Chemical and agrochemical properties of typical rainfed sierozem soils of Uzbekistan

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Abstract. The agrochemical properties of soil are important for its fertility, plant growth and development, and harvesting. In this case, humus is one of the main indicators of the total amount of nutrients. These indicators vary by soil layer. The reduction of the amount of humus in the lower layers of the soil has a negative effect on the agrophysical and agrochemical properties of the soil. Soil humus is a complex of high molecular complex chemicals consisting of protein, amino acid, wax, tar, low molecular organic acids, cellulose, lignin, chitin and other substances. Its amount is closely related to a number of factors and conditions - the amount and quality of biomass falling into the soil, the chemical composition of the soil, the environment, water-air, thermal properties, and physical-mechanical properties. This article presents information on the chemical and agrochemical status of typical rainfed sierozems. According to the results of the study, rainfed sierozems are very low in humus, low to moderate in mineral nitrogen and mobile phosphorus, moderate to high in exchangeable potassium. Carbonates are not evenly distributed along the profile of rainfed silozems, that is, some sections differ from the surface layers in their carbonate content, while in other sections, some accumulation of carbonates is observed in the middle and lower layers.

1 Introduction

Currently, the problems of improving soil fertility are one of the most important current issues in the world, which require complex research. In particular, there are problems in the effective use of mountain soils specific to their conditions [1]. Mountain soils have their own specific characteristics, which are very different from plain soils. The different distribution of mountain relief soils along the belts creates conditions for a large difference in the vegetation distributed on the slope elements, so their improper use leads to the acceleration of erosion processes [2].

The development of erosion processes leads to the change of natural soil cover and deterioration of their agrophysical and agrochemical properties. Therefore, the problems of restoration, protection and preservation of the fertility of eroded mountain soils and their rational use in various natural and ecological regions of Uzbekistan are considered urgent issues of today.

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A number of scientists have conducted research on studying the properties and characteristics of rainfed soils of the mountain and sub-mountain regions of Uzbekistan, maintaining and increasing their productivity, and changing their properties under the influence of erosion processes. For example, Abdurahmanov [1], Artikova and others [2], Bakhodirov [3], Kodirova [4], Gafurova et al. [5], Djalilova and Kadirova [6], Abdurakhmanov [7], Koziev and Sektimenko [8, 9], Maksudov et al. [10], Prosalov [11], Sektimenko and Ismanov [12], Sodikova [13, 14], Tashkoziev and Shadieva [15, 16], Uzokov [17], Shadieva [18], and Shadraimova and Kamilov [19] have contributed to the knowledge of chemical and agrochemical properties of soils in Uzbekistan. However, insufficient scientific research has been conducted on maintaining and increasing the productivity of rainfed soils through the use of resource-efficient technologies [20, 21].

Based on the above, we set ourselves the goal and task of studying the effect of processing on the basis of resource-saving technologies, that is, No-till technology, on the chemical and agrochemical properties of typical rainfed sierozems. This article describes the initial chemical and agrochemical properties of soils before processing based on “No-till” technology.

2 Materials and methods

Typical rainfed sierozems distributed in the experimental field of the Rainfed Agricultural Research institute, Gallaorol district, Jizzakh province, Uzbekistan, were chosen as the research object. Field and laboratory studies were carried out according to standard methods generally accepted in soil science. The chemical and agrochemical properties of soils were analyzed according to Arinushkina's guide to soil chemical analysis: humus - Tyurin, total nitrogen - Keldal, total phosphorus and potassium - Lorentz, nitrate nitrogen - Granval-Lyaju, reactive P_2O_5 and K_2O - according to Machigin methods; and CO_2 were determined by Kudrin's acidimetric method [4-9].

3 Results and discussion

According to the results of the conducted research, due to erosion processes, typical rainfed sierozems are poor in organic matter and basic nutrients, so these soils have a low level of fertility. As a result of erosion processes, the thickness of the humic layer of silozems has decreased, the highest amount of humus corresponds to the arable layer, and the amount of humus decreases towards the sub-arable layer. The amount of humus decreases to 0.44-0.70% in the arable and sub-arable layers of the studied soils, and to 0.12-0.20% in the lower layers. The low amount of humus in the studied soils is explained by the processes of erosion, the sparseness of the plant cover and the lack of moisture in the soil.

