the methods of conjugate symbiotic breeding, and preparations (rhizotorfin) of strains of nodule bacteria (*Sinorhizobium meliloti*) created in the All-Russian Research Institute for Agricultural Microbiology (Saint-Petersburg). A total of 33 strains were studied. In addition, CXM 48 strain with Nod⁺ fix⁻ mutation, which blocks symbiotic nitrogen fixation and switches alfalfa plant to soil nitrogen nutrition, was used as a control. Seeding was continuous row, plot area was 4 m² (control nurseries), 10 m² (competitive variety trial), repetition was four times. Before the sowing, alfalfa seeds were sprayed with a biological preparation at the rate of 400 g of nodule bacteria preparation per 1 ha of sowing. The drug consumption was 10 g per 100 g of seeds. The control was the variant without inoculation. Observations, records, statistical processing were carried out according to the conventional methods⁷⁻⁹.

RESULTS AND DISCUSSION

Over 7 years of research (1990-1997) strains were matched to the varieties Pastbishnaya 88 (CXM 415b), Lada, Vega 87 and Meadow 67

⁷Methodical guidelines for the selection of perennial grasses. Moscow: All-Russian Williams Fodder Research Institute, 1985. 190 p.

⁸Alfalfa breeding for increasing efficiency of symbiosis with nodule bacteria: methodological recommendations. SPb.: VNIISKhM, 1990. 50 p.

⁹Dospekhov B.A. Methodology of Field Experience. Moscow: Kolos, 1973. 335 p.

(CXM 412b), Nakhodka (T 482). On moderately acid (pH 4,5-5,0) and strongly acidic (pH 4,1-4,4) soils the best results with all varieties provided the strain CXM 404b. Strain CXM 412b had the advantage on slightly acidic and near neutral soil (pH 5,1-6,0). The yield of Vega 87, Lada, Pastbishnaya 88, Meadow 67, and Nakhodka varieties inoculated with the CXM 412b strain in the year of sowing was on average 25% higher than in the variant without inoculation (see Fig. 1).

In the next years of life of the plants of variety-microbial systems the average yield decreased to 119, 112% and by the 4th year of life was equal (101%) to the yield of the variant without inoculation. The line of symbiosis efficiency change of the above five varieties inoculated with mutant strain CXM 48 looks like a mirror reflection on the graph. In the year of sowing, the average yield was 22% lower than the variant without inoculation. This can be explained by the fact that the CXM 48 strain is highly competitive and quickly forms numerous small inactive nodules (Nod+ gene) on alfalfa roots, which do not fix air nitrogen (fix-gene). Alfalfa shifts to soil mineral nitrogen nutrition, and the average yield decreases to 78% to the control level. In the 2nd year it increases to 88%, in the 3rd year to 95 and in the 4th year to 98% to the control level (see Fig. 1). The rea-

son is the formation of a secondary symbiotic complex of alfalfa plants with nodule bacteria living in the soil. After each mowing or winter dormancy, the nodules on alfalfa roots die off and the bacteria enter the soil. After plant growth resumes, new nodules are formed by the races (strains) of nodule bacteria most genetically related to alfalfa plants. Most often these are local races of bacteria in the presence of which the variety was created. As a result, the level of symbiotic nitrogen fixation and the yield of variety-microbial systems after one or two years of herbage life is equal to the variant without inoculation. If the inoculant has high competitive ability and genetic complementarity to the host plant, this strain will form highly efficient symbiotic systems from time to time when the secondary symbiotic apparatus is formed. The decrease in the yield will be delayed. CXM 412b strain seems to belong to this category, the decrease of average yield of five variety-microbial systems to the level of the variant without inoculation lasted for 4 years (see Fig. 1).

The second important question is the effect of pre-sowing inoculation on the raw protein content of alfalfa dry matter.

Let us consider this by the example of the varieties Pastbishnaya 88 (Rhizome × Syn 7008) and Nakhodka (Syn 7008 × Rhizome).

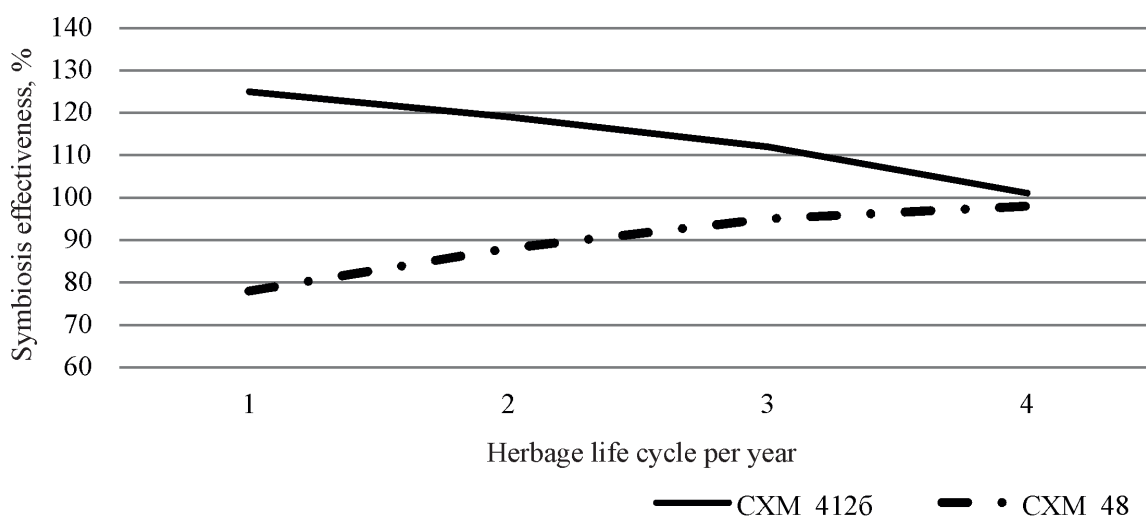


Рис. 1. Динамика средней эффективности симбиоза пяти сортов люцерны (закладка опытов 1991, 1992, 1993 гг., среднее за 1991–1996 гг.)

Fig. 1. Dynamics of the average efficiency of symbiosis of five alfalfa varieties (sowing years 1991, 1992, 1993, average 1991–1996)

The studies were conducted on a plot where alfalfa has been grown for more than 50 years. The effect of inoculation was weakly expressed. Only 8 of 13 strains significantly - by 23-65 g/m² (+7-20%) - increased the productivity of the variety Pastbishnaya 88 and 4 strains - by 28-56 g/m² (+9-18%) of the variety Nakhodka (see Table 1).

The average crude protein content in dry matter of the varieties Pastbishnaya 88 and Nakhodka without inoculation was 19.1 and 20.0%, inoculation increased the protein content by 0.8 and 0.6% in absolute value. A significant increase in protein content in the dry matter of the variety Pastbishnaya 88 was provided by five strains, the variety Nakhodka - by four. And the strain T 482 significantly - by 8 and 11% - increased the dry matter content, by 1.3 and 1.4% - the protein content of both varieties. The CXM 71 strain increased the dry matter yield by 12% and the protein content of the variety Pastbishnaya 88 by 1.7%. In the variety Nakhodka, the best performance (+18 and 1.3%) was provided by the CXM 425a strain (see Table 1).

Analysis of variance showed that the productivity of alfalfa plants of the varieties Pastbishnaya 88 and Nakhodka was determined by

the variant of inoculation by 60 and 62%. The content of crude protein in the dry matter of the plant-microbial systems with the variety Pastbishnaya 88 was 42% dependent on the variant of inoculation, with the variety Nakhodka - 28%.

Correlation and regression analysis revealed no relationship between the accumulation of dry matter of the above ground biomass and its content of crude protein. In the variety Pastbishnaya 88 the correlation coefficient (r) was $0,05 \pm 0,29$, the coefficient of significance $t_r = 0,18 < t_{05} = 2,45$. For the variety Nakhodka: $r = 0,18 \pm 0,28$; $t_r = 0,64 < t_{05} = 2,45$.

Somewhat different results were obtained when determining the dependence of the crude protein content on the productivity of plant-microbe systems formed by the strains with symbiosis efficiency of 7% and higher. There were eight of them in each variety. The average productivity of the best plant-microbial systems with the variety Pastbishnaya 88 reached 362 g/m², 18 g/m² more, the average crude protein content was 19.88%, 0.03% less; $r = -0,34 \pm 0,38$; $b_{yx} = -0,01$; $t_r = -0,90 < t_{05} = 2,45$. There is a tendency of decreasing crude protein content on average by 0.01% in absolute terms with increasing productivity of plant-microbial system

Табл. 1. Продуктивность и содержание сырого протеина; первый цикл пользования в год посева, начало цветения (среднее за 1991 и 1993 гг.)

Table 1. Productivity and crude protein content; the first cycle of use in the year of sowing, the beginning of flowering (the average of 1991 and 1993)

Inoculation option	Dry matter, g/m ²		Crude protein, %	
	Pastbishnaya 88	Nakhodka	Pastbishnaya 88	Nakhodka
CXM 226	347*	324	19,7	21,0*
CXM 4126	342	295	20,2*	20,7
CXM 214	349*	312	19,7	20,2
CXM 126	382*	331	19,6	19,8
CXM 239	336	347*	19,5	20,2
CXM 3	389*	319	19,4	21,0*
CXM 425a	351*	359*	19,7	21,3*
T 482	350*	335*	20,4*	21,4*
T 798	339	333*	20,7*	20,5
CXM 105	341	300	20,4*	20,6
CXM 71	362*	293	20,8*	20,9*
Average value	344	322	19,9	20,6
Control	324	303	19,1	20,0
LSD ₀₅	23	24	1,0	0,8

* Statistically significant, $p \leq 0,05$.

per 1 g dry matter/m². In the variety Nakhodka the average productivity of eight plant-microbe systems was 335 g/m² (+13 g/m²). The average crude protein content (20.66%) increased by 0.06%. There was a slight increase in crude protein content with increasing productivity; $r = 0.26 \pm 0.39$; $b_{yx} = 0.01$; $t_r = 0.65 < t_{05} = 2.45$. Consequently, pre-sowing inoculation of different varieties of alfalfa with preparations of active strains of nodule bacteria differently affects the yield and crude protein content in dry matter of these varieties. Preparations of nodule bacteria can be selected for each variety to increase yield and protein content or one of these traits. The disadvantage of such variety-microbial systems is the relatively low genetic complementarity of macro- and microsymbionts and, consequently, the rapid repopulation of alfalfa roots by inactive local races of nodule bacteria.

Apparently, in order to realize the possibility to manage the metabolism of plant-microbial systems and use the renewable resources of alfalfa-rhizobial symbiosis, it is necessary to create varieties and genetically related strains of nodule bacteria that provide high efficiency of symbiosis for three years and more. One of such varieties is Selena. Table 2 shows the dynamics of productivity of the above-ground biomass of plant-microbial systems of the Selena variety by years of use. In the year of sowing one harvesting in the phase of full flowering was carried out. All plant-microbial pairs (with

the exception of inoculation with CXM 425a strain) were significantly - by 0,5-0,9 kg/m² (+14-26%) - more productive than the variant without inoculation. In the 2nd year of herbage life, 1.70-2.08 kg of dry matter/m² were harvested in three hayings.

Inoculation with CXM 415b, CXM 404b, CXM 412b and T 4 strains significantly increased the crop yield compared to the control by 16-22%. The growing season of 2002 was hot and dry, and the hydrothermal coefficient was 0.62 (the norm was 1.58). One harvesting in the phase of the beginning of flowering was carried out. Plant-microbial systems with strains CXM 412b, CXM 415b and CXM 404b were 11-18% higher than the Selena variety without inoculation (see Table 2).

Inoculation with active strains decreased the content of crude protein to 20.00-21.38% (except for variety-microbial systems with strains CXM 415b and T 2 (23.0 and 24.06%)). A negative correlation was found between the yield of plant-microbial systems and crude protein content: $r = -0.41 \pm 0.34$; $b_{yx} = -7.6$; $t_r = 1.18$; $t_{05} = 2.37$. The exception was CXM 415b strain, which provided yield increases by years of life of 26, 16, and 13%, with a crude protein content of 23.0% in the 3rd year of life.

In 2003, alfalfa grass was used for seed production. Weather conditions were unfavorable, and seed collection was low: from 8.5 to 12.2 g/m². Inoculation with CXM 412b and CXM 404b strains increased the seed yield by 31 and

Табл. 2. Эффективность симбиоза люцерно-ризобийных систем сорта Селена. Посев 2000 г.
Table 2. Efficiency of symbiosis of alfalfa-rhizobial systems of the Selena variety. Sowing in the year 2000.

Inoculation option	Dry matter, kg/m ²			Crude protein, % (1-st cut 2002)	Seeds, g/m ²
	2000	2001	2002** (1-st cut)		
CXM 412b	0,40*	2,06*	0,88*	20,56	11,2*
CXM 425a	0,39	1,85	0,86	20,31	10,0
CXM 404b	0,41*	2,03*	0,93*	20,94	12,2*
T 8	0,43*	1,87	0,79	20,00	9,4
T 4	0,41*	2,08*	0,78	21,38	10,5
CXM 415b	0,44*	1,98*	0,89*	23,00	9,3
T 2	0,42*	1,89	0,75	24,06	9,7
Control	0,35	1,70	0,79	22,38	8,5
LSD ₀₅	0,05	0,21	0,08		2,5

* Statistically significant, $p \leq 0.05$.

**2002 – due to prolonged drought (from 22.06 to 17.09.2002) one full harvest of green mass was obtained.

44% (see Table 2). Thus, pre-sowing inoculation of the Selena variety with CXM 415b strain can be recommended to obtain dry matter with high protein content, and the seeds - with CXM 404b strain.

The next stage in the development of conjugate symbiotic breeding was the development of a method called "Biotechnology of conjugate breeding of varieties with high adaptive capacity". Using this method, the varieties of the variegated alfalfa Agnia (2012), Taisia (2015) were created and included in the State Register of breeding achievements. Agnia VIK variety has been in variety trials since 2021. New "Biotechnology" allows to reduce the breeding process by 5-7 years and ensures the creation of varieties (variety-microbial systems) with high symbiotic nitrogen fixation, yield and adaptive capacity.

The essence of the method: selection of parental plants with very high adaptive ability is carried out on a special selective background, the selected plants are crossed with each other, and form the varieties with desired properties of the obtained hybrids.

The Agnia variety was formed on medium-cultivated soil (pH 5,0-5,8) under inoculation with CXM 412b, CXM 415b, CXM 425a strains. As a result, the variety with high responsiveness to inoculation with CXM 412b and CXM 415b strains was obtained. The increase of pro-

ductivity of the above-ground biomass was 30-40% and higher, and of the seeds - 40-60% and higher in comparison with the cultivation without inoculation. Flowers with lilac coloration predominate in the variety population.

The variety Taisia was formed on acidic soil (pH 3.9-4.5) by inoculation with the strain CXM 404b. The variety is highly resistant to excessive moisture during the growing season and dormancy, as well as to cultivation on acidic soil (pH 4.4 and above). Flowers with variegated coloration prevail in the population.

Figure 2 shows the productivity of the plant-rhizobial systems of the variety Taisia in the first year of herbage use. The variety was tested on an area with acidic soil, where alfalfa had not been grown before. To demonstrate the potential of the new variety the first year of use was chosen, firstly, because in the year of sowing and the first year of use inoculants are most effective, and secondly, during this period young alfalfa plants are most sensitive to the negative effects of soil acidity.

In the first year of use, 0.54 kg of dry matter/m² in the control and 0.79-1.23 kg/m² in the variants with pre-sowing inoculation with 10 rhizobia strains were obtained. Plant-microbial systems with strains A6 and A9 were significantly - by 0.25-0.27 kg/m² (LSD₀₅ = 0.24 kg/m²) - higher than the variety Taisia without inoculation. The remaining strains highly significantly

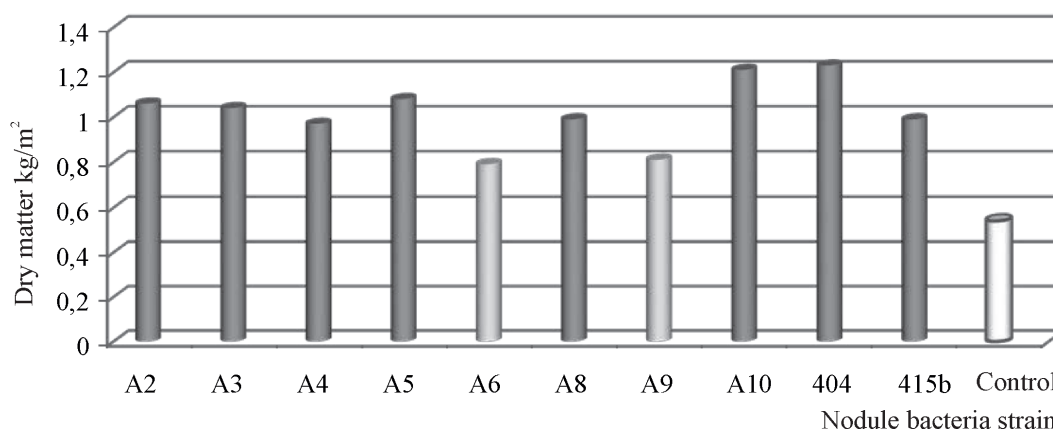


Рис. 2. Продуктивность люцерно-ризобияльных систем сорта Тaisia; возделывание на кислой почве (pH 4,36). Данные 2018 г., посев 2017 г.

Fig. 2. Productivity of alfalfa-rhizobial systems of Taisia variety, cultivation on acidic soil (pH 4.36). Data 2018, seeding 2017

- by 0.43-0.69 kg/m² (LSD₀₁ = 0.34 kg/m²) - increased the dry matter yield. The most productive were the variety-microbial systems with strains A10 and CXM 404b. The gain was 0.67 and 0.69 kg/m² (+124 and 128%) (see Fig. 2).

The economic value of the alfalfa varieties created in different ways was tested in the 2018 sowing nursery. Alfalfa has been grown periodically at this site since 1975. There are native races of nodule bacteria in the soil, so high yield increases from inoculation were not observed. In the variant without inoculation, the average yield for 3 years of use (2019-2021) of Agnia and Taisia varieties was 10.0 and 10.3 t dry matter/ha, while Vega 87 and Meadow 67 varieties were only 8.0 and 8.9 t/ha. Inoculation with the CXM 404b strain increased the yield of the first group varieties to 13,2 and 13,9 t/ha (+32 and 35%), the second to 9,1 and 9,2 t/ha (+14 and 3%).

Seed productivity is one of the adaptive traits of plants: the more seeds a plant produces, the higher the ability of this genotype to survive and expand its range. In the control, the average yield for 2 years of use (2019 and 2020) of Agnia and Taisia varieties was 85.3 and 82.8 kg/ha, Vega 87 and Meadow 67 varieties were 48.2 and 59.1 kg/ha. Inoculation with the CXM 404b strain increased the seed yield of the first two cultivars to 132,9 and 119,4 kg/ha (+56 and 44%); for the second group cultivars it was 59,2 and 76,3 kg/ha (+23 and 29%).

CONCLUSIONS

1. The productivity of variety-microbial systems is mainly determined by the strain of the nodule bacteria (effect of inoculation 60-62%). When cultivating alfalfa on slightly acidic and close to neutral soils (pH 5,1-6,0) the best results are obtained by pre-sowing inoculation with CXM 412b strain, on strongly and moderately acidic soils (pH 4,1-5,0) - with CXM 404b strain, when cultivating alfalfa for seeds - with CXM 404b strain.

2. No relationship between the yield of the above-ground biomass and its content of crude protein was found: the correlation coefficients obtained in different field experiments were -0.41 ± 0.34 - 0.26 ± 0.39 .

3. The symbiosis efficiency of alfalfa cultivars created by symbiotic breeding methods with active rhizobia strains was 26-35% in dry matter and 44-56% in seeds; the efficiency of the cultivars created by traditional methods was only 3-20 and 23-29% respectively.

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НОВЫЙ РАННЕСПЕЛЫЙ СОРТ СОИ СЕВЕРНОГО ЭКОТИПА ЦИВИЛЬ

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Представлены данные о морфобиологических особенностях и основных показателях качества зерна сорта Цивиль. Приведены результаты конкурсного испытания, показана адаптивность сорта к различным условиям возделывания. Отмечена необходимость выведения раннеспелых сортов сои для сельскохозяйственного производства в северных регионах России, так как сорта с вегетационным периодом 110–125 дней не вызревают. Селекционные работы по созданию сортов сои проводили на экспериментальном участке в полевых условиях. Почва опытного поля серая лесная тяжелосуглинистая с содержанием гумуса 4,1, близкая к нейтральной (с реакцией почвенного раствора 5,7), с повышенным содержанием подвижного фосфора и обменного калия. Новый сорт Цивиль имеет вегетационный период 83–105 дней. Сорт сои северного экотипа Цивиль (селекционный номер 116_{4/7-1ск}) выведен методом многократного индивидуального отбора в гибридных популяциях F_3-F_8 , полученных от потомства Чера-1 × ЮГ 30. Сорт включен в Государственный реестр селекционных достижений Российской Федерации с 2022 г. по Центральному региону (3). Новый сорт характеризуется раннеспелостью, повышенной урожайностью, его потенциальная урожайность превышает 3,8 т зерна/га. Сорт Цивиль отличается от районированных сортов повышенным содержанием масла. Содержание жира в семенах сои данного сорта достигает 24%, что выше аналогичного показателя сорта-стандарта СибНИИК 315 на 1,8%. Включение в производственные посевы нового раннеспелого сорта сои северного экотипа Цивиль в почвенно-климатических условиях средней полосы будет способствовать продвижению культуры в северные районы России.

Ключевые слова: соя, северный экотип, сорт

A NEW EARLY-RIPENING SOYBEAN VARIETY OF THE NORTHERN ECOTYPE CIVIL

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The data on morphobiological features and the main indicators of quality of the grain variety Civil are presented. The results of competitive testing are given, and the adaptability of the variety to different conditions of cultivation is shown. The need to develop early-ripening soybean varieties for agricultural production in the northern regions of Russia is noted, since the varieties with a growing season of 110-125 days do not ripen. Breeding work on soybean varieties was carried out at the experimental site under field conditions. The soil of the experimental field is gray forest heavy loam with a humus content of 4.1, close to neutral (with a soil solution reaction of 5.7), with a high content of mobile phosphorus and exchangeable potassium. The new variety Civil has a growing season of 83-105 days. The soybean variety of the northern ecotype Civil (breeding number 116_{4/7-1sk}) was bred by multiple individual selection in a hybrid population of F_3-F_8 obtained from the offspring of Chera-1 x SOUTH 30. The variety has been included in the State Register of Breeding Achievements of the Russian Federation since 2022 for the Central region (3). The new variety is characterized by early maturity, high yield, its potential yield exceeds 3.8 tons of grain/ha. The Civil variety differs from the zoned varieties by an increased oil content. The fat content in soybean seeds of this variety reaches 24%, which is 1.8% higher than that of the SibNIK 315

standard variety. The inclusion of a new early maturing soybean variety of the northern ecotype Civil in the soil and climatic conditions of the midland will contribute to the promotion of the crop in the northern regions of Russia.

Keywords: soy, northern ecotype, variety

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Conflict of interest

The author declares no conflict of interest.

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is a universal food, fodder and technical crop. It is the most common leguminous crop of global importance. The seeds contain on average 36–42% high-grade protein with a high-quality amino acid composition. Protein is characterized by high digestibility and good water solubility. The seeds' content of high-grade vegetable oil is 17–25%, suitable for use in food, feed and technical purposes. Favorable combination of nutrients allows soybean to be widely cultivated as a food, fodder and technical plant [1–4]. The advantage of soybean is the formation of two harvests of protein and fat in 100–120 days, enrichment of the soil with nitrogen (up to 80–100 kg/ha), which increases its fertility and the yield of crops grown after soybean [5, 6].

Regardless of the fact that soybean by its biological characteristics is characterized by high demand for light, heat and moisture, it belongs to those crops that are the basis of "northering" of agriculture and expand the areas of effective cultivation due to resistance to abiotic and biotic stressors [7]. Soybean has a high degree of adaptability to various soil and climatic conditions, which, when using early-ripening varieties, makes its cultivation possible in large areas with a temperate climate (up to the southern regions of the Ryazan and Tula regions) [8–10]. Breeding of early-ripening varieties of the northern ecotype in the soil and climatic conditions of the middle belt will contribute to the promotion of soybean in the

northern regions of Russia. For this reason, the creation of new early maturing varieties of the northern ecotype for cultivation in temperate climates is relevant.

The purpose of the research is to create a new high-yielding, medium early-ripening, technologically advanced, high-protein soybean variety of the northern ecotype for the Central region of Russia.

MATERIAL AND METHODS

The geographical location of the Chuvash Republic determines the climate as moderately continental. Climatic conditions are favorable for growth and development of all regionalized crops, although the territory of Chuvashia belongs to the zone of risky agriculture and is not a soybean-producing region. However, thermal resources of the climate allow the cultivation of soybeans due to the appearance of the northern ecotype varieties [11, 12].

Duration of the vegetational season of agricultural crops is 170–175 days, the sum of active temperatures above 10 °C reaches up to 2100–2300 °C, the average annual rainfall is 450–550 mm, including during the growing season 250–300 mm. In terms of heat supply the territory of the republic belongs to the temperate zone, in terms of moisture it belongs to the slightly arid subzone of the arid zone (HTC 1.1–1.2) [13]. In 2010–2021 the sum of active temperatures during the vegetational season was from 1790° (2017) to 2925° (2010), i.e. early maturing varieties with accumulation of this

sum of active temperatures have time to form a complete seed yield.

The main limiting factor for high yields of soybeans is moisture supply. During the growing season, moisture deficit was observed in 2010, 2014, 2016, 2018, 2021, that is, 5 of the 12 years were dry, and the HTC was 0.5; 0.8; 0.8; 0.7; 0.7, respectively. The longest air and soil drought in 2010 had a negative impact not only on the yield but also on the quality of soybean seeds [14].

Breeding work on soybean varieties was carried out at the experimental plot of the Chuvash Research Institute of Agriculture (NIISKh). The soil of the experimental field is gray forest heavy loam with a humus content of 4.1, close to neutral (with a soil solution reaction of 5.7), with a high content of mobile phosphorus and exchangeable potassium.

In recent years, the Chuvash Research Institute of Agriculture has created soybean varieties adapted to the conditions of growing in the territory of 56°N. [15]. The following varieties were included in the State Register of Breeding Achievements approved for use: the variety Chera-1 for cultivation in the Volga-Vyatka, Sredne-Vyatka, West Siberia, Central Russia; the variety Memory of Fadeev - in the Middle-Vyatka, Volga-Vyatka, Central Russia, Central Chernozem, West Siberia; the variety Lumaria - in the Central Russia, Volga-Vyatka and Middle-Vyatka regions. In 2022, a new early maturing variety of soybean Civil for cultivation in the Central region of the Russian Federation was included in the Register.

RESULTS AND DISCUSSION

Civil variety belongs to the Manchurian subspecies, approbation group Ukrainka (according to Yenken). Quality created by a team of authors of the group of soybean breeding and seed production of the Chuvash Research Institute of Agriculture by crossing the varieties Chera-1 and Yug 30 and multiple individual selection in a hybrid population $F_3 - F_8$. Early maturing, the sum of active temperatures above 10 °C ranging from 1800 to 2000 ° is sufficient for the formation of full beans.

The plants have complete type of development, light gray pubescence of medium thickness, medium height (65-85 cm). The bush is compact, erect, branching is weak (2-3), flowers are white, seeds are globular, yellow, mat of medium size, the scar is short light brown. Table 1 shows morphobiological features of the variety Civil.

The period from sprouting to full maturity of seeds in warm dry years was 83-85 days, in wet cool years - 95-105 days. In the conditions of 2020, full maturation of soybean was recorded on September 10, when the sum of active temperatures was 1950°, and in 2021, hot dry weather accelerated the development phase, and the soybean was ready for harvesting on August 23 (the sum of active temperatures during the vegetation period was 2472°). In the conditions of Chuvashia, sowing of soybean in the middle of May and harvesting at the end of August or at the beginning of September are sufficient for accumulation of the sum of active temperatures within 2000°.

Табл. 1. Характеристика сорта сои Цивиль по некоторым количественным показателям (среднее за 2018–2021 гг.)

Table 1. Characteristics of the Civil soybean variety according to some quantitative indicators (average for 2018-2021)

Variety	Vegetation period	Seed yield, c/ha	Weight of 1000 seeds, g	Plant height, cm	Lower bean height, cm	Number of beans per plant, pcs.	Protein content, %	Fat content, %
Civil	98 (83–105)	28,9 (24,1–32,5)	131 (125–140)	88 (67–92)	13,5 (11–16)	75 (45–110)	38,7 (36,1–42,4)	20,4 (18,7–24,0)
SibNIIK 315 (standard)	102 (90–106)	26,8 (19,3–30,6)	165 (150–173)	73 (57–82)	13,1 (9–17)	56 (35–71)	38,3 (36,7–41,8)	18,6 (16,6–20,7)

The plants of this variety have a fairly strong stem and during the years of testing lodging has not been observed. Beans do not open, the strong attachment of seeds to the bean pods prevents them from shattering. The height of attachment of the lower legume was within 11-16 cm (see Fig. 1), and losses at combine harvesting did not exceed 5-7% of the biological yield of seeds.

At a pre-harvest density of 35-40 plants per square meter, the bush had 60 to 100 beans, and the beans were mostly three-seeded (see Fig. 2). This peculiarity was noted on sparse crops, denser crops of more than 60 plants per unit area leads to a decrease in the number of branches, the number of beans per plant and seeds in the pod.

In Chuvashia, the seed yield of the variety Civil was from 24.1 to 32.5 c/ha (with $LSD_{0.5} = 0.78$ c/ha) by years in competitive variety trials and in breeding nurseries. The excess over the standard variety SibNIIK 315 was on average 2.1 cwt/ha. In 2020, according to SCTS (state crop testing sites) data, yields above 30 cwt/ha in the dry-farming land were in Tula (33.5 cwt/ha), Orel Region (33.8), Mordovia Republic (38.1 cwt/ha).

Protein content averaged 38.7%, which is at the level of the standard variety, the fat content Civil surpassed the released variety by 1.8%. This was especially observed in the dry year of 2021, when the fat content of the new variety was 24%. During the years of testing at an aver-

age yield of 28.9 c/ha the collection of protein and fat per hectare was 1118.4 and 589.6 kg, respectively, which has an excess over the standard variety by 9.0 and 18.3%, respectively.

CONCLUSION

Advantages of the new soybean variety of the northern ecotype Civil compared to the standard are:

- ultra-early maturity, vegetation period 83-85 days (sum of active temperatures 1800°);
- technological efficiency in harvesting (no lodging, cracking or shattering). Losses during combine harvesting do not exceed 5-7% of the biological seed yield;
- high productivity potential (under optimal conditions, the yield reached 38.1 cwt/ha);
- high protein (38.7%) and fat content (20.4%).



Рис. 1. Вид бобов и семян сорта сои северного экотипа Цивиль

Fig. 1. Type of beans and seeds of the soybean variety of the northern ecotype Civil



Рис. 2. Растения сорта сои северного экотипа Цивиль

Fig. 2. Soybean plants of the northern ecotype Civil

Inclusion of a new early maturing soybean variety of the northern ecotype Civil into the production sowings in the regions of the Central region will allow to obtain a stable yield of soybeans and eventually solve the problem of protein in the livestock industry.

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ВЛИЯНИЕ ЭЛЕМЕНТОВ ТЕХНОЛОГИИ ВОЗДЕЛЫВАНИЯ НА СОРНЫЙ КОМПОНЕНТ АГРОФИТОЦЕНОЗА В ПОСЕВАХ ЯРОВОГО РАПСА

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Представлены данные полевых опытов за 2019–2021 гг., проведенные в условиях Северо-Казахстанской области. Показаны приемы совершенствования элементов технологии возделывания сортов и гибридов ярового рапса, направленных на оптимизацию показателей продуктивности. Определены видовой состав, биологические группы сорных растений, компоненты агрофитоценоза и степень засорения сортов и гибридов ярового рапса. Основные учеты и наблюдения проведены согласно методике госсортоиспытания. В исследование были включены сорта Юбилейный, Герос, Майкудык, Хантер, Махаон и гибриды Калибр, Билдер, GEN0009. Изучение сортов и гибридов проведено по двум опытам: на фоне двух предшественников (чистый пар и яровая пшеница); по нормам высева (2,0; 2,5 и 3,0 млн всхожих семян/га). Результаты исследований 2019–2021 гг. показывают, что степень засорения зависела от особенностей сорта или гибрида. Выявлено, что в опыте по предшественникам посевы ярового рапса по чистому пару незначительно чище. За счет проведенной агротехники чистый пар позволяет освободить почву от сорных растений и накопить влагу в корнеобитаемом слое, но статистически достоверные различия не обнаружены. Наиболее чистыми были посевы сорта Майкудык (2,6%) и гибрида Билдер (2,8%). Во втором опыте установлено, что увеличение норм высева от 2,0 до 3,0 млн всхожих семян/га приводило постепенно к снижению засоренности. Наименьшей засоренностью в этом опыте обладали сорт Майкудык (степень засорения 13,9%) и гибрид Билдер (14,7%).

Ключевые слова: степень засорения, сорные растения, яровой рапс, сорта, гибриды

INFLUENCE OF CULTIVATION TECHNOLOGY ELEMENTS ON THE WEED COMPONENT OF AGROPHYTOCENOSIS IN SPRING RAPE CROPS

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Data from field experiments for 2019–2021 conducted under conditions of the North Kazakhstan region are presented. The methods of improving the elements of cultivation technology of spring rape varieties and hybrids aimed at optimizing the indicators of productivity are shown. The species composition, biological groups of weeds, components of agrophytocenosis and the degree of weed infestation of spring rape varieties and hybrids were determined. Basic recordings and observations were made in accordance with the methodology of state variety testing. The following varieties were included in the study: Jubilee, Geros, Maikudyk, Hunter, Mahaon and hybrids: Caliber, Bilder, GEN0009. The study of varieties and hybrids was conducted in two experiments: on the background of two forecrops (complete fallow and spring wheat); by seeding rates (2.0; 2.5 and 3.0 million germinated seeds/ha). The 2019–2021 results show that the degree of infestation depended on the characteristics of the variety or hybrid. It was found that in the experiment on the forecrops the crops of spring rape on complete fallow were slightly cleaner. Due to the implemented agrotechnics, complete fallow allows you to clean the soil from weeds and accumulate moisture in the root layer, but statistically significant differences were not detected. The cleanest crops were the variety Maikudyk (2.6%) and the hybrid Bilder (2.8%). In the second experiment, it was found that increasing seeding rates from 2.0 to 3.0 million germinated seeds/ha led to a gradual decrease in weediness. The variety

Maikudyk (degree of weeding 13.9%) and the hybrid Bilder (14.7%) had the lowest weediness in this experiment.

Keywords: degree of weed infestation, weedage, spring rape, varieties, hybrids

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Conflict of interest

The author declares no conflict of interest.

INTRODUCTION

Over the past few decades, many positions in the technology of cultivation of spring rape have changed: every year there are innovations in the technology of sowing and maintenance of crops. Its varietal composition has also changed prompting trials for further zoning under the changing sharply continental climate [1, 2].

The right choice of a variety or hybrid allows to increase significantly the crop yield, cost recovery and to use the soil-climatic potential more effectively [3]. In this regard, the task is to select the best rape varieties and hybrids of domestic and foreign breeding for each soil and climatic zone, which fully meet the requirements of production [4].

The purpose of the study is to present the elements of spring rapeseed cultivation technology aimed at optimizing the indicators of productivity of spring rapeseed varieties and hybrids in the conditions of the North Kazakhstan region.

The objective of the research is to assess the impact of cultivation technology elements of spring rape varieties and hybrids on the species composition, biological groups of weeds, components of agrophytocenosis and the degree of weed infestation.

MATERIAL AND METHODS

The studies were conducted in 2019-2021 in Esil district of the North Kazakhstan region of the Republic of Kazakhstan. The main records and observations were carried out according to

the methodology of the state variety trials. Empirical and theoretical research methods based on field experiment, laboratory research, analysis and statistical methods were used in the work. Experiments were made on the type of nursery of competitive variety testing. Fourfold repetition, placement of plots is consecutive, the area of the accounting plot is 25 m².

The study of the varieties and hybrids was carried out in two experiments:

- on the background of two forecrops (complete fallow and spring wheat);
- in terms of the seeding rates (2.0; 2.5 and 3.0 million germinated seeds/ha).

The studied varieties were Geros, Maikudyk, Hunter, Makhaon, hybrids - Caliber, Bilder, GEN0009. Spraying of crops was carried out by the herbicide Galion (0.27 l/ha) in the phase of the 3rd-6th leaves of the crop. During the growing season, to control the complex of pests, double treatment with systemic insecticides Biskaya and Decis Profi (0.03 l/ha) was carried out [5].

RESULTS AND DISCUSSION

Rapeseed plants form a large above-ground mass during vegetation, so later they are able to suppress weeds themselves [6]. However, in order for this above-ground mass to be successfully formed, rapeseed crops must be practically clear of weeds during the initial phases of development¹ [7]. Weed control is effective and its results are stable if it is based on the knowledge of their species composition in each specific natural and agricultural region [8, 9].

Weeds of two biological types were encountered in rape cultivation during the years of research: short-lived perennial and perennial dicotyledons. Among short-lived perennial dicotyledons, the most widespread are lady's purse, field pennycress, mayweed, lamb's quarters, cleavers, and redroot pigweed; among the short-lived monocotyledons, yellow foxtail and barnyard grass; among the perennials, yellow sow thistle, field bindweed, winter cress, and common dandelion are the most common. According to our data, depending on the weather conditions of the year, the species composition of the dominant weeds in the variants changed, but insignificantly. Minor weeds accounted for 71% of the total species composition, while perennial weeds accounted for 29%.

Two components of agrophytocenosis - spring rape plants and weeds - were determined in spring rape crops. It was noted that weed infestation in the experiment on the forecrops before herbicide application was at the level of 11.1-14.2% and corresponded to the average degree of weed infestation. On complete fallow it was 1,6-1,7% lower than on spring wheat and amounted before herbicide use to 11,1-12,5% on complete fallow and 12,7-14,2% on spring wheat. A month after herbicide application, the degree of infestation in the experiment decreased by 8.5-10.5%, while for complete fallow it was in the range of 2.6-3.7%. By harvesting spring rape due to the appearance of such winter weeds as lady's purse, field pennycress, mayweed, the degree of contamination increased by 15.6-16.4% and was 18.2-23.7%. Before harvesting on complete fallow, this indicator was lower by 3.1-3.6% than on spring wheat - 18.2- 20.1%. For spring wheat, it was 21,3-23,7%. Comparing the degree of weeding of varieties and hybrids, it should be noted that this indicator for varieties before herbicide use was slightly lower - 11,1-14,2%. A month after herbicide use the degree of weed infestation in the varieties was also slightly less - 2.6-3.4%. Before harvesting it was 18.2-23.7% for these varieties.

The degree of contamination of 11.1% was noted in the cultivation of the variety Maikudyk on the forecrop complete fallow before the application of the herbicide. In a month after its application, this figure decreased by 8.5% and amounted to 2.6%. The lowest indicator before harvesting was 18.2%, which is slightly less than the standard (see Table 1).

In the second experiment, the tendency to increase the degree of contamination of spring rape crops with a decrease in the seeding rate was maintained for each year, being slightly corrected by the weather conditions of a particular year. The varieties and hybrids with the seeding rate of 3.0 million germinated seeds/ha had the lowest degree of infestation. Their degree of weeding was 7,9-8,9%, which is lower than the other tested variants by 3,2-3,6%. Thanks to herbicide use, the degree of infestation decreased by 8.0-8.8% and was 1.9-3.7% a month after application. Before harvesting, this figure was 13.9-15.5% at a seeding rate of 3.0 million germinated seeds/ha: lower by 4.3-4.6% compared with other seeding rates.

The degree of infestation of the varieties before herbicide application was slightly less compared with the hybrids and was at the level of 7.9-12.2%. A month after herbicide application in the varieties it was slightly lower - 1.9-3.3%, before harvesting also slightly less - 13.9-20.1%.

