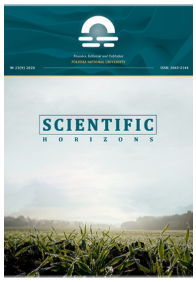
SCIENTIFIC HORIZONS

Journal homepage: https://sciencehorizon.com.ua
Scientific Horizons, 26(12), 76-87



UDC 631.4:631.8
DOI: 10.48077/scihor12.2023.76

The influence of soil-drying inputs on the soil and the productivity of crops

Sultan Kusherbayev
Master of Sciences, Lecturer
Karaganda Buketov University
100024, 28 University Str., Karaganda, Republic of Kazakhstan
https://orcid.org/0009-0007-1590-2524

Iztileu Amanzhol*
Doctor of Medicine, Professor
Karaganda Industrial University
101400, 30 Republic Ave., Temirtau, Republic of Kazakhstan
https://orcid.org/0009-0004-2077-7201

Zhanar Seilkhanova
PhD in Medicine, Associate Professor
Karaganda Buketov University
100024, 28 University Str., Karaganda, Republic of Kazakhstan
https://orcid.org/0000-0002-7020-6595

Gulnyaz Duanbekova
PhD in Medicine, Associate Professor
Karaganda Buketov University
100024, 28 University Str., Karaganda, Republic of Kazakhstan
https://orcid.org/0000-0001-7196-9159

Tolganay Kapparova
Master of Sciences, Lecturer
Karaganda Industrial University
101400, 30 Republic Ave., Temirtau, Republic of Kazakhstan
https://orcid.org/0009-0005-8862-4364

Article's History:
Received: 2.08.2023
Revised: 6.11.2023
Accepted: 27.11.2023

Abstract. In Kazakhstan, agricultural land has been degraded for decades, leading to an overall decline in crop yields. The purpose of the study is to conduct an environmental assessment of the current state of Kazakhstan's soils to increase crop yields using soil protection methods. The following methods were used in the study: cartographic, analysis and synthesis, systematization, abstraction, specification, and forecasting. Agriculture accounts for 86% of Kazakhstan's land. Active land use has led to various forms of degradation, resulting in 90 million hectares of eroded soils, of

Suggested Citation:
Kusherbayev, S., Amanzhol, I., Seilkhanova, Zh., Duanbekova, G., & Kapparova, T. (2023). The influence of soil-drying inputs on the soil and the productivity of crops. *Scientific Horizons*, 26(12), 76-87. doi: 10.48077/scihor12.2023.76.

*Corresponding author

which 29.3 million hectares are almost completely eroded. In 2023, the average yield of grain crops was 9.3 c/ha, oilseeds – 7.1 c/ha, and vegetables – 275.4 c/ha. It is noted that the yield of grain crops in 2023 is 28% lower than in the previous period of 2020-2022, despite the increase in sown areas. Drought and soil degradation are the main reasons for the decline in grain yields. It is noted that the main biological constraints to grain production are soil drought, windstorms, degradation and extreme temperatures, especially in rainfed irrigated farming systems in arid lands such as southern Kazakhstan. In the northern and central parts of Kazakhstan, agricultural land is dominated by black and chestnut soils, and in the south by brown semidesert soils. The largest areas of eroded agricultural land are located in Almaty, Atyrau and Turkestan regions – over 30%, and the smallest – in Akmola, Karaganda, Kostanay and North Kazakhstan regions – 5%. Productive grain growing requires soil monitoring for the main mobile elements that affect plant yields. The average values for the Republic of Kazakhstan are: nitrogen content – 37.5 mg/kg, phosphorus – 16.8 mg/kg, potassium – 419.5 mg/kg, humus – 2.8%. The practical significance of the study is to expand and supplement the theoretical basis of research in the field of soil degradation, and the results obtained are proposed for a comprehensive environmental assessment of soils in Kazakhstan

Keywords: agrochemical analysis; nativeness; rational land management; humus; nitrogen; phosphorus

INTRODUCTION

The use of fertilizers, intensive farming, and high-yielding varieties contribute to successfully overcoming food shortages. These factors eventually lead to soil fertility problems. Stable development of agriculture, growth of production and the welfare of the population largely depends on soil fertility, but over the last few decades there has been a steady degradation of agricultural land and loss of its productivity, which leads to an overall decrease in crop yields and efficiency of crop production. Rational use of nutrients and maintenance of soil fertility is increasingly recognized, especially in countries with high demographic pressure on land resources.

Environmental problems in the Republic of Kazakhstan (RK), are the primary causes of soil degradation, namely reduced humus content, toxicity, erosion, salinization, waterlogging, pollution and desertification. As described in the data of S.B. Kenenbaev *et al.* (2023), the main causes of declining soil fertility are: weakening of vegetation productivity in the apparent absence of pests and diseases; change of soil structure with the appearance of cracks; overabundance of water-soluble chloride, sulphate and carbonate salts with increase of acidity; reduction of organogenic elements by more than 15-20%; reduction of useful microorganisms, worms, insects; development of pathogenic fungi.

Anthropogenic activity imposes an imprint on natural conditions, lack of crop rotations, use of outdated technologies and insufficient application of organic fertilizers. Soil protection measures in RK are based on interrelated principles, namely: avoidance or minimization of mechanical disturbance of soil productivity; constant maintenance of soil covers with plant residues and living cover crops (including legumes used as green fertilizer), which reduces moisture loss and soil erosion; protection from extreme harsh climate conditions through crop rotation and the use of a wide range of new crop varieties and hybrids.

