

UDC: 631.11:631.51:631.816.458.41,4.

**SOIL CONDITION AND CROP PRODUCTIVITY IN THE RAINFED
AREAS OF UZBEKISTAN*****Khaydarov Bekmurod Dusyarovich****PhD in Agricultural Sciences, Senior Researcher****Mamatkulov Ikrom Shavkatovich****PhD in Agricultural Sciences, Senior Researcher****Shakarov Ikrom Vakhobovich****PhD student****Mustafakulova Ugiloy Ismatullo qizi****PhD student**Scientific Research Institute of Rainfed Agriculture*

Abstract. *The article analyzes the current condition of soils in the rainfed areas, including soil bulk density, mechanical composition, and the amount of organic and mineral substances removed with the harvest. The effectiveness of soil-protective resource-saving technologies, as well as the influence of the depth of application of organic and mineral fertilizers on the humus content and its changes in the soil and on crop productivity, were also evaluated. The study highlights the importance of these factors for more fully meeting the demand of the population living in these regions for grain, fodder, and protein-rich leguminous crops, improving their living standards, and enhancing the economic conditions of farming enterprises.*

Keywords: *Rainfed areas, typical sierozem soils, bulk density, mechanical composition, organic and mineral substances, soil fertility, humus, resource-saving technologies, crop rotation system, crop productivity.*

Introduction. Currently, rainfed areas in the world cover about 1.4 billion hectares, accounting for 85–87% of the total cultivated agricultural land. These areas are mainly located in the arid and semi-arid desert regions of almost all continents. Globally, a significant proportion of rainfed lands are found in Asia, particularly in dry regions: about 95% of agricultural lands in the Sahara region, 75% in the Middle East and North Africa, 65% in East Asia, and 60% in South Asia are managed under rainfed conditions.

In recent years, considerable attention has been given to scientific research focused on improving agricultural productivity in arid and semi-arid regions of the

(13th international scientific and practical conference)

world. These studies emphasize the implementation of crop rotation systems, the application of resource-saving soil conservation technologies that enhance natural moisture accumulation, and the efficient annual use of organic and mineral fertilizers to improve soil fertility. In particular, the incorporation of fertilizers into the soil using tillage equipment has been widely recommended. The application of organic fertilizers at rates of 6–12 t/ha annually and mineral fertilizers at 45–60 kg/ha under autumn wheat and row crops applied during deep plowing is considered effective. In addition, increasing attention is being paid to the use of organo-mineral mixtures to enhance soil productivity and sustainability in rainfed farming systems.

Increasing the productivity of cereal crops and expanding total grain production in rainfed agriculture largely depends on the proper selection and implementation of crop rotation systems. Crop rotation is considered one of the most important agrotechnical measures for improving agricultural production and maintaining soil fertility.

In rainfed areas, grain–fallow and grain–occupied fallow crop rotation systems form the basis for achieving stable and high yields under various weather conditions. Within this system, it is essential to cultivate varieties of cereals, grain legumes, and other rainfed crops that are resistant to unfavorable soil and climatic conditions, as well as to diseases and pests. Their cultivation using resource-saving agrotechnologies is one of the most pressing tasks for improving the efficiency and sustainability of rainfed farming.

Research Object and Methods

Research Objects. The research was conducted on moderately eroded, medium loamy rainfed typical sierozem soils located in the foothill plain zone with moderate precipitation. The winter wheat variety “Bakhmal-97” was used as the experimental crop in the study.

Research Methods. During the years of the experiment, soil and plant analyses were conducted according to the following generally accepted methods:

Soil and plant analyses were carried out based on the methodology described in “Methods of Agrochemical, Agrophysical and Microbiological Studies in Cotton-Growing Regions” (Tashkent, 1963). The selection of experimental plots and the arrangement of treatments were conducted according to the guidelines of “Methods of Field Experiments” (2007). Phenological observations and biometric measurements were performed following “Methods of State Variety Testing of Agricultural Crops” (1985). The main analytical methods used in the study included: Soil moisture was determined by the thermostat drying method at 105°C.

Total humus was determined by the I.V. Tyurin method modified by V.N. Simakov.

