RESEARCH ARTICLE AGROBIOLOGICAL RECORDS
ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

THE INFLUENCE OF EFFECTIVE MICROORGANISMS ON SOIL IN DIFFERENT CLIMATIC CONDITIONS OF AZERBAIJAN

Kamala Alizada Seyfaddin [1], Gulnar Aliyeva Rahim [1], Lala Bunyatova Novruz [1], Aida Gahramanova Yarish [1], Gulnara Alakbarli Yashar [1], Vafa Mammadzada Telman [2], Rena Mirzezadeh Islam [2], Turkan Hasanova Allahverdi [3,*] and Gunay Mammadova Israphil [1,2]

[1]Sumgayit State University, Sumgayit, Republic of Azerbaijan
[2]Institute of Geography Public Legal Entity, Baku, Republic of Azerbaijan
[3]Baku State University, Faculty of Ecology and Soil Science, Baku, Republic of Azerbaijan

*Corresponding author: turkanhesenova@mail.ru

ABSTRACT

The study aimed to investigate the impact of the microbiological preparation EM-1 on soil and the yield of crops of national importance. For the first time in the Republic of Azerbaijan, authorization was obtained to apply this product on experimental plots within perennial crop plantations. The study evaluated the efficacy of the soil-applied microbial product (5 L/ha) on the phytosanitary status, fertility, and yield of spring wheat (cv. "Gyzylgul") and soybean. During the trials, the product significantly suppressed the soil-borne pathogen *Bipolaris sorokiniana*: conidial counts were 1.5 times lower than in the control, and biological efficacy ranged from 32.9% to 42.5%. Soil application of the product promoted nutrient accumulation, increasing N-NO3 content to 29.2 mg/kg (2.5 times higher than the control).

***Keywords*:** Soil biological activity, *Bipolaris sorokiniana, Soil* nutrients.

Article History: ABR-26-369 || Received: 22-Sep-2026 || Revised: 12-Oct-2026 || Accepted: 31-Oct-2026 || Published Online: 20-Nov-2026

This is an open-access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. INTRODUCTION

Microorganisms play a fundamental role in soil formation and plant nutrition through their immense enzymatic activity, which drives the cycling of organic and inorganic substances. Total biogenicity refers to the total count of detected microorganisms; it reflects the aggregate impact of active soil microflora on the microbiological conditions for plant growth and indicates the soil's biological activity. Higher microbial species diversity indicates ecosystem stability, the provision of necessary nutrients to plants, and the soil's ability to cleanse itself and maintain ecological balance (Alieva & Mammadova, 2023; Akbarova & Mammadova, 2024; Akhundova et al., 2025). Various factors influence soil microbial activity, including organic matter content, acidity, and soil physical properties. Soils always have a reserve of microbes that are not provided with organic matter and other nutrients. The size of the pool depends less on random fluctuations in temperature, humidity, and the supply of plant residues, and more on soil type and its inherent physical and chemical properties. The main groups of soil microorganisms are represented by actinomycetes, micromycetes and bacteria. The ecological role of actinomycetes most often lies in decomposing complex, stable organic substrates, as well as in synthesizing and accumulating humic substances responsible for fertility (Bahram et al., 2025; Allahverdi et al., 2026; Ahmad et al., 2026). Soil fungi are an ecological group of organisms involved in mineralizing plant and animal organic residues and forming humus. With a potent enzymatic system, they actively transform nitrogen compounds under aerobic conditions and help improve soil structure. During their metabolic activity, fungi secrete various physiologically active substances-such as enzymes, organic acids, vitamins, antibiotics, and toxins-that influence the development of other microorganisms and higher plants (Huseynova, 2022; Gahramanova et al., 2026; Alakbar et al., 2026). Bacteria constitute a significant portion of the soil microbial community. Their abundance reaches several million per gram of soil. This group of soil microorganisms plays an active role in the transformation of soil organic matter (OM), following micromycetes at later stages. A continuous turnover and renewal of the entire living biomass takes place in the soil. By the most conservative estimates, the entire microbial mass regenerates 14–18 times over the course of the summer. Thus, the total microbial production of the arable soil horizon during the growing season amounts to tens of tons of living biomass per unit area (Zafar et al., 2021; Gumbatov et al., 2024).

This consortium comprises mutually complementary groups: Photosynthetic bacteria, which synthesize amino acids, sugars, and beneficial substances from sunlight and soil heat; Lactic acid bacteria, which produce lactic acid a potent sterilizing agent that inhibits the growth of harmful fungi and pathogens; Yeasts, which produce growth

Citation: Seyfaddin, K.A., Rahim. G.A., Novruz. L.B., Yarish. A.G., Yashar, G.A., Telman, V.M., Islam, R.M., Allahverdi, T.H., & Israphil, G.M. (2026). The influence of effective microorganisms on soil in different climatic conditions of Azerbaijan. Agrobiological Records, 26, 298-308. https://doi.org/10.47278/journal.abr/2026.102

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

hormones (auxins, cytokinins) and enzymes that stimulate root cell division; Actinomycetes (filamentous bacteria), which secrete natural antibiotics that suppress pathogenic bacteria; and Fermenting fungi (including mycorrhizae), which break down complex organic matter (such as cellulose), making it available to plants. Applying the product triggers a chain reaction in the soil: Competitive exclusion over 80 strains of beneficial microbes instantly colonize the rhizosphere (root zone) and effectively "out-eat" pathogens, depriving them of nutrients and living space. Production of antibiotic substances beneficial microbiota secrete enzymes and siderophores (iron-binding compounds that make iron unavailable to harmful fungi), leading to the destruction of pathogens causing root rot, Fusarium wilt, late blight, and other diseases. Nutrient mobilization bacteria convert hard-to-absorb P, K, and N from the soil into chelated forms that are readily accessible to the roots (Huseynova, 2023; Hasanova & Mammadova, 2023; Ismayilova et al., 2025a; 2025b; Ibrahimova, 2025; Ikhtiyar et al., 2026).

Active microbial communities play a key role in maintaining soil's natural ability to heal and cleanse itself. High microbial diversity indicates a stable ecosystem that efficiently provides nutrients to plants while maintaining ecological balance. The use of specialized microbiological fertilizer increases the biological activity of the soil by increasing the number of beneficial microbiota. This effect suppresses pathogens and opportunistic microflora and also strengthens plant immunity, which already within one season leads to increased yields and improved product quality (Nasirova, 2023; Hasanova & Abasova, 2024).

The effectiveness of this biofertilizer, containing a diverse consortium of more than 80 strains of microorganisms and fungi, has been proven in various climatic conditions (it is a multi-purpose biological product based on effective microorganisms (EM)). The mixture is based on lactic acid and photosynthetic bacteria, as well as yeast, it also contains important functional groups: nitrogen fixers, phosphate-mobilizing and cellulose-decomposing microorganisms, nitrifiers, ammonifiers, oil-oxidizing bacteria, actinomycetes and plant growth regulators. The action of the consortium is not limited to the simple introduction of introduced microorganisms: it stimulates and directs the activity of the already existing soil microbiome. This targeted effect accelerates the formation of humus, promotes the growth of biological diversity and significantly increases the productivity of agricultural crops. When there is a lot of salt around a microbe, water, according to the laws of physics, begins to leave its cell to the outside (the process of plasmolysis). The cell shrinks and dies or slows down its metabolism to a minimum (Hasanova & Mammadova, 2023; Mammadova et al., 2025; Macnunlu et al., 2025; Hasanova et al., 2026). The relationship of microbiological fertilizers to soil salts is twofold: on the one hand, a high concentration of salts inhibits most bacteria, on the other hand, specialized salt-tolerant biological products are an effective tool for combating soil salinization and reducing salt stress in plants. Unlike non-specialized microbiological fertilizers which are extremely sensitive to increased salt content (especially Cl^-, SO_4^{2-} and Na_2CO_3), the fertilizer used has proven that it is suitable for different crops (Mirismayil, 2025; Mammadova et al., 2026a; 2026b).