It is known that nitrogen accumulates in the soil from plant residues or from the air through nitrogen-fixing microorganisms. In studied typical rainfed sierozems, the content of total nitrogen varies according to the amount of humus. Therefore, these soils are also low in nitrogen. The reason for this can be considered as long-term high temperature, lack of moisture, which reduces the vital activity of soil microflora. The highest accumulation of nitrogen in these soils is mainly observed in the upper layers, and this indicator varies in the range of 0.017-0.044% (Tables 1 and 2).

It is known that nitrates are not absorbed into the soil absorption complex and are very reactive in the soil. Much of it can be leached and lost from the soil through the process of denitrification. Nitrates shift the soil pH from alkaline to neutral and increase the amount of reactive phosphorus by increasing the dissolution of phosphates. The formation of nitrates takes place in the process of nitrification. However, as it moves to the lower layers of the soil, the rate of microorganisms slows down and its amount decreases in the lower layer due to leaching of nitrates.

Table 1. Chemical and agrochemical properties of typical rainfed sierozems.

Soil samples	Soil layers, cm	Humus, %	Total, %		
			N	P	K
1	0-20	0.70	0.044	0.330	1.08
	20-45	0.44	0.035	0.290	1.08
	45-90	0.20	0.032	0.330	1.03
	90-155	0.20	0.030	0.330	1.03
	155-180	0.12	0.025	0.340	1.01
2	0-16	0.66	0.041	0.330	1.26
	16-36	0.50	0.039	0.350	1.14
	36-56	0.31	0.037	0.380	1.13
	56-85	0.27	0.032	0.330	1.11
	85-150	0.23	0.023	0.290	1.10
3	0-15	0.66	0.060	0.250	1.00
	15-25	0.64	0.044	0.320	0.97
	25-70	0.62	0.029	0.230	0.97
4	0-20	0.63	0.041	0.270	1.00
	20-35	0.52	0.038	0.280	0.99
	35-100	0.28	0.035	0.260	0.98
5	0-17	0.75	0.046	0.240	1.14
	17-30	0.61	0.023	0.250	1.08
	30-110	0.32	0.017	0.230	1.07
6	0-15	0.67	0.028	0.260	1.16
	15-27	0.62	0.025	0.270	1.15
	27-105	0.43	0.023	0.250	1.13
7	0-25	0.80	0.037	0.210	1. 03
	25-45	0.70	0.035	0.220	1.03
	45-90	0.66	0.018	0.260	1.08
	90-115	0.23	0.016	0.220	0.78

According to the obtained data, the amount of nitrate nitrogen in the studied soils is not very high, it varies in the range of 2.25-8.27 mg/kg in the tillage and sub-tillage layers. These soils are poor in nitrate forms of nitrogen and are included in the range of soils with very little and low supply of nitrogen in nitrate form.

Table 2. Chemical and agrochemical properties of typical rainfed sierozems.

Soil samples	Soil layers, cm	Reactive, mg/kg			C:N	C:P	CO_2	pH
		N-NO_3	P_2O_5	K_2O				
1	0-20	3.25	41	288	9.2	1.2	4.12	7.28
	20-45	2.50	22	206	7.2	0.8	7.13	7.47
	45-90	2.25	17	96	3.6	0.3	6.44	7.28
	90-155	3.25	14	110	3.8	0.3	5.81	7.13
	155-180	2.50	19	86	2.7	0.2	10.23	7.70
2	0-16	5.50	33	336	9.3	1.1	4.38	7.01
	16-36	3.25	26	244	7.4	0.8	4.86	7.23
	36-56	4.75	14	134	4.8	0.4	5.70	7.15
	56-85	3.75	12	123	4.8	0.4	6.90	7.41
	85-150	3.21	9	119	5.8	0.4	8.30	7.50
3	0-15	6.25	13	290	6.3	1.5	6.07	7.19
	15-25	4.75	26	307	8.4	1.1	5.17	7.04
	25-70	3.87	23	278	12.4	1.5	6.80	7.17
4	0-20	7.25	27	355	8.9	1.3	4.00	7.01
	20-35	6.70	34	291	7.9	1.0	5.70	7.18
	35-100	4.00	31	91	4.6	0.6	6.60	7.22
5	0-17	5.50	10	314	9.4	1.8	5.97	7.21
	17-30	4.00	33	264	15.3	1.4	7.39	7.30
	30-110	3.73	29	204	10.9	0.8	9.63	7.50
6	0-15	3.25	20	326	13.8	1.4	6.23	7.12
	15-27	4.35	34	292	14.3	1.3	6.37	7.11
	27-105	4.00	32	225	10.8	0.9	6.55	7.08
7	0-25	4.00	13	254	12.5	2.2	6.28	7.13
	25-45	2.25	23	228	11.6	1.8	6.76	7.11
	45-90	4.75	21	216	21.2	1.4	6.44	7.10
	90-115	8.25	24	79	8.3	0.6	7.81	7.32

