THE IMPACT OF SOIL TILLAGE AND MINERAL FERTILIZER RATES ON CHANGES IN WATER-PHYSICAL PROPERTIES OF THE SOIL

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Abstract.
The article deals with the effect of soil tillage and mineral fertilizers on the change of water-physical properties of the soil in irrigated gray-brown (chestnut) soils in the Western region of Azerbaijan. It was determined that in the $N_{60}P_{90}K_{60}$ variant cultivated at a depth of 8-10 cm compared to the control (without fertilizer) variant, the moisture in the 0-30 cm soil layer at the beginning of vegetation was 9.60-10.10%, and the total porosity increased 3.76-4.54% and the bulk density decreased by 0.10-0.12 g/cm^3, and the moisture content increased by 5.50-6.60%, and the total porosity increased by 4.88-5.68%, and the bulk density 0.13-0.15 g/cm^3 decreased at the end of the vegetation. In the 0-30 cm soil layer in the 13-15 cm deep area conducted a disk trowel, in the $N_{60}P_{90}K_{60}$ variant, moisture increased by 9.1-9.5%, total porosity increased by 3.39-4.15% and bulk density by 0.09 -0.11 g/cm^3 decreased, at the begining of the vegetation and at the end of vegetation, the moisture content increased by 6.70-7.70%, the total porosity increased by 5.30-6.43%, and the bulk density decreased by 0.14-0.17 g/cm^3. Observing the highest indicators in the $N_{60}P_{90}K_{60}$ variant in the soil layer of 0-30 cm in the ploughed field at a depth of 20-22 cm, at the begining of the vegetation moisture by 10.90-11.60%, and total porosity increased by 3.40-5.60% ,and the bulk density decreased by 0.09-0.15 g/cm^3, at the end of the vegetation, the moisture content increased by 9.70-11.80 %, and the total porosity increased by 5.66-7.56%, and the bulk density 0.15-0.20 g /cm^3 decreased. Numerous studies have determined that the use of different soil tillages in the cultivation of agricultural plants has a significant impact on the maintenance of moisture in the soil, nutrient regime, physical properties of the soil, phytosanitary condition, the height and growth and finally, productivity of plants.

Key words: Soil tillage, soybean, gray-brown, mineral fertilizer rates, depth, bulk density, moisture, total porosity.

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1. Introduction.

Among the agrotechnical measures carried out to increase the effective fertility of the soil and increase the productivity of cultivated agricultural plants, properly conducted mechanical cultivation is very significant. In the process of cultivation, the necessary ratio is created between its solid phase and capillary and non-capillary pores, as a result of its crushing, softening and hardening. Depending on the fulfillment of the task, soil tillage could be carried out both in the planting layer and in any layer. The main issue facing tillage in arid climate is to create a reserve of moisture in the soil and prevent its loss. Tillage in soils with high moisture removes excess moisture from the soil and creates a favorable water-air regime in the planting layer. The vegetation period of fast-growing soybean varieties is 100 days. It is possible to get a high yield when sowing on May 5-10. During this period, the weather conditions are favorable for plant development. Therefore, the most important of the technological cultivations is the application of fertilizers and herbicides (10, p. 136-139).

Food protein deficiency is observed in many countries of the world. The lack of protein in the countries is covered by livestock products. To solve this problem, it is more appropriate to plant high-protein plants. One of these plants is soybean, which is a technical and fodder plant. Its composition is rich in unique irreplaceable vitamins and is considered a valuable raw material in the production of food products (6, p. 20-21).

In the research conducted by A.P. Khudiyev and G.Y. Mammadov in the Ganja-Gazakh region, the fodder yield and quality indicators of pure and mixed crops of soybean and corn were studied under irrigation conditions. It was determined that 5418 kg of feed units and 903 kg of digestible protein were obtained from soybeans cultivated in pure crops (2, p. 76-78).

According to the order issued by the President of Russia regarding soybean, in order to increase the production and export of soybean oil until 2025, it is planned to use the land resources effectively that ensure the increase in product production, to change the structure of the cultivated areas, and to prepare efficient and innovation-oriented scientific works. In order to fulfill this decision, it was considered appropriate to expand the arable land in the regions that traditionally grow soybeans and to plant soybeans in other regions (9, p.81-102).

