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LOSS OF NUTRIENTS AND THEIR RESTORATION IN MEADOW-BROWN SOILS OF AZERBAIJAN UNDER AGROCENOSES

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Abstract *The article presents the results of research on the influence of water consumption, depending on the length (96, 144 and 192) meters of the irrigation furrow with a relief slope of tg = 0.021, on the leaching of nitrogen, phosphorus and humus from irrigated soils of dry subtropics of Azerbaijan under apple trees. Influence of mineral and organic fertilizer systems on the yield of apple trees was also studied under conditions of leaching of nutrients. With a 96-meter furrow and a water flow rate of 0.2 l/s, the content of leachable biogenic elements (N, P) and gross humus with soil was 0.01% for nitrogen and phosphorus, and 0.02% for gross humus. Increasing water flow from 0.2 l/s up to 0.4 l/sec negatively affects the leaching of humus, nitrogen and phosphorus from the soil. These figures increased markedly by 0.01% for humus, nitrogen and phosphorus with a water flow rate of 0.4 l/s. Leaching of nutrients and humus from the soil increases along the length of the irrigation furrow in both rates of water consumption. It has been established that with an increase in the length of the furrow to 192 meters at a water flow rate of 0.4 l/sec. leaching was greater compared to the 96 m furrow, in humus by 0.22%, in nitrogen by 0.07% and in phosphorus by 0.04%. Using of an organic-mineral fertilizer system (Phon + N120P120K90) had a positive effect on the yield of apple trees. Thus, in the unfertilized variant on a 94 meter furrow, the apple tree yield was 274.2 centners per hectare - with the lengthening of the furrow to 192 meters, the yield gradually decreased due to the high content of leachable nutrients and humus (268.5 centners per hectare). When applying N120P120K90 + 10 t/ha of manure, 278.4 q/ha yield was found at 96 m, furrow and at 0.2 l/s and water flow. Whereas with the lengthening of the furrow to 192 m in the same norm of fertilizers and water consumption, the yield decreased to 278.2 c/ha, that is, the lengthening of the furrow was ineffective with slopes tg = 0.021. It has been established that at large slopes, the shorter the furrow, the less nutrients are washed out.*

INTRODUCTION

Losses of nutrients from the soil and fertilizers are associated primarily with the amount of water entering the soil and with the water regime of the soil. The study of the amount and composition of solid runoff carried out by wastewater during irrigation is important in studying changes in the properties of irrigated soils [5,6,11].

One of the main measures to combat irrigation erosion, in which nutrient elements are washed out, is the correct choice of irrigation technology, that is, the establishment of the optimal length of irrigation furrows and water flow in them, depending on the slope of the site and soil type.

The length of the furrow must be set depending on the slope of the area, the permeability of the soil, the size of the water jet, the depth of the moistened layer and the evenness of the field [4,10,12].

For the sustainable and efficient functioning of soil ecosystems, both high and low water permeability are undesirable. The soil has a weak water-retaining and high evaporative capacity with low water permeability. This creates a danger of formation of surface runoff, which contributes to the development of water erosion [8,11,17].

Using fertilizers in irrigated sloping soils and in horticulture has recently received much attention. In this regard, research aimed at studying the removal of nutrients with solid and liquid runoff during irrigation, as well as norms, ratios and fertilizer systems, their dependence on the degree of slope of the terrain is relevant [6,14,15,18].

The purpose of the work is to study the magnitude of the process of washing out nitrogen, phosphorus and humus during irrigation of an apple tree and to develop methods for restoring soil fertility lost with washed away soil.

MATERIALS AND METHODS

The research was carried out in the experimental reference area of the Scientific Research Institute of Horticulture and Tea Growing of the Ministry of Agriculture of Azerbaijan in the village of Zardabi of the Guba district.

The object of the research was irrigated meadow-brown soils. The total area of the experimental plot is 9600 m^2, the feeding area of one tree is 8 x 4m (32 m^2). The experiment was repeated three times. The plot area is 1600 m^2 in each variant. The length of the accounting furrow was taken at 192 m with 48 pcs. trees; per 144 m furrow with 36 pcs. trees, and 96 m furrow were taken 24 pcs. accounting trees. On the experimental plot (apple orchard), the slope of the relief is tg= 0.021; (10 slope=0.017 tg) with water consumption in two norms 0.2 and 0.4 l/s [1.2.7].

