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# INFLUENCE OF BIOLOGICS ON THE BIOCHEMICAL COMPOSITION AND FEED VALUE MELILOTUS IN THE AKMOLA REGION

**Syzdykova G.T.,** 2nd year 8D08101 – Agronomy
GSyzdykova_37@shokan.edu.kz, https://orcid.org/0009-0003-7083-7746
**Memeshov S. K.,** Candidate of Agricultural Sciences, Associate Professor
memeshov@mail.ru, https://orcid.org/0000-0002-0749-5689
**Smailova G.T..**, Candidate of Agricultural Sciences
gulsara-smailova@mail.ru, https://orcid.org/0009-0002-8493-7820
**Kalin A.K.,** PhD
arman.kalin@mail.ru, https://orcid.org/0009-0004-2061-0137

*Sh. Ualikhanov Kokshetau University, Kokshetau, Kazakhstan*

**Annotation.** The article presents the results of research on the influence of microbial bio-preparations on the growth, development, and forage value of sweet clover (Melilotus spp.) under the conditions of risk-prone agriculture in the Akmola region. The aim of the study was to determine the effectiveness of microbiological agents in organic farming to increase crop productivity and improve the biochemical composition of plants. The field experiments were carried out on heavy loamy chernozem soils at the "Kokshetau Experimental Production Facility" LLP during 2024–2025. Modern microbial compositions were used as biological products to supply plants with available forms of nitrogen and phosphorus and to enhance their stress tolerance. The obtained results showed that the application of bio-preparations increased the nutrient content in the dry matter of sweet clover and improved growth parameters compared with the control treatment. The use of biological products in sweet clover cultivation technology enhances crop productivity, improves forage quality, and contributes to the development of environmentally sustainable agroecosystems. The conducted studies confirm the prospects of applying microbial bio-preparations as an effective and safe tool for resource-efficient agriculture in the conditions of Northern Kazakhstan.

**Keywords:** sweet clover, microbial bio-preparations, organic farming, yield, forage value, soil, nitrogen fixation, Akmola region.

**Introduction.** Under conditions of intensifying global climate change and progressive soil degradation, the implementation of sustainable agricultural technologies aimed at increasing the productivity of agroecosystems while simultaneously preserving their ecological stability is becoming increasingly important. The growing anthropogenic pressure on agricultural landscapes, a decline in humus content, and the deterioration of soil agrophysical and agrochemical properties necessitate a revision of traditional farming approaches and a transition toward environmentally oriented agricultural systems.

One of the most promising directions in the development of modern agriculture is the organic technology of forage crop cultivation, which is based on the rejection of synthetic mineral fertilizers and chemical plant protection products and their replacement with biological preparations and agroecological practices. This approach contributes to reducing negative environmental impacts, enhancing soil biological activity, and forming sustainable agroecosystems.

Current trends in agricultural production are focused on the widespread adoption of environmentally safe and resource-efficient technologies, among which organic farming occupies a key position as an important factor in ensuring food security, conserving natural resources, and producing environmentally friendly agricultural products. Under conditions of intensified livestock production and increasing requirements for the quality of the feed base, the search for and implementation of effective biological methods for forage crop cultivation becomes particularly relevant.

In this context, scientific and practical interest in leguminous forage crops is increasing, particularly in sweet clover (*Melilotus spp.*), which is characterized by high forage and energy value, good adaptation to arid conditions, resistance to adverse environmental factors, and the

ability to form substantial biomass. An important biological feature of sweet clover is its capacity for symbiotic fixation of atmospheric nitrogen through interaction with root nodule bacteria, which contributes to improving the soil nitrogen regime and enhancing soil fertility. [1].

One of the priority directions of sustainable agriculture is the use of biological products—microbial agents that improve soil structure and fertility, stimulate plant growth, and enhance plant stress tolerance [2]. The application of such preparations reduces dependence on mineral fertilizers and chemical plant protection agents, while simultaneously increasing yield and improving forage quality [3].