Total nitrogen was determined according to the Kjeldahl method. Total phosphorus was determined using the V.N. Lorenz method. Total potassium was measured using a flame photometer. Nitrate nitrogen (N–NO₃) was determined by the Granwald–Lyazh method. Ammonium nitrogen (N–NH₄) was determined using the Nessler reagent. Available phosphorus and exchangeable potassium were extracted in a 1% ammonium carbonate solution; phosphorus was determined using a photoelectric colorimeter (FEC) and potassium with a flame photometer. Total nitrogen, phosphorus, and potassium in plant samples were determined according to the method of K.E. Ginzburg, G.M. Shcheglova, and E.V. Vulfus (1963). Plant biomass accumulation was determined according to the method of V.A. Kumakov (1982). The statistical analysis of the experimental results was performed according to the methodology of B.A. Dospekhov, “Methods of Field Experimentation” (Moscow, 1985).

Results and Discussion. Agricultural crops grow in soils in all countries of the world. However, one of the most powerful factors that increases crop productivity is the application of mineral and organic fertilizers. Over a period of 20 years, the Food and Agriculture Organization (FAO) of the United Nations conducted experiments in 40 countries to study the effect of fertilizer application on increasing crop yields. The results of these studies demonstrated that the use of fertilizers plays a crucial role in improving soil fertility and significantly increasing agricultural productivity.

One of the most complex organic compounds in soil is soil humus. Its origin and formation are associated with long-term and complex biochemical processes. Soil humus differs fundamentally from the parent material and contains chemical compounds that are generally absent in the parent rock. Humus is one of the most important factors determining soil fertility. It serves as a source of energy and nutrients for plants and is considered an important genetic and morphological characteristic of soil. During the research, soil analyses were conducted on typical sierozem soils of the Gallaaral experimental fields. In virgin lands, the humus content ranged from 5.6235 to 2.4733%, while in the Bakhmal mountainous region with dark sierozem soils it ranged from 5.8083 to 2.4177%. In fields with crop rotation practiced since 1998, the total humus content in typical sierozem soils ranged from 3.2984 to 1.4326%, which can be considered a relatively high indicator. This demonstrates that properly organized farming practices contribute to the gradual enrichment of soils with organic matter. In contrast, in fields where wheat has been continuously cultivated for about 50 years, the humus content in typical sierozem soils was observed to be significantly lower, ranging from 0.9641 to 0.6345%, confirming the negative impact of long-term monoculture on soil organic matter. In rainfed areas, the amount of nutrients removed from the soil with the harvest of winter cereal crops is closely related to weather conditions, grain

and straw yields, fertilizer application rates, timing of fertilizer use, and the level of applied agrotechnical practices.

According to the data of M.Yu. Yunusov (1973), under rainfed conditions with moderate precipitation, the NPK content in winter wheat grain varies depending on the amount of precipitation, yield level, fertilizer application rate, and the type of preceding crop. At the full maturity stage, the nutrient content in the grain was reported as follows: Nitrogen (N): 2.26–2.85%, Phosphorus (P_2O_5): 0.93–1.24%, Potassium (K_2O): 0.49–0.56%.

In experiments conducted in rainfed areas during 2023–2025, the amount of nutrients contained in the yield of winter wheat at harvest, the quantity of nutrients removed with the yield, and the coefficient of utilization of nutrients from mineral fertilizers by plants were determined as follows.

According to the experimental results, the amount of nutrients removed with the yield increased with the increase in fertilizer application rates. In the control treatment, the amount of nitrogen removed with the yield was 18.4 kg/ha. When $N_{30}P_{30}K_{30}$ fertilizer was applied, this indicator increased to 31.3 kg/ha; in the $N_{40}P_{40}K_{40}$ treatment it reached 36.5 kg/ha, while in the $N_{50}P_{50}K_{50}$ treatment the amount of nitrogen removed with the yield was 37.7 kg/ha.

According to the average data over eight years, the amount of phosphorus absorbed by winter wheat together with straw was only 7.6 kg/ha in the unfertilized control treatment, whereas in the fertilized treatments it ranged from 10.5 to 18.4 kg/ha. It should be particularly noted that when all three fertilizers (N, P, and K) were applied together, the amount of phosphorus removed with the yield reached 14.8–18.4 kg/ha.