Ammonium nitrate (34%), simple superphosphate (18%), and potassium sulfate (46%) were used as mineral fertilizers. The organic fertilizer was cattle manure at a moisture content of 60-65%, an average content of 0.5% N, 0.25% P_2O_5 and 0.6% K_2O.

Annual norms of organic fertilizers were applied for plowing in autumn (100%). Mineral fertilizers under apple plants were applied at 3 terms during the growing season during bud swelling, before flowering and at the beginning of fruiting [1,2,6,7].

Field experiments under the conditions of irrigation of meadow-brown soils under apple crops were carried out in triplicate. Laying of the field experiment and conducting of phenological observations were carried out according to Dospekhov B.A.

The degree of susceptibility to leaching of nutrients was determined according to Zaslavsky M.N. Agrotechnical activities were carried out in accordance with the agricultural rules adopted for the region [1,2,7,11].

RESULTS AND DISCUSSION

The soils of the agro-landscape of the Guba-Khachmaz zone, the northwestern part of the Greater Caucasus within Azerbaijan, are intensively used in agricultural production. Some of these soils are in the foothill area and are subject to the process of irrigation erosion, that is, the leaching of basic nutrients and humus with the soil.

Agrochemical properties of soils in the experimental plots were studied to determine the content of leachable nutrients and humus, before laying the experiment. Soil sections were laid in genetic layers up to one meter, soil samples were taken, in which, according to generally accepted methods, soil properties and their significance for fertility were studied. [1,3,4,7,19]

As a result of many years of field experiments, it has been established that the application of mineral fertilizers under fruit crops on sloping lands during irrigation should be carried out differentially, taking into account the elements of the slope (tg), water flow (l/s) and irrigation erosion, that is, leaching of soils of the main nutrient elements [6,11,13,16].

Experiments were carried out and agrochemical properties were studied on experimental fields in an apple orchard and irrigated meadow-brown soils.

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Total humus was 3.12%, gross nitrogen (N) 0.29%, and absorbed ammonium 20.1 mg/kg of soil in arable soil layers.

Table 1

Agrochemical properties of irrigated meadow-brown soils in dry subtropics in Guba-Khachmaz zone of Azerbaijan

Irrigated meadow-brown soils													
Genetic horizons	**Depth, cm**	**Total humus, %**	**Common N , %**	**NNH_4**		**NO_3^-**	**P_2O_5**			**K_2O**			**pH aqueous suspension**
				water soluble	**absorbed**		**Common, %**	**water soluble**	**mobile**	**common, %**	**water soluble**	**exchangeable**	
				mg/kq				**mg/kq**			**mg/kq**		
$A_п$	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_1	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
B_1	43-70	2,35	0,12	3,72	15,3	5,07	0,14	4,35	18,3	1,92	4,03	109	7,9
B_2	70-92	1,26	0,10	3,91	13,9	11,5	0,11	3,72	12,8	1,76	3,12	83,7	8,2
C	92-115	0,64	0,06	2,6	7,35	0,86	0,07	2,63	8,92	1,65	2,23	72,1	8,3

Mobile phosphorus (P_2O_5) in the arable layer was 35.8 mg/kg, and total phosphorus 0.26%, exchangeable potassium 26.4 mg/kg of soil, while total potassium was 3.07%.

The subsurface layers of the soil were also studied according to the A1 genetic horizons (up to 22-43 cm). These indicators gradually decreased with soil depth, respectively, in terms of gross value, humus up to 2.58%, nitrogen (N) up to 0.20%, phosphorus (P2O5) up to 0.19%, and potassium up to 2.54%.

The content of humus and basic nutrients gradually decreased in the lower layers and in the depth of genetic horizons up to 115 cm. All this is due to natural laws.

Thus, irrigated meadow-brown soils are poorly provided in terms of the content of basic nutrients and moderately provided in terms of gross humus.

We also studied the structural composition (water-stable aggregates) of the soils of the experimental plot (Table 2).

Numerous studies indicate that soil structure changes the direction of physicochemical and biological processes and also affects the nature of plant growth and development and the quality of the crop.

Structural soils are distinguished by favorable physical properties and a good nutrient regime; water and air easily penetrate them [3,8,9,16].