Under the conditions of risk-prone agriculture in the Akmola region, the use of microbial bio-preparations in sweet clover cultivation is of particular importance. However, despite the growing interest in this topic, comprehensive scientific data on the effects of microbial preparations specifically on sweet clover remain limited [4].

Studies conducted by various researchers confirm the effectiveness of microbial preparations in the cultivation of leguminous crops. Seed inoculation of leguminous forage crops with active strains of nodule bacteria is a low-cost reserve for increasing yield and improving soil fertility. Effective forms of nodule bacteria on the roots of yellow sweet clover (*Melilotus officinalis*) are capable of fixing up to 300 kg/ha of nitrogen per year. According to the studies of Alborov P. V., the research results revealed that the highly effective strain of rhizotorphin 425a is suitable for seed inoculation of yellow sweet clover under the ecological conditions of the forest-steppe zone of the North Caucasus. This strain promotes more intensive formation of root nodules and enhances atmospheric nitrogen fixation, with nitrogen fixation volumes reaching 168 kg/ha already in the first year of plant growth. Improved availability of biologically fixed nitrogen had a positive effect on plant growth and development. Pre-sowing inoculation of yellow sweet clover seeds with various rhizotorphin strains also contributed to an increase in the number of stems and branches per plant. Inoculation of seeds before sowing with industrial rhizotorphin strains resulted in increased yield and protein productivity of yellow sweet clover stands. Crops established from inoculated seeds significantly outperformed the control variant, providing substantial increases in green mass yield ranging from 0.93 to 3.26 t/ha, or 6.1–21.3% higher than the control. The highest yield (18.1 t/ha) was obtained when seeds were inoculated with the 425a strain. Inoculation of seeds with rhizotorphin strains 404b, 413, and 425a increased protein yield by 0.7–2.02 c/ha and dry matter yield by 11–42%. Therefore, pre-sowing inoculation of yellow sweet clover seeds with rhizotorphin strain 425a contributes to the formation of a powerful symbiotic apparatus and enhances its productivity.

For example, according to Kalin A.K., the use of *BioSleepBW* and *Foliar* on alfalfa increased the phosphorus, nitrogen, fat, and digestible protein content in plants, while decreasing fiber content, which improved forage value [5]. In the experiments of A.N. Artyushchenko, the combination of *Azotovite* and *Bactophosphine* increased alfalfa plant height by 5–6 cm, raised leafiness to 57.7%, and increased protein content to 2.32% compared to the control treatment [6].

The application of microelement fertilizers *(Micromax, Microel)* and microbial preparations on perennial legumes also contributed to an increase in leaf biomass and yield [7]. It has been established that active strains of Rhizotorphin used for the inoculation of yellow sweet clover seeds are capable of fixing up to 300 kg/ha of atmospheric nitrogen. Strain 425a showed the highest efficiency, increasing green mass yield up to 18.1 t/ha and improving protein content [8].

According to the data of vegetative and field experiments conducted by Ovsienko O. L., the application of bacterial preparations was found to have a positive effect on the growth and development of white sweet clover plants. Under vegetative experimental conditions, the use of the biopreparation Phosphoenterin resulted in an increase in the height of inoculated plants by 8% and an increase in biomass by 10% compared with the non-inoculated control. Seed treatment with the nodule bacterium strain Sinorhizobium meliloti contributed to a 14% increase in plant height and a 12% increase in biomass relative to the control variant. The most pronounced positive effect was obtained with the combined inoculation of seeds using Phosphoenterin in combination with the strain Sinorhizobium meliloti D-17, which led to an increase in plant height by 17% and biomass

accumulation by 21% compared with the control [9].

At Veletsk State University (Russian Federation), under the guidance of R. V. Shchuchka, studies were conducted to evaluate the effectiveness of the growth biostimulants Polishans and EnergoShans in soybean cultivation. The biostimulant Polishans is an organo-mineral fertilizer based on marine algae, containing an optimally balanced complex of macro- and microelements. Its application is characterized by high environmental safety and contributes to improved field germination of seeds, enhanced growth and development of the root system, and increased plant resistance to phytopathogens.

