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THE IMPACT OF AGRICULTURAL USE ON THE FERTILITY RATES OF THE ORDINARY BLACK SOILS OF KOSTANAY REGION

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Abstract

The experience of agriculture in the Republic of Kazakhstan and other countries shows that high and sustainable agricultural productivity is possible only with a comprehensive soil examination in order to control and assess changes in

fertility and the level of pollution caused by anthropogenic factors to prevent land degradation.

The article provides a brief description of the soil cover and an assessment of the current state of soil fertility of the Kostanay region, which allows to solve problems with resources and limiting factors of soil fertility, heat, moisture and potential for development of degradation processes, the formation of environmental infrastructure of the agricultural landscape, etc. Morphological and physical and chemical analysis of soils was carried out in the research. The data of previous years have also been studied and the change in soil properties over the course of long-term agricultural use has been analyzed. The analysis of the current state of soils is given and the assessment of soil fertility is carried out.

Keywords: black soil; soil morphology; soil structure; agriculture; soil fertility; humus.

Introduction

The involvement of steppe zone lands in agricultural use is the main factor, as a result of extended plowing of soils, morphological properties of the profile, humus content, agrochemical, physical and chemical properties of the soil change, which ultimately affects their fertility.

With long-time agricultural use of soils, the structure of the soil is mechanically disturbed, the structure of surface layers is destroyed and the subsurface horizon is over-compacted, the humus content decreases due to soil deflation, water and wind erosion, mineralization of humus and the removal of nutrients with the harvest of crops.

The black soil steppe zone is an agricultural zone of grain direction. On average, 19-22% of black soil and 28-30% of humus in Kazakhstan were lost during plowing over 50 years [1].

Today there is a global problem of deterioration of fertility, which leads to degradation of the soil cover [2-10].

Materials and methods

The research was carried out on the black soils of ordinary rural

The purpose of our research is to study the changes in the morphological and physical and chemical properties of ordinary black soils of Kostanay region during prolonged agricultural use.

The purpose of the research is to study the effect of long-term agricultural use on the change in morphological, physical and chemical properties of black soils of Kostanay region.

The research was carried out within the framework of the scientific and technical program: "Development of organic farming technologies for growing crops, taking into account the specifics of the regions, digitalization and export" for 2021-2023, project topic: "Assessment of the agroecological state of agricultural land from the effects of anthropogenic factors and determination of the degree of soil pollution and agricultural systems of steppe and dry steppe zones of Kostanay region" for 2021-2023.

districts of the Karabalyk district of the Kostanay region. Soil sections (keys),

digs and semi-pits were laid, according to which a detailed morphological [11] and physical and chemical examination was carried out.

Soil layers were sampled by sections, in which soil-agrochemical indicators were determined according to generally accepted methods. The following analyses were carried out in the selected soil samples:

Determination of physical and chemical properties ($\text{pH}_{\text{H}_2\text{O}}$ by the potentiometric method, the sum of absorbed bases by the complexometric method, humus by the method of I.V. Tyurin in the modification of TSINAO (GOST

26213-2021), nitrate nitrogen by the ionometric method, mobile forms of phosphorus by the method of B.P. Machigin in the modification of TSINAO (SS 26205-91), exchangeable potassium on a flame photometer) [12].

According to "State Research and Production Center of Land Resources and Land Management" of the Agency of the Republic of Kazakhstan for Land Management, a comparative analysis of changes in the morphological and physical and chemical properties of the soil was carried out to identify their changes during prolonged agricultural use.

Results

According to the results of the survey, the main morphological characteristics were obtained, which are presented below (the article presents sections selectively).

Section No. 1 was laid on a slightly undulating plain of the Smirnovsky rural district of the Karabalyk district of the Kostanay region, on arable land (2021).

