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ABSTRACT

of the dissertation presented for the degree of Doctor of Philosophy (PhD)

BIOLOGICAL EVALUATION OF THE APPLICATION OF BIOHUMUS AND ADSORBENT TO IRRIGATED MEADOW-GREY SOILS UNDER VEGETABLE

Speciality: 2511.01 - "Soil Science"

Field of science: **Agrarian sciences**

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The dissertation work was performed at the "Genesis, geography and cartography of soils" laboratory of the Institute of Soil Science and Agrochemistry of the Ministry of Science and Education of the Republic of Azerbaijan.

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INTRODUCTION

Actuality and degree of development of the subject. Ensuring food security and sustainable development of agriculture in the Republic of Azerbaijan is one of the main priorities of the state. In this regard, the "Strategic Roadmap for the Development of the Agricultural Production and Processing Industry" approved by the decree ofPresident Ilham Aliyev dated December 6, 2016, and the law was further improved and the "State Program for Ensuring Food Security in 2019-2025" was approved in the next years. The document identifies increasing soil fertility, efficient use of water resources, and the application of environmentally sustainable agro-technical measures as one of the main tasks[1].

In modern times, due to the decrease in freshwater resources as a result of the impact of global climate change, water use norms in irrigated agriculture must be strictly controlled. At the same time, one of the most important issues that meet the demands of the time is the production of sustainable agricultural products by saving irrigation water through the application of nanotechnologies. We should note that the magnificent COP 29 conference of the UN on Climate Change, hosted by our state in 2024 and involving all the leading countries of the world, once again indicated that the problem has become serious.

Taking into account the above, the main relevance of the work is to save irrigation water in the experiment we conducted on the bean plant, to maintain soil moisture by applying a natural adsorbent with high absorption capacity, and to preserve the fertility of

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[1]Strategic Roadmap for the production and processing of agricultural products in the Republic of Azerbaijan. Decree of the President of the Republic of Azerbaijan dated December 6, 2016

irrigated meadow-grey soils by applying biohumus, and to increase the productivity of the bean plant.

Object and predmet of the research. The object of the research is irrigated meadow-grey soils and bean plants (small beans - mung beans).

The predmet of the research is the effect of biohumus and zeolite on the physical and chemical properties of irrigated meadow-grey soils, agrobiologically indicators - biological activity (amount of microorganisms, intensity of biochemical processes and activity of enzymes) and bean plant productivity.

The goal and tasks of the research. The main goalof the research is to determine the spatial and temporal dynamics of the effect of using biohumus (vermicompost) and zeolite with high absorption capacity to save irrigation water on the physical and chemical properties of the soil, the amount of nutrients, and microbiological and enzymatic activity in order to preserve the fertility of irrigated meadow-grey soils and improve their ecological conditions, and to obtain a sustainable crop from bean plants (mung beans) by optimizing the mineral nutrition of legumes. To achieve the set goal, the following tasks were carried out:

- morphological description of irrigated meadow-grey soils and determination of changes in morphogenetic properties;
- study of physical and chemical properties of irrigated meadow-grey soils;
- correlation and international nomenclature of irrigated meadow-grey soils to the WRB system;
- determination of the intensity of carbon dioxide release from irrigated meadow-grey soils;
- research of the nitrification process in irrigated meadow-grey soils with the application of biohumus and zeolite under bean plants;
- determination of the effect of biohumus and zeolite on the total amount of microorganisms in the soil;
- determination of the effect of biohumus and zeolite on the intensity of cellulose decomposition in the soil;

- determination of the effect of biohumus and zeolite on the activity of enzymes;
- biological assessment of irrigated meadow-grey soils;
- determination of the effect of biohumus and zeolite on soil productivity and economic efficiency of bean plants.

Research methods. Morphological diagnostics of irrigated meadow-grey soils cultivated under meadow-grey and bean plants, physical, chemical and microbiological indicators, enzymatic activity, quality indicators of beans and economic efficiency of the results obtained were carried out on the basis of modern methods.

The main provisions defended. The following provisions were submitted for defense:

- morphological description of meadow-grey and irrigated meadow-grey soils and determination of changes in morphogenetic diagnostics;
- research of physical and chemical properties of meadow-grey and irrigated meadow-grey soils;
- correlation and international nomenclature of meadow-grey and irrigated meadow-grey soils to the WRB system;
- dynamics of carbon dioxide release intensity from meadow-grey and irrigated meadow-grey soils;
- research of the nitrification process in irrigated meadow-grey soils with the application of biohumus and zeolite under bean plants;
- determination of the effect of biohumus and zeolite on the total amount of microorganisms in the soil;
- determination of the effect of biohumus and zeolite on the intensity of cellulose decomposition in the soil;
- determination of the effect of biohumus and zeolite on the activity of enzymes;
- biological evaluation of irrigated meadow-grey soils;
- studying the effect of biohumus and zeolite on soil productivity;
- determining the economic efficiency of bean crops;
- saving irrigation water by applying zeolite.

Scientific novelty of the research. For the first time, the soils were correlated to the WRB system and given an international classification based on the morphogenetic characteristics of the profile of irrigated meadow-grey soils cultivated under bean plants with the application of biohumus and zeolite; the diagnostic characteristics of soils were determined and evaluated with the application of biohumus and zeolite, the high and low limits of enzyme activity and the activity of microorganisms depending on environmental factors were determined, and the effect of cellulose decomposition intensity and nitrification process intensity was researched in dynamics. Regarding to the global warming process in the world, especially in arid climate conditions, the depletion of fresh water resources, the application of zeolite saved irrigation water and achieved a sustainable crop from bean plants.

Theoretical and practical significance of the research. Optimal ecological and economic norms of biohumus and zeolite for the cultivation of beans on irrigated meadow-grey soils have been determined and proposed for use in farms. The results of the research can be used in biomonitoring and biodiagnostics of the condition of soils in areas where irrigated meadow-grey soils are widespread, in saving irrigation water, in assessing any impact on the environment, in land use planning, in environmental protection and in the implementation of economic measures.

Approbation and application of the work. The results of the research work were discussed in the scientific reports of the Institute of Soil Science and Agrochemistry of the Ministry of Science and Education of the Republic of Azerbaijan for 2019-2022, at international and republican scientific-practical conferences held abroad and in the country: Scientific-practical conference on the topic "Environmental problems and the strategy for its protection: a look into the future" dedicated to the Day of Science, Baku, 2020; Modern science: problems and innovations.Abstracts of IV international scientific and practical conference, Stockholm, 2020; “Problems of transformation of natural landscapes as a result of anthropogenic activity and ways of their solution” international conference. Krasnodar: KubSAU, 2021; Karabakh II. İnternational congress of applied sciences ANAS, 2021; AGROO International Agricultural Conference, IKSAD, ANAS BTEB, Faculty of Agriculture of Ege University, ADAU, 2022; Proc. Int. scientific conf. "Evolution of soils and development of scientific concepts in soil science", Barnaul, Altai State Agrarian University, 2022and etc.

The results of the research were presented with recommendations for application to existing farms in the Ujar district.