The biostimulant EnergoShans contains polysaccharides, betaines, glucosides, and trace elements derived from marine algae and is mainly used for pre-sowing seed treatment of cereal and leguminous crops. Both products exhibit pronounced growth-stimulating properties and have a comprehensive effect on plant growth and development.

According to the results of the experiments, during the pre-sowing seed treatment stage, EnergoShans demonstrated the highest effectiveness, increasing the measured parameters by 2.8 times compared with the control. Meanwhile, during plant treatment in the vegetative growth period, the biostimulant Polishans showed a more pronounced positive effect, exceeding the control in efficiency by 2.9 times [10].

Thus, microbial bio-preparations represent an effective tool for increasing the productivity and forage value of sweet clover. Their application improves the biochemical composition of plants, increases protein and nutrient content, and strengthens the ecological sustainability of agrocenoses.

**Materials and methods.** Field experiments were conducted in 2024–2025 at the Kokshetau Experimental Production Facility LLP, Akmola Region, Zerenda District, Shagalaly village. The soil is classified as typical chernozem with a humus layer depth of 24–26 cm and a humus content of 4.0%. The content of nitrate nitrogen in the arable soil layer was 3.2 mg, phosphorus 8.7 mg, and potassium 35.2 mg per 100 g of soil, indicating moderate nitrogen supply, low phosphorus availability, and high potassium levels. The soil texture is heavy loam, with a bulk density of 1.2 g/cm³ in the arable horizon and 1.29 g/cm³ on average in the one-meter layer.

Laboratory studies were conducted in accordance with GOST 12038-84 for determining seed vigor in forage crops. Field experiments were arranged in a three-replicate randomized design. Standard regional agronomic practices were applied. The experimental plot size was 20 m². The preceding crop was clean fallow. Sowing was carried out on May 17 using a hand-held RS-1 seeder, with a sowing depth of 1.5–2.5 cm. Row and wide-row planting methods were used, with row spacing of 70 cm. The seeding rate for sweet clover under the wide-row method was 5.0 kg/ha.

Foliar application of microbial bio-preparations (2–3 L/ha) during the flowering stage was carried out according to the experimental scheme:

1 – Control

2 – BioSleep BW + *Tekamin Max*

3 – Orgamica S + *Tekamin Max*

4 – *Tekamin Max*

5 – *Pseudobacterin-3 (liquid) + QadamFerti Unileaf 4×5*

6 – *BioSleep BT + QadamFerti Unileaf 4×5*

The biochemical composition and forage nutritional value were analyzed in the certified Laboratory of Biochemistry and Forage Quality Assessment, A.I. Baraev Research and Production Center LLP, Nauchny settlement, Baraev Street 15, Shortandy District (Accreditation Certificate No. KZ.T.03.1538, issued on June 18, 2020).

Weather data from the Shagalaly meteorological station for 2024–2025 indicate that the study period was characterized by a temperate continental climate with pronounced seasonal fluctuations in temperature and precipitation.

In 2024, the total precipitation amounted to 383.5 mm. Most of the precipitation occurred during the warm period (May–August), when more than 250 mm fell. The mean air temperature for the year was +3.3 °C, with a cold winter (−14…−15 °C in January–February) and a relatively warm summer season (+19…+21 °C). In 2025, from January to September, the total precipitation

amounted to 290.3 mm, which is slightly below the long-term average. The mean temperature for this period was +7.7 °C, indicating warmer conditions compared to the previous year.