Morphological description of ordinary medium-sized low-humus heavy loam black soil on cover loams:

- | | | |
|----------------|-----------|--|
| A | 0-24 cm | Dark gray with a faint brownish tinge, medium-coarse structure, and fresh, compacted, heavy loamy, a large number of roots of herbaceous plants, does not boil from hydrochloric acid, the transition is clear in color. |
| B ₁ | 24-56 cm | Brownish-gray, coarse-medium lumpy, heavy loamy, fresh, dense, sparse roots of herbaceous plants, boils from HCl, the transition to the next horizon is gradual. |
| B ₂ | 56-69 cm | Grayish-brown, lumpy structure, heavy loamy, dense, moistened, single grass roots, strongly boils from HCl, carbonates in the form of single spots, the transition to the next horizon is gradual. |
| BC | 69-85 cm | Light grayish-brown, lumpy, moist, dense, sparse roots of herbaceous plants, boils from hydrochloric acid, the transition to the next horizon is gradual. |
| C | 85-130 cm | Yellow-brown, lumpy, moist, heavy loamy, dense, boils violently. |

The morphological profile of ordinary black soil is characterized by a heterogeneously colored upper humus-accumulative horizon, a medium-coarse structure, a large number of plant roots; the B₁ horizon differs from the upper horizon

by boiling from hydrochloric acid, denser addition, and brownish-gray color. The thickness of the humus layer of the soil is 56 cm. Below the horizon B₁ is the horizon B₂, which has single spots of carbonates, lumpy structure and rapid boiling of the soil from hydrochloric acid. The particle size distribution of the soil is heavy loamy.

Carbonate soils were also studied.

Morphological description of ordinary carbonate black soil - section No. 2. The section is laid on a slightly undulating plain.

Morphological description of ordinary carbonate low-humus light-loamy black soil on cover loams:

A	0-22 cm	Dark gray, lumpy structure, light clay, moist, dense, a large number of roots of herbaceous plants, boils from hydrochloric acid, the transition is clear in color.
B ₁	22-46 cm	Brownish-gray, fine-medium-lumpy, light-clay, moist, dense, sparse roots of herbaceous plants, boils from HCl, the transition to the next horizon is gradual.
B ₂	46-64 cm	Gray-brown, lumpy, light-clay, dense, moist, dense, fractured, single roots of herbaceous plants, boils strongly from HCl, the transition to the next horizon is gradual.
BC	64-92 cm	Light gray-brown, lumpy, moist, dense, sparse roots of herbaceous plants, carbonates in the form of spots, the transition to the next horizon is gradual.
C	92-130 cm	Yellow-brown clay, moist, structureless, moist, dense, there are spots of gypsum with a depth of 100 cm.

Soil name: Ordinary carbonate black soil, medium-sized, low-humus, light-loamy on cover loams.

According to the results of a comparative analysis of the morphological properties of soils with previous surveys of State Research and Production Center of Land Resources and Land Management, a number of changes were identified. For 15 years of agricultural use of ordinary black soils, the capacity of the arable horizon of the profile has noticeably decreased to 2 cm, the capacity of the humus horizon of A+ B₁ has decreased and the humus content has decreased, which is associated with annual plowing, over-

compaction of soils by machinery, destruction of agronomically valuable structure, removal of nutrients, etc.

The annual negative transformation of soil properties leads to soil degradation and low productivity of agricultural crops.

As a result of the laboratory surveys, analytical studies of the agrophysical and physical and chemical properties of the soil were carried out, as well as comparative data from previous years on the same areas of seeding were presented (Table 1).

Table 1 - Agrochemical and physical and chemical characteristics of ordinary black soils of the Karabalyk district of Kostanay region.