Seeds of the Maikudyk and Jubilee varieties were marked by the degree of 7.9% weed infestation. In a month after herbicide application, the degree of infestation decreased to 1.9% with a seeding rate of 3.0 million germinated seeds/ha in the variety Maikudyk and the hybrid Bilder. Before harvesting, the degree of contamination of 13.9% was observed in the variety Maikudyk with a seeding rate of 3.0 million germinated seeds/ha, which is slightly less than the standard (see Table 2). Decrease of the seeding rate led to an increase of the degree of infestation of spring rape crops. There were dead instances of weeds, apparently, which could not withstand the competition of spring rape at a seeding rate

¹ Danilov V.P., Polyudina R.I. Assortment of crop varieties for fodder production // My Siberia for animal breeders (special issue of the agrarian business magazine "My Siberia"). December 2017. pp. 8-11.

Табл. 1. Компоненты агрофитоценоза посевов ярового рапса при норме высева 2,0 млн всхожих семян/га по предшественникам (2019–2021 гг.)
Table 1. Components of agrophytocenosis of spring rape crops with a seeding rate of 2.0 million germinating seeds per hectare by forecrops (2019–2021)

Variety, hybrid	Forecrop													
	Pure fallow (control)						Spring wheat							
	Number of plants before herbicide application, pcs./m ²	Degree of infestation, %	Number of plants one month after herbicide application, pcs/m ²	Degree of infestation, %	Number of plants before harvesting pcs./m ²	Degree of infestation, %	Weight of weeds, g/m ²	Number of plants before herbicide application, pcs./m ²	Degree of infestation, %	Number of plants one month after herbicide application, pcs/m ²	Degree of infestation, %	Number of plants before harvesting pcs./m ²	Degree of infestation, %	Weight of weeds, g/m ²
Jubilee (standard)	$\frac{176}{22,3}$	11,2	$\frac{159}{5,1}$	3,1	$\frac{105}{23,6}$	18,4	41,2	$\frac{173}{26,4}$	13,2	$\frac{158}{5,2}$	3,2	$\frac{99}{27,7}$	21,9	44,5
Geros	$\frac{174}{22,6}$	11,5	$\frac{156}{5,3}$	3,3	$\frac{101}{23,8}$	19,1	41,0	$\frac{171}{26,8}$	13,5	$\frac{157}{5,2}$	3,2	$\frac{97}{28,9}$	22,9	45,2
Maikudyk	$\frac{174}{21,7}$	11,1	$\frac{162}{4,4}$	2,6	$\frac{104}{23,2}$	18,2	40,6	$\frac{176}{25,7}$	12,7	$\frac{160}{4,8}$	2,9	$\frac{101}{27,4}$	21,3	43,2
Hunter	$\frac{173}{22,9}$	11,7	$\frac{154}{5,3}$	3,3	$\frac{96}{24,1}$	20,1	42,1	$\frac{167}{26,9}$	13,9	$\frac{157}{5,3}$	3,3	$\frac{96}{28,4}$	22,8	45,1
Mahaon	$\frac{172}{23,5}$	12,2	$\frac{156}{5,2}$	3,2	$\frac{97}{24,2}$	19,9	42,0	$\frac{169}{27,9}$	14,2	$\frac{150}{5,3}$	3,4	$\frac{95}{29,5}$	23,7	46,5
Caliber	$\frac{168}{24,1}$	12,5	$\frac{154}{5,4}$	3,4	$\frac{97}{23,2}$	19,3	40,1	$\frac{166}{27,1}$	14,0	$\frac{151}{5,5}$	3,5	$\frac{96}{29,6}$	23,6	46,3
Bilder	$\frac{175}{22,0}$	11,2	$\frac{165}{4,8}$	2,8	$\frac{98}{23,8}$	19,5	40,3	$\frac{175}{26,8}$	13,3	$\frac{160}{5,0}$	3,0	$\frac{95}{27,8}$	22,6	44,7
GEN0009	$\frac{171}{22,9}$	11,8	$\frac{152}{5,8}$	3,7	$\frac{97}{23,9}$	19,8	41,8	$\frac{168}{27,5}$	14,1	$\frac{151}{5,4}$	3,5	$\frac{94}{29,0}$	23,6	46,2
LSD ₀₅	$\frac{5,3}{3,3}$	4,1	$\frac{5,0}{1,5}$	1,3	$\frac{4,7}{3,5}$	4,5		$\frac{5,7}{3,9}$	4,3	$\frac{5,1}{1,6}$	1,4	$\frac{5,2}{4,2}$	5,1	

Note. Numerator - the number of cultivated plants, pcs./m², denominator - the number of weeds, pcs./m².

Табл. 2. Компоненты агрофитоценоза посевов ярового рапса, размещенных после чистого пара, в зависимости от нормы высева (2019–2021 гг.)
Table 2. Components of agrophytocenosis of spring rape crops placed after complete fallow depending on the seeding rate (2019-2021)

Variety, hybrid	Seed rate of germinated seeds per 1 ha (pure fallow forecrop), mln																			
	2,0 (control)					2,5					3,0									
	Number of plants before herbicide application, pcs./m ²	De-gee of infestation, %	Number of plants one month after herbicide application, pcs./m ²	De-gee of infestation, %	Number of plants before harvesting, pcs./m ²	De-gee of infestation, %	Weight of weeds, g/m ²	Number of plants before herbicide application, pcs./m ²	De-gee of infestation, %	Number of plants one month after herbicide application, pcs./m ²	De-gee of infestation, %	Number of plants before harvesting, pcs./m ²	De-gee of infestation, %	Weight of weeds, g/m ²	Number of plants before herbicide application, pcs./m ²	De-gee of infestation, %	Number of plants one month after herbicide application, pcs./m ²	De-gee of infestation, %	Number of plants before harvesting, pcs./m ²	De-gee of infestation, %
Jubilee (standard)	176 22,3	11,2	159 5,1	3,1	105 23,6	18,4	41,2	219 22,4	9,3	192 5,2	2,6	122 24,7	16,8	261 22,5	7,9	24 5,1	2,0	134 22,0	14,1	39,6
Geros	174 22,6	11,5	156 5,3	3,3	101 23,8	19,1	41,0	216 22,6	9,5	190 5,1	2,6	119 24,9	17,3	260 22,7	8,0	244 5,2	2,1	132 22,5	14,6	40,1
Maikudyk	174 21,7	11,1	162 4,4	2,6	104 23,2	18,2	40,6	216 21,8	9,2	194 4,9	2,5	111 23,5	17,5	257 22,1	7,9	251 4,8	1,9	130 21,0	13,9	38,7
Hunter	173 22,9	11,7	154 5,3	3,3	96 24,1	20,1	42,1	212 22,8	9,7	190 5,2	2,7	106 25,2	19,2	252 23,0	8,4	233 5,3	2,2	127 22,8	15,2	41,2
Mahaon	172 23,5	12,2	156 5,2	3,2	97 24,2	19,9	42,0	215 23,1	9,7	188 5,1	2,6	111 25,0	18,4	256 23,2	8,3	241 5,2	2,1	121 21,2	14,9	40,2
Caliber	168 24,1	12,5	154 5,4	3,4	97 23,2	19,3	40,1	211 24,3	10,3	178 5,0	2,7	106 24,3	18,6	251 24,4	8,9	238 5,1	2,1	120 22,0	15,5	39,5
Bilder	175 22,0	11,2	165 4,8	2,8	98 23,8	19,5	40,3	220 22,2	9,2	190 4,9	2,5	126 23,8	15,9	254 22,7	8,2	247 4,8	1,9	123 21,2	14,7	39,7
GEN0009	171 22,9	11,8	152 5,8	3,7	97 23,9	19,8	41,8	212 22,9	9,7	187 5,7	2,9	114 24,9	17,9	252 22,8	8,3	228 5,7	2,4	125 22,1	15,0	39,9
LSD ₀₅	5,3 3,3	4,1	5,0 1,5	1,3	4,7 3,5	4,5		5,0 3,5	3,8	4,3 1,5	1,4	3,3 3,8	4,7	5,2 3,6	3,2	4,0 1,7	1,2	4,3 3,5	3,9	

Note. Numerator - the number of cultivated plants, pcs./m², denominator - the number of weeds, pcs./m².

of 3.0 million germinated seeds/hectare.

N.Z. Milashchenko called the ratio of the weight of the above-ground part of weeds to the total above-ground mass of agrophytocenosis, expressed as a percentage, the share of weeds, or their harmfulness [10]. It was found that it is possible to conclude that the weed infestation within one field is not the same by the number and species composition of weeds in the accounting framework [11-14].

CONCLUSION

Over the years of our research, it was found that in the experiment on the forecrops sowing of spring rape on complete fallow is insignificantly cleaner. Due to the carried out agrotechnics, complete fallow allows to free the soil from weeds and to accumulate moisture in the root layer, but statistically reliable differences were not found. The cleanest were the crops of the variety Maikudyk (2.6%) and the hybrid Bilder (2.8%). In the second experiment it was found that increasing seeding rates from 2.0 to 3.0 million germinated seeds/ha gradually led to a decrease in weediness. The lowest weediness in this experiment occurred in the variety Maikudyk (degree of weediness 13.9%) and the hybrid Bilder (14.7%).

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ЭФФЕКТИВНОСТЬ И КОНКУРЕНТНАЯ СПОСОБНОСТЬ ФЕСТУЛОЛИУМА В СМЕСИ С ЛЮЦЕРНОЙ ПРИ ВЫРАЩИВАНИИ НА КОРМ

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Представлены результаты анализа урожайности и биологической эффективности совместного возделывания фестулолиума и люцерны при различных способах посева и внесения азотных удобрений в условиях лесостепной зоны Западной Сибири. Совместный посев фестулолиума с люцерной при различном чередовании рядов снижает урожайность зеленой массы на 8,9–15,1% по сравнению с одновидовым посевом фестулолиума. Внесение азота в дозе 30 кг/га достоверно увеличило урожайность смесей фестулолиума с люцерной в вариантах черезрядного посева на 21,2% и в варианте посева смесью семян на 20,2% за счет увеличения количества побегов на растении фестулолиума на 11,1%, массы побега – на 12,5–17,8%. Увеличение дозы азота до 60 кг/га достоверно повысило урожайность фестулолиума на 16,13 т зеленой массы/га (74,1%) по сравнению с неудобренным фоном за счет увеличения количества побегов на растении на 26,6% и увеличения массы одного побега на 30,1%. В смесях отмечено уменьшение на 21,0–30,2% численности побегов злакового компонента и на 76,7–82,1% – бобового. При этом у фестулолиума масса побега увеличилась на 8,3–42,5%, у люцерны – снизилась на 54,3–81,5%, что свидетельствует об ее угнетении. Показатель эффективности использования пашни (LER) отмечен выше в вариантах с внесением удобрений. Без использования азота основная доля фактора принадлежит фестулолиуму. С внесением небольших доз азота возрастает влияние бобового компонента за счет повышения конкурентоспособности (CR). При этом положительное значение коэффициента агрессивности (CA) отмечено у злакового компонента, что характеризует его как доминирующий вид.

Ключевые слова: фестулолиум, люцерна, способы посева, азотные удобрения, конкурентная способность

EFFICIENCY AND COMPETITIVE ABILITY OF FESTULOLIUM MIXED WITH ALFALFA WHEN GROWN FOR FEED

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The results of yield analysis and biological efficiency of joint cultivation of festulolium and alfalfa with different methods of sowing and nitrogen fertilizers in the forest-steppe zone of Western Siberia are presented. The joint sowing of festulolium with alfalfa at different alternation of rows reduces the yield of green mass by 8.9-15.1% compared to the single-seeded festulolium sowing. Nitrogen application at a dose of 30 kg/ha significantly increased the yield of festulolium mixtures with alfalfa in the variants of inter-row sowing by 21.2% and in the variant of sowing by seed mixture by 20.2% due to the increase of shoots on festulolium plant by 11.1%, and the shoot weight - by 12.5-17.8%. An increase in nitrogen dose to 60 kg/ha significantly increased the yield of festulolium 16.13 t/ha

green mass (74.1%) compared with unfertilized background due to an increase in the number of shoots on the plant by 26.6% and an increase in weight per shoot by 30.1%. There was a 21.0-30.2% decrease in the number of shoots of the cereal component in the mixtures and a 76.7-82.1% decrease in the number of shoots of the legume component. At the same time, the shoot mass of festulolium increased by 8.3-42.5%, while that of alfalfa decreased by 54.3-81.5%, indicating its depression. Land equivalent ratio (LER) is higher in the variants with the application of fertilizers. With no nitrogen use, the major share of the factor belongs to festulolium. With the application of small doses of nitrogen, the impact of the legume component increases through increased competitive ratio (CR). At the same time, a positive value of the coefficient of aggressivity (CA) was noted in the cereal component, which characterizes it as the dominant species.

Keywords: festulolium, alfalfa, sowing methods, nitrogen fertilizers, competitive ability

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Конфликт интересов

Автор заявляет об отсутствии конфликта интересов.

Conflict of interest

The author declares no conflict of interest.

INTRODUCTION

Perennial grasses occupy the leading position in solving the problem of obtaining nutritious fodder, balanced by protein, essential amino acids and vitamins. They serve as the basis for biological farming, increase soil fertility, protect it from wind and water erosion, increase environmental safety and sustainability of cheap fodder production [1–5].

Traditional grasses used in meadow farming (common timothy, cock's-foot grass, meadow fescue, awnless brome grass, etc.) are characterized by insufficient content of water-soluble carbohydrates, extensive regrowth rate after regular exclusion cycles, and summer growth depression. In this regard, it is important to expand the assortment of fodder crops by creating, introducing and adapting in production conditions new species and varieties with better economically useful properties¹ [6].

One such promising fodder crop is Festulolium (*Festulolium* F. Aschers. Et Graebn.) - an artificially bred fodder crop, which was obtained using methods of interspecific hybrid-

ization of genera *Lolium* sp. and *Festuca* sp. Festulolium inherited excellent fodder qualities from ryegrasses (high sugar, protein and metabolic energy content), good edibility and fodder digestibility, the ability to intensively form a large number of well-vegetated vegetative shoots, and from fescue - good winter hardiness, drought resistance, resistance to prolonged trampling and trampling [7-9].

Grass mixtures with festulolium are mostly studied in the European part of Russia, while in Western Siberia such data are currently insufficient. In this regard, the need for scientific development of festulolium cultivation and implementation methods in fodder production in Western Siberia aimed at full realization of the biological potential and obtaining sustainable yields of this crop is overdue.

The purpose of the research is to develop methods of cultivation of single-species and mixed crops of festulolium Izumrudny variety with alfalfa in the forest-steppe conditions of Western Siberia.

The research objectives are to establish the feasibility of joint sowing of festulolium Izum-

¹*Perepravo N.I., Ryabova V.E., Kulikov Z.A. Agrobiological features of seed production of interspecific hybrids Festulolium (Festulolium) // Prospects of development of adaptive forage production: Proceedings of the scientific-practical conf. Moscow, Astana: GSU VIC Rosselkhozacademy, 2011. pp. 96-100.*

rudny variety with alfalfa; and to determine the optimal sowing method when applying small (starter) doses of nitrogen.

MATERIAL AND METHODS

The studies were carried out at the Siberian Research Institute of Fodder Crops of the Siberian Federal Research Centre of Agro-BioTechnologies of the Russian Academy of Sciences located in the northern forest-steppe of Western Siberia (Russia).

The soil type is moderately deep middle-loamy leached chernozem with humus content of 4.3-6.5% in the layer 0-40 cm, which characterizes it as medium-supplied. The soil of the experimental plot is relatively well provided with mobile forms of phosphorus and exchangeable potassium. The reaction of soil solution pH = 7.4.

In terms of climatic resources, it is a moderately warm insufficiently humid agroclimatic region with average annual precipitation of 350-450 mm (254 mm in the period April - September, 113-130 mm in June - August). Hydrothermal coefficient according to Selyaninov is 1.0-1.2. Weather conditions in the years of research can be characterized as close to the climatic norm for the place of research: 2019 - HTC - 1,15; 2020 - 1,29; 2021 - 1,0.

Experiment scheme.

Seeding methods (factor A):

- 1) festulolium (control);
- 2) alfalfa (control);
- 3) festulolium 1 row + alfalfa 1 row;
- 4) festulolium 2 rows + alfalfa 1 row;
- 5) festulolium 3 rows + alfalfa 1 row;
- 6) festulolium + alfalfa (sowing with a mixture of seeds).

Nitrogen fertilizer application options (factor B):

- 1) without N₀ fertilizers (control);
- 2) N₃₀ application;
- 3) N₆₀ application.

4-fold repetition of experiments with a systematic arrangement of variants. Sown area of the plots was 36 m². Sowing was carried out in II ten-day period of July.

In 2021 the obtained yield results are analyzed through the "land equivalent ratio" (LER), "competitiveness ratio" (CR) and "coefficient aggressivity" (CA) [10]. These indicators are calculated by the formula

$$LER = (Y_{AB}/Y_{AA}) + (Y_{BA}/Y_{BB}),$$

where LER is the ratio of land equivalents, Y_{AB} is the yield of crop A in a mixed sowing with crop B, t/ha; Y_{BA} is the yield of crop B in a mixed sowing with crop A, t/ha; Y_{AA} and Y_{BB} are the yield of crops A and B respectively in pure sowing, t/ha.

$$CR_{AB} = (LER_A : LER_B)(Z_{BA} : Z_{AB}),$$

$$CR_{BA} = (LER_B : LER_A)(Z_{AB} : Z_{BA}),$$

where CR_{AB} is the coefficient of competitiveness of culture A in a mixture with culture B; CR_{BA} is the coefficient of competitiveness of culture B in a mixture with culture A; Z_{AB} and Z_{BA} is the ratio of cultures A and B in a mixture, %.

$$CA_{AB} = Y_{AB} : (Y_{AA} \cdot Z_{AB}) - Y_{BA} : (Y_{BB} \cdot Z_{BA}),$$

where CA is the coefficient of aggressiveness of crop A in a mixed sowing with crop B; Y_{AB} is the yield per unit area of crop A in a mixed sowing with crop B; Y_{AA} is the yield per unit area of crop A in a pure sowing; Z_{AB} and Z_{BA} is the ratio of cultures A and B in a mixture, %.

Agrotechniques in the experiment: early spring moisture closure in two tracks by tooth harrows BZSS-1,0; pre-sowing cultivation KPS-4,2 with harrowing; rolling by ring rollers ZKSh-6 before and after sowing. Sowing with a seeder CH-16 to a depth of 2-3 cm. Rates of festulolium sowing: in one-species sowing 16 kg/ha; in a mixture with alfalfa 8, 6 and 4 kg/ha; in mixed sowing 8 kg/ha. Seeding rates of alfalfa: in pure form 12 kg/ha, in mixtures 6, 4 and 2 kg/ha, in mixed sowing 6 kg/ha.

Festulolium Izumrudny and variegated alfalfa Vega 87 were used in the experiment. Ammonium nitrate (N) was used as a fertilizer; it was applied in spring at the beginning of re-growth with subsequent incorporation with a tooth harrow.

RESULTS AND DISCUSSION

Emergence of the first shoots was recorded after 7 days, mass shoots - on the 15th day. In joint crops the highest density of cereal grasses was noted in the variant of alternating two rows of festulolium and one row of alfalfa, legume grasses - the variant of intercropping of festulolium and meadow clover (Table 1). In mixed crops the highest density of cereal grasses was observed in the variant of the mixture of festulolium and alfalfa, leguminous grasses in the same variant.

The reserves of water-soluble sugars in the roots of plants before they go into winter are used to judge about their winter-hardiness. The maximum content of water-soluble sugars in festulolium roots is 7.11-7.94%, which can characterize it as winter-hardy species (see Table 2). In alfalfa their content was minimal and decreased from single-species sowing to mixtures from 5.14 to 3.77%.

Survival of festulolium plants after wintering was 84.2-97.4% (see Table 1). In alfalfa in single-seeded crops, survival rate was the highest, while in mixtures it decreased to 46.4-

74.3%. Thus, the assumption of poor wintering of legumes is confirmed by plant survival data.

At different levels of mineral nutrition, the share of festulolium in herbage was 86.5-100%, suppressing the development of alfalfa (see Table 3). High values of the share of cereal component are due to weak development of legume and its low competition in the 2nd year of use. At the same time, the number of plants was almost within the optimal limits.

There was a decrease in the share of festulolium in the first cut in the variant of intercropping with alfalfa as the herbage ages regardless of the level of nitrogen application (see Fig. 1), which was 3.7-10.6%. In similar studies by V.N. Obratsov [11], the reduction in the 4th year of herbage life reached 51.2%, which confirms our data.

When summarizing the results of the study of the yields of festulolium grass herbage with alfalfa it was found that on average for 3 years there was an increase in green mass by 5% in the variant of inter-row sowing and a decrease - by 11.9-20.1% when alternating rows of festulolium with 2 and 3 rows of alfalfa (see Table

Табл. 1. Густота всходов и выживаемость в одновидовых и смешанных посевах, шт./м²
Table 1. Germination density and survival in single-species and mixed crops, pcs/m²

Option	Before wintering, pcs./m ²		After overwintering, pcs./m ²		Survival Rate, %	
	Cereal crop	Legumes	Cereal crop	Legumes	Cereal crop	Legumes
Festulolium	156	–	152	–	97,4	–
Alfalfa	–	82	–	75	–	91,5
Festulolium 1 row + alfalfa 1 row	189	74	170	55	89,9	74,3
Festulolium 2 rows + alfalfa 1 row	196	70	183	45	93,4	64,3
Festulolium 3 rows + alfalfa 1 row	180	74	166	36	92,2	48,6
Festulolium + alfalfa (mixed sowing)	181	84	168	39	92,8	46,4

Табл. 2. Содержание водорастворимых сахаров в корнях многолетних трав перед уходом в зиму, посев 2018 г., % в сухом веществе

Table 2. Water-soluble sugars content in perennial grass roots before wintering, sowing 2018, % in dry matter

Option	Type of herbs	
	Cereal crop	Legumes
Festulolium	7,11	–
Alfalfa	–	5,14
Festulolium (mixed sowing with alfalfa)	7,94	3,77

Табл. 3. Содержание злакового компонента в смешанных посевах фестулолиума с люцерной в зависимости от уровня минерального питания в среднем за 2019–2021 гг., %

Table 3. Cereal component content in mixed crops of festulolium with alfalfa as a function of mineral nutrition levels on average for 2019-2021, %

Option	Nitrogen dose, kg a.i./ha					
	N ₀		N ₃₀		N ₆₀	
	1-st cut	2-nd cut	1-st cut	2-nd cut	1-st cut	2-nd cut
Festulolium 1 row + alfalfa 1 row	93,6	100	94,5	100	96,5	100
Festulolium 2 rows + alfalfa 1 row	100	100	100	100	100	97,6
Festulolium 3 rows + alfalfa 1 row	100	100	100	98,3	100	100
Festulolium + alfalfa (mixed sowing)	100	96,5	100	92,8	100	86,5

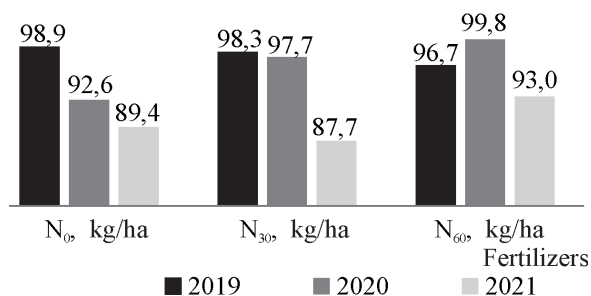


Рис. 1. Содержание злакового компонента в варианте «фестулолиум 1 ряд + люцерна 1 ряд» в первом укосе в зависимости от дозы внесения азота и года использования травостоя, %

Fig. 1 Cereal component content in the variant "Festulolium 1 row + alfalfa 1 row" in the first cut depending on the dose of nitrogen application and the year of herbage use, %

4). The share of factor A (mixture) was only 11%, which is insignificant.

Nitrogen doses of 30 kg/ha significantly increased the yield of mixtures of festulolium with alfalfa at inter-row sowing and sowing with a seed mixture by increasing the proportion of cereal component in the mixture by 11.1% and the weight of shoots by 12.5-17.8%. The yield increased by 5.49-5.77 t/ha.

Increasing the dose of nitrogen to 60 kg/ha significantly increased the yield of festulolium by 16.13 t green mass/ha (74.1%) due to an increase in the number of shoots on the plants by 26.6% and an increase in the weight of one shoot by 30.1%. In the mixtures, the yield decreased to 28.2-36.75 t/ha due to a 21.0-30.2% decrease in the number of shoots of the cereal component and a 76.7-82.1% decrease in the

number of shoots of the legume component. At the same time, if the decrease in the number of festulolium was accompanied by an increase in its shoot mass by 8.3-42.5%, the alfalfa had a decrease of 54.3-81.5%, indicating its depression. Our data are confirmed by the studies of E.R. Klyg [12] and S.T. Esedullaev [13], where nitrogen application on festulolium grass stands with alfalfa is not economically justified and insignificant.

Nitrogen application significantly increases the yield compared with the unfertilized background. The share of the factor is 61%, which is confirmed by the data in Table 4. At the same time, if on the unfertilized background and with an application of nitrogen dose of 30 kg/ha, the maximum yield was observed in the 2nd year of grass use both in pure form and in the variant of intercropping, in other variants the yield reduction occurs with the age of the herbage (see Fig. 2).

At a nitrogen dose of 60 kg/ha, the maximum yield is achieved in the 2nd year of use, and in the 3rd year it stabilizes by variants (see Fig. 3).

The LER of arable use efficiency without fertilizer is significantly higher on row crops and mixed crops, with the major share of the factor belonging to festulolium due to its increased competitiveness (CR) - 1.19 and 1.18, respectively (see Table 5).

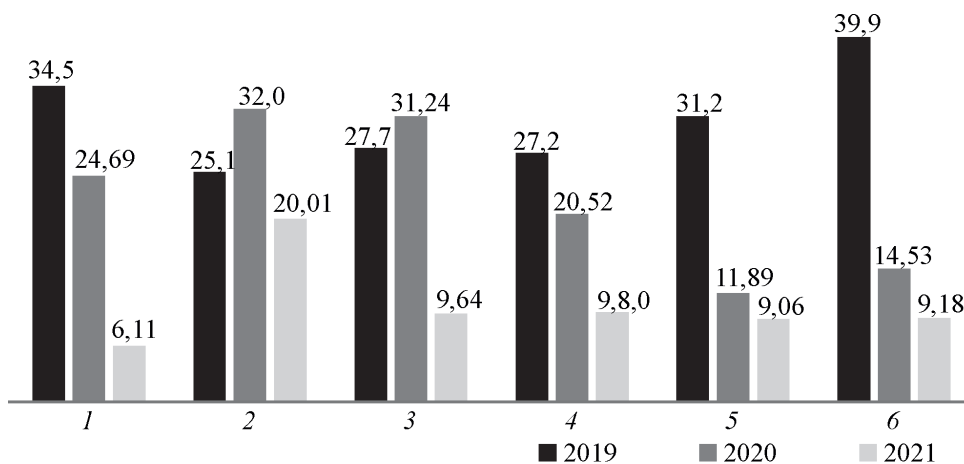
The application of small doses of nitrogen (30 kg/ha) does not reduce the efficiency of arable land use, but the proportion of alfalfa in the herbage increases. Its competitive ability increases in comparison with festulolium from

Табл. 4. Урожайность одновидовых и смешанных посевов многолетних трав в среднем за 2019–2021 гг., т зеленой массы/га

Table 4. Single and mixed crops yield of perennial grasses on average for 2019-2021, t green mass/ha

Option	Dose of applied nitrogen, kg a.i./ha			Increase, ± t/ha		
	N ₀	N ₃₀	N ₆₀	mixture	fertilizer	
					N ₃₀	N ₆₀
Festulolium	21,76	27,13	37,89	–	+5,37	+16,13
Alfalfa	25,70	30,81	31,21	–	+5,11	+5,51
Festulolium 1 row + alfalfa 1 row	22,86	32,9	28,20	+1,1	+10,04	+5,34
Festulolium 2 rows + alfalfa 1 row	19,17	23,02	36,75	–2,59	+3,85	+17,58
Festulolium 3 rows + alfalfa 1 row	17,38	23,19	29,95	–4,38	+5,81	+12,57
Festulolium + alfalfa (mixed sowing)	21,20	32,62	29,96	–0,56	+11,42	+8,76
LSD ₀₅ A (mixture)				0,65		
Б (fertilizer)				0,46		
АБ				1,12		

a



б

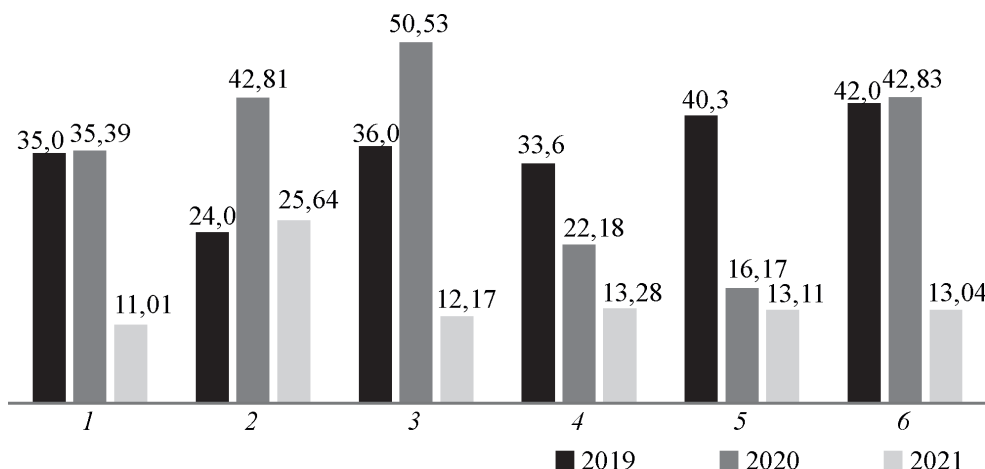


Рис. 2. Урожайность трав в зависимости от года пользования и внесения азота, т зеленой массы/га: *a* – без удобрений; *б* – внесение N₆₀.

Здесь и на рис. 3 варианты посевов: 1 – фестулолиум; 2 – люцерна; 3 – фестулолиум 1 ряд + люцерна 1 ряд; 4 – фестулолиум 2 ряда + люцерна 1 ряд; 5 – фестулолиум 3 ряда + люцерна 1 ряд; 6 – фестулолиум + люцерна (смесь семян)

Fig. 2. Yield of grasses depending on the year of use and nitrogen application, tons of green mass/ha: *a* – without fertilizer; *б* – application of N₆₀.

Here and in Fig. 3 the sowing options: 1 – festulolium; 2 – alfalfa; 3 – festulolium 1 row + alfalfa 1 row; 4 – festulolium 2 rows + alfalfa 1 row; 5 – festulolium 3 rows + alfalfa 1 row; 6 – festulolium + alfalfa (seed mixture)

0,87 (on mixed sowing) to 2,64 (on the variant of alternating rows 3 : 1), but the number of plants per unit area is still small. When the dose of nitrogen is increased to 60 kg/ha, the overall arable efficiency decreases, as does the contribution of each crop. Advantageous competitiveness is higher for alfalfa (1.20-3.60),

but the aggressiveness coefficient (CA) is higher for festulolium.

The data obtained confirm the effectiveness of applying starting doses of nitrogen when growing legumes, which positively affects their competitiveness in the herbage in the neighborhood of a more aggressive species.

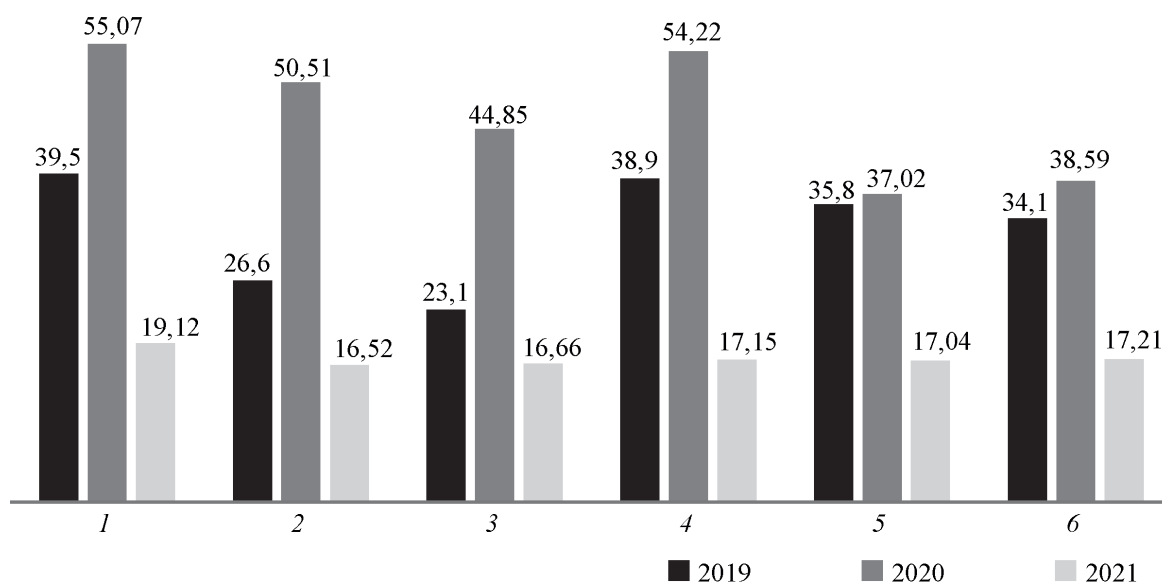


Рис. 3. Урожайность трав в зависимости от года пользования при внесении N₆₀, т зеленой массы /га

Fig. 3. The yield of herbs depending on the year of use when applying N₆₀, tons of green mass/ha

Табл. 5. Оценка эффективности, конкурентоспособности и агрессивности культур в ценозе

Table 5. Evaluation of the effectiveness, competitiveness and aggressiveness of crops in cenosis

Variant of alternating rows of festulolium and alfalfa	LER (festulolium)	LER (alfalfa)	LER	CR (festulolium)	CR (alfalfa)	CA (festulolium)	CA (alfalfa)
<i>Application N₀</i>							
1 : 1	1,05	0,88	1,93	1,19	0,83	0,017	-0,017
2 : 1	0,88	0,74	1,18	0,59	1,68	0,012	-0,012
3 : 1	0,79	0,67	1,46	0,38	2,52	0,010	-0,010
Mixed sowing	0,97	0,82	1,79	1,18	0,84	0,017	-0,017
<i>Application N₃₀</i>							
1 : 1	1,21	2,09	3,30	0,57	1,72	0,020	-0,020
2 : 1	0,84	0,74	1,58	0,56	1,76	0,011	-0,011
3 : 1	0,85	0,75	1,60	0,37	2,64	0,010	-0,010
Mixed sowing	1,20	1,05	2,25	0,95	0,87	0,020	-0,020
<i>Application N₆₀</i>							
1 : 1	0,74	0,90	1,64	0,82	1,21	0,013	-0,013
2 : 1	0,96	1,17	2,13	0,41	2,43	0,013	-0,013
3 : 1	0,79	0,95	1,74	0,27	3,60	0,009	-0,009
Mixed sowing	0,79	0,95	1,74	0,83	1,20	0,010	-0,010

CONCLUSIONS

1. The survival rate of festulolium plants in the first year of life after wintering in a single-crop sowing is 97.4% and decreases in the mixture with alfalfa to 89.9-93.4%. At the same time, the legume component suffers more from a joint sowing, in which the survival rate decreases to 46.4-74.3%.

2. It was found that without the use of nitrogen fertilizers on a single-crop sowing festulolium yield was 28.92 tons of green mass/ha. The joint sowing with alfalfa at intercropping either increased the yield insignificantly (by 5%) or reduced it by 8.9-15.1%.

3. The maximum efficiency in the experiment was obtained by applying nitrogen at a dose of 30 kg/ha. It significantly increased the yield of mixtures of festulolium with alfalfa in the variants of intercropping by 21.2% and in the variant of sowing with seed mixture by 20.2% due to the increased proportion of the cereal component. At the same time, the number of shoots on the plant increased by 11.1% and the shoot weight by 12.5-17.8%.

4. Increasing the nitrogen dose to 60 kg/ha significantly increased the yield of festulolium by 16.13 tons of green mass/ha (74.1%) compared with the unfertilized background by increasing the number of shoots on the plant by 26.6% and increasing the mass of one shoot by 30.1%. In the mixtures there was a 21,0-30,2% decrease in the number of shoots of the cereal component and a 76,7-82,1% decrease in the legume component, which was accompanied by an increase in the shoot mass of festulolium by 8,3-42,5%; in alfalfa there was a 54,3-81,5% decrease, which indicates its depressions. The yield of green mass was 28.2-36.75 t/ha.

5. The index of efficiency of arable land use (LER) is higher on the variants with fertilizer application. Without the use of nitrogen, the main share of the factor belongs to festulolium, with the application of small doses of nitrogen the influence of legume component increases at the expense of increased competitiveness (CR). At the same time, positive value of aggressiveness coefficient (CA) was in the cereal component, which characterizes it as a more aggressive species.

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ЭФФЕКТИВНОСТЬ ФУНГИЦИДНОЙ ЗАЩИТЫ ЯРОВОЙ ПШЕНИЦЫ ОТ МУЧНИСТОЙ РОСЫ И ПИРЕНОФОРОЗА

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Представлены результаты исследования эффективности средств защиты растений против мучнистой росы (*Blumeria graminis*) и пиренофороза (*Pyrenophora tritici-repentis*) для яровой пшеницы. Отмечено, что вероятность массового поражения посевов фитопатогенами определяется запасом инфекционного начала возбудителей болезней, восприимчивостью растения-хозяина и благоприятностью погодных условий для их развития и распространения. Эксперимент проведен с использованием общепринятых в Российской Федерации методик. За период наблюдений степень поражения растений более 20% в фазу колошения отмечена в 46% лет наблюдений (в 2009, 2013, 2014, 2016, 2017 гг.). Эпифитотийное развитие мучнистой росы совместно с бурой листовой ржавчиной (*Puccinia triticina* Eriks.) зарегистрировано в 2013–2014 и 2016–2017 гг. За 2009–2019 гг. степень поражения растений более 20% в фазу колошения отмечена в 46% лет наблюдений (в 2009, 2013, 2014, 2016, 2017 гг.). Эффективную защиту пшеницы от мучнистой росы (75–87%) обеспечивали фунгициды на основе 2–3 действующих веществ. Биологическая эффективность биофунгицида (*Bacillus subtilis*) проявлялась только в годы с умеренным поражением пшеницы и не превышала средний уровень – 58%. Оперативный контроль желтой пятнистости листьев пшеницы целесообразнее осуществлять препаратами на основе таких действующих веществ, как «азоксистробин + эпоксиконазол», «тебуконазол + пропиконазол». Уровень статистически достоверного сохраненного за счет фунгицидной защиты урожая в годы депрессии составлял 5–6%, при умеренном развитии болезней листьев за счет химических фунгицидов – 18%, а биопрепарат обеспечивал прибавку продуктивности 9%. В годы эпифитотий химзащита посевов сохраняла в среднем 24% урожайности пшеницы, лучшей результативностью и стабильностью действия обладали поликомпонентные препараты, а биологическая защита растений в этих условиях была малоэффективна.

Ключевые слова: мучнистая роса, пиренофороз, яровая пшеница, фунгициды

EFFECTIVENESS OF FUNGICIDAL PROTECTION OF SPRING WHEAT AGAINST POWDERY MILDEW AND TAN SPOT

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The results of the study of the effectiveness of plant protection products against powdery mildew (*Blumeria graminis*) and tan spot (*Pyrenophora tritici-repentis*) for spring wheat are presented. It has been noted that the probability of mass destruction of crops by phytopathogens is determined by the stock of the infectious beginning of pathogens, the susceptibility of the host plant and the

favorable weather conditions for their development and spread. The experiment was carried out using the methods generally accepted in the Russian Federation. During the observation period, the degree of plant damage of more than 20% in the heading phase was noted in 46% of the years of observation (in 2009, 2013, 2014, 2016, 2017). Epiphytotic development of powdery mildew together with brown leaf rust (*Puccinia triticina* Eriks.) was registered in 2013–2014 and 2016–2017. For 2009–2019 the degree of plant damage of more than 20% in the heading phase was noted in 46% of the years of observation (in 2009, 2013, 2014, 2016, 2017). Effective protection of wheat against powdery mildew (75–87%) was provided by fungicides based on 2–3 active ingredients. The biological effectiveness of the biofungicide (*Bacillus subtilis*) was manifested only in the years with moderate wheat damage and did not exceed the average level of 58%. It is more expedient to carry out operational control of yellow spotting of wheat leaves with preparations based on such active substances as "azoxystrobin + epoxiconazole", "tebuconazole + propiconazole". The level of statistically significant yield preserved due to fungicidal protection during the years of depression was 5–6%, with a moderate development of leaf diseases due to chemical fungicides - 18%, and the biological product provided an increase in productivity of 9%. During the years of epiphytotic, the chemical protection of crops retained an average of 24% of the wheat yield, polycomponent preparations had the best performance and stability of action, and the biological protection of plants under these conditions was ineffective.

