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# PRODUCTIVITY OF MIXED CROPS OF NARROW-LEAVED LUPINE VARIETIES IN THE MIDDLE PRE-URALS

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**Abstract.** Integrating high-protein crops into the forage component of arable lands and achieving stable development of forage production is a key strategic task for the region in order to support the effective growth of the dairy sector. The study aims to assess the dry matter yield in mixed crops of narrow-leaved lupine with oats and barley in various proportions. The research was carried out on the sod-podzolic soil of the educational, research and production complex Agrotechnopark of the Udmurt SAU in 2024-2025. The studies included two factors: factor A – varieties Ladny and Bryanskiy fodder, factor B – the proportion of components: 1) lupine 100 % seeding rate (SR) – control; 2) lupine 100 % SR + oats 50 % SR; 3) lupine 100 % SR + oats 75 % SR; 4) lupine 80 % SR + oats 50 % SR; 5) lupine 80 % SR + oats 75 % SR; 6) lupine 100 % SR + barley 50 % SR; 7) lupine 100 % SR + barley 75 % SR; 8) lupine 80 % SR + barley 50 % SR; 9) lupine 80 % SR + barley 75 % SR. The comparative analysis of grain components revealed a consistent increase in the productivity of oat mixtures over barley. This is evident in the lupine 80 % + oats 50 % variant, which yields 3.87-3.95 tons per hectare. The research shows that 35 % of yield variation can be attributed to changes in grass height, while only 17 % is linked to weed mass in mixed narrow-leaved lupine crops.
**Key words:** narrow-leaved lupine, agrocenosis, collection of dry matter, collection of crude protein.
**For citation:** Krasnoperov M. Yu., Ukhov P. A., Ryabova T. N., Kokonov S. I., Makarov V. I. Productivity of mixed crops of narrow-leaved lupine varieties in the Middle Pre-Urals. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 5-10. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_5-10.

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# EVALUATION OF SPRING WHEAT VARIETIES AS BREEDING MATERIAL FOR SELECTION IN NORTHERN KAZAKHSTAN

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**Abstract.** The spring wheat is the most widely grown crop in Kazakhstan and it is mainly cultivated in the northern regions of the country. The increasing aridity and the spread of diseases harden the requirements for new varieties. The study purpose is to search for sources of economically valuable traits to create a new breeding material for spring wheat. The research was conducted at the Research and Production Center for Grain Farming named after A. I. Barayev (Kazakhstan) in 2021-2023. The experiments studied 32 varieties of Russian and Kazakhstan selection. Assessments and observations were carried out in accordance with generally accepted methods. The calculation of ecological plasticity was carried out according to the methodology proposed by S. A. Eberhart, W. A. Russel as expounded by Yu. S. Larionov; stress resistance and compensatory ability – according to the equations of A. A. Rossielle and J. Hamblin as expounded by A. A. Goncharenko. The weather conditions were contrastive, the average yield varied within 1.24-2.50 t/ha, and the index of conditions ranged from +0.80 to -0.46. The varieties most responsive to changes in vegetation conditions (bi = 1.06...1.30) have been identified on the basis of the calculation of ecological plasticity in yield: Tselinnaya Yubileynaya, Aina, Asyl Sapa, Kazakhstan 20, Karabalykskaya 90, Karagandinskaya 22, Omskaya 35, Sigma, Taimas, Uralosibirskaya and Shortandinskaya 2007. They can be used in the breeding of intensive varieties. The Licamero and Oral varieties showed high stress resistance in the formation of yields (the index is -0.79 t/ha and -0.84 t/ha, respectively); varieties Karabalykskaya 90, Kazakhstan 20, Baiterek, Shortandinskaya 2017 and Tselinnaya Yubileynaya (2.00-2.23 t/ha) developed genetic flexibility. The Tatiana variety with a growing season of 83 days is of value for further breeding work in order to create early ripening varieties. The varieties Astana, Taimas, Tselina 50 and Shortandinskaya 2012, which formed from 1.29 to 1.53 productive stems per plant, were characterized by relatively high productive tilling capacity in drought conditions. A large and stable quantity of grains per ear over the years was noted in the varieties Kazakhstan 20, Omskaya 18, Oral, Taimas and Shortandinskaya 2017; the mass of 1000 grains – in the varieties Astana, Tauelsizdik 20, Astana 2, Karagandinskaya 22, Omskaya 35, Tselina 50 and Shortandinskaya 2007; the mass of grain per ear – in the varieties Aina, Taimas, Astana, Shortandinskaya 2017 and Darkhan den.

**Key words:** spring wheat, yield, ecological plasticity, stress resistance, growing season, productive tilling capacity, ear productivity.

**For citation:** Sayanov A. T., Babaytseva T. A., Lentochkin A. M., Savin T. V., Kairzhanov Y. K. Evaluation of spring wheat varieties as breeding material for selection in Northern Kazakhstan. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 11-19. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_11-19.

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# HEAVY METAL ACCUMULATION IN THE SOIL-PLANT SYSTEM UNDER THE CONDITIONS OF FLOODPLAIN ECOSYSTEMS OF THE DESNA RIVER

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**Abstract.** The research purpose is to investigate the accumulation of heavy metals in the soil–plant system by the example of floodplain ecosystems of the Desna River (Bryansk Oblast). The study analyzed 55 plant samples of grass and slender tufted-sedge communities. The content of elements was determined by atomic absorption spectroscopy after microwave digestion of samples, and ash content was determined by the dry ashing technique. The accumulation rate was assessed using the coefficients of biological absorption and accumulation as well as the Spearman's rank correlation analysis. Statistical data processing was performed using Statistica and MS Excel. It has been found that the distribution of elements content in plants does not follow the normal distribution law, which necessitated the use of median values for analysis. Based on median content in ash, the elements form the following series: Ni>As>Pb>Cr>Cd. No excesses of maximum permissible levels (MPLs) of heavy metals in plant dry matter were detected. Cadmium showed a significant negative correlation with pH (KCl), while arsenic showed a positive correlation with soil organic matter content. Biological absorption and accumulation coefficients for all elements were highly variable. Heavy accumulation was noted for cadmium and nickel, despite their traditional classification as weak uptake. Differences in the series of biological absorption and accumulation coefficients are explained by calculation specifics and theoretical imperfections of the coefficients. The study results indicate complex dynamics of heavy metal migration and accumulation in floodplain ecosystems, the absence of critical contamination of forage plants, and are in accord with previously published data for floodplain vegetation of other rivers in the region.