2. MATERIALS AND METHODS

The Zaqatala District is located in the northwestern part of the Republic of Azerbaijan, in the Ganikh-Ayrichay Valley on the southern slopes of the Greater Caucasus Range. The terrain is mountainous in the north and northeast, and flat in the south and southwest. Elevations range from approximately 200–600 m in the plains to 3,648 m in the mountainous areas (41°33′ N, 46°43′ W) (Fig. 1A and B).

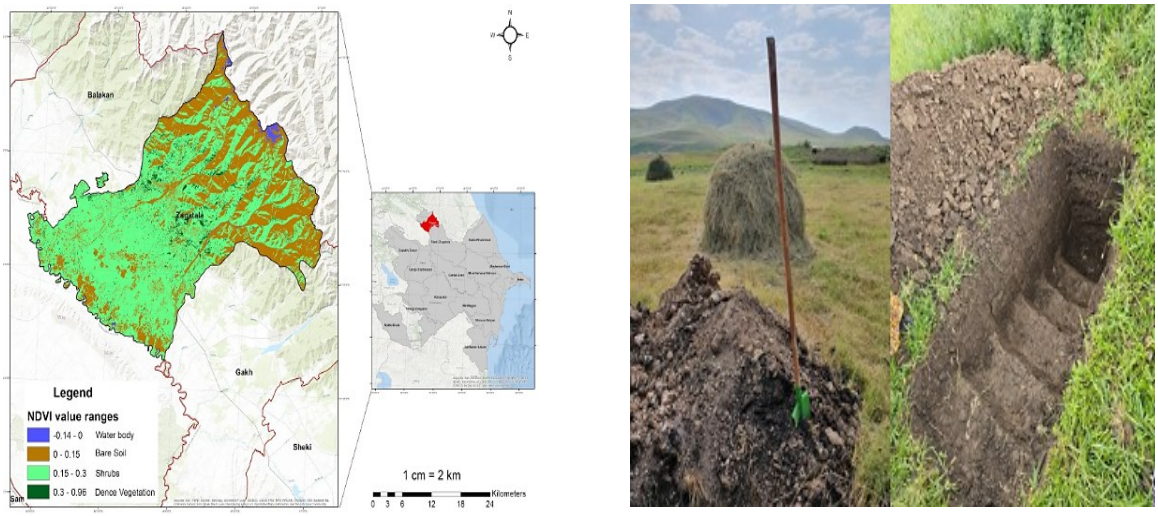


Fig. 1: Stude area Zagatala region in Republic of Azerbaijan (A); Soil studies in field (B); Note: by author T. A. Hasanova in 2023 year.

Citation: Seyfaddin, K.A., Rahim. G.A., Novruz. L.B., Yarish. A.G., Yashar, G.A., Telman, V.M., Islam, R.M., Allahverdi, T.H., & Israphil, G.M. (2026). The influence of effective microorganisms on soil in different climatic conditions of Azerbaijan. Agrobiological Records, 26, 298-308. https://doi.org/10.47278/journal.abr/2026.102

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Sampling scheme: The "envelope" method or a Z-shaped (diagonal) grid pattern is used. Sampling points are marked out on each plot to capture the site's variability as fully as possible. Number of samples: Spot samples are collected from 5–10 points within the plot, extending to the depth of the arable layer (0–30 cm). These spot samples are combined into a single composite sample weighing approximately 1–1.5 kg (prepared separately for each plot) (Li et al., 2023). Sample preparation: A representative sample (approx. 300 g) is obtained from the composite sample using the quartering method. For microbiology: The soil is sieved through a 2 mm mesh, cleared of roots, and stored at +4°C (analysis within 24–48 hours) or used fresh. For agrochemistry: The soil is air-dried. The number of microorganisms per gram of absolutely dry soil is calculated using the formula: $CFU=N\cdot10^{a}/V\cdot K$; N - average number of colonies per Petri dish; 10^{a} - dilution factor (e.g., 10^{4}; V - volume of suspension applied to the dish (usually 0.1 or 1.0 ml); K^{m} - soil moisture factor (accounts for conversion to an absolutely dry sample weight) (Maharram et al., 2024; Gahramanova et al., 2026). Methods for the identification and enumeration of bacteria – Enumeration: Plates containing between 30 and 300 colonies are counted. Identification: Assessment of colony morphology. Gram staining is performed to determine tinctorial properties and cell shape via microscopy. Methods for the identification and enumeration of actinomycetes Enumeration: Characteristic dense, leathery or radially folded colonies often growing into the agar are counted. Identification: Microscopy of aerial and substrate mycelia; assessment of spore chain structure. Specific quantification of *Bipolaris sorokiniana* (the causative agent of helminthosporiosis): Flotation method (Kononova or Tyulin): To directly quantify conidia in the soil, spores are recovered by washing through a sieve system or by centrifugation in sucrose solutions, followed by counting the conidia in a Goryaev chamber. Selective medium plating method: Identification is based on colony characteristics - they are fast-growing, dark olive to almost black, and have a velvety texture. Under the microscope, the conidia appear large, dark brown, and spindle-shaped, with 2-9 transverse septa; they germinate only from the polar cells (a characteristic feature of the genus *Bipolaris*). Determination of OM – Tyurin method (GOST 26213); Determination of $N\text{-}NO_3$ ionometric method (GOST 26951) (Zafar et al., 2023; Karimova & Hasanova, 2025; Safeer et al., 2026; Sadigov et al., 2026; Samadov et al., 2026).

The research structure comprised three independent experiments involving different application protocols for the microbiological product:

1. Experiment 1 (Rates of 6 and 20 L ha^{-1}): Evaluation of residual and direct effects on soybean and spring wheat crops.
2. Experiment 2 (Rate of 5 L ha^{-1}): Continued monitoring of efficacy involving three applications within the spring wheat production cycle (2024–2025).
3. Experiment 3 (Rate of 3 L ha^{-1}): Research program on bare fallow (2024) followed by spring wheat sowing.

