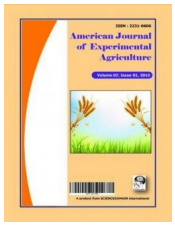

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Dynamics of Microbial Population in the Irrigative Grey-Brown and Grey-Meadow Soils under Vegetable Cultures of Dry Subtropical Zone

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Authors' contributions

This work was performed in cooperation between all authors. Authors were responsible for quality control to guarantee a stream research materials against introduction to the conclusions and corresponded whole all content of the paper with what was expressed in the summary to make sure that there was a sequence in the paper. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The objective of this study was to examine the distribution of microorganisms in different types of agricultural soils.
Study Design: Comparative analysis of quantity of microorganisms in a crop rotation and constant (permanent) in a dry subtropical zone in different types of soils.
Methodology: Microorganisms quantity has been defined by (microorganisms total quantity meat-peptone-agaric (MPA) and starchy-ammoniac-agaric (SAA), actinomycetes starchy - agaric- agaric (SAA) and microscopic fungus quantity have been defined on Chapek agaric environment on the basis of the method received in the Institute of Microbiology of Moscow.
Results: The results showed that the quantity of microorganisms in a crop rotation was more, than

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permanent cultivation of these cultures. A mineralization of organic substances in soils under constant cultures occurred more intensively, than in a crop rotation.
Conclusion: Including in a crop rotation of legume cultures (Lucerne, haricot, bean) increases quantity of microorganisms, also slows down intensity mineralization of organic substances.

Keywords: Irrigative soils of dry subtropical zones; quantity of microorganisms; crop rotation; constant *(permanent) cultures; coefficient of mineralization.*

1. INTRODUCTION

Soils contain a very high, but mostly unknown biodiversity, and soil biology remains an under studied topic. Soil organisms are a key factor for soil development and in turn depend on soils as a habitat [1]. Soils are home to a vast and still poorly known diversity of organisms that perform essential ecosystem functions. An ecosystem is greatly influenced and in some cases even controlled by microbial activities. Microorganisms carrying out metabolic processes remove nutrients from the ecosystem and use them to build new cells. At the same time, they excrete waste products back into the environment. Thus, microbial ecosystems expand and contract, depending on the resources and conditions available. Over time, the metabolic activities of microorganisms gradually change their ecosystems, both chemically and physically [2].

Understanding and maintaining biodiversity has become an increasingly important field of research, as well as a resource management goal. In soil microbial communities, maintaining critical functions may ultimately be more important than maintaining taxonomic diversity. One essential microbial function in soils is the processing and recovery of key nutrients from detrital inputs and accumulated soil organic matter [3]. Soil microorganisms are actively involved in soil biochemical processes, including organic matter decomposition, nutrient mineralization and cycling [4]. The decomposition of organic matter by soil organisms has an immense influence on soil fertility, plant growth, soil structure, and carbon storage.

Although microorganisms are the smallest forms of life, collectively they constitute the bulk of biomass on Earth and carry out many necessary chemical reactions for higher organisms. In the absence of microorganisms, higher life forms would never have evolved and could not now be sustained [2]. Functional diversity of the soil microbial community is commonly used in the assessment of soil health as it relates to the activity of soil microflora involved in carbon cycling [5].

Microorganisms are the backbone of all ecosystems. Microbes are decomposers, with the ability to recycle nutrients from other organisms' waste products. These microbes play a vital role in biogeochemical cycles [6]. Due to high soil heterogeneity, the spatial distribution of microbial metabolic activity is a key to understand functional variability of soil microhabitats [7]. In addition, information regarding the spatial variability of soil microbial metabolic diversity, and the factors that determine these patterns could lead to more accurate predictions of microbial properties and functions [4]. This in turn would provide important information regarding mechanisms that regulate ecosystem function, including C and nutrient cycling [7,8]. Earth‘s atmosphere consists of 78% of N making it the largest pool of N which would be unavailable for plants as well as animals and human world if there is no N_2 reduction i.e. N_2 fixation [9]. Through the process of biological N_2 fixation-BNF, particular prokaryote organisms possessing enzyme nitrogenase can reduce i.e. fix atmospheric N_2 gas into the ammonia (NH_3) form of N that will be converted into other organic form of nitrogenous compounds [10]. In exchange for reduced nitrogen from the bacteria (NH_3 followed by amino acids), the plant provides rhizobia with reduced carbon (carbohydrates) and all the essential nutrients required for bacterial metabolism [10]. To achieve efficient exchange of metabolites between the symbionts (rhizobial bacteria and host plant) there has to be the appropriate compatibility between them because nodulation and nitrogen fixation efficiency is a complex activity, involving and interacting genes in both symbionts [11]. Specificity, competition, mobility and virulence as well as N_2 fixing activity are important rhizobial characteristics [10].

The purpose of this study was to evaluate dynamics of microbial population in the irrigative

grey-brown and grey-meadow soils under growing cultures in dry subtropical zone.

2. MATERIALS AND METHODS

2.1 Materials of Researches

Materials of researches were irrigated grey-brown (Irragic Gypsic Calcisols in WRB) and grey-meadow (meadow-sierozemic) soils (Irragic Calcisols in WRB) of arid subtropical zones and crop rotation and permanent cultures.

2.1.1 Irrigated grey-brown soils (irragric gypsic calcisols)

Irrigated gray-brown soils (Irragric Gypsic Calcisols according to the WRB) on the terraces of the Caspian Sea were developed under climatic conditions with a sufficient heat supply to ensure efficient irrigation farming. The humus content in these soils is 1.5–1.9%, the soil reaction is slightly alkaline (pH 8.3–8.5), and these soils are characterized by the chloride–sulfate type of salinization.