The existence of different opinions about land cultivation is directly related to its zonal nature. This means that any order and method of soil cultivation should be chosen taking into account the specific agro-ecological conditions of the area. In modern farming, based on the soil conservation and energy-saving direction: conventional tillage with and without plough, deep tillage with and without plough, deep tillage with and two plough, surface cultivation, minimization, zero (No-till) cultivations are used. These rules and methods of soil tillage are effective if they are chosen correctly based on specific requirements. At this time, the soil-climate conditions of the area, the biological characteristics of the cultivated plants, the fertility indicators of the soil and the phytosanitary condition should be taken into account. During the vegetation period, direct sowing or zero (No-till) cultivations can be applied in soils with sufficient moisture collected in the sowing layer, the natural equilibrium mode is close to the optimal mode required by plants and with favorable phytosanitary conditions (1, p. 7-10).

D.S. Marlamova, a former employee of Azerbaijan Scientific Research Institute of Cotton Growing, notes in her article - “Technology of cotton cultivation without plough” that in recent years, many countries have developed the system of cultivation without plough and prefer to cultivate the soil at a depth of 5-7 cm. Currently, 21% of the total cultivated area in the United States, 57% in Canada, 50% in Latin America, and 70% in Paraguay prefer no-till cultivation. This method is stable and economically efficient in agriculture. For many years, the main soil tillage in Azerbaijan was freeze plough with turning of the layer. In the conducted studies, traditional soil tillage under the cotton plant and zero tillage were compared.

It was concluded that in traditional soil tillage (25-27 cm plough), the energy spent on freeze plough, preparation of the field for ploughing, soil tillage before sowing, and the labor costs incurred for them lead to an increase in the cost of the product. Soil compaction is prevented because of the reduced operations in no-plough technology. As a result, soil volume decreases and porosity increases. Subsequently the activity of microorganisms in the soil, a favorable environment is created in the soil, their activity

increases, and due to this, the fertility of the soil increases (3, p. 69-71).
In the research conducted by A.S. Bushnev in the Western Caucasus, the effect of soil tillage (20-22 cm deep ploughing, 30-32 cm deep ploughing, 12-14 cm deep mulching) on the agro physical properties of the soil, weeding of crops and productivity of soybeans were the subject. The application of surface tillage did not significantly affect the change of soil density. In these options, it increased by 0.07 g/cm^2 and reached 1.35 g/cm^2 in the 10-30 cm soil layer. The high seed yield of soybean was 1.89 t/ha in the variant ploughed at a depth of 20-22 and 30-32 cm, and the productivity decreased by 0.07-0.27 t/ha in the surface coating (4, p.39-47).

In the studies conducted by V.M. Gulayev, S.N. Zudulin and N.V. Gulaeva in Middle Volga, optimal water-physical properties created in the soil when ploughing 25-27 cm under soybean, affected the height and development of the plant, obtaining a high seed yield (5, p. 1090-1092).

Numerous studies have established that the use of different soil tillage in the cultivation of agricultural crops has a significant effect on soil moisture retention, nutrient regime, soil physical properties, phytosanitary condition, plant growth and development, and finally productivity. In production, ploughing from soil tillage, ploughing without turning the soil with cushions, and surface tillage of the soil are widespread. Each of these methods, being agro technically important, has its shortcomings. Choosing the optimal soil tillage depends on the soil-climate conditions and the biological characteristics of cultivated plants (7, p. 199-203).

At present, cotton and other agricultural crops are planted, cultivated on hectares of cotton, in the cotton-growing regions of our republic after the barley harvest. The major purpose of the research is to study the combined effect of soil cultivation and mineral fertilizers on the yield, quality, water-physical properties of the soil, and the fertility of soybeans planted after barley harvesting on irrigated gray-brown (chestnut) soils in the Ganja-Gazakh region.

