

Change of the Microorganisms Quantity in Irrigative Grey-Brown and Grey-Meadow Soils under Vegetable Cultures

ABSTRACT

The biological equilibrium sustained in the soils of natural ecosystems under the impact of various factors can be strongly disturbed under the impact of anthropogenic loads. The biochemical and microbiological soil properties are of particular importance in this context. In this context, data on the microbiological characteristics of soils are necessary, because they make it possible to evaluate the effect of agricultural practices and crop rotation systems on the biological properties of soils.

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

Six-field vegetable-fodder crop rotation scheme in irrigative grey-brown soils (I scheme) 1. lucerne annual+barley for green folder; 2. lucerne two year; 3.water-melon; 4. potato; 5. garlic; 6. white-head cabbage + tomato and five-field vegetable-bean crop rotation scheme (II scheme): 1.potato; 2.vegetable bean; 3. water-melon; 4. tomato; 5.vegetable bean. For a comparison as a tomato, water-melon, potato, garlic, white-head cabbage and vegetable bean are used in constant sowing.

A research - work in grey-meadow soils has been conducted in four-field vegetable fodder crop rotation: 1.lucerne annual; 2. lucerne two year, 3. cucumber: 4.tomato. A tomato and a cucumber has been used in the constant sowing (in Shirvan plain) and in five-field crop rotation: 1. clap; 2. corn; 3. tomato; 4. lucerne annual; 5. lucerne two year (in Mugan plain)

The results of the long-term investigations in dynamics for study of the conditions of taxonomic groups of microorganisms of irrigated grey-brown and meadow-sierozemic soils of the dry subtropical zone under vegetable crops in rotation with the continuous growing of these cultures have been presented. The results of the researches study demonstrated an important vibration of the microorganisms quantity under growing cultures happens. The less quantity of microorganisms, consuming organic nitrogen is observed in irrigative grey-brown and meadow-sierozemic soils of the dry subtropical zone. Intensity of mineralization of organic matters was more in irrigative grey-brown and meadow-sierozemic soils. A quantity of microorganisms was lower, but a coefficient of mineralization was higher under continuous cultures as compared the analogous soils under crop rotation. These data show that a type of the soil influence on the rhizosphere microflora insignificantly, while plant shows a significant effect on its quantity and compositions.

Keywords: irrigative soils of dry subtropical zones, quantity of microorganisms, crop rotation, permanent cultures, coefficient of mineralization.

1. INTRODUCTION

Soil plays an important role in biosphere life, it defines a necessity of organization and conduction of soil monitoring in the environment protection (Dobrovolsky and et al., 1985). The biological equilibrium sustained in the soils of natural ecosystems under the impact of various factors can be strongly disturbed under the impact of anthropogenic loads. In this context, data on the microbiological characteristics of soils are necessary, because they make it possible to evaluate the effect of agricultural practices and crop rotation systems on the biological properties of soils. Postharvest and root residues in agroecosystems serve as the substrate and the main source of energy for soil microflora. Polyanskii et al. (1990] noted that soil enrichment with

organic matter in the form of humus and plant residues increases the activity of microorganisms and stimulates various biological processes in the soil. Microorganisms play an important role in soil fertility and plant nutrition; their quantity and quality determine the character, intensity, and direction of the soil microbiological processes (Voynova-Roykova and et al., 1986; Kazeev and et al., 2004). More functionality of microb complex, their sensitiveness to any changes in soil give a chance to use from microbiological characters as criterion in estimation of soil condition (Larionova and et al., 2006).

This study was aimed at revealing the character of the changes in the populations of the main taxonomic groups of microorganisms (bacteria, sporeforming bacteria, actinomycetes, and microscopic fungi) participating in the transformation of organic matter in soils of the subtropical zone of Azerbaijan.

2. OBJECTS AND METHODS

2.1 Objects

Gray-brown and meadow-sierozemic soils of arid subtropics have been studied.