Name of the organization where the dissertation work was carried out. The dissertation work was carried out in accordance with the subject plan of the Institute of Soil Science and Agrochemistry of the Ministry of Science and Education of the Republic of Azerbaijan in 2019-2021.

Published works.9 scientific articles and 6 theses on the dissertation work, of which 7 articles and 3 theses were published abroad. 5 of the published articles were placed in the international index system.

The volume and structure of the dissertation work. The dissertation work consists of an introduction, 5 chapters, conclusions, farm recommandations, a list of 192 literatures, 34 figures, 23 tables, 18 appendices, and the total volume is 186 pages. The introduction of the dissertation consists of 5 pages of 8039 characters, the first chapter of 6 pages of 56178 characters, the second chapter of 8 pages of 14110 characters, the third chapter of 39 pages of 68330 characters, the fourth chapter of 29 pages of 51330 characters, the fifth chapter of 20 pages of 37389 characters, conclusions of 3 pages of 5279 characters, recommendations for the economy of one page of 725 characters, the list of used literature of 22 pages of 32966 characters, and appendices of 21 pages. The general text part of the dissertation (excluding images, tables, graphs, results, recommendations for the economy, appendices and the list of used literature) consists of 240799 characters.

CHAPTER I.NATURAL-GEOGRAPHICAL CONDITIONS OF THE SHIRVAN PLAIN

Chapter 1 of the dissertation work provides detailed information about the geographical position, relief, geological and geomorphological structure, climate, soil and vegetation cover, as well as the use of lands in agriculture of the Shirvanplain, where the research object is located. The Shirvanplain, which is the largest in terms of area (211 km^2), is located on the left bank of the Kura river, occupies part of the Kura-Araz lowland between the southern slope of the Greater Caucasus and the Kura river and has an altitude of 16-100 m above sea level[2]. The Shirvanplain is a genetically heterogeneous inclined accumulative plain with weakly noticeable elevations from west to east and from north to south, and mainly represents the contact zone of two large tectonic regions: zones of subsidence and uplift.

The relief of the plain is determined by the presence of diluvial and proluvial deposits, which create a colourful landscape of the surface and cause sorting and redistribution of alluvial material, and is characterized by the presence of sometimes weak, sometimes more clearly expressed alluvial cones. The climate of the Shirvan plain is dry subtropical with long hot summers and short, relatively mild winters. The average annual air temperature varies between 14,1°-14,5°C. Relative humidity increases from northwest to southeast and varies between 71-72%. The amount of precipitation is unevenly distributed and reaches a maximum in the autumn-winter period, ranging from 254 to 510 mm. The annual evaporation rate is approximately 1000-1050 mm.[3] Detailed information about the vegetation of the Shirvanplain is found in the researches of A.A. Grosheim, L.L. Prilipko and E.M. Gurbanov[4]. The soils of the Shirvanplain have been studied by Y.A. Rozanov, V.R. Volobuyev, M.P. Babayev, R.H. Mammadov, Y.J. Hasanov, G.Z. Azizov, I.M. Abduyev and others. Scientists of the Institute of Soil Science and Agrochemistry A.I. Ismayilov, M.P. Babayev, V.H. Hasanov and S.M. Huseynova have identified 5 soil types in the Shirvanplain, which is included in the Central

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[2] Museyibov M.A. - Physical geography of Azerbaijan, Baku, 1998, 400 p.
[3] Shikhlinsky E.M. Climate of Azerbaijan, Baku: Elm, 1968, 340 p.
[4] Gurbanov E.M. Vegetation of Azerbaijan, Baku: "Elm", 2024, 536 p.

Aran[5] economic district, on the 1:200000 scale soil map of the economic districts of Azerbaijan (2022): 1. Meadow-grey; 2. Irrigated meadow-grey; 3. Meadow-marsh; 4. Marsh; 5. Saline.

CHAPTER II. OBJECT OF THE RESEARCH AND METHODOLOGY

Research work was carried out in 2019-2021 on irrigated meadow-grey soils of the Ujar DM of the ISSA according to the following experimental scheme: 1. Control; 2. Biohumus 5 t/ha; 3. Zeolite 5 t/ha; 4. Biohumus 5 t/ha+zeolite 5 t/ha; 5. Biohumus 7,5 t/ha; 6. Zeolite 7,5 t/ha; 7. Biohumus 7,5 t/ha+zeolite 7,5 t/ha. The total area of the experiment was 1050 m^2, with each variant having an area of 50 m^2. The seeding norm of the bean plant was 40-50 kg/ha and the scheme was 70 cm×20 cm.15 main and additional soil sections were established in the experimental area, and soil samples were taken according to genetic layers. Analyses of physical and chemical parameters of soils (granulometric composition, specific gravity, bulk density and porosity according to N.A. Kachinski, humus-according to I.V. Tyurin, absorbed nitrogen-by the Kjeldahl method, pH-potentiometer of water suspension, carbonation-by the Scheibler method with a calcimeter, in the complex of absorbed basesCa and Mg-by the Ivanov method, ammonium nitrogen ($N-NH_4$) by Nesler reagent-by D.M. Konev, nitrate nitrogen ($N-NO_3$)-by Grandval-Lyaju, mobile phosphorus (P_2O_5)-by Machigin, nitrification capacity of the soil according to N.I. Bolotin and E.N. Abramov, total water weight of the soil according to Y.V. Arinushkina[6]) were determined, enzyme activity (invertase, catalase and phosphatase-according to F.Kh. Khaziyev), and theamountof microorganisms was carried out at the AR MESInstitute of Microbiology. Soil temperature and soil moisture was determined. The intensity of

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[5] Ismayilov A.I., Babayev M.P., Hasanov V.H. and Huseynova S.M. Soil map of the Central Aran Economic District at a scale of 1:200000

[6] Arinushkina E.V. Guide to chemical analysis of soils. M., Moscow State University, 1970, 483 p.

cellulose decomposition was determined by the method of I.S. Vostrov, the amount of soil respiration CO_2 was determined by N.G. Fedores. Economic efficiency was calculated according to S.O. Babirov. Morphological diagnostics of soils was studied based on the FAO methodology[7], and the international soil classification was correlated based on the WRB (World reference base for soil resources)[8]. Mathematical and statistical calculation of standard errors of the obtained actual figures with a probability of P=0,95 was carried out according to B.A. Dospekhov[9]. The Pearson correlation coefficient was used to calculate the correlation between soil parameters and was performed in Excel 2016.

CHAPTER III. ANALYSIS OF MORPHOGENETIC DIAGNOSTICS, PHYSICAL AND CHEMICAL INDICATORS OF IRRIGATED MEADOW-GREY SOILS

To study of soil morphology allows us to determine the nature of soil formation and the processes occurring in the soil. Morphological characteristics indicate the origin, development, evolution and relationship of the soil with the geographical environment. The morphological diagnostic analysis of the studied meadow-grey and irrigated meadow-grey soils shows that the colour of the soil profile varies from dark grey to yellowish grey and from brownish grey to grayish-straw. The colour of the layers in the profile is almost sharply different, clearly differentiated. The granulometric composition is heavy loamy in the arable and subsoil layers, and light loamy in the lower layers. Carbonates are found in various forms (dots, mold, white spots) along the profile, moderate boiling is observed. Boiling of the soil under the influence of hydrochloric acid is a characteristic feature of meadow-grey soils

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[7] FAO. 2006. Guidelines for soil description. 4th edition. Rome.97 p.