2. Research methodology.

Researches were conducted after barley harvest on gray-brown (chestnut) soils irrigated with Umanskaya-1 soybean variety in Ganja Regional Agrarian Science and Innovation Center located in Samukh district of the Ministry of Agriculture of the Republic of Azerbaijan. Field experiments with 2 factors (2x4) were established after autumn barley harvest (after the 1st decade of June). Factor A: Soil cultivation: 1. Plough 20-22 cm deep; 2. 13-15 cm deep disc trowel; 3. Cultivation at a depth of 8-10 cm; Factor B: mineral fertilizer rates: 1. Control (without fertilizer); 2. $N_{30}P_{60}K_{30}$; 3. $N_{60}P_{90}K_{60}$; 4. $N_{90}P_{120}K_{90}$.

The area of the accounting section of each option is 54.0 m^2 (30x1.80 m), the experiments were carried out in 3 repetitions, with 30 kg of seeds per hectare, in a 45x10 cm sowing scheme using the sowing row method. Nitrogen-ammonium nitrate 34.7%, phosphorus-simple superphosphate 18.7% and potassium-potassium sulfate 46% of mineral fertilizers in the experimental field, phosphorus and potassium 70% after barley harvest, the remaining 30% of phosphorus and potassium in feeding, in the branching phase, between the rows, nitrogen is given once. Phenological observations were conducted on 25 plants, and agro-technical measures were carried out according to the order adopted for the region.

3. Discussion and analysis of research results.

In 2018-2020, the change of soil tillage and mineral fertilizer norms under soybeans planted after barley harvest on gray-brown (chestnut) soils, in soil layers of 0-10, 10-20 and 20-30 cm; the effect of the change at the beginning and at the end of the vegetation moisture (%), bulk density (g/cm^3) and total porosity (%) was studied. The results of the study are indicated in the table as an average of 3 years.

The change in the amount of the moisture, bulk density and total porosity was detected in studied soil layers, in accordance with the soil cultivation and mineral fertilizer rates. At the begining and the end of the vegetation depending on the soil tillage and mineral fertilizer rates, moisture and bulk density increased, while total porosity was decreased.

As it is obvious from the table, in the control (without fertilizer) version at the beginning of vegetation, in the field cultivated at a depth of 8-10 cm; in 0-10, 10-20 and 20-30-cm layers, moisture were 12.8; 15.5 and 17.5%, bulk density 1.22 g/cm^3; 1.24 g/cm^3 and 1.27 g/cm^3, total porosity as 53.96%; 52.20% and 52.20%, at the end of vegetation in 0-10, 10-20 and 20-30 cm layers, indicators were as following: Moisture -

14.4%; 17.3% and 13.0%, bulk density - 1.26 g/cm^3; 1.29g/cm^3 and 1.31g/cm^3, total porosity - 52.57%; 51.19% and 50.43%.

Depending on the mineral fertilizer norms, moisture content and total porosity in the soil layers increased, and bulk density decreased, in comparison with the control (without fertilizer) option. Therefore., at the beginning of vegetation, in the $N_{60}P_{90}K_{60}$ option, in the layers of 10-20 and 20-30 cm, moisture becomes 13,8%; 16,5 % və 18,7; bulk density 1.19 g/cm^3; 1.22 g/cm^3 and 1.26 g/cm^3, total porosity 54.96%; 54.09% and 52.57%. At the end of vegetation, in the above-mentioned option, in 0-10; 10-20 and 20-30 cm layers, indicators become as follows: moisture - 15,3%; 17,9% və 20,3%; bulk density - 1.22 g/cm^3; 1.24 g/cm^3 and 1.27 g/cm^3; total porosity 54.09%; 53.33% and 52.07%. The highest indicators are observed in the $N_{60}P_{90}K_{60}$ variant, in the layers of 0-10; 10-20 and 20-30 cm; at the beginning of vegetation, moisture 14,5%; 17,5 % and 20,8% ; bulk density 1.20 g/cm^3; 1.22 g/cm^3 and 1.25 g/cm^3, total porosity 54.72%; 54.96% and 53.20% indicates. At the end of vegetation in the mentioned variant, in the 0-10; 10-20 and 20-30 cm layers, moisture 16,3%; 19,1% və 20,9%, bulk density 1.22 g/cm^3; 1.24 g/cm^3 and 1.27 g/cm^3, total porosity 54.09%; 53.33% and 52.07%, as the rates of mineral fertilizers increase, the indicators studied in the $N_{90}P_{120}K_{90}$ option decrease compared to the $N_{60}P_{90}K_{60}$ option, in the 0-10; 10-20 and 20-30 cm layers, at the beginning of vegetation moisture 14,5%; 17,5%, 20,8%; bulk density 1.20 g/cm^3; 1.22 g/cm^3 and 1.25 g/cm^3, total porosity 54.72%; 53.96% and 53.08%, at the end of vegetation in 10-20 and 20-30-cm layers , moisture 15,9%; 18,5% and 20,0%, bulk density 1.23 g/cm^3; 1.25 g/cm^3 and 1.28 g/cm^3, total porosity was 53.71; 52.00 and 51.69%.