Irrigated gray-brown soils (Irragric Gypsic Calcisols according to the WRB) on the terraces of the Caspian Sea are 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.

Irrigated meadow-sierozemic soils (Irragric Calcisols) are 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 Schema

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

2.3 Methods

The study was based on the comparative geographical analysis of the data on the dynamics of different groups of microorganisms. Their numbers were determined by the inoculation method. The total number of bacteria utilizing organic nitrogen was determined on meat infusion agar (MIA), the total number of bacteria utilizing mineral nitrogen was determined on starchandammonia agar (SAA), and the number of soil microscopic fungi was determined on Czapek's medium. The total number of colonies grown on the particular medium was counted,

and the population density of the particular physiological group of microorganisms was determined. The plow (0–25 cm) and subplow (25–50 cm) layers were subjected to the analysis. The inoculation was performed in triplicate. The statistical processing of the data was performed by the routine methods to ensure a 95% significance level.

3. RESULTS AND DISCUSSION

The anthropogenic influence on the soil is especially great in intensive farming systems. In this case, the regimes of the soil nutrients, air, and water are subjected to considerable changes. These changes should be carefully studied in order to maintain and improve the soil fertility. The possible competition between plant roots and microorganisms for nutrients (mainly, mineral nitrogen) is one of the adverse effects in agrocenoses. The rhizosphere of each plant is a dynamic system, and soil microorganisms are known to be an important factor of soil fertility (Bab'eva and et al., 1989, Kasumova, 1985; Orudzheva, 2008; 2012). The plant nutrition with mineral substances and the crop productivity depend on microorganisms. In this context, a comprehensive study of the soil fertility with due account for the agrochemical and biological soil characteristics is of special interest.

3.1 Dynamics of microorganisms quantity in irrigative grey-brown soils

We studied the dynamics of the population density of the microorganisms in the soils under crop rotation systems and under continuous vegetable crops. The results of this study demonstrated that the population densities of the soil microorganisms in the rotation systems are highly variable. In the irrigated gray-brown soils, the population densities 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–fall periods during the first year of rotation (alfalfa + barley) (Table 1). The population density of the bacteria gained its maximum (1.7 to 2.2×10^6 CFU/g of dry soil) under the alfalfa of the second year, whereas the population density of the sporeforming bacteria was minimal. Plant roots improve the chemical and physical conditions in the soil and favor a significant increase in the population density of the soil microflora in the root zone.

The population densities of the bacteria ranged from 1.2 to 1.9×10^6 ; those of actinomycetes, from 4.6 to 6.0×10^5 ; and those of microscopic fungi, from 1.5 to 3.1×10^3 CFU/g of dry soil under the watermelons (rotation I) in the plow horizon and below it during the growing season. The population density of the microorganisms remained relatively high under the watermelons, and this can be explained by the influence of the alfalfa as a precursor. Actinomycetes constituted the maximal part of the microorganisms in the summer. The number of microorganisms in the soil of scheme II under the watermelons was 41% lower than in the soil of crop rotation I. The average number of microorganisms in the case of the continuous growing of watermelons comprised in the plow horizon 1.2×10^6 , and this was 60% lower than that in the soil of crop rotation I.

147 **Table 1.** Average biogeneity of irrigated grey-brown soils of dry subtropics

Field no., crop	Depth, cm	Total number of microorganisms							
		thousand CFU/g dry soil				% of the total number			
		spring	summer	autumn	average	bacteria	spore-forming bacteria	actinomycetes	microscopic fungi
1	2	3	4	5	6	7	8	9	10