In order to determine the effect of the microbiological fertilizer on soil biogenicity. Studies were carried out on soil biogenicity over three years (2023–2025), which were due to the fact that there is a complex form of connection between individual elements of technology, their combinations and the activities of different groups of microorganisms that transform various organic substances in the soil (Mirzezadeh et al., 2025a; Yelmarli, 2026). The main groups of microorganisms include lactic acid bacteria, photosynthetic microorganisms, and yeasts. In addition, the composition comprises nitrogen-fixing bacteria, yeasts, plant growth regulators, soil acidity regulators, ammonifiers, hydrocarbon-oxidizing bacteria, nitrifying bacteria, bacterial growth regulators, phosphorus-mobilizing bacteria, cellulose-degrading bacteria, actinomycetes, and fungi (Mammadova et al., 2025; Makki et al., 2025). The consortium functions not only by replenishing the soil microflora but also by stimulating and directing the microorganisms already present in the soil to maintain ecological balance. The experiments were carried out on a field located in a land use area dominated by dark brown, medium-humus, heavy-loamy soil. The humus content in the arable horizon is 5.2%. Structural condition – good; content of water-resistant aggregates (0.25–10 mm) 65-73%. Soil density is optimal for cultivated soil and for most crops cultivated in this zone - 1.02–1.17 g/cm^3. The capillary moisture capacity is optimal and is 41%, total - 47%. Data from a location near the experimental fields were used to characterize soil temperature and moisture conditions. Weather conditions in 2023 were unfavorable for crop cultivation due to severe drought. Average monthly temperatures in April and May exceeded long-term averages. Low precipitation in May and high temperatures had an adverse effect on crop emergence. Weather conditions in 2024–2025 were more favorable than in 2023 (Mammadzada et al., 2025; Samadov et al., 2026; Khudaverdi et al., 2025). Higher precipitation and moderate temperatures during this period facilitated the initiation of soil restoration and purification processes following the application of the test product. A single 100-hectare field was selected for the experiment, with the test crop and the preceding crop rotated annually. In the first year, application rates for the product were 3 and 6 l/ha across the experimental variants (with a working solution application rate of 300 l/ha). In 2024 and 2025, these rates were increased to 6 and 20 l/ha, respectively (Macnunlu et al., 2025; Mirzezadeh et al., 2025b).

Multifactorial analysis of variance (ANOVA) structured in strict accordance with the original experimental design is used to assess the significance of the effects of the factors under study on soil microbiological parameters (CFU group counts, *Bipolaris sorokiniana* population density) and agrochemical indicators (OM content, $N\text{-}NO_3$.

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

The analysis is based on an experimental setup featuring four replicates (n = 4) and a randomized plot layout within each block to minimize the impact of spatial soil heterogeneity. Prior to ANOVA, the raw data are checked against key statistical criteria: normality of residual distribution and homogeneity of variances. Mathematical processing, assumption testing, and analysis of variance are performed using the Statistica v. 13.5.0 statistical software package. Initial data aggregation, calculation of standard errors of the mean, and visualization of results are carried out using Microsoft Excel 2021. The significance level of the obtained results (P) did not exceed 0.05 (Nazim & Oqtay, 2024; Zafar et al., 2024; Nazim et al., 2025; Mammadova et al., 2026c).

3. RESULTS

The application of EM-1 resulted in a slight reduction in micromycete counts, particularly in the 6 l/ha treatment group. This is likely attributable to the fact that the preparation consists primarily of bacterial microflora, the activity of which contributed to a decrease in mold fungi populations (Table 1). The results of the microbial population count at the second sampling date showed that the stimulating effect of the preparation, observed at the first sampling date, persisted. This was particularly evident in the soybean crop. Total soil biological activity under soybean crops was nearly twice as high with the application of the preparation at a rate of 6 l/ha compared to the control, and four times higher at a rate of 20 l/ha (Table 2). The abundance of microscopic fungi varied only slightly across the experimental treatments; the exception was the spring wheat crop, where an increase in abundance was observed following the application of the preparation at rates of 6 and 20 l/ha specifically, a 1.5-fold and 1.8-fold increase, respectively (Table 3). The total level of phytopathogen infestation was 22.8% including 8.5% for root rots which is below the economic injury threshold. The seeds were free from common bunt. Research into the efficacy of applying a microbiological preparation to the soil continued in 2025. In May, the preparation was again applied to the same field specifically to the treatment plot receiving fertilizer at a rate of 5 д/ha, five days prior to spring wheat sowing. By September, in the control plot (where no preparation was applied to the soil), the count of root rot conidia had risen to 149 per gram of soil. N-NO_3 levels increased to 11.6 mg/kg over the growing season, and the OM content stood at 2.8%. In the plot where the preparation was applied for the third time (before sowing spring wheat), soil infestation by the phytopathogen *Bipolaris sorokiniana* also increased, reaching 100 conidia per gram of soil (remaining at a critical level). The total number of pathogen conidia was 1.5 times lower than in the control (Table 4 and 5). The biological efficacy was 32.9%. The N-NO_3 level accumulated over the season was 29.2 mg/kg, which is 2.5 times higher than the control value. Applying the preparation to the soil both on fallow land in 2024 and prior to sowing spring wheat suppressed the pathogen load responsible for helminthosporium root rot in cereal crops. Two applications on fallow land reduced the count of *Bipolaris sorokiniana* conidia by nearly half, achieving a biological efficacy of 42.5%. Soil application of the preparation five days before sowing spring wheat the following year further suppressed the pathogen population by a factor of 1.5, with a biological efficacy of 32.9%. As expected, the control variant, where the preparation was not applied during 2024–2025 yielded 45 c/ha of spring wheat (Table 6). Incorporating this preparation into the crop protection system via soil application (twice on fallow land and once before sowing the following year) at a rate of 5 l/ha increased productivity to 57.3 c/ha; this is 12.3 c/ha higher than the control (a yield increase of 27.3%).

Table 1: Experimental design for the application of EM-1 with four replicates in the Absheron region over the 2023–2025 period

Experience indicators	2023			2024			2025		
	I	II	III	I	II	III	I	II	III
Predecessor	SW	L	S	L	C	S	WW	S	SW
Current crop	L	S	C	WW	S	SW	S	SW	Sf
Control	-	-	-	-	-	-	-	-	-
1 l/ha	3	3	3	6	6	6	6	6	6
2 l/ha	6	6	6	20	20	20	20	20	20

Note: L – lentils; S – soybean; Sf – sunflower; SW - spring wheat; WW – winter wheat; C – corn.

On lands with a shallow water table containing saline groundwater, an inverse relationship was observed between salt accumulation and organic matter content in the topsoil, and a significant effect of salt leaching on organic matter was also noted (Fig. 2).

Linear Regression Analysis: Used to determine the mathematical relationship and trendline between the independent and dependent variables (Fig. 2). Correlation Analysis R^2: The coefficient of determination R^2 measures how well the regression line represents the data. Fig. 2A shows a very strong fit of $R^2 = 0.94$. Fig. 2B shows a strong fit of $R^2 = 0.86$. Significance Testing p -value: Indicated by the asterisks (**), demonstrating that the correlation is statistically significant at a level of $P \leq 0.05$. Independent Variable (X): Organic matter content in topsoil (%). Dependent Variable (Y): For 2A: Salt accumulation percentage (%) For 2B: Salt leaching percentage (%) Negative Linear Correlation (Fig. 2A): $Y = 723.8 - 288.9X$; Positive Linear Correlation (Fig. 2B): $Y = 31.0 + 23.1X$.