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Table 2

Structural composition (water-stable aggregates) of dry subtropical soils in Guba-Khachmaz zone of Azerbaijan

Irrigated meadow-brown soil under an apple orchard, %					
Genetic horizons	**Depth, sm**	**Aggregate size, mm**			
		<0,25	**0,25-1,0**	**1,0-10,0**	**SUM >0,25**
$A_п$	0-22	**74,4**	**12,9**	**12,7**	**25,6**
A_1	22-43	43,7	21,8	34,5	56,3
B_1	43-70	23,8	21,4	54,8	76,2
B_2	70-92	47,5	23,2	29,3	52,5
C	92-115	53,8	42,6	23,6	66,2

Maintaining favorable physical conditions in the soil at the level necessary for a particular crop is facilitated by the presence in it of an agronomical valuable water-resistant fine-grained structure.

The structure of soils is closely related to their genesis; depending on the soil and climatic conditions, a certain shape and water resistance of soil aggregates are formed. A soil layer of 0-30 cm in terms of the sum of fractions (0.25-10 mm) exceeding 60% of the soil mass, according to the assessment scale of S.I. Dolgov [9], was characterized by a good structural condition.

Table 3 shows water-stable aggregates in irrigated meadow-brown soil under an apple orchard. As can be seen from the data in the table, water-stable aggregates in the arable and subsurface layers of soils in the amount of 0.25-1.0 mm were 12.9 and 21.8%, respectively, which indicates a poor structural state of the soils. Slope in the experimental plot was tg α - 0.021, and the length of the irrigated furrow was 96, 144 and 192 meters, respectively in irrigated meadow-brown soil under apple and agrocenoses. The content of humus, gross nitrogen and phosphorus was determined in the solid runoff (Table 3). When irrigating furrows with a water flow rate of 0.2 l/s, the content of gross humus, nitrogen (N) and phosphorus (P) at the beginning of the furrow was 3.12, respectively; 0.28 and 0.25%.

Table 3

The content of humus, common nitrogen and phosphorus in solid runoff, % in the control (used) variant in irrigated meadow-brown soil (apple orchard)

Slope, tg α	**Water consumption, l / sec**	**Furrow start**			**Furrow end (waste water)**		
		Humus	**N**	**P**	**Humus**	**N**	**P**
Furrow length 96 m							
0,021	0,2	3,12	0,28	0,25	3,14	0,29	0,26
	0,4	3,12	0,28	0,25	3,15	0,30	0,27
	Furrow length 144 m						
	0,2	3,12	0,28	0,25	3,25	0,33	0,27
	0,4	3,12	0,28	0,25	3,29	0,34	0,28
	Furrow length 192 m						
	0,2	3,12	0,28	0,25	3,32	0,35	0,29

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	0,4	3,12	0,28	0,25	3,36	0,37	0,31

Note: 1^0 slope = 0,017 tg α

At a water flow rate of 0.2 l/s and 0.4 l/s, the content of gross forms of humus, nitrogen and phosphorus, with a furrow length of 96 m at the end of the furrow, respectively, was 3.14 for humus; and 3.15, for nitrogen 0.29 and 0.30% and for phosphorus 0.26 and 0.27%. The content of common forms of humus, nitrogen and phosphorus washed out with the soil increased gradually at the end of the 144-meter furrow.

Removal of nutrients and humus was also studied in the experimental field with a water flow rate of 0.2 and 0.5 l / s, when irrigated with washed solid runoff from alluvial meadow-forest soils (Table 4).

The content of common forms of nitrogen and phosphorus humus was at a water flow rate of 0.2 and 0.4 l / s, respectively, for humus 0.05 and 0.07%, and at a furrow of 192 m, respectively, these indicators were 0.09 and 0.011% at the end of the 192-meter furrow. Such regularities are also shown for nitrogen and phosphorus by changing their content at the beginning and at the end of the furrow.

The results of soil analysis for the content of humus, common nitrogen and phosphorus indicated a significant change in soil fertility, depending on the slope and degree of erosion, soil nutrients as a result of irrigation.

Table 4

Removal of biogenic elements and humus with washed soil of agricultural crops in the control (used) variant on experimental fields (apple orchard)

Slope, tg α	**Variants**		**Humus, %**	**N %**	**P %**
	Furrow length	**Water consumption, l/sec.**			
0,021	96	0,2	0,02	0,01	0,01
		0,4	0,03	0,02	0,02
	144	0,2	0,05	0,05	0,02
		0,4	0,07	0,06	0,03
	192	0,2	0,09	0,07	0,04
		0,4	0,11	0,09	0,06

Irrigation waters of the irrigation systems of the Republic of Azerbaijan carry out on average 0.66-0.98 kg of $N\text{-}NH_4$ and 0.88 kg of $N\text{-}NO_3$; 7.0 kg P 70 kg K and 162 kg organic matter per hectare of soil [11].