148 **I Scheme - The six-field vegetable-fodder crop rotation**

I Annual lucerne+ barley	0-25	2411	1947	2054	2137	73.2	07.4	19.3	0.2
	25-50	1672	1266	1456	1465	73.7	08.2	17.9	0.1
	0-50	2042	1607	1755	1801	73.5	07.6	18.7	0.1
II Lucerne of the second year	0-25	3633	3016	3317	3322	73.3	6.1	20.4	0.1
	25-50	2461	2143	2295	2300	69.4	8.3	22.2	0.1
	0-50	3047	2580	2806	2811	71.7	7.0	21.1	0.1
III Watermelon	0-25	3499	2323	2962	2928	73.5	7.9	18.5	0.1
	25-50	1595	1364	1508	1489	63.4	9.6	26.8	0.1
	0-50	2547	1843	2235	2208	70.1	8.5	21.3	0.1
IV Potato	0-25	1576	1375	1506	1486	66.2	9.7	24.0	0.2
	25-50	1254	1007	1195	1152	67.0	10.0	22.9	0.1
	0-50	1416	1191	1351	1319	66.5	9.8	23.5	0.1
V Garlic	0-25	1259	1185	1180	1208	65.2	9.5	25.2	0.1
	25-50	1094	948	996	1013	67.6	10.6	21.7	0.1
	0-50	1177	1067	1088	1111	66.3	10.0	23.6	0.1
VI White head cabbage+ tomato	0-25	2086	1798	1985	1956	67.0	10.2	22.7	0.1
	25-50	1237	1109	1176	1174	68.3	11.7	19.9	0.1
	0-50	1662	1454	1581	1566	67.5	10.8	21.6	0.1

149 **II scheme - The five-field vegetable-bean crop rotation**

I Potato	0-25	1516	1325	1447	1429	65.5	10.3	24.1	0.10
	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 Vegetable bean	0-25	2590	1922	2286	2266	70.4	5.8	23.6	0.20
	25-50	1555	1370	1542	1489	68.3	7.8	23.7	0.20
	0-50	2133	1746	1914	1931	68.7	6.4	24.7	0.20
III Watermelon	0-25	1846	1288	1711	1615	68.2	9.0	22.6	0.10
	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 Potato	0-25	1764	1402	1445	1537	67.6	8.9	23.4	0.14
	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 Vegetable bean	0-25	2607	1897	2294	2266	67.9	5.8	26.1	0.16
	25-50	1691	1469	1569	1576	67.8	7.5	24.6	0.14
	0-50	2149	1683	1932	1921	67.9	6.5	25.5	0.15

150
151

Monoculture

Tomato	0-25	1331	1063	1126	1173	63.5	7.7	28.6	0.13
	25-50	829	423	510	587	64.3	12.0	23.6	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	22.7	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	11.3	28.5	0.10
	0-50	1090	769	906	922	66.0	8.3	25.7	0.10
Garlic	0-25	853	627	798	759	64.7	8.2	26.9	0.10
	25-50	518	345	478	447	64.2	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	10.9	25.1	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

The number of microorganisms in the layer of 0-50 cm ranged from 0.8 to 1.5×10^6 CFU/g of soil in the soil of crop rotation II under potatoes in the spring– autumn periods, and this was 14% less in comparison with crop rotation I. The activity of the microflora in the plow and the underplow horizons (in the layer of 0-50 cm) ranged from 0.5 to 1.4×10^6 CFU/g of soil in the case of the continuous growing of potatoes. It is Mishustin's opinion (1988] that the maximum biological activity and the maximum biogeneity are typical of the upper layers of the soil profile. The total number of microorganisms ranged from 1.2 to 1.3×10^6 CFU/g of soil in the plow horizon under the garlic and was 16% greater than in the underplow horizon. Bacteria comprised 65.2% and actinomycetes comprised 25.2% of the 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.