[8] World Reference Base for Soil Resources. International soil classification system for naming soils and creating legends for soil maps. 4th edition, 2022, 236 p.

[9] Dospekhov B.A. Methodology of field experiment, M."Kolos", 1979, 416p.

and is explained by the carbonate content of the soil-forming rocks. Blackish-blue spots are found in the profile. This is explained by the seasonal closeness of groundwater to the surface and, as a result, the presence of divalent iron compounds in conditions of excessive moisture and anaerobic conditions. At the same time, red spots are also found in the profile. This is explained by the presence of 3-valent iron oxide as a result of irrigation. The profile of meadow-grey soils is characterized by signs of gleyicity and salinity depending on the soil formation process. Carbonates are washed out and accumulated in the middle layer in the profile of all irrigated meadow-grey soils. As a result of the conducted researches, it was found that the soil profile has more pores in the variant ofbiohumus 5 t/ha+zeolite 5 t/ha, the colour of the soil is sharply different from other sections, and the structure is spherical-granular in the upper layer. Thus, the high porosity in the soil profile improves the air, water, and temperature regimes, and creates conditions for plant roots to use nutrients. All this has a positive effect on increasing productivity and intensifies the soil formation process. In section No. 6, signs of gleyicity are observed starting from layer B and the profile is moisture. This can be explained by the fact that zeolite retains water.It is evident that the amount of humus in these soils is very low when considering the physical and chemical properties of meadow-grey and irrigated meadow-grey soils. The amount of humus in meadow-grey soil decreases from 2,65% to-0,45% along the profile (section No. 1). A relatively high amount of humus is observed in section No. 7 (2,71-0,63%) and section No. 9 (2,72-0,65%) in irrigated meadow-grey soils.The amount of humus was interesting, because section No. 6 was selected according to its economic efficiency. Thus, the amount of humus (2,69-0,59%) does not differ sharply from the sections with a high indicator (table 1). These soils are assessed as sufficient in terms of the amount of humus according to the scale compiled by R.H. Mammadov[10],

[10] Mammadov R.G. Agrophysical characteristics of soils of the Araks zone of the Azerbaijan SSR, Baku, 1970, 321 p.

(table 2). The nitrogen content was also high in section No. 7 (0,21-0,09 %) and section No. 9. The nitrogen content prevailed in section No. 6 (0,20-0,07 %). The C:N ratio was almost similar in all sections. The soil condition reaction was between 7,79-8,39 in meadow-grey soils, and between 8,06-8,71 in irrigated meadow-grey soils. The $CaCO_3$ content in meadow-grey soils was 12,58 % in the upper layer, increasing to 19,78 % in the middle layers, and decreasing to the lower layers. In irrigated meadow-grey soils, the lowest conductivity was 11,69 %, and the highest was 18,80 %. In these soils, the accumulation of $CaCO_3$ in the middle layers was also observed. The reason for this is explained by the leaching of calcium carbonate as a result of the effect of irrigation (Table 1).

Thus, these soils are considered carbonate according to R.H. Mammadov (table 2). Calcium ion is 2 times more than magnesium ion of the absorbed bases. In meadow-grey soils, the amount of calcium decreases along the profile towards the lower layers (20,0-7,2 mmol-eq.), while the amount of magnesium increases (7,9-14,1 mmol-eq.), constituting only 6,5 mmol-eq. in the 49-90 cm layer. In irrigated meadow-grey soils, the amount of calcium in the crop and subsoil layers varies between approximately 18-25 mmol-eq., and the amount of magnesium varies between 8-11 mmol-eq. (table 1).

These soils are considered to be high in calcium and low in magnesium according to R.H. Mammadov (table 2). Meadow-grey soils are medium and heavy loamy according to the granulometric composition. <0.001 mm fraction varies between 11,87-25,98%, 0.01 mm fraction – 44,87-60,80%.

The sowing and subsoil layers of irrigated meadow-grey soils are heavy loamy,<0,001 mm fraction - 19,81-24,41%, <0,01 mm fraction - 49,87-60,70%.

Table 1

Main physical and chemical indicators of meadow-grey and irrigated meadow-grey soils

Section, №	Coordinates	Depth, cm	Humus, %	Nitrogen, %	C:N	$CaCO_3$, %	pH	Absorption capacity, mmol-eq			Granulometric composition, mm,%	
								Ca^{++}	Mg^{++}	Total	<0,001	<0,01
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Meadow-grey soils												
Section №1	N – 40º 28′52,27″	0-16	2,65	0,20	6,96	12,58	7,79	20,0	7,9	27,9	13,90	48,21
Gulaband village	E – 47º 42′ 39,85″	16-49	2,15	0,17	6,64	16,05	8,20	24,1	8,1	32,2	18,70	53,59
	h=14 m	49-90	1,63	0,14	6,11	19,78	8,09	16,0	6,5	22,5	22,80	58,89
		90-131	1,11	0,10	5,83	14,78	8,24	19,5	11,5	31,0	25,98	60,80
		131-172	0,45	0,06	3,94	14,70	8,39	7,2	14,1	21,3	11,87	44,87
Irrigated meadow-grey soils												
Section №2	N – 40º 30′19,77″	0-25	2,28	0,18	6,65	11,69	8,06	18,4	8,2	26,6	19,81	50,98
Primary soil	E – 47º 40′ 25,56″	25-50	1,90	0,15	6,65	12,06	8,33	21,1	10,9	32,0	23,38	59,28
(2019 year)	h=13m	50-72	1,03	0,10	5,41	16,79	8,26	22,5	12,0	34,5	28,80	65,97
		72-97	0,69	0,08	4,53	14,95	8,44	17,0	14,6	31,6	24,69	69,59
		97-129	0,14	0,04	6,89	12,99	8,71	14,0	11,1	25,1	20,82	66,23
Section №3	N – 40º 30′19,84″	0-25	2,31	0,18	6,74	12,91	8,40	20,7	9,0	29,7	20,90	5015
Control	E – 47º 40′ 25,64″	25-50	1,92	0,12	6,46	13,13	8,71	23,9	11,7	35,6	24,41	60,13
	h=13m	50-73	1,49	0,13	6,02	18,80	8,32	24,8	12,7	37,5	28,80	67,09
		73-99	1,13	0,11	5,39	15,91	8,51	16,5	14,9	31,4	25,10	70,23
		99-131	1,09	0,10	5,72	13,94	8,94	13,7	11,0	24,7	21,12	66,56
		131-151	0,27	0,05	2,84	13,70	8,17	7,9	10,9	18,8	24,05	60,09
Section №4	N 40^0 30′ 19,64″	0-25	2,60	0,20	6,77	13,17	8,24	22,5	8,3	30,8	20,10	54,30
Biohumus, 5t/ha	E 47^0 40′ 25,57″	25-50	2,10	0,17	6,30	13,93	8,45	23,9	9,8	33,7	22,40	60,10
	h=15m	50-71	1,62	0,14	6,08	17,87	8,47	24,9	11,0	35,9	27,10	55,20
		71-92	1,19	0,11	5,68	16,09	8,58	16,6	13,0	29,6	22,10	68,10
		92-128	0,69	0,08	4,53	12,95	8,61	12,1	10,7	22,8	19,90	57,10
Section №5	N 40^0 30′ 19,65″	0-25	2,37	0,18	6,60	14,01	8,30	21,7	9,4	31,1	23,50	60,20
Zeolite, 5 t/ha	E 47^0 40′ 25,80″	25-50	1,95	0,16	6,43	16,90	8,35	23,6	9,1	32,7	25,20	59,10
	h=14m	50-69	1,41	0,13	5,69	17,95	8,45	23,8	11,7	35,5	25,90	59,40