Keywords: powdery mildew, tan spot, spring wheat, fungicides

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Conflict of interest

The authors declare no conflict of interest.

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INTRODUCTION

Significant damage to the yield and quality of spring wheat grain is caused by infectious diseases, mainly of fungal etiology. Losses of grain crops from their influence can reach 30% [1]. An operational method of controlling phytopathogens feeding on leaves is the use of fungicides that inhibit and (or) stop the development of microorganisms. However, the intensive use of pesticides of biocidal nature leads to chemical pollution of ecosystems, as well as to the emergence of pesticide-resistant forms of pathogens. The use of this method in the plant protection system should be justified [1–3].

The causative agents of such cereal diseases as powdery mildew and tan spot or yellow leaf spot are harmful infections that can cause yield

losses ranging from 5–10% during moderate development of infections to 35–50% in the years of epiphytotic [1, 2]. All bread and many fodder and wild cereals are affected by powdery mildew. *Blumeria graminis* (DC.) Speer f. sp. *Triticum March* is a complex fungus species that includes specialized forms capable of infecting one or more cereal species [2–4].

The distribution of powdery mildew is quite wide: Europe, Asia, Africa, America, and Australia. In Russia, the disease is observed everywhere, but it is particularly harmful in the Ural and Volga-Vyatka regions, the North Caucasus, the Volga region, and the Central Black Earth region [3, 4]. It has economic importance in Belarus, Kazakhstan, Ukraine, the Baltic countries, Transcaucasia, as well as in other grain-

growing regions of Eurasia [4]. Areas with the cultivation of winter and spring cereal crops are in a special zone of phytosanitary risk, because fungi build a highly effective "food conveyor". The harmfulness of powdery mildew is manifested primarily in the reduction of the assimilating surface and in the destruction of chlorophyll and other pigments [2, 5]. Based on practical experience, it should be noted that agronomists often do not perceive the infestation of plants by this pathogen as a threat to crops, unlike, for example, rust. As a result, timely protection measures are not taken, which leads to the loss of wheat yield and reduction of grain quality, accumulation of inoculum on the fields.

Powdery mildew can only feed on living green plants, that is, as long as the host plant is green, so long as the fungus lives. It does not produce toxins and does not quickly try to kill the plant. The agent of pyrenophorosis, which is a necrophyte and produces host-specific toxins, has a different attitude toward the host plant [2, 5-8]. These toxins induce symptoms of necrosis or chlorosis when interacting with their corresponding susceptibility genes [9].

Yellow leaf spot is a relatively new wheat disease for the Ural region. The causative agent is ascomycete fungus *Pyrenophora tritici-repentis* (Died.) Drechsler. In North America and Australia, it appeared at the epiphytotic level as early as in the 70s of the XX century; in Europe (including Russia) - in the 80s. Epiphytotic of this disease are periodically observed in different countries of the world; grain losses in susceptible varieties reach 65% [5, 7-10]. It should be remembered that excessive attention to the creation of varieties resistant to one of the diseases can lead to genetic vulnerability to other diseases as it occurred earlier in Canada. The spread of yellow spot disease could also be promoted by the modern system of tillage (mini-till, no-till), which leaves a large amount of crop residues on its surface, where *P. tritici-repentis* pseudoperithecia inhabit [11, 12].

Operational control of leaf infections is carried out by treating plants with fungicides. The question of their justified use is not easy to answer, since the use of plant protection products is an investment in an often-unpredictable fu-

ture. For the effectiveness of protective measures, fungicides should be applied in a targeted manner, taking into account the level of tension of the phytosanitary situation, the spectrum of the drug, the price categories for grains and pesticides. Numerous scientific (own and literature) data show that one or another stock of infection may not always lead to massive disease development. It is important to monitor the development of phytopathogens and weather conditions of the growing season [13, 14].

The issues of leaf spot control are relevant almost in every crop season. In the present realities, when traditional tillage technologies are replaced by resource- and moisture-saving systems (mini-till, no-till), the stubble residues in the field successfully retain the stock of infectious origins of such plant diseases as powdery mildew, tan spot, septoriose, fusarium disease, etc.

The purpose of the research is to determine the level of powdery mildew and tan spot development on spring wheat (*Triticum aestivum* L.) under Trans-Ural conditions and the effectiveness of fungicide preparations for phytopathogen control.

MATERIAL AND METHODS

The research was conducted in 2009-2019 in the experimental field of the Kurgan Research Institute of Agriculture - a branch of the Ural Federal Agrarian Research Center of the Ural Branch of the Russian Academy of Sciences (UrFARC UB RAS) under the State assignment of the Ministry of Science and Higher Education on "Improvement of adaptive landscape agriculture for the Ural region and creation of new generation agro-technology based on minimization of tillage, diversification of crop rotations, rational application of pesticides and biopreparations, preservation and improvement of soil fertility and development of information-analytical complex of computer programs, providing innovative management of farming system". Spring wheat (*Triticum aestivum* L.) of Omskaya 36 variety was used in the experiments. Pure early fallow was the forecrop. The soil of the experimental plot was medium-humic middle-loamy leached chernozem. Crop

treatment with fungicides was carried out in the phase of flag leaf emergence (phase 37 according to Tsadok) with a Solo 456 sprayer equipped with a meter boom, the working solution consumption of 300 l/ha. The plot area was 20 m², 4-fold repetition, and the placement of plots was systematic. Background treatment with a tank mixture of herbicides was carried out to eliminate the influence of weeds. Observations and records were made by the methods generally accepted in the Russian Federation¹⁻³. Calculation of biological effectiveness of preparations was carried out according to Abbott's formula.

The experiment scheme included the following foliar fungicides: propiconazole 250 + cyproconazole 80 g/L (Alto Super), spiro xamine 250 + tebuconazole 167 + triadimenol 43 g/L (Falcon), propiconazole 300 + tebuconazole 200 g/L (Colosal PRO), thiophanmethyl 310 + epoxiconazole 187 g/L (Rex Duo), propiconazole 140 + tebuconazole 140 + epoxiconazole 72 g/L (Triad), tebuconazole 225 + flutriafol 75 g/l (Strike Forte), propiconazole 390 g/l (Title 390), cyproconazole 400 g/l (Recruit), tebuconazole 250 g/l (Chancil), azoxystrobin 240 + epoxiconazole 160 g/l (Spirit), *Bacillus subtilis*, strain 26D (Fitosporin-M, Zh), and control without fungicide protection.

RESULTS AND DISCUSSION

Monitoring of fungal infections on the leaves of spring wheat showed that powdery mildew fed on them almost annually, the primary symptoms of the lesion were noted, as a rule, at the end of the phase of emerging into the tube (phenophase 34- 36 according to Tsadoks). Epiphytotic development of powdery mildew in combination with brown leaf rust (*Puccinia triticina* Eriks.) was recorded in 2013, 2014 and 2016, 2017. In 2015-2017 during flowering - grain ripening period, straw and stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Erikss. et Henn.) lesions were also observed. For 2009-

2019, the degree of plant infestation over 20% in the earing phase was observed in 46% of the years of observations (in 2009, 2013, 2014, 2016, 2017).

The results of field experiments on determining the protective effect of fungicides showed that the high biological efficacy (more than 80%) against tan spot was provided by the combinations of fungicide active substances, such as "azoxystrobin 240 + epoxiconazole 160 g/l", "propiconazole 300 + tebuconazole 200 g/l", "thiophanate-methyl 310 + epoxiconazole 187 g/l", and also by the preparation on the tebuconazole base (see Table 1). Weak control of *Pyrenophora tritici-repentis* fungus was noted in the variants with single-component fungicides based on cyproconazole and propiconazole (38.0-45.6%) (see Table 1). Only Spirit preparation based on azoxystrobin and epoxiconazole reduced the prevalence of infections up to 45%.

Initial signs of wheat powdery mildew were recorded mainly in the phase of leaf-tube formation. The further rate of infection development directly depended on hydrothermal conditions. Long-term data indicate that the development of *Blumeria graminis* was significantly negatively related ($r = -0,65-0,70$) to the temperature during the periods from tillering to flag leaf emergence and from earing to flowering, and also strongly positively related ($r = 0,77-0,82$) to precipitation during the period of wheat stem formation.

In the years with moderate and mass plant infestation, good (more than 70%) biological effectiveness of chemical fungicides was noted. Biological fungicide under epiphytotic and depression conditions failed to cope with the protective function (33-35% technical efficiency) (see Table 2).

In 2011 and 2015, the degree of plant infestation was characterized as moderate development (10% in p. 51-61). Biological effectiveness of the studied chemical fungicides was

¹Ecological monitoring and methods to improve protection of grain crops from pests, diseases and weeds: guidelines / edited by V.I. Tansky. SPb.: VIZR, 2002. 76 p.

²Methods of State Variety Testing of Agricultural Crops. Moscow: Kolos, 1989. 239 p.

³Methodological guidelines for registration testing of fungicides in agriculture. SPb.: VIZR, 2009. 378 p.

Табл. 1. Поражение пшеницы яровой пиренофорозом в зависимости от применения фунгицидных препаратов, 2018, 2019 гг.

Table 1. Damage to spring wheat by *Pyrenophora tritici-repentis* depending on the use of fungicides, 2018, 2019

Option	Disease development during grain ripening (ph. 71-73), %	Biological effectiveness of the preparation, %*	Disease prevalence during the grain ripening period, %
Control without fungicide treatment	3,89	–	75,0
Propiconazole 390 g/l (Titul 390 0.26 l/ha)	2,12	45,6	72,5
Cyproconazole 400 g/l (Recruit 0.2 l/ha)	2,41	38,0	75,0
Tebuconazole 250 g/l (Chancil 1 l/ha)	0,60	84,5	80,0
Propiconazole 250 + cyproconazole 80 g/l (Alto Super 0,4 l/ha)	1,17	69,9	76,5
Propiconazole 300 + tebuconazole 200 g/l (Kolosal PRO 0,4 l/ha)	0,62	84,2	63,5
Thiophanat-methyl 310 + epoxiconazole 187 g/l (Rex Duo 0.5 l/ha)	0,73	81,2	67,5
Tebuconazole 225 + flutriafol 75 g/l (Strike Forte 0.5 l/ha)	1,00	74,4	75,5
Azoxystrobin 240 + epoxiconazole 160 g/l (Spirit 0.6 l/ha)	1,00	94,4	45,0
Spiroxamine 250 + tebuconazole 167 + triadimenol 43 g/l (Falcon 0.6 l/ha)	1,83	53,0	82,5
Propiconazole 140 + tebuconazole 140 + epoxiconazole 72 g/l (Triada 0.6 l/ha)	0,79	79,7	71,0
<i>Bacillus subtilis</i> , strain 26D (Phytopsporin-M 1 l/ha)	4,14	5,4	70,0

* The calculation is carried out according to Abbott's formula.

77-79%, which is almost at the level of effectiveness in the years of mass development of infections. The biological preparation reduced the degree of plant infestation by 58% in moderate powdery mildew development. In these years less drought phenomena were observed in the second half of the vegetation period and the effectiveness of bacteria inoculation on wheat leaves increased significantly. In years of mass development of aerogenic infections, timely fungicide treatments preserved a significant part of the wheat yield. At the same time, the correlation relationship between the yield and the degree of disease infestation was characterized as strongly negative ($r = -0.94$). With moderate plant infestation, the close correlation decreased ($r = -0.85$).

The biological efficacy of fungicidal preparations with respect to total lesions of all leaf infections was characterized as good (66-68%) for Titul 390 and Recruit variants and reached 80-90% for treatments with preparations based on 2-3 active substances. The biological fungicide Fitosporin-M provided leaf disease con-

trol by an average of 40% over the years of research. Yield capacity of spring wheat in the experiment was on average 21.9 c/ha (from 10 c/ha in very dry years 2010 and 2012 to 39 c/ha in favorable 2011), which is a good productivity for conditions with moisture supply during growing season of 175-200 mm.

The level of the yield saved by fungicide protection was 5-6% in the years of depression. Application of chemical fungicides with moderate development of leaf diseases saved 18% of the yield, and the biopreparation provided an increase in productivity of 9% compared to the control, which was statistically reliable in all cases. In the years of epiphytotics, chemical protection of crops saved an average of 24% of the wheat yield; polycomponent preparations had the best efficiency and stability of action.

CONCLUSIONS

1. Monitoring of fungal infections on leaves of spring wheat showed that powdery mildew fed on them almost every year, the primary signs of lesions were noted, as a rule, at

Табл. 2. Биологическая эффективность фунгицидных препаратов при разных уровнях поражения пшеницы мучнистой росой, 2009–2017 гг.

Table 2. Biological effectiveness of fungicidal preparations at different levels of wheat damage by powdery mildew, 2009-2017

Option	Epiphytosity of leaf infections (2009, 2013, 2014, 2016, 2017)		Moderate development of infections (2011, 2015)		Depression (2018, 2019)	
	R, %	BE, %	R, %	BE, %	R, %	BE, %
Control without fungicide treatment	38,9	–	10,0	–	3,4	–
Propiconazole 250 + cyproconazole 80 g/l (Alto Super 0,4 l/ha)	9,9	75	2,3	77	1,1	68
Propiconazole 300 + tebuconazole 200 g/l (Kolosal PRO 0,4 l/ha)	9,1	77	2,2	78	0,9	74
Thiophanat-methyl 310 + epoxiconazole 187 g/l (Rex Duo 0.5 l/ha)	8,6	78	2,1	79	1,6	53
Spiroxamine 250 + tebuconazole 167 + triadimenol 43 g/l (Falcon 0.6 l/ha)	5,1	87	2,3	77	1,7	50
<i>Bacillus subtilis</i> , strain 26D (Phytosporin-M 1 l/ha)	25,9	33	4,2	58	2,2	35

Note: R - disease development during earing - flowering period (ph. 55-65 according to Tsadoks); BE - biological efficacy of the preparation according to the Abbott formula.

the end of the leaf-tube formation phase (phenophase 34-36 according to Tsadoks). For 2009-2019, the degree of plant infestation more than 20% in the earing phase was noted in 46% of years of observations (in 2009, 2013, 2014, 2016, 2017).

2. Effective protection of wheat against powdery mildew (75-87%) was provided by fungicides based on 2-3 active substances. Biofungicide showed medium biological effectiveness only in the years with moderate infestation of wheat.

Prompt control of yellow leaf spot disease (tan spot) in wheat is more appropriate to carry out with preparations based on such active substances as "azoxystrobin + epoxiconazole", "propiconazole + tebuconazole". Biological fungicide had weak control over this type of phytopathogen.

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БИОЛОГИЧЕСКИЕ И МОЛЕКУЛЯРНО-ГЕНЕТИЧЕСКИЕ СВОЙСТВА *TRICHOPHYTON BENHAMIAE* – НОВОГО ВОЗБУДИТЕЛЯ ДЕРМАТОМИКОЗОВ КОШЕК

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Представлены результаты выделения двух штаммов OVB_T.b-19 и OVB_T.b-20 нового вида микроскопического гриба *Trichophyton benhamiae* из проб биологического материала от кошек с клиническими признаками дерматомикоза. Данный вид гриба впервые изолирован от домашних кошек на территории России. Молекулярно-генетические исследования, видовая идентификация и определение свойств выделенных культур проведены с помощью утвержденных методических рекомендаций и определителей патогенных и условно-патогенных грибов. Изучены кератинолитическая и биохимическая активность, культурально-морфологические (фенотипические) и молекулярно-генетические свойства *T. benhamiae*. Оба штамма гриба характеризовались разнообразием фенотипических свойств: формировали на питательных средах колонии, отличающиеся по морфологии и окраске воздушного и субстратного мицелия. У них выявлено сходство микроморфологии: наличие септированного бамбукообразного мицелия с характерным ветвлением двухслойных макроконидий и микроконидий. Изученные штаммы характеризовались схожими биохимическими свойствами (выраженная сахаролитическая и уреазная активность) и кератинолитической активностью. Выявленная кератинолитическая активность у штаммов *T. benhamiae* свидетельствует об их этиологической роли в развитии дерматомикозов у домашних кошек. Фенотипические характеристики полностью соответствовали культуре микроскопического гриба *T. benhamiae*. В результате молекулярно-генетических исследований выявлено, что выделенные от кошек микроскопические грибы принадлежали роду *Trichophyton*, виду *Benhamiae*. Молекулярно-генетические исследования установили идентичность последовательностей полученных нами штаммов OVB_T.b-19 и OVB_T.b-20. Оба штамма внесены в базу данных GenBank с присвоением индивидуальных номеров в международной базе данных NCBI – ON479483 и ON479484.

Ключевые слова: дерматомицеты, *Trichophyton*, фенотипические свойства, штаммы, мицелий, макроконидии, микроконидии

BIOLOGICAL AND MOLECULAR GENETIC PROPERTIES OF *TRICHOPHYTON BENHAMIAE*, A NEW PATHOGEN OF DERMATOMYCOSES IN CATS

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The results of isolation of two strains OVB_T. b-19 and OVB_T. b-20 of a new microscopic fungus species *Trichophyton benhamiae* from the samples of biological material from cats with clinical signs of dermatomycosis are presented.

This type of fungus was isolated from domestic cats for the first time in Russia. Molecular genetic studies, species identification and determination of the properties of the isolated cultures were carried out using approved methodological recommendations and determinants of pathogenic and opportunistic fungi. The keratinolytic and biochemical activity, cultural-morphological (phenotypic) and molecular-genetic properties of *T. benhamiae* were studied. Both strains of the fungus were characterized by a variety of phenotypic properties: they formed colonies on the nutrient media that differed in morphology and color of aerial and substrate mycelium. They revealed the similarity of micromorphology: the presence of a septate bamboo-like mycelium with characteristic branching of two-layer macroconidia and microconidia. The studied strains were characterized by similar biochemical properties (pronounced saccharolytic and urease activities) and keratinolytic activity. The identified keratinolytic activity of the *T. benhamiae* strains indicates their etiological role in the development of dermatomycoses in domestic cats. The phenotypic characteristics fully corresponded to the culture of the microscopic fungus *T. benhamiae*. Molecular genetic studies revealed that microscopic fungi isolated from cats belonged to the genus *Trichophyton*, species *Benhamiae*. Molecular genetic studies established that the sequences of OVB_T. b-19 and OVB_T. b-20 strains that had been obtained were identical. Both strains are listed in the GenBank database with individual numbers in the international NCBI database, ON479483 and ON479484.

Keywords: dermatomycetes, *Trichophyton*, phenotypic properties, strains, mycelium, macroconidia, microconidia

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Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Conflict of interest

The authors declare no conflict of interest.

INTRODUCTION

Trichophyton benhamiae is a new species of microscopic fungus capable of causing lesions of the skin and its derivatives in humans and various species of domestic and wild animals [1]. Over the past 15 years, the prevalence of zoonotic infectious diseases in animals caused by *T. benhamiae* has been steadily increasing worldwide [2]. Cases of *T. benhamiae* isolation from humans and animals in the Czech Republic, Poland, Germany, Italy, Finland, Switzerland, Iran, Egypt, Taiwan, Japan, the United States, and Russia have been described [3, 4].

T. benhamiae was most often isolated from samples of biological material from humans [5]. In cases of its isolation from animals, guinea pigs, foxes [1], rabbits [6], and dogs were the main hosts of pathogenic strains [7]. Cases of isolation of the fungus from domestic and stray cats have been described. Most cases of isolation of *T. benhamiae* pathogen from cats have

been described in the example of stray animals. The authors put forward the assumption that wild rodents were the source of their infection [8, 9].

Many researchers misdiagnosed *T. benhamiae* as *Microsporum canis* [10, 11] or *T. mentagrophytes* var. *porcellae* [2] because of similar phenotypic features or similar micromorphology [10].

Given the morphological features of the colonies, two phenotypes have been described for *T. benhamiae* strains: yellow and white [3, 12-15]. The yellow phenotype is the most common. This phenotype forms flat colonies with aerial mycelium of beige to yellow velvety appearance with substrate mycelium of bright yellow, ochre to brown or reddish color. The white colony phenotype is characterized by powdery, granular, radiate, and flat aerial mycelium, sometimes slightly yellowish at the edges. This phenotype is characterized by a rapid growth

rate, the formation of numerous spherical and club-shaped microconidia, and single club-shaped and cigar-shaped macroconidia [10, 13, 16]. This phenotype of *T. benhamiae* is morphologically very similar to *T. mentagrophytes*, which may well have caused errors in its identification and establishment of its role in the development of dermatomycoses.

Strains with the white phenotype described by some authors account for about 20% of the cases and can be confused with the *T. mentagrophytes* complex (*T. mentagrophytes*, *T. interdigitale*) [10, 13].

T. benhamiae has not previously been registered as a causative agent of feline dermatomycoses in the Russian Federation.

The purpose of this work is to study the biological and molecular genetic properties of two strains of *T. benhamiae* isolated for the first time in Russia from biomaterial samples from cats with clinical signs of dermatomycoses.

MATERIAL AND METHODS

The studies were conducted in 2021, 2022 in the Laboratory of Biotechnology - Diagnostic Center of the Institute of Experimental Veterinary Science of Siberia and the Far East SFSCA RAS and in the Laboratory of Collective Use of the Research Platform of Agricultural Biotechnology.

Surface cultivation and isolation of fungal monocultures and study of their phenotypic properties were performed in Petri dishes and Kaden blocks with Sabouraud, Czapek, honey, corn and potato agar media at 28 °C. For detailed characterization of *T. benhamiae* cultures and study of biochemical properties, they were surface cultured on Hiss media with maltose, mannitol, lactose, sucrose, and glucose, Christensen's medium, and modified nutrient medium with keratin.

The micromorphology of *T. benhamiae* was studied in a light microscope at $\times 400$. For this purpose, Kaden agar blocks were prepared after 24, 48, 72 h or more of growth. Species identification of isolated cultures was performed according to the methods described in the literature [3, 17].

Amplification of the internal transcribed region (ITS) DNA marker genes was performed in a 25 μ l final reaction volume containing 1 \times Phusion HF buffer, 2.5 mM MgCl₂, 1U Phusion DNA polymerase, and 200 μ M dNTP (New England BioLabs Inc.), 25 pmol of each primer, and 20 ng of extracted DNA from a single sample. PCR was performed under the following thermocycling conditions: 95°C for 30 s, 52°C for 40 s, 72°C for 50 s, and final elongation for 5 min at 72°C. The amplified DNA products were analyzed by horizontal electrophoresis in 1% agarose gel using 1 \times TAE buffer solution and EtBr. Electrophoresis parameters were 120 V, 250 mA, 50 W, and reaction time was 30 min.

The amplified DnA fragments were sequenced using the Sanger method using the BigDye terminator sequencing kit according to the manufacturer's specifications. To ensure sequencing accuracy, the amplified fragments were sequenced with two primers: forward (ITS 4 TCCT-CCGC-TTAT-TGAT-ATGC) and reverse (ITS5 GGAA-GTAA-AAGT-CGTA-ACAA-GG). Sequencing products were studied on an ABI 3130XL genetic analyzer (Applied Biosystems). The chromatograms were analyzed and edited using Sequencing Analysis 5.2, Patch 2 (Applied Biosystems). The sequences of *T. benhamiae* strains KU257463, LN874020, LC388864, AB458143, KU496914, MT261760, JN134088, AB458165, MF152781, LS444190, and OK376997 published in GenBank were used for comparative analysis.

The sequences obtained were deposited in the GenBank international database.

RESULTS AND DISCUSSION

Mycological examination of biomaterial samples obtained from cats with a preliminary diagnosis of microsporiosis resulted in the isolation of two dermatomycete strains. The study of their cultural and morphological properties showed their difference from the classical cultures of the fungus *M. canis*. A more detailed study of the cultural and morphological and molecular genetic properties of the isolated dermatomycete cultures identified a new species of

the causative agent of feline dermatomycosis that had not previously been found in Russia.

The cultural and morphological studies established that they differed in a variety of phenotypic traits (see Fig. 1).

Strain *T. benhamiae* OVB_T.b-19 formed floury round colonies with a crater-shaped center and a stepping beige-cream colored slightly powdery mycelium on Sabouraud agar. The reverse side of the colony and the substrate mycelium on Sabouraud agar were stained brown and wine-colored. The formation of fluffy my-

celium in the form of thin threads both on the surface and in the depth of the agar was noted along the edge of the colony.

Strain *T. benhamiae* OVB_T.b-20 grew as powdery, white, in some places creamy, rounded colonies with pronounced zoning. The reverse side of the colonies was orange in color. The growing edge of the *T. benhamiae* colony was flat.

Microscopy revealed the presence of septate bamboo-like mycelium with characteristic branching and similar microstructures: abun-

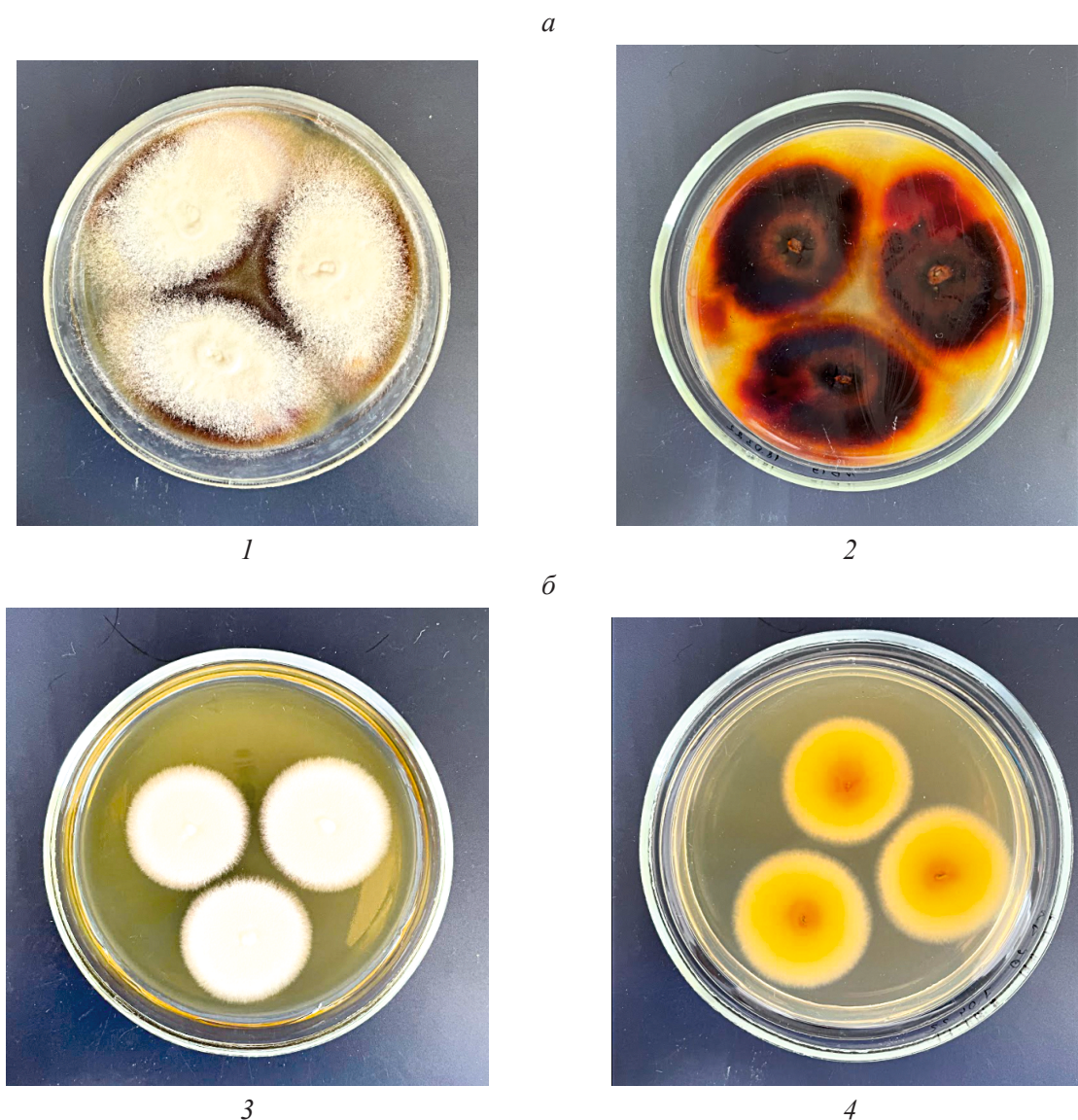


Рис. 1. Колонии штаммов *T. benhamiae*, агар Сабуро; 28 °С, 20 сут:

a – штамм *T. benhamiae* OVB_T.b-19: 1 – лицевая сторона; 2 – обратная сторона;

б – штамм *T. benhamiae* OVB_T.b-20: 3 – лицевая сторона; 4 – обратная сторона

Fig. 1. Colonies of *T. benhamiae* strains, Saburo agar; 28 °C, 20 days:

a – strain *T. benhamiae* OVB_T.b-19: 1 – front side; 2 – reverse side;

б – strain *T. benhamiae* OVB_T.b-20: 3 – front side; 4 – reverse side

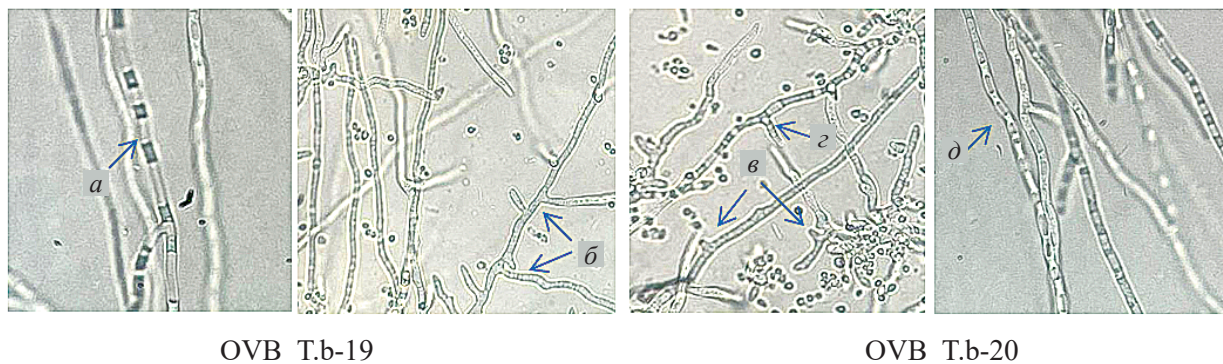


Рис. 2. Строение мицелия у штаммов *T. benhamiae*: на агаровых блоках с агаром Сабуро; 28 °С; ×400, 3 сут:

a – септированный бамбукообразный мицелий; *б* – ветвление; *в* – микроконидии;
г – макроконидии; *д* – артроспоры

Fig. 2. Mycelial structure of *T. benhamiae* strains: on agar blocks with Saburo agar; 28 °C; ×400, 3 days:
a – septated bamboo-like mycelium; *б* – branching; *в* – microconidia; *г* – macroconidia; *д* – arthrospores

dant microconidia, single macroconidia with characteristic constrictions of forming arthrospores in both strains of *T. benhamiae* (see Fig. 2).

The strains differed in some morphological features: *T. benhamiae* OVB_T.b-19 revealed a septate branching colorless mycelium, and *T. benhamiae* OVB_T.b-20 showed a colorless septate bamboo-like mycelium with pronounced branching. In both strains, characteristic macroconidia with a two-loop cell wall and a prominent constriction and microconidia sitting on hyphae were found (see Fig. 3).

The study of biochemical properties revealed pronounced urease activity in the *T. benhamiae* fungus strains tested. Both strains actively digested sucrose, maltose, and lactose, weakly cleaved glucose, and practically did not ferment mannitol on Hiss media.

T. benhamiae strains showed keratinolytic properties in the hair perforation test. These were expressed in abundant growth and the appearance of fairly prominent "pegs" and hair surface pitting (see Fig. 4).

For the detection of keratinolytic properties, Sabouraud media with the addition of keratin hydrolysate from human hair and finely ground cat hair were prepared. On the media with keratin addition of human and feline hair, the strains formed spores faster than on the control medium without hair addition. The surface of the colonies on the control medium was more delicately structured and velvety; on the medium with keratin, it was more granular and denser (see Fig. 5).

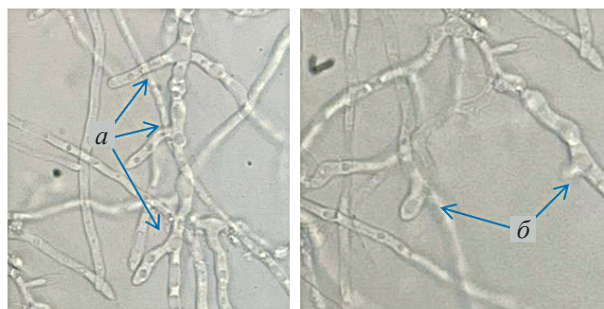


Рис. 3. Морфология макроконидий (*a*) и микроконидий (*б*) *T. benhamiae*; среда Сабуро, агаровые блоки; 28 °С, ×400, 7 сут; стрелкой указаны перетяжки

Fig. 3. Morphology of *T. benhamiae* macroconidia (*a*) and microconidia (*б*); Saburo medium, agar blocks; 28 °C, ×400, 7 days; the arrow indicates constrictions

Also, during the growth and formation of colonies, a more pronounced zone of transparency around each strain was noted, which was manifested by a more intense colored background. We believe that this phenomenon is associated with thinning and destruction of hair under the influence of keratinolytic enzymes.

Genotyping confirmed a 98-99% match in 649 nucleotide sequences of the two isolated fungal strains with the sequences of strains KU257463, LN874020, LC388864, AB458143, KU496914, MT261760, JN134088, AB458165, MF152781, LS444190 and OK376997 of *T. benhamiae* published in the GenBank.

Both strains have been systematized and deposited in the NCBI international database.

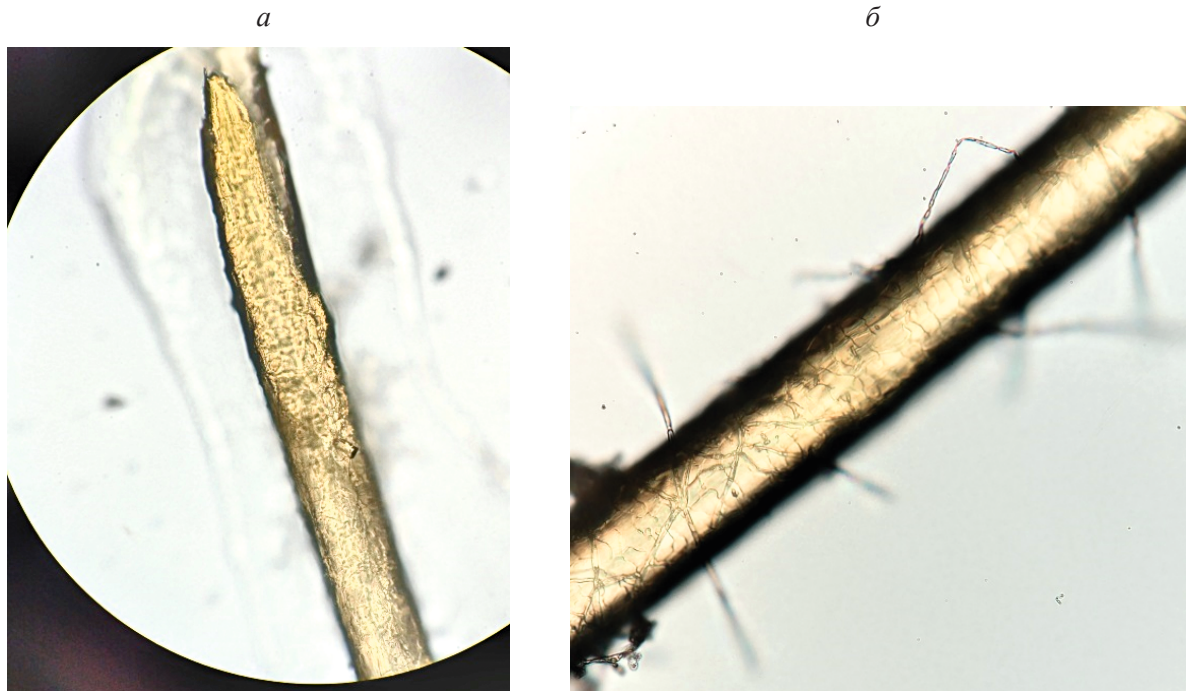


Рис. 4. Разрушение волоса под действием кератинолитических ферментов *T. benhamiae*:
a – штамм № 19; *б* – штамм № 20
Fig. 4. Hair destruction under the action of *T. benhamiae* keratinolytic enzymes:
a – strain No. 19; *б* – strain No. 20

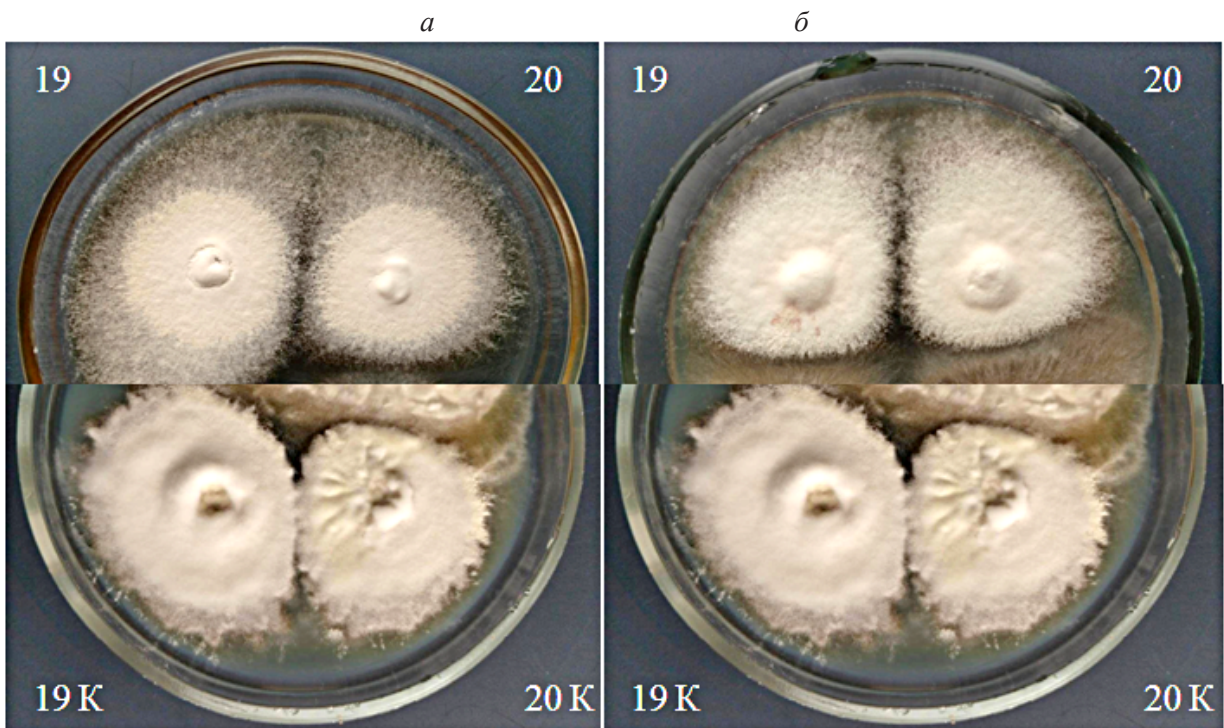


Рис. 5. Особенности роста штаммов *T. benhamiae* на модифицированной среде с добавлением кератина волос:
a – кератин из волос человека; *б* – кератин кошачьих волос
Fig. 5. Peculiarities of *T. benhamiae* strains growth on a modified medium with hair keratin addition:
a – keratin from human hair; *б* – keratin from feline hair

They are assigned the inventory number *T. benhamiae* OVB_T.b-19 (ON479483) and *T. benhamiae* OVB_T.b-20 (ON479484).

CONCLUSIONS

1. The study of the cultural and morphological properties of two fungus cultures isolated from domestic cats established their differences from the main causative agent of feline dermatomycosis *M. canis*. Molecular genetic studies revealed that the microscopic fungi isolated from cats belonged to the genus *Trichophyton*, species *Benhamiae*. The nucleotide sequences of *T. benhamiae* strains OVB_T.b-19, OVB_T.b-20 were deposited in the GenBank under the numbers ON479483 - ON479484.