Citation: Seyfaddin, K.A., Rahim. G.A., Novruz. L.B., Yarish. A.G., Yashar, G.A., Telman, V.M., Islam, R.M., Allahverdi, T.H., & Israphil, G.M. (2026). The influence of effective microorganisms on soil in different climatic conditions of Azerbaijan. Agrobiological Records, 26, 298-308. https://doi.org/10.47278/journal.abr/2026.102

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Table 2: The influence of microbiological fertilizer on the total biogenicity of the soil depending on the application dose and the crop grown

Application rates of the product	Bacteria	Actinomycetes	Micromycetes	Total Biogenicity
Microorganism count in the 0–30 cm soil layer (1st sampling date)				
Soybean				
Control	35.25	3.97	0.00132	39.22
3 l/ha	36.94	3.44	0.00086	42.64
6 l/ha	63.11	5.61	-	68.72
Lentil				
Control	29.39	1.84	-	31.23
3 l/ha	38.64	2.22	0.00178	41.04
6 l/ha	36.91	4.39	0.00088	41.39
Corn				
Control	41.77	3.75	-	45.52
3 l/ha	47.47	1.34	0.00045	42.81
6 l/ha	47.86	1.84	-	49.70
0–30 cm soil layer, CFU/g soil ·10³ 1st determination period in 2024 May, 19				
Soybean				
Control	5.178	1.430	28	6.635
6 l/ha	4.335	2.023	26	6.385
20 l/ha	4.815	3.413	21	8.249
Spring wheat				
Control	4962	2932	29	7923
6 l/ha	6677	3986	19	10682
20 l/ha	7043	3570	23	10635
Winter wheat				
Control	5197	3042	24	8263
6 l/ha	4997	2984	20	8001
20 l/ha	5584	3278	19	8881
0–30 cm soil layer, CFU/g soil ·10³ 2nd determination period in 2025 May, 12				
Soybean				
Control	2071	2318	18	4406
6 l/ha	2746	4913	21	7690
20 l/ha	5 002	13558	14	18575
Spring wheat				
Control	2123	1592	39	3753
6 l/ha	2481	1894	30	4406
20 l/ha	2591	3687	10	6288
Winter wheat				
Control	1920	1278	24	3222
6 l/ha	2347	2098	17	4462
20 l/ha	2680	5035	21	7736
0–30 cm soil layer, CFU/g soil ·10³ 3rd determination period in 2025 August, 05				
Soybean				
Control	3994	1358	41	5392
6 l/ha	4471	1357	28	5857
20 l/ha	9584	3168	18	12770
Winter wheat				
Control	3676	1141	19	4835
6 l/ha	10917	2495	20	13432
20 l/ha	11890	2083	44	14016
Sunflower				
Control	4235	2055	28	6318
6 l/ha	6909	1332	19	8260
20 l/ha	7270	1084	29	8383
0–30 cm soil layer on average for the growing season (CFU/g soil ·10³)				
Soybean				
Control	2783	1052	24	3 859
6 l/ha	3399	1862	22	5285
20 l/ha	5639	2383	24	8 046
Winter wheat				
Control	3701	1621	16	5338
6 l/ha	6888	2393	24	9306
20 l/ha	8860	1270	29	10159
Sunflower				
Control	3579	2039	26	5644
6 l/ha	5649	2053	25	7727
20 l/ha	6878	2939	29	9846

Experiment 1: Evaluation of 3 and 6 L/ha dosages (Spring 2023) – This trial assessed the impact of moderate product dosages on soil microflora. General trend: The 6 L/ha dosage produced the largest increase in overall soil biological

Citation: Seyfaddin, K.A., Rahim. G.A., Novruz. L.B., Yarish. A.G., Yashar, G.A., Telman, V.M., Islam, R.M., Allahverdi, T.H., & Israphil, G.M. (2026). The influence of effective microorganisms on soil in different climatic conditions of Azerbaijan. Agrobiological Records, 26, 298-308. https://doi.org/10.47278/journal.abr/2026.102

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Table 3: Effect of the preparation on the soil-borne root rot pathogen and on N-NO_3 and OM content in a fallow field Sheki-Zagatala economic region

Indicators	Experimental variants (Control)	Application of the product to the soil in June and July at a rate of 5 l/ha
Initial state of the field (June, 2024)		
Total number of *Bipolaris sorokiniana* conidia per 1 g of soil	90.0	
N-NO_3 мg/кg	18.0	
OM content, %	3.9	
State of the field 1 month after the 1st application of the MP (July, 2024)		
Total number of *Bipolaris sorokiniana* conidia per 1 g of soil	90.0	71.0
N-NO_3 мg/кg	11.6	7.0
State of the field (August, 2024)		
Total number of *Bipolaris sorokiniana* conidia per 1 g of soil	120.0	69.0
N-NO_3 мg/кg	<7	<7
OM content, %	3.6	3.5

Table 4: Experimental field characteristics in 2nd year of research

Indicators	Experience Options		
	Control	Applying the MP to the soil	Deviation (+, –)
Field condition (September, 2024; May, 2025)			
Total number of *Bipolaris sorokiniana* conidia per 1 g of soil	120.0 (dangerous condition)	69.0 (critical condition)	-51
N-NO_3 мg/кg	<7	<7	-
OM content, %	3.4	3.1	-0.3
State of the field (September, 2025)			
Total number of *Bipolaris sorokiniana* conidia per 1 g of soil	149.0 (dangerous condition)	100.0 (critical condition)	-49 HCP_{05} = 144.8
N-NO_3, мg/кg	11.6	29.2	+17.6
OM content, %	2.8	3.7	+0.9

Note: The preparation was applied twice to the soil of the fallow field (2024) + application 2-4 days before sowing spring wheat in 2025.

Table 5: Impact of MP applying to the soil on spring wheat yield (2nd year)

Indicators	Control	MP applying to the soil
Density of productive stem stand, pcs/m^2	1062	1133
Grain content, number of grains in an ear	22.2	34.4
Weight of 1,000 grains, g	38.0	58.6
Yield, centners/ha	45.0	57.3
Yield increase:	-	12.3 (HCP_{05} = 14.01)
centners/ha %	-	27.3

The preparation was applied twice to the soil of the fallow field (2024) + application 2-4 days before sowing spring wheat in 2025.

Table 6: Impact of MP application on growth and development of root system of soybean variety and activity of nodule bacteria

Variants	Length of the main root, cm	Mass of roots of a single plant, g	Number of nodules per plant, pcs.	Mass of nodules per plant, g
Control (untreated)	17.1	3.8	7.2	0.034
Treatment with the preparation	19.5	4.1	12.8	0.063
Growth, %	14.0	7.9	77.8	85.3

Table 7: The effect of the MP on soybean yield

Variants	Productivity at harvest humidity, t/ha	Grain moisture content at harvest, %	Productivity at standard humidity, t/ha
Control (without processing)	2.34	18	2.23
Treatment with the preparation	2.63	18	2.51 HCP_{05} = 0.15

activity. Soybeans: Showed the greatest responsiveness; biological activity increased by 75% compared to the control. Spring wheat: The effect was less pronounced; at the 6 L/ha application rate, only a slight increase in activity was recorded 17% above the control variant. Experiment 2: Evaluation of 6 and 20 L/ha dosages (Spring 2024) – Research conducted in the spring of 2024 showed that rising soil temperatures further stimulated the development of indigenous microflora. Results varied significantly depending on dosage and crop: Winter wheat: Application of the product led to a moderate increase in microorganism populations—approximately 10%. Spring wheat: Demonstrated high sensitivity to increased dosage. At a rate of 6 L/ha, soil biological activity increased by 20%, while increasing the dose to 20 L/ha resulted in a 50% increase. Notably, the population of actinomycetes (key agents in humus formation) surged nearly eightfold compared to the control. Soybeans: In this trial, the 6 L/ha dosage proved ineffective. The effect was observed only at the maximum dose of 20 L/ha, resulting in a 60% increase in the measured parameter

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

relative to the control. Experiment 3: Application of EM-1 at a dosage of 5 L/ha (Spring 2024) – A separate, independent study evaluated the effect of EM-1 at a fixed dosage: Spring wheat: Application at a rate of 5 L/ha resulted in a 70% increase in the microbial population (the original text contained a discrepancy regarding the 20 L/ha rate; the figure has been adjusted to reflect the specific conditions of this trial). Soybeans: Under the same treatment, the microbial population increased by 30%. For both crops, active actinomycete proliferation was the key driver of this growth at the given dosage.