Table 1 continuation

1	2	3	4	5	6	7	8	9	10	11	12	13
		69-96	1,02	0,10	5,36	16,34	8,59	15,9	13,4	29,3	18,8	57,8
		96-133	0,55	0,07	4,13	14,01	8,57	11,5	10,8	22,3	-	-
Section №6 Biohumus 5 t/ha + zeolite 5 t/ha	N – 40º30′ 19,83″ E – 47º40′ 25,55″ h=12m	0-25	2,69	0,20	7,06	13,20	8,66	22,7	8,6	31,3	20,1	49,87
		25-50	2,19	0,17	6,97	14,67	8,57	25,4	10,9	36,3	23,4	58,76
		50-79	1,75	0,14	6,56	18,42	8,58	23,9	12,9	36,8	29,8	69,20
		79-105	1,37	0,12	5,99	17,79	8,34	15,7	8,1	23,8	25,1	70,10
		105-149	0,59	0,07	4,43	14,04	8,17	9,5	7,9	17,4	21,0	62,50
Section №7 Biohumus 7,5 t/ha	N 40^0 30′ 19,87″ E 47^0 40′ 25,73 h=13m	0-25	2,71	0,21	6,58	13,41	8,20	23,0	8,3	31,3	19,9	59,30
		25-50	2,21	0,17	6,45	15,01	8,38	24,1	9,3	33,4	23,0	60,70
		50-74	1,64	0,14	6,15	18,39	8,44	25,0	10,7	35,7	25,8	61,00
		74-92	1,21	0,11	5,78	18,05	8,51	17,0	12,7	29,7	24,5	63,90
		92-134	0,63	0,09	3,68	14,07	8,49	12,9	10,2	23,1	19,1	64,70
Section №8 Zeolite 7,5 t/ha	N 40^0 30′ 19,86″ E 47^0 40′ 25,98″ h=13m	0-25	2,43	0,19	6,71	14,20	8,27	22,0	9,1	31,1	20,5	53,60
		25-50	1,99	0,16	6,21	17,03	8,37	23,9	9,4	33,3	23,1	59,70
		50-74	1,38	0,12	6,04	18,11	8,46	24,1	11,3	35,4	27,9	57,10
		74-88	1,06	0,10	5,57	16,91	8,57	16,2	13,6	29,8	22,3	67,50
		88-113	0,52	0,07	3,90	14,72	8,55	12,1	10,8	22,9	20,5	57,40
Section №9 Biohumus 7,5 t/ha + zeolite 7,5 t/ha	N 40^0 30′ 19,74″ E 47^0 40′ 26,12″ h=13m	0-25	2,72	0,21	6,65	13,92	8,58	23,4	8,0	31,4	21,0	54,90
		25,50	2,23	0,17	6,66	16,89	8,53	25,8	8,9	34,7	23,7	59,10
		50-72	1,76	0,15	6,16	18,22	8,59	24,2	10,2	34,4	25,9	66,10
		72-102	1,38	0,12	6,04	17,05	8,30	16,2	11,2	27,4	25,1	67,30
		102-151	0,65	0,08	4,27	13,08	8,20	10,1	9,7	19,8	18,9	63,90

The granulometric composition in layer B is light clay (table 1). According to the scale compiled by V.R.Volobuyev, meadow-grey soils are assessed as weakly saline (table 2). For the first time in Azerbaijan, the international naming of meadow-grey and irrigated meadow-grey soils was carried out by M. Babayev, Ch.Jafarova and S. Huseynova[11,12].

Table 2.

Evaluation of meadow-grey and irrigated meadow-grey soils according to diagnostic indicators

Indicators	Evaluation	
	Meadow-grey soils	**Irrigated meadow-grey soils**
Granulometric composition,<0,01mm, % (According to N.A. Kachinsky)	44,87-60,80 Medium to heavy clay	49,87-70,23 Heavy clayey-light clayey
Carbonation$CaCO_3$, % (According to R.H. Mammadov)	12,58-19,78 Carbonate	12,91-18,80 carbonate
Humus, % (According to R.H. Mammadov)	0,45-2,65 Very little humus-sufficient	0,19-2,72 Very little humus-sufficient
pH(in aqueous solution) (According to R.H Mammadov)	7,79-8,39 Alkaline	8,17-8,94 alkaline
Total absorbed bases, mmol-eq, Total Ca Mg (According to R.H. Mammadov)	 21,3-32,2 Sufficient-medium 7,2-,24,1 High calcium 6,5-14,1 Low magnesium	 17,4-37,5 Low (low)-medium level 7,9-25,8 High calcium 7,9-14,9 Poor magnesium
Salination (According to V.R.Volobuyev)	0,389-0,433 Low saline	0,187-0,359 Very weakly saline-weakly saline

The meadow-grey soil type **Calcisols** is the Soil Reference Group. The international naming of soils in the research area: 1.Gypsiric Gleyic **Calcisols**Loamic Ochric; 2. Gleyic **Calcisols**Aric ClayicIsopteric Ochric; 3. Cambic Gleyic

[11]Babayev M.P., Hasanov V.H., Jafarova C.M., Huseynova S.M. Morpho-genetic diagnostics, nomenclature and classification of Azerbaijan soils Baku: Elm, 2011, 452 p.

[12]Amin İsmayilov, Maharram Babayev, Fikrat Feyziyev The correlation of Azerbaijan arid soils with WRB-2014, / Eurasian J Soil Sci 2020, 9 (3) 202 – 207

Calcisols Aric Clayic Isopteric Ochric; 4.Cambic Gleyic **Calcisols** Aric Clayic Isopteric Ochric.

CHAPTER IV. MODERN SITUATION OF SOIL BIOLOGICAL ACTIVITY

The main part of the CO_2 emission from the soil into the atmosphere is associated with the activity of heterotrophic microorganisms in the soil. More than 90% of the carbon dioxide produced by soil organic matter is produced as a result of the activity of microorganisms, only 10% depends on human activity and the respiration of living organisms, 2/3 of the carbon dioxide released under aerobic conditions is accounted for by fungi and 1/3 by bacteria. According to the results of our three-year research, the intensity of carbon dioxide release from the soil (0-50 cm) was between 1,5-2,7 in the control, 2,7-4,7 in the biohumus 5 t/ha variant, 2,1-3,4 in zeolite 5 t/ha, 3,5-5,5 in biohumus 5 t/ha + zeolite 5 t/ha, 3,3-5,3 in biohumus7,5 t/ha, 2,2-3,6 in zeolite 7,5 t/ha, and 3,7-6,0 mg CO_2 per 10 g of soil/24 hours in biohumus7,5 t/ha + zeolite 7,5 t/ha. Thus, the amount of CO_2 released from irrigated meadow-grey soils varied depending on both the growth phase of the bean plant and the given norms of zeolite and biohumus (Figure 1).