Influence of different furrow lengths (m) and water consumption (l / s) at different irrigation rates has a different effect on the leaching of nutrients (N, P) and common humus with washed away soil in irrigated meadow-brown soil under an apple orchard. Furrow and a water flow rate of 0.2 l / s, the content of leached nutrients (N, P) and common humus with washed-out soil was established from a 96-meter, respectively, for humus - 0.02%, for nitrogen and phosphorus - 0.01 % in meadow brown soil under an apple orchard.

These indicators increased markedly by 0.01% for nitrogen and phosphorus, and by 0.002% for gross humus with an increased water consumption of up to 0.4 l/sec.

The leaching of humus and nutrients from the washed-out soil slightly increased compared to the length of the furrow of 96 m with an increase in the length of the furrow to

144 meters, at the same water consumption rates. An increase in the content of leached elements in these indicators up to 0.03% was found with a 144-meter furrow.

The process of leaching of biogenic elements was further enhanced in comparison with the 96-meter furrow with the lengthening of the furrow up to 192 m, with a water flow rate of 0.2 l/sec.

Washouts increased compared to a short (96 m) furrow with a 192 m furrow. Leaching was less than in the 192 m furrow at water flow rates of 0.2 and 0.4 l/s in the 96 m furrow. Thus, lengthening the furrow was not effective.

Leaching of nitrogen, phosphorus and humus at a water flow rate of 0.2 l / s was greater compared to the 144 m furrow for nitrogen by 0.04%, for phosphorus by 0.1%, according to humus 0.11% with a slope tg α -0.021 by an elongation of the furrow. It was found that at a water flow rate of 0.4 l / s, the leaching of biogenic elements and humus was greater compared to a water flow rate of 0.2 l / s.

Leaching of humus and biogenic elements during irrigation depended mainly on water flow (l/s) and furrow length.

Nutrients were removed by washed away soil particles and in solutions with wastewater.

With a slope of tg α - 0.021, the amount of removal of nutrients and common humus during irrigation along the furrows was directly dependent on the amount of water consumption, the length of the furrow and the slope of the relief.

We also studied the effect of the fertilizer application system at different furrow lengths (96 m, 144 and 192 m) when biogenic elements were washed out with washed soil on the yield of an apple tree at the same fertilizer application rate and different water consumption rates (0.2 and 0.4 l / sec) and with a slope of tgα-0.021 (table 6).

Fertilizer systems, as well as different furrow lengths and water application rates, affected apple yields in different ways.

In the control variant with an irrigation furrow length of 96, 144 and 192 meters at a water flow rate of 0.2 l/s, respectively, the average yield was 183.4; 181.8 and 179.7 q/ha. With an increase in water consumption to 0.4 l / s, the average yield of an apple tree decreased, respectively, to 180.2; 179.4 and 174.8 q/ha. In the experiment, more positive indicators were noted in a 96-meter furrow at low water consumption (0.2 l/sec.) and when using an organic-mineral fertilizer system at the rate of N120P120K90 + 10 t/ha, which was 278.4 c/ha.The yield of apple trees decreased and amounted to 275.9 and 273.2 c/ha, respectively with a furrow length of 144 m and 192 m, at a water consumption of 0.2 l/sec. And with an increase in water consumption to 0.4 l / s, the yield in this variant was 270.3 and 268.5 c/ha, respectively, which indicates the inefficiency of extending the furrow to 192 meters. With a water flow rate of 0.2 l/sec, the use of organic and mineral fertilizers at a rate of N120P120K90 +10 t/ha of manure, the average yield of an apple tree increased with a furrow length of 96 m, 144 and 192 m, compared with the control, respectively, up to 278 ,4; 275.9 and 273.2 q/ha. At the same time, in the 96 m furrow, the increase from the control was 95 q/ha or 51.8%; in the 144-meter furrow was 94.0 q/ha or 51.7%; and at 192 m furrow, the yield increase was 93.5 and 52.0%. Thus, using of different fertilizer systems and different furrow lengths had a different effect on the yield of apple trees under irrigation conditions on meadow-brown soils. Using of an organic-mineral fertilizer system had a positive effect on the yield of an apple tree. The yield decreased due to washed out soils with an increase in water consumption to 0.4 l / s. Yield of the apple tree was 180.2 c/ha in the unfertilized variant on the 96 m furrow. Yield gradually decreased due to soil leaching with the lengthening of the furrow to 144 and 192 meters and an