**Table 1 – Weather data of the Shagalaly post for 2024-2025**

| Month | Precipitation, mm | Air temperature, °From |
|---|---|---|
| **1** | **2** | **3** |
| 2024 | | |
| January | 30.6 | -14.3 |
| February | 8.6 | -14.9 |
| March | 10.5 | -5.9 |
| April | 18.6 | +8.2 |
| May | 65.1 | +9.1 |
| June | 65.0 | +20.9 |
| July | 67.5 | +19.5 |
| August | 56.0 | +17.1 |
| September | 21.8 | +10.5 |
| October | 15.5 | +2.9 |
| November | 15.8 | -5.1 |
| December | 8.5 | -8.2 |
| Total | 383.5 | +3.3 |
| 2025 | | |
| January | 12.9 | -10.1 |
| February | 2.6 | -9.3 |
| March | 10.9 | -2.8 |
| April | 39.9 | 9.3 |
| May | 13.0 | 15.3 |
| June | 73.0 | 19.1 |
| July | 45.7 | 19.0 |
| August | 51.5 | 16.7 |
| September | 40.8 | 11.7 |
| Total | 290.3 | +7.7 |

Precipitation during the autumn–winter period (September–March) served as the main source of productive soil moisture accumulation; however, its amount was insufficient relative to the multi-year climatological norm, which could have resulted in a certain moisture deficit at the beginning of the spring vegetation period of crops.

**Results and Discussion.** Along with mineral and organic fertilizers, biological products are becoming increasingly important worldwide for improving crop productivity. Their application is justified by low cost, high efficiency, and environmental safety, making them an integral component of modern agricultural technology [12].

To supply plants with essential mineral nutrients, Organit P and Organit N were applied, which enhance the bioavailability of phosphorus and potassium and improve nitrogen nutrition. Growth stimulants Fertigrain Start CoMo, Tecamin Max, and Yield On were also used. Fertigrain Start CoMo provides seeds with nitrogen and micronutrients, increases germination energy, stress tolerance, and inoculation efficiency. Tecamin Max, formulated with amino acids and vitamins, activates growth processes and enhances plant resistance to adverse environmental factors. Yield On stimulates cell division, nutrient transport, and contributes to increased yield.

For leguminous crops, the biostimulant Biodux was applied for seed treatment and during the growing season. It promotes root system development, improves nutrient uptake, and enhances plant resistance to diseases [13].

Plant protection against fungal and bacterial infections was provided by the biofungicides Orgamica S and Pseudobacterin-3, which exhibit strong antagonistic and growth-promoting activity. To control insect pests, the bioinsecticides BioSleep BW and BioSleep BT were used. The

former is effective against a wide range of phytophagous insects, while the latter is a stomach-acting agent providing up to two weeks of protective effect. The integrated application of these biological products improves nutrition, growth processes, plant tolerance, and increases crop productivity [14, 15]. The use of biological products in sweet clover crops contributed to an increased nutrient content in the dry biomass compared to the control.

**Table 2 – Biochemical Composition and Nutritional Value of Melilotus**

| Name | of NFE | Nutritional value 1 kg. perear | | |
|---|---|---|---|---|
| | | Digested protein, % | Exchange energy, MJ | Feed units, kg/kg |
| | Method of TsINAO 2002 (green feed) | | | |
| *Melilotus albus* Sretensky grade 1 | | | | |
| Control - without treatment | 52.65 | 9.17 | 10.40 | 0.877 |
| BioSleep BW + Tecamine Max | 53.94 | 10.14 | 10.89 | 0.961 |
| Orgamica S + Tecamine Max | 54.4 | 11.41 | 11.21 | 1.018 |
| Tecamine Max | 55.24 | 10.14 | 11.21 | 1.018 |
| Pseudobacterip-3, W - + QadamFerti Unileaf 4*5 | 53,02 | 10,77 | 10,83 | 0,949 |
| BioSleep QadamFerti Unileaf10,83 0,949 BioSleep BW QadamFerti Unileaf 4*5 | 54,32 | 11,74 | 11,22 | 1,019 |
| *Melilotus officinalis* variety Omsk early Ripening | | | | |
| Control-without treatment | 53.19 | 10.09 | 10.83 | 0.951 |
| BioSleep BW + | 52.53 | 11.05 | 10.93 | 0.967 |
| Tecamine Max | | | | |
| Orgamica S + Tecamine Max | 53.41 | 9.45 | 10.63 | 0.915 |
| Tecamine Max | 53.86 | 11.05 | 11.23 | 1.021 |
| Pseudobacterip-3, W - + | 53,16 | 11,05 | 10,97 | 0,974 |
| QadamFerti Unileaf 4*5 | | | | |
| BioSleep BW QadamFerti Unileaf 4*5 | 52,55 | 11,69 | 11,27 | 1,029 |