S.M. Farahat *et al.* (2022) noted that agricultural land management is a complex system involving land use forecasting, land supervision and physical monitoring as the development of agricultural areas is directly dependent on their land and resources. One fifth of RK lands are not cultivated, which requires diagnosing new signs of types and kinds of soil degradation. The study of L. Kuanova *et al.* (2023) shows that the area of the RK agricultural land fund is 37.6% of the total area of 102.6 million ha, including arable land – 24.3 million ha, irrigated land – 1.7 million ha, fallow land – 2.6 million ha, hayfields – 2 million ha, pastures – 70 million ha. The qualitative composition of land suitable for farming is as follows: 16.1 million ha of arable areas, 58.2 million ha of solonetz soils, 43.1 million ha of scrubby soils, 35.3 million ha of saline soils, while the genetic and geographical features of soil degradation in RK remain unidentified.

As noted by M.A. Ansari *et al.* (2023), monoculture adoption usually leads to soil degradation and reduced crop yields, while the concept of conservation agriculture aims at obtaining acceptable profits while preserving the environment, therefore, double cropping with reduced tillage and utilization of crop residues is recommended. S. Turebayeva *et al.* (2022) report that proper and rational use of fertilizers can improve soil fertility and crop yields, while haphazard application of mineral fertilizers can have a negative impact. The main measure to protect the soil from contamination by mineral fertilizers and related compounds is scientifically justified fertilizer application at the optimal time. The intensive farming system involves the use of large quantities of mineral fertilizers, pesticides and other products of the chemical industry. Soil-protective measures are based on strengthening natural biological processes, by eliminating to a minimum chemical means of protection, fertilizers of mineral or organic origin. To improve soil degradation zoning of the RK territory, it is necessary to carry out continuous soil monitoring, as well as bonitet, soil-ecological and economic assessments.

The aim of the study is to assess the ecological state of RK soils and use soil-protective methods to increase crop yields.

LITERATURE REVIEW

Ecological problems of soils take place not only in RK, but also on a world scale, as can be seen from the data of world congresses in Europe, America, Turkey, China and near abroad, devoted to degradation, pollution, desertification, soil and environmental protection. A.M. Fortuna *et al.* (2023) report that soil is a unique natural resource that is utilized by mankind in agriculture and forestry for food independence, livestock rearing and industrial raw materials. Indicators of soil analysis include percentage of organic matter, biotic and microbial biomass, carbon amount, enzymatic activity, pH, electrical conductivity, cation exchange capacity of nitrogen, phosphorus, potassium, sulphur available to plants, porosity, aggregate stability, infiltration, bulk density, water available in soil. Topography has a significant influence on the formation of climate, soils, natural landscape and land cover. As reported by T. Darbayeva *et al.* (2020), the geological structure of the RK territory is complex and diverse: from low surface elevations to glacial highlands.

As noted in the data of A. Tokbergenova *et al.* (2018), more than 70 million ha of land in RK suffers from erosion, which is 26% of the territory of the republic, of which more than 52 million ha suffered from wind erosion and 17 million ha from water erosion. Wind erosion is widespread in the plains' region, especially in dry steppe areas, and it is most pronounced on soils of light mechanical composition in Zhambyl, Mangistau and Pavlodar oblasts. R. Zhu *et al.* (2023) report that water erosion is the result of unsystematic human use of land resources, it occurs during prolonged rainfall and snowmelt, when moisture does not have time to soak into the soil, washes out soil particles and forms potholes. Strong water flow forms deep gullies, reducing the area of cultivated land and creating inconvenience for field cultivation. According to K Khosravi *et al.* (2023), important parameters such as maximum water absorption and plasticity number decrease with increasing degree of soil washing. The fertility of such soils is lower than that of non-washed soils and is one of the major causes of agricultural production losses due to erosion. In a study by M. Koza *et al.* (2021) noted that the total amount of trace elements – copper, zinc, cobalt, and manganese – as well as the amount of chelates of these elements available to plants decreases in highly eroded medium- and high-treated layers of chernozem.

Practically all agrophysical parameters deteriorate due to loss of power fraction and run-off as a result of soil erosion, as well as indicators of pesticides. A.I. Derepaskin *et al.* (2023) point out that in eroded soils, the number of permeable aggregates larger than 1 mm is almost twice as large as in fully formed soils. As a result of loss of silt particles and humus, the physical and hydraulic properties of soil deteriorate, eroded soil becomes less water-holding and permeable. Specific and volumetric masses increase as humus content decreases and coarse dust content increases. In typical arable layers of chernozem and chestnut eroded soils, the content of silt and physical clay decreases by 5-6%, while the content of coarse dust increases by 4-5%. D.L. Corwin (2021) evaluates soil protection measures in agriculture, which are aimed at maintaining optimal phytosanitary conditions for crops, in particular, at protecting crops from weeds. The number of weed seeds in the arable layer ranges from 20 million to 5 billion seeds/ha, with a weed threshold of 10-20 seeds/m^2 for spring crops and 2-3 seeds/m^2 for perennial crops.