2. *T. benhamiae* strains have characteristic cultural and morphological features widely described in the scientific literature [3, 14]. The strains were also distinguished by high saccharolytic activity and the ability to break down urea. Both strains actively digested sucrose, maltose, and lactose, weakly digested glucose, and practically did not ferment mannitol on Hiss media.

3. The revealed keratinolytic activity of *T. benhamiae* strains indicates their etiological role in the development of dermatomycoses in domestic cats.

The study of phenotypic and molecular genetic properties of the isolated cultures of microscopic fungi made it possible to identify two strains of *T. benhamiae*, a new causative agent of dermatomycosis in cats in Russia.

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МЕТОД ПОВЫШЕНИЯ РЕЗИСТЕНТНОСТИ МОЛОДНЯКА КРУПНОГО РОГАТОГО СКОТА

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В условиях Магаданской области проведены исследования по использованию кормовой добавки на основе морских водорослей (*Laminaria Bullatelancet-likelargekelp*, фукус *Fucusevanescens* С. Agardh) в сочетании с лишайниками (*Cladonia alpestris* и *Cetraria islandica*) в рационах кормления помесного молодняка крупного рогатого скота. Опытная и контрольная группы молодняка в возрасте от 15 до 17 мес были подобраны по методу пар-аналогов. В группы вошли помесные бычки герефордской и абердин-ангусской пород первого поколения. Молодняк опытной группы в добавление к основному рациону ежедневно получал кормовую добавку: ламинарию в количестве 120 г/гол. с лишайниками 50 г/гол. в сутки. Стимулирующее действие добавки на организм обусловлено содержанием в ней широкого спектра биологически активных веществ, являющихся фактором, способствующим росту и развитию сельскохозяйственных животных и оказывающих положительное влияние на их иммунную систему. Включение в рационы кормовой добавки повлияло на повышение абсолютного прироста массы опытного молодняка на 5,62 кг, относительного прироста – на 12,53%, среднесуточного прироста – на 93,8 г (12,55%) относительно контрольных бычков ($p \leq 0,001$). Относительная скорость роста по С. Броди была выше у опытного молодняка в возрасте от рождения до 17 мес на 1,31% относительно контроля. Применение кормовой добавки улучшило физиологическое состояние и резистентность молодняка опытной группы. Содержание эритроцитов в его крови повысилось на 0,32 млн/мкл (5,18%), гемоглобина – на 1,1 г/дл (11,48%), кальция – на 0,06 ммоль/л (2,37%).

Ключевые слова: ламинария, лишайник, кормовая добавка, крупный рогатый скот, рацион кормления

THE METHOD OF INCREASING THE RESISTANCE OF YOUNG CATTLE

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In the conditions of the Magadan region researches on the use of a feed additive based on seaweeds (*Laminaria Bullatelancet-likelargekelp*, fucus *Fucusevanescens* С. Agardh) in combination with lichens (*Cladonia alpestris* and *Cetraria islandica*) in the diets of young cattle of mixed cattle were conducted. Experimental and control groups of 15-17-month-old young animals were matched by the pairwise method. The groups included first-generation crossbred Hereford and Aberdeen Angus steers. Young animals of the experimental group received daily feed supplement in addition to the basic diet: kelp in an amount of 120 g/head with lichens 50 g/head/day. The stimulating effect of the supplement on the body is due to the content of a wide range of biologically active substances that are a factor in the growth and development of farm animals and have a positive effect on their immune system. Inclusion of the feed additive into the diets increased the absolute weight gain of the experimental bulls by 5,62 kg, the relative gain by 12,53%, and the average daily gain by 93,8 g (12,55%) as compared to the control bulls ($p \leq 0,001$). The relative growth rate according to S. Brody was 1.31% higher in experimental young animals from birth to 17 months of age compared to the control. The use of the feed additive improved the physiological condition and resistance of the young animals of the experimental group. The content of erythrocytes in their blood increased by 0.32 million/ μ L (5.18%), hemoglobin by 1.1 g/dL (11.48%), and calcium by 0.06 mmol/L (2.37%).

Keywords: kelp, lichen, feed additive, cattle, feed ration

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Conflict of interest

The author declares no conflict of interest.

INTRODUCTION

According to the results of 2018 the number of beef cattle in the Russian Federation amounted to 2.26 million heads. Beef production increased by 1.9% (by 31.5 thousand tons) relative to 2017 and amounted to 1645.1 thousand tons in 2018 [1]. Special importance of beef as the main source of protein of animal origin in the human diet is confirmed by the order of the Ministry of Health of the Russian Federation from August 19, 2016 № 614 "On approval of recommendations on rational norms of food consumption that meet modern requirements of a healthy diet".

It is impossible to increase the meat herd and the production of high-quality ecologically pure beef in the Magadan region only by importing to the region a small number of animals of specialized meat breeds. The main solution of this problem can be the creation of mixed meat herds. The most popular meat breeds used for industrial crossbreeding of dairy cattle in our country are Hereford and Aberdeen Angus. Animals are distinguished by their early maturity, good meat qualities and fodder payment, and have a high adaptive ability to acclimatize to all zones of the country.

Recently, scientists have increased their interest in feed additives that increase productivity, immunity of animals, acclimatization to new conditions and reduce the effects of stress factors on them. Aminova A.L. used a water-dispersed extract from birch and larch wood that allowed to activate metabolic processes in the body of calves and increase the live weight gain by 20.3 and 34.5% respectively [2]. The search for new unconventional solutions led V.E. Beldin to the wide use of Fulvate feed additive based on humic and fulvic acids from lowland peat as a substitute for antibiotics for

body detoxification and disease prevention of animals [3]. A mineral and vitamin fodder additive was introduced into the rations of the Black and White breed calves. Its use improved hematological indicators of young animals. The number of erythrocytes increased by 6,6-16,75%, hemoglobin by 6,93-15,27, protein by 1,99-3,58, calcium by 16,02-27,07, carotene by 10,92-20,21% [4]. Under the conditions of Yakutia, the positive effect of feed additive from local resources on the digestibility of nutrients and milk productivity of cows has been experimentally proved [5, 6].

The system of feeding young cattle is determined by natural and climatic conditions, peculiarities of the local forage base and economic factors. Purchase and delivery of special vitamin-mineral supplements and premixes to the Magadan region entails additional costs. At the same time, there is an opportunity to eliminate deficiencies in feeding young animals through the use of feed additives based on regional plant resources: regional lichens and seaweeds, the stocks of which are rich in the coastal waters of the Sea of Okhotsk. The use of seaweeds (*Laminaria Bullatelanacet-likelargekelp*, *Fucus Fucusevanescens* C. Agardh) eliminates the need to import mineral and iodine preparations from the central regions of the country.

In our experiment with cows receiving the feed additive from kelp with salts of trace elements (cobalt chloride, zinc sulfate), the fat content of milk increased by 0.21%, the cost of feed per 1 liter of milk decreased by 0.03 cfu relative to control. The economic effect was 14.4% with a base fat content of milk of 3.6% [7].

Amino acids contained in algae have an active influence on all vital functions of cattle organism: formation of structural and protective tissues, regulation of metabolism. They

carry out a role of precursors of many important non-protein components of an organism, and also influence productive and reproductive functions [8]. The composition of kelp includes antioxidants that slow down the oxidation of unsaturated fatty acids ^{1,2}.

Iodine is an important element in the metabolism of the animal body. Its deficiency is manifested by joint pathology, pregnancy pathology and impaired reproductive function. In kelp plants iodine is contained in the mineral form. The composition of kelp includes iodo-amino acids: mono- and diiodothyrazine, diiodo-thiranine and diiodothyroxine. Significant content of such organic compounds makes the use of seaweeds as iodine supplements in animal husbandry extremely effective [7, 9, 10]. Earlier studies of plant raw materials showed that non-traditional components of the diet have antimicrobial, antioxidant and anti-inflammatory properties³.

P. Nival Colen found that algae saccharides have immunostimulating, antioxidant and antithrombic properties and slow down the development of viruses and carcinogenesis. He recommends including algae in animal diets in an amount of 2-4% [11].

Lichens include vitamins B12, C and E, which are necessary for the vital activity of the body. Lack of vitamin B12 causes anemia in animals, reducing productivity. Some polysaccharides contained in lichens increase the production of nitrous oxide by macrophages, change the levels of anti-inflammatory cytokines production by macrophages and dendritic cells. The high content of biologically active substances in lichens allows their use in medicine⁴. Vitamins C and E have been proven to have a synergistic effect of biologically active

substances. Vitamin C contained in lichens increases gastric juice secretion and significantly increases the digestive power of pepsin, controls the release of corticosterone by the adrenal glands, reducing its production and secretion. However, during stress, endogenous vitamin C is depleted in the adrenal glands, causing systemic secretion of this powerful adrenal glucocorticoid. Supplementation of vitamin C from an exogenous source helps to reduce the effects of stress and minimizes its negative effects on productivity [12].

Biochemical blood analysis is one of the main methods that characterize the functional state of the animal's organism. Research results of A.A. Lamanov et al. [13] found changes in hematological blood parameters of animals depending on genotype, age, physiological state, feeding and housing conditions [2, 13]. I.A. Pushkarev and others studied the effect of tissue biostimulator on biochemical blood serum indices of young cattle. Application of biostimulator improves the content of total protein in blood serum by 1,4 % ($p < 0,05$), glucose by 22,6 % ($p < 0,05$) and lowers the content of cholesterol by 12,3 % ($p < 0,05$) [14].

In the Magadan region since 2018, research work on the feeding of crossbred young cattle of Hereford and Aberdeen-Angus breeds has been carried out.

The purpose of the research is to study the effect of the feed additive of kelp and lichens on hematological parameters, and the overall resistance of the crossbred young cattle.

The objectives of the study included:

- preparation of the feed additive;
- study of chemical composition of fodder and additive;

¹Balina K., Romagnoli F., Blumberga D. Chemical Composition and Potential Use of Fucus Vesiculosus from Gulf of Riga // Energy Procedia. 2016. Vol. 95. P. 43–49. DOI: 10.1016/j.egypro.2016.09.010.

²Moubayed N.M.S., Jawad Al Ho uri, H., Al Khulaifi M.M., Al Farrari D.A. Antimicrobial, antioxidant properties and chemical composition of seaweeds collected from Saudi Arabia (Red Sea and Arabian Gulf) // Saudi Journal of Biological Sciences. 2017. Vol. 24 (1). P. 162–169. DOI: 10.1016/j.sjbs.2016.05.018.

³Gheisar M.M., Kim I. H. Phytobiotics in poultry and swine nutrition e a review // Italian Journal of Animal Science. 2017. Vol. 17. P. 92–99. DOI: 1080/1828051X.2017.1350120.

⁴Shrestha G., Clair L.L.St., O'Neill K.L. The immunostimulating role of lichen polysaccharides: a review // Phytotherapy Research. 2015. Vol. 29 (3). P. 317–322. DOI: 10.1002/ptr.5251.

- research of feed additive influence on live weight, growth rate and hematological indices of young pigs at the age of 15-17 months.

MATERIAL AND METHODS

We have conducted studies on the inclusion of a feed additive consisting of laminaria meal (*Laminaria*) and lichens - *Cladonia alpestris* and *Cetraria islandica* in the ration of crossbred steers of the first generation at the age of 3 to 6 months. It is proved that the application of this additive affects the growth and development, contributes to improving the physiological state, resistance of steers of the experimental group. Blood serum of the experimental group steers increased by 9,8 g/l (14,37%), hemoglobin - by 0,2 g/dl (1,86%), lymphocytes - by 1,2%, leukocytes - by 1,02 thousand/ml (9,57%) compared to young animals of the control group.

Generally accepted methods were used for the research⁵. Laboratory studies of the chemical composition of feed and feed additive were performed at the agrochemical service station "Magadanskaya" and in the Magadan Research Institute of Agriculture. The results of the experiments were statistically processed according to the method of N.A. Plokhinsky⁶⁻⁹.

Determination of mineral content in feeds and kelp was performed in the laboratory of X-ray spectral analysis of the N.A. Shilo North-East Interdisciplinary Scientific Research Institute FEB RAS according to the methods developed in this institute. Atomic emission spectral analysis with arc excitation (AES) was performed on an atomic emission spectrograph DFS-13 (Russia) [15].

The object of the research was young crossbred cattle. The scientific and production experiment to study the effect of the feed additive on the physiological condition of the crossbred

young cattle was carried out during 60 days in the production conditions of the "Komarova" farm in 2021. The experimental and control groups of 10 young cattle aged from 15 to 17 months were selected by the paired-analog method. The groups included crossbred steers of the first generation of Hereford and Aberdeen-Angus breeds. The animals of the experimental and control groups were kept in the same conditions and received the same ration. The youngsters of the experimental group got the following daily addition to the main ration: kelp 120g/head with lichen 50g/head/day. The norm of the supplement was calculated according to the norm of the young animals' need for trace elements in the diet.

For the experiment 75 kg of kelp flour and 30 kg of lichen flour were prepared. The technology of obtaining it consists of drying raw materials in a specially equipped storage room on mesh racks, and then preparing flour with particle size of 0.5-1.5 mm. The flour was stored in craft bags in storage-type rooms.

The growth and development of young animals were studied by live weight on the basis of monthly weighings in experimental bulls. Average daily and absolute growth was calculated on the basis of weighing results. Relative growth rate was calculated according to the formula of S. Brody

$$B = [(W_1 - W_0) \times 100] : [(W_1 + W_0) \times 0,5],$$

where W_1 and W_0 are the final and initial live weight, respectively.

Hematological analyses of the calves were performed according to the methods of veterinary clinical laboratory diagnostics by I.P. Kondrakhin¹⁰.

⁵Kuzmina I.Yu., Kuzmin A.M. Methods of correcting stress adaptation of young cattle // BIO Web of Conferences. 2021. Vol. 36.

⁶Methodological recommendations on the organization and conduct of research on cow feeding on industrial farms and complexes. Dubrovitsy, 1983. 55 p.

⁷Methodological instructions for calculating the total nutrition of forages. M., 1981. 24 p.

⁸State Standards (GOST) Catalog. M., 2011.

⁹Plokhinsky N.A. Guide to biometrics for zootechnicians. Moscow: Kolos, 1969. 256 p.

¹⁰Methods of veterinary clinical laboratory diagnostics: handbook / edited by I.P. Kondrakhin. Moscow: Kolos, 2004. 520 p.

RESULTS AND DISCUSSION

Evaluation of their nutritive value was carried out based on the results of the analysis of the chemical composition of the main fodder and the feed additive from kelp in combination with lichens (see Table 1). The composition of fodder in the farm is typical for the Priokhotskaya zone of the Magadan region. The established type of feeding of young cattle when growing and fattening cattle for meat in the autumn-winter period in the farm "Komarova" is silage-concentrate. Concentrates account for 31.84% and silage for 66.42% of the young cattle feeding structure. The basic ration of young stock consisted of silage (oats, peas) and mash (barley, corn, peas). The diet contained 91.51% of the normal energy feed units, 90.22% dry matter, 84.13 digestible protein, and 99.81% crude fiber. The diet lacked 100 g of sugars (15.76%), which is typical for the Magadan Region and negatively affects protein assimilation. Sugar-protein ratio is low - 0.17.

The concentration of energy feed units in 1 kg of dry matter was 0.97 g (80.665% of the norm). The digestible protein per 1 energy feed unit was 82.7 g (59% of the norm).

In order to study the nature of the feed addi-

tive effect on the health of experimental steers their blood was examined. The hematological data show that for the period of the experiment the indicators of physiological condition of steers of the experimental group in comparison with the control analogues have improved (see Table 2).

Administration of the feed additive reduced the content of leukocytes in the blood of the steers of the experimental group by 0.56 thousand/ μ l (5.75%). These data testify to the fact that supplementation restrains leukocytosis and has a beneficial effect on the body of young bulls. During the experimental period there was a decrease in lymphocytes by 7.4% and in eosinophils by 0.8% relative to control. The ratio of different forms of leukocytes in the experimental group calves was as follows. During the experimental period the number of segmented neutrophils increased by 7.2%, stab neutrophils - by 0.4, basophils - by 0.2, monocytes - by 0.4% compared to the control group. Higher content of neutrophils and monocytes indicates an increase of protective functions of the body of the animals, since this group of cells are phagocytes and have high activity. Moreover, neutrophils produce enzymes that activate bactericidal action.

Табл. 1. Химический состав и питательность кормов в КФХ «Комарова» и кормовой добавки (в 1 кг натуральной влажности) в стойловый период

Table 1. Chemical composition and feed nutrition in the AE "Komarov" and the feed additive (in 1 kg of natural humidity) during the housing period

Type of feed	EFU	Metabolizable energy, MJ	Dry matter, kg	Crude protein, g	Digestible protein g	Crude fiber, g	Crude fat, g	Calcium, g	Phosphorus, g	Sodium, g	Potassium, g	Carotin, mg/kg	Sum of digestive nutrients (SDN), g in 1 kg
Wild herbs dry fodder	0,73	7,25	0,92	41,2	21,84	345	11,8	5,84	1,1	0,51	1,92	2,3	467,8
Oat-pea silage	0,26	2,66	0,28	64,8	47,3	88,1	10,6	1,19	0,64	1,59	3,18	11,8	
Grinding	0,7	6,99	0,76	102,6	67,72	42,5	27,8	0,9	0,6	0,3	4,2	0,25	478,74
Feed supplement	0,88	8,76	0,93	68,2	50,47	263	66,4	2,1	1,11	0,48	3,9	2,4	476,28

Application of the feed additive contributed to a more intense increase in the number of red blood cells and their saturation with hemoglobin. The erythrocyte content in the blood of the young animals of the experimental group increased by 0.32 mln/ μ l (5.18%), hemoglobin by 1.1 g/dl (11.48%) compared with the control group. Sedimentation rate of the erythrocytes in the blood of young animals of both groups during the experiment was within normal limits.

The calcium content in the blood serum of the experimental calves increased slightly by 0.06 mmol/l (2.37%) and phosphorus by 0.06 mmol/l (2.43%) in relation to the control group calves.

The protein content in the blood serum of the experimental group calves decreased by 2.0 g/l (2.92%) compared to the control group animals, remaining within the physiological norm.

The indices of absolute growth increased in the mixed young cattle receiving the feeding additive in addition to the diet by 5,62 kg, relative growth by 12,53%, and average daily growth by 93,8 g (12,55%) ($p \leq 0,005$) during the period of the experiment (from 15 to 17

months of age) relative to the analogues of the control group. The average daily growth rate of the control group calves was 747.6 g, while that of the experimental calves increased to 841 g ($p \leq 0.001$). Relative growth rate according to S. Brody in the experimental young calves was 1.31% higher relative to the control group.

Protein consumption of feed per 1 kg of live weight gain in the experimental group was 86.67 g (9.95%) less than in the control group; reduction of metabolic energy consumption of feed was 10.3 MJ (3.42%), respectively.

CONCLUSIONS

1. Raw material for the preparation of feed additive refers to wild fruits, growing in nature in sufficiently large quantities. It does not require significant costs for procurement and preparation for feeding. In this connection its application is a cost-effective way to enrich the diets with biologically active substances. Introduction of the additive from kelp and lichen in the ration of crossbred young Hereford and Aberdeen-Angus breeds at the age of 15-17 months when growing for meat has a positive

Табл. 2. Гематологические показатели подопытных бычков ($M + m$)

Table 2. Hematological indicators of experimental bulls ($M + m$)

Indicator	Control group	Experimental group	Norm
Erythrocytes, mln/ μ l	6,18 \pm 0,27	6,50 \pm 0,19***	5–7,50
Hb, g/dL	9,58 \pm 0,29	10,68 \pm 0,34	9,9–12,90
ESR, mm/h	0,50 \pm 0,00	0,50 \pm 0,00	0,5–1,50
Leukocytes, th/ μ l	9,74 \pm 0,96	9,18 \pm 0,84	4,5–12,00
Neutrophils:			
bacillary	2,80 \pm 0,86	3,20 \pm 0,58	2–5
segmentonuclear	21,40 \pm 2,11	28,60 \pm 2,40	20–35
Eosinophils, %	1,80 \pm 0,20	1,00 \pm 0,32***	3–8
Basophils, %	0,00 \pm 0,00	0,20 \pm 0,20***	0–1
Monocytes, %	3,60 \pm 0,40	4,00 \pm 0,32*	2–7
Lymphocytes, %	70,40 \pm 2,20	63,00 \pm 1,87	40–75
TP (total protein), g/l	68,60 \pm 1,57	66,60 \pm 1,17	58–80
Ca, mol/L	2,53 \pm 0,10	2,59 \pm 0,09***	
P, mmol/L	2,47 \pm 0,17	2,53 \pm 0,19	

* $p \leq 0,05$.

*** $p \leq 0,001$.

effect on the absolute and average daily gain, relative growth rate, blood parameters of young cattle.

2. Inclusion of the feed additive into the diets of young animals increased the absolute weight gain by 5,62 kg, the relative gain by 12,53%, the average daily gain by 93,8 g (12,55%) relative to steers of the control group ($p \leq 0,001$). Relative growth rate according to S. Brody was 1,31% higher in the experimental bulls at the age from birth to 17 months compared to the control. Application of the feed additive improves the resistance of the experimental calves. The content of erythrocytes in the blood of young calves of the experimental group increased by 0.32 million/ μ l (5.18%), hemoglobin by 1.1 g/dl (11.48%), calcium by 0.06 mmol/l (2.37%), phosphorus by 0.06 mmol/l (2.43%) as compared with the control group.

3. The results confirm the feasibility of using the developed feed additive to enrich the diet of young cattle with enzymes, antimicrobials and vitamins in order to increase the overall resistance of the body.

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ИНФОРМАЦИЯ ОБ АВТОРЕ

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ПЕРСПЕКТИВА ПРИМЕНЕНИЯ ПРИРОДНОГО АДАПТОГЕНА ИЗ ЛИЧИНОК БОЛЬШОЙ ВОСКОВОЙ МОЛИ В ВЕТЕРИНАРИИ

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Проведен сравнительный анализ адаптационных эффектов тестом «Принудительное плавание» фракционируемых растворов, полученных из продуктов жизнедеятельности личинок большой восковой моли (*Galleria mellonella*) на биологические системы. Методом рентгенофотоэлектронной спектроскопии определено, что в полученной легкой фракции продуктов жизнедеятельности личинок высокоэнергетическая составляющая N1s спектров (~402,0 эВ) и энергия связи для углерода в C-N связи (~286,0 эВ) свидетельствуют о присутствии в образцах протонированных аминокислот. Поглощение при 1700 см⁻¹ можно связать с наличием дикарбоновых аминокислот (глутаминовой и аспаргиновой) и других органических кислот, которых значительно меньше в тяжелой фракции. При пероральном введении исследуемых экстрактов установлено их разнонаправленное воздействие на кишечник лабораторных мышей. Выявлено негативное влияние тяжелой фракции на микробиоценоз кишечника по качественному составу микрофлоры. При применении легкой фракции микрофлора кишечника близка к контролю. Анализ количества лейкоцитов тонкого кишечника при введении фракций отразила ответную местную иммунную реакцию организма. Содержание этих клеток на собственной пластинке слизистой оболочки мышей, которым вводили легкую фракцию, выше на 67,2%, чем у контрольных мышей ($p \leq 0,05$). Содержание лейкоцитов на собственной пластинке слизистой оболочки мышей, которым вводили тяжелую фракцию, выше в 2,7 раза по сравнению с контролем, что свидетельствует о воспалительной реакции. Разница между опытными группами достоверна ($p \leq 0,001$). Сравнительный эффект фракций показал, что их пероральное введение разнонаправленно повлияло на время плавания в сравнении с контролем. Через 20 дней эксперимента у мышей, которым вводили тяжелую фракцию, достоверно увеличилось время плавания в сравнении с первыми сутками ($p \leq 0,05$). Однако при этом заметен отрицательный адаптогенный эффект в сравнении с контрольной группой. Выявлена достоверная разница между результатами на 30-е сутки между опытными группами, что свидетельствует о выраженной разнице полученных результатов.

Ключевые слова: большая восковая моль, личинки, продукты жизнедеятельности, тест «Принудительное плавание», микробиоценоз кишечника, лейкоциты, ИК-Фурье

THE OPPORTUNITIES OF USING A NATURAL ADAPTOGEN FROM THE *GALLERIA MELLONELLA* LARVAE IN VETERINARY MEDICINE

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A comparative analysis of the adaptation effects of the Porsolt test of fractionated solutions obtained from the products of the larvae of the large wax moth (*Galleria mellonella*) on biological systems was performed. The method of X-ray photoelectron spectroscopy determined that in the obtained light fraction of the products of larval life there is a high-energy component of N1s spectra

(~402.0 eV) and bond energy for carbon in the C-N bond (~286.0 eV), which indicates the presence of protonated amino groups in the samples. Absorption at 1700 cm⁻¹ can be attributed to the presence of dicarboxylic amino acids (glutamic and aspartic) and other organic acids, which are much less in the heavy fraction. During oral administration of the studied extracts, their multidirectional effect on the intestines of laboratory mice was found. The negative effect of heavy fraction on the microbiocenosis of the intestine by the qualitative composition of the microflora was detected. When the light fraction is used, the intestinal microflora is close to the control. Analysis of the number of leukocytes of the small intestine when the fractions were injected reflected the local immune response of the body. The content of these cells on the mucosal plate of mice injected with the lung fraction was 67.2% higher than that of the control mice ($p \leq 0.05$). The content of leukocytes on the own plate of the mucosa of mice injected with the heavy fraction was 2.7 times higher compared to the control, indicating an inflammatory reaction. The difference between the experimental groups is significant ($p \leq 0.001$). The comparative effect of the fractions showed that their oral administration had a different effect on the swimming time compared to the control. After 20 days of the experiment, mice injected with the heavy fraction had significantly increased their swimming time compared to the first day ($p \leq 0.05$). However, a negative adaptogenic effect compared to the control group is noticeable. A significant difference was found between the results on the 30th day between the experimental groups, which indicates a pronounced difference in the results obtained.

Keywords: *Galleria mellonella*, larvae, waste products, Porsolt test, intestinal microbiocenosis, leukocytes, Fourier transform infrared spectroscopy

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Конфликт интересов

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Conflict of interest

The authors declare no conflict of interest.

INTRODUCTION

Stress is a set of unspecific reactions of the body to various stimuli. According to the results of many studies 70-80% of stress comes from improper feeding and housing of animals, 20-30% - due to other factors¹ [1]. When stressed, animals get serious psycho-emotional stress, lose weight, the body's resistance to infections decreases, which ultimately leads to economic losses [2]. The effect of stimulants with adaptogenic effect, increasing the body's resistance: the extract of spiny *Eleutherococcus*, ascorbic acid, fumaric acid and succinic acid has been proved². From this point of view, it is interesting to study the larva of large bee moth (*Galleria mellonella*) as an adaptogen.

Traditionally, the larva of large bee moth (*G. mellonella* L.) is a pest in beekeeping. It eats wax and bee bread, destroying the integrity of bee families, gnawing through the honeycomb and disrupting the molting process of bees [3].

A large-scale study of *G. mellonella* larvae is currently underway, confirming their versatility as an alternative model for toxicological, pharmacological, and other studies [4]. It was revealed that the larvae are capable of eating synthetic polymers [5]. In addition, the larvae of *G. mellonella* have a high nutritional value and are considered an alternative source of proteins and fats [6]. In alternative medicine, an extract based on the larvae of *G. mellonella* is used which has multidisciplinary properties

¹Tostopyatova E.P. Influence of stress on the productivity of farm animals // Scientific Proceedings of students of the Izhevsk State Agricultural Academy. Izhevsk, 2021. pp. 1390-1392.

²Sedoshkina K.A., Filioglo S.V. The use of adaptogens under stress in farm animals // International scientific review of the problems and prospects of modern science and education. Collection of scientific articles LXIII International correspondence scientific and practical conference. Boston: Problems of sciences, 2019. pp. 92–94.

(anti-tuberculosis, cardiotropic, immunoprotective, etc.) [7].

Three groups of biologically active compounds of flavanoid, irioid and steroid nature were identified in the larvae activity products. Based on the results obtained, it was concluded that the products of vital activity are no less promising medicinal raw materials than the larva itself³.

A group of scientists led by S.V. Savchuk (2018) conducted studies on the effect of larval products on the hematological parameters of Japanese quail, proving that the feeding of *G. mellonella* larvae had a positive effect on the hemoglobin content in birds. There was a tendency of increased leukocyte content in the blood of quail that received the addition of products of larvae to the basic diet, so one can assume their higher protective immune mechanisms [8].

In 2019 S.V. Savchuk and others conducted morphofunctional studies of the gastrointestinal tract of quails with the addition of larval products. It was found that the greatest changes were in the submucous membrane of the bird's stomach - an increase in its thickness, which is characteristic of the consumption of high-protein and hard-to-digest fodder. The authors suggest that in this case beeswax, which is the main component of larvae products, played a role. The duodenal villi of the birds that consumed this supplement were longer than in the control group, indicating the possibility of increasing the intensity of absorption [9].

Thus, the obtained studies on the effect of the products of the *G. mellonella* larvae vital activity on the organism allow us to assert their positive effects. Nevertheless, there are still many questions about the mechanism and systemic effect on animal organism.

The relevance of the research is to find a natural substance as a natural adaptogen that increases the stress resistance of the body for the rational and effective breeding of farm animals and obtain high quality products.

The purpose of the study was to conduct a comparative analysis of the products of light (LF) and heavy fraction (HF) of the *G. mellonella* L. larvae in the Porsolt test as a natural adaptogen.

The research objectives are:

- to determine the physicochemical composition of the investigated fractions of life products;
- to estimate the level of adaptogenicity according to swimming time of laboratory mice with oral administration of the fractions in the Porsolt test;
- to establish the impact of the fractions on the qualitative composition of the intestinal microbiota on the background of stress;
- to identify the features of cell morphology of the small intestine wall of laboratory mice when injected with different fractions of products of vital activity of the large wax moth larvae.

MATERIAL AND METHODS

The experiments were performed in accordance with the ethical standards of animal handling, observing the recommendations and requirements of the European Convention for the Protection of Experimental Animals (Strasbourg, 1986)⁴. The work was performed at the Udmurt State University in 2020. Mice were kept in the vivarium in standard cages on an ordinary food ration in accordance with GOST R-50258-92 "Full-fed compound feeds for laboratory animals". The animals had free access to food and water.

White unilinear mice at 9 weeks of age were tested. Three groups of 10 animals each were formed:

- control: plain water;
- 1st experimental group: 10% aqueous solution of LF products of *G. mellonella* larvae's vital functions;
- 2-nd experimental group: 10% aqueous solution of HF products of *G. mellonella* lar-

³Gromovoy V.N. About the product of vital activity of wax moth larvae // Advances in apitherapy: materials of the XIII All-Russian scientific-practical conference (11-13 October 2007). Rybnoe: Publishing house of the Research Institute of Beekeeping, 2008. pp. 134-137.

⁴European convention for the protection of vertebrate animals used for experimental and other scientific purpose: Council of Europe 18.03.1986. Strasbourg, 1986. p. 52.

vae's vital functions at a dosage of 0.5 µl/g live weight.

Mice were force-fed daily from a micropipette of a certain dosage according to the solution delivery scheme.

The level of adaptive abilities of mice was determined by the duration of swimming with a load of 10% of the animal's body weight using the Porsolt test. During the experiment, the animals were tested every 10 days - on days 1, 10, 20, and 30. The mouse was lowered into a 30-cm-high vessel with warm water (27 ± 1 °C) poured into it. The test was terminated when the animal dipped to the bottom of the vessel for more than 5 s at the end of the experiment. The duration of animal swimming was recorded with a stopwatch with an accuracy of 1 s. The test was performed at the same time - from 11 to 13 h. Deprivation of food was performed 2 h before the experiment.

To confirm the effect of the fractions on microbiocenosis at the end of the experiment, the feces of mice were collected for microbiological analysis. The studies were conducted in accordance with the Methodological Recommendations of the Ministry of Agriculture of the Russian Federation No. 13-5-02/1043 dated 11.05.2004. 10-fold dilutions of feces on sterile saline were prepared. Plants were made on meat-peptone agar by deep-seeding, Endo medium, yolk-salt agar, sulfite agar for clostridium isolation, and bifidum medium. Kligler's medium was used for primary identification of *E. coli* microorganisms. Morphology of microorganisms was studied by microscopy of Gram-stained smears. Identification of *E. coli* bacteria was performed using the test kit "DS-DIF-Enter-24" [10].

The qualitative composition was evaluated at the Department of Epizootology and Veterinary and Sanitary Expertise of the Izhevsk State Agricultural Academy. The obtained smears were stained by Gram stain. Evaluation of microorganism occurrence was carried

out at $\times 900$ using oil immersion on a 4-point scale. More than 1×10^{10} colonies of aerobic and anaerobic bacilli were determined on meat-peptone agar (MPA); on Endo medium, the prevalence of lactose-negative colonies and a moderate content of lactose-positive colonies were determined.

In order to prove the effect of different fractions of vital products on the main systems of the body, histological structures of the ileum of mice were studied. The obtained histological material was fixed in a 10% solution of buffered formalin for 24 h, washed with running water and embedded in paraffin according to the standard procedure. Histological preparations were prepared according to the standard conventional technique.

Microsections were made on a CM-1 microtome. Sections 4-7 µm thick were stained with hematoxylin and eosin. Morphometry was performed using a QImaging MicroPublisher 3.3 RTV digital camera on a Nikon Eclipse E200 microscope, 4x, 10x/0.20, and 40x/0.65 objectives. Image Pro Insight software was used for measurements of cells of the studied organs.

Absolute number of mononuclear and polymorphonuclear cells in the proper mucous plate of the ileum (PMP) was determined by applying Avtandilov grid by direct cell counting in each square. The level of significance between the formed groups was assessed using Mann-Whitney criterion. At the 95% level, the values were considered statistically significant as distinct ($p \leq 0.05$).

The samples of fractions pre-plated on copper substrates were studied by X-ray photoelectron spectroscopy (XRFES) on a SPECS electron spectrometer (SPECS GmbH, Germany)⁵. FTIR studies were performed on a Varian Excalibur 3100 spectrometer in KBr tablets (2 mg of the test substance + 300 mg KBr). Spectra were obtained in the range of 400-4500 cm^{-1} with a resolution of 1 cm^{-1} ⁶.

⁵Beamson G., Briggs D. High Resolution XPS of Organic Polymers. The Scienta ESCA300 Database, Wiley&Sons, Chichester etc., 1992.

⁶NIST Chemistry WebBook, National Institute of Standards and Technology. Gaithersburg, 2011. URL: <http://webbook.nist.gov/chemistry>.

RESULTS AND DISCUSSION

X-ray photoelectron spectroscopy method showed that for the studied fractions the main maximum was at $E_{cv} \sim 400$ eV, which is typical for a number of organic substances, as well as for the salts of ammonium bases. The second maximum with $E_{cv} \sim 402$ eV is characteristic of protonated amino groups (containing an additional hydrogen atom); its intensity is 1.5 times higher for the light fraction (see Fig. 1).

The heavy fraction contains the maximum amount of oxygen in two non-equivalent chemical states. Also, this fraction contains the maximum number of compounds of carbon with oxygen, the maximum amount of nitrogen of potassium (or compounds with its participation). The light fraction has a higher concentration of potassium (or compounds with its participation) and a higher content of protonated amino groups.

The IR study showed that the spectra of the samples are similar and characterized by broad absorption bands (see Fig. 2). The most characteristic of all spectra is a wide absorption band at 1640 cm^{-1} where peaks at 1700 , 1550 and 1515 cm^{-1} are visible. Their intensity varies depending on the sample. Another band with 1400 cm^{-1} with an arm about 1450 cm^{-1} is characteristic for all spectra, which suggest that the main components of the extracts are polypeptides and amino acids.

IR spectra for different amino acids differ significantly, but, as a rule, they are characterized by absorption around 1600 and 1400 cm^{-1} , associated with the formation of zwitter ions. The latter is in good agreement with the XRFES data, since the high-energy component of the N1s spectra (~ 402.0 eV) and the bond energy for carbon in the C-N bond (~ 286.0 eV) indicate the presence of protonated amino groups in the samples. These results may indicate that nitrogen is mainly a part of polypeptides. Thus, polypeptides are the main components of HF and amino acids to a lesser extent. Sugars and phosphate derivatives are also present. Changes

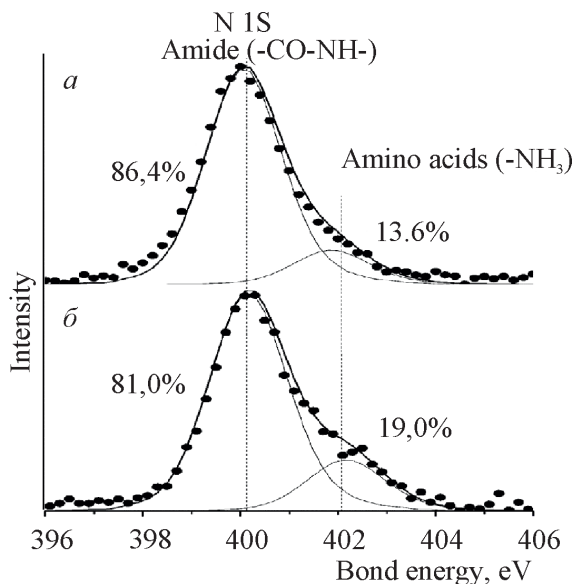


Рис. 1. N1s-спектры образцов:

a – тяжелая фракция; *б* – легкая фракция

Fig. 1. N1s-spectra of samples:

a – heavy fraction; *б* – light fraction

in XRFES and FTIR depending on the type of sample indicate that there are more amino acids in LF and less in HF where there are more polypeptides.

During the experiment, observations were made on the general condition of the experimental animals. The feces of control mice and those injected with LF had a dense consistency and were formal. When HF was injected, the character of feces in mice changed. They had a smeary consistency, and were unformed.

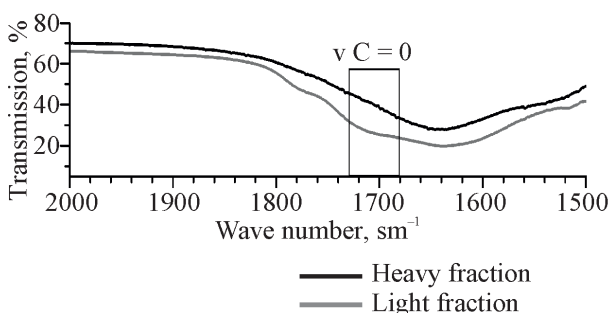


Рис. 2. ИК-Фурье спектры исследуемых образцов

Fig. 2. IR-Fourier spectra of the studied samples

⁷Arslanova N.A., Rudich M.P., Novoselova V.A., Aleksandrova A.V., Yarullina D.R., Yakovlev O.V. Study of the effect of lactobacilli on the cognitive functions of mice in disordered gut microflora // Hippocampus and memory: norm and pathology: proceedings of the conference (25-29 June 2018). Pushchino: Synchrobook Publishing House, 2018. pp. 31-32.

Control specimens had a variety of microflora typical of laboratory mice: a significant number of anaerobic non-sporulating bacilli (bifidobacteria, lactobacilli) and a sufficient number of typical enterobacteriaceae and enterococci.

The number of Enterobacteriaceae (giving lactose-positive colonies) decreased when LF was used. The number of anaerobic non-sporulating bacilli remained quite high. There is no *E. coli*, which has hemolytic properties. The content of clostridia, staphylococci, and molds is low.

The number of anaerobic non-sporulating bacilli and enterococci sharply decreased with the introduction of HF. A large number of both lactose-positive and lactose-negative colonies were determined on Endo medium (along with typical *E. coli*, variants with pathogenic properties appeared). The number of conditionally pathogenic microflora - *St. aureus*, *Klebsiella*, *Proteus vulgaris*, as well as yeast fungi - increased. Thus, a picture of dysbacteriosis was observed when using HF.

A comparative analysis of the experimental groups against the background of normal gut microflora of the control group showed a negative impact of HF on the gut microbiocenosis in terms of the qualitative composition of the microflora, while the application of LF gut microflora is close to the control.

It is known that the Porsolt test is indicative in determining the performance capacity and development of adaptive mechanisms in extreme conditions (see the table).

Analysis of the data obtained showed that the oral administration of the studied solutions had a different effect on the swimming time compared with the control. In spite of the fact that after 20 days of the experiment the mice injected with HF significantly increased the swimming time in comparison with the first day ($p \leq 0,05$), a negative adaptogenic effect was observed in comparison with the control group. There were statistically significant differences between the results on the 30th day between the experimental groups, which indicates a pronounced difference in the results obtained. Introduction of a light fraction is the most indicative: a reliably increasing effect of adaptation to the load on the 30th day ($p \leq 0,001$) was revealed.