The data presented in the table demonstrate the effect of various biological preparations on the content of nitrogen-free extractives (NFE) and the nutritional value of the dry matter of Melilotus albus and Melilotus officinalis. It was found that the treatment of plants with biological preparations contributed to an increase in NFE content compared with the control. In M. albus, the maximum NFE value (55.24%) was recorded when using Tecamin Max, exceeding the control (52.65%) by 2.59%. A similar trend was observed in M. officinalis, where the NFE content ranged from 52.53% to 53.86%. The use of biological preparations also had a positive effect on the feed nutritional value. In M. albus, the highest digestible protein content (11.74%) and metabolizable energy (11.22 MJ/kg) were obtained with the combined application of BioSleep BW and QadamFerti Unileaf 4*5, corresponding to 1.019 feed units (F.U.) per kg of dry matter.

In M. officinalis, the highest nutritional indicators were also observed under the treatment with BioSleep BW + QadamFerti Unileaf 4*5, where digestible protein reached 11.69%, metabolizable energy 11.27 MJ/kg, and feed units amounted to 1.029 F.U./kg. Thus, based on the obtained results, it can be concluded that the use of complex biological preparations, especially the combinations BioSleep BW + QadamFerti Unileaf 4*5 and Tecamin Max, improves the nutritional characteristics of melilot green mass by increasing the levels of NFE, digestible protein and energy value of the feed.

**Conclusions.** Thus, based on the results of the conducted studies, it was established that the treatment of sweet clover seeds with biological preparations had a pronounced positive effect on plant growth, development, and productivity formation. The application of biopreparations

contributed to the activation of physiological and biochemical processes, improvement of mineral nutrition, and increased plant resistance to unfavorable environmental factors, which collectively ensured more intensive formation of vegetative biomass.

As a result of using biological agents, a statistically significant increase in the content of nitrogen-free extractive substances, digestible protein, metabolizable energy, and feed units was observed compared to the control treatment, indicating an improvement in the nutritional and energy value of sweet clover green mass. Particularly high efficiency was recorded when using complex combinations of biopreparations BioSleep BW + QadamFerti Unileaf 4×5 and Tecamin Max, which ensured an optimal balance of major nutrients and the most favorable indicators of forage quality. The obtained results confirm the expediency of incorporating biological preparations into the technology of sweet clover cultivation as one of the key elements of organic farming. The use of biological agents makes it possible not only to increase crop yield and forage quality but also to reduce the dependence of agricultural technologies on chemical inputs, decrease anthropogenic pressure on agroecosystems, and improve the agroecological condition of soils. Overall, the introduction of biological preparations into sweet clover cultivation technology represents a promising direction for the formation of environmentally sustainable and productive agrocenoses under the conditions of the Akmola region and may also be considered an effective tool for enhancing the economic and environmental efficiency of forage production in areas of risky farming.

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# БИОПРЕПАРАТТАРДЫҢ АҚМОЛА ОБЛЫСЫ ЖАҒДАЙЫНДА ТҮЙЕЖОҢЫШҚАНЫҢ БИОХИМИЯЛЫҚ ҚҰРАМЫ МЕН АЗЫҚТЫҚ ҚҰНДЫЛЫҒЫНА ӘСЕРІ

**Сыздыкова Г.Т.,** 8D08101 – Агрономия ББББ-ның 2-курс докторанты
**Мемешов С.К.,** ауыл шаруашылығы ғылымдарының кандидаты, қауымдастырылған профессор
**Смаилова Г.Т.,** ауыл шаруашылығы ғылымдарының кандидаты
**Калин А.К.,** PhD

