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CHANGES OF SOME AGROPHYSICAL PROPERTIES OF AZERBAIJAN DRY SUBTROPICS SOILS USING VARIOUS FERTILIZER SYSTEMS

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Abstract

In the irrigated soils of Azerbaijan dry subtropics, the positive effect of the organic fertilizer system on increase in soil aggregates of 10-0.25 mm in size has been established. With the introduction of 40 t/ha of cattle manure, the content of agronomically valuable aggregates in the arable and subarable layers of soils increased on average of 13.0% compared with the control variant. When studying permeability of alluvial meadow-forest zones under apple orchards, irrigated meadow-brown soils under vegetable crops and alfalfa, and also irrigated gray-brown soils under pastures found that the average water absorption rate is, respectively, the above then honed soils -0.0282 m/hour; 0.0691 m/h; 0.0768 m/h and - 0.5664 m/h. For the sustainable and effective functioning of the soil ecosystem, both unnecessarily high and low water permeability undesirable.

Key words*: aggregate composition of soils, fertilizer system, water permeability, dry subtropics of Azerbaijan.*

INTRODUCTION

Structural soils are distinguished by favorable physical properties and good nutrients regime, water and air easily penetrate into them. Due to good water permeability, all water falling into the surface of the structural soil is absorbed and not lost. Such soils can provide a solid supply of water in the soil, amounting to 80-85% of the annual rainfall (Kachinsky, 1920, 1963; Guliyev, 2014; Mamedov et al., 2012; Practicum..., 1986).
Numerous studies indicate that the soil structure changes the pace and direction of physicochemical and biological processes in it, affects the plant growth nature and development and crop quality (Karpachevsky, 2005; Mamedov, 1988; Methodology..., 1985).
Changes in soil structure under the influence of mineral and organic fertilizers are not well understood. Analyses of the structural-aggregate composition according to the Savinov method, nitrate nitrogen by the disulfophenolic method, gross forms of nitrogen according to Ginzburg K.E. give very uncertain results, which to a large extent depend on the cultivated crop, tillage, fertilizer system.
Currently, it is relevant to search for ways and methods to restore the ecological functions of the soil, improve its physical condition and structural-aggregate composition, which lead to the formation of favorable soil properties as a habitat. Optimization of the soil physical state, namely the improvement of its structural-aggregate composition, the preservation of the granular structure, is paramount.
And also when using soils for agricultural purposes, it can lead to a deterioration in their water-permeable properties, which is explained by a change in the structural state, density, porosity, ratio of solid and gas phases due to swelling of hydrophilic soil colloids, etc. The water permeability of the soil, due mainly to its granulometric composition, structural state, density and porosity, is an important condition that affects the leaching of soluble substances, the movement and deposition of food, weathering and soil formation. The nature of the absorption and accumulation of water, the formation of the water balance, depend on it (Agrochemical methods..., 1975; Arinushkina, 1970; Babayev, 1975; Belyuchenko et al., 2013; Dobrovolsky, 1989).
For the sustainable and effective functioning of the soil ecosystem, both excessively high and low water permeability undesirable (Gummatov et al., 1991). With excessive and failed water permeability, the soil has a low

water retention and high evaporation capacity, while low creates the risk of formation surface runoff contributing to the development of water erosion (Gorbyleva et al., 2002; Khasanova et al., 2013; Puzanov et al., 2014; Shane, 2005).

Therefore, improving water permeability (including using various doses of organic fertilizers), as well as optimizing the water-physical properties of soils, is one of the most important tasks in the field of soil science, agrochemistry and ecology.

The aim of the research is to establish the influence of different fertilizer systems on the aggregate composition and to identify the water permeability of alluvial meadow-forest irrigated meadow-brown and gray-brown soils under various agrocenoses in the conditions of the dry subtropics of Azerbaijan.

MATERIALS AND METHODS

The studies were carried out according to the generally accepted methods under various agrocenoses: in the apple orchard on irrigated meadow-brown soils and under vegetable crops (tomatoes) on alluvial meadow-forest soils of the Guba-Khachmaz zone and gray-brown soil under the pastures of Azerbaijan. Agrotechnical measures were consistent with generally accepted agricultural regulations for the region (Lalomova, 2003; Zubkova, 1998).