**Key words:** alluvial soils, heavy metals, natural grass stand, accumulation coefficient.
**For citation:** Chekin G. V., Silaev A. L. Heavy metal accumulation in the soil-plant system under the conditions of floodplain ecosystems of the Desna River. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 19-25. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_19-25.

Original article DOI 10.48012/1817-5457_2026_2_26-34

# PHENOLOGY DYNAMICS OF ASIAN SPECIES OF THE GENUS *CLEMATIS* L. IN THE URBAN ENVIRONMENT OF UFA

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**Abstract.** The article presents the results of long-term (2009-2013 and 2019-2023) phenological monitoring of five Asian species of the genus Clematis L., introduced under the conditions of the Bashkir Cis-Urals (Ufa city). The aim of the study is to assess the response of the seasonal development rhythm of plants to the modern climatic changes in order to develop a scientific basis for selecting a sustainable assortment for reforestation and urban landscaping. All studied species have successfully acclimatized and reached a stable generative stage. The methodology included observations of seven unified phenological phases. A comparative analysis of the two five-year periods revealed statistically significant shifts in the timing of most phases towards an earlier onset. The most significant shifts occurred in spring: vegetation began 3-5 days earlier, and shoot growth started 4-5 days sooner on average. The phases of the beginning and end of flowering also occured 3-5 days earlier. The obtained data indicate an intensification of spring development and the shortening of the vegetation period, which is a phenological response to regional warming. Based on the identified patterns, the practical significance of the results for forestry and landscaping is substantiated. Specific recommendations are provided for using the resilient clematis species, particularly Siberian clematis (C. alpina subsp. Sibirica) and Tangut clematis (C. tangutica), to enrich the biodiversity and enhance the aesthetics of urban forests, parks, and squares in Ufa. The species are proposed for vertical gardening, slope stabilization, and creating stable edge plantations, which will help adapt the city's green infrastructure to changing climatic conditions.

**Key words:** Clematis, introduction, phenology, seasonal development, phenological phases, climate change, climatic response.

**For citation:** Bilalova R. A., Martynova M. V., Odintsov G. E., Gabdelkhakov A. K., Garfutdinova S. I. Phenology dynamics of Asian species of the genus Clematis l. in the urban environment of Ufa. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 26-34. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_26-34.

Original article DOI 10.48012/1817-5457_2026_2_35-47

# ASSESSMENT OF REFORESTATION DYNAMICS BASED ON EARTH REMOTE SENSING DATA IN THE REPUBLIC OF TATARSTAN

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**Abstract.** The relevance of the study is due to the need of monitoring the spatial and temporal changes in vegetation cover, which have a significant impact on the state of ecosystems, biodiversity and the land use efficiency. The research purpose is the application of geographic information systems (GIS) and remote sensing methods for monitoring the dynamics of colonization by tree and shrubbery vegetation. The paper discusses the methodology for analyzing vegetation by the example of the Republic of Tatarstan for the period 2013–2021, based on open Landsat 8 satellite data. Five sites were selected for remote sensing data processing in the Laishevsky, Privolzhsky, Vysokogorsky, and Pestrechinsky Districts, which differed in their characteristics and plant composition. The key tool is the Normalized Difference Vegetation Index (NDVI), which is quantified and visualized using the QGIS software. The calculated NDVI values and the constructed time series allowed us to identify the spatial and temporal features of overgrowth in the studied areas. The analysis of the dynamics showed that in most areas, there was a decrease in the area size with NDVI > 0.3, which indicated a reduction in the density of vegetation cover. The exception was the area in the Vysokogorsky District (the village of Berezka), where the NDVI index showed a steady increase. The maximum NDVI values for most plots were in 2018-2020, which may be due to favorable climatic conditions and the implementation of forestry measures. The constructed time series and visualization by means of the Timelapse tool in QGIS demonstrated the high informative value of the method for monitoring spatial and temporal dynamics. The obtained results of geoinformational modeling have an applied significance for environmental control, rational nature management, agroforestry, contributing to the development of effective measures for biodiversity conservation and increasing the land productivity under the conditions of digitalization and transformation of ecosystems.

**Key words:** geoinformational systems (GIS), vegetation dynamics, land overgrowth, monitoring, rational nature management, Landsat 8, NDVI, QGIS.

**For citation:** Gibadullin N. F., Musin H. G., Larionov A. D., Romanov N. O., Vagizov M. R. Assessment of reforestation dynamics based on Earth remote sensing data in the

Republic of Tatarstan. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2(86): 35-47. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_35-47.

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# BIOMETRIC ASSESSMENT OF GROWTH AND CONDITION OF COMMON PINE SEEDLINGS (PINUS SYLVESTRIS L.) IN A FOREST NURSERY

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**Abstract.** Biometric indicators of growth, vital state and relationship of the growth process with the level of phenotypic diversity according to the quantitative indicators of common pine seedlings grown in the forest nursery of the Educational and Scientific Center of the Bashkir State Agrarian University have been studied. The study ensures compliance with a systematic approach to the morphometric assessment of common pine seedlings, as well as with the methodological requirements for conducting the field stage of research. The study provides a statistical evaluation of the growth of seedlings in an experimental sample of 458 plants. Four groups of seedlings have been identified based on their growth energy, which are characterized by distinctive size indicators of the analyzed traits: the diameter and height, growth of axial shoots of the trunk, lateral shoots development and vital state, reflecting the unique characteristics of their genotypes. Differences in common pine seedlings in terms of growth and condition were confirmed by the corresponding regression equations and the calculation of coefficients of determination and correlation. The most robust and vigorous common pine seedlings, with distinct phenotypic and genotypic traits, are of high value in forestry production.