As can be seen from the table, in the control (without fertilizer) variant, at the beginning of vegetation, in the field where the disc trowel was carried out at a depth of 13-15 cm, in 0-10, 10-20 and 20-30 cm soil layers, moisture was 13.1%; 16.2% and 18.5%, bulk density 1.20 g/cm^3; 1.22 g/cm^3 and 1.24 g/cm^3, total porosity 54.72%; 54.96% and 53.96%, at the end of vegetation in this variant, in layers of 0-10, 10-20 and 20-30 cm, moisture 14,7%; 17,8% and 20,1%, bulk density 1.24 g/cm^3; 1.27g/cm^3 and 1.30g/cm^3, and total porosity was 53.07%; 51.94% and 50.81%.

In accordance with the fertilizer norms, as it occured in soil tillage of 8-10 cm, in comparison with the control (without fertilizer) version, moisture and total porosity increased in the soil according to the layers, while bulk density decreased. So, in the $N_{30}P_{60}K_{30}$ option, at the begining of the vegetation, in 0-10, 10-20 and 20-30 cm soil layers, moisture 15,0%; 17,5% and 19,9%, bulk density 1.18 g/cm^3; 1.20 g/cm^3 and 1.24 g/cm^3, total porosity was 55.59%; 54.84% and 53.71%, at the end of vegetation, in the , in 0-10, 10-20 and 20-30 cm soil layers, moisture 15,7%; 19,1% and 20,8%, bulk density 1.23 g/cm^3; 1.25 g/cm^3 and 1.28 g/cm^3, and total porosity indicated as 53.58%; 52.70% and 51.69%. The highest indicators observed in the $N_{60}P_{90}K_{60}$ variant, as , in 0-10, 10-20 and 20-30 cm soil layers, at the beginning of vegetation, moisture was 15,5%; 19,2% və 22,4%, bulk density 1.16 g/cm^3; 1.18 g/cm^3 and 1.23 g/cm^3, total porosity was 56.35%; 55.47% and 53.71%. At the end of vegetation, in 0-10, 10-20 and 20-30 cm soil layers, moisture indicators were 16,1%; 20,2% and 23,5%, bulk density 1.20 g/cm^3; 1.22 g/cm^3 and 1.24 g/cm^3, total porosity 54.72; 53.96 and 53.07%, as the rates of mineral fertilizers increase, the indicators studied in the $N_{90}P_{120}K_{90}$ variant decrease compared to the $N_{60}P_{90}K_{60}$ variant in 0-10, 10-20 and 20-30 cm soil layers, moisture 15,1%; 18,3% and 21,6%, bulk density 1.17 g/cm^3; 1.19 g/cm^3 and 1.24 g/cm^3, total porosity observed 55.97%; 55.09% and 53.33%, at the end of vegetation in 0-10, 10-20 and 20-30 cm soil layers, moisture 15,9%; 19,9% and 22,7%, bulk density 1.22 g/cm^3; 1.24 g/cm^3 and 1.27 g/cm^3, total porosity 54.09%; 53.20% and 52.07% indicated.