The agrochemical, physico-chemical and agrophysical properties, as well as the structurally aggregate composition of the studied soils, were studied according to generally accepted methods (Armor, 1985; Barber et al., 2001; Gedroits, 1925).

The structurally-aggregate composition of soils was determined by the method of N.I. Savvinov, density of the addition of the soils solid phase (specific gravity) soil was determined by the psychometric method according to S.N.Dolgov; total porosity - by calculation method; grading - pipette method using a dispersant - sodium pyrophosphate; hygroscopic moisture - by gravimetric method; carbonate ($CaCO_3$) - by a Scheibler method, absorbed calcium and magnesium - "Trilon B" (displacement of 3N NaCl according to the method of Ivanov; absorbed sodium - according to K.K. Gedroits; total forms of phosphorus and potassium were determined in apparatus "ContrAA-700" "AnalyticYena" by atomic absorption method; total nitrogen Ginsburg K.E; ammonia nitrogen (N-NH_4), nitrate nitrogen (N-NO_3), mobile phosphorus P_2O_5 and exchange potassium K_2O by the colorimetric method (Biernbaum et al., 2005; Gummatov, 2012; Savinov, 1931; Vershinin, 1958). The resulting materials were subjected to mathematical processing on the method (Vershinin, 1958).

Cattle manure was used as organic fertilizer at a humidity of 65%, containing on average 0.5% of nitrogen, 0.25% - P_2O_5 and 0.55% - K_2O.

The total area of the experimental plot on irrigated meadow-brown soils was 9600 m^2, the nutrition area of one tree was 8 x 4 m (32 m^2). The repetition of experiment was three times. In each variant, the plot area is 1600 m^2, the total number of trees (together with the second variant) is 48 PCs, of which 9 - accounting (area - 288 m^2).

Field experiments on alluvial meadow-forest soils under vegetable crops (tomatoes) were laid in triplicate. The plot area was 30 m^2, the nutritional area of one plant was 2.1 m^2 (70 x 30 cm), in each variant one row is protective:

1. When transferring seedlings to the field;
2. At the beginning of budding;
3. At the beginning of fruiting;

And in fruit orchards under apple trees, mineral fertilizers are introduced:

1. When transferring seedlings to the field;
2. At the beginning of budding;
3. At the beginning of fruiting;

And in fruit orchards under apple trees, mineral fertilizers are introduced:

1. During the period of shoot swelling.
2. After flowering.
3. When tying fruit.

In field experiments, the following options were investigated using organic and mineral fertilizer systems (Table 1).

1. Control (without fertilizer).
2. Cattle manure - 40 t/ha, Organic fertilizer system.
3. $N_{60}P_{60}K_{120}$ + cattle manure - 20 t/ha, Organic and mineral system.
4. $N_{90}P_{120}K_{140}$ + cattle manure - 10 t/ha, Organic and mineral fertilizer system.
5. $N_{120}P_{160}K_{180}$, Mineral fertilizer system.

Table 1. The application of mineral fertilizers according to the development of plant stages (according to the annual norms of the active substance)

Mineral fertilizers	The periods under the culture of tomato			Periods under the apple tree		
	1	2	3	1	2	3
Nitrogen (%)	30	50	20	20	40	30
Phosphoric (%)	60	30	10	70	20	10
Potash (%)	30	40	30	40	40	20