**Key words**: common pine, root neck diameter, trunk height, axial shoot growth, lateral shoot growth, regression, correlation.
**For citation:** Konovalov V. F., Rakhmatullin Z. Z., Sabirzyanov I. G., Muftakhova S. I., Rafikova D. A. Biometric assessment of growth and condition of common pine seedlings (Pinus sylvestris L.) in a forest nursery. 2026; 2 (86): 47-55. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_47-55.

Original article DOI 10.48012/1817-5457_2026_2_56-61

## USING SEEDLINGS WITH A CLOSED ROOT SYSTEM FOR ESTABLISHING FOREST PLANTATIONS IN NORTHERN KAZAKHSTAN

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**Abstract.** The survival rates of forest plantations of Scots pine (Pinus sylvestris L.) established by using seedlings with the open and closed root systems during the spring and summer-autumn periods in Northern Kazakhstan were analyzed. It has been found that the survival rate of forest crops significantly depends on planting dates and weather conditions during the growing season. Seedling survival rates were significantly higher when planted in the summer and autumn compared to those when forest plantations were established in the spring. The average height of seedlings used in summer and autumn planting was 17.52±0.55 cm with a central root length of 18.32±1.43 cm. Moreover, forest plantations established with seedlings with a closed root system exhibited better survival rates. The reason, in our opinion, is that when forest crops are established in late August and September, the roots of seedlings with a closed root system have time to emerge from the peat briquettes and efficiently utilize precipitation moisture the following spring. When planted in spring, the survival rate of seedlings with a closed root system was 3.99 % lower than that of seedlings with an open root system. This indicates that the use of seedlings with an open root system is more promising in years with unfavorable weather conditions. Low survival rates of forest crops necessitate the further research to determine the feasibility of replacing open root seedlings with closed root seedlings, optimal planting dates and technologies for creating forest plantations.

**Key words:** forest plantations, seedlings, survival rate, closed root system, open root system, Scots pine.
**For citation:** Kochegarov I. S. Using seedlings with a closed root system for establishing forest plantations in Northern Kazakhstan. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 56-61. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_56-61.

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## MITIGATION OF PEAT FIRE HAZARDS UNDER CHANGING CLIMATE CONDITIONS

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**Abstract.** The research purpose is to analyze the dynamics of peat fires and their specific characteristics under changing climate conditions, using the Sverdlovsk Region as an example, and on the basis of these data, develop proposals for minimizing the damage they cause. It has been established that drained peatlands pose the greatest risk of peat fires. Climate change, combined with the cessation of peat extraction and, consequently, the cessation of fire protection in drained peatlands, has led to a sharp increase in the number of wildfires. The peat fires accounted for 9.81 % of all forest fires in the Sverdlovsk region in 2023. The main cause of peat fires was fugitive spring ground fires. Furthermore, the prevalence of single-site peat fires has shifted from single-site to multiple-site fires. Since extinguishing peat fires is associated with significant labor and financial costs, they often continue being unextinguished during the winter, increasing the risk of ground fires the following spring. In order to minimize damage from peat fires, innovative extinguishing methods have been developed. In summer, this involves flooding or raising the groundwater level. In winter, this involves raising smoldering peat to the surface and cooling it to 40°C. The situation with peat fires can be fundamentally improved by restoring unused drained peatlands (not used for peat extraction) to their natural state, which involves blocking the drainage channels.
**Key words:** peat fires, flammability, flooding, suppression, original state.
**For citation:** Kuksin G. V., Sekerin I. M., Yeritsov A. M., Zalesov S. V. Mitigation of peat fire hazards under changing climate conditions. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 62-69. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_62-69.

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## PATTERNS OF WATER CONSUMPTION BY PASTURE GRASSES UNDER THE INFLUENCE OF FOREST AND HYDRAULIC RECLAMATION IN THE VOLGA UPLAND STEPPE

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**Abstract.** The aim of the study was to establish the influence of forest and hydraulic engineering amelioration on water consumption and productivity of pasture grasses. The problem solving process involved the determination of influence of forest belts, water-retaining ramparts, and a pond on water consumption and the productivity of pasture grasses, and the establishment of patterns of the impact of forest and hydraulic reclamation on the water consumption coefficient of pasture grass. The research methodology was based on the recommendations of scientists from the All-Russian Research Institute of Agroforestry Melioration (1960), A. N. Kostyakov (1980), B. A. Dospekhov (2012). The experiments were conducted at Vavilov University at the runoff and erosion station of Niva LLC, Tatishchevsky

District, Saratov Region. The main factors determining the amount of water consumption and productivity of the pasture grass stand were the amount of precipitation during the autumn-winter period, forest and hydraulic engineering amelioration. Snow water reserves increase by 70% in forest belt systems during winters with minimal snow accumulation, relative to open pasture areas. In years with a dry May-June period followed by a winter with minimal snow accumulation, the impact of forest and hydraulic reclamation on pasture productivity increases to 74.1%, while in years with a wet May-June period and snowy winters, it drops to 2.9%. The contribution of soil moisture to pasture grass water consumption ranges from 24% in years with increased moisture availability to 80% or more in dry years. This dynamic indicates that pasture plants maximize the use of soil moisture reserves during periods of insufficient precipitation. A close correlation was established between the productivity of pasture grasses in May-June with the snowiness of winters, moisture conditions and the protection of lands by forest belts and water-retaining ramparts at the level of determination coefficients $R^2$=0.93-0.97.
**Key words:** pasture grasses, protective forest plantations, hydraulic structures, grass water consumption, dispersion, correlation.
**For citation:** Proezdov P. N., Mashtakov D. A., Eskov D. V., Yashin I. P. Patterns of water consumption by pasture grasses under the influence of forest and hydraulic reclamation in the Volga Upland steppe. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 69-78. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_69-78.