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increase in leached nutrients. Apple yield reached 179.4 and 174.8 c/ha, respectively in these variants. Impact on the decrease in yield of the same doses of fertilizers during the lengthening of the furrow is due to an increase in the leaching of nutrients from the upper runoff. Norm is Phon + N120P120K90, the yield of an apple tree in 96, 144 and 192 m furrows, respectively, was 274.2; 270.3 and 268.5 q/ha when using the organic-mineral system of fertilizers. At the same time, it was established that, compared with the 192 m furrow in 144 and 96 m furrows, the yield of the apple tree is gradually increasing. Fertilized variants did not change the patterns of leaching of nutrients and humus with the washed away soil, depending on the slope of the relief and the length of the furrow. With an increase in the irrigation rate and water consumption up to 0.4 l / s, the content of leached soils simultaneously increased due to an increase in the leaching of the main biogenic elements and gross humus by the soil. At the same time, the yield gradually decreased depending on the applied fertilizers. Application of fertilizers compensated for the content of leachable elements.

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Table 5

Productivity of apple trees on irrigated meadow-brown soils depending on the removal of biogenic elements and humus with washed soil and using of mineral and organic fertilizers

№	Variants experience	With a water flow of 0.2 l / s.									With a water flow of 0.4 l / s.								
		Average productivity, c/ha			Increase from control						Average productivity, c/ha			Increase from control					
		Account length furrows, m			at 96 m furrows		at 144 m furrows		at 192 m furrows		Account length furrows, m			at 96 m furrows		at 144 m furrows		at 192 m furrows	
		96	144	192	c/ha	%	c/ha	%	c/ha	%	96	144	192	c/ha	%	c/ha	%	c/ha	%
1.	Control – (free/f)	183,4	181,8	179,7	-	-	-	-	-	-	180,2	179,4	174,8		-	-	-	-	-
2.	Manure-10t/ha-Phon	192,5	190,7	188,5	9,1	4,9	8,9	4,8	8,8	4,9	189,2	186,5	187,9	9,0	5,0	7,1	13,9	13,1	7,5
3.	Phon + $N_{90}P_{90}K_{90}$	212,7	211,2	208,3	29,3	15,9	29,4	16,7	28,6	15,9	209,7	208,6	206,7	29,5	16,3	31,9	16,2	31,9	18,2
4.	Phon + $N_{120}P_{90}K_{90}$	234,2	232,5	228,7	50,8	27,7	50,7	27,8	49,0	27,2	230,3	226,6	229,8	50,1	27,8	50,2	27,9	53,0	29,7
5.	Phon + $N_{120}P_{120}K_{90}$	278,4	275,9	273,2	95,0	51,8	94,0	51,7	93,5	52,0	274,2	270,3	268,5	90,9	50,6	93,9	55,6	93,7	53,6
6.	Phon + $N_{120}P_{90}K_{120}$	247,3	244,9	243,6	63,9	34,8	63,1	34,7	63,9	35,5	245,2	242,5	245,7	65,0	36,1	65,1	36,2	74,7	42,7

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RESULTS AND DISCUSSIONS

1. It was found that irrigated meadow-brown soils are generally poorly provided with common humus, total nitrogen and phosphorus as a result of research. So, in the arable layer, these indicators were respectively 3.12%, 0.29% and 0.26%, in the lower soil layers, these indicators gradually decreased.
2. Agrochemical indicators of soils have been studied. Water-resistant aggregates in the arable and subsurface layers in the amount of 0.25-1.0 mm meso-aggregates (agronomical valuable) amounted to 12.9 and 21.8%, respectively, which indicates a poor structural condition.
3. It was found that the leaching of nutrients at different lengths of the furrow, at different rates of water consumption was different. Washout in a 96 m furrow at a water flow rate of 0.2 l/sec was 0.02% for humus, 0.01% for nitrogen, and 0.01% for phosphorus. With an increase in water consumption to 0.4 l / s, these indicators increased, respectively, for humus by 0.03% and for nitrogen and phosphorus by 0.02%. An increase in water flow to 0.4 l/s had a negative effect on the leaching of biogenic elements from the soil, from the content of nutrients in the soil increased.
4. The greatest loss of nutrients from the soil was observed in the upper part of the slope in a 192-meter furrow at a water flow rate of 0.4 l/sec. The smallest losses of nitrogen, phosphorus and humus were observed in the 96-meter furrow with a lower water flow of 0.2 l/sec.
5. Length of the furrow is more than 96 m, when the relief is sloping under irrigation conditions under apple trees that is, 144 and 192 meter furrows affect the increased leaching of nutrients from the soil. The efficiency of a 96-meter furrow was established under such conditions.
6. At a water flow rate of 0.2 l/s, the use of organic and mineral fertilizers at a rate of N120P120K90+10 t/ha of manure increased the average yield of an apple tree with a furrow length of 96 m, 144 m, and 192 m compared to the control, respectively, up to 278.4; 275.9 and 273.2 q/ha. The average yield of the apple tree was 274.2 c/ha, while the increase to the unfertilized variant was 94.0 q/ha or 50.2% when using the organic-mineral fertilizer system at the rate of N120P120K90 + 10 t/ha of manure (96 meter furrow and water consumption of 0.4 l/sec.).