Changes in the intestinal microflora of mice injected with HF allow to indirectly judge about the possible influence on the border structures (epithelium) by the response of the local immune system and the possible potential impact on the peripheral immune system by increasing the lymphohistiocytic infiltration of the immune response cells. Against the background of control histological sections, a slight leukocyte infiltration into the mucosa and submucosa of mice injected with LF is noticeable. No leukocyte release was detected in the lumen of the blood vessel. Histological studies of the small intestine of mice injected with HF confirm changes in the epithelial layer against the background of developing dysbacteriosis. The capillaries of the blood and lymphatic systems

Результаты эксперимента «Принудительное плавание» при введении разных фракций продуктов жизнедеятельности личинок *G. mellonella* L.
Results of the "Porsolt test" experiment with the introduction of different fractions of the waste products of *G. mellonella* L.

Group	24 hours			
	1-st	10-th	20-th	30-th
Control	147,8 ± 3,14	242,2 ± 10,80	230 ± 19,22	216,8 ± 33,29
Cv, %	4,74	9,97	18,69	34,33
1-st experimental	129,4 ± 3,14*	216,4 ± 10,80*	258,4 ± 19,22	272,6 ± 33,29***
Cv, %	10,01	1,92	20,14	6,81
2-nd experimental	133,8 ± 3,14	185,2** ± 10,80	177,4 ± 19,22	200,2 ± 33,29
Cv, %	17,06	24,64	40,45	24,15

At a credible difference from the control * $p \leq 0,05$; ** $p \leq 0,001$.

of mice were found to be dilated. The walls of the submucosal base vessels were in the state of plasmatic swelling with the phenomena of perivascular lymphoid infiltration.

To confirm the changes observed, morphometry of the small intestine lumen was carried out. In the control group it showed that the content of mononuclear and polymorphonuclear cells was 5.8 cells per unit area (see Fig. 3).

Analysis of the number of small intestinal leukocytes during fraction administration reflected the local immune response of the body. The content of the same cells in the PMP of mice injected with LF was 67.2% higher than that of controls ($p \leq 0.05$). The content of leukocytes in PMP of mice injected with HF was significantly higher by 2.7 times compared to the control, indicating an inflammatory reaction.

Thus, in the control group of mice, the leukocyte output in PMP was within normal limits. When the light fraction was injected, activation of mononuclear and polymorphonuclear cells of the intestine was noted. When the heavy fraction was injected, a significant number of leukocytes outside the circulatory system was detected. Infiltration of PMP indicates an inflammatory response which disrupts the integrity of the epithelium, which is often seen in dysbacteriosis. Disruption of the barrier integrity of the intestinal lumen, which entails immune activation of mononuclear and polymorphonuclear cells, strains the overall immune response.

It is known that microbiota disorder levels off with changes in cognitive functions 7, which suggests that the introduction of HF decreased this function on the background of dysbacteriosis. When administering LF, the opposite effect was noted: the adaptogenic properties of the body increased.

CONCLUSIONS

1. Physicochemical analysis of the fractions of larval products showed that the light fraction contained 1.5 times more amino acids than the heavy fraction, which contained more polypeptides.

2. Analysis of the physical abilities of the animals in the Porsolt test with oral administra-

tion of the fractions of vital products showed that the light fraction significantly increased the level of adaptation by the end of the experiment. When introducing a heavy fraction, no such effect was noted.

3. Against the background of stress when the light fraction was injected, anaerobic bacilli and enterococci (resident microflora) dominated in the intestinal microflora of mice. An increase in the species diversity of microorganisms, i.e. a picture of dysbacteriosis developed, was observed after the introduction of HF.

4. Morphometry of the small intestine wall of mice injected with the light fraction revealed activation of mononuclear and polymorphonuclear cells, which reflects the activation of immunity within the normal range. Administration of the heavy fraction increases the level of leukocytes outside the bloodstream, indicating an inflammatory response and strain of the immune response.

5. The isolated fractions have differently directed influence on systems of an organism.

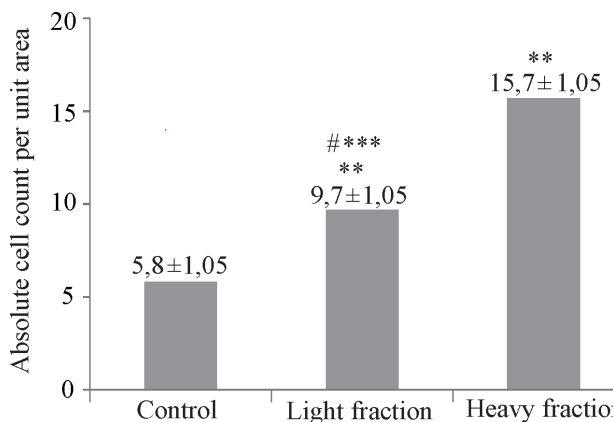


Рис. 3. Сравнительный анализ абсолютного количества мононуклеарных и полиморфоядерных клеток тонкого кишечника на единицу площади.

При достоверной разнице от контроля

** $p \leq 0,05$;

*** $p \leq 0,001$

Fig. 3. Comparative analysis of the absolute number of mononuclear and polymorphonuclear cells of the small intestine per unit area

At significant difference from the control

** $p \leq 0,05$;

*** $p \leq 0,01$

The studied phenomena of heavy fraction influence make it possible to state the decrease of adaptogenicity to stress factors. Light fraction, on the contrary, increases the level of adaptogenic properties of the organism, which suggests that it is promising for further study and use as a natural adaptogen in veterinary medicine.

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ВЛИЯНИЕ УРОВНЯ КОРМЛЕНИЯ НА ПОКАЗАТЕЛИ ГЕНЕТИЧЕСКОЙ ИЗМЕНЧИВОСТИ САМОК НОРОК

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Представлены результаты оценки индивидуальной генетической изменчивости у молодых самок коротковолосой норки в различные биологические периоды. Эксперименты проведены в условиях существующей технологии содержания и кормления в 2019, 2020 гг. Для опыта сформировали две группы по 40 ремонтных самок (в возрасте 2 мес) коротковолосой норки стандартной черной породы (*Neovison vison*). Контрольную группу самок в возрасте 2–4 мес кормили по рекомендуемым энергетическим нормам. Опытной группе самок ограничили уровень кормления (по энергии) на 10,0%. Установлена зависимость частоты встречаемости эритроцитов, содержащих микроядра, в периферической крови самок от уровня кормления в различные периоды онтогенеза и фазы репродуктивного цикла. Данный способ может быть использован для прогноза успешности воспроизводства самок норок. У ремонтных самок контрольной группы частота встречаемости эритроцитов с микроядрами в возрасте 4 мес в период формирования у них репродуктивных функций была в 2 раза выше, чем в опытной ($2,97 \pm 0,42$ против $6,01 \pm 2,75\%$). В половозрелом возрасте (10 мес) частота встречаемости эритроцитов с микроядрами у ремонтных самок статистически достоверно выше $14,36 \pm 1,87$ – $14,89 \pm 3,67\%$ ($p < 0,05$, $p < 0,01$), чем в возрасте 4 мес. Получены следующие показатели продуктивности у исследуемых самок в контрольной и опытной группах: плодовитость самок – $5,63 \pm 0,64$ и $5,67 \pm 0,77$ щенка, выход молодняка на основную самку – $4,4 \pm 0,77$ и $4,67 \pm 0,85$ щенка соответственно. В опытной группе не было непокрытых и пропустовавших самок, выход молодняка на самку зарегистрирован на 0,27 щенка больше. Микроядерный тест может быть использован для оценки стабильности генетического аппарата в различные фазы репродуктивного цикла самок норок и прогноза успешности воспроизводства самок.

Ключевые слова: норка, геномная стабильность, микроядерный тест, ремонтные самки, обменная энергия, онтогенез, воспроизводство

THE EFFECT OF FEEDING LEVEL ON THE GENETIC VARIABILITY OF FEMALE MINKS

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The results of the assessment of individual genetic variability in young female short-haired mink at different biological periods are presented. The experiments were conducted under the conditions of the existing technology of housing and feeding in 2019, 2020. For the experiment, two groups of 40 rearing females (at the age of 2 months) of the short-haired mink of the standard black breed (*Neovison vison*) were formed. The control group of females at the age of 2–4 months was fed according to the recommended energy standards. The experimental group of females was limited in the level of feeding (in terms of energy) by 10.0%. The frequency of erythrocytes containing microkernels in the peripheral blood of females was found to depend on the level of feeding during different periods of ontogenesis and the reproductive cycle phases. This method can be used to predict the reproductive success of female minks. The frequency of erythrocytes with microkernels in the rearing female minks of the control group at the age of 4 months during the formation of their reproductive functions was 2 times higher than in the experimental group (2.97 ± 0.42 vs. $6.01 \pm 2.75\%$). At the age of puberty (10

months) the frequency of erythrocytes with microkernels in rearing females is statistically significantly higher - $14,36 \pm 1,87$ - $14,89 \pm 3,67\%$ ($p < 0,05$; $p < 0,01$), than at the age of 4 months. The following productivity indices were obtained in the studied females of the control and experimental groups: the fertility of females - $5,63 \pm 0,64$ and $5,67 \pm 0,77$ pups, the yield of pups per a main female - $4,4 \pm 0,77$ and $4,67 \pm 0,85$ pups respectively. There were no unbred females and those which mated with males but did not have a litter in the experimental group, and the yield of pups per a female was 0,27 more. The microkernel test can be used to assess the stability of the genetic apparatus during different phases of the reproductive cycle of female minks and predict the reproductive success of females.

Keywords: mink, genomic stability, micronucleus test, replacement females, metabolizable energy, ontogenesis, reproduction

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Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Conflict of interest

The authors declare no conflict of interest.

INTRODUCTION

Feeding of fur-bearing animals, in particular breeding female minks, must meet the needs of animals in nutrients and energy, ensuring the realization of their genetic potential and growth of productivity. The stability of the genetic apparatus of animals must be evaluated in the process of adaptation of short-haired mink to the keeping and feeding technology currently existing in fur farming. Studies are carried out in order to predict the stability of functional systems of the animals' organism and to find out the efficiency of application of the existing technology of mink breeding and rearing. To solve this problem, we can use a micronucleus test - the index of the frequency of erythrocytes with micronuclei (EMN) in blood to assess the stability of the genetic apparatus of animals. This method is widely used in the assessment of organism homeostasis and is used to characterize individual genetic variability (genomic instability) in poultry and industrial fish farming¹ [1, 2]. The frequency of nuclear anomalies is influenced by biological processes of the organism itself. It is necessary to know how the frequency of nuclear anomalies can change

depending on endogenous factors: species and breed affiliation, age and physiological state of clinically healthy animals. The stability of the genetic apparatus to the influence of natural and anthropogenic factors including the unbalanced nutrition was estimated by means of the micronucleus test in different breeds of cattle, sheep and goats, horses, birds and fish. A comparative analysis of micronucleus test results was performed in connection with the peculiarities of animal origin (belonging to different breeds and species, hybrid populations), the age of animals and birds, and the physiological state of healthy animals and birds [3-11].

The purpose of the study was to examine the indicators of genetic variability in female short-haired mink during different periods of ontogenesis and phases of the reproductive cycle under changing levels of feeding.

MATERIAL AND METHODS

The first scientific and economic experiment was carried out at the "Saltykovsky" state fur breeding farm in the Moscow Region on a mink farm. In June 2019, two groups of 40 repair females (at the age of 2 months) of short-haired

¹Patent 2014144153 RF. T.T. Glazko, V.I. Glazko, A.M. Zubali, M.K. Chugreev, I.S. Tkacheva. Method for determining the expression of genomic stability (instability), genetic variability in groups, populations of fish and their individuals. 2016. Bulletin. no. 15. 6 p.

mink of the standard black breed (*Neovison vison*) were formed taking into account their average live weight, date of birth and origin. In the experiment on adaptation of breeding female short-haired mink to the existing housing and feeding technology, the control group of females at the age of 2-4 months, in the period of formation of their reproductive functions, were fed according to the recommended energy standards² [12]. The experimental group of females, similar in age and origin, was limited in the level of feeding (in terms of energy) by 10.0%. The amount of fodder was dosed by groups. After the end of the experiment (late August), the minks were transferred to a diet based on energy standards² [12].

According to the results of the valuation of experimental replacement females in November according to the type of their feeding in July-August, two groups were formed for further evaluation of their reproductive performance. In the second scientific and economic experiment, the reproductive ability of breeding female minks at the age of puberty (10 months) that received different energy levels of feeding during the formation of their reproductive functions was studied. During the experiments, female minks received a general farm diet. At the end of the experiments, the reproductive indices of females were recorded (number of covered, littered females; fertility; yield of young animals per the main female).

In August 2019, at 4 months of age, and in February 2020, at 10 months of age (before estrum), in 10 female siblings from each group, the degree of genomic stability (instability) was determined using a micronucleus test. The blood smears were prepared as follows: a drop of peripheral blood was spread evenly over a slide, dried under room conditions and stained with May-Grunwald test (1st method); washed with distilled water after 3 minutes and dried; the EMN were counted (not less than 3000 cells) and the data were expressed in ppm (‰). The preparations were examined using a Micros binocular microscope with a built-in digital camera at 1000× magnification. The results

were processed by methods of variation statistics using Microsoft Office Excel computer program and Student's *t*-criterion.

RESULTS AND DISCUSSION

At 4 months of age, the degree of genomic stability (instability) in females was determined using a micronucleus test. At this period, the live weight of the females in both groups was practically the same (1242.0 and 1266.5 g). The incidence of EMN in animals of the control group at the age of 4 months was 2 times higher than in the experimental group (when feeding with energy restriction by 10%) - $6,01 \pm 2,75\%$ against $2,97 \pm 0,42\%$. Among the individuals of the control group this index was registered in the range from 0 to 21,7‰, genomic instability being expressed to a greater extent. Among the females of the experimental group, it varied within a narrow range from 2.0 to 3.77‰. After transferring the experimental animals to rationed feeding in September-October, the females had a higher growth rate and reached a higher live weight (by 11.2%) by November 1, 2019 at the age of 6 months: 1610.0 ± 64.1 g vs. 1439.0 ± 55.1 g in the control ($p < 0.1$). During the rearing period (June - November) of replacement females, the actual nutrient content in the feed mixture per 100 kcal of metabolizable energy (ME) was: protein, 7.6-9.9 g; fat, 3.7-4.9; carbohydrates, 2.9-5.1 g.

The lowered level of energy supply of female short-haired replacement minks (10% below the recommended norms (see the footnote 2)) in July-August (220-260 kcal per head/day) provided the receiving of the planned live weight (1,5 kg) by November 1. The dependence of the frequency of EMN in the blood of female short-haired mink in different periods of ontogenesis on the level of feeding has been established, which agrees with the data of other researchers on the relationship between the influence of various environmental conditions on this indicator [9, 13].

At the age of puberty (10 months) the reproductive ability of breeding female minks that received different energy levels of feed-

²Feeding standards and feed consumption standards for fur-bearing animals and rabbits / Edited by N.A. Balakirev, V.F. Kladovschikov. Reference manual. Moscow: Russian Agricultural Academy, 2007. 185 p.

ing during the formation of their reproductive functions was studied. The possibility of using the micronucleus test to predict the probability of decreased reproductive functions in females was assessed.

The need of females for nutrients during reproduction and lactation was provided at the expense of the following contents of nutrients in feeding stuff according to the accepted norms (see footnote 2), on average (g/100 kcal ME): in January - March - protein - 10,6, fat - 4,2, carbohydrates - 3,2; in April - May - 10,1; 4,1; 4,0 accordingly. The average daily caloric intake by females in January-March 2020 was 240.0 kcal ME per head, in April-May 430.0 kcal ME. At sexually mature age the frequency of EMN in blood of breeding females was significantly higher: $14,36 \pm 1,87$ - $14,89 \pm 3,67\%$ ($p < 0,05$, $p < 0,01$) than at the age of 4 months. At this age, genomic instability was more pronounced in females, since all of them had erythrocytes containing micronuclei in blood. Perhaps, such an increase is associated with the accumulation of spontaneous mutations in somatic cells of animals with age. There is evidence in the literature that in black and white cattle the frequency of EMN³ was found to increase with age [3]. It has been established that high somatic chromosomal instability leads to impaired reproductive function of animals and may serve as a marker of increased probability of decreased reproductive function⁴.

The fertility of females in the control and experimental groups was $5,63 \pm 0,64$ and $5,67 \pm 0,77$ pups, the yield of young animals per a main female was $4,40 \pm 0,77$ and $4,67 \pm 0,85$ pups respectively. There were no unbred females and those which mated with males but did not have a litter in the experimental group, due to which the yield of the young per female was 0.27 pups more. The increased incidence of EMN seems to be related to the different level of feeding of females during the rearing period.

A similar trend of increasing the number of females without litter was established in the control group in the scientific and economic experiment during the reproduction period, where similar data on productivity of females were obtained (see table).

According to the data of the scientific and economic experiment, the following indicators of female productivity were obtained in the control and experimental groups respectively: 35 and 36 females were pregnant in total, the number of barreners was 2.63 and 0%; the number of those which mated with males but did not have a litter was 5.26 and 0%, cases of dysfunctional delivery were 0 and 2.70%, the number of stillborn pups was 2.39 and 1.35% and the fertility of females was 5.97 ± 0.28 and 6.37 ± 0.44 pups, the yield of young per a main female was 5.13 ± 0.40 and 5.24 ± 0.43 pups.

It is known that a moderate energy level of feeding during the growth period in July-

Результаты воспроизводства молодых самок коротковолосяй норки
Reproduction results of young female short-haired mink

Group	n	Indicator						
		Dead females, %	Barreners, %	Females leapt by males but did not have litter, %	DD* of females, %	Stillborn kits, %	Fertileness, heads, $M \pm m$	The yield of the young on the main female, heads, $M \pm m$
Control	38	–	2,63	5,26	–	2,39	$5,97 \pm 0,28$	$5,13 \pm 0,40$
Experiment	37	2,70	–	–	2,7	1,35	$6,37 \pm 0,44$	$5,24 \pm 0,43$

*DD – dysfunctional delivery.

³Semenova O.N. Changes in hematological, cytogenetic and immunological parameters in cattle with leukemia on the background of anaplasmosis invasion: Ph. Novosibirsk, 2004. 137 p.

⁴Semenov A.S. Cytogenetic screening in different populations of Holstein cattle. M., 2010. 28 p.

September best meets the needs of the breeding growing females and ensures the formation of their good reproductive qualities and contributes to an increase in the reproductive performance of replacement females and males of mink and foxes⁵ [12, 14, 15]. In the autumn period, moderate restriction of the diet of female minks eliminates extreme fluctuations in body weight throughout the reproduction period, increases the number of pups in a litter and improves weight recovery after lactation; in young females, it reduces DNA damage [16]. Using the micronucleus test it is possible to predict the increased probability of decreased reproductive functions of farm animals [3, 13], which is consistent with the data obtained. The method is used to compare experimental models of rat ovarian deficiency [17].

Reduced level of energy nutrition of short-haired mink reproductive females during the growth period in July-August (by 10% below the recommended rates), their subsequent transfer to feeding according to the recommended rates in September and subsequent months satisfy the needs of breeding growing females and provide formation of their high reproductive ability. With a decrease in the level of energy nutrition in July-August, the cost of feed in this period was reduced by 10.3%.

CONCLUSION

As a result of the experiments, the frequency of erythrocytes with micronuclei in the blood of female short-haired mink in different periods of ontogenesis depends on the level of feeding. An increase in the occurrence of EMN during the formation of reproductive functions in females at the age of 4 months in the range from 3.77‰ to 21.7‰ predicts an increased probability of a decrease in their reproductive functions. The decrease of energy supply to replacement females during the growth period in July-August (by 10% lower than the recommended norms) meets the demand of females and provides the formation of their high reproductive ability: fertility of females - $5,63 \pm 0,64$ and $5,67 \pm 0,77$

pups, yield of cubs per a main female - $4,4 \pm 0,77$ and $4,67 \pm 0,85$ pups, it reduces feed expenses during this period by 10,3%.

When using the intensive breeding technology of female short-haired mink and adapting to the conditions of modern fodder base, the micronucleus test can be used to assess the stability of the genetic apparatus during different periods of ontogenesis and phases of the reproductive cycle of female mink, characterize the physiological state of the organism, predict the increased probability of reduction of reproductive functions in females and clarify the effectiveness of the used mink breeding technology.

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СРАВНИТЕЛЬНЫЕ ВИРУЛЕНТНЫЕ СВОЙСТВА ЭПИЗОТИЧЕСКИХ ШТАММОВ БАКТЕРИЙ *ESCHERICHIA COLI*

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Представлены результаты исследования по определению вирулентности производственных штаммов и эпизоотических изолятов *Escherichia coli*, выделенных на территории Московской и Тульской областей в животноводческих хозяйствах и в частном секторе с 2016 по 2022 г. В опыте вирулентность эшерихий изучали путем определения LD₅₀ изолятов эшерихий для биологических тест-систем. Самым вирулентным штаммом из музейной коллекции оказался *E. coli* № ТП-85; авирулентными – *E. coli* № 727 и *E. coli* № Д616. Выделенные нами изоляты показали следующие результаты: наиболее вирулентными были *E. coli* 22/20, *E. coli* 3/16, *E. coli* 20/20, *E. coli* 24/21 – *E. coli* 7/16, *E. coli* 19/2, *E. coli* 18/20, *E. coli* 9/17, *E. coli* 5/16, *E. coli* 28/21, *E. coli* 29/21. Авирулентными были изоляты *E. coli* 25/21 и *E. coli* 17/20. LD₅₀ для них составила $22,36 \times 10^8$. Исследование музейных штаммов изолятов *E. coli* в сравнении с полученными в Московской и Тульской областях изолятами позволило сделать заключение, что при длительном хранении коллекционных штаммов снижается их вирулентность. Также отмечена тенденция утраты физико-химических свойств (стабильности) у штаммов при лиофилизации. Причин этому может быть несколько: несовершенство контроля и хранения на разных этапах жизненного цикла культуры; неправильно проведенная лиофилизационная сушка, когда штаммы не подверглись глубокой заморозке; несоблюдение этапов сушки, что со временем привело к изменению генетической структуры штамма.

Ключевые слова: эшерихии, *E. coli*, патогенные биологические агенты, энтеробактерии, колибактериоз, вирулентность, эпизоотические изоляты

COMPARATIVE VIRULENCE PROPERTIES OF EPIZOOTIC STRAINS OF *ESCHERICHIA COLI* BACTERIA

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The results of the study to determine the virulence of production strains and epizootic isolates of *Escherichia coli* isolated in the Moscow and Tula regions in livestock farms and in the private sector from 2016 to 2022 are presented. In the experiment, the virulence of *Escherichia coli* was studied by determining the LD₅₀ of *Escherichia coli* isolates for biological test systems. The most virulent strain from the museum collection was *E. coli* No. TP-85; the most avirulent were *E. coli* No. 727 and *E. coli* No. D616. The isolates selected by us showed the following results: the most virulent were *E. coli* 22/20, *E. coli* 3/16, *E. coli* 20/20, *E. coli* 24/21 – *E. coli* 7/16, *E. coli* 19/2, *E. coli* 18/20, *E. coli* 9/17, *E. coli* 5/16, *E. coli* 28/21, *E. coli* 29/21. Avirulent were the isolates *E. coli* 25/21 and *E. coli* 17/20. LD₅₀ for them was $22,36 \times 10^8$. The study of museum strains of *E. coli* isolates compared with the isolates obtained in the Moscow and Tula regions led to the conclusion that during long-term storage of collection strains, their virulence decreases. The tendency of strains to

lose their physicochemical properties (stability) during lyophilization has also been noted. There could be several reasons for this: imperfect control and storage at different stages of the culture life cycle; improper lyophilization drying when strains were not deep-frozen; and failure to follow drying steps, which over time led to a change in the genetic structure of the strain.

Keywords: *Escherichia*, *E. coli*, pathogenic biological agents (PBA), enterobacteria, colibacillosis, virulence, epizootic isolates

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Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Conflict of interest

The authors declare no conflict of interest.

INTRODUCTION

Escherichia coli is a conditionally pathogenic microorganism, a Gram-negative bacillus, whose species can lead to severe toxic infections with fatal outcome in humans and animals. Colibacillosis is an acute infectious disease of young animals of all types of farm animals caused by pathogenic *E. coli* [1-3]. Vaccine prophylaxis is a preventive measure to avoid this disease in animals. It is recommended to immunize pregnant females to protect newborns. Immunity in young animals initially depends on antibodies obtained from the mother's colostrum for early protection against infections, since immune mechanisms are not ready for normal functioning. Vaccination against colibacillosis is carried out in all countries [4-18].

Technology for developing immunobiological preparations is constantly improving. In this regard, the principle of designing vaccines against escherichiosis has changed in recent years, taking into account the role of protective antigens of the pathogen. Vaccines made or enriched with protective bacterial cell components are more effective and less reactogenic than those consisting only of bacterial cells. The addition of an adhesive antigen to the vaccine ensures the formation of antibodies delivered with the colostrum into the intestines of newborns, which prevent the attachment of pathogenic escherichia to the intestinal epithelium.

The purpose of the study was to determine the virulence of production strains and epizo-

otic isolates of *Escherichia coli* isolated in the territory of Moscow and Tula regions.

MATERIAL AND METHODS

The work was carried out at the Moscow State Academy of Veterinary Medicine and Biotechnology named K.I. Skryabin. Separate studies were performed at the Laboratory of Quality and Standardization of Bacterial Drugs of the All-Russian State Center for Quality and Standardization of Veterinary Drugs and Feed.

Species diversity of epizootic *Escherichia* strains was studied in cattle farms and in the private sector in the Moscow and Tula regions. Laboratory conditions were used to study pathological and biological material to find the most virulent strains. 31 *E. coli* isolates from 27 animals were isolated from 100 samples of biological material. In addition to *E. coli*, representatives of other genera of Enterobacteriaceae were also found, but their further identification was not the purpose of our studies. *Escherichiae* were isolated from the liver, small and large intestine, and spleen of 7- to 20-day-old calves and piglets.

RESULTS AND DISCUSSION

According to the literature, one of the indicators of virulence is the formation of toxins. Virulence is a quantitative measure of pathogenicity measured most often in specific units. LD₅₀ is the minimum lethal dose equal to the smallest amount of the pathogen that would

cause the death of 50% of infected animals in a given mode of infection. Virulence is also related to toxigenicity - the ability of the organism to produce a toxin that negatively affects the functions of the susceptible organism.

In our experiment, the virulence of *Escherichia coli* was studied by determining the LD₅₀ of *Escherichia coli* isolates for biological test systems. For this purpose, the culture of the isolate under study was grown on MPA, incubated after 24 h, then washed with sterile physiological solution (pH 0.9) from the beveled MPA, suspended in a test tube, and the concentration was adjusted to 1 billion microbial cells (m.c.) per 1 cm³ using an optical turbidity standard. White mice were infected intraperitoneally with 0.5 cm³ of prepared culture. The observation was carried out within 7 days from the moment of infection. The diagnosis in case of death was confirmed by bacteriological tests.

The virulence of an isolate was judged after calculating the LD₅₀: if no mice died in the experiment, it was considered avirulent; if at least one animal died, it was considered virulent. Cultures that caused death of all experimental animals were considered highly virulent.

LD₅₀ was calculated according to the Kerber formula modified by Ashmarin-Vorobyov

$$\lg LD_{50} = \lg D - \sigma (\Sigma L_i - 0,5),$$

where IgD is the maximum infectious dose in the experiment; σ is the logarithm of the multiplicity of the tested dilutions; ΣL_i is the sum of L_i values, the ratio of the number of animals that died from administration of a given dose to the total number of animals in the group (see the table).

The most virulent strain in the collection was *E. coli* no. TP-85: 4.47×10^8 (447 million); avirulent were *E. coli* No. 727 and *E. coli* No. D616: 11.7×10^8 (1 billion 17 million) each.

The isolates we isolated showed the following results: *E. coli* 22/20, *E. coli* 3/16, *E. coli* 20/20, *E. coli* 24/21 - *E. coli* 7/16, *E. coli* 19/2, *E. coli* 18/20, *E. coli* 9/17, *E. coli* 5/16, *E. coli* 28/21, *E. coli* 29/21 were the most virulent. The *E. coli* 25/21 and *E. coli* 17/20 isolates were avirulent. The LD₅₀ for them was 22.36×10^8 (see the table).

For *Escherichiaceae*, the most virulent strain had an LD₅₀ of 47 million germ cells, which is a very good value.

Due to the fact that *E. coli* is a commensal (saprophyte), it is difficult to select animals for the experiment (laboratory model) that will most accurately demonstrate the results of the experiment. In this case, an experiment was observed where the toxic effect was pronounced: white mice in the experiment died from exposure to the toxins released by *E. coli*. The pathogenicity of the strain would be in the disease of the animals and in the manifestation of the clinical picture.

CONCLUSION

A study of the virulence of museum strains of *E. coli* isolates in comparison with the isolates obtained in Moscow and Tula regions allowed us to conclude that the virulence of strains decreases during long-term storage. The tendency of strains to lose physicochemical properties (stability) during lyophilization was also noted. There may be several reasons for this: imperfect control and storage at different stages of the culture life cycle; improper lyophilization drying when strains were not deep frozen; failure to observe the drying stages, which eventually led to a change in the genetic structure of the strain.

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Вирулентность музейных штаммов и выделенных на территории Московской и Тульской областей изолятов *E. coli*

Virulence of museum strains and *E. coli* isolates isolated in the Moscow and Tula regions

Strain	Dose, m.k.	Alive	Dead	LD ₅₀ , mln м.к.
<i>E. coli</i> museum strains				
<i>E. coli</i> № 727	2,0 bln	5	0	9 × 10 ⁸
	400,0 mln	4	1	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> w/o No. O101	2,0 bln	4	1	8,51 × 10 ⁸
	400,0 mln	4	1	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> № Д616	2,0 bln	4	1	9,10 × 10 ⁸
	400,0 mln	5	0	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> ГДР	2,0 bln	3	2	6,17 × 10 ⁸
	400,0 mln	4	1	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> w/o No. O9	2,0 bln	4	1	6,17 × 10 ⁸
	400,0 mln	4	1	
	80,0 mln	3	2	
	16,0 mln	5	0	
<i>E. coli</i> № 397-37/14	2,0 bln	4	1	8,51 × 10 ⁸
	400,0 mln	3	2	
	80,0 mln	5	0	
	16,0 mln	5	0	
<i>E. coli</i> № 398-37/14	2,0 bln	3	2	8,51 × 10 ⁸
	400,0 mln	5	0	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> № Т- 85П-85	2,0 bln	2	3	4,47 × 10 ⁸
	400,0 mln	5	0	
	80,0 mln	3	2	
	16,0 mln	5	0	
<i>E. coli</i> № 2005	2,0 bln	4	1	8,51 × 10 ⁸
	400,0 mln	3	2	
	80,0 mln	5	0	
	16,0 mln	5	0	
<i>Selected isolates of E. coli</i>				
<i>E. coli</i> 3/16 Га.Тул	2,0 bln	0	5	0,47 × 10 ⁸
	400,0 mln	1	4	
	80,0 mln	3	2	
	16,0 mln	4	1	
<i>E. coli</i> 9/17 Га.Мос	2,0 bln	1	4	1,2 × 10 ⁸
	400,0 mln	1	4	
	80,0 mln	4	1	
	16,0 mln	5	0	

Strain	Dose, m.k.	Alive	Dead	LD ₅₀ , mln м.к.
<i>E. coli</i> 5/16 Гр.Мос	2,0 bln	1	4	1,2 × 10 ⁸
	400,0 mln	1	4	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> 7/16 Г.Г.Тул	2,0 bln	0	5	0,89 × 10 ⁸
	400,0 mln	1	4	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> 17/20 Га.Тул	2,0 bln	5	0	22,36 × 10 ⁸
	400,0 mln	5	0	
	80,0 mln	5	0	
	16,0 mln	5	0	
<i>E. coli</i> 24/21 Г.П.Мос	2,0 bln	0	5	0,65 × 10 ⁸
	400,0 mln	0	5	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> 18/20 Г.Г.Мос	2,0 bln	1	4	0,89 × 10 ⁸
	400,0 mln	1	4	
	80,0 mln	3	2	
	16,0 mln	5	0	
<i>E. coli</i> 19/20 Г.Г.Тул	2,0 bln	0	5	0,89 × 10 ⁸
	400,0 mln	1	4	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> 25/21 Г.П.Тул	2,0 bln	5	0	22,36 × 10 ⁸
	400,0 mln	5	0	
	80,0 mln	5	0	
	16,0 mln	5	0	
<i>E. coli</i> 20/20 Г.Г.Мос	2,0 bln	0	5	0,47 × 10 ⁸
	400,0 mln	0	5	
	80,0 mln	3	2	
	16,0 mln	5	0	
<i>E. coli</i> 28/21 Г.П.Мос	2,0 bln	3	2	3,2 × 10 ⁸
	400,0 mln	3	2	
	80,0 mln	0	5	
	16,0 mln	0	5	
<i>E. coli</i> 21/20 Г.Г.Мос	2,0 bln	4	1	8,5 × 10 ⁸
	400,0 mln	4	1	
	80,0 mln	4	1	
	16,0 mln	5	0	
<i>E. coli</i> 29/21 Г.П.Тул	2,0 bln	3	2	6,1 × 10 ⁸
	400,0 mln	3	2	
	80,0 mln	5	0	
	16,0 mln	5	0	
<i>E. coli</i> 22/20 Г.Г.Мос	2,0 bln	5	0	0,46 × 10 ⁸
	400,0 mln	5	0	
	80,0 mln	2	3	
	16,0 mln	0	5	
<i>E. coli</i> 23/20 Г.Г.Мос	2,0 bln	1	4	8,5 × 10 ⁸
	400,0 mln	2	3	
	80,0 mln	0	5	
	16,0 mln	0	5	

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БАЗОВАЯ КОНЦЕПТУАЛЬНАЯ СХЕМА МОЛОТИЛЬНО-СЕПАРИРУЮЩЕГО УСТРОЙСТВА ПОДБОРЩИКА-ОЧЕСЫВАТЕЛЯ ЛЬНА-ДОЛГУНЦА

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Уборку льна-долгунца для получения волоконной и семенной продукции осуществляют в зависимости от конкретных условий по различным технологиям: прямой, отдельной и заводской. Представлено технико-технологическое исследование отдельной уборки льна-долгунца путем совершенствования базовой концептуальной схемы подборщика-очесывателя. Рассмотрены традиционные технологии уборки льна-долгунца и технические средства, обеспечивающие выполнение технологических операций, связанных с отдельной технологией уборки. Выявлены недостатки технических средств, используемых при отдельной технологии уборки льна-долгунца. Они заключаются в различной степени воздействия молотильно-сепарирующих очесывающих органов уборочных машин как грабельного, так и роторного типа на стебли, что вызывает неравномерность их вылежки по длине и приводит к ухудшению качества волокна, уменьшению номера выхода особо ценного длинного волокна и потерям семенной части урожая. Предложена концептуальная схема базового молотильно-сепарирующего устройства вальцового типа для отдельной технологии уборки льна-долгунца путем совершенствования подборщика-очесывателя. Предлагаемый вариант устройства обеспечивает одновременный обмолот лент льна-долгунца и создает благоприятные условия для качественной вылежки соломы до состояния тресты одновременно по всей длине стебля путем ее равномерного плющения в зазорах между обрезиненными вальцами. Подборщик-очесыватель, оборудованный молотильно-сепарирующим устройством вальцового типа, позволяет производить выделение семян из неочесанной ленты льна-долгунца вне зависимости от расположения семенной части относительно направления движения уборочного агрегата. Универсальность, простота и широкий диапазон применения молотильно-сепарирующего устройства вальцового типа целесообразно использовать при проектировании машин для уборки льна-долгунца для прямой, отдельной и заводской технологий уборки.

Ключевые слова: льноуборочная машина, вальцовое молотильное устройство, лен-долгунец, равномерность вылежки, треста

BASIC CONCEPTUAL SCHEME OF THE THRESHING AND SEPARATING DEVICE OF THE FLAX FIBER COMBING MACHINE

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Harvesting of flax for fiber and seed production is carried out depending on the specific conditions by different technologies: direct, separate and factory. A technical and technological study of separate harvesting of flax fiber by improving the basic conceptual scheme of the picker-combing

machine is presented. The traditional technologies of harvesting flax fiber and technical means that ensure the implementation of technological operations related to the separate technology of harvesting are considered. Disadvantages of the technical means used in the separate harvesting technology of flax fiber are revealed. They consist in varying degrees of impact of threshing and separating combing bodies of harvesting machines of both rake and rotor type on the stems, which causes uneven curing along their length and leads to the deterioration of fiber quality, reduction of the number of extra valuable long fiber and losses of the seed part of the crop. A conceptual scheme of the basic threshing and separating device of a roll-fulling type for separate technology of flax fiber harvesting by improving the picker-combing machine is proposed. The proposed device variant provides simultaneous threshing of flax fiber strips and creates favorable conditions for quality curing of straw to the state of flax straw simultaneously along the entire stalk length by its uniform conditioning in the gaps between the rubberized rollers. The combing header equipped with a threshing and separating device of the roll-fulling type allows to separate the seeds from the uncombed flax strip regardless of the location of the seed part relative to the movement direction of the harvesting machine. Versatility, simplicity and wide range of application of the threshing and separating device of the roll-fulling type are reasonable to use when designing machines for harvesting flax fiber for direct, separate and factory harvesting technologies.

Keywords: flax puller, roll-fulling threshing device, flax fiber, uniformity of maturation, flax straw

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Conflict of interest

The authors declares no conflict of interest.

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INTRODUCTION

Fiber flax is cultivated for fiber and seeds. World flax fiber production, according to FAO-STAT, exceeded 330 thousand tons per year. In the Russian Federation the harvest of flax fiber is 38.8 thousand tons. In the Siberian Federal District, the sown areas of flax fiber decreased from 16.1 thousand hectares in 1990 to 11.1 thousand hectares in 2019.

The main biological contradiction in harvesting is that different phases of maturity and harvesting at the appropriate calendar dates are appropriate for obtaining quality fiber and seeds. Fibre flax harvested in the early yellow

ripeness phase provides the highest fiber yield, and the seeds ripened in the bolls are suitable for sowing purposes. In order for the flax mill to make a profit and carry out equipment upgrades, it is necessary that the flax straw coming in for processing is not lower than number 1.5. Harvesting of fibre flax for fiber and seed production is carried out depending on specific conditions by different harvesting technologies: direct, separate and factory [1, 2]^{1,2}.

The purpose of the study is to present a technical and technological study of the separate harvesting of fiber flax by improving the basic conceptual scheme of the picker-combing machine.

¹Rozhmina T.A., Ponazhev V.P. State and prospects of development of the flax sector in Russia // Globalization and environmental and economic development of regions: proceedings of scientific and practical conference. Moscow, 2015. pp. 181-190.

²Kovalev M.M., Kolchina L.M. Technologies and equipment for the production and primary processing of flax and hemp: handbook. Moscow: Rosinformagrotech, 2013. 184 p.

The research tasks included analysis of information resources on technical and technological support of flax harvesting and search for conceptual scheme of threshing and separating device (TSD) of basic harvesting tool for realization of separate harvesting technology.

MATERIAL AND METHODS

The search for technical solutions and testing of experimental samples of threshing and separating devices for the implementation of separate and factory harvesting technologies to improve the quality of flax products was conducted from 2001 to 2020. The research was conducted in the laboratory of the Siberian Research Institute of Mechanization and Electrification of Agriculture and in the farms of the Novosibirsk region: OJSC "Bugotaksky flax plant" and OJSC "Legostaevsky flax plant"³⁻¹⁴.

Scientific works and information resources related to the improvement of the working bodies of flax harvesting machines for the implementation of direct, separate and factory harvesting technologies of fibre flax, as well as specialized multifunctional units for seed production are used in the work.

The main method of identifying and evaluating the factors determining the improvement of flax production quality and related to the nature, intensity and uniformity of the impact of the working elements of flax harvesting machines by the length of the stalk is an expert-logical analysis of information resources related to the improvement of the working elements of TSD flax harvesting machines when implementing direct, separate and factory technologies of fiber flax harvesting.

³Glants V.V., Kuznetsov A.V., Burlakov Yu.V. Influence of combing bodies type and their kinematic modes on completeness of flax-fibre seeds combing at separate harvesting method // Mechanization and electrification of agricultural production: materials of international scientific and practical conference (Novosibirsk, April 22-23, 2003). Novosibirsk. 2003. pp. 62-63.