The water permeability of the soil was determined by the method of filling the sites. For this, metal frames of two sizes were used: internal (accounting) 30 x 30 cm and external (protective) 50 x 50 cm, which prevents water seeping from the registration area and spreading it to the side. Frames deepened into the soil by 15 cm. The area of the water mirror in the registration frame was 0.09 m^2. In the middle of the reference square, a millimeter scale rail was installed to monitor maintaining a constant water level. Water filling of both sites was carried out simultaneously. Water accounting was recorded at the beginning of the experiment, at the end of the fifth minute, and later, depending on the water permeability of the soil, at 5, 10 and 20 minute intervals. The height of the water layer "h" at the site when determining the absorption rate was 5 cm.
Observations of water absorption by the soil were carried out until a constant absorption rate was established. The resulting materials were subjected to mathematical processing by the method (Gummatov et al., 1991).
All annual norms of organic fertilizers (100%) were plowed in the fall, and mineral fertilizers were applied in 3 terms during the growing season under tomato plants: When filling the site, the level (h) of water was established during the first 10-20 seconds. The amount of water to be poured was measured with 10 liter cylinders. The time report was made by a stopwatch. The experiment continued until the absorption rate was established.
After completion of the field experiment, based on the obtained experimental data, the average rate of water absorption into the soil was calculated. The calculations were carried out according to the method (formulas) of A.N. Kostyakova. The average value of the absorption rate over a period of time *t* is determined by the following formula here:

$$K_{av} = \frac{K_0}{t_\alpha}$$

Where: K_{av} – an average rate of the water absorption mm/min;
K_0 – the water absorption rate in the given soil, during the first unit time mm/min;

$$K_0 = \frac{K_1}{1-\alpha}$$

Where: K_1 the rate of water absorption into the soil at the end of the first unit of time, mm/min;

$$K_1 = k_\alpha \cdot t_2$$

Where: the steady rate of water absorption into the soil, mm/min;
k_α - time of completion of infiltration, min;
t_2 - time of completion of infiltration, min;
α - the curvature coefficient, the curve characterizing the rate of absorption of water into the soil, is determined by the following formula:

$$\alpha = \frac{\lg kg - \lg kg}{\lg t_2 - \lg t_1}$$

Where: t_1 - time interval accepted during the experiment at the period of infiltration in minutes

RESULTS AND DISCUSSIONS

The aggregate totality of various sizes, forms of porosity, mechanical strength and water resistance, characteristic for each soil and its horizons, makes up the soil structure, which has long been established by agricultural practices. This is generally recognized, since many soil properties, especially physical conditions, water, air, biological and nutrient regimes, and, consequently, the living conditions of higher plants and microflora, depend on the nature of the soil structure, which is as if focus, where all or at least most of its properties are reflected, the structure to a large extent determines all these properties (Arinushkina, 1970; Mamedov, 2007, 1988; Methodology..., 1985; Mortar et al., 1995; Practicum..., 1986, Skuratov N.S. et al., 2000). The soils of the dry subtropics of Azerbaijan within the Guba-Khachmaz zone are mainly used for agricultural crops. Alluvial meadow-forest soils are poorly provided with basic nutrients. So, in a layer of 0-115 cm of these soils, the humus content is 0.41-3.95%, and the gross forms of nitrogen, phosphorus and potassium vary, respectively, in the range 0.01-0.24%, 0.03-0.16 % and 1.43-3.66% (Table 2).

Table 2. Agrochemical properties of alluvial meadow-forest soil of dry subtropics of Azerbaijan (Guba-Khachmaz zone)

Genetic horizon	Depth, cm	Total humus, %	N gross, %	N-NH4		N-NO3, mg/kg	P_2O_5			K_2O			pH H_2O
				Soluble, water, mg/kg	Absorbed, mg/kg		Gross, %	Soluble water, mg / kg	Soluble, mg / kg	Gross, %	Soluble water, mg /kg	Exchange, mg / kg	
A ar	0-18	3.95	0.24	4.95	17.4	8,13	0.16	4.22	23.2	3.66	25.4	23.1	7.5
A_1	18-37	2.87	0.17	3.52	11.2	5,25	0.12	3.05	21.7	3.18	24.7	208	7.8
B_1	37-65	1.75	0.11	3.05	9.75	3,10	0.09	2.18	13.1	2.56	21.5	198	8.1
B_2	65-90	1.06	0.04	2.16	6.84	1,08	0.06	1.48	10.2	1.73	17.8	160	8.0
C	90-115	0.41	0.01	1.12	4.92	0,12	0.03	1.19	7.2	1.43	14.7	139	8.1

At the same time, in irrigated meadow-brown soils, these indicators are as follows: humus - 0.64-3.12%; total nitrogen - 0.06-0.29%; total phosphorus - 0.07-0.26%; total potassium - 1.65-3.07% along the soil profile (0-115 cm), which is higher compared with alluvial meadow-forest soils (Table 3). In general, the studied soils of the dry subtropics of the Guba-Khachmaz zone according to the easily assimilated forms of nitrogen, phosphorus and potassium in the upper horizons are characterized as poorly provided, and in terms of acidity, they are almost weakly alkaline (pH 7.5-7.8 units) - Tables 3 and 4.