BIBLIOGRAPHY

AGROCHEMICAL METHODS OF SOIL RESEARCH. Moscow, Nauka, 1975, p.656.

AGROPHYSICAL METHODS OF SOIL RESEARCH (under the editorship of Dolgov S.I.) Moscow, "Nauka", 1966, 354p.

AKHMEDOV M.SH. Scientific and practical substantiation of fertilizer systems and soil content in the orchards of the foothills of Azerbaijan: Abstract of the thesis. diss. Doctor of Agricultural Sciences. Leningrad, 1989, 39 p.

ARMOR B.A. Methods of field experience. Moscow, Agropromizdat, 1985, 352p.

BABAYEV M.P. Irrigated soils of the Kur-Araz lowland and their productive capacity. Baku, "Elm", 1984, 176s.

BORIS BOINCEAN, DAVID DENT Soil fertility and sustainable, resilient agriculture in the republic of Moldova.

GURBANOV E.A., MAMMADOV G.M. Loss of nitrogen, phosphorus and humus from soils during irrigation erosion to prevent. //Agrochemistry, Moscow, "Nauka", No. 10, 2009, pp. 48-52.

KHAMDANOV KH.KH., TSOI V.K., BABAKHODZHAEV I.I. The intensity of irrigation erosion depending on the relief of the field. // Report of the VNKhNIL, 1986, No. 3, pp. 16-18.

KUDEYAROV V.N., SEMENOV V.M. Assessment of the modern contribution of fertilizers to the agrotechnical cycle of nitrogen, phosphorus and potassium. //Soil Science, No. 12, 2004, pp. 1140-1446.

LAPA V.V., BOSAK V.N. The influence of long-term use of fertilizers on the productivity of crop rotation and the fertility of soddy-podzolic light loamy soil. //Agrochemistry, No. 10, 2006, pp. 15-18.

MAMMADOV G.M. The influence of different fertilizer systems on the aggregate composition of alluvial, meadow-forest and meadow-brown soils of dry subtropics of Azerbaijan. //Soil Science and Agrochemistry No. 2 (59) July-December, 2017, pp. 76-87

MAMMADOV G.M., EYYUBOVA S.M., R.A. PASHAYEV, JAFAROV V.I. Application of various fertilizer systems for apple crops on meadow-brown soils of Azerbaijan. // Agrochemistry, "Science" 2012, No. 1, p.50-55

MAMMADOV G.M., GURBANOV E.A. Agrochemical methods for increasing the fertility of irrigated soils, dry subtropics of Azerbaijan. // Agrochemistry, Moscow, "Nauka", No. 7, 2016, p.20-24.

MAMMADOV G.SH. Ecological assessment of soils in Azerbaijan. Baku "Elm", 1997, 282s.

MAMMADOV G.SH., MAMMADOV G.M. Fertile properties of irrigated meadow-brown soils of the Guba-Khachmaz zone of Azerbaijan // Reports of the National Academy of Sciences of Azerbaijan. T. LXVI, No. 2. Baku, "Elm, 2010, pp. 101-110.

MAMMADOV GOSHGAR, TAMARA LEAH Changes of some agrophysical properties of Azerbaijan dry subtropics soils using various fertilizer systems University of Agronomic Sciences and Veterinary Medicine of Bucharest faculty of agriculture volume LXN. no. 2. Bucharest 2021, p.63-70.

MAMMADOV R.G. Agrophysical properties of soils of the Azerbaijan SSR. Baku "Elm", 1989, 244p.

MOVSUMOV Z.R. Nitrogen in the agriculture of Azerbaijan. Baku, "Elm", 1978, 162p.

ZASLAVSKI M.I. Erosology. Moscow, Higher School, 1983, 320p.