2.1.2 Irrigated meadow-sierozemic soils (irragric calcisols)

Irrigated meadow-sierozemic soils (Irragric Calcisols in WRB) were formed under conditions of increased soil hydromorphism; the groundwater dynamics in these soils are of great importance. The features of salinization and gleyzation are often seen in the soil profiles. The plow horizon contains 1.3–2.8% humus. The humus content increases from the newly irrigated soils to the old-irrigated soils. In the recently irrigated soils, the exchangeable sodium percentage increases from the depth of 30–40 cm; the presence of exchangeable sodium and the alkaline reaction lead to the development of solonetzic features in these soils.

2.2 Methods

2.2.1 Microbiological analyses

For microbiological analyses soil samples were taken from 0-20 cm and 25-50 cm depth three times in a vegetation period: June, August and October.

The number of different groups of microorganismss were determined by the inoculation method. 1 qr dry soil is dissolved in the water for analysis, it is diluted some times by taking 1 ml from suspension (10^{-5} and 10^{-6}). From the same suspension 1 ml was planted in the standard nutritious environment. Incubation temperature was 28°C, while incubation time depended on the tested group of microorganisms.

The standard environment was used for definition of taksonomik group microorganisms: Ammonifiers assimilating the organic forms of nitrogen were determined on meat-peptone agar (MPA). Spore-forming bacteria was determined in the heated mixed environment during 20 minutes in 80ºC. Bacteria assimilating the mineral forms of nitrogen were determined on the starch-ammonia agar (SAA). The total number of actinomycetes was determined on starch-ammonia agar (SAA). The total number of fungi was determined on malt agar (Czapek's agar medium) dilution of 1:1000. All microbiological analyses were performed in three replications and the average number of microorganisms was calculated at 1.0 g absolutely dry soil. The statistical processing of the data was performed by the routine methods to ensure a 95% significance level [12].

2.2.2 Crop rotation design

In the irrigated grey-brown soils the following crop rotation scheme were used: a six-field crop rotation - (scheme I) (alfalfa of the first year + barley, alfalfa of the second year, watermelons, potatoes, garlic, and white cabbages+tomatoes) and a five-field crop rotation-(scheme II) with vegetables and legumes (tomatoes, kidney beans, watermelons, potatoes, and kidney beans) were applied. For comparison, the soils under monocultures of tomatoes, watermelons, potatoes, garlic, white cabbages, and kidney beans were examined.

In the irrigated meadow-sierozemic soils (in Shirvan plain), a four-field rotation (alfalfa of the first year, alfalfa of the second year, cucumbers, and tomatoes) was applied. The soils under monocultures of cucumbers and tomatoes were also examined.

On the irrigated meadow sierozemic soils (in Mugan plain), a five-field rotation (alfalfa of the first year, alfalfa of the second year, clap, corn and tomatoes) was applied.

3. RESULTS AND DISCUSSION

Land use change is one of the greatest threats to biodiversity worldwide [13]. The use of

biologically balanced farming systems must be accompanied by ecological and economic assessment of environmental change. Among the indicators of environmental changes the leading place belongs to soil microorganisms: the structure of the microbial community and its biological activity. Microbiological monitoring of the soil in biological farming is an important and necessary element in the management and preservation of fertility of agricultural land. Function and response of soil biocenosis on human intervention has both general laws for all types of soils and their zonal characteristics that are unique to a particular type of soil, which determines the need for research, particularly in view of the zonal aspect [14].

Therefore, the issues of improving the environmental situation in modern agricultural landscapes, maintenance, and reproduction in soil fertility and increase crop productivity is being acquired special urgency. There is a need to create not only a sustainable and environmentally sound technologies and techniques, but also to conduct a biological farming system as a whole. One of the most promising measures in improving soil fertility is organic farming: crop rotation, the introduction of legumes in crop rotation, perennial legumes and legume-grass mixtures, the intensification and maximum use of associative and symbiotic nitrogen fixation, the use of green manure and non-market part of the harvest for fertilizer , the use of organic fertilizers, crop adaptive highly productive varieties and hybrids that are resistant to pests and diseases, a moderate use of mineral fertilizers and pesticides, coupled with differentiated minimum tillage [14]. Agriculture benefits from the cycling of nutrients by microorganisms. For example, a number of major crop plants are legumes. Legumes live in close association with bacteria that form structures called nodules on their roots. In the root nodules, these bacteria convert atmospheric nitrogen (N_2) into ammonia (NH_3) that the plants use as a nitrogen source for growth [2]. We studied an effect of the growing plants on soil microflora activity the plants of the same name are compared on the crop rotation and constant tillage grey-brown and grey-meadow soils under an irrigative condition. The results of this study demonstrated that the population quantities of the soil microorganisms in the rotation systems are highly variable.

The use of biologically balanced farming systems must be accompanied by ecological and economic assessment of environmental change. Among the indicators of environmental changes leading place belongs to soil microorganisms: the structure of the microbial community and its biological activity. Microbiological monitoring of the soil of biological farming is an important and necessary element in the management and preservation of fertility of agricultural land [14].

The soil is habitat for many and various microorganisms that form its biological phase. Intensive agricultural production, irrational use of large quantities of pesticides and mineral fertilizers, wastewater irrigation, significantly impairs the quality and fertility of agricultural soils [15].

The obtained consequences show that the different agrotechnical measures applied in plants growing-fertilizer, irrigation, soil cultivation alternation of the plants on crop rotation and others effect on soil biogeniness to a significant degree, learning of the soil microbiological feature is necessary from the stand point of definition of the agrotechnical measures and growing plants effect on soil biological features.