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## GROWTH AND AGROMELIORATIVE EFFICIENCY OF FIELD PROTECTING PLANTATIONS IN THE VORONEZH REGION

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**Abstract.** In the Voronezh Region, there are about 600,000 hectares of plantations that perform protective functions in the surrounding landscapes, and the share of windbreaks is about 135,000 hectares. Their composition consists of pure and mixed forest plantations, with the common oak, drooping birch, and balsam poplar being the main species under the forest-steppe conditions. The purpose of the studies is to substantiate the optimal parameters for the formation of field protecting forest strips on the basis of their silvicultural and forestry-reclamation assessment for the creation of highly efficient forest melioration complexes under the conditions of the Voronezh Region. Generally accepted methods in land and forest reclamation are used in the research. Under optimal soil conditions (typical chernozem), tree

species exhibit the highest growth rates and demonstrate high survival rates at planting density of 3,334 trees per hectare. Within the system of field protecting forest plantations, snow is accumulated with the water content in the snow cover of 536-618 m3/ha. The greatest ameliorative efficiency during microclimate formation among protective plantings is noted under the influence of forest belts characterized by a dense upper canopy and a sparser lower part. The biological productivity of crops increases by 9-24 %. in protected areas of agrolandscapes. The agromeliorative effect of forest strips is manifested from 6 to 17 years, depending on the species composition and structure of the plantations. Field protecting plantations could boost winter wheat production by 121.9 thousand tons in the Voronezh region.
**Key words:** field protecting plantations, growth, survivability of species, structure of forest strips, agromeliorative efficiency.
**For citation:** Kharchenko N. N., Mikhina V. V. Growth and agromeliorative efficiency of field protecting plantations in the Voronezh Region. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 78-85. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_78-85.

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## INFLUENCE OF THE SIMMENTAL X HOLSTEIN CROSSBREED GENOTYPE ON GROWTH, MILK PRODUCTIVITY AND FEED CONVERSION

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**Abstract.** The aim of this study was to investigate the growth and development characteristics of animals, milk productivity, feed conversion, and the yield of essential nutrients in the milk of purebred Holstein cows during the first lactation. Four groups of animals were formed with Holstein blood percentages of 75.0%, 87.5%, 93.75% and 96.87%, with 30 animals in each group. Replacements and dairy cows were housed at the complex and had identical feeding and housing conditions. Milk yield was recorded every ten days, and dry matter, fat, and protein content were determined monthly in the dairy complex laboratory using a MilkoScan FT2. During the growing period, heifers with high pedigree blood percentage (31/32) had a higher growth rate than the heifers of the same age with lower feed consumption per 1 kg of gain. With an increased proportion of Red-and-White Holstein blood, when reared intensively, crossbred young animals respond better to feeding conditions, indicating their precocity. The average live weight at successful insemination for heifers with the 3/4 genotype was 404 kg, and the insemination age was 14.1 months; for heifers with the 7/8 genotype — 400 kg and

13.8 months, respectively; for heifers with the 15/16 genotype — 416 kg and 14.1 months; and for heifers with the 31/32 genotype — 420 kg and 13.7 months. Milk yield of high-blooded cows with the 31/32 genotype is 148-586 kg higher than that of the other cows of the same age. As Holstein bloodlines increase, milk production in cows increases, with a stable dry matter content of 12.81-12.85%, fat of 3.95-4.0%, and protein of 3.24-3.27%. Milk production profits ranged from 114,930 to 138,075 rubles for the experimental animals. The difference between the groups amounted to 11,365 – 23,145 rubles, in favour of cows with the 31/32 genotype. The highest profitability (62.24%) was observed in cows with the 31/32 genotype.
**Key words:** genotype, crossbreeding, milk yield, fat, protein, feed, growth, insemination.
**For citation:** Velmatov A. P., Tishkina T. N. Gibalkina N. I. Influence of Simmental x Holstein crossbreed genotype on growth, milk productivity and feed conversion. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 86-91. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_86-91.

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# THE IMPACT OF FEEDING RATION STRUCTURE FOR PREGNANT COWS ON FETAL DEVELOPMENT AND THE OCCURANCE OF ANTENATAL HYPOTROPHY IN CALVES

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**Abstract.** Hypotrophy in young animals is observed at different stages of calf ontogenesis, often starting in the antenatal period. The study is relevant as it identifies the factors that contribute to intrauterine hypotrophy. The aim of this research was to identify criteria for the inadequacy of cow diets at all stages of pregnancy in dairy farms of the Saratov Region and to establish their relationship with antenatal hypotrophy in calves. Several objectives were established: to determine the incidence of antenatal hypotrophy in calves; to analyze the structure and nutritional value of the diet for pregnant cows. The study was conducted on the basis of three dairy farms in the Marksovsky and Atkarsky Districts of the Saratov Region in 2025. Three groups of cows at different stages of pregnancy were formed, with 25 animals in each group. The diagnostic complex for antenatal hypotrophy was confirmed using rectal palpation and ultrasound fetometry during the third trimester of pregnancy (210-270 days). This article presents the results of studying the clinical and diagnostic criteria of intrauterine fetal hypotrophy in cows and their pathophysiological relationship with nutritional factors. A significant decrease in fetal length to 54.2±3.1 cm and eye diameter to 21.4±0.8 mm (deviation from normal >18-20%) was established. Functional disorders are characterized by pronounced fetal tachycardia (154±6.2 bpm) and a decrease in the quality of visualization of its anterior

part to 55-65 %. A direct correlation was established between the incidence of hypotrophy in calves and the quality of feeding of breeding stock in different districts of the Saratov Region. In the farms of the Atkarsky District, the birth rate of hypotrophic calves reaches 47 % due to a deficiency of metabolic energy (up to 16.5 MJ) and crude protein (up to 406.4 g), while in the Marksovsky District, with a relatively balanced diet, this indicator is 12%. A combined deficiency of energy, protein, and macronutrients leads to the suppression of microbial synthesis in the rumen and the development of chronic fetoplacental insufficiency.
**Key words:** dairy farms, antenatal period, calf hypotrophy, pregnant cows, dairy cows, dry period, feeding ration, metabolism, fetometry.
**For citation:** Kapotova E. Yu., Kalyuzhny I. I., Kalinkin N. A. The impact of feeding ration structure for pregnant cows on fetal development and the occurrence of antenatal hypotrophy in calves. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 92-99. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_92-99.