*Ш.Уәлиханов атындағы Көкшетау университеті, Көкшетау қ., Қазақстан*

**Аңдатпа.** Мақалада биологиялық заттардың түйежонышқа (melilotus spp.) өсуіне, дамуына және жемшөп құндылығына әсерін зерттеу бойынша зерттеу нәтижелері келтірілген.) Ақмола облысының қауіпті егіншілік жағдайында. Жұмыстың мақсаты өсімдіктердің өнімділігін арттыру және биохимиялық құрамын жақсарту үшін органикалық егіншілікте микробиологиялық агенттерді қолданудың тиімділігін анықтау болды. Эксперименттің далалық бөлігі 2024-2025 жылдары "Көкшетау тәжірибелік-өндірістік шаруашылығы" ЖШС қара топырақты ауыр сазды топырақтарында жүргізілді. Биологиялық препараттар ретінде өсімдіктерді азот пен фосфордың қол жетімді түрлерімен қамтамасыз ететін, сондай-ақ стресстік жағдайларға төзімділікті арттыратын заманауи композициялар қолданылды. Нәтижелер биологиялық препараттарды қолдану тәтті беде құрғақ массасындағы қоректік заттардың көбеюіне және бақылаумен салыстырғанда өсу қарқынының жақсаруына ықпал еткенін көрсетті. Түйежонышқа өсіру технологиясында биологиялық құралдарды қолдану мәдениеттің өнімділігін арттырады, жемнің сапасын жақсартады және экологиялық тұрақты агроценоздардың қалыптасуына ықпал етеді. Жүргізілген зерттеулер биопрепараттарды Солтүстік Қазақстан жағдайында ресурстарды үнемдейтін егіншіліктің тиімді және қауіпсіз құралы ретінде қолдану перспективасын растайды.

**Тірек сөздер**: түйежонышқа, биопрепараттар, органикалық егіншілік, өнімділік, азықтық құндылық, топырақ, азотфиксация, Ақмола облысы.

# ВЛИЯНИЕ БИОПРЕПАРАТОВ НА БИОХИМИЧЕСКИЙ СОСТАВ И КОРМОВУЮ ЦЕННОСТЬ ДОННИКА В УСЛОВИЯХ АКМОЛИНСКОЙ ОБЛАСТИ

**Сыздыкова Г.Т.,** докторант 2-курса по ОП 8D08101 – Агрономия
**Мемешов С.К.,** кандидат сельскохозяйственных наук, ассоциированный профессор
**Смаилова Г.Т**., кандидат сельскохозяйственных наук
**Калин А.К.,** PhD

[1] *Кокшетауский университет имени Ш. Уалиханова, Кокшетау, Казахстан*

**Аннотация.** В статье приведены результаты исследований по изучению влияния биопрепаратов на рост, развитие и кормовую ценность донника (Melilotus spp.) в условиях рискованного земледелия Акмолинской области. Целью работы являлось определение эффективности применения микробиологических средств в органическом земледелии для повышения урожайности и улучшения биохимического состава растений. Полевая часть эксперимента проводилась на чернозёмных тяжелосуглинистых почвах ТОО «Кокшетауское опытно-производственное хозяйство» в 2024–2025 гг. В качестве биологических препаратов использовались современные композиции, обеспечивающие растения доступными формами азота и фосфора, а также повышающие устойчивость к стрессовым условиям. Полученные результаты показали, что применение биопрепаратов способствовало увеличению содержания питательных веществ в сухой массе донника и улучшению показателей роста по сравнению с контролем. Использование биологических средств в технологии возделывания донника обеспечивает повышение продуктивности культуры, улучшает качество корма и способствует формированию экологически устойчивых агроценозов. Проведённые исследования подтверждают перспективность применения биопрепаратов как эффективного и безопасного инструмента ресурсосберегающего земледелия в условиях Северного Казахстана.

**Ключевые слова**: донник, биопрепараты, органическое земледелие, урожайность, кормовая ценность, почва, азотфиксация, Акмолинская область.