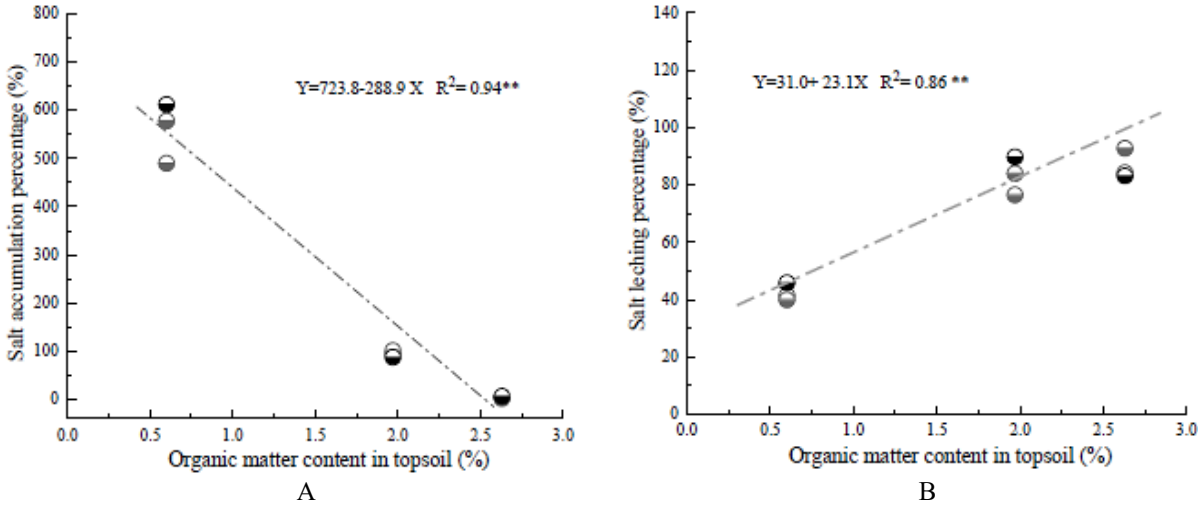


Fig. 2: Correlative relationship between the percentage of salt accumulation and leaching under various treatments. Note: ** significance level at P≤0.05.

4. DISCUSSION

Analysis conducted in 2023 revealed a correlation between the increase in soil biological activity and the type of crop cultivated; this is attributed to differences in plant nutrition and, consequently, rhizosphere characteristics, as well as the influence of soil microbiota and its interaction with the root-associated microbial community (Nasirova, 2024; Novruz et al., 2025). Overall, a significant rise in total biological activity was observed at a dosage of 6 L/ha, with the most pronounced increase (75%) noted in soybean crops. An assessment of microbial populations following the product's application in the spring of 2024 indicated that rising soil temperatures stimulated the development of indigenous microflora: population numbers increased by approximately 10% in winter wheat crops, whereas growth in soybean and spring wheat crops amounted to 30% and 80%, respectively. For soybeans, efficacy was demonstrated only at a dosage of 20 L/ha, which resulted in a 60% increase in the measured parameter compared to the control. In spring wheat crops, application of the product at dosages of 6 L/ha and 20 L/ha led to increases in soil biological activity of 20% and 50%, respectively. Actinomycetes showed the most active response: their population increased nearly eightfold compared to the control. This specific group of microorganisms plays the primary role in the processes of humus formation. In spring wheat crops, the effect of applying the preparation was significantly less pronounced. An application rate of 6 l/ha resulted in a slight increase in soil biological activity 17% higher than in the control variant. Applying EM-1 at a rate of 20 l/ha led to a 70% increase in the microbial population. Moreover, as was the case in the soybean experiment, the growth of actinomycetes was primarily stimulated. A similar pattern is also observed in winter wheat crops. The main trends persisted at the third sampling date. Analyses of soil microorganism counts conducted in 2025 at the end of the growing season showed that total soil biological activity in spring wheat crops remained high following the application of the preparation, primarily due to bacterial microflora (exceeding the control by 2.7–3 times). In soybean crops, a significant increase in the total number of microorganisms was noted when the microbiological preparation (MP) was applied in a dose 20 l/ha, and in sunflower crops the differences in the options with different doses of the MP were insignificant, but exceeded the control by an average of 30%. During the growing season in the soil layer of 0–30 cm when stubble is treated with the MP, an increase in the number of colony-like units is observed bacteria, and twice as much when applied at a dose of 20 l/ha for all crops. In this treatment, no clear patterns regarding actinomycete counts were observed in spring wheat crops; meanwhile, soil samples from under soybean and sunflower also showed an increase in the abundance of this group of microorganisms, though to a lesser extent than the bacterial population.

Three years of experiments demonstrated the positive effect of treating the soil with the preparation on the

Citation: Seyfaddin, K.A., Rahim. G.A., Novruz. L.B., Yarish. A.G., Yashar, G.A., Telman, V.M., Islam, R.M., Allahverdi, T.H., & Israphil, G.M. (2026). The influence of effective microorganisms on soil in different climatic conditions of Azerbaijan. Agrobiological Records, 26, 298-308. https://doi.org/10.47278/journal.abr/2026.102