The amount of potassium removed with the winter wheat yield varied depending on the fertilizer rate and ranged from 24.7 to 38.6 kg/ha.

In the control treatment, where winter wheat had been continuously cultivated for many years without the application of organic or mineral fertilizers, the humus content in the plow layer of typical sierozem soils was 0.9641%. It was observed that the humus content sharply decreased toward the deeper soil layers.

Such changes in climate and weather conditions require reconsideration of previously developed recommendations and agrotechnical practices, making appropriate adjustments, and conducting comprehensive scientific research to address these challenges.

Under the conditions of typical rainfed sierozem soils, the influence of organic and mineral fertilizers applied at different soil depths on the changes in total humus content, determined by the I.V. Tyurin method modified by Simakov, showed the following results.

**Effect of the Depth of Application of Organic and Mineral Fertilizers on
Humus Content in Typical Rainfed Sierozem Soils
(Gallaaral, 2023–2025)**

№	Treatments	Soil Layer, cm	20.02.2023 y		10.06.2025 y		Change in Humus Content	
			%	t/ha	%	t/ha	±%	±t/ha
1	Without Fertilizer (Control)	0-20	0,725	18,12	0,612	15,30	-0,113	-2,82
		20-40	0,415	10,79	0,354	9,20	-0,061	-1,59
2	10 t/ha manure + N ₄₀ P ₄₀ K ₄₀ applied on the soil surface (broadcast method)	0-20	0,725	18,12	0,804	20,12	+0,079	+2,00
		20-40	0,415	10,79	0,519	13,49	+0,104	+2,70
3	20 t/ha manure + N ₃₀ P ₃₀ K ₃₀ applied on the soil surface (broadcast method)	0-20	0,725	18,12	0,849	21,12	+0,124	+3,00
		20-40	0,415	10,79	0,535	13,90	+0,120	-3,11
4	30 t/ha manure + N ₂₀ P ₂₀ K ₂₀ applied on the soil surface (broadcast method)	0-20	0,725	18,12	0,870	21,74	+0,145	+3,62
		20-40	0,415	10,79	0,596	15,49	+0,181	+4,70
5	10 t/ha manure + N ₄₀ P ₄₀ K ₄₀ applied at a depth of 10 cm (band method)	0-20	0,725	18,12	0,958	23,94	+0,233	+5,82
		20-40	0,415	10,79	0,585	15,20	+0,170	+4,42
6	20 t/ha manure + N ₃₀ P ₃₀ K ₃₀ applied at a depth of 10 cm (band method)	0-20	0,725	18,12	1,025	25,61	+0,300	+7,49
		20-40	0,415	10,79	0,567	14,75	+0,152	+3,96
7	30 t/ha manure + N ₂₀ P ₂₀ K ₂₀ applied at a depth of 10 cm (band method)	0-20	0,725	18,12	1,156	29,64	+0,430	+11,52
		20-40	0,415	10,79	0,674	17,52	+0,259	+6,79
8	10 t/ha manure + N ₄₀ P ₄₀ K ₄₀ applied at a depth of 20 cm (band method)	0-20	0,725	18,12	0,948	23,70	+0,220	+5,58
		20-40	0,415	10,79	0,490	12,75	+0,075	+1,96
9	20 t/ha manure + N ₃₀ P ₃₀ K ₃₀ applied at a depth of 20 cm (band method)	0-20	0,725	18,12	1,027	25,67	+0,300	+7,55
		20-40	0,415	10,79	0,543	14,12	+0,128	+3,33
10	30 t/ha manure + N ₂₀ P ₂₀ K ₂₀ applied at a depth of 20 cm (band method)	0-20	0,725	18,12	0,929	23,21	+0,200	+5,09
		20-40	0,415	10,79	0,545	14,7	+0,130	+3,91

The data presented in the table show that during the three-year study period, the negative humus balance in typical rainfed sierozem soils in the control treatment ranged from 0.061 to 0.113%, which corresponds to 1.59–2.82 t/ha. The rate and depth of application of organic and mineral fertilizers played an important role in the changes in soil humus content. During 2023–2025, when 10 t/ha of manure combined with N₄₀P₄₀K₄₀ fertilizers was applied by broadcasting on the soil surface, the increase in humus content was only 0.079–0.104% (2.0–2.7 t/ha). However, when the same fertilizer rate was applied at a depth of 10 cm in the soil, the increase in humus content reached +0.170–0.233%, or +4.42–5.82 t/ha.