⁴Patent № 2243643, A01D45/06 "Device for flax stalk combing" (Russian Federation) / V.P. Bekasov, Yu.V. Burlakov, V.V. Glants, A.V. Kuznetsov, G.E. Chepurin; application dated 10.07.2002; published 10.01.2005; Coll. no. 1.

⁵Patent № 2243644, A01D45/06 "Device for flax stalk combing" (Russian Federation) / V.P. Bekasov, Yu.V. Burlakov, V.V., V. V. Glants, A.V. Kuznetsov, G.E. Chepurin, I.N. Petryagin; applied December 30, 2002; publ. 10/01/2005; bul. no. 1.

⁶Kuznetsov A.V., Surilova G.V., Burlakov Yu. V. Prospective technologies of separate harvesting of fiber flax seeds in Siberia // Modern and advanced technologies of the agro-industrial complex in Siberia: materials of the international scientific and practical conference (Novosibirsk, July 8-9, 2006). Novosibirsk. 2006. pp. 47-48.

⁷Burlakov Yu. V., Nikolashkin V.I. The results of the study of the effect of the type of combing bodies and their kinematic modes on the completeness of combing flax seeds with separate harvesting method // Modern and advanced technologies of the agro-industrial complex in Siberia: materials of the international scientific and practical conference (Novosibirsk, July 8-9, 2006). Novosibirsk. 2006. pp. 49-50.

⁸Burlakov Yu.V., Kuznetsov A.V., Surilova G.V., Nikolashkin V.I. The results of the study of experimental flax thresher work // Engineering and technical support of technological processes in the agro-industrial complex of Siberia: collection of scientific papers / Siberian Branch of the Russian Academy of Agricultural Sciences, SibIME. Novosibirsk. 2007. pp. 38-46.

⁹Кузнецов А.В., Сурилова Г.В., Булаков Ю.В. Kuznetsov A.V., Surilova G.V., Burlakov Yu.V. Influence of fibre flax harvesting methods on the sowing qualities of seeds // Engineering and technical support of technological processes in the agro-industrial complex of Siberia: Collection of scientific papers / Siberian Branch of Russian Academy of Agricultural Sciences, SibIME. Novosibirsk. 2007. pp. 47-51.

¹⁰Kuznetsov A.V., Surilova G.V., Burlakov Yu.V. The quality of harvesting of fibre flax seeds in Siberia // Machine-technical, energy and service support of agricultural producers in Siberia: materials of the international scientific and practical conference (Krasnoobsk, June 9-11, 2008) / Siberian Branch of the Russian Academy of Agricultural Sciences, SibREME. Novosibirsk. 2008. pp. 495-499.

¹¹Burlakov Yu.V. Technology of harvesting fibre flax seeds in Siberia // Machinery in agriculture. 2013. № 4. pp. 3-4.

¹²Burlakov Yu.V. The choice of the combing apparatus type for stationary thresher of fiber flax // Scientific and technical support of the Siberian agro-industrial complex: proceedings of the international scientific and technical conference (Krasnoobsk, June 7-9, 2017) / SFSCA RAS, SibIME. Novosibirsk. 2017. T. 1. pp. 83-89.

¹³Burlakov Yu.V. Performance of a stationary laboratory installation of roller type for threshing fibre flax // Scientific and technical support of the agro-industrial complex of Siberia: materials of the international scientific and technical conference (Krasnoobsk, October 3-4, 2019) / SFSCA RAS, SibIME. Novosibirsk, 2019. pp. 23-28.

¹⁴Burlakov Yu.V., Chemodanov S.I. Threshing and separating device of roller type for threshing flax tapes with factory harvesting technology // Agrarian science to agriculture: materials of the XVII international scientific and practical conference (February 9-10, 2022) in 2 books Barnaul: RIO Altai State Agricultural University, 2022. pp. 18-19.

RESULTS AND DISCUSSION

During direct harvesting of fiber flax in the Russian Federation flax harvesters LK-4D, LEN-4, KL-1,5 Rusich, KL-1,5 Seliger, KL-1,5 "Valday" with rake combing bodies are used that separate seeds from stems at different moisture content [3-5]. Foreign manufacturers of flax harvesting machinery Union, Depoortere (Belgium), Dehondt (France), Gomselmash and Bobruiskagromash (Belarus) also produce a wide range of highly productive specialized trailed and self-propelled flax harvesters, such as flax-cutters, flax harvesters, flax pickers, flax balers. The main disadvantage of these known technical means is that on different parts of the flax stalk along its length the combing working bodies of harvesting machines of both rake and rotor type have different deforming influence [6]. As a result, flax stems have different seasoning stages along their length. If the apex part of the stem has already reached normal seasoning, the middle part has already over-ripened, its quality has deteriorated; while the trunk part

has not yet reached optimal quality (see Fig. 1).

In the process of dew retting, pectin-degrading bacteria and fungi, which are part of the microflora, penetrate through the tiny cracks in the fiber flax stalk, which are caused by the working bodies of flax harvesting machines. In this case the straw changes its original color, covered with small gray specks and eventually turns dark gray, turning into flax straw. On those parts of the stalk where there are no damages or they are minimal, the process of flax straw formation is slower, and where there was a penetration by flattening the stalks, seasoning of straw is accelerated by 15-20%.

The implementation of the above-described harvesting technology leads to a decrease in the amount of fiber due to unevenly matured along the length of the stalk of the flax straw fiber and a decrease in the yield of especially valuable long fiber. Therefore, flax farms aiming for high profits pay special attention to the monitoring of seasoning. For example, the average number of long fiber in normal maturing in dew retting



Рис. 1. Характерный вид тресты в результате завершения вылежки стеблей льна-долгунца в процессе росной мочки

Fig. 1. Characteristic appearance of flax straw as a result of flax fiber stalks ripening in the process of dew retting

conditions of fiber flax tape may correspond to 16, in under-maturing - only to 12, in its over-maturing - only to 10 and below¹⁵.

Farm technologists have an opportunity to influence the general terms of flax straw preparation by implementing such technological operations with fiber flax tapes as wrapping and fluffing, which help to equalize the uniformity of flax seasoning in the upper and lower parts of the flax stalk. It is not possible to influence the uniformity of seasoning along the length of the stalk, since the situation is already inherently laid by the different nature of the impact of the working bodies of flax harvesting machines.

The most active deformation effect on the flax stems in their middle part is produced by the clamping conveyor of the flax mill, which has a complex profile and wavy relief. It deforms the middle part of the flax stalk, where later a characteristic, lighter color of the trust is observed, as this part of the stalk matures much faster than the apex and butt end parts [7]. The main advantage of the separate harvesting technology compared to combine harvesting is the use of solar energy potential for drying the stems and maturation of seeds in the seed bolls, as well as the ability to start harvesting earlier, which ultimately results in fiber and seeds of higher quality. Flax straw maturation periods as a result of using the technological process of conditioning and wrapping can reduce the time of harvesting by 14 days, provide a higher number of flax straw, increase the germination energy of seeds and their germination ability [8].

The harvesting of fibre flax by machines with rake implements is widely used for direct harvesting in both single- and double-threaded

machines. However, they are practically unacceptable for implementation of the separate harvesting technology by both single-flow and double-flow schemes, since the fibre flax tapes during their stacking, tedding and wrapping due to wind load and violation of technological processes do not always have a straight direction¹⁶⁻¹⁸ [9]. One of the significant disadvantages of seed heap received from flax harvesters with rake combing bodies is the difficulty of its further processing in order to obtain seeds¹⁹. There are various types of working bodies suitable for the process of separating the seed part of products from fibre flax tapes in field conditions²⁰ [10, 11]. The situation on separation of the seed part by working bodies is complicated by the growth of negative indicators influencing on the fiber flax tape at different stages of its seasoning from straw to flax straw in the process of dew retting. For example, the stalks extension in the flax tape after flax-combing is 1.09 times, and after its wrapping it increases up to 1.21 times. A similar situation for the stalk: the stalks at the root have a coefficient of variation of 3.44%, and after the flax harvester - 19.30% or more. After the technological operation of wrapping, this index increases to 28.61% [12].

Selection of such a tape and combing of seed bolls by the rake working tools when implementing the separate harvesting technology is also complicated by the fact that the boll location area is on one side of the belt. The operator of a flax harvester has to control the combing machine so that the combing device is on the side of the seed boll location, which requires a high level of skill and great concentration, since

¹⁵ Obyedkov M.G. Fiber flax. Moscow: Rosselkhozizdat, 1979. 223 p.

¹⁶ Loyko S.F., Perechaev A.N., Starosotnikov S.V. Machines for cultivation and harvesting of fibre flax // Scientific and technological progress in agricultural production: proceedings of the international scientific and technical conference. 2015. Vol. 2. pp. 138-146.

¹⁷ Rostovtsev R.A., Shishin D.A. To the question of separating the seed part of the crop from the stems // Machine-technological modernization of flax agro-industrial complex on the basis of innovation: collection of scientific works of VNIIML. Tver, 2014. pp.100-103.

¹⁸ Smirnov N.A., Lobachev A.A., Rymar O.N., Vakarchuk S.I. Analysis of the devices for the separation of seeds from the stems in the implementation of harvesting technologies of fiber flax // Innovative developments for the production and processing of bast crops: materials of the international scientific and practical conference. Tver, 2017. pp. 213-216.

¹⁹ Perepechaev A.N., Karpunin V.I. On the expediency of developing a machine for pre-combing of seeds // Scientific and technological progress in agricultural production: materials of the international scientific and technical conference dedicated to the 70th anniversary of the RUE "NPC NAS Belarus on Mechanization of Agriculture". 2017. pp. 126-129.

the width zone of seed bolls with seeds does not exceed 30 cm [13, 14].

The current situation is the conceptual and technological scheme of the known devices of the combers with different working bodies, potentially used for the implementation of the separate technology of fibre flax harvesting (see Fig. 2). According to the established technological scheme of the devices, the uncoated flax-fibre tape is picked up by the device I and delivered to the zone of the clamping conveyor II, which brings the uncoated part of the tape to the zone of the combing bodies III. The working bodies have a deforming and detaching effect on the bolls and separate the seed part of the crop from the stem part. Then, the stem part of the crop is transported by the clamping conveyor to the wrapper-tape stacker V for laying it on the field surface and further seasoning to the condition of flax straw under the dew retting conditions. During the implementation of combing the stalks are damaged and deformed due to the impact of the working bodies, which leads to accelerated seasoning up to the condition of flax straw of only that part of the stalk which fell into this zone. In this case, the stem butt end part either does not receive any de-

forming effects in the area of its location IV, or receives them by crushing or squeezing one or two pairs of roller working tools, which are installed additionally. It is necessary to ensure the operation of an additional drive of these conditioning pairs coordinating their linear velocity with the linear velocity of the working surface of the clamping conveyor. As a result, the stems along the length receive different in nature mechanical impact, which leads to a decrease in the quality of the fiber obtained from such flax straw during its further processing.

The most interesting of all working tools, along with the rake ones, are the roller working tools. For realization of the separate technology of the fiber flax harvesting the mounted picker-combers with the roll working bodies were used, for example, the pick-up thresher MLN-1,0 designed by VISKhOM (All-Russian Research Institute of Agricultural Machinery named after V. P. Goryachkin) and the flax pick-up thresher LMN-1,0. When operating machines with rubberized roll working bodies the stems are not pulled out into the clumps and the stems are well flattened between the roll pairs, forming favorable conditions for seasoning the stems to a flax straw state²¹. However, the rollers do not

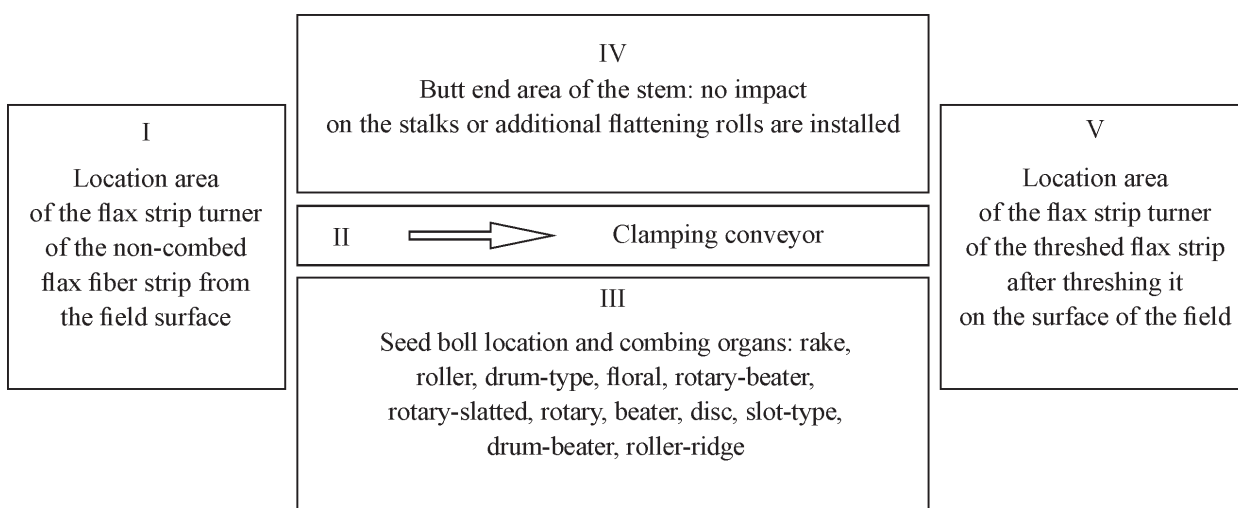


Рис. 2. Сложившаяся концептуальная схема подборщиков-очесывателей с молотильно-сепарирующим устройствами различных типов

Fig. 2. The established conceptual scheme of pickers-combers with threshing and separating devices of various types

²⁰Fadeev D.G. Classification and analysis of combing apparatus schemes of flax harvesting machines // Innovative developments for the production and processing of bast crops: proceedings of the international scientific and practical conference. pp. 224-235.

²¹Kasparova S.A. Separate harvesting of fiber flax // Proceedings of the All-Union Research Institute of Agricultural Engineering. Moscow: VISKHOM, 1961. Issue. 32. pp. 129-152.

flatten the stem along its entire length; as a result, seasoning in the apical part is completed earlier than in the butt end part.

The proposed conceptual technological scheme of the roller threshing and separating device could be the solution to this problem (see Fig. 3)²².

The device operates as follows: after 7-10-days of maturing in the field, the unbleached flax tape (in accordance with the separate harvesting technology) is lifted by the pick-up device I and delivered to the zone of the roll type II TSD, where during its passage between the rubberized rollers 1 and 2 it is flattened and threshed 4 times evenly by destruction of seed bolls throughout the width of the tape in the gaps between the upper and lower rollers. Stability of uniform band flattening between the rubberized rollers is ensured by its compression force (not less than 16 kN) with self-centering device 6 [15].

On the whole way of the tape between rubberized rollers it is securely held between upper and lower rubberized endless tapes 5, 7. The tape is blown in the gaps between the rollers by directed air flow along the direction of stems from nozzles 4 in the direction from the butt end part of the plants to the apex part. Endless upper and lower rubberized tapes are equipped with tensioning mechanisms 3 and 8 to adjust their tension. After threshing, the tape is delivered to the wrapper-tape stacker III and laid on the surface of the field for further seasoning until it becomes a flax straw. The threshed seed straw from the threshing and separating device is sent to the seed stacker IV.

The proposed basic conceptual technological scheme of realization of the threshing and separating device of the roller type for the baling machine implies threshing of the bolls in the fiber flax tape with simultaneous uniform flattening of the stems along their entire length during threshing between the rubberized rollers. This scheme forms a favorable situation for further uniform seasoning of the stems during the dew retting and creates conditions for a higher quality fiber yield. This makes it possible

to select the tapes and to thresh them independently of the box area and the direction of the machine's movement on the tape. In addition, it also allows the threshing of disoriented tapes, i.e. those which rake and rotor tools are unable to thresh due to a disturbance in the technological process. The resulting seed clumps are practically free of clutter, and the stalks are not shortened or damaged.

CONCLUSIONS

1. When implementing the separate fibre flax harvesting technology, the proposed version of the basic threshing and separating device of roller type forms favorable conditions for further uniform seasoning of straw as a result of dew retting to the state of flax straw along the entire width of the threshing belt by evenly flattening the stems over the entire length.

2. The proposed variant of rubberized roller working tools provides a stable technological process of threshing of fiber flax tape with minimal damage to the stem part of the crop and their withdrawal into the waste.

3. Picker-combing machine with the proposed basic conceptual scheme of the threshing and separating device of the roller type allows to pick up and thresh regardless of the orientation of the seed part of the crop in the belt relative to the direction of the harvesting machine movement.

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²²Patent 259797979, IPC A01F11/02 (Russian Federation). Roller threshing device / Yu.V. Burlakov; № 2015119862/13; Application 26.05.15; publ. 20.09.16; Bul. no. 26.

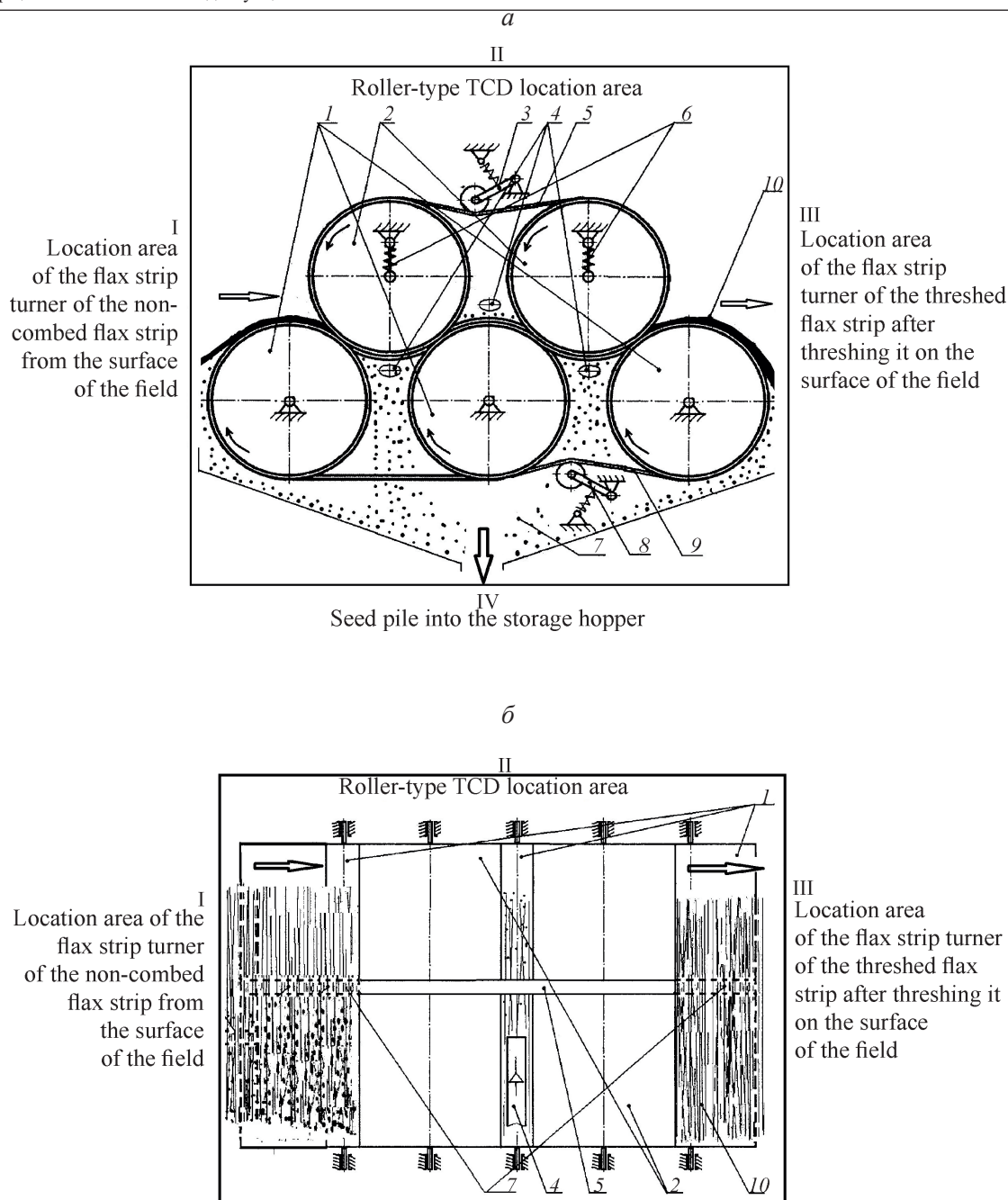


Рис. 3. Предлагаемая концептуальная схема базового молотильно-сепарирующего устройства вальцового типа для подборщика-очесывателя:

a – вид сбоку; *б* – вид сверху: 1 – нижние обрезиненные вальцы; 2 – верхние обрезиненные вальцы; 3 – натяжной механизм верхней бесконечной обрезиненной ленты; 4 – сопла для направленной подачи воздуха вдоль стеблей; 5 – бесконечная обрезиненная лента, объединяющая верхние обрезиненные вальцы; 6 – подпружиненный самоцентрирующийся прижимной механизм верхних обрезиненных вальцов; 7 – бесконечная обрезиненная лента, объединяющая нижние обрезиненные вальцы; 8 – натяжной механизм нижней бесконечной обрезиненной ленты; 9 – сборник семенного вороха; 10 – лента льна-долгунца

Fig. 3. The proposed conceptual scheme of the basic threshing and separating device of the roller type for the picker-comber, where: *a*) - side view; *б*) top view):

1 - lower rubberized rollers; 2 - upper rubberized rollers; 3 - tension mechanism of the upper infinite rubberized tape; 4 - nozzles for directional air supply along the stems; 5 - infinite rubberized tape uniting the upper rubberized rollers; 6 - spring-loaded self-centering clamping mechanism of the upper rubberized rollers; 7 - infinite rubberized tape uniting the lower rubberized rollers; 8 - tension mechanism of the lower infinite rubberized tape; 9 - seed pile collector; 10 - flax fiber tape

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ОЦЕНКА ВЛИЯНИЯ ВЛАЖНОСТИ ПОЧВЫ ПРИ ПОСЕВЕ НА ГЛУБИНУ ЗАДЕЛКИ СЕМЯН ЗЕРНОВЫХ КУЛЬТУР

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Приведена оценка глубины заделки семян зерновых культур после посева агрегатами, оборудованными анкерными и лаповыми типами сошников, в условиях различной влажности почвы степной зоны Сибири. Исследования проведены с 2018 по 2021 г. в степной зоне Алтайского края. Влажность почвы определяли при помощи электронного влагомера НН-2 фирмы Delta-T Devices, принцип работы которого основан на измерении электропроводности почвы. Глубину заделки семян определяли по этиолированной (осветленной) части растений. При сравнении результатов принята величина стандартных отклонений от среднего значения глубины заделки семян, поскольку по принципу оценки она соответствует агротехническим требованиям к посеву. Проанализированы найденные в диапазоне влажности почвы от 12 до 40% стандартные отклонения от глубины заделки семян после посева орудиями, оборудованными анкерными и лаповыми типами сошников. Стандартные отклонения от средней определенной глубины заделки семян сведены в диаграммы рассеяния. Все отклонения от глубины заделки после посева данными сошниками находились в допустимых пределах изменений агротехнических требований, которые составляют ± 10 мм. Установлена взаимосвязь отклонений от средней глубины заделки семян и влажности почвы на момент посева. Уравнения связи данных показателей имеют высокую значимость, что подтверждается высокими коэффициентами детерминации. Данные уравнения позволят сельхозтоваропроизводителям степной зоны Алтайского края при знании влажности почвы на момент посева спрогнозировать его качественную составляющую после всходов, поскольку равномерность распределения семян по глубине заделки влияет на урожайность культур.

Ключевые слова: глубина заделки, анкерный сошник, лаповый сошник, влажность почвы, степная зона Сибири

EVALUATING THE EFFECT OF SOIL MOISTURE DURING SOWING ON THE DEPTH OF CEREAL CROPS SEEDING

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Evaluation of the depth of seeding cereal crops after sowing by units equipped with tyne coulters and tine cultivators under different soil moisture conditions in the steppe zone of Siberia is given. The studies were conducted from 2018 to 2021 in the steppe zone of the Altai Territory. Soil moisture was determined using an НН-2 electronic moisture meter from Delta-T Devices, the principle of operation of which is based on measuring the electrical conductivity of the soil. The depth of seed placement was determined by the etiolated (clarified) part of the plants. When comparing the results, the value of standard deviations from the average value of seed placement depth was taken, because according to the principle of evaluation it corresponds to the agrotechnical requirements for sowing. The standard deviations from the seed placement depth after sowing by the machines equipped with tyne coulters and tine cultivators found in the soil moisture range from 12 to 40% were analyzed. Standard deviations from the average defined seed placement depth are summarized in scatter

diagrams. All deviations from the depth of placement after sowing with these coulters were within the acceptable limits of changes in agrotechnical requirements, which are ± 10 mm. The relationship between deviations from the average depth of seeding and soil moisture at the time of sowing was established. Relationship equations of these indicators are highly significant, as evidenced by high coefficients of determination. These equations will allow agricultural producers of the steppe zone of the Altai Territory with knowledge of soil moisture at the time of sowing to predict its quality component after sprouting, since the uniformity of seed distribution on the depth of seeding affects the crop yield.

Keywords: sowing depth, tyne coulters, tine cultivator, soil moisture, Siberian steppe zone

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Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Conflict of interest

The authors declare no conflict of interest.

INTRODUCTION

Currently, agricultural enterprises of the steppe zone of Siberia, engaged in crop production, use a variety of seeders and seeding complexes for sowing crops. The fundamental difference between these machines is the type of the main working tools - coulters, which are most often of the disk, tyne and tine type. According to the widespread data confirmed by the Ministry of Agriculture of the Altai Territory, in connection with the mass transition of farmers to resource-saving sowing technologies, sowing machines equipped with tyne and tine coulters which implement no-till and minimum sowing technologies are more often used, respectively. In this regard, it is these types of working tools that are considered in this article [1, 2].

There are different opinions and disputes among farmers about the preference for using each type of coulters in certain operating conditions of sowing machines. One of the main selection criteria in this case are such indicators as draught resistance, respectively, and fuel consumption of the sowing units [3-6].

For example, when working in the conditions of increased soil moisture, the tine coulters experience more draught resistance due to a larger resistance area, while the anchor coulters experience less resistance due to a smaller area,

which is also reflected in the quality of seeding. According to numerous data, it is known that moisture is one of the most important soil properties affecting the quality of seeding, which can vary in a wide range during the sowing season [7-14].

To objectively assess the quality of sowing, there are many indicators specified in the agrotechnical requirements for sowing. Uniformity of seed distribution by depth of seeding is one of the most important requirements that affect the final yield of grain crops.

The purpose of the study is to justify the choice of the coulters type in terms of uniformity of seed depth distribution in the work of seeding units under the conditions of different soil moisture.

MATERIAL AND METHODS

To estimate soil moisture before sowing grain crops from 2018 to 2021, soil moisture measurements were carried out on a large number of fields (about 300) in the farms located in the steppe zone of the Altai Territory. The soil type on which the research was conducted was southern chernozem. After the sowing season, in those fields where soil moisture was measured, the depth of seed placement was checked to determine the qualitative component of sowing.

The studies were conducted in the fields after sowing by seeding machines and seeding complexes equipped with tyne and tine coulters (see Fig. 1). Most often seeding was carried out with such seeding machines as PK Kuzbass and PK Kuzbass-A, SZS 2.1, SKP 2.1 "Omichka", PK FeatAgro L and A series, Agromaster Agrator and Agrator Ancer, Amazone Primera DMC and Condor, John Deere 1830 and 1870, Morris Concept 2000, etc.

Soil moisture in the layer from 0 to 100 mm was determined with an electronic moisture meter HH-2 from Delta-T Devices, which operates based on measuring the electrical conductivity of the soil (see Fig. 2).

The depth of seed embedding was determined by the etiolated (lightened) part of the plants (see Fig. 3)¹ [15].

The seeding depth after sowing with tools with tyne coulters and tine cultivators was determined under conditions of a wide range of soil moisture from 10 to 40%.

RESULTS AND DISCUSSION

The value of standard deviations is adopted to trace the logic of the process and to find out how much the values differ from the average, allowing for an objective comparison of this indicator in accordance with the agronomic requirements.



Рис. 1. Вид исследуемых анкерных и лаповых типов сошников

Fig. 1. Type of researched tyne coulters and tine cultivators



Рис. 2. Электронный влагомер почвы HH-2 Delta-T Devices

Fig. 2. Electronic soil moisture meter HH-2 Delta-T Devices



Рис. 3. Исследуемые растения

Fig. 3. The plants under study

¹Gataulina, G.G., Obyedkova M.G. Practical work on plant growing. Moscow: Kolos, 2000. 215 p.

When analyzing the experimental data obtained, standard deviations from the average value of the seed embedment depth for each case corresponding to a particular field and seeding unit were found.

The sample was quite extensive and consisted of about 300 values, so the standard deviations from the average defined seed placement depth are summarized in scatter diagrams (see Figs. 4 and 5).

The points showing the value of the standard deviation from the average seed placement depth on the diagrams correspond to the soil moisture at the time of sowing in the given field, where the plants were selected.

These diagrams show that sowing was carried out in a wide range of soil moisture. The greater number of points on the diagram with tyne coulters indicates that within this sample the seeding machines with these coulters prevailed (see Fig. 5).

These diagrams will make it possible in the future to determine the soil moisture range for sowing with tyne coulters or tine cultivators in which sowing is most often carried out. The optimum range for sowing, from the point of view of agronomic compliance, will be where the standard deviations from the seeding depth are lowest.

The entire range of soil moisture from 10 to 40% included in our study was divided into six intervals, the value of each interval being 5%. The values of deviations from the seed placement depth and their corresponding soil moisture values falling in each of the intervals were averaged to facilitate the data analysis procedure (see Figs. 6 and 7).

For seeding machines with tyne coulters, the relationship between the deviation of the seeding depth (y) and soil moisture (x) is described by the following equation:

$$y = 0,0119x^2 - 0,4979x + 11,641. (1)$$

Equation (1) has high significance, which corresponds to the coefficient of determination $R^2 = 0,95$.

After sowing with tyne coulters in the soil moisture range from 12 to 39%, the standard deviations of the embedment depth varied from 6 to 10 mm. The smallest standard deviation from the embedment depth at an average depth of 44.7 mm was recorded as 6.4 mm, obtained when sowing in a soil moisture of 21%, the largest (9.25 mm) - moisture of 38%.

For seeding machines with tine cultivators, the interrelation of the deviations from the depth of seed placement and soil moisture is described by the following equation:

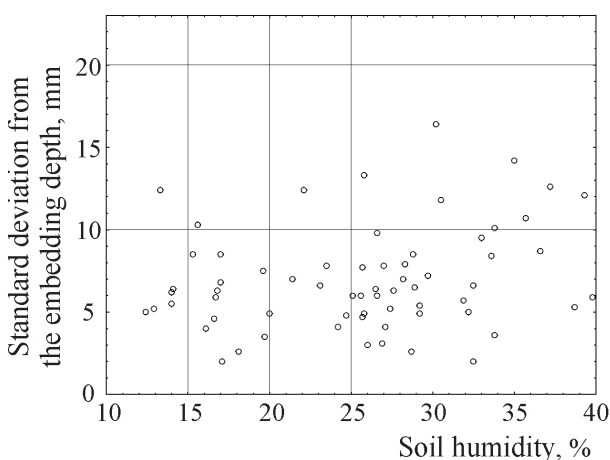


Рис. 4. Диаграмма рассеяния стандартных отклонений от глубины заделки семян после посева анкерными сошниками

Fig. 4. Scatter diagram of standard deviations from the seed placement depth after sowing with tyne coulters

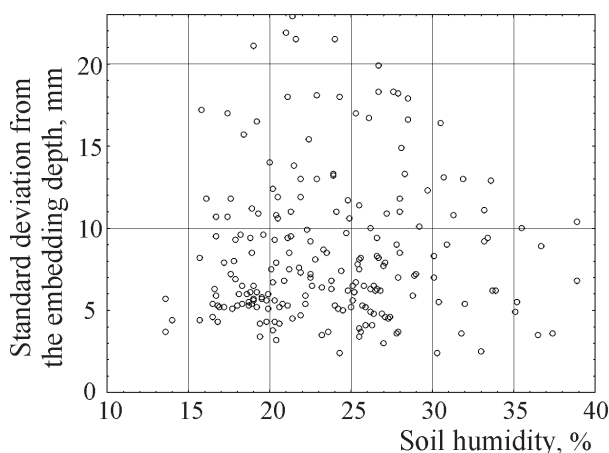


Рис. 5. Диаграмма рассеяния стандартных отклонений от глубины заделки семян после посева лаповыми сошниками

Fig. 5. Scatter diagram of standard deviations from the seed placement depth after sowing with tine cultivators

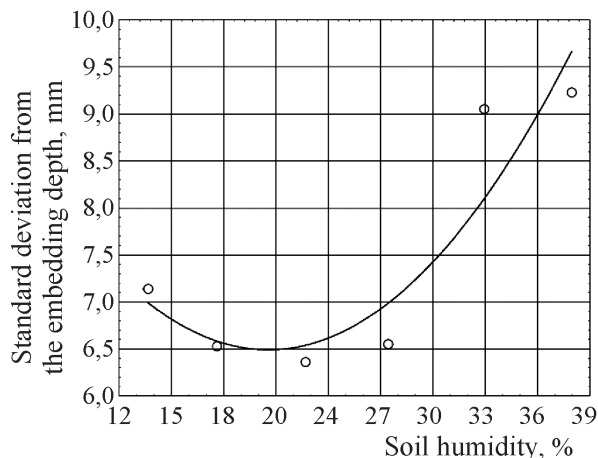


Рис. 6. Зависимость отклонений глубины заделки семян от влажности почвы после посева анкерными сошниками

Fig. 6. Dependence of seeding depth deviations on soil moisture after sowing with tyne coulters

$$y = 0,001x^2 - 0,0091x + 8,2782. (2)$$

Equation (2) is also highly significant with a fairly high coefficient of determination $R^2 = 0,84$.

After sowing with tine coulters in the soil moisture range from 12 to 39%, the standard deviations of the embedment depth varied from 8 to 10 mm. The smallest standard deviation from the embedment depth at an average depth of 44.9 mm was recorded as 8.15 mm, obtained when sowing in a soil moisture of 14%, the largest (9.35 mm) - moisture of 37%.

It also follows from these graphs that the standard deviation of the embedment depth in these cases is within the limits of acceptable changes in agronomic requirements for sowing cereals – ± 10 mm.

CONCLUSIONS

1. The obtained scatter diagrams create prerequisites for determining the agronomically optimal soil moisture level for sowing with tools equipped with tyne coulters and tine cultivators.

2. The equations of correlation between deviations from the depth of seeding and soil moisture during seeding grain crops obtained for seeding machines equipped with tyne coul-

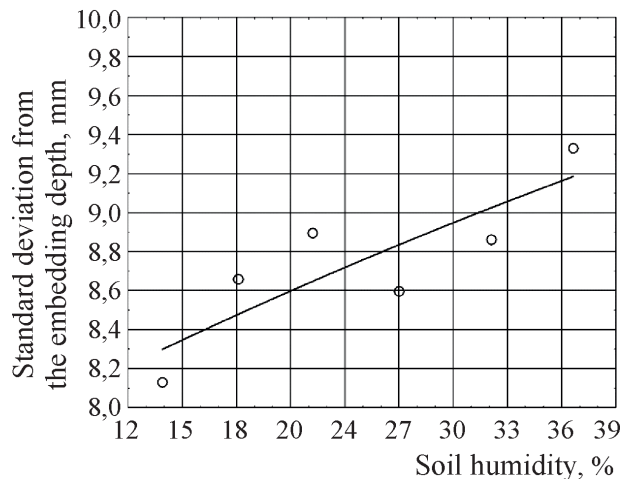


Рис. 7. Зависимость отклонений глубины заделки семян от влажности почвы после посева лаповыми сошниками

Fig. 7. Dependence of seeding depth deviations on soil moisture after sowing with tine cultivators

ers and tine cultivators will allow agricultural producers of the steppe zone of the Altai Territory to predict its quality component after sowing in the future if they know the soil moisture at the time of seeding.

3. The quality of sowing can greatly influence the final yield of crops, so future research in this area in the context of regions with other soil and climatic conditions will continue to be of interest.

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ИСТОРИЯ РАЗРАБОТКИ ДОКУМЕНТОВ ПО ПЕРЕВОДУ ВЕТЕРИНАРНОЙ СЛУЖБЫ НА ПЛАТНЫЕ ВЕТЕРИНАРНЫЕ УСЛУГИ

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Представлены материалы по истории разработки документов и опыт работы ветеринарной службы по совершенствованию государственного ветеринарного надзора за безопасностью продукции животного происхождения в новых экономических условиях. Многолетний опыт ветеринарного обеспечения животноводства выявил ряд существенных недостатков в постановке ветеринарного дела: отсутствие надлежащих условий для работы ветеринарных специалистов госветсети и хозяйств; несовершенство оплаты труда, зарплата ветеринарных специалистов не зависит от уровня их профессиональной подготовки, сложности и качества выполнения работы; недостаточная материально-техническая обеспеченность; слабая правовая защищенность; несовершенство законодательства по ветеринарии; отвлечение специалистов для выполнения других не свойственных их профессии хозяйственных работ; отсутствие нормальных социально-бытовых условий. Все это приводит к потере престижа профессии ветеринарного работника, оттоку ветеринарных специалистов в другие сферы производства. Отсюда низкая обеспеченность кадрами ветеринарных учреждений и хозяйств. Учеными и ветеринарными специалистами Новосибирска проделана работа по поиску таких форм организации ветеринарного обслуживания животноводства. Предложена система организации хозрасчетных объединений, которые могут эффективно функционировать во всех категориях хозяйств. Разработаны необходимые руководящие документы для организации и их последующей практической деятельности. Опыт работы хозрасчетных ветеринарных объединений в ряде районов показал, что производительность труда возросла в 1,5–2,0 раза, увеличилась нагрузка на одного ветеринарного специалиста, соответственно возросла заработная плата. Проведенная работа доказала необходимость совершенствования деятельности государственной ветеринарной службы в условиях экономических реформ.

Ключевые слова: научно-технический совет, ветеринарные специалисты, новые формы, экономические взаимоотношения

HISTORY OF DOCUMENT DEVELOPMENT ON THE TRANSFER OF ANIMAL HEALTH OFFICE TO FEE-BASED VETERINARY SERVICES

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The materials on the history of the development of documents and the experience of the veterinary service to improve the state veterinary inspection over the safety of products of animal origin in the

new economic conditions are presented. Many years of experience in veterinary support of cattle breeding revealed a number of significant shortcomings in the organization of veterinary business: lack of adequate conditions for the work of veterinary specialists of the state veterinary network and farms; imperfect remuneration of labor, veterinary specialists' salary does not depend on the level of their professional training, complexity and quality of work; lack of material and technical support; weak legal protection; imperfect legislation on veterinary services, diversion of specialists to perform unrelated to their profession labor activities, and lack of normal social and living conditions. All this leads to the loss of prestige of the veterinary profession, the outflow of veterinary professionals to other areas of production. Hence the low staffing of veterinary institutions and farms. Scientists and veterinary specialists of Novosibirsk have done work on the search for such forms of organization of veterinary services for cattle breeding. The system of organization of self-supporting associations which can effectively operate in all categories of farms is proposed. The necessary guiding documents for the organization and their subsequent practice have been developed. The experience of self-supporting veterinary associations in a number of districts showed that labor productivity increased by 1.5-2 times, the workload per veterinary specialist increased and the salary increased accordingly. The work carried out has proved the need to improve the activities of the state veterinary service in the context of economic reforms.

Keywords: scientific and technical council, veterinary specialists, new forms, economic relations

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Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Conflict of interest

The authors declare no conflict of interest.

At the meeting of Scientific Council of the Institute of Experimental Veterinary Science of Siberia and the Far East (IEVSS&FE) (Novosibirsk) on 10 May 1990 the development of the system and normative documents on transferring veterinary institutions and veterinary services to full cost accounting and self-financing were discussed. It was decided to approve the regulation and regulatory documents for the transfer of veterinary and sanitary expertise laboratories in markets and submit them to the Main Veterinary Administration under the State Commission of the USSR Council of Ministers on Food and Procurement¹.