Phosphorus, one of the important macroelements for soil and plants, is an important biological element included in protoplasm, a number of enzymes and vitamins.

It is known that sierozem is rich in the element phosphorus. The main amount of total phosphorus is observed in the humic accumulation layer, especially in typical and dark-colored sierozems. Phosphorus has the same pattern as nitrogen. In studied typical rainfed sierozems, in addition to humus and nitrogen, the amount of some other nutrients, in particular gross and reactive forms of phosphorus, is also reduced. The data show that the total phosphorus content in the upper layers of the studied soils decreases from 0.330 to 0.350%, and in the lower layers to 0.220-0.290% (Tables 1 and 2).

It is known from many studies that the demand for phosphorus of all plants is high in its initial phases. The lack of phosphorus in the soil at these stages sharply reduced the development of the root system, the degree of rooting, and the resistance to unfavorable abiotic and biotic factors.

The amount of reactive phosphorus in the soil is also important for plant nutrition. The amount of reactive phosphorus is less variable, and the excess amount is transferred to a form that cannot be absorbed by plants. This is especially true in non-irrigated rainfed soils.

In studied typical rainfed sierozems, the amount of reactive phosphorus is 41 mg/kg in the arable layer, while it decreases to 9 mg/kg as it moves to the lower layers. According to reactive phosphorus supply, it was found that the upper layer of the soil is moderately supplied, and the lower layers are supplied with little or very little. Most of the total amount of phosphorus in sierozems is firmly bound to the mineral part of the soil, and the plant absorbs this element with difficulty. Therefore, these soils require phosphorus fertilizers.

Sierozems are rich in potassium because they are formed in loess and loess-like rocks that store potassium. The main part of potassium is stored in the crystal lattices of primary and secondary minerals such as biotite, muscovite, potassium feldspars, hydromicas, and is in a form that cannot be transferred to plants.

Like potassium, nitrogen and phosphorus, it performs an important physiological function in plants, participates in the normal course of the photosynthesis process in plants, in the synthesis of some vitamins, and in increasing the activity of enzymes. The amount of total potassium in the investigated soils is 1.16-1.26% in plowed and under-plowed layers, and 1.00-1.13% in lower layers.

Potassium is stored in the soil in the absorbed state (exchangeable and non-exchangeable) and in the form of simple salts. Exchangeable potassium is the main source of plant nutrition. The more the soil is saturated with exchangeable potassium, the better and faster its transfer to plants. After exchangeable potassium is absorbed, its reserve is replenished with non-exchangeable potassium.

According to the results of the study, the amount of exchangeable potassium is 355-336 mg/kg in the arable layer of the soil, and decreases as it moves to the lower layers and is 91-79 mg/kg.

Exchangeable potassium is important in plant nutrition. Exchangeable potassium consists of potassium absorbed into the soil absorption complex and potassium in the soil solution. Plants can absorb them directly. The amount of exchangeable potassium is several tens of times higher than the amount of mineral nitrogen and reactive phosphorus, which of course depends on the amount of aluminosilicate minerals distributed in soil profiles. According to the studied soil layers, it was found that its upper layers are high in exchangeable potassium, and the sub-soil and lower layers are at the level of medium and low supply.