By the end of the experiment, the highest increase in total humus content in typical rainfed sierozem soils was observed in the treatments where 20 and 30 t/ha of

(13th international scientific and practical conference)

manure combined with mineral fertilizers at rates of $N_{30}P_{30}K_{30}$ and $N_{20}P_{20}K_{20}$ were applied. In these treatments, the humus content in the 0–20 cm soil layer increased by 0.300–0.430%, which corresponds to 7.49–11.52 t/ha.

Effect of Fertilizers Applied at Different Soil Depths on Wheat Yield (Gallaaral-2023–2025)

T/p	Treatments	Yield by Years, c/ha			Average, c/ha	Additional Yield Compared to the Control	
		2023	2024	2025		±s/ha	%
1	Without Fertilizer (Control)	11,3	8,8	5,2	8,4	-	100
2	10 t/ha manure + $N_{40}P_{40}K_{40}$ applied on the soil surface (broadcast method)	16,0	12,3	6,7	11,7	+3,3	139
3	20 t/ha manure + $N_{30}P_{30}K_{30}$ applied on the soil surface (broadcast method)	17,5	12,9	6,8	12,4	+4,0	147
4	30 t/ha manure + $N_{20}P_{20}K_{20}$ applied on the soil surface (broadcast method)	14,3	11,8	6,2	10,8	+2,4	128
5	10 t/ha manure + $N_{40}P_{40}K_{40}$ applied at a depth of 10 cm (band method)	14,8	15,8	7,8	12,8	+4,4	152
6	20 t/ha manure + $N_{30}P_{30}K_{30}$ applied at a depth of 10 cm (band method)	18,0	13,9	8,2	13,4	+5,0	159
7	30 t/ha manure + $N_{20}P_{20}K_{20}$ applied at a depth of 10 cm (band method)	17,1	16,2	8,0	13,8	+5,4	164
8	10 t/ha manure + $N_{40}P_{40}K_{40}$ applied at a depth of 20 cm (band method)	14,8	15,2	7,8	12,6	+4,2	150
9	20 t/ha manure + $N_{30}P_{30}K_{30}$ applied at a depth of 20 cm (band method)	16,4	14,0	8,0	12,8	+4,4	152
10	30 t/ha manure + $N_{20}P_{20}K_{20}$ applied at a depth of 20 cm (band method)	18,3	12,5	7,9	12,9	+4,5	153
M, %		1,3	1,65	1,6			
SDL₀₅, kg/ha		2,8	2,0	1,4			

According to the experimental results, when organic and mineral fertilizers at different rates were applied at a depth of 20 cm, a positive humus balance was observed in the soil. However, the increase in humus content was not higher than in the treatments where fertilizers were applied at a depth of 10 cm.

During 2023–2025, the yield of the winter wheat variety “Bakhmal-97” varied depending on the rates of organic and mineral fertilizers and the depth of their application, which showed the following results.

(13th international scientific and practical conference)

The data presented in the table show that during the experimental years, the effectiveness of organic and mineral fertilizers applied at different soil depths varied depending on weather conditions. In 2009, when precipitation exceeded the long-term average by 110 mm, the additional grain yield of the winter wheat variety “Tezpushar” obtained due to fertilizer application ranged from 3.0 to 7.0 centners per hectare, depending on the fertilizer rate and depth of application. In 2010, which was characterized by high precipitation (489 mm), the additional grain yield also ranged from 3.0 to 7.0 centners per hectare. However, in the dry year of 2011 (200 mm of precipitation), this indicator was significantly lower, amounting to only 1.0–3.0 centners per hectare.

According to the results of the three-year micro-field experiment, the average yield of the winter wheat variety “Bakhmal-97” in the control treatment (based only on the natural soil fertility of typical rainfed sierozem soils) was 8.4 centners per hectare (c/ha). Depending on the rates and depth of application of organic and mineral fertilizers, the additional grain yield obtained ranged from 2.4 to 5.4 c/ha (128–164%). During the experimental years, the highest wheat yields were obtained in the treatments where organic and mineral fertilizers were applied at a depth of 10 cm, reaching 12.8–13.8 c/ha. Based on the results of the experiments conducted during 2009–2011, the following conclusions can be drawn:

Conclusions.