In their studies, S.T. Shah *et al.* (2022) report that destruction of the most fertile topsoil, deterioration of agrochemical and hydrophysical characteristics of soil inevitably leads to significant reduction in yields of cultivated crops in all regions. Soil estimation of humus content noted by K. Kunanbayev *et al.* (2022), informs about the availability of nitrogen, phosphorus, and potassium in the arable layer of the North-Kazakhstan region and shows that the yield of major grain crops (wheat, barley, oats, and maize) on slightly eroded soils decreases by 15-18%, on moderately eroded soils – by 30-40%, on highly eroded soils – by 40-50% compared to the yield on unaffected soils. Soil conservation measures have the potential to reduce the impact of climate change, in particular by regulating greenhouse gas emissions. As reported by R. Lal (2020), agricultural activities increase the stock of soil organic matter that can sequester carbon from carbon dioxide and store it safely for long periods of time, e.g. 25-50 years, before soil carbon saturation reaches a new stabilization level.

The benefits of proper crop rotation are increased yields and reduced costs; it is an integral part of the farming system. W. Grzebisz *et al.* (2022) found that a well-planned crop rotation not only enhances insect, disease and weed control, but also helps to maintain and improve soil structure and organic matter content. H. Li *et al.* (2023), in turn, characterized the crop diversity that can be used to reduce the negative impact of weeds, evenly distribute the load and prevent soil erosion, reduce biotic and abiotic stresses, and reduce economic risks.

MATERIALS AND METHODS

Fundamental and conceptual developments of the problem of determining the state of soil cover and its suitability for solving various tasks of agricultural production served as the basis of the scientific research. The following methods were used in the research: cartographic, analysis and synthesis, systematization, abstraction, concretization, forecasting.

The method of cartographic analysis was used to consider the soil cover of eroded agricultural lands as one of the largest reclaimed groups in terms of area. According to the East National Technology Support Centre (ENTSC), the Soil Management Assessment Framework (SMAF) was evaluated. Soil quality within the farmland was characterized by certain levels of performance, namely the ability to provide crops with moisture, macro- and micronutrients. RK soils were classified on a latitudinal basis and were represented by: chernozem in the northern part of the country, chestnut, brown semidesert and desert sandy soils in the south. Soil structure in the RK territory was determined by the thickness of humus horizon, humus content, pH, hydrolytic acidity, nitrogen, phosphorus, and potassium content. Using the method of systematization, the RK soil structure was formed, which allowed collecting and analysing data based on the principles of state regulation of potential resources and to determine the productivity of high quality crop and livestock production at different levels of development.

The work was based on the main factors of soil fertility depletion: wind and water erosion, pollution, reduction of biological productivity of natural pastures, secondary salinization and waterlogging of irrigated areas, desertification, and use for construction. On the basis of soil degradation and fertility losses, the factors of water and wind erosion were determined. The development of soil erosion processes is caused by a combination of natural conditions (such as climate, relief, mechanical composition of soils and other natural conditions), but the increased level of anthropogenic impact and the degree of intensity of land use, especially agricultural land, significantly accelerates degradation. To substantiate the planning of land management in RK, methods of analysis and synthesis have been used to determine the prospects for the use of land funds in the regions, determining the efficiency and effectiveness of agricultural land use, based on analysed and processed information of the Bureau of National Statistics (2023).

Natural and climatic conditions of RK have a significant impact on the yield and growth period of grain crops, ensuring high yields, as well as improving the quality of marketable products and raw materials. The noticeable effects of RK climate change are signalled by the occurrence of severe droughts that manifest with high intensity. According to United Nations (2013) climate parameters were set: summer high temperatures of 24-35°C with dust storms; winter low temperatures and snowstorms, with average temperatures of 13°C. In the research system, SWOT-analysis of RK agricultural land by soil condition and plant productivity was made. SWOT-analysis allowed finding out the optimal parameters of land use for building a model of sustainable development of the agro-industrial complex. Soil survey materials, materials on redistribution of agricultural land, land cadastre data, materials on socio-economic development and nature protection were used as input data for the survey.

RESULTS

The peculiarity of the RK ecological and geographical position is low stability of the natural environment to anthropogenic impacts. Four soil-geographical zones are distinguished on the RK plains: middle humid forest-steppe, middle arid steppe, dry desert steppe and desert. Geographical boundaries of natural zones correspond to the size of soil zone types. In RK 86% of the area falls on plains, where three main types of soils are present: chernozem, chestnut, grey-brown loamy soils, as well as in some areas' riverside soils – fluvisols and marsh soils – histosols. According to Sh. Smagulova *et al.* (2022) it is established that the scale of actively used agricultural land in RK as of 2022, is: 38.5%, of which more than 70% of arable land is in Akmola, Kostanay, Pavlodar and North-Kazakhstan oblasts, more than 60% of irrigated arable land in Almaty and South-Kazakhstan oblasts, as well as small areas of pastures in Karaganda – 18.8% and Almaty – 44.1% oblasts.

Reduction of soil degradation is ensured by the use of sustainable land use practices, as traditional tillage with intensive ploughing destroys soil structure and leads to soil degradation. In contrast, no-till or minimum tillage systems increase organic matter content, retain moisture and minimize soil degradation. Crop rotation prevents degradation; it is the alternation of crops of different families on the same plot to control pests and diseases, increase fertility and reduce the risk of nutrient deficiencies. Strip farming is the alternation of legumes and cover crops with cereals and continuous crops to prevent soil degradation. Precision efficient irrigation, such as drip irrigation, can prevent a range of negative impacts, especially secondary salinization and sanding of fields. Satellite imagery can be used to analyse crop conditions and determine the right amount of fertilizer to be applied to a particular area, helping farmers get the desired yields without damaging nature. Organic farming with natural fertilizers helps prevent soil degradation, and the use of integrated crop protection methods avoids the application of chemicals that pollute the environment. Planting cover crops with living mulch protects the soil from damage, improves soil structure, increases nutrients and provides effective weed control. Contour ploughing using earthen ridges or dikes to collect water prevents fields from eroding and flooding.