Table 3. Agrochemical properties of irrigated meadow-brown soil of the Guba-Khachmaz zone

Genetic horizon	Depth, cm	Total humus ,%	N gross, %	N-NH4		$N\text{-}NO_3$ mg/kg	P_2O_5			K_2O			pH H_2O
				Solublewater, mg/kg	Absorbed, mg/kg		Gross,%	Mobile soluble, mg/kg	soluble, mg / kg	Gross,	Soluble water	Exchange, mg/kg	
Aar	0-22	3.12	0.29	6.08	20.1	12.2	0.26	8.07	35.8	3.07	26.2	264	7.8
A,	22-43	2.58	0.20	5.14	16.9	11.6	0.19	5.96	27.6	2.54	16.3	187	7.7
B1	43-70	2.35	0.12	3.72	15.3	5.,07	0.14	4.35	18.3	1.92	4.05	109	7.9
B2	70-92	1.26	0.10	3.91	13.9	1.15	0.11	3.72	12.8	1.76	3.12	83.7	8.2
C	92-115	0.64	0.06	2.60	7.35	0.86	0.07	2.63	8.92	1.65	2.23	72.1	8.3

The absorbed Ca^{2+} and Na^{+} cations prevailed in alluvial meadow forest soils (Ca^{2+} - 78.1%; Na^{+} - 5.0%). The Mg^{2+} content was 16.8%. At the same time, in irrigated meadow-brown soils, compared to alluvial meadow-forest soils, Mg^{2+} prevailed in the upper horizons, the content of which in the soil layer of 0-22 cm reached 30.0% of the total absorbed cations. In these horizons, the content of absorbed Ca^{2+} was equal to 66.9%, Na^{+} - 3.1% of the total cations.
The inter-aggregate total porosity in the upper horizons of alluvial meadow-forest soils varied between 37.5-45.7% and varied from 37.2 to 40.3% of the total porosity. In the irrigated meadow-brown soils, the total porosity in the upper horizons was 44.0-43.6%, in the lower horizon C decreased to 39.3%.

Table 4. Physico-chemical and agrophysical properties of alluvial meadow-forest soil of dry subtropics of Azerbaijan (Guba-Khachmaz zone)

Genetic horison	Depth, cm	CO_2, %	$CaCO_3$, %	Absorbed bases mEq/100 g soil				The proportion of absorbed cations,% from the sum			Total porosity, %	Hygroscopic moisture,%	Granulo-metric compo-sition, %	
				Ca^{2+}	Mg^{2+}	Na^{+}	sum	Ca^{2+}	Mg^{2+}	Na^{+}			<0,001 мм	<0,01 мм
A ar	0-18	1.61	3.66	28.8	6.2	1.86	36.9	78.1	16.8	5.04	45.7	2.95	19.8	38.1
A1	18-37	1.82	4.14	31.6	7.4	1.72	40.7	77.6	18.2	4.22	37.5	3.42	16.5	39.1
B1	37-65	1.59	3.62	32.1	13.8	3.36	49.3	65.2	28.0	60.8	40.3	3.98	25.0	58.2
B2	65-90	1.75	3.98	24.6	20.5	2.85	48.0	51.3	42.8	5.94	39.1	4.75	17.2	32.4
C	90-115	1.48	3.37	18.8	22.7	2.14	43.6	43.1	52.0	4.90	37.8	5.20	12.3	28.7