Crop residue typically retains up to 1 percent nitrogen and can have a C:N ratio of up to 50. However, as organic residues are re-transformed, the soil becomes enriched with nitrogen and the C:N ratio also decreases. Therefore, the C:N ratio is an indirect indicator that allows to determine the degree of rotation of organic matter into humus. In the studied soils, the C:N ratio fluctuates between 2.7-21.2, while the highest value of the C:N ratio is in the upper layers (with the exception of some samples), and it decreases towards the lower layers. Therefore, we can consider that the humus of sierozems is rich in plasma nitrogen.

In the studied soils, the C:P ratio is not high, that is, it varies between 0.2-2.2. The soil reaction depends on the presence of hydrogen (H^+) and hydroxyl (OH^-) ions in the soil solution and their concentration ratio, expressed by pH. Depending on the ratio of the concentration of hydrogen and hydroxyl ions resulting from the interaction between the dissolved substances in the soil solution and the solid part of the soil, the soil will have a neutral (pH-7), acidic (pH < 7) or alkaline (pH > 7) reaction. Soil reaction is caused by the interaction of many factors.

The results of determination of pH of the soil environment show that the environment of the soil reaction changes directly depending on the amount of carbonates in the soil profile in the studied soils. It was observed that the high carbonate-free layers are close to neutral (pN 7.0-7.1), and the weak carbonate layers are weakly alkaline (pN 7.4-7.7). The reaction of the soil environment varies depending on the chemical and mineralogical composition of the mineral part of the soil, the presence of free salts, the amount and quality of organic matter, soil moisture, and the life activity of various organisms. Therefore, it has a great impact on soil fertility.

According to the research, it was observed that the distribution of carbonates along the cross-section of the studied soils is also different. The amount of carbonates is also important in evaluating soil fertility. Carbonates affect the soil environment (pH) and provide its alkalinity. Carbonates play an important role in converting reactive phosphorus into a form that cannot be absorbed by plants. In the soil, carbonate ions combine mainly with calcium and partially with magnesium to form calcium and magnesium carbonates.

The amount of carbonates in the studied silozems fluctuated in the range of 4.12-10.23% along the soil profile. Variation of the amount of CO_2 carbonates in the soil layers depends on the depth of the carbonate-illuvial layer, the depth of soil wetting, the level of carbonation of the soil-forming parent rocks, and the topography of the place.

According to the obtained data, the amount of carbonates significantly increases and the amount of humus decreases sharply along the soil profile from the upper layers to the lower layers (Figure 1). An increase in the amount of carbonates and a decrease in the amount of humus towards the lower layers along the soil profile is one of the characteristics of sierozems. With a decrease in the ratio of humus to carbonate, the dispersity of soils and their susceptibility to erosion increases.

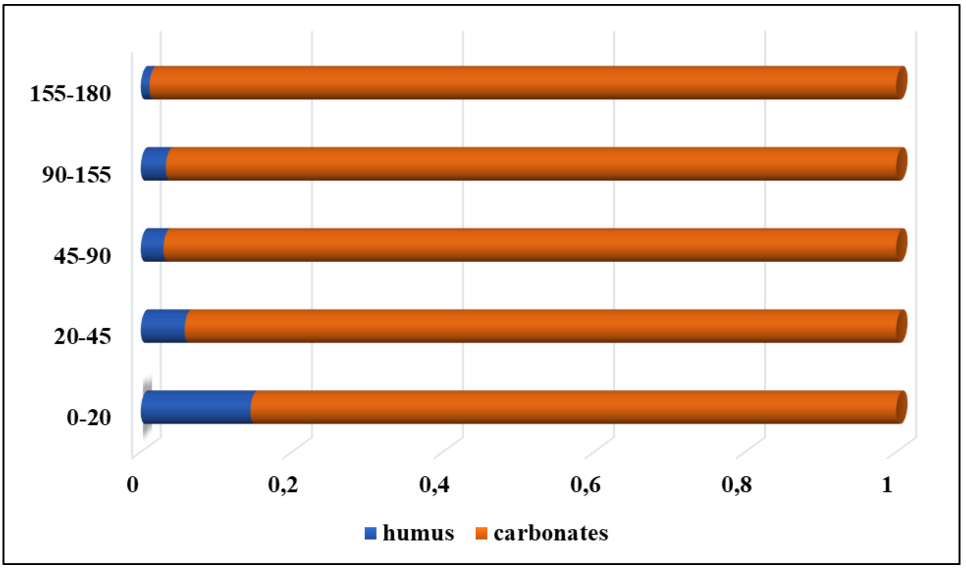

Figure 1. Variation of humus and carbonates (CO_2) content along the soil profile in typical rainfed silozems.