In the irrigated grey-brown soils, the numbers of bacteria varied from 1.1 to 1.5×10^6; spore-forming bacteria, from 0.1 to 0.2×10^6; actinomycetes, from 2.6 to 4.0×10^5; and microscopic fungi, from 2.2 to 3.1×10^3 CFU/g of dry soil in the spring-autumn periods during the first year of rotation (Table 1).

Nitrogen (N) is one of the most important plant nutrient. Its deficiency of soil N immediately influences quantity and quality of crop yield [9]. Rhizobium-legume symbiosis provides about 50% of the total amount of nitrogen fixed (N_2) on the Earth which makes the symbiotic association the most efficient which reflected in increment of crop yield spatially legumes. Effectiveness of rhizobia is its ability to satisfy plant needs for nitrogen (N) [9]. The best known N_2 fixing bacteria are: symbiotic (rhizobial) bacteria and nonsymbiotic free leaving (*Azotobacter, Clostridium*) [9]. Legume cover cropping has been widely used as an efficient strategy to improve soil fertility. Although this management practice is important to resolve N deficiency for the transition from conventional to organic production systems, optimization is necessary to determine legume cover crop species and termination methods [16]. Thanks to the activities of these nitrogen-fixing bacteria, the legumes have no need for costly and polluting nitrogen

fertilizers [2]. Alfalfa is the most important legume that, in addition to high yield potential and quality of biomass, is characterized by an intense process of biological nitrogen fixation [17]. The root of alfalfa deeply penetrates the soil, improving aeration, structure and microbiological activity of it. In the rhizosphere of alfalfa, there are numerous microorganisms which can have different effects on the plant development [17].

3.1 Dynamics of Microorganisms Quantity in Irrigated Grey-brown Soils

A total quantity of the microorganisms on the tillage and under tillage layers under the annual lucerne+barley was (1.6-2.0)×10^6 , bacteria were (1.1-1.5)×10^6, spore-forming bacteria-(0.1-0.2)×10^6, actinomycetes-(2.6-4.0)×10^5 and microscopic fungi were in (2.2-3.1) ×10^3 CFU/g dry soil in the grey-brown soils in the spring-autumn seasons. A total number of microorganisms under the two-year lucerne was more than an annual lucerne, on the tillage and under tillage layers it was in (2.6-3.0)×10^6 CFU/g soil. A quantity of the microscopic fungi on both versions was in (2.2-4.3)×10^3 CFU/g soil by reducing on 0-50 cm of layer along the profile. Plant roots improve the chemical and physical conditions in the soil and favor a significant increase in the population of the soil microflora in the root zone. A maximum quantity of actinomycetes was in summer, a maximum quantity of the spore-forming bacteria was in autumn. The mathematic analyses show that total quantity of the microorganisms under an annual lucerne+barley and two-year lucerne was 2036-3447 on the tillage layer, 1387-2374 thousand/g dry soil on the under tillage layer and a variation coefficient was 8.82-14.57% (Table 2).

A quantity of the bacteria entering the microflora structure changed by (1.3-1.9)×10^6 on the tillage and under tillage layers, actinomycetes-(4.5-4.6) × 10^5 and microscopic fungi (1.5-3.1)×10^3 CFU/g dry soil under the watermelon on the 1st scheme at the vegetation period. The microflora activity was more than other vegetable plants growing in the soils under the watermelon, it can be explained by a positive effect as a predecessor. A sort structure changed together with the microorganisms quantity at the vegetation period. A quantity of actinomycetes raised in summer in comparison with the spring, its reason was to ensure the microorganisms with the food and to protect itself under unfit condition. A total number of microorganisms in the soils under the watermelon on the 2nd scheme was got 0.9 × 10^6 CFU/g soil less than the watermelon on the 1st scheme, (1.1-1.5)×10^6 on tillage layer AI^I_a, bacteria-(0.6-1.1)×0^6 CFU/g, spore-forming bacteria-0.09×10^6 CFU/g, actinomycetes (2.7-3.5) × 10^5 and fungi–(1.8-2.2)×10^3 , on the under tillage layer was AI^{II}_a (8.7-1.1)×10^6; (0.5-0.8)×10^6; (0.7-1.5)×10^5; (2.2-2.8)×10^5 and (1.0-1.1)×10^3 CFU/g dry soil. A total quantity of microorganisms on the watermelon constant tillage was 1.2×10^6 on the tillage layer and 0.6×10^6 CFU/g on the under tillage layer at the vegetation period. Bacteria on the tillage horizon under the constant watermelon formed 68.4% from a total number of microorganisms, actinomycetes–22.5%, spore-forming bacteria–9.0% and microscopic fungi–0.1% and a total quantity of microorganisms was 1.3 × 10^6 CFU/g dry soil less than the watermelon on the 1st scheme of the crop rotation, 0.4 × 10^6 CFU/g dry soil less than the 2nd scheme. The mathematic analyses show that a total number of microorganisms in the grey-brown soils under watermelon changed by 2738-3118 thousand/g dry soil on the tillage layer; 1436-1542 thousand/g dry soil on the under tillage horizon on the 1st scheme; 1508-1722; 951-1051 on the 2nd scheme; 1108-1284 and 495-641 thousand/g dry soil on the constant tillage, a variation coefficient changed by 9.78-35.0%. A total quantity of microorganisms under a potato on the 1st scheme changed by (1.4-1.6)×10^6 on the tillage layer and (1.0-1.3)×10^6 CFU/g on the under tillage layer, the microflora activity was 0.3×10^6 CFU/g less on the scheme than the 1st scheme. A total number of microorganisms in the soils under the potato on the II scheme changed by (0.8-1.6)×10^6 CFU/g on the tillage and under tillage horizons in summer-autumn seasons. The least activity of microflora is found in August (1.1×10^6 CFU/g on 0-50 cm of layer). The microflora activity in the soils under the constant potato was weaker than the crop rotation and the microorganisms quantity was (0.5-1.4)×10^6 CFU/g soil on the tillage and under tillage horizons (on 0-50 cm of layer) at a vegetation period. The mathematic calculations show that the a total quantity of microorganisms was high in crop rotation in comparison with the constant potato tillage, a variation coefficient changed in the largest interval on the constant tillage.