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# MORPHOLOGICAL COMPOSITION AND TISSUE RATIO IN CARCASSES OF RED STEPPE BULL-CALVES AND THEIR CROSSES WITH LIMOUSIN AND HEREFORD BREEDS

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**Abstract.** A significant national economic task of the Russian agro-industrial complex is to increase meat production. A promising direction for solving this issue is the use of various crossbreeds in cattle breeding. This increases meat productivity, as well as improves the quality of meat products obtained from crossbred animals. The aim of the research was to examine the effect of the bull-calves genotype on the morphological composition of the carcass and the tissue ratio in it. It was found that Red Steppe bulls were inferior to first–generation crossbreeds with Limousin (1/2 Red Steppe x 1/2 Limousin) and Hereford (1/2 Red Steppe x 1/2 Hereford) in terms of absolute shortloin weight by 1.8 kg (15.65 %) and 2.1 kg (18.26 %), respectively, and relative weight by 0.5 % and 0.8 %. At the same time, purebred bulls were inferior to the other bulls of the same age in terms of absolute weight of beef haunch by 4.0 kg (10.75 %) and 3.5 kg (9.41 %), while their relative weight was higher by 0.1 % and 0.5 %. In terms of the absolute weight of the edible part of the half-carcass, the crossbreeds outperformed purebred bull-calves by 10.4 kg (11.44 %) and 11.0 kg (12.1 %), in relative

weight - by 0.8 % and 1.3 %. The analysis of the absolute mass of the muscle and adipose tissue has revealed a comparable pattern of intergroup differences, which is consistent with previously obtained results. The following pattern is observed in the structure of the relative mass of tissues: purebred bull-calves have an increased proportion of muscle tissue, while crossbred bull-calves have an increased proportion of fat tissue. The highest bone yield was recorded in Red Steppe bull-calves. When assessing key indicators of meat productivity, it was revealed that purebred bull-calves were inferior to crossbreeds in terms of meat index (pulp yield per 1 kg of bones) by 0.8 kg (19.90 %) and 0.51 kg (12.69 %), in terms of pulp yield per 100 kg of pre-slaughter live weight – by 1.06 kg (2.65 %) and 2.35 kg (5.88 %), as well as the ratio of edible and inedible parts of the carcass – by 0.62 kg (17.82 %) and 0.42 kg (12.07 %).
**Key words:** beef cattle breeding, bull-calves, meat carcass, morphological composition, tissue ratio.
**For citation:** Kosilov V. I., Yuldashbaev Yu. A., Rakhimzhanova I. A., Kalyakina R. G., Nikonova E. A. Morphological composition and tissue ratio in carcasses of Red Steppe bull-calves and their crosses with Limousin and Hereford breeds. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 100-106. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_100-106.

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## GENETIC PREDICTORS OF MILK PRODUCTIVITY IN COWS WITH DIFFERENT AGES OF CULLING FROM THE BREEDING HERD

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**Abstract.** The research aims to compare the milk productivity of Red-and-White dairy cows culled from the herd at various ages, considering their lineage. The study was based on the materials of agricultural enterprise Dolzhanskoye in the Veydelovsky District of the Belgorod Region for the period 2019–2024. The study examines 389 animals, categorized by age at culling (young – up to 5 years, mature – 6 years and over) and belonging to three primary pedigree lines: Reflection Sovereign 198998, Vis Back Ideal 1013415, and Montwick Chiften 95679. It has been found that mature cows provide a significantly higher lifetime milk yield (on average, 59,120 kg versus 22,840 kg for young cows), while the productivity level for 305 days of lactation remains comparable (8,210 and 8,430 kg; p = 0.12). The analysis revealed a clear relationship between the genetic line, body type and the duration of economic use. Cows of the Reflection Sovering 198998 line are characterized by the balanced milk composition, strong physiological resilience, and prevalence among older animals (68.6 % reached the age

of 6+ years). At the same time, animals of the Vis Back Ideal 1013415 and Montwick Chiftein 95679 lines, despite high milk yields at an early age, demonstrate an increased proportion of early culling (more than 62 % before the age of 6). This is due to an imbalance in the constitution, either excessive capacity or insufficient strength. The data obtained confirm that the long-term profitability of milk production depends not so much on peak productivity as on the animal's ability to sustainably realize its potential over several lactation periods. Practical recommendations for selective breeding have been formulated, with a focus on the exterior conformation and constitutional traits associated with productive longevity.
**Key words:** milk productivity, productive longevity, genealogical lines, exterior-constitutional type, Red-and-White dairy breed, lifetime milk yield, age of culling, selective breeding.
**For citation:** Kutin D. D., Hohlova A. P. Genetic predictors of milk productivity in cows with different ages of culling from the breeding herd. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 106-114. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_106-114.

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## FORMATION OF MEAT PRODUCTIVITY IN ABERDEEN ANGUS YOUNG STOCK USING THE ACTIV PRO FEED ADDITIVE IN DIETS

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**Abstract.** Improving the feeding system of cattle is a determining factor contributing to a higher degree of realization of the genetic potential for meat productivity, as well as an increase in the output of meat raw materials – biologically complete beef. The aim of the research was to improve the feeding system and study its influence on the growth, development, and specific features of meat productivity formation in Aberdeen Angus young stock. The objectives are to analyze the nutritional and biological value of the protein-mineral-vitamin complex (PMVC) Activ Pro; to determine the dosage of the feed additive for bull-calves and surplus replacement heifers of the meat breed; to study the intensity of growth and development of Aberdeen Angus young stock when introducing the complex additive into the diet; to analyze the results of control slaughter of bull-calves and surplus heifers; to provide recommendations for improving the feeding system for beef cattle. The duration of the experimental period in animals was from 10 to 17 months old. 3 groups of bull-calves and surplus replacement heifers at the age of 10 months, 15 heads in each group, were formed: 1st group was a control one; for the animals in the 2nd and 3rd experimental groups a part of the

concentrate feeds (in terms of crude protein content) was replaced with PMVC Activ Pro at the rate of 50% and 75%, respectively. The live weight of bull-calves in the 2nd and 1st experimental groups significantly ($p \leq 0.01$, $p \leq 0.05$) exceeded the indicator of bull-calves in the control group by 35.6 kg (7.4%) and 19.7 kg (4.1%), respectively. The live weight of heifers in the 2nd and 1st experimental groups significantly ($p \leq 0.05$) exceeded the indicator of heifers in the control group by 33.9 kg (8.0%) and 22.2 kg (5.2%), respectively. The results of the control slaughter of bull-calves and heifers revealed significantly maximum indicators in the young stock of the 1st and 2nd experimental groups.
**Key words:** protein-mineral-vitamin complex, live weight, control slaughter, average daily gain.
**For citation:** Lekomtseva A. A., Batanov S. D., Starostina O. S., Atnabaeva N. A. Formation of meat productivity in Aberdeen Angus young stock using the feed additive Activ Pro in diets. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 115-124. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_115-124.