As it is mentioned in the table, in the field ploughed to a depth of 20-22 cm; at the beginning of vegetation, in the control (without fertilizer) variant, in 0-10, 10-20 and 20-30 cm soil layers, moisture 14,0%; 16,6% and 19,9%, bulk density 1.18 g/cm^3; 1.20 g/cm^3 and 1.22 g/cm^3, and total porosity indicators were as 55.47%; 54.72% and 53.96%. At the end of vegetation, in 0-10, 10-20 and 20-30 cm soil layers, moisture 15,3%; 19,2% and 20,8%, bulk density 1.21 g/cm^3; 1.22 g/cm^3 and 1.26 g/cm^3, and total porosity was between 54.34%; 53.91% and 52.45%.

On the condition that, as in soil cultivation at a depth of 8-10 and 13-15 cm, in comparison with the control (without fertilizer) variant, moisture and total porosity in the soil increased, while bulk density decreased.

On the point of the $N_{30}P_{60}K_{30}$ option, in 0-10, 10-20 and 20-30 cm soil layers, moisture 15,7%; 19,1% və 21,0%, bulk density 1.16 g/cm^3; 1.18 g/cm^3 and 1.20 g/cm^3, and total porosity indicated as 56.22%; 55.34% and 54.59%, at the end of vegetation, in 0-10, 10-20 and 20-30 cm soil layers, moisture 16,8%; 20,6% and 22,4%, bulk density 1.18 g/cm^3; 1.20 g/cm^3 and 1.23 g/cm^3, total porosity was 55.34%; 54.59 and 53.71-53.96%, while the highest indicators were observed in the $N_{60}P_{90}K_{60}$ variant, as in other soil tillage, in the soil layers of 0-10, 10-20 and 20-30 cm, moisture at the beginning of vegetation is 17.1; 20.5 and 24.1%, bulk density 1.14 g/cm^3; 1.16 g/cm^3 and 1.18 g/cm^3, total porosity 57.10%; 56.35% and 55.59%, at the end of vegetation, in 0-10, 10-20 and 20-30 cm soil layers, moisture 18,5%; 22,1% and 25,4%, bulk density 15 g/cm^3; 1.17 g/cm^3 and 1.20 g/cm^3, total porosity 56.47%; 55.72% and 54.84%, as the mineral fertilizers rates increase, the indicators studied in the $N_{90}P_{120}K_{90}$ option decrease, compared to the $N_{60}P_{90}K_{60}$ option, in the soil layers of 0-10, 10-20 and 20-30 cm, at the begining of the vegetation, moisture 16,3%; 20,3% and 23,3%, bulk density 1.15 g/cm^3; 1.17 g/cm^3 and 1.19 g/cm^3, total porosity was 56.73%; 55.97% and 55.09%, at the end of vegetation in the soil layers of 0-10, 10-20 and 20-30 cm, moisture 17,2%; 20,6% and 23,9%, bulk density 1,18 q/cm^3; 1,20 q/cm^{3}və 1,22 q/cm^3, total porosity was 55.59%; 54.72% and 53.96%.

The impact of soil tillage and mineral fertilizer rates on changes in water-physical properties of the soil (2018-2020)