Identifying soil erosion hotspots is the first step in improving environmental remediation strategies. Various methods can be used, including analysing aerial photographs, using soil erosion models and more detailed scaling. D. Malakhov *et al.* (2022) report a large volume of soil, reclamation, soil-erosion and soil-geochemical surveys with a number of thematic soil maps. The main volume of RK soil surveys totalled: 96.4 million ha or 52.1% of the total surveyed area in the period up to 1990; 3.2 million ha each in 2014-2015; 2.3 million ha in 2016; 5.2 million ha in 2017, 7.2 million ha in 2018, 7.3 million ha in 2021, and 7.8 million ha in 2022.

The agricultural lands of RK are characterized by the presence of chernozem, chestnut soils in the northern part, brown semidesert soils are marked to the south. Chernozem are subdivided into leached soils with humus content of 3-6%, ordinary soils and southern soils. Regions with chernozem include Northern, Kostanay, Akmola, Pavlodar, Aktobe and West Kazakhstan regions and occupy 25.5 million ha or 9.5% of the country's territory. Unlike other types of soils, chernozem are characterized by a high level of natural fertility, thick humus layer, significantly higher content of humus and total nitrogen in inclusions, which gradually decreases by soil layers, detailed agrochemical analysis of chernozem is considered in Table 1.

Table 1. *Chernozem – agrochemical properties*

Subtype	Humus horizon thickness, cm	Humus, %	Salt extract, pH	Acidity (hydrolytic) meq/100 g	Absorption capacity meq/100 g
Ordinary	65-135	5.5-8.5	7-7.8	0-1	40-50
Leached	75-145	9-9.4	5.4-6	2-4	45-55
Typical	100-175	8.5-12	6.4-7.1	0.5-3	50-60
Southern	45-85	3-6.5	7.2-8.1	0-0.5	25-35

Source: *compiled by the authors based on M.K. Zhumagulova et al. (2022)*

Chestnut soils are subdivided into dark chestnut, chestnut, and light chestnut soils, they occupy most of the plains of the central RK, the northern part of the Caspian lowland and East Kazakhstan oblast, covering 90.6 million ha or 34% of the country's territory. Chestnut soils are widespread in Northern, Central, Eastern and Western Kazakhstan.

Humus content in chestnut soils is 2-3%, detailed agrochemical analysis of chestnut soils is considered in Table 2.

Table 2. *Chestnut soils – agrochemical properties*

Subtype	Humus horizon thickness, cm	Humus, %	Nitrogen, %	Phosphorus, %	Salt extract, pH	Total number of cations, meq/100 g
Dark chestnut	36-46	4-5	0.22-0.28	0.15-0.25	6.8-7.2	30-35
Chestnut	30-40	3.5-4	0.18-0.22	1.13-0.18	7.2-7.5	20-13
Light chestnut	25-30	2.5-3	0.11-0.16	0.09-0.13	7.4-8.2	12-15

Source: *compiled by the authors based on A.B. Kaldybekov et al. (2022)*

Brown and grey-brown soils are located to the south of chestnut soils and cover an area of 120 million ha, or 44% of the RK territory. Morphological features of brown soils include an upper humus layer of lighter colour, predominantly brown in the profile. The humus layer is 12-15 cm thick, weakly stratified, structureless, loose, light brown. The humus content in brown soils varies in the region of 1-2%, so it is suitable only for use in livestock areas, and farming is possible only under irrigation, which is clearly shown in Table 3.

Table 3*. Gray-brown soils – agrochemical characteristics*

Subtype	Salt extract, pH	Humus horizon thickness, cm	Humus, %	Transitional phosphorus mg/100 g soil	Transitional potassium mg/100 g soil
Gray-brown	4-5.8	20-30	1.2-2	<5	<10
Brown	4.3-4.8	15-20	1-2	5-8	10-15

Source: *compiled by the authors based on K. Kunanbayev et al. (2022)*

When assessing soil degradation in the context of damage to agriculture due to climate change, the most frequent focus is on crop production, which is increasingly affected by the unevenness of precipitation over the year. However, livestock production is equally affected by climate change, leading to degradation of pastures, low productivity of hayfields – and as a consequence, the inability to keep livestock in many regions of RK. Reducing conventional tillage and the correct use of herbicides can significantly improve weed control efficiency, reduce chemical costs and reduce the risk of environmental pollution. For better utilization of moisture, spring soil preparation techniques are of great importance: one or two cultivations with harrowing, also timely carrying out of these operations improves moistening of the sowing layer, ensures active sprouts and weed control. Data on land quality characteristics in RK counts 90 million ha of eroded soils, of which 29.3 million ha are almost completely eroded. Figure 1 illustrates the extent of eroded soils.