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## THE EFFECTIVENESS OF GROWING BROILERS ON DEEP LITTER UNDER VARYING AIR CIRCULATION INTENSITY IN POULTRY HOUSES DURING THE WARM PERIOD OF THE YEAR

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**Abstract.** The efficiency of broiler meat production largely depends on the habitat of the livestock. Currently, special attention is paid to the microclimate in poultry houses, since the productivity of chickens depends on the environmental conditions they experience. The warm summer season is the most difficult period of the year for creating an optimal microclimate in poultry houses located in zones of continental and sharply continental climate. The research aims to scientifically validate the need for enhanced air circulation in poultry houses during the warm season when raising broilers on deep litter. Three groups of day-old chickens were formed for the experiment, which were placed in three production buildings. In the experimental groups, additional elements of the ventilation system were used to increase the uniformity of air exchange – SF-550-02 circulating axial fans, each with a capacity of 8.5 thousand m3/h (3 units were used in Group 2, 5 units– in Group 3). It has been experimentally established that in order to increase the efficiency of broiler meat production, it is recommended to increase the intensity of air circulation in the warm season by applying additional air circulation with an intensity of 42.5 thousand m3/h using 5 circulation fans, each

with a capacity of 8.5 thousand m3/h in an enclosed space with a total floor area of 1,152 m2. The circulation fans should be turned on from the age of 3 days of broilers, synchronously with the operation of open-burning gas generators. Production recommendations are based on calculated values of temperature amplitude, relative humidity and the microclimate uniformity index, which eliminate microclimatic zoning in the poultry house.

**Key words:** broilers, microclimate, microclimate uniformity index, air exchange, air circulation, zootechnical and economic efficiency.

**For citation:** Malorodov V. V. The effectiveness of growing broilers on deep litter under varying air circulation intensity in poultry houses during the warm period of the year. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 125-131. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_125-131.

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## THE INFLUENCE OF VARIOUS PRESERVATIVES ON THE CORN SILAGE QUALITY

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**Abstract**. Silage is the primary and unique succulent feed in the rations of dairy cows within the Middle Volga region; and therefore, it is subject to higher quality requirements. The purpose of the study is to determine the best preservative for corn silage. The experiment was conducted under laboratory conditions on the basis of the Ogarev Mordovia State University. The analysis of the samples of the mature silage was performed using a NIRS DA 1650 spectral analyzer, FOSS from NOVA. In terms of nutrient content, the silage with the Probactil biopreservative was superior to samples without a preservative and with the Enteracid chemical preservative in terms of protein content by 0.47 and 0.41 %; fat content by 0.20 and 0.12 %, and metabolic energy by 0.9 and 0.3 MJ, respectively. The use of Probactil made it possible to reduce the pH to an optimal value of 4.2, which contributed to the improvement of lactic acid fermentation. The amount of lactic acid in the Probactyl variant was 13.00 % higher than in the chemical preservative variant, and 1.89 % higher than in the control sample. The variant without a preservative had a pH of 4.8, which is higher than the optimal range (3.8–4.2); up to 2.5 % butyric acid was also detected. The Enteracid sample showed a high acetic acid level of 37.5 %, and its pH was below normal – at 3.5. The best corn silage was obtained using Probactil biopreservative, it had the highest content of nutrients and energy and corresponded to quality class 1. The samples containing preservatives showed no butyric acid,

suggesting no rotting occurred and indicating high-quality silage. The organoleptic evaluation of silage treated with Probactil scored 5 points.
**Key words:** silage, preservatives, quality, nutritional value, energy rating.
**For citation:** Mungin V. V., Gipkina N. I., Sazanova E. V., Yagodkina T. V. The influence of various preservatives on the corn silage quality. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 132-136. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_132-136.

Original article DOI 10.48012/1817-5457_2026_2_137-146

## NOVEL PROPERTIES OF DAIRY PRODUCTS USING ENZYMATIC LACTOSE HYDROLYSIS

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**Abstract.** The lactose-free dairy segment is one of the market's fastest-growing food categories. The increased demand for such products is driven by the need of a certain group of people with a diagnosis of lactase deficiency, as well as the emerging trend towards healthy food products. These include dairy products with a reduced milk sugar content. Various techniques exist for eliminating or altering lactose, with the most prevalent method being enzymatic hydrolysis with the usage of microbial lactases (β-galactosidases). The research purpose was to study the effect of enzymatic hydrolysis of milk lactose on technological processes and the quality of the finished product in the dairy production. The experiments were conducted to create yogurt, cottage cheese, drinking baked milk, and condensed milk. The control and experimental samples were prepared for each product. Test samples were prepared with Lacta-free enzyme preparation (Italy) containing lactase obtained from Aspergillus oryzae microorganisms. In the production of fermented dairy products, enzymatic hydrolysis of milk sugar, both pre-hydrolysis and hydrolysis during milk fermentation, does not affect the intensity of lactic acid fermentation, but the glucose and galactose produced during hydrolysis increase the perceived sweetness of the product. When manufacturing products with prolonged high-temperature exposure to milk, pre-treatment of the raw material with lactase accelerates the melanoidin formation process, which helps to reduce the production time for such products. Compared to products obtained by using the classical technology, baked milk and condensed milk that have been fermented with lactase have a darker color and a more pronounced sweet taste.
**Key words:** lactose intolerance, lactase, enzymatic hydrolysis, lactose-free dairy products, yogurt, cottage cheese, baked milk, condensed milk, melanoids, sweetness coefficient.

**For citation:** Utkina O. S., Yudin V. M., Bazueva D. A. Novel properties of dairy products using enzymatic lactose hydrolysis. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 137-146. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_137-146.