In close connection with the physical properties of the studied soils their water features. The value of humus and hygroscopic moisture varied according to the profile depending on the content of physical clay: in alluvial meadow-forest soil the humus content was 2.95% in the upper and 5.20% in the lower layers, in the irrigated meadow-brown soil - 4.11% and 3.91%, respectively.
The studied alluvial soils are carbonate - and the $CaCO_3$ content on the soil profile (0-115 cm) varied from 3.37% to 3.66% in meadow-forest and from 7.95% to 11.7% in meadow brown soil (Table 5).
The number of agronomically valuable water-resistant aggregates (<0.25 mm) on profile in alluvial meadow-forest and irrigated meadow-brown soils varied respectively in the range of 27,8-46,2 and 26.6-46.6%. Soil conditions along with soil density and productive moisture reserves also determine such indicators as the structural coefficient and the number of agronomically valuable aggregates. The combination of macro- aggregates of soil particles on various shapes and sizes over 0.25 mm forms aggregate composition of the soil, it can be considered as an object that reflects the results of not only soil-forming processes, but also agricultural activity.
An analysis of the data shows that the use of an organic (cattle manure) fertilizer system improves the structural condition of soils. The use of organic-mineral (manure + nitrogen, phosphorus and potassium fertilizers) fertilizer systems positively influenced the structural

state of alluvial meadow-forest irrigated meadow-brown soils under fruit and vegetable.

On average, over three years with the introduction of organic fertilizers (cattle manure 65% moisture) under tomatoes in for alluvial meadow-forest soil, an increase in the fraction of the valuation range (0.25-10.0 mm) in 0-60 cm soil layer was noted, where the structural coefficient (Kst) in comparison with the non-fertilized version increased on average to 0.7 units.

Table 5. Physico-chemical and agrophysical properties of irrigated meadow-brown soil of dry subtropics of Azerbaijan (Guba-Khachmaz zone)

Genetic horison	Depth, cm	$CaCO_3$, %	Absorbed bases mEq/ 100 g soil				For absorbed cations mq/ 100 g soil			Hygroscopic moisture, %	Total porosity, %	Particle size distribution structure, %	
			Ca^{2+}	Mg^{2+}	Na^{+}	sum	Ca^{2+}	Mg^{2+}	Na^{+}			<0,001mm	<0,01mm
A ar	0-22	7.95	28.3	12.7	1.32	42.4	66.9	30.0	3.11	4.08	43.6	20.3	36.8
A1	22-43	8.37	31.0	5.12	1.81	37.9	81.7	13.5	4.77	4.11	44.0	17.5	37.2
B1	43-70	9.05	32.9	7.56	1.28	41.7	78.8	18.1	3.06	3.92	41.6	27.2	54.7
B2	70-92	13.9	25.5	13.9	2.65	42.0	60.7	33.0	6.30	3.28	40.9	14.6	33.5
C	92-115	11.7	24.0	12.6	1.72	38.3	62.7	32.9	4.49	3.70	39.3	11.8	27.3

Preservation of a unique gummy-granular structure and well distinguishable soil lumps and aggregates is an important function of the soil after exposure of water.

The change in the aggregate composition and structural coefficient of alluvial meadow-forest soil under vegetable crops (tomato) depending on the fertilizer system (average data for 2014-2016) are shown in Table 6.

The results of determining the content of structural aggregates showed that when applying organic as well as organic-mineral fertilizers, this property was higher compared to the variable control. The content of soil aggregates with a value less than 0.25 mm in the 0-60 cm soil layer in the control variant averaged 42%, where as in the variant where the system of organic (40 t/ha of manure) and organic-mineral fertilizers (20 t/ha manure + $N_{60}P_{90}K_{120}$), these values were 31% and 33%, respectively.

Moreover, in these variants, the average content of agronomically valuable aggregates of 10.0-0.25 mm in size increased to 9.2%.

An analysis of the obtained data shows that the use of organic and organic-mineral fertilizer systems on irrigated meadow-brown soil also positively affected the structural state of soils in comparison with the control variant. So, the content of soil aggregates of <0.25 mm in the arable horizon in the control version is 46.2%, while using organic fertilizers (40 t/ha of manure), these indicators decreased to 28.7%, and the content of agronomically valuable particles in the amount of 10.0-0.25 mm increased to 71.3% in alluvial meadow-forest soil under tomato cultivation.