In the variant with white cabbage + tomatoes, the number of microorganisms in the layer of 0-25 cm was 2.1×10^6 CFU/g of soil in the spring, it decreased by 14% in the summer, and it increased by 9.4% in the autumn. The number of microorganisms was $(1.4-1.8) \times 10^6$ in the layer of 0–25 cm and $(0.9-1.1) \times 10^6$ CFU/g of soil in crop rotation II under tomatoes during the growing period. The population density of the microorganisms was $(1.1-1.3) \times 10^6$ in the plow horizon and $(0.4-0.8) \cdot 10^6$ CFU/g of soil in the subplow horizon during the grow ing period in the case of the continuous growing of tomatoes, and $(1.0-1.5) \times 10^6$ and $(0.7-1.0) \times 10^6$ CFU/g of soil, respectively, in the case of the continuous growing of white cabbage. Under kidney beans, the number of microorganisms in the layer of 0–50 cm ranged from 1.4 to 2.6×10^6 CFU/g of soil in the crop rotation and from 1.1 to 1.9×10^6 CFU/g of soil in the monoculture.

3.2 Dynamics of microorganisms quantity in irrigative grey-meadow soils

Many authors have studied the number of microorganisms in irrigated meadow-serozemic soils under different crops (Abduyev, 1987; Agabekova, 1984; Babayev and et al., 2009). In the irrigated meadow-serozemic soils, the total number of microorganisms under the alfalfa of the first year comprised in the layer of 0–50 cm $(1.6-2.0) \times 10^6$ bacteria, $(0.3-0.4) \times 10^6$ sporeforming bacteria, $(4.1-5.5) \times 10^5$ actinomycetes, and $(2.7-5.4) \times 10^3$ CFU/g of soil microscopic fungi (Table 2). The population density of the microorganisms under the alfalfa of the second year was 14% greater as compared with the alfalfa of the first year. The bacteria comprised 57.5–60.6%, the sporeforming bacteria comprised 16.0–17.1%, and the actinomycetes comprised 23.2–26.3% of the microorganisms.

187

Table 2. Average biogeneity of irrigated grey-meadow soils of dry subtropics

Field no., crop	Depth, cm	Total number of microorganisms							
		thousand CFU/g dry soil				% of the total number			
		spring	summer	autumn	average	bacteria	spore-forming bacteria	actinomycetes	microscopic fungi

188

The four-field vegetable-fodder crop rotation

I Annual lucerne	0-25	2196	1872	2213	2094	58.7	16.2	24.8	0.2
	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 Lucerne of the second year	0-25	2585	2304	2641	2510	58.6	17.1	24.1	0.2
	25-50	1887	1697	2011	1865	60.6	16.0	23.2	0.2
	0-50	2236	2001	2326	2188	59.4	16.7	23.7	0.2
III Cucumber	0-25	2490	2145	2416	2350	51.3	17.7	30.8	0.2
	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 Tomato	0-25	2298	2247	2529	2358	50.7	20.2	28.9	0.2
	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

189

Monoculture

Tomato	0-25	1207	1078	1260	1182	46.2	21.6	32.0	0.2
	25-50	678	657	726	687	48.2	24.0	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	31.1	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	29.8	0.2

190

191 Under the cucumbers, the population density of the microorganisms ranged from 2.1 to 2.5×10^6
 192 in the layer of 0–25 cm and from 1.6 to 1.8×10^6 CFU/g of soil in the layer of 25–50 cm. The
 193 bacteria comprised 50.2%, the sporeforming bacteria comprised 19.3%, the actinomycetes
 194 comprised 30.3%, and the microscopic fungi comprised 0.2% in the layer of 0–50 cm. The
 195 number of microorganisms was 59.3% lower under the monoculture of cucumbers than under the
 196 cucumbers grown in the crop rotation.

197 The average number of microorganisms under the tomatoes was in the plow horizon 2.3×10^6
 198 CFU/g of soil; the share of bacteria was 50.7%, that of actinomycetes was 28.9%, and that of
 199 microscopic fungi was 0.2%. In the case of the continuous growing of tomatoes, the total number
 200 of microorganisms in the plow horizon was 1.2×10^6 CFU/g of soil. The bacteria comprised
 201 46.2%, the sporeforming bacteria comprised 21.6%, the actinomycetes comprised 32.0%, and the
 202 microscopic fungi comprised 0.2% of the microorganisms. The highest biogeneity in the crop
 203 rotation was determined under the cucumbers and tomatoes by the effect of the alfalfa as the
 204 preceding crop. Hence, the survival of the crops in the irrigated meadowserozemic soils under
 205 the conditions of salinization (chloride salinization, Na 10–12%) was accompanied by an
 206 increase of the share of bacteria and actinomycetes.