The microorganisms quantity in the soils under the garlic changed by (1.2-1.3)×10^6 CFU/g on the tillage layer AI^I_a at the vegetation period and was 0.2×10^6 CFU/g more than under tillage horizon (Table 1,2). 65.1% of the microorganisms total

quantity was bacteria, 25.2% was actinomycetes, a number of the microscopic fungi changed by (1.1-2.1)×10^3 CFU/g on 0-50 cm of layer descending along profile and maximum quantity was in spring. The microflora number in the constant garlic tillage was less than the crop rotation, it changed by (0.3-0.9)×10^6 CFU/g on the tillage and under tillage layers at the vegetation period. On the constant tillage unfit soil condition was a reason for decrease of the fungus number year by year and actinomycetes (26.9%) were more from the total quantity of microorganisms. The number of microorganisms was smaller in comparison with crop rotation, and they were dominated by actinomycetes in the case of the continuous growing of garlic. The statistic calculations show that microflora activity in the soils under the garlic formed 1171-1245 on the tillage layer and 979-1047 thousand/g dry soil on the under tillage layer on the 1st scheme, 685-807 and 399-495 thousand/g dry soil on the constant tillage and the variation coefficient changed by 8.50-29.15%.

The microorganisms quantity on the version of the white head cabbage+tomato was 2.1×10^6 on the tillage layer (0-25 cm), it was 1.8×10^6 in summer and 2.0×10^6 CFU/g by increasing again in autumn. A maximum quantity of actinomycetes was noted in summer (5.3×10^5 CFU/g soil). A quantity of the spore-forming bacteria and total bacteria increased in autumn. The microflora activity in the soils under the tomato on the 2nd scheme changed by (1.4-1.8)×10^6 on the tillage layer and (0.9-1.1)×10^6 CFU/g soil on the under tillage layer at the vegetation period. 67.6% of bacteria, 23.4% of actinomycetes, 8.9% of spore-forming bacteria and 0.14% of microscopic fungi formed a total number of microorganisms under the tomato. The microorganisms number in the soils under the tomato on the constant tillage changed by (1.1-1.3)×10^6 on the tillage layer and (0.4-0.8)×10^6 on the under tillage horizon, (1.0-1.5)×10^6 and (0.7-1.0)×10^6 CFU/g in the whitehead cabbage and a maximum number was in spring. Despite an increase of the total quantity of microorganisms in autumn in comparison with the summer, it was some less than spring maximum. A total quantity of bacteria in the soils under the tomato and whitehead cabbage on the constant tillage was 71.2-76.7% (not forming of spore and spore-forming bacteria), actinomycetes were 23.1-28.6%, microscopic fungi – 0.1-0.2%. The statistic calculations show that microflora activity formed 1875-2037 on the tillage layer and 1122-1224 thousand/g dry soil on the under tillage layer under the version of the white head cabbage+tomato; 1455-1619 and 922-1012 thousand/g dry soil under the tomato version of the 2nd scheme and was higher than constant tillage, a variation coefficient changed in the largest interval on the constant tillage.

The microorganisms number in the soils under the vegetable bean was (1.9-2.6)×10^6 on the tillage layer, (1.5-1.7)×10^6 CFU/g soil on the under tillage layer. Bacteria formed 67.9-70.4% and actinomycetes formed 23.6-26.1% of the microorganisms total number. The microorganisms total number under the constant vegetable bean was less than the crop rotation, changed by (1.1-1.9)×10^6 CFU/g soil on the tillage and under tillage layers (0-50 cm) and bacteria formed 70.0%, actinomycetes formed 23.1% from the microorganisms total number. The analyses for number of microorganisms under the vegetable bean version show that this indicator was higher on the crop rotation than the constant tillage, the variation coefficient was contrary to it.

The higher activity of microflora under the plants entering the crop rotation was observed on the version of the two-year lucerne, white head cabbage+tomato and vegetable bean, but the least activity was observed under the garlic. Bacteria formed 63.6-73.7%, actinomycetes formed 17.9-26.8% from the microorganisms total number under growing plants on the crop rotation.

3.2 Dynamics of Microorganisms Quantity in Irrigated Meadow-Sierozemic Soils

The carried out researches show that a change of the microorganisms number on the crop rotation and constant tillage in the Shirvan plain irrigative grey-meadow soils possesses a seasonal character. The microorganisms number formed (1.6-2.0)×10^6 on 0-50 cm of layer under an annual lucerne, bacteria -(0.9-1.3)×10^6, spore-forming bacteria -(0.2-0.3)×10^6, actinomycetes -(4.2-5.5)×10^5, microscopic fungi -(2.7-5.4)×10^3 CFU/g soil. Bacteria changed by 57.5-60.6%, spore-forming bacteria -16.0-17.1%, actinomycetes -23.2-26.3% from a total number of the microorganisms in the grey-meadow soils under the lucerne (Tables 3 and 4).