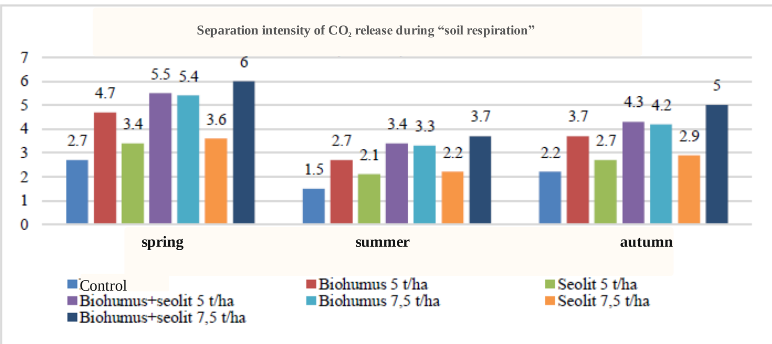
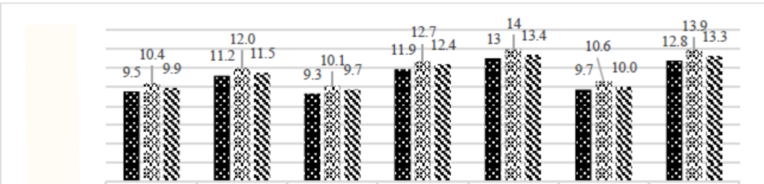


Figure 1. Seasonal separation intensity of carbon dioxide release from irrigated meadow-grey soil

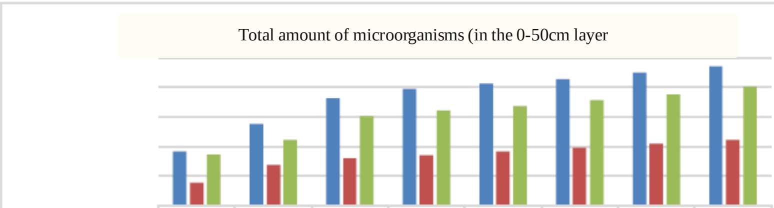
Depending on the variants, the intensity of the nitrification process in irrigated meadow-grey soils under bean plants, according to a three-year study, varied in the interval from 9,5-10,4 in the 0-50 cm layer in the first control, 11,2-12,0 in the biohumus 5 t/ha variant, 9,3-10,1 in the zeolite 5 t/ha, 11,9-12,7 in the biohumus 5 t/ha+zeolite 5 t/ha, 13,0-14,0 in the biohumus 7,5 t/ha, 9,7-10,6 in the zeolite 7,5 t/ha and 12,8-13,9 in the biohumus 7,5 t/ha+zeolite 7,5 t/ha (mg/kg) (Figure 2). The lowest indicator of the intensity of the nitrification process was in the spring. It reached a maximum in the summer. Due to the decrease in temperature in autumn, the intensity again decreased compared to summer.



	Control	Biohumus 5 t/ha	Zeolite 5 t/ha	Biohumus+ seolit 5 t/ha	Biohumus 7.5 t/ha	Zeolite 7.5 t/ha	Biohumus+ seolit 7.5 t/ha
spring	9.5	11.2	9.3	11.9	13	9.7	12.8
summer	10.4	12.0	10.1	12.7	14	10.6	13.9
autumn	9.9	11.5	9.7	12.4	13.4	10.0	13.3

Figure 2. Seasonal intensity of nitrification process in irrigated meadow-grey soils

The variation of the amount of microorganisms during the vegetation period of bean plants in irrigated meadow-grey soils by years, seasons and variants was studied, the difference was greater by variants. The results obtained show that the overall amount of microorganisms was higher in spring - during the initial growth of the plant, but with the increase in temperature and decrease in humidity in summer, their amount decreased significantly and changed to increase again in autumn. During the bean vegetation period, the maximum amount of microorganisms was recorded in the biohumus 7,5 t/ha+zeolite 7,5 t/ha variant in spring (May)-2640,43 thousand g/soil (0-50 cm), soil t=23,3ºC, W=26% and in autumn -2252,09 thousand g/soil (September), soil t=23,9ºC, W=23,6%, while the minimum amount of microorganisms was recorded in summer -1264,72 thousand g/soil (July), soil t=27,4°C, W=24,9% (Figure 3).



	Xam	Control	Biohumus 5 t/ha	Zeolite 5t/ha	Biohumus 5 t/ha+ Seolit 5t/ha	Biohumus 7,5t/ha	Zeolite 7,5t/ha	Biohumus 7,5 t/ha+ Seolit 7,5t/ha
MAY	911.48	1382.7	1809.12	1969.97	2060.42	2132.26	2239.59	2358.31
JULE	383.69	692.44	801.41	846.99	912.73	983.83	1041.2	1111.83
SEPTEMBER	860.36	1112.5	1508.23	1602.25	1687.28	1775.04	1877.49	2002.87

Figure 3. Dynamics of microorganisms in meadow-grey and irrigated meadow-grey soils

In terms of profitability, in the biohumus 5t/ha+zeolite 5t/ha variant that we offer to the farm, the total amount of microorganisms (0-50 cm) in spring (May) was $2060{,}42 \times 10^3$ g/soil, soil t=23,0^0C, W=25%; in summer (July)-$912{,}73 \times 10^3$g/soil, soil t=28,3^0C, W=23,3%; in autumn (September)-$1687{,}28 \times 10^3$ g/soil, soil t=24,2^0C, W=22,6%. Compared to the control variant, a 30-35% increase in the total amount of microorganisms was observed in the biohumus 5t/ha +zeolite 5t/ha variant, and a 40-45% increase in the biohumus 7,5t/ha + zeolite 7,5t/ha variant. It should be noted that the application of zeolite during the vegetation period in irrigated meadow-grey soils under bean plants was able to maintain soil moisture at 22-24% even at high soil temperatures, providing the plant with moisture that could meet its needs.

The intensity of decomposition of flax fabric, which determines the biological activity of soils (the "application" method), allows us to determine not only the activity of cellulose-decomposing soil microorganisms, but also the degree of mobilization of nitrogen and other agronomically valuable elements. The intensity of decomposition of flax fabric placed in the 0-25 cm layer of the soil profile changed dynamically during the vegetation period, depending on the rate of fertilizer applied under the bean plant. During the period of the research, the activity varied between 21,2-36,0%, depending on the variants (Figure 4). The intensity under the bean plant decreases from spring to summer, and a relative increase is observed from summer to autumn in irrigated meadow-grey soils.The max. value was obtained in spring for all variants.