Horizon	Hum	Nitrat	Mobile, mg/kg	Absorbed bases, mg/eq per	Absorbed bases in %
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and depth of sampling, cm	us, %	e nitrogen, mg/kg	of soil		100 gr. of soil				of the amount or capacity		
			Phosphorus	Potassium	Ca ²⁺	Mg ²⁺	Na ⁺	The amount	Ca ²⁺	Mg ²⁺	Na ⁺
Ordinary medium-sized black soil, 2021											
A 0-24	4,60	16,4	15,7	330	23,6	5,2	0,10	28,90	81,67	17,99	0,34
B ₁ 24-56	3,12	6,3	7,7	650	20,0	6,0	0,13	26,13	76,54	22,96	0,50
B ₂ 56-69	1,75	7,1	9,5	500							
Ordinary medium-sized black soil, 2006											
A 0-25	4,92	-	-	360	27,6	5,2	0,16	32,96	83,74	15,77	0,49
B 25-56	3,26	-	-	-	24,4	6,4	0,13	30,93	78,81	20,69	0,42
BC 56-85	2,03	-	-	-	-	-	-	-	-	-	-
Ordinary carbonate black soil, 2021											
A 0-22	4,70	8,2	16,1	420	31,0	4,36	0,47	35,83	86,52	12,17	1,31
B ₁ 22-46	3,22	10,4	8,5	600	25,5	8,16	0,25	33,91	75,20	24,06	0,74
B ₂ 46-64	1,75	4,3	10,5	654	16,6	10,1	1,67	28,40	58,45	35,67	5,88
Ordinary carbonate black soil, 2006											
A 0-22	4,46	-	16,0	504	32,0	6,0	0,26	38,26	83,64	15,68	0,68
B ₁ 22-48	3,86	-	-	-	27,2	9,6	0,97	37,77	72,01	25,42	2,57
B ₂ 48-62	2,74	-	-	-	-	-	-	-	-	-	-

The data indicate that over the years of soil use in agriculture, the process of dehumidification has increased, especially on ordinary medium-sized black soils, where, compared with 2006, the humus content has decreased from 4.92 to 4.60% in the upper arable horizon, the same pattern has remained in the underlying horizons. At a depth of 24-56 cm and 56-85 cm of the soil profile, the humus content decreased from 3.26% to 3.12% and from 2.03% to 1.75%, respectively (Table 1). The content of humus is largely determined by the applied farming system and natural conditions. When cultivating grain crops, 0.5-1.0 t/ha of humus is consumed annually from the soil, almost twice as much when growing row crops. On average, the annual decrease in humus in the soils of the main agricultural areas is about 0.6 t/ha. The decrease in humus reserves in arable soils of the steppe zone is caused

by the deflation process - blowing out the thinnest, organic matter-rich particles and irrational use of soils.

In the upper horizon (A 0-22 cm) of ordinary carbonate black soil, the humus content over a 15-year period, on the contrary, increases from 4.46% to 4.70%, but a different picture is observed in the lower horizons of the soil profile, and according to 2021, the humus content decreases from 3.86% to 3.22% in the horizon B₁ 22-46 cm and from 2.74% up to 1.75%, in the B₂ horizon 46-64 cm, respectively. The loss of humus in the lower horizons is associated with the removal of crop residues with yield, which leads to a reduction in biomass in the fields and a decrease in the intake of organic residues into the underlying soil horizons.

The content of nitrate nitrogen in the surveyed soils in the arable horizon ranges from 8.2 mg/kg to 16.4 mg/kg,

in the horizon B₁ its content was 6.3 mg/kg and 10.4 mg/kg, respectively.

The content of mobile phosphorus in ordinary medium-sized and carbonate black soils is low and amounts to 7.7 mg/kg and 8.5 mg/kg, in the B₁ horizon from 4.3 mg/kg to 7.1 mg/kg.

In general, for the period from 2006 to 2021, there is a tendency to increase the content of mobile phosphorus in ordinary carbonate black soils by 0.1 mg/kg, which does not significantly show a difference over the years.

The content of exchangeable potassium in black soils was high from 330 mg/kg to 504 mg/kg. Over the past 15 years, there have been decreases in the amount of exchangeable potassium in black soils, which may be due to the blowing of fine particles from the upper horizons.