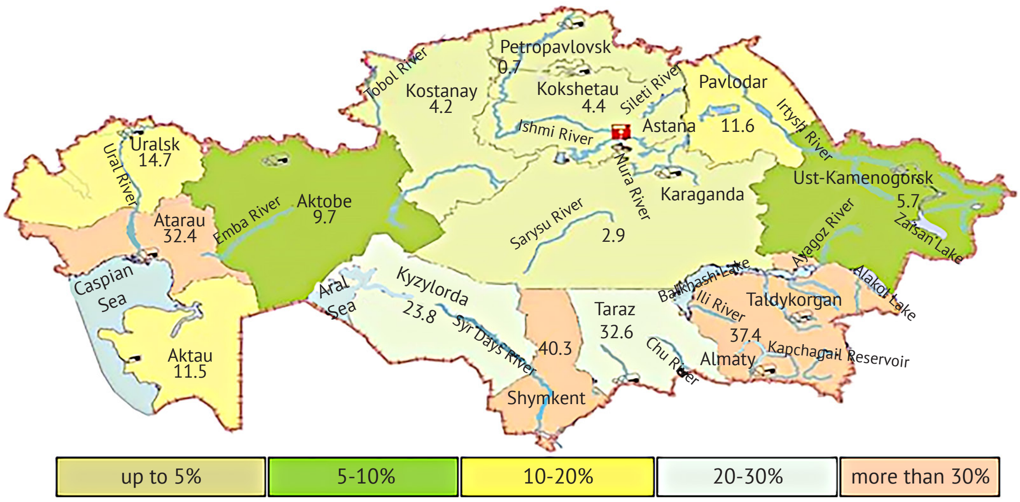


Figure 1. *Rhodinated soils of the Republic of Kazakhstan*
Source: *compiled by the authors based on S.K. Makenova et al. (2023)*

The largest share, more than 30% of eroded agricultural land from the total area falls on Almaty, Atyrau and Turkestan oblasts, on the contrary the smallest share up to 5% on Akmola, Karaganda, Kostanay and North-Kazakhstan oblasts. The effectiveness of agricultural technologies is assessed by plant productivity, which depends on a number of factors, including the growing season and weather conditions of the previous autumn, winter, and spring. The vegetation in RK is distributed by zones: the wet northern zone is located in the forest-steppe zone, the arid southern zone is located in the steppe, semidesert and desert zones. Due to the diversity of soil vegetation and relief within each zone, in addition to the characteristic zonal vegetation scattered throughout Kazakhstan, there is striped vegetation – for example: riparian forests, desert buckthorn and other wetlands. The current RK flora includes trees – 68 species, shrubs – 266, semi-shrubs – 433, perennial – 2598, annual – 849 herbs.

Drought and temperature extremes are the main biological constraints to cereal production, especially in rainfed dry farming systems such as in the southern part of RK. The average yield of cereals in 2023 was 9.3 kg/ha, oilseeds 7.1 kg/ha, and vegetable crops 275.4 kg/ha. During the 2021-22 harvest period, Kazakhstan harvested 22 million tonnes of grain, which is 34% more than in 2021, of which: wheat – 16.4 million tonnes, barley – 3.3 million tonnes. In 2023, RK's average grain yields are 28% lower than the previous 2020-2022 figures. The reason for the fall in cereal yields was atmospheric and soil drought, dry spells and soil degradation. One of the main problems of crop production in RK is unstable crop yields due to progressive soil degradation. According to M. Kazlauskas *et al.* (2022), it was found that the yield of winter wheat on moderately podzolic soils with non-washed loamy turf was 31.7 c/ha, on moderately washed soils – 15.3 c/ha, on heavily washed soils – 2 c/ha.

A large amount of research is devoted to the use of mineral fertilizers, microelements and growth regulators, as well as their effect under different treatments and conditions. RK is developing technologies of direct sowing and pre-sowing tillage for winter wheat without main tillage in three-field crop rotation under rainfed conditions. Wheat is a strategic crop for the RK economy and the issue of resource efficient winter wheat production technologies in the south of the country is one of the strategic priorities that are being developed, tested and adapted. More detailed research is needed, especially in arid climatic conditions with erratic rainfall and temperature regimes. At the time of maize sowing, the best moisture reserves are in the one and a half metre layer of soil and are observed after winter wheat. Significantly less moisture in the soil ball by 30-50 mm is observed after sunflower, barley, Sudan grass, sugar beet. Provision of soils with three main mobile elements, which affect plant yields on the example of cereals, on average in RK the content of humus on arable areas is 2.8%, nitrogen – 37.5 mg/kg, phosphorus – 16.8 mg/kg, potassium – 419.5 mg/kg, which is noted in Table 4.

Table 4. *Composition of humus and productivity of grain crops by regions of the Republic of Kazakhstan*

Regions	Humus, %	Nitrogen, mg/kg	Phosphorus, mg/kg	Potassium, mg/kg	Grain yield in 2022/23, c/ha
North Kazakhstan	4.6	47.5	16.1	454.1	20.9
Kostanay	4.2	49.2	18.2	483.7	9.1
East Kazakhstan	3.8	36.4	21.3	404.7	23.6

Table 4, Continued

Regions	Humus, %	Nitrogen, mg/kg	Phosphorus, mg/kg	Potassium, mg/kg	Grain yield in 2022/23, c/ha
West Kazakhstan	3.7	35.1	18.9	563.3	13.8
Akmola	2.6	48	12.4	424.3	14.1
Aktobe	2.9	36.9	15.5	276.8	9.2
Pavlodar	2.5	33.6	15.4	464.6	12.7
Turkestan	2.5	15.8	19.1	323.3	31.4
Karaganda	2.4	56.4	10.6	433.6	12.9
Kyzylorda (irrigated lands)	2.1	57.9	9.9	344.1	13.1
Zhambyl	1.9	16.7	23	456.8	29.1
Almaty	1.3	16.5	20.8	399.8	28.8