The meeting of the Scientific and Technical Council of the State Commission of the USSR Council of Ministers for Food and Procurement in the Veterinary Section (Minutes № 4 of 21.09.90)² was attended by G.F. Koromyslov, V.P. Shishkov, A.S. Bessonov, D.F. Osidze, A.D. Tretyakov, V.P. Karev, F. Kurchenko, MA Sidorov, V.I. Kostyrin, A.I. Malygin, MG Tarshis, Ch.I. Dulinets, as well as by well-known scientists and specialists from the organizations under the State Commission: O.Z. Iskhakov, Y. E. Shatokhin, E.G. Andreva ("Head Veterinary Office of the Ministry of Agriculture and Food of the RSFSR"),

¹Implement new forms of veterinary services for animals on five farms in three districts of the Novosibirsk Region: 1995 research report, Siberian Branch of the Russian Academy of Agricultural Sciences, IEVSS&FE. Novosibirsk. 1995. 43 p.

²Minutes of the meeting of the Scientific and Technical Council of the State Commission of the USSR Council of Ministers for Promotion and Procurement (Veterinary Section) № 4 of 21.09.90. Moscow.

S.I. Dzhupina, L.Y. Yushkova (IEVSS&FE), A.I. Lapshin, V.P. Yazhmin (Souzovetsnabprom), V.A. Garkavtsev (journal "Veterinary Science"), V.V. Vinokurov (All-Russian Research Institute of Veterinary Sanitation, Hygiene and Ecology (ARRIVSHE)), P.A. Chulkov (The Russian State Center for Animal Feed and Drug Standardization and Quality (VGNKI of the Federal Service for Veterinary and Phytosanitary Surveillance)), V.F. Voskoboynik (Moscow Veterinary Academy (MVA)), V.M. Puchov (All-Russian Scientific Research Institute for Fundamental and Applied Parasitology of Animals and Plant named after K. I. Skryabin).

We elaborated on those present to emphasize the importance of the meeting and the decision of the documents discussed.

The director of IEVSS&FE, Doctor of Science in Veterinary Medicine S.I. Dzhupina spoke on the issue of organization of service for livestock veterinary self-supporting associations in the Novosibirsk region, the co-reporter was the head of the Novosibirsk region Veterinary Association A.I. Lapshin.

The report stated the following.

Many years of experience in veterinary support of livestock has revealed a number of significant shortcomings in the organization of veterinary affairs:

- lack of proper conditions for the work of veterinary specialists of the state veterinary network and farms;
- remuneration imperfections;
- salary of veterinary specialists does not depend on the level of their professional training, complexity and quality of work;
- insufficient material and technical provision;
- weak legal security;
- imperfect veterinary legislation;
- diversion of specialists to perform other, not inherent in their profession labor activities;
- lack of normal social and living conditions.

All this leads to the loss of prestige of the profession of veterinary worker, the outflow

of veterinary professionals in other areas of production. This leads to low staffing levels on veterinary institutions and farms. In connection with the adoption of a number of laws in the USSR (on cooperation, on state enterprises, on individual labor activity, on small enterprises, etc.), the creation in the country of multiform agro-industrial production, the transition to market relations, the formation of free enterprise zones, the expansion of foreign economic relations, it became necessary to find new forms of economic relations between veterinary services and serviced farms. The Institute of Experimental Veterinary Science of Siberia and the Far East has done work on the search for such forms of organizing veterinary services for livestock. A system of organizing self-supporting associations, which can function effectively in all categories of farms, was proposed. Necessary guiding documents for organization and their further practical activity are developed. The experience of self-supporting veterinary associations in a number of districts of Novosibirsk, Kuibyshev and other regions of the RSFSR showed that labor productivity increased by 1,5-2,0 times, the load on one veterinary specialist increased and the salary increased accordingly.

O.Z. Iskhakov, V.P. Shishkov, V.V. Vinokurov, A.D. Tretiakov, V.I. Kasyuk spoke on the issue under discussion. In the course of opinion sharing, they spoke in favor of broader development of various forms of veterinary activity including self-supporting associations, establishments and organizations of state veterinary service, privately practicing veterinarians with individual licenses or engaged in medical care combined into cooperatives, small enterprises or other associations. At the same time the participants of the meeting paid special attention to the need to preserve the state veterinary service and giving it special powers in solving all-union tasks, as well as in exercising state supervision over compliance with veterinary legislation in all parts of the agro-industrial complex by departmental veterinary services, self-supporting associations, cooperatives and

private practitioners with the establishment of licensing their activities.

The Section of the Scientific and Technical Council decided to:

- approve the materials presented by IEVSS&FE on organization of self-supporting veterinary associations for servicing farms, as well as the experience of their work in a number of districts of Novosibirsk and other regions of the RSFSR;

- recommend to veterinary services of the Union republics, regions, territories and districts to study the proposed experience of these associations to serve farms, as well as the district veterinary associations operating in the Kuybyshev region of the RSFSR;

- Create model districts in each oblast, krai and ASSR and on their basis organize training for veterinary specialists of all levels to further implement it in practice;

- ask IEVSS&FE (S.I. Dzhupina, L.Ya. Yushkova), ARRIVSHE (V.V. Vinokurov) to submit comments and recommendations to the Main Veterinary Administration on the current laws of the USSR until 01.12.90 (on cooperation, on self-employment, on small enterprises etc.) on their use in the organization of various forms of veterinary activity;

- ask the VASKHNIL Department of Veterinary Medicine to form the composition of the section on economics and organization of veterinary science;

- recommend that the veterinary services of the Union republics hold meetings and seminars to improve the structure of the state veterinary service and create self-supporting veterinary institutions.

In 1993, a meeting of the Scientific and Technical Council of the Ministry of Agriculture and Food of the Russian Federation was held on January 12. The Council meeting was attended by the representatives of about 70 organizations and well-known scientists³: V.M. Avilov, V.I. Antonov, Ch.K. Avylov, L.P.

Bashkatov, N.V. Blynskaya, I.E. Williams, A.S. Gerasimov, S.V. Zakharov, B.A. Kobzev, V.A. Nikitenko, V.P. Novgorodov, V.F. Pylinin, O.I. Sukharev, Y.E. Shatokhin (Ministry of Agriculture and Food of the Russian Federation); A.T. Boldyrev (Republican Epizootic Unit of the Main Veterinary Administration of the Ministry of Agriculture of the Russian Federation); T.I. Kozyrenko, V.I. Kosenko (Republican Scientific Production Veterinary Laboratory); V.K. Shcherbinin (Rossvinoprom); O.A. Budko (V/O "Roszovetsnab"); V.P. Tischenko (Rosselkhozakademy); A.I. Shurygin (Rosagrobioprom Group); I.F. Vishnyakov (All-Russian Scientific Research Institute of Veterinary Virology and Microbiology); A. Gusev (All-Russian Research Institute for Animal Protection); G.F. Koromyslov (All-Russian Research Institute of Experimental Veterinary Medicine); A.N. Panin (All-Russian State Scientific Research Institute for Control, Standardization and Certification of Veterinary Preparations); A.M. Smirnov (All-Russian Research Institute of Veterinary Sanitation, Hygiene and Ecology); V.V. Sochnev (Research Veterinary Institute of the Non-Chernozem Zone of the Russian Federation); V.P. Urban (Veterinary Association of Russia); V.V. Usha (Moscow Institute of Applied Biotechnology); L.Ya. Yushkova (State Enterprise SPS "Orgvetkhov", Novosibirsk); E.A. Marinin (Vologda Veterinary Research Station); V.M. Barannikov (AIC "Ramenskoye", Moscow Region); V.G. Merman (Veterinary Association of the Kemerovo Region Administration); E.F. Zhdanov (Department of Agriculture, Belgorod Region); A.L. Yatsyuta (Moscow meat processing plant).

Some of those present at the Scientific and Technical Council have passed away, some have been out of work for a long time. Let's remember them by describing that important meeting of this council...

³Protocol of the meeting of the Scientific and Technical Council of the Ministry of Agriculture of the Russian Federation № 23 of 12.01.93. Moscow.

The agenda of the meeting included a discussion of reforming the structure of the State Veterinary Service and new forms of veterinary services for farm animals.

The speaker was L.Ya. Yushkova, PhD in Veterinary Science, Senior Researcher at the IEVSS&FE, Director of the State Enterprise SPS "Orgvetkhoz"; the co-reporter was Y.E. Shatokhin, Deputy Head of the Department of Veterinary Medicine of the Ministry of Agriculture and Food of the Russian Federation.

Having heard and discussed the report and the co-report, as well as the reports of the official opponents (V. V. Sochnev, Director of the Research Veterinary Institute of the Non-Chernozem Zone of the Russian Federation, Doctor of Science in Veterinary Medicine, Corresponding Member of RAAS, V. G. Merman, Head of the Veterinary Association of the Kemerovo Administration), scientific and technical council noted that years of experience of the veterinary livestock support revealed several significant drawbacks in the veterinary case: imperfections of labor, load, diversion of professionals, insufficient material and technical support, lack of normal social and living conditions.

In connection with the adoption of a number of laws in the Russian Federation, in accordance with the assignment of the RF Ministry of Agriculture to conduct research "On reforming the structure of the State Veterinary Service and new forms of veterinary services for farm animals" and at the request of regional agricultural departments and departments of agriculture and land reform (Saratov, Kemerovo, Novosibirsk, Rostov and other regions; total - 20) the need to find new forms of organization of veterinary affairs and veterinary and sanitary services for livestock arose. The work on solving this problem was carried out on the basis of farms, state veterinary institutions of veterinary agencies of 20 regions and republics of the Russian Federation, the state enterprise of scientific-production system organization of veterinary self-support "Orgvetkhoz", the Institute of Experimental Veterinary Sci-

ence of Siberia and the Far East (IEVSS&FE), the Research Veterinary Institute of the Non-Chernozem Zone of the Russian Federation (RVI NChZ RF), the Department of Veterinary Medicine Ministry of Agriculture and Food of the Russian Federation.

The work has been carried out since 1986:

- studies have been conducted to find forms of organization of veterinary services for livestock breeding;
- the system of organization of self-supporting associations which can effectively operate in all categories of farms has been proposed;
- together with the Ministry of Agriculture of the Russian Federation the necessary guiding documents for the organization and their subsequent practical activities have been developed.

During the exchange of opinions, the participants of the Council expressed their support for the broad development of various forms of veterinary activities. At the same time, special attention was paid to the need to preserve the state veterinary service and give it special powers in solving problems, as well as in exercising state supervision over compliance with veterinary legislation by departmental veterinary services, self-supporting associations, cooperatives and private practitioners with the establishment of licensing their activities.

Positive experience was also noted in the work of the veterinary service in the Kemerovo region (V.G. Merman) and the organization of all forms of livestock veterinary services IEVSS&FE (L.Ya. Yushkova).

The Scientific and Technical Council decided to:

- approve the recommendations "On reforming the structure of the State Veterinary Service and new forms of veterinary services for farm animals" prepared by the specialists of research institutes (IEVSS&FE, RVI NChZ RF, etc.) together with the state enterprise of research and production system "Orgvetkhoz", agro-industrial associations of several regions of Russia, as well as the Main Veterinary Administration;

– recommend that the veterinary services of the republics, territories, regions of the Russian Federation should implement the proposed recommendations for reforming the structure of the state veterinary services developed with the experience of the 20 regions of the republic and the state veterinary associations operating in the Kemerovo region, St. Petersburg, Moscow, Samara and other cities;

– consider it advisable to create model districts with the organization in them self-supporting associations to serve farms and organize training for veterinary specialists at all levels for further implementation in practice on their basis;

– instruct the group of authors to finalize the recommendations, taking into account the comments made at the meeting of the Council and submit them for approval to the Main Veterinary Administration by March 1, 1993;

– to create a commission consisting of V.M. Avilov, Y.E. Shatokhin, Ch.K. Avylov, L.Y. Yushkova, V.V. V.Ya. Yushkova, A.T. Stadnik, V.G. Merman. The recommendations finalized and prepared for publication should be submitted to the Department of Veterinary Medicine of the Ministry of Agriculture and Food of the Russian Federation for inclusion in the publication plan 1993;

– instruct the Chief Veterinary Administration to work with the Main Science Department to find a way to continue funding this development.

The protocol was approved by the First Deputy Minister of Agriculture and Food of the Russian Federation V.N. Shcherbak.

We show the way of approval and implementation of our elaboration. We present the main provisions of the Protocol № 28 of the Scientific and Technical Council of the Ministry of Agriculture and Food of the Russian Federation of November 22, 1995.

There were representatives of about 50 organizations⁴: Ministry of Agriculture and

Food, heads of regional and republican veterinary departments (Sverdlovsk region, Koryak District of the Kamchatka region, Altay Territory, Khakassia, Astrakhan, Novosibirsk region, Yamal-Nenets region, Yekaterinburg, Moscow region, Udmurt Republic, Barnaul, Belgorod region ("Interzoovetservice"), Ulyanovsk, Novgorod and Kemerovo regions, Grozny region, Rostov-on-Don, Republic of Kalmykia, Bryansk, Tyumen regions, Nizhny Novgorod State Agricultural Academy, Kaluga, Tula, Irkutsk regions, Krasnoyarsk region, Saint Petersburg, Ust-Ordyn Buryat Autonomous District, Tatarstan, Ingushetia, Chechen Republic, Bashkortostan, specialists of the Veterinary Department of the Ministry of Agriculture and Food of Russia, Jewish Autonomous Region, IEVSS&FE, Novosibirsk) etc.

Meeting agenda: consideration of the regulatory framework for veterinary support of enterprises and institutions for the production, processing, storage and sale of animals and livestock products in a market economy on the example of Novosibirsk and the Novosibirsk region.

Head of the laboratory of the IEVSS&FE, Doctor of Science in Veterinary Medicine L.Ya. Yushkova made the report "New approaches in the organization of veterinary support in a market economy enterprises and institutions associated with the production, processing, storage and transport of animals and livestock products".

Co-reporters:

– A.S. Bogomolov, Head of the Veterinary Department and Veterinary Sanitary Inspection of the Novosibirsk Mayor's Office: "Organization, structure and information about the work of the Veterinary Department and Veterinary Sanitary Inspection of the Novosibirsk Mayor's Office";

– O.A. Rozhkov, Deputy Head of the Veterinary Department and Veterinary Sanitary Inspection of the Novosibirsk Mayor's Office:

⁴Minutes of the meeting of the Scientific and Technical Council of the Ministry of Agriculture and Food of the Russian Federation № 28 of 11.1995, Moscow.

"Improvement of state veterinary supervision over the safety of products of animal origin (sources of funding; registration of enterprises and citizens engaged in harvesting, processing, storage and sale of products and raw materials of animal origin; veterinary and sanitary control in trade and public catering enterprises)".

V. Stadnik, T.A. Aleksandrova, L.S. Trubitsyna, and N.T. Pontiushenko were the official opponents. The speakers at the debate were V.V. Sochnev, V.A. Apalkin, L.Ya. Yushkova, Yu.E. Shatokhin.

Having heard the report, co-reports, reports of the official opponents, speeches of the participants of the meeting, the Scientific and Technical Council decided that the work prepared by the authors' team L.Ya. Yushkova, V.V. Sochnev, Yu.E. Shatokhin, A.S. Bogomolov, A.I. Lapshin and others, *is relevant and has an important practical value*. The current system of state veterinary monitoring in urbanized areas, especially in large industrial centers, under conditions of liberalization of procurement, storage, simplified technology of processing and sale of livestock products, despite the law "On Veterinary Medicine" does not meet the needs of a modern city to strengthen control over the supply of high-quality food products. There is a need to create new structural forms of organization of veterinary affairs in the formation of market relations and different forms of ownership. In this regard, work to improve the veterinary case for the safety of animal products in the new economic conditions has been carried out in Novosibirsk. The Novosibirsk Mayor's Office of Veterinary Affairs with Veterinary and Sanitary Inspection has been organized, which includes the following structural units:

– veterinary and sanitary inspection (veterinary and sanitary inspection laboratories of markets, units of state veterinary inspec-

tion at enterprises for processing and storage of products of animal origin, departments of veterinary and sanitary control districts, cities, service veterinary and sanitary inspectors (veterinary and sanitary inspectors), quarantine stations for small animals, birds, fish and bees);

– city service for the prevention and treatment of animal diseases (city veterinary clinic, district departments for the prevention and treatment of animal diseases; anti-epizootic unit, veterinary pharmacies);

– shop for the processing of conditionally approved products;

– housekeeping department;

– finance department.

A feature of this reorganization was that the issues of veterinary and sanitary expertise of animal products and issues of prevention and treatment of animal diseases are not mixed together, as it was before, but entrusted to the Veterinary Department and Veterinary Sanitary Inspection of Novosibirsk two structures: Veterinary and Sanitary Inspection and the city service for the prevention and treatment of animal diseases^{5,6}.

The decision to create a veterinary and sanitary inspection of the city was due, above all, to the fact that products began to arrive at trade and catering enterprises not centralized, as before, but uncontrolled, since stores, canteens, cafes, restaurants have become the same markets with the only difference that in official markets there is veterinary and sanitary control, and in trade and catering it is virtually absent. The first days of the state veterinary inspection showed that every second enterprise of trade and catering did not comply with veterinary and sanitary requirements and products did not meet safety requirements. During 10 months of this year during 5515 inspection inspections at 1944 controlled objects revealed

⁵Managing means anticipating: monograph / V.M. Avilov et al. Novosibirsk, 1996. 280 p.

⁶Functional-cost method in assessing the optimal forms of veterinary structures // Methodology of prevention and elimination of diseases of farm animals: collection of scientific papers / Siberian Branch of the Russian Academy of Agricultural Sciences, IEVSS&FE. Novosibirsk, 1995. pp. 235-238.

1644 violations of veterinary legislation, fines were imposed in excess of 137 million rubles, 360 tons of meat of all kinds, 15 - meat products, 9 - fish and fish products, 27 tons of dairy products as not conforming to veterinary and sanitary requirements. The facts of storage in public catering enterprises of meat obtained from dead animals or from animals that were in the agonal state were established. Meat from animals sick with tuberculosis, leukosis, phinosis, staphylococcosis and other infectious diseases was taken off sale. The facts of storage of livestock products in basements, garages and other unsettled places were revealed and suppressed.

During the work of the new structure of the Novosibirsk State Veterinary and Phytosanitary Service the following documents have been developed and approved:

– Regulation "On the order of charging fees for licensing. Carrying out veterinary and sanitary examination and certification of agricultural products and raw materials of animal origin". Approved by the decision of the small council of the Novosibirsk city council of people's deputies (№ 61 from 30.03.93);

– Resolution of the Novosibirsk City Administration (№ 12 of 12.01.94) "On the structure and staffing of the Veterinary Administration with the Veterinary and Sanitary Inspection of the Mayor's Office of Novosibirsk";

– Resolution of the Novosibirsk City Administration (№ 1358 of 13.12.93) "On the reorganization of the city veterinary service";

– Order of the Department of Social Policy of the Novosibirsk City Administration (№ 154 of 01.11.94) "On compulsory veterinary and sanitary inspection of agricultural products in the markets of the city";

– Resolution of the Novosibirsk City Administration (№ 715 of 13.07.95) "On the establishment of state veterinary inspection units at enterprises for processing and storage of livestock products";

– Resolution of the Novosibirsk City Administration (№ 714 of 13.07.95) "On measures to protect the population from diseases

common to humans and animals, and food poisoning";

– Resolution of the Novosibirsk City Administration (№ 578 of 15.06.93) "On the introduction of recording of incoming products and accompanying documents at enterprises".

The conducted work has proved the need to improve the activities of the state veterinary service in the context of economic reforms. At the same time the most urgent problems facing the state veterinary service have been identified:

– the procedure for issuing veterinary documents (certificates, veterinary certificates) approved by the Chief State Veterinary Inspector of the Russian Federation and registered by the Ministry of Justice has not been developed. Many owners of livestock products have recently refused to follow the requirements coming from the Department of Veterinary Medicine without registration with the Ministry of Justice;

– there are no rules stipulated by the Russian Federation Law "On Veterinary Medicine" for the provision of paid and free services by state veterinary services to non-state and state-financed enterprises. Government Decree No. 815 "On Approving the Rules for Providing Veterinary Services" provides for payment for veterinary services only for citizens;

– no legal mechanism has yet been established for the seizure of products that do not meet veterinary and sanitary safety requirements, and no list of diseases in which the alienation of animals or the seizure of livestock products is allowed, as provided for in the Russian Federation Law "On Veterinary Medicine", has been approved;

– there is no state protection for employees of state veterinary inspection in the performance of their official duties, as is customary for other bodies of state control (in particular for Gossanepidnadzor (State Sanitary and Epidemiological Surveillance Department)) by the Federal Law "On State Protection of Judges, Law Enforcement and Supervision Officials";

– a government document has not been adopted on the division of product quality control functions between state supervision services (Gosanepidnadzor, Gosvetnadzor, Gosstandart and Gostorginspektsiya));

– in order to strengthen the service of the Novosibirsk state veterinary inspection it is necessary to organize training and retraining of veterinary specialists.

IEVSS&FE has prepared the following documents to address these problems:

– draft decree of the Government of the Russian Federation "On the assignment of types of products to state supervision bodies";

– draft agreement "On interaction and delimitation of functions of territorial bodies of state sanitary and veterinary inspection in carrying out their control over procurement, processing, transportation, storage and sale of products of animal origin";

– draft resolution of the Government of the Russian Federation "On approval of the rules for the provision of paid and free services by state veterinary service institutions to non-state and budgetary enterprises";

– regulation "On the fund of the state veterinary service of the city (district) to protect the population from diseases common to humans and animals, and food poisoning" (using the example of Novosibirsk).

Scientific novelty of the work lies in the fact that for the first time in the Russian Federation a model of an institution to monitor the safety of products has been created; the payment for veterinary and sanitary expertise by non-state enterprises has been worked out.

The practical value of the project is that it can be used for implementation in other regions of the Russian Federation.

Research materials and the main provisions of the work were published in scientific articles, methodological recommendations, normative documents, discussed in IEVSS&FE, Nizhny Novgorod Agricultural Institute, at the meetings of veterinary specialists in Moscow, Novosibirsk, Rostov-on-Don, Kaluga, Irkutsk. Specialists from Chita, Yekaterinburg,

Magadan, Kemerovo, Irkutsk and other cities were already working following the example of Novosibirsk. Positive results have been obtained. The participants of the Council meeting welcomed the efficient experience of the Novosibirsk veterinary services and at the same time made a number of suggestions and wishes for further improvement and enhancement of this important work.

Conclusions of the Scientific and Technical Council

1. Approve the experience of the State Veterinary Service of the city of Novosibirsk in the organization of veterinary and sanitary monitoring of the safety of products of animal origin. Recommend the developed and tested documents on improvement of work of the State Veterinary Service of the city of Novosibirsk for management and introduction.

2. Recommend to the Novosibirsk City Administration on the basis of the interregional association "Siberian Agreement" and the Department of Veterinary and Sanitary Inspection of the Novosibirsk City Administration to organize a Center for training and retraining of veterinary and sanitary inspectors of Siberia and the Far East regions.

3. Veterinary services of republics, territories, regions should use the experience of the Novosibirsk Veterinary Service to improve the state veterinary monitoring over the safety of animal products in the new economic conditions.

The Chief Veterinary Administration of the RSFSR Ministry of Agriculture (O.Z. Iskhaikov), the magazine "Veterinary Medicine" (V.A. Garkavtsev) were instructed to prepare and publish materials on the experience and have a column in each issue on the results of the veterinary service.

It should be noted that all 85 (formerly 89) subjects of the Russian Federation and the CIS used the described experience in their organizations.

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ВЛИЯНИЕ БИОПРЕПАРАТОВ НА РАЗВИТИЕ ПЕРВИЧНОЙ КОРНЕВОЙ СИСТЕМЫ ЛЬНА МАСЛИЧНОГО

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Изучено влияние биологических препаратов на начальные ростовые процессы семян льна масличного. Эксперимент проведен в лабораторных условиях в 2022 г. Объекты исследования – сорт льна масличного Дар, биопрепараты АгроМик, Ж (норма расхода при предпосевной обработке семян 1,0 л/т), Гордебак, Ж (1,0 л/т), Бактофиш, Ж (1,0 л/т), Бактопин, Ж (2,0 л/т), Вермикс, Ж (2,0 л/т). Исследованы показатели длины зародышевого корешка на 3-и сутки (9,29–14,95 мм в рулонах, 20,59–23,33 мм в чашках Петри), на 5-е сутки (39,52–50,50 мм в рулонах, 40,38–54,48 мм в чашках Петри), на 7-е сутки (92,42–103,15 мм в рулонах, 60,36–76,64 мм в чашках Петри). Анализ суммарной длины зародышевых корешков на 3-и, 5-е и 7-е сутки проращивания позволил выделить препараты Гордебак, Ж (4687,75 мм), АгроМик, Ж (4712,50 мм) и Бактофиш, Ж (4953,75 мм) как наиболее эффективные при проращивании в рулонах; Гордебак, Ж (3389,25 мм) и АгроМик, Ж (3546,25 мм) – при проращивании в чашках Петри. При взвешивании массы зародышевого корешка и семядолей 7-дневных проростков наиболее высокие значения получены в вариантах с применением препаратов АгроМик, Ж (0,0345 и 0,0220 г; 0,0108 и 0,0074 г) и Бактофиш, Ж (0,0341 и 0,0211 г; 0,0106 и 0,0067 г). Результаты исследований свидетельствуют о том, что развитие проростка в рулоне проходит более интенсивно, чем при проращивании в чашках Петри. Однако при этом отмечена схожая динамика: препараты, у которых зарегистрирован высокий эффект при проращивании в рулонах, подтверждают его и в чашках Петри. Поэтому при использовании любого из изученных методов данные будут объективными. Как наиболее эффективный во всех вариантах выявлен препарат АгроМик, Ж.

Ключевые слова: лен масличный, биологические препараты, первичная корневая система льна, проростки, семядоли

INFLUENCE OF BIOLOGICAL PREPARATIONS ON THE DEVELOPMENT OF OIL FLAX PRIMARY ROOT SYSTEM

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The effect of biological preparations on the initial growth processes of oil flax seeds was studied. The experiment was conducted under laboratory conditions in 2022. Subjects of the study were oil flax variety Dar, biopreparations AgroMik, L (consumption rate for seed pre-sowing treatment 1.0 l/t), Gordebak, L (1.0 l/t), Bactofish, L (1.0 l/t), Bactopin, L (2.0 l/t), Vermix, L (2.0 l/t). Embryonic root length values were examined on day 3 (9.29-14.95 mm in rolls, 20.59-23.33 mm in Petri dishes), day 5 (39.52-50.50 mm in rolls, 40.38-54.48 mm in Petri dishes), and day 7 (92.42-103.15 mm in rolls, 60.36-76.64 mm in Petri dishes). Analysis of the total length of embryonic roots during

the 3rd, 5th and 7th days of germination made it possible to identify the preparations Gordebak, L (4687.75 mm), Agromik, L (4712.50 mm) and Bactofish, L (4953.75 mm) as the most effective for germination in rolls; Gordebak, L (3389.25 mm) and Agromik, L (3546.25 mm) for germination in Petri dishes. When measuring the weight of the embryonic root and cotyledons of seven-day-old seedlings, the highest values were obtained in the variants with Agromik, L (0.0345 and 0.0220 g; 0.0108 and 0.0074 g) and Bactofish, L (0.0341 and 0.0211 g; 0.0106 and 0.0067 g). The results show that a seedling development in a roll is more intense than when germinating in Petri dishes. However, similar dynamics was observed: the preparations with a high effect registered when germinating in rolls confirmed it in Petri dishes as well. Therefore, the data will be objective when using any of the methods studied. As the most effective in all variants the preparation Agromik, L. was identified.

Keywords: oil flax, biological preparations, flax primary root system, seedlings, cotyledons

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Конфликт интересов

Автор заявляет об отсутствии конфликта интересов.

Conflict of interest

The author declares no conflict of interest.

INTRODUCTION

In plant life the initial stage of ontogenesis, specifically the process of seed germination, is the most critical period, which ensures the survival of plants in the process of vegetation and affects the final result both in quantitative and qualitative terms [1]. Creation of effective biological pre-sowing methods of cultivated plants seed treatment on the background of modern absolutely "chemical" farming conditions has theoretical and practical importance in the design of agrobiocenoses on biological platform [2]. In order to maintain the current potential of agricultural production, biopreparations should replace and then, perhaps, displace chemical fertilizers, pesticides, growth regulators, etc. [3]. Worldwide interest in the problems of microbiology in agriculture has recently increased significantly [4, 5].

Microbiological preparations are based on live cultures of microorganisms and products of their metabolism. Technologies are mainly based on the use of microbiological preparations representing living cells of microorganisms selected for their useful properties. Such a preparation makes it possible to create a high

concentration of useful forms of microorganisms (one gram of the preparation contains up to 1.0-1.5 billion bacterial cells) in the right place and at the right time. Due to this, the introduced forms can successfully compete with native microflora and capture the ecological niches provided to them by the plant [6].

In this regard, pre-sowing treatment of seeds and vegetative plants with biological preparations is very promising from the environmental point of view and can become an essential and valuable part of modern effective technological systems of crop cultivation, including flax [7-11]. The use of biological preparations makes it possible to better realize the potential of varieties and hybrids, as well as to improve the quality of the obtained products [12-16].

The purpose of the research is to study the effect of preparations of biological origin on the initial growth processes of oilseed flax under laboratory conditions.

The objectives are:

– to study the dynamics of germinal root system formation at the initial stages of oilseed growth, conduct a comparative analysis of the results obtained when germinating seeds in rolls and Petri dishes;

- to study changes in the weight of germinal roots and cotyledons of 7-day-old flax seedlings under the influence of biological preparations;
- identify the most effective preparations of biological origin and recommend them for use.

MATERIAL AND METHODS

The research was conducted in 2022 under laboratory conditions. The parent materials were: oilseed flax variety Dar, biopreparations AgroMik, L (the consumption rate for seed pre-sowing treatment 1.0 l/t), Gordebak, L (1.0 l/t), Bactofish, L (1.0 l/t), Bactopin, L (2.0 l/t), Vermix, L (2.0 l/t). Untreated seeds and seeds treated with Vitaros, WSC pretreater were used as a control (the consumption rate for seed pretreatment 1.5 l/t). Germination was carried out in rolls and Petri dishes at constant temperature 20 °C for 7 days according to GOST¹. The following morphometric parameters were determined: root length, weight of roots and seedlings. Number of seeds per repetition - 50 pcs, number of repetitions - four.

RESULTS AND DISCUSSION

When tested in rolls during the first 3 days the plants formed germinal root length of 9.27-14.95 mm. The minimum values of 9.29 and 9.27 mm were observed in the variants with Vitaros, WSC and Vermix, L, respectively

(see Table 1). Maximum values of the length were 14.13 and 14.95 mm when using AgroMik, L and Gordebak, L.

On the 5th day, the minimum length of germinal root was 39.52 mm in the variant with the preparation Vitaros, WSC, maximum - 50.50 mm with the preparation AgroMik, L. Maximum growth of the root length in the analyzed period was 35.46-35.55 mm in experiments with Vermix, L and AgroMik, L respectively.

Analysis of the plants on the 7th day found the average length of germinal roots in this period at 97.06 mm with a variation of this indicator ranging from 92.42-103.15 mm. The maximum length, as well as the maximum growth - 68.85 mm, was observed in the variant with the preparation Bactofish, L.

Fig. 1 shows the dynamics of germinal root growth when using the preparations AgroMik, L and Bactofish, L. With a slight difference in the plant growth observed on day 3 of the study with the preparation Vitaros, WSC, by day 5 a delay in growth was observed, resulting in lower values on day 7 of the study. It should be noted that the use of biological preparations contributes to stimulation of seed germination.

When analyzed in Petri dishes, the germinal root length on the 3rd day of germination was 20.14-23.33 mm, which exceeded the values obtained in the experiments with rolls (see Table 2).

Табл. 1. Динамика роста первичной корневой системы сорта льна масличного при использовании биопрепаратов при проращивании в рулонах, мм

Table 1. Growth dynamics of primary root system of oilseed flax cultivar with the use of biopreparations in bale germination, mm

Biopreparation	Embryonic root length		Growth dynamics	Embryonic root length on day 7	Growth dynamics
	on day 3	on day 5			
AgroMik, L	14,95	50,50	35,55	97,94	62,39
Gordebak, L	14,13	45,28	31,16	95,68	64,52
Bactofish, L	13,82	48,12	34,30	103,15	68,85
Bactopin, L	11,52	45,94	34,42	98,87	64,46
Vermix, L	9,27	44,74	35,46	95,90	60,44
Vitaros, WSC	9,29	39,52	30,23	92,42	62,19
Control (distilled water)	11,35	45,28	33,93	95,45	61,51
LSD ₀₅	0,87	1,28	0,78	1,28	1,06

¹GOST 12038-84 Seeds of agricultural crops. Methods of germination. Date of entry: 01.07.1986. 47 p.

The maximum length was observed in the variants with AgroMik, L (22.86 mm) and Vitaros, WSC (23.33 mm).

Analysis of data for 5 days of germination showed that the average length of germinal root was 48.77 mm, the maximum values, as well as the maximum growth in this period were observed in the experiments with AgroMik, L (54.48 and 31.62 mm respectively) and Gordebak, L (54.81 and 33.25 mm respectively). On average, the results for the variants exceeded those of the cultivation in rolls.

The maximum length of the germinal root on the 7th day of the study was 76.64 mm and was

noted in the variant with the use of AgroMik, L. The maximum growth dynamics in this period was 23.02 mm and was noted when using the preparation Bactopin, L.

Fig. 2 shows the dynamics of root growth during germination in Petri dishes.

On the 3rd day of germination almost equal values were observed, as in the case of germination in rolls. By the 5th day, differences were established due to more intensive growth in AgroMik, L. By the 7th day, the smallest germinal root length was observed in the control variant, Bactofish, L showed the values of this indicator at the control level. The results obtained testify

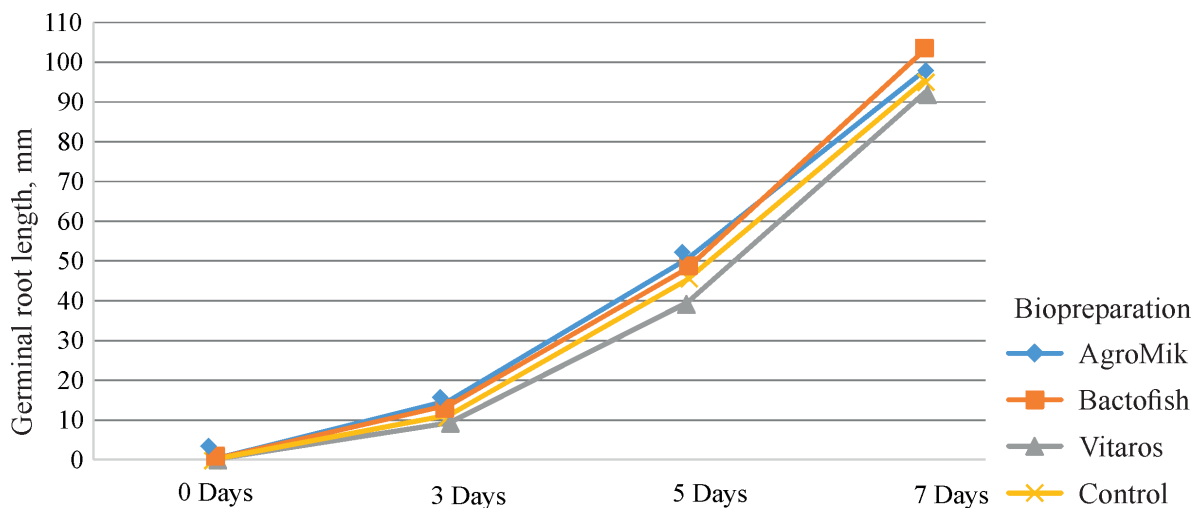


Рис. 1. Динамика роста зародышевого корешка при использовании биопрепаратов в рулонах, мм
Fig. 1. Dynamics of embryonic root growth when using biopreparations in rolls, mm

Табл. 2. Динамика роста первичной корневой системы сорта льна масличного при использовании биопрепаратов при проращивании в чашках Петри, мм

Table 2. Growth dynamics of the primary root system of oilseed flax cultivar when using biopreparations in Petri dishes, mm

Biopreparation	Embryonic root length		Growth dynamics	Embryonic root length on day 7	Growth dynamics
	on day 3	on day 5			
AgroMik, L	22,86	54,48	31,62	76,64	22,15
Gordebak, L	21,56	54,81	33,25	73,18	18,37
Bactofish, L	20,14	47,09	26,95	67,01	19,93
Bactopin, L	21,05	40,38	19,33	63,40	23,02
Vermix, L	21,58	50,73	29,15	69,36	18,63
Vitaros, WSC	23,33	43,87	20,54	66,14	22,27
Control (distilled water)	20,59	50,04	29,44	60,36	10,32
LSD ₀₅	0,44	2,02	2,02	2,11	1,64

to the different influence of the preparations on the germinal root system development in oil-seed flax plants.

A comparative analysis of the experiments in Petri dishes on the 3rd day showed significantly longer germinal root length than in rolls, the excess was 6.32-14.04 mm (see Fig. 3).

At the same time, the interval of variation of the index in germination in rolls was significantly higher and was 5.69 mm, while the value of this index in Petri dishes was 3.20 mm.

On the 5th day of germination in rolls and in Petri dishes an alignment of the germinal root length was observed, and in some variants (Bactopin, L, Bactofish, L) a slight excess of the analyzed index was noted in the germination in rolls. Thus, the length of roots on the 5th day in rolls was 39,52-50,50 mm, in Petri dishes - 40,38-54,81 mm. The range of variation was 10,99 mm (in rolls), 14,43 mm (in Petri dishes). The most intensive growth of plants in germination in rolls was observed for 5-7 days.

During this period, plants formed a germinal root length of 92.42- 103.15 mm and significantly exceeded similar samples in Petri dishes, where a germinal root length of 60.34- 76.64 mm was noted. On average, the excess was 29.05 mm.

Then, analysis of the total length of germinal roots on the 3rd, 5th, and 7th days of germination in Petri dishes and rolls was carried out (see Table 3).

The total length of germinal roots of 408.0-732.0 mm was formed in 3 days of germination of seeds in rolls. The maximum values were noted in the variant with AgroMik, L. On the 5th day of the research the seeds formed the total length of roots of 1891,5-2481,0 mm. Maximum values were also recorded in the variant with AgroMik, L. Dynamics of growth during this period was 1451.5 mm (Vitaros, WSC) - 1748.5 mm (AgroMik, L). Total length of germinal roots on the 7th day was 4294,75-4953,75 mm. During this period, the greatest increase in length was also observed, averaging 2,414.64 mm. The smallest increase was observed in the variant with AgroMik, L (2231.50 mm), the maximum with Bactofish, L (2652.50 mm). As the most effective, according to the formed total length of the germinal root, the preparations Gordebak, L (4687.75 mm), AgroMik, L (4712.50 mm) and Bactofish, L (4953.75 mm) were selected.