Table 1. Average of microorganisms of irrigated grey-brown soils of dry subtropics

Field no., crop	Depth, cm	Total number of microorganisms							
		thousand/g dry soil				% of the total number			
		spring	summer	autumn	average	bacteria	spore-forming bacteria	actino-mycetes	micros copic fungi
1	2	3	4	5	6	7	8	9	10
I Scheme - The six-field vegetable-fodder crop rotation									
I	0-25	2411	1947	2054	2137	73.2	7.4	19.2	0.20
Annual lucerne+	25-50	1672	1266	1456	1465	73.7	8.3	17.9	0.10
barley	0-50	2042	1607	1755	1801	73.5	7.7	18.7	0.10
II	0-25	3633	3016	3317	3322	73.3	6.2	20.4	0.10
Lucerne of the	25-50	2461	2143	2295	2300	69.4	8.3	22.2	0.10
second year	0-50	3047	2580	2806	2811	71.7	7.1	21.1	0.10
III	0-25	3499	2323	2962	2928	73.5	7.9	18.5	0.10
Watermelon	25-50	1595	1364	1508	1489	63.4	9.7	26.8	0.10
	0-50	2547	1843	2235	2208	70.1	8.5	21.3	0.10
IV	0-25	1576	1375	1506	1486	66.2	9.6	24.0	0.20
Potato	25-50	1254	1007	1195	1152	67.0	10.0	22.9	0.10
	0-50	1416	1191	1351	1319	66.5	9.9	23.5	0.10
V	0-25	1259	1185	1180	1208	65.2	9.5	25.2	0.10
Garlic	25-50	1094	948	996	1013	67.6	10.6	21.7	0.10
	0-50	1177	1067	1088	1111	66.3	10.0	23.6	0.10
VI	0-25	2086	1798	1985	1956	67.0	10.2	22.7	0.10
White head	25-50	1237	1109	1176	1174	68.3	11.7	19.9	0.10
cabbage+ tomatoes	0-50	1662	1454	1581	1566	67.5	10.8	21.6	0.10
II scheme - The five-field vegetable-bean crop rotation									
I	0-25	1516	1325	1447	1429	65.5	10.3	24.1	0.10
Potato	25-50	862	794	826	827	66.0	11.8	22.1	0.10
	0-50	1189	1059	1137	1128	65.7	10.8	23.4	0.10
II	0-25	2590	1922	2286	2266	70.4	5.8	23.6	0.20
Vegetable	25-50	1555	1370	1542	1489	68.3	7.8	23.7	0.20
bean	0-50	2133	1746	1914	1931	68.7	6.4	24.7	0.20
III	0-25	1846	1288	1711	1615	68.2	9.1	22.6	0.10
Watermelon	25-50	1109	873	1021	1001	64.9	10.1	24.9	0.10
	0-50	1478	1081	1366	1308	67.0	9.4	23.5	0.12
IV	0-25	1764	1402	1445	1537	67.6	8.9	23.4	0.14
Potato	25-50	1096	881	923	967	64.2	12.0	23.7	0.11
	0-50	1430	1142	1185	1252	66.2	10.1	23.5	0.13
V	0-25	2607	1897	2294	2266	67.9	5.8	26.1	0.16
Vegetable	25-50	1691	1469	1569	1576	67.8	7.5	24.6	0.14
bean	0-50	2149	1683	1932	1921	67.9	6.5	25.5	0.15

Constant

1	2	3	4	5	6	7	8	9	10
Tomato	0-25	1331	1063	1126	1173	63.5	7.8	28.6	0.13
	25-50	829	423	510	587	64.3	12.0	23.5	0.20
	0-50	1080	743	818	880	63.8	9.1	27.0	0.16
Watermelon	0-25	1417	990	1180	1196	68.4	9.0	22.5	0.11
	25-50	777	375	551	568	65.5	11.4	23.0	0.18
	0-50	1097	682	865	881	67.5	9.8	22.6	0.14
Potato	0-25	1357	1063	1235	1218	69.0	6.7	24.2	0.10
	25-50	823	475	576	625	60.0	11.4	28.5	0.10
	0-50	1090	769	906	922	66.0	8.2	25.7	0.10
Garlic	0-25	853	627	798	759	64.7	8.3	26.9	0.10
	25-50	518	345	478	447	64.3	11.6	24.0	0.10
	0-50	686	486	638	603	64.6	9.4	25.9	0.10
Whitehead cabbage	0-25	1488	996	1517	1334	61.5	15.2	23.1	0.20
	25-50	1008	687	828	841	64.0	10.8	25.0	0.20
	0-50	1248	842	1173	1088	62.4	13.5	23.9	0.20
Vegetable bean	0-25	1902	1381	1563	1615	70.0	6.8	23.1	0.10
	25-50	1449	1113	1168	1243	73.8	6.4	19.7	0.10
	0-50	1675	1248	1366	1430	71.6	6.6	21.7	0.10

Table 2. Statistical processing quantity of microorganisms in the irrigated grey-brown soils (average 5-6 y.)