Source: *compiled by the authors based on A. Rau et al. (2023)*

Nitrogen is the main element of soils, as it has the greatest influence on plant growth and is the building material for new cells. The leaders in terms of nitrogen content in soil are: Karaganda region – 56.4 mg/kg, Kostanay region – 49.2 mg/kg, Akmola region – 48 mg/kg, North Kazakhstan region – 47.5 mg/kg. The main importance of phosphorus is acceleration of metabolic processes in cells, which determines the speed and quality of crop maturation, as well as resistance to plant diseases. In terms of phosphorus content prevails: Zhambyl region – 23 mg/kg, East Kazakhstan region – 22.5 mg/kg, Kyzylorda region – 20.4 mg/kg, Almaty region – 19.5 mg/kg, West Kazakhstan region – 19.4 mg/kg. Potassium is involved in the process of photosynthesis, as well as in the movement of carbohydrates, protein synthesis, provides resistance to fungal diseases of plants. In the case of potassium deficiency, plants develop and grow slowly, leaves turn yellow, stems thin, seeds lose germination energy. According to the content of potassium in the soil are leading: West Kazakhstan region – 563.3 mg/kg, as well as Zhambyl region – 456.8 mg/kg, Kostanay region – 483.7 mg/kg, Pavlodar region – 464.6 mg/kg, North Kazakhstan region – 454.1 mg/kg. Correlation with the percentage of humus content is noticeable in the content of nitrogen, phosphorus, potassium, as these elements of plant nutrition are contained in humus.

The formation of energy plantations of bush willow biomass Salix Viminalis prevents soil erosion and contributes to the improvement of the environment, this project is ideal for seedlings on RK lands consisting of low-productive and polluted in terms of crop cultivation, as well as in erosion control measures to strengthen soils, a natural filter to clean the soil from pesticides. Soil-forming plant growth activators are presented in the form of potassium and sodium humates of biological metabolites in dilution of 5-10 ml per litre of water, with the rate of application of the preparation 2-4 l/ha. Preparations based on potassium and sodium humates stimulate the growth of the root system, simultaneously increase yield and mobilize the immune system, in combination with herbicides they reduce stress for the main crop, increase the efficiency of photosynthesis, nitrogen uptake by plants, participate in the accumulation of sugars and protein synthesis. M.A. Abdelfattah *et al.* (2021) reported that humates contain less than 200 g/l dry matter, humic, citric, succinic, ascorbic organic acids, vitamin complexes B1, B3 and B1 less than 80 g/l; potassium and sodium salts of humic acid more than 60 g/l, carbon more than 35 g/l, complexes of macro- and microelements. The most comprehensive tool for analysing agricultural land for sustainable farming in RK is SWOT-analysis, it is a general method of assessing various phenomena and factors, presented in Table 5.

Table 5. *SWOT analysis of the formation of sustainable land use in the Republic of Kazakhstan*

Strengths	Weaknesses
• waterlogging of the soil due to mulching; • absence of water and wind erosion; • formation of an active microbiota with the presence of micro- and macroelements; • accumulation of carbon in the soil; • reduction of carbon dioxide emissions into the atmosphere.	• treating fields with pesticides before sowing and during the growing season.
Opportunities	**Threats**
• natural accumulation of humus in soils; • improvement of agrophysical and agrochemical properties of soils; • diversification of resource-saving technologies; • marketing of agricultural products; • modernization of agricultural machinery.	• infestation by pests and diseases; • economic damage from a lack of fertilizers and a decrease in soil fertility.

Source: *compiled by the authors based on B. Hnatkivskyi et al. (2022)*

The phenomena and factors of SWOT-analysis are divided into four categories: Strengths, Weaknesses, Opportunities, Threats. The SWOT-analysis allowed identifying internal and external factors of development, determined the best standards of land use organization and formed the basis of the sustainable land use model in RK.

DISCUSSION

The formation of crop yields in RK is influenced by natural soil fertility, as well as climate, organic and mineral fertilizers, seeds, tillage, fertilizers, ameliorants, plant protection products. It is noted that the average yield of cereal crops in RK in 2023 is low at 9.3 kg/ha. L. Rayichuk *et al.* (2023) report that wheat ranks third among cereals in terms of production, behind only rice and maize. But it should be taken into account that the world leaders in wheat yield, are characterized by high productivity indicators: Germany – 75.3 c/ha, France – 68 c/ha, Egypt – 64 c/ha, China – 57 c/ha. From the reviewed facts, it is found that only application of soil protection measures can raise plant productivity in RK.

Firstly, it is necessary to introduce innovative farming systems in RK: water accumulation, regulation of water exchange, gas exchange and heat exchange processes. Obtaining high and stable yields of grain crops in severe hydrothermal conditions requires taking into account soil-climatic zonality: in the north of RK agricultural lands are represented by chernozem and chestnut soils, and in the south – brown semidesert soils. Unforeseen weather conditions and drought lead to loss of fertility. To ensure the sustainability of crop yields, it is necessary to carry out reclamation measures with the application of organic and synthetic mineral fertilizers. According to D.S. Peixoto *et al.* (2020), in order to conserve natural resources, maintain water, air and soil quality, and stabilize crop yields, it is necessary to implement soil-protective resource- and moisture-saving farming methods: No-Till, Strip-Till, Mini-Till, Conservation Agriculture. These technologies envisage preservation of integral, intact structure, leaving on the field stubble and mulch of shredded plant residues, and are also applied in the form of soil-protective crop rotations, terracing of slopes, snow retention, improvement of conservation planting, hydraulic engineering construction. It should be agreed that the alternate application of the most effective No-Till, Strip-Till and Mini-Till tillage technologies in RK will improve soil fertility and crop yields with minimal environmental impact.