Determining the correlations between the agrochemical properties of soils and certain parameters is of the greatest importance in the formation of soil fertility and in knowing the

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mechanism of soil formation processes. The study of the correlation between the amount of humus and C:N, C:P ratio in the studied soils showed that they are positively related and represent the general course of the processes of humus formation in the soil profile. The correlation coefficient between humus and C:N, C:P ratio varied between R^2 = 0.45-0.88 (Figure 2).

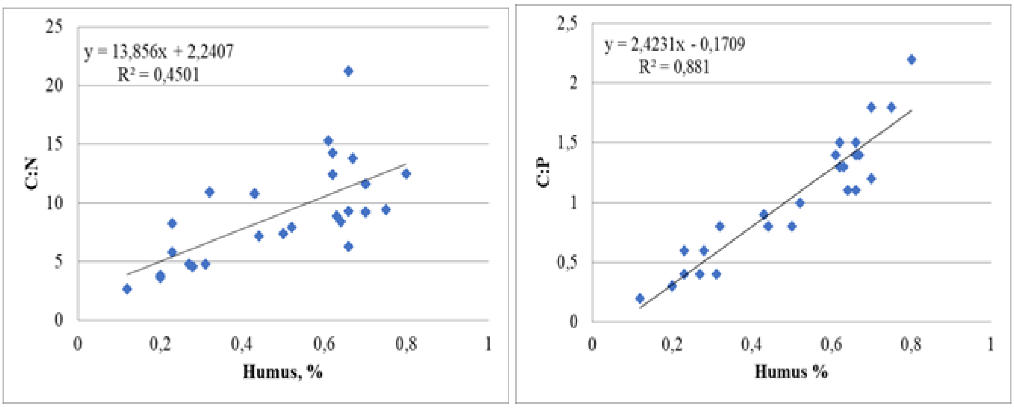

Figure 2. Correlations between humus, S:N, and C:P ratios in typical rainfed silozems.

4 Conclusions

Thus, the described soils are characterized by a low amount of humus, gross and reactive forms of nutrients. The studied soils belong to the group of very low and low supply of nitrogen in the form of nitrate. According to the amount of reactive phosphorus, it was found that the upper layer of the soil is low, and the layer up to 1 m is moderately, low and very low.

According to the amount of exchangeable potassium, the studied soils can be included among the average and highly supplied soils, which indicates that there is no need to use potassium fertilizers in these lands. The low amount of nutrients is related to the sparseness of plant cover, which is the main source of organic matter to the soil.

Carbonates are not uniformly distributed along the profile of rainfed sierozems, that is, some samples differ from the surface layers in their carbonate content, while in other samples, some accumulation of carbonates is observed in the middle and lower layers. Due to low rainfall and erosion processes, the washing of the upper layers and the exposure of the lower carbonate-illuvial layers led to the appearance and increase of carbonates in the soil. This causes the reaction of the soil environment to increase. Studying the correlation between humus content and C:N, C:P ratio in the studied soils showed that they are positively related.

References

1. Abdrakhmanov T., Tursunov L., Jabbarov Z., Artikov X., Kaharova M. Introduction to Soil Science. (Textbook). Tashkent, "Universitet" Press, 2014. p. 136.
2. Artikova G.K. Nitrogen, Phosphorus and potassium assimilation and nitrogen use coefficient of wheat depending on the period of application of nitrogen fertilizers, Proc. of the 5th Congress of the Society of Soil Scientists and Agrochemists of Uzbekistan. T. 2016 year. September 16-17. pp. 199-202.