Variants	**Depth, cm**	**n**	**$x_{average}$ thousand/g dry soil**	**s**	**V**	**s_x**	**s_x%**	**$x \pm t_{05} s_x$**	**$x \pm t_{01} s_x$**
I scheme – Six-field vegetable-fodder crop rotation									
I Annual lucerne+ barley	0-25	54	2137	283,35	13,26	38,56	1,80	2137±78	2137±101
	25-50	54	1465	213,38	14,57	29,04	1,98	1465±58	1465±78
II Lucerne of the second year	0-25	54	3322	342,28	10,30	46,58	1,40	3322±94	3322±125
	25-50	54	2300	202,97	8,82	27,62	1,20	2300±56	2300±74
III Watermelon	0-25	54	2928	525,03	17,93	71,45	2,44	2928±143	2928±190
	25-50	54	1489	145,18	9,78	19,76	1,33	1489±40	1489±53
IV Potatoes	0-25	54	1486	179,11	12,05	24,37	1,64	1486±49	1486±65
	25-50	54	1152	131,87	11,45	17,95	1,56	1152±36	1152±48
V Garlic	0-25	54	1208	102,63	8,50	13,97	1,16	1208±28	1208±37
	25-50	54	1013	93,83	9,26	12,77	1,26	1013±26	1013±34
VI White head+ tomatoes	0-25	54	1956	223,08	11,40	30,36	1,55	1956±61	1956±81
	25-50	34	1174	143,42	12,22	19,52	1,66	1174±39	1174±52
II scheme - The five-field vegetable-beans crop rotation									
I Potatoes	0-25	45	1429	149,39	10,45	22,27	1,56	1429±45	1429±60
	25-50	45	827	74,29	8,99	11,07	1,34	827±22	827±30
II Vegetable bean	0-25	45	2266	330,68	14,59	49,03	2,18	2266±99	2266±132
	25-50	45	1489	143,93	9,67	21,46	1,44	1489±43	1489±58
III Watermelon	0-25	45	1615	268,88	16,65	40,08	2,48	1615±81	1615±107
	25-50	45	1001	126,13	12,60	18,80	1,88	1001±38	1001±50
IV Tomatoes	0-25	45	1537	205,00	13,34	30,56	1,99	1537±61	1537±82
	25-50	45	967	113,15	11,70	16,87	1,74	967±34	967±45
V Vegetable bean	0-25	45	2266	319,28	14,09	47,60	2,10	2266±96	2266±128
	25-50	45	1576	179,51	11,39	26,76	1,70	1576±54	1576±72

Tomatoes	0-25	54	1173	241,05	20,55	32,80	2,80	1173±66	1173±88
	25-50	54	587	220,80	37,61	30,05	5,11	587±60	587±81
Watermelon	0-25	54	1196	241,45	20,18	32,86	2,75	1196±66	1196±88
	25-50	54	568	198,83	35,00	27,06	4,76	568±54	568±73
Potatoes	0-25	54	1218	194,69	15,98	26,49	2,17	1218±53	1218±71
	25-50	54	625	176,06	28,17	23,96	3,83	625±48	625±64
Garlic	0-25	54	759	204,06	26,89	27,77	3,66	759±56	759±74
	25-50	54	447	130,30	29,15	17,73	3,97	447±36	447±48
Whitehead cabbage	0-25	54	1334	306,78	23,00	41,75	3,13	1334±84	1334±112
	25-50	54	841	174,34	20, 73	23,73	2,82	841±48	841±64
Vegetable bean	0-25	45	1615	334,35	20, 70	49,84	3,09	1615±100	1615±134
	25-50	45	1243	240,80	19,37	35,90	2,89	1243±72	1243±96

Note: n – Quantity of frequency; x – average; V% – coefficient variation

Table 3. Average of microorganisms of irrigated meadow-sierozemic soils of dry subtropics

Field no., crop	Depth, cm	Total number of microorganisms								
		thousand/g dry soil				% of the total number				
		spring	summer	autumn	average	bacteria	spore-forming bacteria	actino-mycetes	micro scopic fungi	
The four-field vegetable-fodder crop rotation										
I	0-25	2196	1872	2213	2094	58.7	16,3	24.8	0.2	
Annual lucerne	25-50	1741	1411	1816	1656	57.5	16.0	26.3	0.2	
	0-50	1969	1642	2014	1875	58.2	16.1	25.5	0.2	
II	0-25	2585	2304	2641	2510	58.6	17.1	24.1	0.2	
Lucerne of the	25-50	1887	1697	2011	1865	60.6	16.0	23.2	0.2	
second year	0-50	2236	2001	2326	2188	59.4	16.7	23.7	0.2	
III	0-25	2490	2145	2416	2350	51.3	17.7	30.8	0.2	
Cucumber	25-50	1840	1618	1773	1744	48.6	21.5	29.7	0.2	
	0-50	2165	1881	2094	2047	50.2	19.3	30.3	0.2	
IV	0-25	2298	2247	2529	2358	50.7	20.2	28.9	0.2	
Tomato	25-50	1776	1602	1619	1666	53.2	18.9	27.7	0.2	
	0-50	2037	1925	2074	2012	51.8	19.6	28.4	0.2	
Constant										
Tomato	0-25	1207	1078	1260	1182	46.2	21.6	32.0	0.2	
	25-50	678	657	726	687	48.2	24.1	27.5	0.2	
	0-50	943	868	993	935	46.9	22.5	30.4	0.2	
Cucumber	0-25	1048	974	1068	1030	48.0	20.8	31.0	0.2	
	25-50	661	589	659	636	46.5	25.6	27.7	0.2	
	0-50	855	782	864	834	47.4	22.7	29.7	0.2	

The microorganisms quantity on 0-25 cm of layer under the cucumber changed by 2.1-2.5×10^6 and on the under tillage layer it changed by (1.6-1.8)×10^6 CFU/g soil. Bacteria on 0-50 cm of layer formed 50.2%, spore-forming bacteria 19.3%, actinomycetes 30.3%, microscopic fungi 0.2% from the microorganisms total number. An average mark of the total quantity of microorganisms under the constant cucumber was 0.8×10^6 on 0-50 cm of layer, bacteria were 0.4×10^6, spore-forming bacteria–0.2×10^6, actinomycetes - 2.5×10^5 CFU/g soil and bacteria were 47.4%, sporeforming bacteria 22.7%, actinomycetes 29.8%, microscopic fungi 0.2% from the total number. The microorganisms total quantity under the cucumber was 1.2×10^6 CFU/g soil (59.3%) more than the constant cucumber.