Soils contain more carbon than the atmosphere and all vegetation in general, and the introduction of crops such as legumes and cereals into the farming system allows it to be biologically sequestered into organic matter, as well as balancing the nitrogen content of the soil. W.P. Zhang *et al.* (2023) noted that stems, stubble, roots, and leaf litter of crops are important additions of nutrients to the soil, but crops such as root crops and fruiting vegetables leave very little nutrients in the soil. Also, in the work of K.K. Shah *et al.* (2021), an improved crop rotation system that significantly improves soil structure, physical and chemical properties and increases the availability of nitrogen, phosphorus, potassium and other elements in the soil are described. Certainly, this study confirms the importance of this intervention in maintaining soil fertility.

Different crops are adapted to different types of extreme weather events, and crop rotation effectively reduces the risks of yield loss as well. RK has developed a technology of direct seeding and pre-sowing tillage without main tillage for winter wheat in a three-field rotation in rainfed conditions. A.P. Pinto *et al.* (2023) take into account the basic principles of building dynamic rotations of conservation agriculture: avoiding the alternation of crops of similar origin; respecting the optimal return period of crops on the same site; consideration of soil-ecological groups, soil peculiarities; availability of machinery, farm evaluation, economic conditions. As an additional confirmation, it is noted that modern harmonious crop rotation combines the ecological possibility of reducing the use of synthetic mineral fertilizers and pesticides in the soil with the economic aspect of profit maximization through the growth of highly profitable yields.

In RK, new methods of bio-agriculture, including cover crops, plant growth stimulators, liquid fertilizers in the form of humates, organic acids and B vitamins are used to increase crop production. To date in RK, conservation technologies have reached about 7.5 million ha of agricultural land, but the main problem is the annual removal of essential nutrients from the soil after harvesting. Productive cultivation of food crops in the soil assumes the presence of the main mobile elements affecting plant yield, namely nitrogen – 37.5 mg/kg, phosphorus – 16.8 mg/kg, potassium – 419.5 mg/kg. In the case of unfertilized sowing, only 15-20% of nutrients taken up by plants with harvesting are returned to the soil, therefore, it is necessary to apply a large amount of mineral and organic fertilizers. According to S. Sharma *et al.* (2022), nitrogen and potassium should be returned to the soil by 80%, and phosphorus – by 85%, so potassium fertilizers are recommended to be applied to grain crops from autumn in the amount of 90-120 kg/ha, and phosphorus fertilizers at seed sowing – 60-80 kg/ha due to the introduction of synthetic mineral fertilizers. It is worth refuting this opinion, but the use of synthetic mineral fertilizers is an effective way to ensure constant yields, although it contradicts the concept of soil-saving agriculture. And the work of T. Bayu (2020) pointed out effective ways to restore soil fertility through intensification of agricultural production using organic fertilizers and plant growth regulators. It is also found that the combined application of manure and mineral fertilizers is more economical to maintain sustainable agricultural productivity. Maximum sustainable crop yield of 2.88 t/ha is obtained by applying 69 kg of mineral fertilizer with 10 t/ha of manure. As a result, it can be agreed that organic matter in soil is of fundamental importance in providing nutrient elements to plants, especially under the conditions of continuous increase in potential yield of RK degraded soils. Consequently, it is possible to agree with the statement that organic matter in soil has fundamental importance in providing plants with nutrient elements, especially under conditions of necessity of constant increase of potential crop yields for RK degraded soils.

To increase humus levels in RK soils, it is necessary to create a dense cover of plant material, with gradual application of organic, organomineral fertilizers that disperse surface run-off, attenuating the force of winds under contour ploughing and strip farming. Assessing the quality of agricultural land requires a significant amount of soil sampling for humus content. Monitoring estimates of humus content in the arable layer of chernozem ranges from 3% to 12%; in chestnut soils from 2.5 to 5%; grey-brown soils from 1 to 2%. L. Kang *et al.* (2021) report that in order to preserve and reproduce soil fertility, in particular its main indicator – humus, it is necessary to apply crop rotations with annual and perennial grasses, and to apply organic fertilizers. It is worth agreeing with this statement, because the mineral fertilizer system does not provide stabilization of humus content in grain and fallow crop rotation, irrespective of the method of main tillage.

Energy plants are natural filters for soil purification, in RK there are prerequisites for mass use of modern methods of cultivation and processing of such biomass. Of particular relevance are arrays of energy willow, which can be used as buffer zones in places of accumulation of biological wastes of farms and become natural filters for removal of agro-industrial wastes. As noted in the work of S. Jain & A.R. Tembhurkar (2022), the development of bioenergy technologies will diversify the country's energy supply, improve soil and air ecology, and promote local employment. In addition, plantations are effectively used in anti-erosion measures to strengthen the soil, enrich the soil with macro- and microelements and nutrients of natural origin. It is difficult to disagree with this study, as bioenergetics is a promising branch of agriculture, for radiation-contaminated, unproductive and degraded lands, plantations of energy plants, which become the only cost-effective and safe maintenance of land fertility.