207 The soils of the dry subtropics differed significantly in the population density of the studied
 208 microorganisms. The data on the population densities of the microorganisms in the irrigated
 209 gray-brown and meadow-serozemic soils demonstrate that the microorganisms are represented in
 210 the spring under the optimal temperature and moisture conditions mostly by ammonifying
 211 bacteria. The population density of the bacteria gradually decreased by the end of the summer
 212 and increased again by the autumn, but it did not reach the spring maximum. The maximum
 213 population densities of the microorganisms were observed under the alfalfa and kidney beans

and minimum ones under the garlic. The shares of bacteria and actinomycetes were maximal and the share of microscopic fungi was minimal in the studied soils. The gray-brown soils were populated more densely with actinomycetes and the meadow-serozemic soils with bacillary forms of organisms in comparison. Actinomycetes, similar to the spore-forming bacteria, increase their life activity when organic substances in the soil become less available. This group of microorganisms exceed the group of sporeforming bacteria in their population density; actinomycetes reproduce well under neutral and alkaline reactions of the soil solution. The population density of the actinomycetes is determined not only by the soil conditions (the moisture and temperature) and humus content but also by the biological features of the crops in the crop rotations (Dzhanaev and et al., 2007).

Depending on the year's conditions and the cultivated crop, the number of actinomycetes in the crop rotation ranged during the growing period from 1.2×10^5 to 2.3×10^5 CFU/g of dry soil in the gray-brown soil, from 3.4×10^5 to 4.7×10^5 CFU/g of dry soil in the meadow-serozemic soil. The population density of the actinomycetes in the studied soils gradually increased from the spring to the summer and decreased again in the autumn. The studied soils were characterized by the maximum population densities of the bacteria and actinomycetes and by a low number of microscopic fungi (Orudzheva, 2006; 2008; Babayev and et al., 2009). It is known that the agricultural use and especially the cultivation of soils results in a significant decrease of the microscopic fungi in them (Mukha and et al., 1983; Polyanskii et al. 1990).

Polyanskii et al. (1990) consider that the decrease of the number of microscopic fungi in arable soils is one of most serious disturbances of the composition of the soil biota after soil involving into agriculture. This group of microorganisms, despite its paucity (when determined with the inoculation method), is largely responsible for the soil fertility, participating in the destruction of plant and animal residues and in the formation of a waterstable soil structure (Bab'eva and et al., 1989). The number of microscopic fungi in the crop rotation averaged during the growing period $(1.7-4.8) \times 10^3$ in the graybrown soil, $(4.2-5.9) \times 10^3$ CFU/g of dry soil in the meadow-serozemic soils. As for the seasonal dynamics of the population density of the fungi, it was the maximal in the spring, it decreased gradually by the end of the summer, and it increased slightly by the end of the plant growth. The increase of the intensity of the anthropogenic impact in the arable soil was accompanied by the increase of the number of aminotrophic organisms, and this resulted in the intensification of the processes of the organic compounds' mineralization (Pol'yakova and et al., 2007). The intensity of the mineralization processes can be judged by the coefficients of the mineralization and immobilization (Mishustin, 1972). The mineralization coefficient (SAA/MIA) determines the intensity of the mineralization (Pol'yakova and et al., 2007). The mineralization coefficient ranged in the gray-brown soils under the crops in the crop rotation from 0.26 to 0.38 and from 0.33 to 0.45 under the monoculture; in the meadowserozemic soils, it was 0.41–0.57 and 0.67–0.82 respectively.