3. Bahadirov M., Rasulov A. Soil science. Tashkent: Ukituvchi Press. 2005 pp. 327-336.
4. Gafurova L.A., Kadirova D.A. Eroded soils of the Turkestan Range and their biological activity. Monograph. T .: "Fan" Press, 2014. pp. 47-57.
5. Gafurova L.A., Abdrakhmanov T.A., Jabbarov Z.A., Saidova M.E. Land degradation and landscapes. Textbook. Tashkent, 2013. 220 p.
6. Dzhalilova G. T., Kadirova D. A. The agrochemical properties of soils are one of the indicators of the level of fertility of rainfed lands. Russian Research Institute for Land Reclamation Problems. Ways to improve the efficiency of irrigated agriculture. Collection of scientific papers Issue 50 - Novocherkassk Helikon, 2013. P. 60-67
7. Koziev R.Q., Abdurahmonov N.Yu., Yuldashev A., Karaev A.Kh. Methodological manual for assessing the productivity of rainfed soils of the Republic of Uzbekistan. Tashkent, 2014. 20 p.
8. Kuziev R.K., Sektimenko V.E. Soils of Uzbekistan.-Tashkent, Ehrtemum Press, 2009. pp. 351-352.
9. Koziev R.Q., Sektimenko V.E., Ismanov A.J. Atlas of soil covers of the Republic of Uzbekistan, Tashkent: State committee of land resources, geodesy, cartography and state cadastre of the Republic of Uzbekistan, 2010. 44 p.
10. Maksudov Kh.M., Gafurova L.A., Turapov I., Mountain and foothill soils of Uzbekistan, their genetic features and protection, Lecture notes and abstracts of the III Congress of Soil Scientists and Agrochemists. 2020, pp. 44-55.
11. Prosalov L.I. Soil types in different countries, Eurasian Soil Science. 2006. pp. 16-17.
12. Sektimenko V.E., Ismanov A.Zh. Soil characteristics of the rainfed land fund of the Samarkand region, Soil science and agrochemistry in the 21st century: a collection of materials of the international scientific and practical conference, Tashkent, 2004. pp. 193-197.
13. Sodikova G.S. Agrochemical properties of eroded typical rainfed sierozems, Soils and land resources of Uzbekistan: their rational use and protection: materials of the scientific-practical conference. May 14-16, 2008. pp. 171-172.
14. Sodikova G., Temirov Sh., Kadirova D. Microbiological activity of dark-colored sierozems formed in different deposits and the effect of erosion processes on them, National University of Uzbekistan named after Mirzo Ulug'bek. Climate change and rational use of natural resources. Collection of scientific articles - Tashkent, 2012pp. 151-153.
15. Toshkuziev M.M., Shadieva N.I. Influence of Natural and Anthropogenic Factors on the Properties of Eroded Soils in the Foothills of the Sanzar River Basin, Soils and land resources of Uzbekistan: their rational use and protection: materials of the scientific-practical conference. May 14-16, 2008. Tashkent, 2008. pp. 85-86.
16. Shadieva N.I. Effects of erosion processes on the chemical properties of rainfed soils distributed in Jizzakh region, Proceedings of the scientific-practical conference on the problems of effective use of land resources. Tashkent, 2007. pp. 102-105.
17. Uzokov P. Soil science. Samarkand, Fan Press 2006. pp. 130-133.
18. Shadieva N.I. The role of plant cover in the formation of humus in the soils of mountain and sub-mountain regions, Journal of Biology of Uzbekistan. Tashkent, 2015. 6. -pp. 47-49.
19. Shadraimova K.I., Kamilov.B.S. Erosion processes and distribution of micronutrients in rainfed dark sierozems according to crop species, Soil science and agrochemistry in

the 21st century: Proceedings of the international scientific and practical conference. - Tashkent, 2004. -pp. 512-517.

20. Gafurova L.A., Djalilova G.T., Yergas'heva O.X., Abdukarimova K.D. Measures on yerosion-preventive forest melioration in mountain areas of Uzbekistan. Journal of Critical Reviews, 2020, 7(2), pp. 283–287
21. Gafurova L.A., Kodirova D.A., Djalilova G.T., Yergas'heva O.Kh. Degraded Soils of Surkhan-s'herabad valley and their biological activity Journal of Critical Reviews, 2020, 7(2), pp. 292–295.