1. During the three-year study, a negative humus balance was observed in the control treatment of typical rainfed sierozem soils, where winter wheat had been continuously cultivated. The decrease in humus content ranged from 0.061 to 0.113%, which corresponds to 1.59–2.82 t/ha. The rate and depth of application of organic and mineral fertilizers played an important role in the change of soil humus content. When 10 t/ha of manure combined with $N_{40}P_{40}K_{40}$ fertilizers was applied by broadcasting on the soil surface, the increase in humus content was only 0.079–0.104% (2.0–2.7 t/ha). However, when the same fertilizer rate was applied at a depth of 10 cm, the increase in humus content reached +0.170–0.233%, or +4.42–5.82 t/ha.

2. By the end of the experiment, the highest increase in total humus content in typical rainfed sierozem soils was observed in the treatments where 20 and 30 t/ha of manure combined with mineral fertilizers at rates of $N_{30}P_{30}K_{30}$ and $N_{20}P_{20}K_{20}$ were applied. In these treatments, the humus content in the 0–20 cm soil layer increased by 0.300–0.430%, which corresponds to 7.49–11.52 t/ha.

References

1. Методы агрохимических, агрофизических и микробиологических

(13th international scientific and practical conference)

- исследований в хлопковых районах. (Тошкент, 1963)
2. Большаков Ф.Ф. Водный режим богарных почв Узбекистана. // Труды почвенного института им. В.Д. Докучаева. Т.32. изд. АН СССР. М. 1950.-С. 159-162.
 3. Лавронов Г.А. Богарное земледелие в Узбекистане. // Т. «Узбекистан» 1979.- С 479.
 4. Маманиёзов С.М. Водно-физические свойства и водной режим почв районов богарного земледелия Узбекистана. // Автореферат кандидатской диссертации. Ташкент, 1968.-С.17.
 5. Методика Государственного сорто испытания сельскохозяйственных культур (1985)
 6. Роде А.А. Водный режим и его регулирование. // Изд. АН СССР, М., 1963. –С. 15-19.
 7. Юнусов М.Ю. Агрохимические свойства типичных богарных сероземов и пищевой режим пшеницы по различным предшественникам. // Диссертация на соискание ученой степени кандидата с/х наук. Галлярал, 1973.
 8. Юсупов Х. Биологик хусусиятлари турлича бўлган буғдой намуналари-нинг суғориш тартиботи ва озиклантириш меъёри ва тартиботига таъсирчан-лиги. // Ўзбекистонда буғдой селекцияси ва уруғчилиги ва етиштириш технологиясига бағишланган 1-миллий конференция материаллари тўплами. Т.,2004.-Б 314-318
 9. Юсупов Х., Мураткасимов А., Нишонов Ж. Лалмикор майдонларда тупрокдаги табиий намликдан самарали фойдаланишнинг агротехнологик омиллари // Ўзбекистоннинг жанубий ҳудудларида бошокли дон экинлари селекцияси, уруғчилиги ва етиштириш агротехнологияларининг ҳолати ва ривожланиш истиқболлари мавзусидаги Республика илмий-амалий конференцияси материаллари тўплами. Қарши 2018.-Б.325.
 10. Юсупов Х., Холматов М. Суғориладиган майдонларда кузги ғалла экинларини бегона ўтлар, касаллик ва зараркунандаларга қарши кимёвий препаратларни уйғунлашган ҳолда қўллаш самарадорлиги.
 11. Ўзбекистонда буғдой селекцияси ва уруғчилиги ва етиштириш технологиясига бағишланган 1-миллий конференция материаллари тўплами. Т., 2004.-Б 428.
 12. Шевцов Н.М. Способы повышения плодородия и продуктивности почвв богарном и орошаемом земледелии// Нива Поволжья. 2011. -№ 1 (18). –С. 72-
<https://www.fao.org/3/i1688r/i1688r.pdf>.