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), and this value suggests the high intensity of the mineralization processes resulting in a decrease of the humus content in the soil (Dzhanaev and et al., 2007). The number of bacteria utilizing the mineral forms of nitrogen was much greater in the meadowserozemic soil. A conclusion can be reached on the basis of the data on the microflora's composition that the processes of the mineralization of the plant and animal residues are relatively intense in the studied soils. The mineralization coefficient was greater under the continuously cultivated crops than under the crop rotation.

4. CONCLUSIONS

The following conclusions can be reached on the basis of the data on the longterm study of the dynamics of the amount and composition of the microorganisms in the soils of the subtropical zone under vegetable and forage crops.

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

268 The meadowserozemic soils were characterized by the maximal intensity of the mineralization of
269 the plant residues among the studied soils.

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

272

273 **COMPETING INTERESTS**

274

275 The authors have declared that no competing interests exist.

276

277 **REFERENCES**

278 Babaev M P, Orudzheva N I. Assessment of the Biological Activity of Soils in the Subtropical
279 Zone of Azerbaijan. *Eurasian Soil Science*. 2009; 42(10):1163-1169.

280 Dzhanayev GG, Farniev AT, Dzhanayev ZG. Impact of Regular Fertilization on the Agrichemical
281 and Biological Properties of Chestnut Soils and Crop Yields in Rotation. *Agrokhimiya*
282 2007;10:32-38.

283 Larionova A A, Sapronov DV, Lopez de Gerenyu VO, Kuznetsova LG, Kudeyarov VN.
284 Contribution of Plant Root Respiration to the CO₂ Emission from Soil. *Eurasian Soil Science*.
285 2006;10:1248-1266.

286 Polyanskii LM, Lukin SM, Zvyagintsev DG. Changes in the Composition of the Microbial
287 Biomass of Soils upon Their Cultivation. *Pochvovedenie*. 1990;7:67-74.

288 Orudzheva N H. Ecologo-Biological estimation of soils under vegetable cultures as the indicator
289 fertility of soils. *Journal of International Environmental Application and Science*.
290 2008;3(5):351-357.

291 Orudzheva NĬ. Change of the Microorganisms Quantity in Irrigative Gleyey-Yellow under
292 Vegetable Soils. *American Journal of Plant Sciences*. 2012; 3(12):1746-1751.
293 <http://www.scirp.org/journal/Home.aspx?JournalID=207>.

294 Mishustin E N. Soil Treatment and Its Efficient Fertility. In *Study of the Impact of Soil*
295 *Treatments on the Microbiological Processes*. Moscow, 1988.

296 Mukha V D, Vasil'eva L I. Changes in the Biological Activity of a Typical Chernozems under
297 the Impact of Its Different Agricultural Uses. *Gorky*, 1983;33-36.

298 13. Polyakova NV, Redkina NV. Changes in Some Microbiological Parameters of ForestSteppe
299 Soils upon Their Agricultural Use. *Agrokhimiya*. 2007;8:71-75.

300 Orudzheva N I. Biogeneity of Irrigates Soils of Subtropical Zones under Vegetable and Fodder
301 Crops. In: *Materials Int. Conf. Problems of Sustainable Functioning of Aquatic and Terrestrial*
302 *Ecosystems*. Rostov-Don. 2006:304–306.

303 Babyeva I P, Zenova GM. *Soil Biology*. Moscow;1989.

304 Dobrovolsky GV, Grishina L A. *Soil protection*. Moscow;1985.

305 Kazeev K Sh, Kolesnikov S I, Valkov V F. *Biology of Russian Soils*. Rostov-na Donu;2004.

306 Kasumova GS. *Basics of Microbiology and Virology*. Baku;1985.

307 Mishustin EN. *Microorganisms and Farming Productivity*. Moscow;1972.

308 Voynova-Roykova Zh, Rankov V, Ampova G. *Microorganisms and Soil Fertility*.
309 Moscow;1986.

310 Abduev I M. *Extended Abstract of Candidate's Dissertation in Agriculture*. Baku;1987.

311 Agabekova R A. *Extended Abstract of Candidate's Dissertation in Agriculture*. Baku;1984.