After finishing the rotation in the soils under the potato an average mark of the microorganisms number was 2.4×10^6 on the tillage layer, 1.7×10^6 CFU/g soil on the under tillage horizon, bacteria formed 51.8%, spore-forming bacteria - 19.6%, actinomycetes-28.4%, microscopic fungi-0.2% from the microorganisms total quantity.

Table 4. Statistical processing quantity of microorganisms in the irrigated meadow-serozemic soils (average 4 y.)

Variants	Depth, cm	n	$x_{average}$ thousand/g dry soil	s	V	s_x	s_x%	$x \pm t_{05}s_x$	$x \pm t_{01}s_x$
Four-field vegetable fodder crop rotation									
I	0-25	36	2094	170,36	8,13	28,39	1,36	2094±57	2094±76
Annual lucerne	25-50	36	1656	220,98	13,34	36,83	2,22	1656±74	1656±99
II Lucerne of	0-25	36	2510	171,27	6,80	28,55	1,14	2510±57	2510±77
the second year	25-50	36	1865	157,55	8,40	26,26	1,41	1865±53	1865±70
III	0-25	36	2350	199,73	8,50	33,29	1,42	2350±67	2350±89
Cucumber	25-50	36	1744	174,08	9,98	29,01	1,66	1744±58	1744±78
IV	0-25	36	2358	141,77	6,01	23,63	1,00	2358±47	2358±63
Tomatoes	25-50	36	1666	116,55	7,00	19,42	1,17	1666±39	1666±52
Constant									
Tomatoes	0-25	36	1182	215,24	18,21	35,87	3,03	1182±72	1182±96
	25-50	36	687	75,76	11,03	12,63	1,84	687±25	687±34
Cucumber	0-25	36	1030	115,70	11,23	19,28	1,14	1030±39	1030±52
	25-50	36	636	137,00	21,50	22,83	3,59	636±46	636±61

A total number of the microorganisms under the potato on the constant tillage was 1.2×10^6 on the tillage layer, 0.7×10^6 CFU/g soil on the under tillage horizon and bacteria formed 46.2%, spore-forming bacteria 21.6%, actnomycetes 32.0% and microscopic fungi 0.2% from them. Preserving of the microorganisms quantity in a higher level in the soils under the cucumber and tomato is connected with the effect of the lucerne as a predecessor. The bacteria quantity from the microorganisms total number under the cucumber and tomato was less than the lucerne, therefore a special weight of spore-forming bacteria (17.7-21.5%) and actinomycetes (27.7-30.8%) raised. This indicator under the constant cucumber and tomato got the highest mark, spore-forming bacteria vibrated 20.8-25.6% and actinomycetes 27.5-32.0%. Hence, the survival of the crops in the irrigated meadow-serozemic soils under the conditions of salinization (chloride salinization, Na 10–12%) was accompanied by an increase of the share of bacteria and actinomycetes.

The statistic analyses show that number of microorganisms of the irrigative grey-meadow soils under an annual lucerne version changed by 1557-2170 thousand/g dry soil on the under tillage and under tillage layer (0-50 cm), 1795-2587 thousand/g dry soil under the two-year lucerne; 1666-2439 thousand/g dry soil under the cucumber, 1614-2421 thousand/g dry soil under the tomato, 653-1278 thousand/g dry soil under the constant tomato; 575-1082 thousand/g dry soil under the cucumber, a variation coefficient changed by 6.01-13.34% on the crop rotation and 11.03-21.50% on the constant tillage. The biogeniness of the irrigative grey-brown soils is characterized by much special weight of bacteria, actinomycetes, but little fungus from the microorganisms total number.

The microorganisms maximum quantity under the growing plants was in the spring, but minimum one was in August. The microflora number increase was observed in the autumn, but an activity was less than spring. The bacteria number decreased and actinomycetes quantity increased in comparison with the crop rotation on the constant tillage.

3.3 Comparison of Microorganisms in Different Types of Soils of Dry Subtropic Zone

The soils of the dry subtropic zone are distinguished to an important degree for a quantity and sort structure of studied microorganisms. Any type of soil has its own characteristic micro-biocenosis and the way of soil use may have positive or negative effects on microbiological activities and what is directly reflected on soil fertility [18].

All investigated microbial groups were found in all locations. Number of the microorganisms was uneven by type of soil. Ammonoficators of the different group microorganisms spread widely in the irrigated grey-brown and meadow-serozemic soils, the not spore-forming forms were its main part.

Learning of the microflora activity in the irrigative grey-brown and grey-meadow soils shows that the microorganisms quantity was high on the tillage layer in June the ammonifixing bacteria formed a main part of microflora in an optimum temperature and humidity regime.

The maximum amount of ammonifiers often occurs in the spring and autumn, when the soil has fresh vegetable residues and sufficient moisture [14,19,20].

The microorganisms number changed in a decrease direction gradually till the end of the summer and began to increase in the autumn again not reaching the spring maximum.

An important part of the soil microflora, both in quantitative and qualitative terms belongs to actinomycetes. In our experiments, the most active growth and propagation of actinomycetes in the soil of studied treatments observed in summer period.