It was found that on the 3rd day of germination in Petri dishes the total length of germinal roots was from 910,0 to 1087,0 mm. The low-

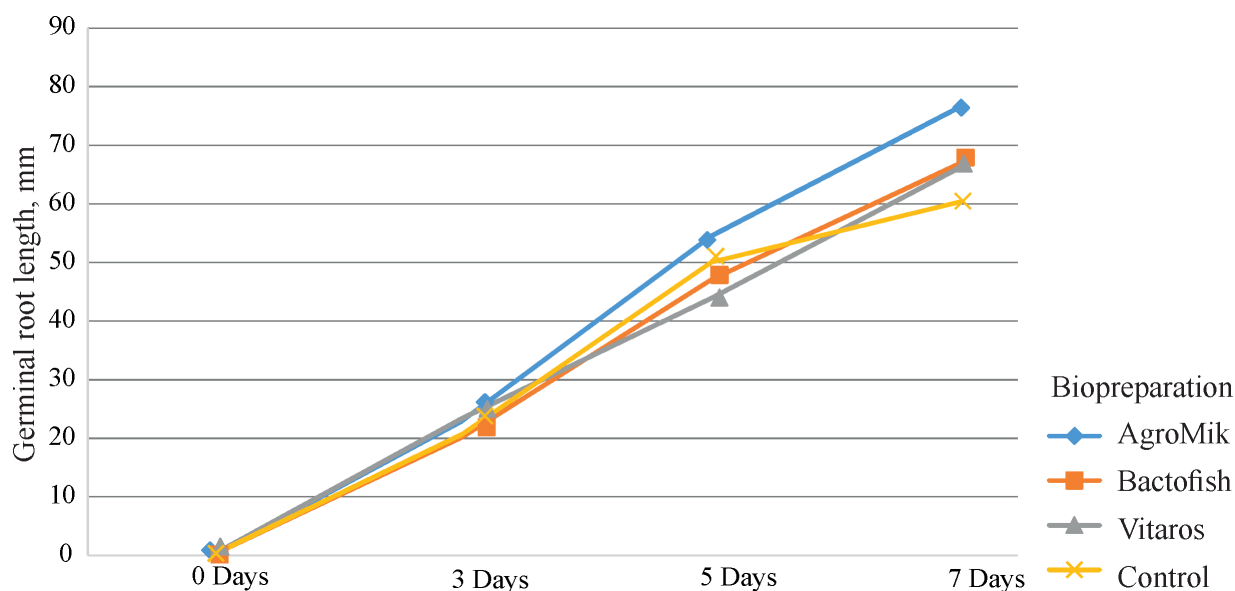


Рис. 2. Динамика роста зародышевого корешка при использовании биопрепаратов в чашках Петри, мм

Fig. 2. Dynamics of embryonic root growth when using biopreparations in Petri dishes, mm

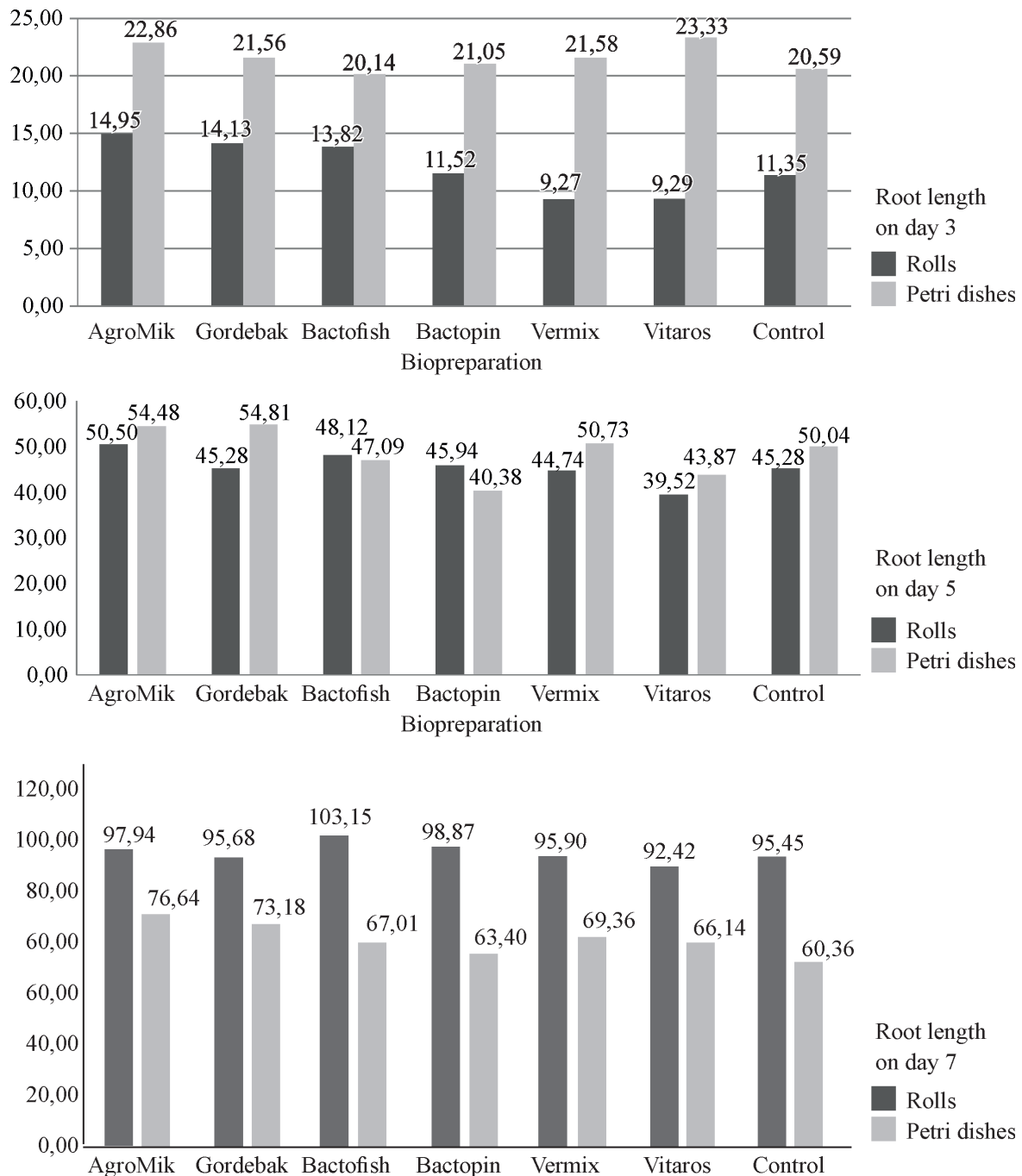


Рис. 3. Сравнительный анализ влияния биопрепаратов при проращивании в рулонах и чашках Петри, мм

Fig. 3. Comparative analysis of the effect of biological products during germination in rolls and Petri dishes, mm

est values were recorded in the control variant (931,75 mm) when seeds were treated with Bactopin, L (910,0 mm) and Bactofish, L (931,0 mm), the highest - when seeds were treated with AgroMik, L (1084,5 mm) and Vermix, L (1087,0 mm). On the 5th day of the study, the lowest dynamics of growth was recorded in the

variants with Bactopin, L (876.75 mm) and Vitaros, WSC (975.0 mm), while the variants with AgroMik, L and Gordebak, L showed growth of 1505.0 and 1596.75 mm respectively. The total length of germinal roots during this period ranged from 1786.75 mm (Bactopin, L) to 2616.0 mm (Gordebak, L). Analysis of the re-

Табл. 3. Суммарная длина корней льна масличного при проращивании, мм

Table 3. The total length of the oil flax roots during germination, mm

Biopreparation	Total embryonic root length		Growth dynamics	Total embryonic root length on day 7	Growth dynamics
	on day 3	on day 5			
<i>Rolls</i>					
AgroMik, L	732,50	2481,00	1748,50	4712,50	2231,50
Gordebak, L	688,25	2218,00	1529,75	4687,75	2469,75
Bactofish, L	689,00	2301,25	1612,25	4953,75	2652,50
Bactopin, L	531,00	2134,25	1603,25	4497,00	2362,75
Vermix, L	408,00	2003,50	1595,50	4294,75	2291,25
Vitaros, WSC	440,00	1891,50	1451,50	4425,00	2533,50
Control (distilled water)	533,00	2125,25	1592,25	4486,50	2361,25
LSD ₀₅	48,9	73,13	34,03	83,08	55,22
<i>Petri dishes</i>					
AgroMik, L	1084,50	2589,50	1505,00	3546,25	956,75
Gordebak, L	1019,25	2616,00	1596,75	3389,25	773,25
Bactofish, L	931,00	2188,00	1257,00	3087,50	899,50
Bactopin, L	910,00	1786,75	876,75	2905,75	1119,00
Vermix, L	1087,00	2390,75	1303,75	3291,75	901,00
Vitaros, WSC	1055,00	2030,00	975,00	2916,00	886,00
Control (distilled water)	931,75	2276,25	1344,50	2764,75	488,50
LSD ₀₅	29,10	112,78	98,85	108,88	73,34

sults at day 7 revealed a decrease in root length gain in all variants, the lowest value of this indicator was noted in the control variant and amounted to 488.5 mm, the maximum value - 1119.0 mm when using the preparation Bactopin, L.

The maximum total mass of germinal roots (3546,25 mm) was formed in the seeds treated with AgroMik, L, the minimum (2764,75 mm) in the control variant. As the most effective for the total length of germinal roots during germination in Petri dishes, the preparations Gordebak, L (3389,25 mm) and AgroMik, L (3546,25 mm) were selected. Diagrams were plotted and analyzed to identify the differences in the formation of total root length (see Fig. 4).

It was noted that during the first 3 days of germination the seeds in rolls formed shorter roots, the average values of the total length of germinal roots were 2 times lower than in Petri dishes, and were 574,54 and 1002,64 mm, respectively. By day 5, the alignment of values was observed due to higher dynamics of growth

in rolls, the average values were 2164.96 mm in rolls and 2268.18 mm in Petri dishes at this stage. The growth of the root length in the rolls continues intensively, and by the 7th day, the average value of their total length is 4579.61 mm with the value of this indicator in Petri dishes 3128.75 mm.

Then the weight of germinal root and cotyledon of 7-day-old seedlings was weighed. When germinating in rolls the interval of variation of germinal root weight was 0,0280-0,0345 g, the highest weights were observed in the variants with AgroMik, L, Bactofish, L and Bactopin, L and were 0,0345; 0,0341 and 0,0329 g respectively (see Table 4).

The values of this indicator in Petri dishes were significantly lower and amounted to 0.0163-0.0220 g. However, the highest germinal root mass was in the variants with AgroMik, L (0,0220 g) and Bactofish, L (0,0211 g). When analyzing seedling weight, the same pattern was observed in Petri dishes: the values obtained were lower than in the rolls. However,

the maximum values in all variants were recorded with AgroMik, L (0.0108 and 0.0074 g, respectively), Bactofish, L (0.0106 and 0.0067 g, respectively) and Gordebak, L (0.0103 and 0.0064 g, respectively). Seeds treated with Ag-

roMic, L, Bactofish, L, and Gordebak, L formed the highest germinal root mass and the highest seedling mass.

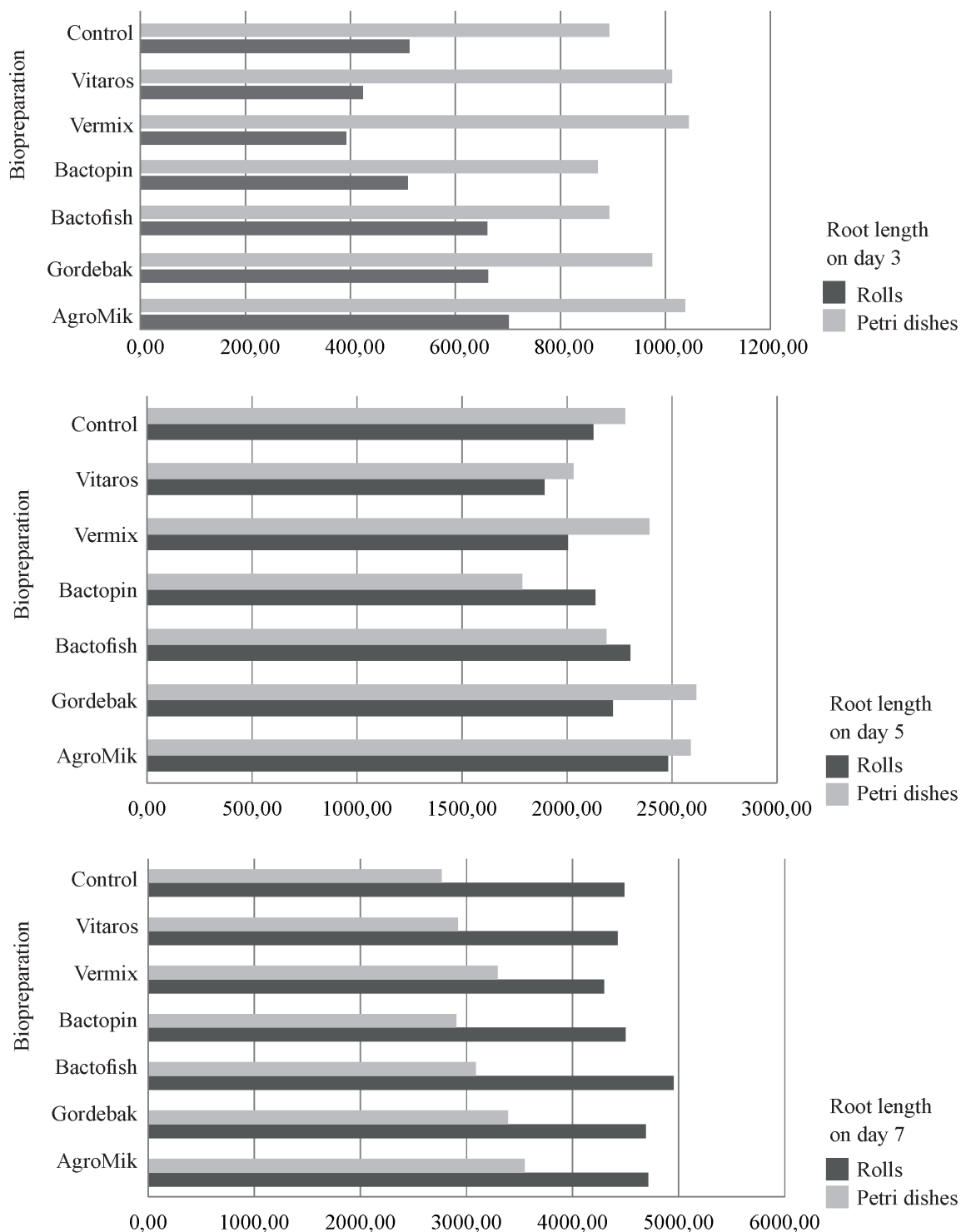


Рис. 4. Суммарная длина зародышевых корешков, мм

Fig. 4. The total length of the embryonic roots, mm

Табл. 4. Масса зародышевого корешка и проростков льна, г**Table 4.** The mass of the embryonic root and flax seedlings, g

Biopreparation	Weight			
	embryonic root		cotyledon	
	Germination in rolls	Germination in Petri dishes	Germination in rolls	Germination in Petri dishes
AgroMik, L	0,0345	0,0220	0,0108	0,0074
Gordebak, L	0,0315	0,0174	0,0103	0,0064
Bactofish, L	0,0341	0,0211	0,0106	0,0067
Bactopin, L	0,0329	0,0171	0,0089	0,0055
Vermix, L	0,0286	0,0205	0,0085	0,0068
Vitaros, WSC	0,0280	0,0164	0,0086	0,0062
Control (distilled water)	0,0282	0,0163	0,0087	0,0062
AgroMik, L	0,0311	0,0187	0,0095	0,0064
LSD ₀₅	0,0011	0,0009	0,0004	0,0002

CONCLUSION

As a result of the research, the dynamics of primary root system development of oilseed flax when using microbiological preparations has been determined, and a comparative analysis of seed germination in rolls and Petri dishes has been carried out. It was found out that the use of biological preparations leads to the stimulation of seed germination. The different influence of preparations on germinating root length can be proved by the values of this index on the 3rd day (9,29-14,95 mm in rolls, 20,59-23,33 mm in Petri dishes), on the 5th day (39,52-50,50 mm in rolls, 40,38-54,48 mm in Petri dishes), on the 7th day (92,42-103,15 mm in rolls, 60,36- 76,64 mm in Petri dishes). Analysis of total germinal root length on 3, 5 and 7 days of germination showed that Gordebak, L (4687,75 mm), AgroMik, L (4712,50 mm) and Bactofish, L (4953,75 mm) were the most effective for germination in rolls, Gordebak, L (3389,25 mm) and AgroMik, L (3546,25 mm) for germination in Petri dishes. Weighing of germinal root and cotyledon weights of seven-day-old seedlings showed the variation interval of this parameter in the range of 0,0280-0,0345 g in rolls and 0,0163-0,0220 g in Petri dishes. The highest values were obtained in the variants with AgroMik, L (0,0345 and 0,0220 g; 0,0108 and 0,0074 g) and Bactofish, L (0,0341 and 0,0211 g; 0,0106 and 0,0067 g). The results

indicate that the development of seedling in a roll is more intense than when germinating in Petri dishes. However, a similar dynamics was noted: the preparations with high effect registered during germination in rolls confirmed it in Petri dishes as well. Therefore, when using any of the studied methods, the data will be objective. The preparation AgroMik, L was found to be the most effective in all the variants. The obtained results will be used for the development of effective biological methods of pre-sowing treatment of oilseeds in the technology of their cultivation.

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ВАСИЛИЙ ЗАХАРОВИЧ ЯМОВ
(1933–2014)



Академику Российской академии наук, академику Российской академии сельскохозяйственных наук, Международной академии информатизации, Российской академии естественных наук, доктору биологических наук, профессору, Заслуженному деятелю науки Российской Федерации Василию Захаровичу Ямову в 2023 г. исполнилось бы 90 лет.

Василий Захарович Ямов родился в крестьянской семье 4 января 1933 г. в Тюменской области. В 1954 г. окончил с отличием Тобольский зооветеринарный техникум, в 1959 г. – Омский государственный ветеринарный институт и до 1968 г. занимался хозяйственной и советско-партийной работой. В 1966 г. он успешно защитил кандидатскую диссертацию. В 1968 г. В.З. Ямов в Тюмени организовал Всесоюзный (с 1990 г. Всероссийский) научно-исследовательский институт ветеринарной энтомологии и арахнологии, директором которого был более 30 лет.

Результатом научно-исследовательской и организаторской работы стала подготовка и защита докторской диссертации в 1982 г. В 1983 г. она была утверждена, и в этом же году В.З. Ямову присвоено звание профессора по специальности «Паразитология».

Научно-производственная деятельность Василия Захаровича посвящена проблемам обеспечения ветеринарного благополучия сибирского животноводства, проведению исследований по важнейшим вопросам фундаментального и прикладного характера, направленным на разработку и внедрение в сельскохозяйственное производство новых средств, методов и технологий борьбы с болезнями животных. В результате научных исследований и разработок В.З. Ямова и его учеников создано и внедрено в ветеринарную практику более 30 высокоэффективных ветеринарных препаратов для профилактики и терапии арахноэнтомозов животных.

За разработку и внедрение биологических основ, новых средств и методов борьбы с гиподерматозом крупного рогатого скота в 1981 г. Василий Захарович был удостоен премии Совета Министров СССР.

За заслуги в ветеринарной науке в 1985 г. В.З. Ямов был избран членом-корреспондентом ВАСХНИЛ, в 1990 г. – действительным членом (академиком) Россельхозакадемии.

В.З. Ямовым создана сибирская школа энтомологов-паразитологов, научным направлением которой является разработка и внедрение биологических основ, средств и методов борьбы с арахноэнтомозами сельскохозяйственных животных. Под его руководством подготовлены 18 докторов и 35 кандидатов наук. Ученики Василия Захаровича работают практически во всех странах СНГ.

С 1993 г. В.З. Ямов – заслуженный деятель науки Российской Федерации. В 1995 г. избран действительным членом международной академии информатизации и в 1996 г. – Российской академии естественных наук.

Василию Захаровичу принадлежит более 200 научных работ, научная новизна которых подтверждена 25 авторскими свидетельствами, 6 патентами на изобретения. Материалы научных исследований вошли в 7 монографий: «Подкожные оводы – вредители животных», «Вольфартиоз овец», «Справочник ветеринарного врача» и другие, а также более чем 85 утвержденных нормативно-технических документов.

В.З. Ямов внес большой вклад в ветеринарное обеспечение АПК регионов Урала, Сибири и Дальнего Востока. Как талантливый ученый и организатор, В.З. Ямов критически переосмысливал традиционные взгляды и подходы в современной практической ветеринарии, генерировал новые идеи и научные направления. Василий Захарович был наставником и воспитателем молодежи, много внимания уделял передаче своего опыта и знаний студентам Государственного аграрного университета Северного Зауралья, где благодаря ему в 1992 г. организован факультет ветеринарной медицины, который он возглавлял более 10 лет.

На протяжении ряда лет В.З. Ямов являлся председателем ученого совета Всероссийского научно-исследовательского института ветеринарной энтомологии и арахнологии Россельхозакадемии, председателем диссертационного совета при ВНИИВЭА, принимал участие в редакционном совете журналов «Сибирский вестник сельскохозяйственной науки» СО РАСХН и «Аграрный вестник Урала».

Научные заслуги Василия Захаровича отмечены 14 правительственными наградами: орденом Трудового Красного Знамени, орденом Почета, медалями, многими почетными грамотами сельскохозяйственных и научных организаций страны.

Василий Захарович был известен в нашей стране и за ее пределами как крупный исследователь в области арахноэнтомозов животных, как педагог, высокоидейный ученый, который был примером преданного служения сельскохозяйственной науке.

Светлая память о Василии Захаровиче Ямове, прекрасном ученом, широко эрудированном, обаятельном, доброжелательном и интеллигентном человеке, навсегда сохранится в сердцах его коллег, учеников и всех, кто его знал.

Академики Российской академии наук:

*Г.А. Романенко, В.И. Фисинин, А.С. Донченко, В.В. Альт,
Ф.И. Василевич, А.Н. Власенко, Н.Г. Власенко,
Г.П. Гамзиков, Н.И. Кашеваров, В.А. Солошенко, И.Ф. Храмцов;*

члены-корреспонденты:

Н.А. Донченко, К.Я. Мотовилов, Р.И. Рутц, Н.В. Цугленок

ПРАВИЛА ДЛЯ АВТОРОВ

Правила для авторов составлены на основе этических принципов, общих для членов научного сообщества, и правил публикации в международных и отечественных научных периодических изданиях, а также в соответствии с требованиями ВАК для периодических изданий, включенных в Перечень российских рецензируемых научных журналов, в которых должны быть опубликованы основные научные результаты диссертаций на соискание ученой степени доктора и кандидата наук.

Журнал публикует оригинальные статьи по фундаментальным и прикладным проблемам по направлениям:

- общее земледелие и растениеводство;
- селекция, семеноводство и биотехнология растений;
- агрохимия, агропочвоведение, защита и карантин растений;
- кормопроизводство;
- инфекционные болезни и иммунология животных;
- частная зоотехния, кормление, технологии приготовления кормов и производства продукции животноводства;
- разведение, селекция, генетика и биотехнология животных;
- технологии, машины и оборудование для агропромышленного комплекса;
- пищевые системы.

Статья, направляемая в редакцию, должна соответствовать тематическим разделам журнала «Сибирский вестник сельскохозяйственной науки»:

Наименование рубрики	Шифр и наименование научной специальности в соответствии с Номенклатурой научных специальностей, по которым присуждаются ученые степени
Земледелие и химизация	4.1.1. Общее земледелие и растениеводство 4.1.3. Агрохимия, агропочвоведение, защита и карантин растений
Растениеводство и селекция	4.1.1. Общее земледелие и растениеводство 4.1.2. Селекция, семеноводство и биотехнология растений
Защита растений	4.1.3. Агрохимия, агропочвоведение, защита и карантин растений
Кормопроизводство	4.1.1. Общее земледелие и растениеводство 4.1.2. Селекция, семеноводство и биотехнология растений 4.1.3. Агрохимия, агропочвоведение, защита и карантин растений
Зоотехния и ветеринария	4.2.3. Инфекционные болезни и иммунология животных 4.2.4. Частная зоотехния, кормление, технологии приготовления кормов и производства продукции животноводства 4.2.5. Разведение, селекция, генетика и биотехнология животных
Механизация, автоматизация, моделирование и информационное обеспечение	4.3.1. Технологии, машины и оборудование для агропромышленного комплекса
Переработка сельскохозяйственной продукции	4.3.3. Пищевые системы
Проблемы. Суждения	4.1.1. Общее земледелие и растениеводство
Научные связи	4.1.2. Селекция, семеноводство и биотехнология растений
Из истории сельскохозяйственной науки	4.1.3. Агрохимия, агропочвоведение, защита и карантин растений
Краткие сообщения	4.2.3. Инфекционные болезни и иммунология животных
Из диссертационных работ	4.2.4. Частная зоотехния, кормление, технологии приготовления кормов и производства продукции животноводства 4.2.5. Разведение, селекция, генетика и биотехнология животных 4.3.1. Технологии, машины и оборудование для агропромышленного комплекса 4.3.3. Пищевые системы

В журнале также публикуются обзоры, краткие сообщения, хроника, рецензии, книжные обозрения, материалы по истории сельскохозяйственной науки и деятельности учреждений и ученых.

Число публикаций одного автора в номере журнала не должно превышать двух, при этом вторая статья допустима лишь в соавторстве.

К рассмотрению принимаются материалы от различных категорий исследователей, аспирантов, докторантов, специалистов и экспертов в соответствующих областях знаний.

Все статьи рецензируются и имеют зарегистрированный в системе CrossRef индекс DOI.

Публикации для авторов **бесплатны**.

При направлении статьи в редакцию журнала «Сибирский вестник сельскохозяйственной науки» рекомендуем руководствоваться следующими правилами.

РЕКОМЕНДАЦИИ АВТОРУ ДО ПОДАЧИ СТАТЬИ

Представление статьи в журнал «Сибирский вестник сельскохозяйственной науки» подразумевает, что:

- статья ранее не была опубликована в другом журнале;
- статья не находится на рассмотрении в другом журнале;
- все соавторы согласны с публикацией текущей версии статьи.

Перед отправкой статьи на рассмотрение необходимо убедиться, что в файле (файлах) содержится вся необходимая информация на русском и английском языках, указаны источники информации, размещенной на рисунках и в таблицах, все ссылки оформлены корректно.

ПОРЯДОК НАПРАВЛЕНИЯ РУКОПИСЕЙ СТАТЕЙ

1. Отправка статьи осуществляется через электронную редакцию на сайте журнала <https://sibvest.elpub.ru/jour/index>. После предварительной регистрации автора, в правом верхнем углу страницы выбрать опцию «Отправить рукопись». Затем загрузить рукопись статьи (в формате *.doc или *.docx) и сопроводительные документы к ней. После завершения загрузки материалов обязательно выбрать опцию «Отправить письмо», в этом случае редакция автоматически будет уведомлена о получении новой рукописи.

Сопроводительные документы к рукописи статьи:

- скан-копия письма от организации с подтверждением авторства и разрешением на публикацию (образец на <http://sibvest.elpub.ru/>);
- скан-копия авторской справки по представленной форме (образец на <http://sibvest.elpub.ru/>), в которой должно быть выражено согласие на открытое опубликование статьи в печатном варианте журнала и его электронной копии в сети Интернет;
- скан-копия рукописи с подписями авторов. Автор, подписывая рукопись и направляя ее в редакцию, тем самым передает авторские права на издание этой статьи СФНЦА РАН;
- анкеты авторов на русском и английском языках (образец на <http://sibvest.elpub.ru/>);
- скан-копия справки из аспирантуры (для очных аспирантов).

2. Все поступающие в редакцию рукописи статей регистрируются через систему электронной редакции. В личном кабинете автора отражается текущий статус рукописи.

3. Нерецензируемые материалы (материалы научной хроники, рецензии, книжные обозрения, материалы по истории сельскохозяйственной науки и деятельности учреждений и ученых) направляются на e-mail: sibvestnik@sfcsa.ru и регистрируются ответственным секретарем.

ПОРЯДОК ОФОРМЛЕНИЯ СТАТЬИ

Текст рукописи оформляется шрифтом Times New Roman, кеглем 14 с интервалом 1,5, все поля 2,0 см, нумерация страниц внизу. Объем статьи не более 15 страниц (включая таблицы, иллюстрации и библиографию); статей, размещаемых в рубриках «Из диссертационных работ» и «Краткие сообщения», – не более 7 страниц.

Структура оформления статьи:

1. **УДК**
2. **Заголовок статьи на русском и английском языках (не более 70 знаков).**
3. **Фамилии и инициалы авторов, полное официальное название научного учреждения, в котором проведены исследования на русском и английском языках.**

Если в подготовке статьи принимали участие авторы из разных учреждений, необходимо указать принадлежность каждого автора к конкретному учреждению с помощью надстрочного индекса.

4. **Реферат на русском и английском языках.** Объем реферата не менее 200–250 слов. Реферат является кратким и последовательным изложением материала статьи по основным разделам и должен отражать основное содержание, следовать логике изложения материала и описания результатов в статье с приведением конкретных данных. Не следует включать впервые введенные термины, аббревиатуры (за исключением общеизвестных), ссылки на литературу. В реферате не следует подчеркивать новизну, актуальность и личный вклад автора; место исследования необходимо указывать до области (края), не упоминать конкретные организации.

5. **Ключевые слова на русском и английском языках.** 5–7 слов по теме статьи. Желательно, чтобы ключевые слова дополняли реферат и название статьи.

6. **Информация о конфликте интересов либо его отсутствии.** Автор обязан уведомить редактора о реальном или потенциальном конфликте интересов, включив информацию о конфликте интересов в соответствующий раздел статьи. Если конфликта интересов нет, автор должен также сообщить об этом.

Пример формулировки: «Автор заявляет об отсутствии конфликта интересов».

7. **Благодарности на русском и английском языках.** В этом разделе указываются все источники финансирования исследования, а также благодарности людям, которые участвовали в работе над статьей, но не являются ее авторами.

8. **Основной текст статьи.** При изложении оригинальных экспериментальных данных рекомендуется использовать подзаголовки:

ВВЕДЕНИЕ (постановка проблемы, цели, задачи исследования)

МАТЕРИАЛ И МЕТОДЫ (условия, методы (методика) исследований, описание объекта, место и время проведения)

РЕЗУЛЬТАТЫ И ОБСУЖДЕНИЕ

ЗАКЛЮЧЕНИЕ или **ВЫВОДЫ**

СПИСОК ЛИТЕРАТУРЫ. Количество источников не менее 15. В список литературы включаются только рецензируемые источники: статьи из научных журналов и монографии. Самоцитирование не более 10% от общего количества. Библиографический список должен быть оформлен в виде общего списка в порядке упоминания в тексте, желательны ссылки на источники 2–3-летнего срока давности. Правила оформления списка литературы – в соответствии с ГОСТ Р 7.05–2008 (требования и правила составления библиографической ссылки). В тексте ссылка на источник отмечается порядковой цифрой в квадратных скобках, например [1]. Литература в списке дается на тех языках, на которых она издана. В библиографическое описание публикации необходимо вносить всех авторов, не сокращая их одним, тремя и т.п. Недопустимо сокращение названий статей, журналов, издательства.

Если необходимо сослаться на авторефераты, диссертации, сборники статей, учебники, рекомендации, учебные пособия, ГОСТы, информацию с сайтов, статистические отчеты, статьи в общественно-политических газетах и прочее, то такую информацию следует оформить в *сноску* в конце страницы. Сноски нумеруются арабскими цифрами, размещаются постранично сквозной нумерацией.

Внимание! Теоретические, обзорные и проблемные статьи могут иметь произвольную структуру, но обязательно должны содержать реферат, ключевые слова, список литературы.

ПРИМЕРЫ ОФОРМЛЕНИЯ СПИСКА ЛИТЕРАТУРЫ, REFERENCES И СНОСК

СПИСОК ЛИТЕРАТУРЫ:

Монография

Климова Э.В. Полевые культуры Забайкалья: монография. Чита: Поиск, 2001. 392 с.

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Холмов В.Г. Минимальная обработка кулисного пара под яровую пшеницу при интенсификации земледелия в южной лесостепи Западной Сибири // Ресурсосберегающие системы обработки почвы. М.: Агропромиздат, 1990. С. 230–235.

Периодическое издание

Пакуль А.Л., Лапишинов Н.А., Божанова Г.В., Пакуль В.Н. Технологические качества зерна мягкой яровой пшеницы в зависимости от системы обработки почвы // Сибирский вестник сельскохозяйственной науки. 2018. Т. 48. № 4. С. 27–35. DOI: 10.26898/0370-8799-2018-4-4.

REFERENCES:

Составляется в том же порядке, что и русскоязычный вариант, по следующим правилам:

Фамилии И.О. авторов в устоявшемся способе транслитерации, англоязычное название статьи, *транслитерация названия русскоязычного источника (например через сайт: <https://antrophob.ru/translit-bsi>) = англоязычное название источника*. Далее оформление для монографии: город, англоязычное название издательства, год, количество страниц; для журнала: год, номер, страницы). (In Russian).

Пример: Avtor A.A., Avtor B.B., Avtor C.C. Title of article.

Транслитерация авторов. Англоязычное название статьи

Zaglavie jurnala = Title of Journal, 2012, vol. 10, no. 2, pp. 49–54.

Транслитерация источника = Англоязычное название источника

Монография

Klimova E.V. *Field crops of Zabaikalya*. Chita, Poisk Publ., 2001, 392 p. (In Russian).

Часть книги

Kholmov V.G. Minimum tillage of coulisse-strip fallow for spring wheat with intensification of arable agriculture in southern forest-steppe of Western Siberia. *Resource-saving tillage systems*, Moscow, Agropromizdat Publ., 1990, pp. 230–235. (In Russian).

Периодическое издание

Pakul A.L., Lapshinov N.A., Bozhanova G.V., Pakul V.N. Technological grain qualities of spring common wheat depending on the system of soil tillage. *Sibirskii vestnik sel'skokhozyaistvennoi nauki = Siberian Herald of Agricultural Science*, 2018, vol. 48, no. 4, pp. 27–35. (In Russian). DOI: 10.26898/0370-8799-2018-4-4.

СНОСКИ:

Цитируемый текст¹.

¹Климова Э.В., Андреева О.Т., Темникова Г.П. Пути стабилизации кормопроизводства Забайкалья // Проблемы и перспективы совершенствования зональных систем земледелия в современных условиях: материалы науч.-практ. конф. (Чита, 16–17 октября 2008 г.). Чита, 2009. С. 36–39.

Цифровой идентификатор Digital Object Identifier – DOI (когда он есть у цитируемого материала) необходимо указывать в конце библиографической ссылки.

Пример:

Chu T., Starek M.J., Brewer M.J., Murray S.C., Pruter L.S. Assessing lodging severity over an experimental maize (*Zea mays* L.) field using UAS images // *Remote Sensing*. 2017. Vol. 9. P. 923. DOI: 10.3390/rs9090923.

Наличие DOI статьи следует проверять на сайте <http://search.crossref.org/> или <https://www.citethisforme.com>.

Для этого нужно ввести в поисковую строку название статьи на английском языке.

РИСУНКИ, ТАБЛИЦЫ, СКРИНШОТЫ И ФОТОГРАФИИ

Рисунки должны быть хорошего качества, пригодные для печати. Все рисунки должны иметь подрисуночные подписи. Подрисуночную подпись необходимо перевести на английский язык. Рисунки нумеруются арабскими цифрами по порядку следования в тексте. Если рисунок в тексте один, то он не нумеруется. Отсылки на рисунки оформляются следующим образом: «На рис. 3 указано, что ...» или «Указано, что ... (см. рис. 3)». Подрисуночная

подпись включает порядковый номер рисунка и его название. «Рис. 2. Описание жизненно важных процессов». Перевод подрисуночной подписи следует располагать после подрисуночной подписи на русском языке.

Таблицы должны быть хорошего качества, пригодные для печати. Предпочтительны таблицы, пригодные для редактирования, а не отсканированные или в виде рисунков. Все таблицы должны иметь заголовки. Название таблицы должно быть переведено на английский язык. Таблицы нумеруются арабскими цифрами по порядку следования в тексте. Если таблица в тексте одна, то она не нумеруется. Отсылки на таблицы оформляются следующим образом: «В табл. 3 указано, что ...» или «Указано, что ... (см. табл. 3)». Заголовок таблицы включает порядковый номер таблицы и ее название: «Табл. 2. Описание жизненно важных процессов». Перевод заголовка таблицы следует располагать после заголовка таблицы на русском языке.

Фотографии, скриншоты и другие нерисованные иллюстрации необходимо загружать отдельно в виде файлов формата *.jpeg (*.doc и *.docx – в случае, если на изображение нанесены дополнительные пометки). Разрешение изображения должно быть >300 dpi. Файлам изображений необходимо присвоить название, соответствующее номеру рисунка в тексте. В описании файла следует отдельно привести подрисуночную подпись, которая должна соответствовать названию фотографии, помещаемой в текст.

Следует обратить внимание на написание формул в статье. Во избежание путаницы необходимо греческие (α , β , π и др.), русские (А, а, Б, б и др.) буквы и цифры писать прямым шрифтом, латинские – курсивным (*W*, *Z*, *m*, *n* и др.). Математические знаки и символы нужно писать также прямым шрифтом. Необходимо четко указывать верхние и нижние надстрочные символы (W^1 , F_1 и др.).

ВЗАИМОДЕЙСТВИЕ МЕЖДУ ЖУРНАЛОМ И АВТОРОМ

Редакция просит авторов при подготовке статей руководствоваться изложенными выше правилами.

Все поступающие в журнал «Сибирский вестник сельскохозяйственной науки» статьи проходят предварительную проверку на соответствие формальным требованиям. На этом этапе редакция оставляет за собой право:

- принять статью к рассмотрению;
 - вернуть статью автору (авторам) на доработку с просьбой устранить ошибки или добавить недостающие данные;
 - вернуть статью автору (авторам) без рассмотрения, оформленную не по требованиям журнала;
 - отклонить статью из-за несоответствия ее целям журнала, отсутствия оригинальности, малой научной ценности.
- Переписка с авторами рукописи ведется через контактное лицо, указанное в рукописи.

Все научные статьи, поступившие в редакцию журнала «Сибирский вестник сельскохозяйственной науки», проходят обязательное двухстороннее «слепое» рецензирование (double-blind – автор и рецензент не знают друг о друге). Рукописи направляются по профилю научного исследования на рецензию членам редакционной коллегии.

В спорных случаях редактор может привлечь к процессу рецензирования нескольких специалистов, а также главного редактора. При положительном заключении рецензента статья передается редактору для подготовки к печати.

При принятии решения о доработке статьи замечания и комментарии рецензента передаются автору. Автору дается 2 месяца на устранения замечаний. Если в течение этого срока автор не уведомил редакцию о планируемых действиях, статья снимается с очереди публикации.

При принятии решения об отказе в публикации статьи автору отправляется соответствующее решение редакции.

Ответственному (контактному) автору принятой к публикации статьи направляется финальная версия верстки, которую он обязан проверить.

ПОРЯДОК ПЕРЕСМОТРА РЕШЕНИЙ РЕДАКТОРА/РЕЦЕНЗЕНТА

Если автор не согласен с заключением рецензента и/или редактора или отдельными замечаниями, он может оспорить принятое решение. Для этого автору необходимо:

- исправить рукопись статьи согласно обоснованным комментариям рецензентов и редакторов;
- ясно изложить свою позицию по рассматриваемому вопросу.

Редакторы содействуют повторной подаче рукописей, которые потенциально могли бы быть приняты, однако были отклонены из-за необходимости внесения существенных изменений или сбора дополнительных данных, и готовы подробно объяснить, что требуется исправить в рукописи для того, чтобы она была принята к публикации.

ДЕЙСТВИЯ РЕДАКЦИИ В СЛУЧАЕ ОБНАРУЖЕНИЯ ПЛАГИАТА, ФАБРИКАЦИИ ИЛИ ФАЛЬСИФИКАЦИИ ДАННЫХ

Редакция научного журнала «Сибирский вестник сельскохозяйственной науки» в своей работе руководствуется традиционными этическими принципами научной периодики и сводом принципов «Кодекса этики научных публикаций», разработанным и утвержденным Комитетом по этике научных публикаций, требуя соблюдения этих правил от всех участников издательского процесса.

ИСПРАВЛЕНИЕ ОШИБОК И ОТЗЫВ СТАТЬИ

В случае обнаружения в тексте статьи ошибок, влияющих на ее восприятие, но не искажающих изложенные результаты исследования, они могут быть исправлены путем замены pdf-файла статьи. В случае обнаружения в тексте статьи ошибок, искажающих результаты исследования, либо в случае плагиата, обнаружения недобросовестного поведения автора (авторов), связанного с фальсификацией и/или фабрикацией данных, статья может быть отозвана. Инициатором отзыва статьи может быть редакция, автор, организация, частное лицо. Отзывная статья помечается знаком «Статья отозвана», на странице статьи размещается информация о причине отзыва статьи. Информация об отзыве статьи направляется в базы данных, в которых индексируется журнал.

УВАЖАЕМЫЕ ПОДПИСЧИКИ!

Подписку на журнал «Сибирский вестник сельскохозяйственной науки»

(как на годовой комплект, так и на отдельные номера)

можно оформить одним из следующих способов:

- на сайте Почта России. Зайти в раздел «Онлайн-сервисы», затем – «Подписаться на газету или журнал». Подписной индекс издания ПМ401;
- в агентстве подписки ГК «Урал-Пресс» по индексу 014973. Ссылка на издание https://www.ural-press.ru/catalog/97210/8707659/?sphrase_id=392975. В разделе контакты зайти по ссылке <http://ural-press.ru/contact/>, где можно выбрать филиал по месту жительства;
- в редакции журнала (телефон 7-383-348-37-62; e-mail: sibvestnik@sfscs.ru).

Полнотекстовая версия журнала

«Сибирский вестник сельскохозяйственной науки»

размещена на сайте Научной электронной библиотеки:

<http://www.elibrary.ru>.