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

abundance of agronomically beneficial soil microorganism groups throughout the growing season. Application of the preparation at a rate of 20 l/ha had the greatest impact on these indicators of soil biological activity. Consequently, in the third year of application, spring wheat yield increased significantly by 2.7 centners per ha. This result is attributed not only to increased humus formation and soil nutrient levels but also to a reduction in phytopathogens, which can compromise plant immunity and cause disease, given that plant vitality depends directly on the composition and abundance of microorganisms in the soil environment. Quantitative and qualitative indicators of soil microflora status can also serve as early indicators of changes in the soil. In this regard, it is difficult to underestimate the role of introduced microflora into the soil to reduce plant diseases and the level of phytopathogens in the soil. Experiments conducted over two years on the effect of the MP against soil infection of conidia - the causative agent of helminthosporium (common) root rot *Bipolaris sorokiniana* in the soil and root rot of spring wheat during the growing season, showed high efficiency in increasing the self-purifying ability and maintaining the ecological balance of the soil. At the beginning of the experiment (2024), the phytosanitary condition of the field in terms of colonization by conidia of the fungus *Bipolaris sorokiniana* was assessed as critical. Total average number of conidia per field was 89 pcs/g of soil (dangerous condition), which is 4.5 times higher than the harmfulness threshold of 20 pcs/g of soil. With such an infestation, the yield of grain crops susceptible to root rot is reduced by more than 15%. Wheat or barley cannot be placed here, especially with intensive technologies for their cultivation (Tables 4 and 5). The low proportion of degraded conidia (19%) indicated the low activity of antagonistic saprophytic microflora, the number of which depends on the content of OM in the soil. Degraded conidia reduce the likelihood of plant infection, but do not exclude it. Under favorable conditions for root rot development (deep seeding, lack of mineral and organic fertilizers, drought), partially degraded conidia can germinate and infect susceptible crops (Zafar et al., 2026). At the same time, the soil was poor, with a humus content of 3.9% and, accordingly, had a small amount of nitrate nitrogen $N\text{-}NO_3^-$ 18 mg/kg. In 2024, the preparation was applied twice (in June and July) to fallow land. According to autumn phytopathological and agrochemical soil analyses, the total count of *Bipolaris sorokiniana* conidia the dominant pathogen causing helminthosporium root rot in cereal crops was 120 units per gram of soil (indicating a hazardous level) in the control plot where the preparation was not applied. Double application of the MP to the soil in a steam field made it possible to contain the number of infections to the level of 69 conidia per 1 gram of soil (critical state), which is almost 2 times below the control number of the pathogen in the area where the MP was not applied. The content of $N\text{-}NO_3$ and OM was at the control level – less than 7 mg/kg and 3.1% accordingly. The continuation of the experiment in 2025 consisted of assessing the effectiveness of the MP when applied to the soil in the same areas for two years in a row against soil infection of *Bipolaris sorokiniana* conidia in the soil, as well as root rot of spring wheat (2025) during the growing season. The overall level of soil infestation by soil-borne pathogens can be influenced by the contamination of the seeds themselves, which are introduced into the soil and may carry infections and pathogenic microorganisms. Consequently, this factor can affect the results of evaluating the product's efficacy when it is applied solely to the soil. A preliminary analysis established that the 'Gizilgul' wheat seed material used in the experiment met varietal standards and complied with requirements for purity and germination capacity. An increase in soil fertility, as well as phytosanitary cleanliness of the soil through regular annual application of the MP to the soil, was noted in the territory, where an experiment carried out over the course of just one season showed a significant increase in soybean yield. Thus, when applying the MP to the soil at a dosage of 5 l/ha in 2024, as well as treating soybeans during the growing season with 0.6 l/ha, a positive effect on the phytometric indicators of soybeans was noted: the leaf surface area increased by 8.1%, the number of leaves on the plant - by 9.1%, the weight and the yield of green mass - by more than 17%, the mass of leaves per 1 m^2 - by 13.4%. In addition, the effect of the MP on the growth and development of the soybean root system and the activity of nodule bacteria was noted. the length of the main root increased by 14%, the weight of the roots - by 7.9%, the number of nodules on the plant - by 77.8%, and the weight of nodules on the plant - by 85.3%. As a result, at a standard moisture content of 14%, the grain yield was 2.51 t/ha, exceeding the untreated control variant by 12.6%. Thus, it can be concluded that the preparation had a significant impact on soybean yield. The experiments described in the article lead to the conclusion that the preparation which contains a unique consortium of effective microorganisms accelerates and enhances OM formation processes by boosting and stimulating soil microbiota activity; as OM formation is a crucial factor in optimizing the soil's ecological condition, this not only increases the stability of soil biodiversity but also positively influences crop yields (Verdiyeva et al., 2026).

5. CONCLUSION

The application of this microbial product leads to a significant increase in crop yields (by up to 12.6%) by stimulating soil microbiota and enhancing biological activity. Performance metrics vary by crop: for instance, in 2023, a dosage of 6 L/ha resulted in an increase in soil activity of up to 75%, while in 2024, a dosage of 20 L/ha yielded an increase of up to 60%. Future research will focus on validating these results across the diverse soil and climatic conditions of the Republic of Azerbaijan to confirm optimal dosages, as well as on investigating specific changes in

Citation: Seyfaddin, K.A., Rahim. G.A., Novruz. L.B., Yarish. A.G., Yashar, G.A., Telman, V.M., Islam, R.M., Allahverdi, T.H., & Israphil, G.M. (2026). The influence of effective microorganisms on soil in different climatic conditions of Azerbaijan. Agrobiological Records, 26, 298-308. https://doi.org/10.47278/journal.abr/2026.102

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

microbiota composition and microbial community structure that drive the observed shifts in biological activity.

Declarations

Funding: This study did not get any financial support from any organization/agency.

Acknowledgement: The authors express their gratitude for the support of the scientific and technological research project to the Sumgayit State University and Baku State University.

Conflicts of Interest: All authors declare no conflict of interest.

Data Availability: Data will be available at request.

Ethics Statement: This article does not contain any studies with humans/animals, thus requires no ethical approval.

Author's Contributions: Kamala Alizada, Gulnar Aliyeva and Lala Bunyatova: Conceptualization, Supervision; Aida Gahramanova, Vafa Mammadzada. Methodology, Supervision, Writing – original draft; Gunay Mammadova, Lala Bunyatova, Turkan Hasanova, and Gulnar Aliyeva: Investigation, Validation, Visualization, Data curation, Formal analysis; Turkan Hasanova, Rena Mirzezadeh, Gulnara Alakbarli, Lala Bunyatova and Kamala Alizada: Software, Validation, Writing – Review & Editing, Aida Gahramanova, Turkan Hasanova, Kamala Alizada, and Gunay Mammadova: Data curation, Verification, Writing – Editing. All authors have read and approved the final version for publication.

Generative AI Statements: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

Publisher's Note: All claims stated in this article are exclusively those of the authors and do not necessarily represent those of their affiliated organizations or those of the publisher, the editors, and the reviewers. Any product that may be evaluated/assessed in this article or claimed by its manufacturer is not guaranteed or endorsed by the publisher/editors.

REFERENCES

Ahmad, P. S., Latifaga, A. R., Mirismayil, M. A., Ikhtiyar, A. N., Nazim, R. M., Telman, V. M., Aghayeva, T. S., & Shirinova, G. F. (2026). Eco-biological features of mountain gray-brown soils development in the Karabakh Steppe (Republic of Azerbaijan). International Journal of Agriculture and Biosciences, 15(4), 1691–1699. https://doi.org/10.47278/journal.ijab/2026.063

Akbarova, C., & Mammadova, A. (2024). Chorological analysis and phenological observations of some species of the family Crassulaceae J.ST.-HIL. in the Lesser Caucasus of Azerbaijan. Advances in Biology and Earth Sciences, 9(2), 301–309. https://doi.org/10.62476/abes9301

Akhundova, S., Mammadova, G., Bunyatova, L., Alakbarli, G., Ahmadova, A., Aliyev, F., Bagirova, C., & Shammadova, I. (2025). Study of the modern bio-ecological state of Absheron coastlines. Advances in Biology and Earth Sciences, 10(1), 168–176. https://doi.org/10.62476/abes.101168

Alakbar, R. H. B., Ikhtiyar, A. N., Mirismayil, M. A., Vagif, A. S., Allahverdi, T. H., & Farhad, G. A. (2026). Current state of soil microstructure in the Kur-Araz lowland of Azerbaijan by remote sensing and photometry. Bulgarian Journal of Agricultural Science, 32(3), 566–572. https://doi.org/10.61308/pjw6w377

Alieva, M., & Mammadova, R. (2023). Determination of phytomass species diversity in mountain-forest brown and mountain forest brown soils in recent years. Advances in Biology and Earth Sciences, 8(1), 103–106.