Fairly clear results were obtained for absorbed bases (Table 1). Over a 15-year period of agricultural use of black soils, some changes in the amount of absorbed bases resulted.

The cation exchange capacity of ordinary medium-sized black soil according to State Research and Production Center of Land Resources and Land Management (2006) in the upper arable horizon (A 0-25 cm) was 32.96 mg-eq per 100 g, in the transitional horizon (25-56 cm) 30.93 mg-eq per 100 g of soil. Whereas according to the research data (2021), the capacity of cation exchange varied

Discussion

Studies have shown that in the territory of the Karabalyk district of the Kostanay region, common black soils are ordinary ordinary and carbonate medium-sized low-humus, where the

in arable A and B₁ horizons from 28.90 mg-eq per 100 g to 26.13 mg-eq per 100 g of soil. The degree of saturation of calcium cation reached according to 2006 data was 83.74% in the arable horizon and 78.81% in the transition horizon. A slight decrease in the proportion of calcium cation in the soil-absorbing complex occurred in 2021, where it was 81.67% in the arable horizon and 76.13% in the sub-arable horizon, but the proportion of magnesium ion increased in these horizons, which is also confirmed by the results of research by other scientists [13].

The sum of exchange cations of ordinary carbonate black soil according to 2006 data was 38.26 mg-eq per 100 g in the upper arable horizon and 37.77 mg-eq per 100 g of soil in the sub-arable horizon. The same tendency to decrease the amount of cations in the soil persists as in ordinary black soils in 2021, where the capacity of cation exchange decreases to 35.83 mg-eq per 100 g in the arable horizon and 33.91 mg-eq per 100 g of soil in the sub-arable horizon. In the soil-absorbed composition of ordinary carbonate black soil, the proportion of calcium decreased compared to 2006 data and amounted to 83.64% - 75.20% in the arable horizon and 72.01% - 58.45% in the sub-arable horizon due to an increase in the proportion of magnesium in the composition of the soil-absorbing complex.

following set of horizons is distinguished in the structure of the morphological profile of soils: A – B₁ – B₂ – BC – C and the thickness of the humus layer (A+B₁) is 46-56 cm. In the

profile of ordinary medium-sized black soils, carbonates are observed already in 24-25 cm depth, and in the section of ordinary carbonate black soils from hydrochloric acid boil already from the surface. During the 15-year period of agricultural use of ordinary black soils, there were noticeable decreases in the capacity of the arable horizon of the profile by 1 cm (A 0-24 cm), a separate allocation of the horizon B₂ 56-69 cm, as well as a decrease in the humus layer by 2 cm.

In the conditions of agricultural production, the problem of preserving humus has become one of the most urgent. In our studies, over a 15-year period of agricultural use, there is a tendency to decrease humus in ordinary black soils due to the blowing of thin, organic-rich particles.

The availability of the arable horizon of soils with mobile phosphorus – to a very low and low degree, with exchangeable potassium – to a high, very high (more than 330 mg / kg in the A horizon). The content of nitrate nitrogen in the surveyed soils in the arable horizon ranges from 8.2 to 16.4%.

By the amount of the sum of the exchange bases, ordinary black soils

are estimated as high. Over the 15-year period of soil use in agriculture, the cation exchange capacity of ordinary black soils decreased, in the arable horizon by 2.43-4.06 and in the sub-arable horizon by 3.86-4.80 mg-eq per 100 g of soil and the degree of saturation of calcium cation in the soil-absorbing complex of ordinary black soils decreased by 2.07-8.44% in the arable horizon and by 2.68-13.56% in the sub-arable horizon, respectively.

Based on the conducted research, it is necessary to carry out a set of measures for the preservation and reproduction of soil fertility in Kostanay region: to conduct an agroecological assessment of the entire territory, identify the degree of soil degradation, apply agrotechnologies taking into account soil characteristics, apply fertilizers and others.