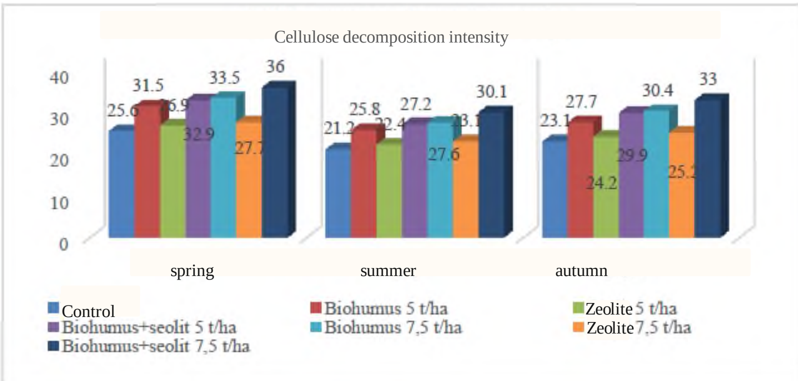
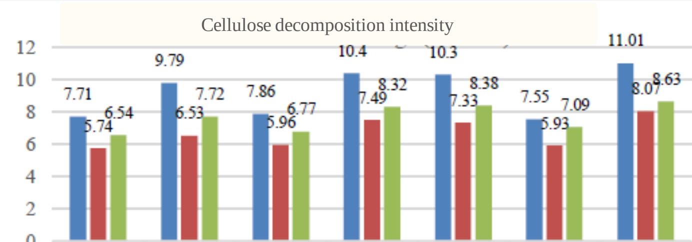


Figure 4. Seasonal dynamics of cellulose decomposition intensity in irrigated meadow-grey soil

The three-year average value of the seasonal dynamics of invertase enzyme activity in the 0-50 cm layer varied between 5,74-7,71 mg glucose in the control, 6,53-9,79 in the biohumus 5 t/ha variant, zeolite 5 t/ha-5,96-7,86, biohumus 5 t/ha+zeolite

5 t/ha-7,49-10,40, biohumus 7,5 t/ha-7,33-10,30, zeolite 7,5 t/ha -5,93-7,55, biohumus 7,5 t/ha+zeolite 7,5 t/ha-8,07-11,01 mg glucose (Figure 5). Comparison of the variants shows that the activity of the invertase enzyme did not differ significantly from the control in the variants where zeolite was applied, but the activity was relatively high in the variants where different doses of biohumus were applied and in the biohumus+zeolite variants.

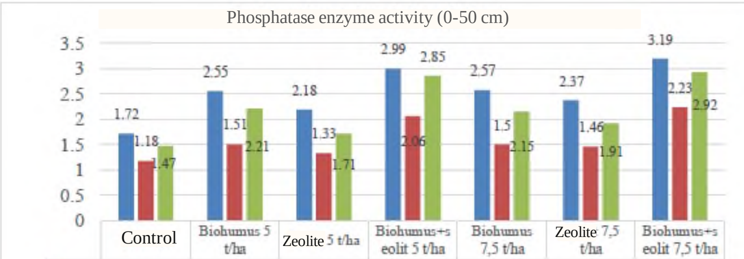


	Control	Biohumus 5 t/ha	Zeolite 5 t/ha	Biohumus +seolit 5 t/ha	Biohumus 7,5 t/ha	Zeolite 7,5 t/ha	Biohumus +seolit 7,5 t/ha
spring	7.71	9.79	7.86	10.4	10.3	7.55	11.01
summer	5.74	6.53	5.96	7.49	7.33	5.93	8.07
autumn	6.54	7.72	6.77	8.32	8.38	7.09	8.63

Figure 5. Seasonal dynamics of invertase enzyme activity in irrigated meadow-grey soils

The reason for the high enzyme activity (in May) during the vegetation period of the plant, at the initial stage of growth, can probably be explained by the favorable temperature and moisture regime in the soil at that time. Despite irrigation in the summer (flowering period), high temperature caused a decrease in the activity of the invertase enzyme, but in the fall (full ripening), as the temperature decreased and the plant continued to develop, and favorable soil-climatic conditions were created, the activity relatively increased again (Figure 5). This consistency was recorded in all variants.

The three-year results of the total phosphatase activity of soils show that, depending on the growth phase of beans, the activity was highest in the irrigated meadow-grey soils under beans in the 0-50 cm layer with biohumus 7,5 t/ha+zeolite 7,5 t/ha variant. According to the results of the researches conducted on the hydrothermal regime of the soil, it can be noted that the maximum indicator of phosphatase enzyme activity is achieved in spring - 3,19 mg P_2O_5, soil t=23,3ºC, W=26,0%, and the minimum indicator is achieved in summer- 1,18 mg P_2O_5, t=30,3 ºC, W=19,5% (Figure 6).



	Control	Biohumus 5 t/ha	Zeolite 5 t/ha	Biohumus+seolit 5 t/ha	Biohumus 7,5 t/ha	Zeolite 7,5 t/ha	Biohumus+seolit 7,5 t/ha
spring	1.72	2.55	2.18	2.99	2.57	2.37	3.19
summer	1.18	1.51	1.33	2.06	1.5	1.46	2.23
autumn	1.47	2.21	1.71	2.85	2.15	1.91	2.92

Figure 6. Seasonal dynamics of phosphatase enzyme activity in irrigated meadow-grey soils

Referring to the average figures of the three-year research, it can be said that the activity of the catalase enzyme varied in the range of 3,8-6,2 cm^3 O_2 in the 0-50 cm layer in the control variant, 5,4-7,0 in the biohumus 5 t/ha variant, 4,2-6,5 in the zeolite 5 t/ha variant, 6,1-7,4 in the biohumus 5 t/ha+zeolite 5 t/ha variant, 6,9-8,2 in the biohumus 7,5 t/ha variant, 4,5-6,8 in the zeolite 7,5 t/ha variant and 7,2-8,5 cm^3 O_2 in the biohumus 7,5 t/ha+zeolite 7,5 t/ha variant (Figure 7).It can be stated that the maximum indicator of catalase enzyme activity in summer was 8,3 cm^3O_2, soil t=30,3ºC, W=24,9%, and the minimum indicator was 3,8 cm^3O_2, soil t=20,8 ºC, W=21,4% in spring based on observations made on soil temperature and soil moisture.

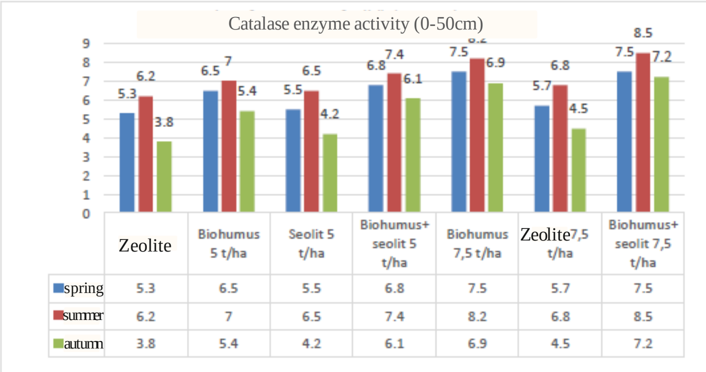


Figure 7. Seasonal dynamics of catalase enzyme activity in irrigated meadow-grey soils

CHAPTER 5. BIOLOGICAL EVALUATION AND ECONOMIC EFFICIENCY OF IRRIGATED MEADOW-GREY SOILS

The diversity of units of various biological indicators creates difficulties in their evaluation.Just as biological indicators of soils are diverse, their units of determination, and the measures that evaluate them are also diverse. In order to combine numerous biological indicators of soils, a method for determining the integral indicator of the ecological and biological state of the soil (TBVIG) has been developed, which allows assessing the totality of biological indicators.TBVIG for invertase enzyme activity under bean plants varied between 76-100%. TBVIG for phosphatase enzyme activity varied between 53-100%, and TBVIG for catalase enzyme activity varied between 15-87% in irrigated meadow-grey soils.In the variants where zeolite was applied, the increase compared to the control was between 3-4 units. TBVIG for the amount of microorganisms varied between 75-100% depending on the variants, the highest indicator in comparison was recorded in the variants where biohumus was applied.