Soil cultivation	Mineral fertilizer norms	Depth, sm	The beginning of vegetation			End of vegetation		
			Humidity, %	Volume mass, q/sm^3	Total porosity, %	Humidity, %	Volume mass, q/sm^3	Total porosity, %
8-10 sm cultivation	Control (without fertilizer)	0-10	12,8	1,22	53,96	14,4	1,26	52,57
		10-20	15,5	1,24	53,20	17,3	1,29	51,19
		20-30	17,5	1,27	52,20	13,0	1,31	50,43
	$N_{30}P_{60}K_{30}$	0-10	13,8	1,19	54,96	15,3	1,24	53,33
		10-20	16,5	1,22	54,09	17,9	1,27	51,94
		20-30	18,7	1,26	52,57	20,3	1,30	51,09
	$N_{60}P_{90}K_{60}$	0-10	15,0	1,18	55,59	16,3	1,22	54,09
		10-20	18,8	1,20	54,72	19,1	1,24	53,33
		20-30	21,8	1,24	53,33	20,9	1,27	52,07
	$N_{90}P_{120}K_{90}$	0-10	14,5	1,20	54,72	15,9	1,23	53,71
		10-20	17,5	1,22	53,96	18,5	1,25	52,00
		20-30	20,8	1,25	52,00	20,0	1,28	51,69
13-15 sm disc trowel	Control (without fertilizer)	0-10	13,1	1,20	54,72	14,7	1,24	53,07
		10-20	16,2	1,22	54,96	17,8	1,27	51,94
		20-30	18,5	1,24	53,20	20,1	1,30	50,81
	$N_{30}P_{60}K_{90}$	0-10	15,0	1,18	53,59	15,7	1,23	53,58
		10-20	17,5	1,20	54,84	19,1	1,25	52,70
		20-30	19,9	1,24	53,07	20,8	1,28	51,69
	$N_{60}P_{90}K_{60}$	0-10	15,5	1,16	56,35	16,1	1,20	54,72
		10-20	19,2	1,18	55,47	20,2	1,22	53,96
		20-30	22,4	1,23	53,71	23,5	1,24	53,07
	$N_{90}P_{120}K_{90}$	0-10	15,1	1,17	55,97	15,9	1,22	54,09
		10-20	18,3	1,19	55,09	19,9	1,24	53,20
		20-30	21,6	1,24	53,33	22,7	1,27	52,07
20-22 sm tillage	Control (without fertilizer)	0-10	14,0	1,18	55,47	15,3	1,21	54,34
		10-20	16,6	1,20	54,72	19,2	1,22	53,91
		20-30	19,9	1,22	53,96	20,8	1,26	52,45
	$N_{30}P_{60}K_{90}$	0-10	15,7	1,16	56,22	16,8	1,18	55,34
		10-20	19,1	1,18	55,34	20,6	1,20	54,59
		20-30	21,0	1,20	54,59	22,4	1,23	53,71
	$N_{60}P_{90}K_{60}$	0-10	17,1	1,14	57,10	18,5	1,15	56,47
		10-20	20,5	1,16	56,35	22,1	1,17	55,72
		20-30	24,1	1,18	55,59	25,4	1,20	54,84
	$N_{90}P_{120}K_{90}$	0-10	16,3	1,15	56,73	17,2	1,18	55,59
		10-20	20,3	1,17	55,97	20,6	1,20	54,72
		20-30	23,3	1,19	55,09	23,9	1,22	53,96

Conclusion.

Subsequently, mineral fertilizer different rates application under soybean in the background of soil tillage, comparatively studied all three soil layers, the amount of bulk density decreased, moisture and general porosity increased significantly. As, in $N_{60}P_{90}K_{60}$ variant cultivated in 8-10 cm depth, moisture in 0-30 soil layer at the beginning of the vegetation increased by 9,60-10,10%, general porosity by 3,76-4,54%, while bulk density decreased by 0,10-0,12 q/sm^3 . At the end of the vegetation moisture 5,50-6,60%, general porosity increased by 4,88-5,68%, but bulk density decreased by 0,13-0,15 q/sm^3 .

In the 0-30 cm soil layer in the 13-15 cm deep area with a disk trowel, the moisture in the $N_{60}P_{90}K_{60}$ variant, at the beginning of vegetation increased by 9.1-9.5%, and the total moisture content increased by 3.39-4.15% and the bulk density decreased by 0.09-0.11 g/cm^3, and at the end of vegetation, the moisture content increased by 6.70-7.70%, and the total porosity increased by 5.30-6.43%, and the bulk density decreased by 0.14-0, 17 g/cm^3.

The highest indicators were observed in the $N_{60}P_{90}K_{60}$ variant in the soil layer of 0-30 cm in the ploughed field at a depth of 20-22 cm. At the beginning of the vegetation, moisture increased by 10.90-11.60%, and total porosity increased by 3.40-5.6%. and the mass decreased by 0.09-0.15 g/cm^3, at the end of vegetation, the moisture content increased by 9.70-11.80%, and the total porosity increased by 5.66-7.56%, and the bulk density decreased by 0.15-0.20 g /cm^3.

In all three soil tillage, the amount of moisture, the increase of general porosity and the decrease of bulk density in 0-30 cm soil layer, consequently led to an increase in soybean grain yield. The highest indicators among soil tillage was obtained, in which ploughed to a depth of 20-22 cm and $N_{60}P_{90}K_{60}$ norm of the mineral fertilizer.

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