In the dry subtropic zone soils the most quantity of aminoheterotrophs is found the organisms using of organic nitrogen as a main food source are met in the grey-brown soils, it is explained by a higher activity of microflora in the same soils.

The soils under the growing plants changed for a microflora composition, too, because the soil-climate condition and different agrotechnical measures influence on a quantity and composition of rizospher microflora to an important degree. In grey-brown and grey-meadow soils, the dynamics of microorganisms number, change of the ratio between bacteria and actinomycetes depending on season depend on structure and quantity of the organic residues to an important degree and defined by soils condition humidity and temperature.

The more constant organic substances in the soil are mainly subjected to mineralization.

Actinomycetes begin a life activity reducing a quantity of the easy assimilated organic combinations. At this period the very complicated organic combinations exceed in the soil, they can be assimilated by microorganisms possessing only high proteolithic ferment system. Actinomycetes are inseparable structural part of the soil microbiosenoz, they form 20-30% of the total number of bacteria, can increase under neutral and alkaline soil environment [21].

This group of microorganisms exceed in comparison with spore-forming bacteria for a quantity.

The actinomycetes number is defined not only by soil condition (humidity, temperature) and humus quantity, but also by biological features of the growing plants on the crop rotation [19,20,21].

An average mark of actinomycetes changed by $(1.2\text{-}2.3)\times10^5$ CFU/g in the grey-brown soils on the crop rotation at vegetation period. It changed by $(3.4\text{-}4.8)\times10^5$ CFU/g in grey-meadow soils depending on research year and growing plant. The higher quantity of actinomycetes among the investigative soils was observed in grey-meadow soils. So, actinomycetes number increased from spring to summer, decreased in autumn again in the investigative soils.

The research soils biogenness is characterized by a high quantity of bacteria actinomicets and little number of microscopic fungi.

In this study, the minimum propagation of fungi in the studied soil observed in summer due to a reduction in the soil organic matter, high temperatures and intense evaporation of moisture, and the soil compaction.

The authors works show that using of them under the agricultural plants especially, the soils cultivation were a reason for decrease of microscopic fungi to an important degree and formation of the serious changes in soil biota [22]. A quantity of micromicets -microscopic fungi was less in grey-brown and grey-meadow soils, and along the profile reduction was observed towards down. Despite minority of this group of microorganisms they determines soil fertility in many cases, forms water-stable structure of soil by participating in splintering of the plant and animal residues [23].

Ray fungi, having a potent enzymatic apparatus, are actively involved in the decomposition of soil organic matter, complex carbon compounds, which are inaccessible to other taxonomic groups of microorganisms [14]. An average mark of the

microscopic fungi quantity at the vegetation period changed by (1.7-4.8)×10^3 CFU/g in grey - brown soils, (4.2-5.9)×10^3 CFU/g in grey-meadow soils. The seasonal dynamics of the microscopic fungi got a maximum mark in spring, reduced towards the end of summer, increased towards autumn again. The microorganisms high quantity on the crop rotation was noted under the lucerne and vegetable bean consequently the less-under garlic.

A quantity of actinomycetes increased in summer, but bacteria number reduced. The bacteria quantity increased again in autumn. Grey-brown soils are rich in actinomycetes from microorganisms representatives, but grey-meadow soils are rich in bacilli.

3.4 Coefficient of the Mineralization of the Irrigated Soils of Dry Subtropic Zone

While increasing the antropogen effect an increase of aminotrophs quantity which intensifies mineralization of the organic combinations was observed in the soils [22]. We can express an idea about mineralization and immobilization coefficient for an intensity of the mineralization process. The mineralization coefficient (SAA/MPA) determines the intensity of the mineralization [22].

The mineralization intensity of organic substances under the growing plants in the grey-brown soils changed by 0.26-0.38; 0.33-0.45 on the constant tillage; accordingly 0.41-0.57 and 0.67-0.82 in the grey-meadow soils. It is obvious form the consequences that high mineralization was observed in grey-meadow soils consequently and the same soils are rich in bacteria using from nitrogen mineral form.

Every year plaguing, fertilizing rises entering of organic substances the soil, therefore the bacteria quantity using from organic nitrogen as a food source rises, and this reduces SAA/MPA ratio, therefore weakens mineralization process. The ratio between the bacteria utilizing mineral and organic nitrogen comprised in the crop rotation 2.3:1(1.5:1 in the leached chernozem), this value suggests the high intensity of the mineralization processes resulting in a decreases of the humus content in the soil [21]. A reason of the mineralization process intensity height is little ensurement of plant residues with nitrogen. Grounding on the essential indicators we can come to such a conclusion for the microflora structure that mineralization of the plant and animal residues in the soils was enough active.

So, a mineralization coefficient under the plants on the constant tillage was higher than the crop rotation, because planting of the culture in the same place for a long time, one - sided using of the nutrient intensifies the mineralization process. Because of entering little plant residue the soil on the constant tillage the mineralization intensity of organic matters was enough higher than the crop rotation.

4. CONCLUSION

The following conclusions can be reached on the basis of the data on the long term study of the dynamics of the amount and composition of the microorganisms in the soils of the subtropical zone under vegetable and forage crops. This study showed that the soil microbial metabolic functional diversity had high variability.

The number of bacteria in the irrigated meadow-serozemic soils was smaller than in the gray-brown soils, and the number of actinomycetes was on the contrary higher in the grey-brown and meadow-serozemic soils.

The meadow-serozemic soils were characterized by the maximal intensity of the mineralization of the plant residues among the studied soils.

The number of microorganisms was smaller and the mineralization coefficient greater under the monocultures than under the crop rotations.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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