When using the organic-mineral fertilizer system, an increase in the content of particle sizes (10.0-0.25 mm) from 66.2% to 71.3% in the arable layer of soils under vegetable crops was also established.

When using fertilizers at a dose of $N_{60}P_{90}K_{120}$ + 20 t/ha of manure (cattle), the content of soil agronomically valuable aggregates in the arable layer of soils was 63.5%, and in the sub-arable one it reached 67.8%. The structural factors were 1.7 and 2.1, respectively.

When applying only mineral fertilizers in a dose of $N_{120}P_{160}K_{180}$, a positive effect on the content of soil aggregates 10.0-0.25 mm in size (agronomically value) was not established in comparison with the control variant, but on the contrary, the content of particles <0.25 mm in size increased slightly, that led to a deterioration in water-physical soil indicators.

When using an organic fertilizer system (40 t/ha of cattle manure), the best indicators were found in the content of agronomically valuable particles with a size of 10.0-0.25 mm, which was 60.2-53.7% in a layer of 0-60 cm soil, on average arable the layer was 66.8%. Also, high values of the structural coefficient were noted. In the arable and subsurface layers of the alluvial meadow-forest soil under the tomato culture, these indicators were 1.2 and 1.4, respectively.

If in the control variant the average content of soil aggregates with a particle size of 10.0-0.25 mm in the 0-60 cm soil layer was 60.8% (60.76), then when using organic (40 t/ha of manure) and organic-mineral (20 t/ha of manure + $N_{60}P_{90}K_{120}$) of fertilizer systems, these figures are respectively equal to an average of 68.2 and 66.8% (Table 6).

An analysis of these data shows that, on average for 3 years of research using an organic-mineral fertilizer system in irrigated meadow-forest soil under tomatoes at the end of the growing season, the content of agronomically valuable aggregates (10.0-0.25 mm) increases to about 9.2% and this is the best result compared with the control option in the experiment.

Table 6. The influence of the fertilizer system on the aggregate composition and structural coefficient of alluvial meadow-forest soil under vegetable crops (tomato) (Guba-Khachmaz zone, 2014–2016)

Fertilizer system	Fertilizer dose	Soil layer, cm	The size of soil aggregates, content,%			Structural coefficient (K_{st})
			>10	10-0,25	<0,25	
Without fertilizer (control)	–	0–20	0.1	53.7	46.2	1.2
		20–40	0.3	59.1	40.6	1.4
		40–60	0.4	60.2	39.4	1.5
Organic fertilizer	40 t/ha	0–20	–	71.3	28.7	2.5
		20–40	–	67.8	32.2	2.1
		40–60	0.1	61.2	38.8	1.6
Organic mineral	$N_{60}P_{90}K_{120}$+ 20 t/ha manure	0–20	0.2	67.8	32.2	2.1
		20–40	0.4	68.9	27.8	2.2
		40–60	–	63.8	36.2	1.8
Organic mineral	$N_{90}P_{100}K_{140}$+ 20 t/ha manure	0–20	0.3	66.2	33.5	2.0
		20–40	0.1	62.5	37.4	1.7
		40–60	–	58.8	41.2	1.4
Mineral	$N_{120}P_{160}K_{180}$	0–20	0.4	59.4	40.2	1.5
		20–40	0.2	61.1	38.7	1.6
		40–60	0.5	57.2	42.3	1.3
$SED_{0.95}$(the smallest essential difference)						**0.18**

It was established that with the joint application of mineral and organic fertilizers with an increase in the doses of mineral fertilizers and a decrease in the doses of organic fertilizers, the content of soil aggregates of 10.0-0.25 mm in size gradually decreased, that is, a decrease in the doses of organic fertilizers negative affected the content of agronomically valuable aggregates.