There was no significant difference between the variants in terms of cellulose decomposition intensity. Thus, this indicator varied in the interval of 78-100%, the highest indicator (100%) was recorded in the variant of biohumus 7,5 t/ha + zeolite 7,5 t/ha. In irrigated meadow-grey soils, TBVIG varied between 42-100% depending on the variants,and in terms of the intensity of the nitrification process, it varied between 74-100%. Calculation of TBVIG according to the obtained biological indicators shows that the biological evaluation of irrigated meadow-grey soils under beans was between 67-100% (table 3).

Table 3.

Irrigated meadow-grey TBVIG (0-50 cm)

Variants	Integral indicator of the biological condition of soils, %		
	0-25	25-50	0-50
Control	67	63	66
Biohumus 5 t/ha	82	78	80
Zeolite 5 t/ha	75	72	74
Biohumus 5t/ha+zeolite 5 t/ha	94	91	93
Biohumus 7,5 t/ha	90	89	90
Zeolite 7,5 t/ha	79	77	78
Biohumus 7,5t/ha+zeolite7,5 t/ha	100	100	100

Bean seed yield varied between 2,5-2,8 in the control, 3,7-3,8 in the biohumus 5 t/ha variant, 3,0-3,3 in the zeolite 5 t/ha, 4,4-4,6 in the biohumus 5 t/ha+zeolite 5 t/ha, 4,2-4,4 in the biohumus 7,5 t/ha, 3,3-3,4 in the zeolite 7,5 t/ha and 4,9-5,0 in the biohumus 7,5 t/ha+zeolite 7,5 t/ha (Fig. 8). In calculating the economic efficiency of plants, operating costs, expenses, and sales prices of products were calculated according to market prices and the recommendations of S.O.Babirov, R.I.Mustafayev, C.J.Mammadov, etc,:net income=income from sales - incurred costs; profitability=(net income: incurred costs) × 100; cost price=incurred costs: harvested product.

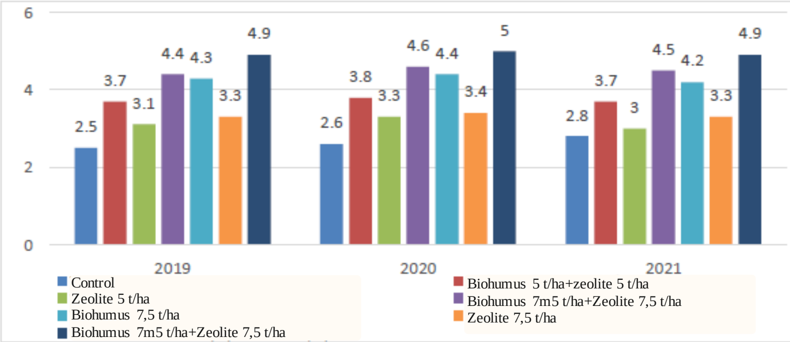


Figure 8. Productivity of bean plants on irrigated meadow-grey soils

The market selling price of the product was compared with the costs incurred for the production of the product, the cost price was calculated, and the profitability was calculated. The costs incurred in cultivating bean plants were 2500 manats in the control, gradually increasing in the variants where biohumus and zeolite were applied. Depending on the variants, the cost price in cultivating beans fluctuated between 0,93-1,51 manats, and the profitability varied between 56,5%. Thus, the variant where biohumus 5 t/ha + zeolite 5 t/ha was applied in the norm can be proposed as a more efficient variant for the farm.In the goals and objectives of the dissertation work, the main goal of the conducted scientific research work is to save irrigation water in agriculture due to the shortage of fresh water resources, which is one of the main ecological problems of the republic. In this regard, the application of zeolite, which has a high absorption capacity, in our experience, while the irrigation rate during the vegetation period of the bean plant is 3500 m^3, 1600 m^3 of water was given to the field, and due to the maintenance of soil moisture at 22-24%, 50% of irrigation water was saved, and due to the application of vermicompost, a sustainable product was obtained with a productivity of 4,5 t/ha and a profitability of 56,5%. The variant of applying biohumus

5 t/ha+zeolite 5 t/ha at a rate can be proposed as a more efficient variant for the farm.

CONCLUSION

1. The conducted researches revealed that in the variant with biohumus 5 t/ha+zeolite 5 t/ha, the soil profile has more pores, the colour of the soil is darker than other sections, the structure is lumpy-grained in the upper layer. The high porosity in the soil profile improves the air, water, and temperature regimes, and creates conditions for plant roots to use nutrients. This has a positive effect on increasing productivity and intensifies the soil formation process. At the same time, the onset of signs of clayeyness from layer B and the profile is moisture. This can be explained by the fact that zeolite retains water.
2. It was determined that irrigated meadow-grey soils are heavy loamy and light loamy-(<0,01 mm 44,87-70,10 %, <0,001 mm 11,87-25,98%), hygroscopic moisture content 2,2-2,8%. The amount of humus in the upper layer is 2,65% - sufficient, in the lower horizons 0,52% - extremely low humus. The reaction of the condition-pH 7,79-8,39 is weak and moderately alkaline. Carbonates ($CaCO_3$%) washed and accumulated in the middle layers of the profile and amount was 17-18%, and is consedered carbonated, absorbed bases in the crop and subsoil layers was evaluated as 36,30-32,20 mmol per 100 g of soil - medium level. The soils were sulfate-chloride saline, and 0,217-0,270% in the upper 0-25 cm soil layer was evaluated as weakly saline.
3. The international name of the meadow-grey soils: Gypsiric Gleyic CalcisolsLoamic Ochric. The international name of the irrigated meadow-grey soils cultivated in the control variant under the bean plant: Gleyic Calcisols Aric ClayicIsopteric Ochric. The international name of the

irrigated meadow-grey soils cultivated in the variant with biohumus5 t/ha under the bean plant: Cambic Gleyic Calcisols Aric ClayicIsopteric Ochric. The international name of the irrigated meadow-grey soils cultivated in the variant with biohumus 5 t/ha+zeolite 5 t/ha under the bean plant: Cambic Gleyic Calcisols Aric ClayicIsopteric Ochric.