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# INFLUENCE OF TECHNOLOGICAL CONDITIONS ON SPERM PRODUCTION INDICATORS IN SIRE BULLS

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**Abstract.** The sperm production of sire bulls is influenced by both genetic potential, the physiological condition of the animals, and paratypic factors. The technological conditions of bull keeping can either mitigate the negative effects of seasonal factors or exacerbate them. The aim of this study was to investigate the impact of technological conditions, specifically the temperature regime in rooms with different climate control systems, on the quantitative and qualitative indicators of sperm production in sire bulls at Mozhgaplem LLC. The object of the research was the herd of Holstein sire bulls, placed in two buildings. Building 1 is equipped with a forced ventilation system with partial heating of the incoming air in winter. Building 2 has the natural ventilation. In the conditions of Building 1, the best sperm production indicators were observed in the autumn period. The maximum concentration of sperm in the ejaculate was recorded in November (10.19 billion), and high results were also observed in May (9.35 billion) and September–October (9.08–9.11 billion). The lowest percentage of sperm defects was observed in September (1.2 %). In the conditions of Building 2, there was a similar seasonal pattern in the sperm production of sire bulls. The highest concentration of spermatozoa and ejaculate volume in bulls was achieved in October, with an average of 9.64 billion and 5.10 ml, respectively. It has been established that the optimal season for obtaining high-quality sperm is autumn, while the winter period is characterized by a decrease in indicators due to the minimum temperatures, with the most pronounced drop observed in the housing with a less advanced climate control system.

**Key words:** sire bulls, sperm production, sperm concentration, ejaculate volume, defective native sperm, ventilation system, air temperature.

**For citation:** Faizova Z. I., Isupova Ju. V. Influence of technological conditions on sperm production indicators in sire bulls. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 146-154. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_146-154.

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# MORPHOMETRIC ANALYSIS OF ABORIGINAL BEES IN UDMURTIA FOR THEIR CONFORMITY TO THE BREED STANDARD OF THE DARK FOREST BEE

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**Abstract.** Beekeepers frequently transport and introduce southern honey bee breeds across various regions of Russia. This leads to the formation of a hybrid honey bee population, posing a threat to the genetic integrity of native bee populations and risking the loss of their economically valuable and biologically significant traits. The purpose of the study is to provide a morphometric assessment of bee colonies of the Udmurt Republic for compliance with the breed standard of the Central Russian (dark forest) bee and to determine the degree of their hybridization. The morphometric analysis was performed on the following parameters: proboscis length, width and length of the right forewing, third tergiteand sternite, cubital index, and discoidal displacement. Measurements were carried out using a digital caliper and the following trinocular microscopes: Microoptix MX-300 T and Levenhuk M1200 PLUS (digital model). The study has revealed that the population as a whole preserves the key phenotypic characteristics of the native breed. Specifically, negative discoidal displacement occurs in 65–96% of the individuals, while most morphometric measurements vary within the established standard values. At the same time, statistically significant deviations have been identified, indicating crossbreeding with southern breeds. The average proboscis length (6.04 mm) is at the lower limit of the standard, and it falls below 6.0 mm in the apiaries of Balezinsky, Vavozhsky, Zavyalovsky, Seltinsky, Syumsinsky, Uvinsky, Sharkansky, and Yukamensky districts. The cubital index decreased to 53.3-59.8% in the Votkinsk, Zavyalovsky, Syumsinsky, Igrinsky, Sharkansky, and Yarsky districts. The discrepancy of both traits was recorded at the apiaries of Balezinsky (apiary No.1), Vavozhsky (apiary No.2), and at all three apiaries of Syumsinsky districts. Only 12 out of 42 apiaries (28.6%) fully comply with the breed standard. The increased proportion of bees with a positive discoidal displacement correlates with zones of active hybridization. The following morphological anomalies were identified: wing structure abnormalities (21.4% of bee colonies); elongated abdomens (64.3% of bee colonies).

**Key words:** Central Russian breed, dark forest honeybee, morphometry, crossbreeding, breed, proboscis length, cubital index, discoidal displacement.

**For citation:** Yudin V. M., Tronina A. S., Vorobyeva S. L. Morphometric analysis of aboriginal bees in Udmurtia for their conformity to the breed standard of the dark forest bee. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 154-160. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_154-160.

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# DETERMINING THE MAXIMUM CONCENTRATION OF CRUSHED GRAIN PARTICLES DENSELY LAYERED IN A TRIANGLE

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**Abstract.** The research aim is to determine the maximum possible concentration of crushed grain particles when they are densely placed in a triangle in a single layer on the surface. We have proposed a method for determining the particle size of crushed grain, which is based on photographing grain samples and processing the resulting image. The implementation of this method implies the distribution of particles on the surface without their intersection. To do this, you need to know the maximum possible concentration of particles, which is achieved when they are layered. The article discusses three methods for calculating the area of crushed grain particles when they are densely placed in a triangle in a single layer on the surface. In calculations, it is assumed that the particles are arranged on a plane in dense rows in one layer so that the particle center of each even layer is shifted relative to the odd particle radius. In a "rough" calculation, all particles are placed in two rows, while the number of particles in the rows is the same or differs by no more than 1 particle. The refined calculation considers the area occupied by 3 particles, taking into account the voids around them. As for an accurate calculation, there may be cases with or without a residue of particles in the rows. The condition for the absence of "extra" particles is to divide the sum of the particles in an even and odd row by three. If this occurs, two cases are possible: the equality of particles in an even and odd row and the number of particles in an even and uneven row with a difference of 1 particle. When considering all three cases, expressions are obtained for calculating the areas occupied by N number of particles of a given size. Comparative results of area calculations using three methods are presented, as well as a comparison with experimental results. It has been found that when calculating the laying of particles by a triangle, the error of the rough calculation relative to the accurate does not exceed 5 % with a particle number greater than 95, and between the refined and accurate – more than 15 pieces. The use of a refined calculation, which requires significantly less effort compared to an accurate one, proves to be sufficient. The degree of convergence between theoretical and experimental findings is more than 90 % for particles with diameters up to 1.7 mm, and 70 % for particles of 2.75 mm diameter.