Soil surveys were carried out within the framework of the Program "Assessment of the agroecological condition of agricultural lands from the effects of anthropogenic factors and determination of the degree of soil pollution and agricultural systems of steppe, dry-steppe zones of Kostanay region" for 2021-2023.

Conclusion

The ordinary black soils studied by us over a 15-year period of agricultural use have undergone a number of changes in the morphological profile and in the physical and chemical properties of soils. A decrease in the capacity of the humus horizon was revealed, the deterioration of the soil structure, as well as the humus content decreased along the soil profile, the content of plant nutrition elements decreased and the composition of the soil-absorbing complex changed.

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ВЛИЯНИЕ СЕЛЬСКОХОЗЯЙСТВЕННОГО ИСПОЛЬЗОВАНИЯ НА ПОКАЗАТЕЛИ ПЛОДОРОДИЯ ЧЕРНОЗЕМОВ ОБЫКНОВЕННЫХ КОСТАНАЙСКОЙ ОБЛАСТИ

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Аннотация

Опыт ведения сельского хозяйства в Республике Казахстан и других странах свидетельствует, что высокая и устойчивая продуктивность земледелия возможна лишь при комплексном обследовании почв с целью контроля и оценки изменения плодородия, уровня их загрязнения под воздействием антропогенных факторов, чтобы не допустить деградацию земель.

В статье приведена краткая характеристика почвенного покрова и оценка современного состояния плодородия почв Костанайской области, которая позволяет решать задачи по ресурсам и лимитирующим факторам почвенного плодородия, тепла, влаги и потенциала развития деградационных процессов, формирования природоохранной инфраструктуры агроландшафта и др. В

исследованиях проведен морфологический и физико-химический анализ почв. Также изучены данные прошлых лет и проанализировано изменение свойств почвы с течением длительного сельскохозяйственного использования. Дан анализ современного состояния почв и проведена оценка плодородия почв.

Ключевые слова: чернозем обыкновенный; морфологические свойства почв; структура почвы; сельскохозяйственное использование; плодородие почв; гумус.

ҚОСТАНАЙ ОБЛЫСЫНЫҢ КӘДІМГІ ҚАРА ТОПЫРАҚТАРЫНЫҢ ҚҰНАРЛЫЛЫҚ КӨРСЕТКІШТЕРІНЕ АУЫЛ ШАРУАШЫЛЫҒЫНА ПАЙДАЛАНУДЫҢ ӘСЕРІ

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Қазақстан Республикасында және басқа елдерде ауыл шаруашылығын жүргізу тәжірибесі егіншіліктің жоғары және тұрақты өнімділігі жердің тозуын болдырмау үшін антропогендік факторлардың әсерінен құнарлылықтың өзгеруін, олардың ластану деңгейін бақылау және бағалау мақсатында топырақты кешенді зерттеу кезінде ғана мүмкін болатындығын айғақтайды.

Мақалада Қостанай облысының топырақ жамылғысының қысқаша сипаттамасы және топырақ құнарлылығының қазіргі жағдайының бағалауы келтірілген, бұл топырақ құнарлылығының, жылудың, ылғалдың және деградациялық процестердің даму әлеуетінің ресурстары мен шектеуші факторлары, агроландшафттың табиғатты қорғау инфрақұрылымын қалыптастыру және т.б. бойынша міндеттерді шешуге мүмкіндік береді. Зерттеулерде топырақтың морфологиялық және физикалық-химиялық талдауы жүргізілді. Сондай-ақ, өткен жылдардағы деректер зерттеліп, ұзақ уақыт ауылшаруашылық мақсатта пайдалану кезінде топырақ қасиеттерінің өзгеруіне талдау жасалды. Топырақтың қазіргі жағдайына зерттеліп, топырақтың құнарлылығын бағалау жүргізілді.

Кілт сөздер: кәдімгі қара топырақ; топырақтың морфологиялық қасиеттері; топырақ түйіртпектілігі; ауылшаруашылық қолданылуы, топырақ құнарлылығы; қарашірінді.