The structural coefficient in the meadow-brown soil in the control (without fertilizers) variant at 0-60 cm layer averaged 1.7; with an organic fertilizer system, the average value was 2.2, and in the version where an organic-mineral fertilizer system ($N_{60}P_{90}K_{120}$ + 20 t/ha of manure) was used, 2.0.

The structural-aggregate composition of soils in the of the organic-mineral system compared to the organic fertilizer system turned out to be lower in the version of the organic system (40 t/ha manure) where the structural coefficient was 2.17, and 0 in the option 20 t/ha manure + $N_{60}P_{90}K_{120}$ this value was 2.0. The average value of Kst in the layer of 0-60 cm was 6.7.

It was revealed that the use of the mineral fertilizer system reduces the structural coefficient, which is on average 1.4 over the soil profile. In addition, the content of soil aggregates in the soil with a particle size <0.25 mm increases, that worsens the soil structure and negatively affects the chemical soil environment. When studying the aggregate composition and structural coefficient in an irrigated meadow-brown soil under fruit trees, the similar results were obtained.

According to the experience in the general studied soils under different agrocenoses, the best option was to use an organic fertilizer system. The structural coefficient in the alluvial meadow-forest soil was: 2.1-2.5 in the arable layer, and 2.0-2.4 in the irrigated meadow-brown soil. Changes in the aggregate composition and structural coefficient of irrigated meadow-brown soil under fruit crops (apple tree) depending on the fertilizer system are shown in Table 7.

The water permeability of soils of the dry subtropics under various agrocenoses was also studied. The water permeability of soils was studied according to the above method on alluvial meadow-forest and irrigated meadow-brown soils of the Guba-Khachmaz zone.

Table 7. Aggregate composition and structure coefficient in the irrigative meadow-brown soils under fruit (apple) cultures depending on fertilizer systems (Guba-Khachmaz, 2014-2016)

Fertilizer system	Fertilizer norm	Soil layer, cm	Size of the soil aggregates, mm			Structure coefficient K(st)
			>10	10-0.25	<0.25	
Unfertilized (control)	–	0-20	2.6	52.6	45.4	1.2
		20-40	2.1	57.0	40.9	1.3
		40-60	4.3	72.7	23.0	2.7
Organic	40 t/ha manure	0-20	1.8	66.2	32.0	2.0
		20-40	1.4	70.5	28.1	5.4
		40-60	3.9	67.8	28.3	2.1
Mineral organic (joint application)	$N_{60}P_{90}K_{120}$ + 20 t/ha of manure	0-20	2.0	63.5	34.5	1.7
		20-40	1.7	67.8	30.5	2.1
		40-60	2.2	69.1	28.7	2.2
Mineral organic (joint application)	$N_{90}P_{100}K_{140}$ + 20 t/ha of manure	0-20	1.7	61.8	36.5	1.6
		20-40	1.5	63.7	34.8	1.8
		40-60	2.6	66.8	30.6	2.0
Mineral	$N_{120}P_{160}K_{180}$	0-20	2.7	50.7	46.6	1.0
		20-40	2.3	54.8	42.9	1.2
		40-60	3.8	69.6	26.6	2.3
$SED_{0.95}$ (the smallest essential difference)						**0.27**

The research results are presented in the following order. In the irrigated meadow-brown soils of the Guba-Khachmaz region in the zone of meadow-forest soils reserved for growing vegetables and alfalfa, the water permeability of soils was studied. The results of field studies under various agrocenoses on soil water permeability are also given in Tables 8 and 9.

Based on the results of field work to determine the water permeability of soils in various experimental plots according to the formulas of A.N. Kostyakov, a calculation was made to determine the average rate of water absorption in the experimental plots.