4. In the variant where biohumus 5t/ha and zeolite 5/ha were applied, the intensity of soil "respiration" and biological processes were related to each other, with a low level of activity recorded in summer (3,5 mg/10 g soil/24 hours), an average level in autumn (4,3 mg/10 g soil/24 hours), and a high level in spring (5,5 mg/10 g soil/24 hours).
5. The maximum of the nitrification process was in summer, and the minimum in spring and autumn. This is due to the creation of favorable conditions for the decomposition of nitrogenous organic compounds in the soil during the mass flowering phase of the bean plant. In autumn, the weakening of the hydrothermal regime and the use of nutrients during the formation of fruit led to a decrease in intensity.
6. It was determined that in the control variant, the total amount of microorganisms in the 0-50 cm soil layer reaches a maximum of 1382,7 thousand per 1 g of absolute dry soil in May, when the soil temperature is 20,8 ºC and W = 19,4%. In July, when the soil temperature is t=30,3 ºC, and the soil temperature drops sharply to W=13,5% due to increased evaporation, the total amount of microorganisms decreases by about 2 times and amounts to 692,44 thousand per 1 g of absolute dry soil. In September, when the soil temperature is t=22,4 ºC and W = 23,01%, a sharp increase in the total amount of microorganisms is observed compared to the summer period and amounts to 1112,5 thousand per 1 g of absolute

dry soil. It should be noted that the meadow-grey soils irrigated under beans were provided with moisture that could meet the needs of the plant, remaining within the range of W – 22-24% even at high soil temperatures, thanks to the joint application of biohumus and zeolite during the vegetation period. In the variant with biohumus 5t/ha + zeolite 5t/ha, the total amount of microorganisms increased by 30-35%, and in the variant with biohumus 7,5 t/ha + zeolite 7,5 t/ha, a 40-45% increase was observed in all phases of bean plant growth.

7. The maximum intensity of cellulose decomposition is 37,2% (spring) in the biohumus 7,5 + zeolite 7,5 t/ha variant, in the spring season, when the 3-year average soil temperature is 22,5ºC and the moisture is 25,5%, and the minimum indicators are 31,1% in the summer, t=26,2ºC and W=24,8%.
8. The highest indicators of the invertase enzyme activity (in the 0-50 cm layer), regardless of the experimental variants, correspond to the conditions in the spring – 11,01 mg of glucose, in the conditions of the soil t=23,3ºC and W= 26,0%, min. indicator in summer – 5,74 mg glucose, soil t=30,2^0 C, W=19,5%, the maximum indicator of phosphatase enzyme activity also corresponded to the indicator in spring – 3,19 mg P_2O_5, soil t=23,3 ºC, W=26,0%, the min. indicator in summer – 1,18 mg P_2O_5, t=30,2 ºC, W=19,5%, and the catalase enzyme, on the other hand, had the max. indicator in summer – 8,5 cm^3O_2, soil t=27,4ºC, W=24,9%, and the min. indicator in autumn – 3,8 cm^3O_2, soil t=22,4 ºC, W=19,5%.
9. The calculation of TBVIG according to the obtained biological indicators shows that the biological evaluation of the meadow-grey soils irrigated under beans was between 67-100%. TBVIG was 67% in the control variant, biohumus 5 t/ha – 82%, zeolite 5 t/ha – 75%, biohumus 5

t/ha + zeolite 5 t/ha – 94%, biohumus 7,5 t/ha – 90%, zeolite 7,5 t/ha – 79% and 100% in the biohumus 7,5 t/ha + zeolite 7,5 t/ha variant.

10. It was determined that the yield of bean plants increased by 1,8-2,2 t/ha, i.e., 67-81%, compared to the control, in the variant where biohumus 5 t/ha + zeolite 5 t/ha and biohumus 7,5 t/ha + zeolite 7,5 t/ha were applied together.
11. Taking into account productivity, conditional net income, and costs incurred, the variant of applying biohumus 5 t/ha + zeolite 5 t/ha, which is more economically efficient for the farm, is proposed, and the profitability in this variant was 56,5%.
12. In order to save irrigation water, in our experience, the application of zeolite, which has a high absorption capacity, while the irrigation rate of the bean plant during the vegetation period was 3500 m^3, 1600 m^3 of water was applied to the field, and approximately 50% of irrigation water was saved due to maintaining soil moisture at 22-24%,due to the application of vermicompost, the productivity was 4,5 t/ha, and the profitability was 56,5%, and a sustainable product was obtained.

List of published scientific works related to the dissertation topic

1. Isagova V.G. Application of biohumus and adsorbent on irrigated meadow-sierozem soils used for bean cultivation // Materials of the Scientific and Practical Conference on “Environmental Problems and the Strategy for Its Protection: A Look into the Future”, Institute of Soil Science and Agrochemistry of ANAS. - Baku, Azerbaijan: - 2020, - pp. 61– 62.
2. Isagova V.G. The impact of biohumus and zeolite on the soil// Modern science: problems and innovations.

Abstracts of VI International Scientific and Practical Conference. August 23-25, - Stockholm: - 2020, - pp. 26-29.
3. Orujova N.I., Isagova V.G. Influence of vermicompost and zeolite on the biological activity of irrigated meadow-grey soils // Problems of transformation of natural landscapes as a result of anthropogenic activity and ways of their solution. Collection. of scientific. works on materials of int. scientific. ecol. conf., dedicated to the year of science and technology. KubSAU. - Krasnodar: - 2021. - pp.123-127.
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5. Isagova V.G. Influence of vermicompost and zeolite on the content of mobile phosphorus in irrigated meadow-serozem soils // Ecological Bulletin of the North Caucasus. Vol. 18, No. 2. ISSN 2308-3875. KubSAU. - Krasnodar: - 2022 - pp. 81-83.
6. Isagova V.G., Orujova N.H. Effect and Evaluation of Zeolite and Biohumus on Biological Indicators of Irrigated Seed-gray Soils // Asian Research Journal of Agriculture. 15 (4). - UK: - 2022, - pp. 170-179. https://doi.org/10.9734/arja/2022/v15i4368
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8. Isagova V.G., Orujova N.I. Influence of vermicompost and zeolite on biological parameters of irrigated meadow-grey soils // Proc. int. sci. conf. "Soil evolution and development of scientific concepts in soil science" dedicated to the 90th anniversary of the birth of Honored Scientist of the

Russian Federation, Doctor on Agricultural Sciences, Professor of the Department of Soil Science and Agrochemistry of the Altai State Agricultural University Lidiya MakarovnaBurlakova. - Barnaul: - 2022, - pp. 247-251.

9. Isaqova V.G., Orujova N.H. The effect of biohumus and zeolite on enzyme activity in irrigated meadow-grey soils // Agro International Conference on Agriculture. Azerbaijan State Agrar University ANAS Department of Biology and Medicine Ege University, Faculty of Agriculture Institute of Economic Development and Social Research - IKSAD. Proceedings book. - Azerbaijan, Baku: - 2022, - pp. 89-94.
10. Isagova V.G. Influence of vermicompost and zeolite on the fertility of irrigated meadow-grey soils and bean productivity // Bulletin of Science and Practice. Vol.9, No.1. - Russia: - 2023, - pp.136-143.
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