Allahverdi, T. H., Musa, A. J., Maharram, S. H., Gudrat, V. I., Israphil, G. M., Madnee, M., & Farhad, G. A. (2026). Modeling humus stocks and introducing a saturation coefficient to assess soil organic carbon capacity in forest soils of the Sheki-Zagatala Region, Azerbaijan. International Journal of Agriculture and Biosciences, 15(5), 2134–2146. https://doi.org/10.47278/journal.ijab/2026.116

Bahram, F. V., Allahverdi, T. H., Eyvaz, M. I., Yusif, E. H., Elshad, T. J., & Farhad, G. A. (2025). Bioecological characteristics of modern soil cover in subtropic regions of Azerbaijan. International Journal of Advances in Applied Sciences, 14(4), 1200–1207. https://doi.org/10.11591/ijaas.v14.i4.pp1200-1207

Gahramanova, A. Y., Mammadova, R. N., Hasanova, T. A., Alakbarli, G. Y., Mammadova, G. I., & Asgarova, G. F. (2026). Studies on gray-brown soils with rapeseed (Brassica napus L.) as a forage crop in the Sheki region of the Greater Caucasus. SABRAO Journal of Breeding and Genetics, 58(1), 432–441. https://doi.org/10.54910/sabrao2026.58.1.40

Gumbatov, M. O., Sadigov, R. A., Huseynov, M. A., & Shirinova, D. B. (2024). Intensification of the process of producing phosphorus-containing fertilizers using industrial waste. BIO Web of Conferences, 126, Article 01001. https://doi.org/10.1051/bioconf/202412601001

Hasanova, T., & Abasova, N. (2024). Statistical analysis of the soil activity in Sheki-Zagatala economic region. EUREKA: Life Sciences, 3, 3–10. https://doi.org/10.21303/2504-5695.2024.003564

Hasanova, T., & Mammadova, G. (2023). The impact of changes in soil moisture indicators on biological activity in recent years on the southern slope of the Greater Caucasus. Nature & Science, 5(3), 7–12. https://doi.org/10.36719/2707-1146/30/7-12

Hasanova, T., Mammadova, G., Tsitsiagi, M., & Lapitov, N. (2026). Modelling moisture dynamics of agricultural steppe soils in the Greater Caucasus. Nature & Science, 8(4), 5–12. https://doi.org/10.36719/2707-1146/67/5-12

Huseynova, H. Z. (2022). Vegetation of the southern part of the Caspian Coast and its nutritional value. Biosystems Diversity, 30(3), 205–212. https://doi.org/10.15421/012222

Huseynova, H. Z. (2023). New distribution areas of some species of plants on the southern part of the Caspian coast. Biosystems Diversity, 31(1), 123–130. https://doi.org/10.15421/012313

Ibrahimova, L. (2025). Modern ecological state of the soils of the Absheron Peninsula and ways of solving related problems. Reliability: Theory & Applications, 7(83), 155–161. https://doi.org/10.24412/1932-2321-2025-27019

Ikhtiyar, A. N., Gudrat, V. I., Islam, R. M., Yarish, A. G., Novruz, L. B., Israphil, G. M., Allahverdi, T. H., Farhad, G. A., & Nazim, R. M. (2026). Changing the biological activity of soil in sunflower crops. Proceedings of the Bulgarian Academy of Sciences, 79(1), 145–156. https://doi.org/10.7546/CRABS.2026.01.18

Ismayilova, A. A., Mirzezadeh, R. I., Bunyatova, L. N., Mammadova, G. I., Hasanova, T. A., Asgarova, G. F., & Madnee, M. (2025a). Biomass and enzymatic activity assessment of the coniferous-deciduous forests in Azerbaijan. SABRAO Journal of Breeding and Genetics, 57(6), 2584–2595. https://doi.org/10.54910/sabrao2025.57.6.31

Ismayilova, A., Shukurov, S., Hasanaliyeva, L., Osmanova, S., Asgarova, G., & Hasanova, T. (2025b). Modern soil cover of natural cenoses and agrocenoses landscapes of the Kur-Araz Plain. Advances in Biology and Earth Sciences, 10(2), 314–325. https://doi.org/10.62476/abes.102314

Karimova, L., & Hasanova, T. (2025). Improving minimization of cultivation of gray-brown soils in Sheki-Zagatala Economic Region. Journal of Forest and Ecosystem Sciences, 1(2), 21–28. https://doi.org/10.54414/ZFEX8050

Khudaverdi, S. S., Azer, A. I., Ali, R. S., Javanshir, M. K., Allahverdi, T. A., & Farhad, G. A. (2025). Determination of soil salinization by hyperspectral remote sensing in the Shirvan Plain. International Journal of Advances in Applied Sciences, 14(3), 662–670. https://doi.org/10.11591/ijaas.v14.i3.pp662-670

Li, Q., Wang, L., & Fu, Y. (2023). Transformation of soil organic matter subjected to environmental disturbance and preservation of organic matter bound to soil minerals: A review. Journal of Soils and Sediments, 23(3), 1485–1500. https://doi.org/10.1007/s11368-022-03381-y

Macnunlu, K., Hasanova Baba-zade, R., & Hasanova, T. (2025). Ecological sustainability of agroecosystem and productivity assessment in the Barda area using NDVI and SAVI. Advances in Biology and Earth Sciences, 10(1), 148–157. https://doi.org/10.62476/abes.101148

Maharram, S. H., Pirverdi, M. B., Ismayil, A. I., & Musa, A. J. (2024). Taxonomic attribution of the haplic gleysols of the Azerbaijan Republic in the World Reference Base for Soil Resources. International Journal of Advances in Applied Sciences, 13(1), 116–122. https://doi.org/10.11591/ijaas.v13.i1.pp116-122

Makki, H. A., Saeed, A., Hussain, T., Rafay, T., Madnee, M., Abid, M., Hasanova, T. H., & Nurrochmat, N. A. (2025). Enhancing soil rehabilitation in saline and sandy soils of Punjab, Pakistan, using wastewater reuse and native tree species. Egyptian Journal of Soil Science, 65(4), 2039–2054. https://doi.org/10.21608/ejss.2025.426305.2378

Mammadova, G. I., Bunyatova, L. N., Gahramanova, A. Y., Isaqova, V. G., Fatdayeva, A. K., Alakbarli, G. Y., & Hasanova, T. A. (2026a). Environmental pollution in soil, plant leaves, and roots using bioindication in hazelnut fields. SABRAO Journal of Breeding and Genetics, 58(3), 1436–1444. https://doi.org/10.54910/sabrao2026.58.3.46

Mammadova, G. I., Salimova, Sh. J., Jafarov, A. M., Huseynova, S. M., Isayeva, K. K., Isagova, V. G., & Hasanova, T. A. (2026b). Rocky soil compositions influence on the microorganisms and vegetation at the Sheki-Zagatala Economic Region, Azerbaijan. SABRAO Journal of Breeding and Genetics, 58(3), 1407–1414. https://doi.org/10.54910/sabrao2026.58.3.43