**Key words:** crushed grain, concentration, residue, error, area, laying, row, calculation method, column, triangle, particle.

**For citation:** Bulatov S. Yu., Isupov A. Yu., Sergeev A. G., Malyshev G. S., Krestinkov V. G. Determining the maximum concentration of crushed grain particles densely layered in a triangle. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 161-168. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_161-168.

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# EFFECTIVE USE OF A CLOSED SOIL CHANNEL IN THE PROCESS OF IMPROVING THE SEEDER WORKING PARTS

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**Abstract.** To replicate field conditions as accurately as possible, closed soil channels are being installed in educational institutions and research institutes. They are widely used for laboratory practical classes and comprehensive scientific research of agricultural machinery in its interaction with the soil, regardless of the time of year and weather conditions. The aim of the study was to increase the efficiency of crop sowing by improving the working parts, which promotes high-quality seed distribution across the feeding area at the required seeding depth. The object of the study was the process of interaction of crop seeds with the working parts of seeders. The effective use of a closed soil channel is achieved through a relatively simple operating principle and the use of special equipment. The experimental studies on the distribution quality of carrot seeds were carried out using a coulter of the SO-4.2 seed drill for row sowing, and a coulter with an active seed spreader for strip sowing. It has been found that during the row sowing with a double-disc coulter, as the seed rate increases, the feeding area decreases (with the seeding rate of Q=3 kg/ha Sп = 6.11 cm2, and with Q=4 kg/ha Sп = 4.5 cm2). A coulter with an active spreader for strip sowing distributes seeds with an increased feeding area when the seeding rate is increased (at Q=4 kg/ha, it is Sп = 5.01 cm2). The research was also conducted on the working parts being under development of a stubble drill for grain crops, resulting in a design scheme. Currently, we have developed, manufactured, and put into operation a small-sized mounted seed drill on the basis of the experience and the analysis of well-known design and technological schemes of working bodies of devices for seed distribution and embedding. The positive results of scientific studies confirm the potential for further research aimed at improving the working parts of seed drills.
**Key words:** closed soil channel, agricultural crops, laboratory installation, working parts, seeding machine, seeder, uniform distribution.
**For citation:** Maximov L. L., Shklyaev K. L., Deryushev I. A., Maximova E. V., Savelyeva M. A. Effective use of a closed soil channel in the process of improving the seeder working parts.

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# LEVELS OF VARIATION IN FACTORS DURING THE TESTING OF UPGRADED HEAT EXCHANGERS FOR OPERATIONAL DURABILITY

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**Abstract.** The widespread use of heat exchangers in industry, energy sector, and agriculture imposes high reliability requirements on them. Measuring the rate of corrosion wear is crucial for estimating the lifespan of a heat exchanger. The article presents the factors affecting the rate of corrosion, and the main ones are selected, mainly affecting the reliability of heat exchangers. These include the index of equilibrium saturation of water with calcium carbonate – Langelier index (J), the content of sulfates in water ($SO_4^{2-}$), and chlorides ($Cl^-$). The purpose of the study is to determine the levels of variation of the main influencing factors affecting the corrosion rate during bench tests to assess the operational durability of upgraded heat exchangers. To obtain the statistical characteristics of the main factors affecting the corrosion rate of the heat exchanger, the data from laboratory analyses of well water were processed using probability theory methods, and the sampling included water samples from 21 wells. The Pearson's chi-square test showed that the factors under consideration are distributed according to normal laws. To experimentally determine the corrosion rates, the levels of factor variation were established for each operating mode of the heat exchanger according to the 23 factor planning matrix. The upper level of the affecting factor corresponds to "+3σ," and the lower level corresponds to "-3σ," where σ is the standard deviation of the factor. Depending on the requirements for bench tests for reliability, understanding the distribution densities of the affecting factors, it is possible to adjust their variation levels during the experiments.

**Key words:** heat exchanger, corrosion rate, affecting factors, levels of variation.
**For citation:** Saplin L. A., Butorin V. A., Andreeva M. V. Levels of variation in factors during the testing of upgraded heat exchangers for operational durability. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2(86): 179-186. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_178-186.

Original article DOI 10.48012/1817-5457_2026_2_186-192

# DISTRIBUTION AND SATURATION OF OZONE AND NEGATIVE IONS MOLECULES IN REPAIR AND DIAGNOSTIC WORKSHOPS

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**Abstract.** The article presents the results of a study of ozonation systems, the distribution and saturation of ozone and negative ion molecules in repair and diagnostic workshops. The air purification system, combined with ozonators (corona and barrier discharge) and sensors (concentration of harmful substances, ozone, negative ions, and temperature), allows for the reduction of harmful dust, gas, and microbial concentrations in repair and diagnostic workshops to the permissible limits. The dependencies of the changes in ion and ozone concentrations in the repair and diagnostic room are obtained, as well as the duration of persistence of these concentrations after switching off the ozonation and ionization systems. It is determined that ozone molecules concentrate at 21 mg/m³ at the ozonator's outlet (38 %) and diminish to 1 mg/m³ (2 %) at a 2-meter distance. Negative ions reach 2500 pCl/m³ at the outlet (33 %) and drop to 580 pCl/m³ (3 %) at the same distance. After 30 minutes of operation, the saturation levels are 52 %: 15 mg/m³ for ozone and 2800 pCl/m³ for negative ions. When the ozonator shuts off, ozone and negative ions persist at these concentrations for 15 minutes, then decline to zero within 30 minutes. Equations of change in concentrations of ozone and negative ions molecules in the profiles of movement of air mass of the ozonator jet are obtained.

**Key words:** air ozonation system, microclimate, concentrations of harmful substances and microorganisms in the air, concentrations of ions and ozone.

**For citation:** Storchevoy V. F., Storchevoy A. V., Timasheva D. D., Korolev D. I., Khayretdinova K. T. Distribution and saturation of ozone and negative ion molecules in repair and diagnostic workshops. The Bulletin of Izhevsk State Agricultural Academy. 2026; 2 (86): 186-192. (In Russ.). https://doi.org/10.48012/1817-5457_2026_2_186-192.