Table 8. The results of field experiments to determine the water permeability of soils.(Guba-Khachmaz zone)

Experimental plots	The time interval taken during the experiment t_1 minutes	Time to complete the infiltration t_2 minutes	The rate of absorption of water into the soil at the end of the first unit of time mm / min K_1	Steady soil absorption rate mm / min K_2
Alluvial meadow-forest soil under vegetable	1	65	2.60	0.15
Irrigated meadow-brown soil under apple orchards crops	1	66	6.51	0.31
Irrigated meadow brown soils under alfalfa culture	1	61	6.20	0.50

The calculation procedure for determining the average rate of soil absorption is given in the "Research Methodology" section. The calculation results are shown in the Table 8.
From Table 9 it is seen that the average rate of absorption of water into the alluvial-meadow-forest soils of the Guba-Khachmaz zone under apple orchards is 0.47 mm/min or 0.0282 m/h. In the plot of irrigated meadow-brown soils of the Guba-Khachmaz zone under vegetable crops, the average rate of absorption of water into the soil is 0.0691 m/h, and under the alfalfa culture, the average rate of absorption of water into the soil is 0.0768 m/hour (Table 9).

Table 9. The results of determining the rate of absorption of water in various types of soil under various agrocenoses (Guba-Khachmaz zone)

Experimental plots	**Calculation results**				
	$\alpha = \frac{\lg kg - \lg kg}{\lg t_2 - \lg t_1}$	$k_1 = k_\alpha \cdot t_2^\alpha$	$k_o = \frac{k_1}{1-\alpha}$	$K_{av} = \frac{K_0}{t_2^\alpha}$	
	-	**mm/min**	**mm/min**	**mm/ min**	**m/h**
Alluvial meadow-forest soil under vegetable crops	0.68	2.56	8.0	0.47	0.0282
Irrigated meadow-brown soil under apple orchards	0.73	6.62	24.53	1.15	0.0691
Irrigated meadow-brown soil under culture alfalfa	0.61	6.20	15.70	1.28	0.0768

Meadow-brown soils are characteristic representatives of a number of hydromorphic soils of the moderate dry subtropics of Azerbaijan. In their geographical confinement, they are locally distributed among the brown soils of the foothill plains of the Great and Little Caucasus, including the Guba-Khachmaz Plain, where periodically surface and ground moisture are available.
These soils are formed under thinned forests and shrubs with well-developed grass stands. A significant area of meadow-brown soils is plowed and used for orchards and crops.
Soil-forming rocks are diluvial - proluvial and ancient alluvial deposits of clay-loamy composition or small-earth pebble, often carbonate, sediments of mountain river outflow cones. The influence of groundwater and surface runoff on soil formation is periodic. Groundwater lies at a depth of 2.5-5.0 and deeper. In the soils described, biological processes occur with moderate moisture (10-25%) and temperature (18-23^{0}C), the vital activity of microorganisms occurs under normal conditions.
The characteristic morphological features of meadow-brown soils are: the presence of well-defined grayish-brown or dark-humus horizon (AUvz) with a thickness of 30-35 cm, a granular-lumpy structure, noticeable clayness and compaction of the middle part of the profile with the lumpy-nutty structure (Btg- 35-40cm), separation of relatively loose gleying of low horizons (Cgca).

CONCLUSIONS

An analysis of the agrochemical and agrophysical indicators of the studied alluvial meadow-forest and irrigated meadow-brown soils of the Guba-Khachmaz zone of Azerbaijan showed that the following measures are necessary to increase their fertility: application and improvement of mineral and organic fertilizer systems.
In the variant where the organic fertilizer system was used (40 t/ha of manure), the highest indicators of improvement and conservation of agronomically valuable soil aggregates of alluvial meadow-forest soil were revealed. At the same time, the values of the structural coefficient in the arable and subsurface layers of the soil are 2.5 and 2.1, respectively.
When using the organic-mineral fertilizer system under vegetables in the $N_{60}P_{90}K_{120}$ + 20 t/ha manure variant, the aggregate composition of the studied soils is also improved - the

content of agronomically valuable aggregates in the arable and subsurface layers of the soil increased in comparison with the control (without fertilizers) option, respectively, by 2.1 and 2.2%.

The structural coefficient increased with the organic fertilizer system compared with the control by about 1.3 times.

Alluvial meadow-forest soils of the Guba-Khachmaz zone under apple orchards belong to the group of poorly permeable soils.

The irrigated meadow-brown soils of the Guba-Khachmaz zone under vegetable crops and under alfalfa belong to the medium-permeable soil groups.

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