Mammadova, G., Salimova, Sh., Aliyeva, G., Isagova, V., & Hasanova, T. (2026c). Modern approaches in the study of soil bioactivity in Katekh and Garakli village (Azerbaijan) irrigated alluvial meadow and mountain forest brown soils. Bulgarian Journal of Agricultural Science, 32(2), 278–285. https://doi.org/10.61308/sp7p2257

Mammadova, R., Hasanova, T., & Aliyeva, M. (2025). Ecological state of modern soil cover in agrocenoses of the Greater Caucasus Sheki region. In Ecological Systems Modelling (pp. 57–73). Scientific Route OÜ. https://doi.org/10.21303/978-9908-9706-6-0.ch3

Mammadzada, V. T., Aliyeva, M. M., Rzayeva, A. L., Nasirova, A. I., & Mammadova, R. N. (2025). Soil bioactivity study through innovative approaches in Lankaran-Astara Region, Azerbaijan. SABRAO Journal of Breeding and Genetics, 57(3), 1180–1191. https://doi.org/10.54910/sabrao2025.57.3.29

Mirismayil, M. A. (2025). Activity of soil biota in the modern soil cover of Ujar, Kurdamir, and Salyan regions. Bulgarian Journal of Agricultural Science, 31(6), 1086–1091.

Mirzezadeh, R. I., Ramazanova, F. M., Hasanova, T. A., Mammadova, G. I., & Asgarova, G. F. (2025a). Assessment of variations caused by biological activities in the Greater Caucasus forest soils used for agriculture. SABRAO Journal of Breeding and Genetics, 57(4), 1634–1643. https://doi.org/10.54910/sabrao2025.57.4.29

Mirzezadeh, R., Hasanova, T., & Asgarova, G. (2025b). Comprehensive studies of Greater Caucasus river valleys soils. EUREKA: Life Sciences, 1, 11–18. https://doi.org/10.21303/2504-5695.2025.003654

Nasirova, A. (2023). Cultivation of Malva sylvestris L. species in the Ganja-Kazakh economic region in recent years. Advances in Biology and Earth Sciences, 8(1), 114–117.

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Nasirova, A. (2024). Modern and comprehensive soil studies in grape agrocenoses in Azerbaijan. International Journal of Advances in Applied Sciences, 13(2), 217–224. https://doi.org/10.11591/ijaas.v13.i2.pp217-224

Nazim, R. M., & Oqtay, A. M. (2024). Study of bio-ecological indicators of oak species in Azerbaijan. Proceedings of the Bulgarian Academy of Sciences, 77(10), 1466–1473. https://doi.org/10.7546/CRABS.2024.10.06

Nazim, R. M., Jafar, S. S., Maharram, S. H., Israphil, G. M., Allahverdi, T. H., Latif, H. R., & Ali, G. J. (2025). Plant leaves as a biogeochemical indicator of the environmental state in different regions of Azerbaijan. Proceedings of the Bulgarian Academy of Sciences, 78(11), 1601–1610. https://doi.org/10.7546/CRABS.2025.11.03

Novruz, L. B., Israphil, G. M., Allahverdi, T. H., Yarish, A. G., Maharram, S. A., & Yashar, G. A. (2025). Main eco-properties of hazelnut (Corylus avellana L.) in the Sheki-Zagatala economic region. International Journal of Advances in Applied Sciences, 14(1), 77–85. https://doi.org/10.11591/ijaas.v14.i1.pp77-85

Sadigov, R., Huseynova, M., & Baghirova, M. (2026). Evaluation of granulometric characteristics and biogenic element diagnostic indicators of mountain gray-brown soils in the Gazakh-Tovuz Economic Region according to the WRB system. Scientific Work, 20(5), 272–283. https://doi.org/10.36719/2663-4619/129/272-283

Safeer, M., Zubair, M., Hussain, T., Khan, M. A., Madnee, M., & Hasanova, T. A. (2026). Socioeconomic drivers and farmers' perception of climate change impact on agroforestry adoption: A regression-based study in South Punjab, Pakistan. Agroforestry Systems, 100(7), Article 208. https://doi.org/10.1007/s10457-026-01570-z

Samadov, P. A., Mammadov, Z. R., Aliyeva, M. M., Rzayeva, A. L., Nasirova, A. I., Mammadova, R. N., Mammadzade, V. T., Aliyeva, B. B., & Sadikhova, M. E. (2026). Eco-biological indicators of mountain forest soils in the Lankaran Region, Azerbaijan. SABRAO Journal of Breeding and Genetics, 58(1), 442–452. https://doi.org/10.54910/sabrao2026.58.1.41

Verdiyeva, F. B., Abdullayeva, R. K., Ismayilzadeh, N. N., Fatdayeva, A. K., Mammadova, G. I., Hasanova, L. U., Asgarova, G. F., & Hasanova, T. A. (2026). Biosynthesis of seeds and bioecological parameters of gray-meadow soils by remote sensing (Republic of Azerbaijan) under wheat crops. International Journal of Agriculture and Biosciences, 15(4), 1907–1914. https://doi.org/10.47278/journal.ijab/2026.075

Yelmarli, T. (2026). Agrochemical characteristics of chernozems of mountainous Shirvan Economic Region: A case study of Ismayilli district. Nature & Science, 8(4), 78–84. https://doi.org/10.36719/2707-1146/67/78-84

Zafar, M. M., Manan, A., Razzaq, A., Zulfqar, M., Saeed, A., Kashif, M., Khan, A. I., Sarfraz, Z., Mo, H., Iqbal, M. S., Shakeel, A., & Ren, M. (2021). Exploiting agronomic and biochemical traits to develop heat resilient cotton cultivars under climate change scenarios. Agronomy, 11(9), Article 1885. https://doi.org/10.3390/agronomy11091885

Zafar, M. M., Chattha, W. S., Khan, A. I., Zafar, S., Subhan, M., Saleem, H., Ali, A., Ijaz, A., Anwar, Z., Qiao, F., Shakeel, A., Seleiman, M. F., Wasonga, D. O., Parvaiz, A., Razzaq, A., & Xuefei, J. (2023). Drought and heat stress on cotton genotypes suggested agro-physiological and biochemical features for climate resilience. Frontiers in Plant Science, 14, Article 1265700. https://doi.org/10.3389/fpls.2023.1265700

Zafar, M. M., Iqbal, M. S., Kamal, H., Khan, A. I., Sarfraz, A., Razzaq, A., & Shakeel, A. (2024). Advancing heat tolerance in cotton through integration of multiple stress tolerance indices and multivariate analyses. International Journal of Agriculture and Biosciences, 13(1), 65–75. https://doi.org/10.47278/journal.ijab/2024.088

Zafar, H. H., Aydin, S. M., Ali, R. S., Oqtay, N. M., Fakhraddin, A. H., & Madnee, M. (2026). Seasonal dynamic study of soil cover and plant productivity in pastures in the Khachmaz, Neftchala and Lankaran-Astara Regions. Agrobiological Records, 24, 165–174. https://doi.org/10.47278/journal.abr/2026.034