Diversification of agriculture is done by planning and ensuring a high level of land use through specialized digital maps with photo images corresponding to the current state of the land, which should cover 100% of the RK territory. The results of RK soil surveys, indicate environmental problems and risks of agricultural land use related to landscape degradation, especially for arable land. According to Y. Cai *et al.* (2022), modern assessment of soil profile status and potential is impossible without the application of Geographic Information System (GIS) land use indicators, which determines the net amount of carbon assimilated by photosynthesis and autotrophic respiration over a certain period of time for biological production of fibre and protein. It is impossible to disagree that in this study, the main emphasis is placed on the construction of balance relationships in the agro-landscape, their use for the optimization of natural-anthropogenic systems aimed at raising the level of productivity of farms with low yields.

CONCLUSIONS

Soil research, which was conducted, has shown that soil erosion has a detrimental effect on the economy, as the gradual degradation of fields inevitably leads to lower crop yields. Regular monitoring of fields helps to detect the first signs of problems. Intensive farming aims to generate as much profit as possible through the use of fertilizers and pesticides, intensive and extreme land use with significant inputs, abundant irrigation, extensive cropping, high-yielding varieties and expansion into new areas. At the same time, the potential of degraded fields is significantly reduced and more attention needs to be paid to their management practices, including ways of applying additional mineral organic fertilizers to increase productivity. Despite the length and complexity of the process, it is also necessary to analyse the short-term effects of soil erosion using vegetation indices. Establishing a natural crop rotation can effectively improve soil physical and chemical properties while increasing soil enzyme activity, fertility and ultimately soil stability in the process of resisting RK weather extremes.

Modern agricultural technologies allow not only achieving significant success in preventing soil erosion and its consequences, but also finding rational solutions to this problem. At the same time, the choice of optimal methods and strategies depends on effective management decisions, climatic conditions, resource availability and soil utilization plans. Soil erosion monitoring and control can be adapted to the requirements of specific agribusinesses. For example, digital mapping of fields based on satellite images and the use of mathematical models allows analysing the current state of soils and taking appropriate protective measures. In the process of climate change and global warming, modern agriculture is far from classical methods that ensure adequate storage and utilization of soil moisture, as even on fertile soils plant productivity may not give the expected yield due to lack of soil moisture.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Abdelfattah, M.A., Rady, M.M., Belal, H.E.E., Belal, E.E., Al-Qthanin, R., Al-Yasi, H.M., & Ali, E.F. (2021). Revitalizing fertility of nutrient-deficient virgin sandy soil using leguminous biocompost boosts *Phaseolus vulgaris* performance. *Plants*, 10(8), article number 1637. doi: 10.3390/plants10081637.

[2] Ansari, M.A., Ravisankar, N., Hak Ansari, M., Babu, S., Layek, J., & Panwar, A.S. (2023). Integrating conservation agriculture with intensive crop diversification in the maize-based organic system: Impact on sustaining food and nutritional security. *Frontiers in Nutrition*, 10, article number 1137247. doi: 10.3389/fnut.2023.1137247.

[3] Bayu, T. (2020). Review on contribution of integrated soil fertility management for climate change mitigation and agricultural sustainability. *Cogent Environmental Science*, 6(1), article number 1823631. doi: 10.1080/23311843.2020.1823631.

[4] Bureau of National Statistics. (2023). *Industry statistics: Statistics of agriculture, forestry, hunting and fisheries*. Retrieved from https://stat.gov.kz/en/industries/business-statistics/stat-forrest-village-hunt-fish/.

[5] Cai, Y., Zhang, F., Duan, P., Jim, C.Y., Chan, N.W., Shi, J., Liu, C., Wang, J., Bahtebay, J., & Ma, X. (2022). Vegetation cover changes in China induced by ecological restoration-protection projects and land-use changes from 2000 to 2020. *Catena*, 217, article number 106530. doi: 10.1016/j.catena.2022.106530.

[6] Corwin, D.L. (2021). Climate change impacts on soil salinity in agricultural areas. *European Journal of Soil Science*, 72(2), 842-862. doi: 10.1111/ejss.13010.

[7] Darbayeva, T., Ramazanova, N., Chashina, B., Berdenov, Zh., Mendybayev, E., Wendt, J.A., & Atasoy, E. (2020). Modeling soil erosion in the Chagan River basin of the west Kazakhstan with using RUSLE and GIS tools. *Journal of Environmental Biology*, 41(2), 396-404. doi: 10.22438/jeb/41/2(SI)/JEB-18.

[8] Derepaskin, A.I., Polichshuk, Y.V., Shayakhmetov, A.B., Bedych, T.V., Kuvaev, A.N., & Tokarev, I.V. (2023). Influence of parallel driving systems and differentiated fertilizer application on the efficiency of using machine and tractor units in the southern chernozem of North Kazakhstan. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 71(1), 43-51. doi: 10.11118/actaun.2023.004.

[9] Farahat, S.M., Rakhimgalieva, S.Zh., & Esbulatova, A.Zh. (2022). Digital technologies for agrochemical soil survey. *Science and Education*, 2(4(69)), 103-114. doi: 10.52578/2305-9397-2022-4-2-103-114.

[10] Fortuna, A.-M., Starks, P.J., Moriasi, D.N., & Steiner, J.L. (2023). Use of archived data to derive soil health and water quality indicators for monitoring shifts in natural resources. *Journal of Environmental Quality*, 52(3), 523-536. doi: 10.1002/jeq2.20476.

[11] Grzebisz, W., Diatta, J., Barłóg, P., Biber, M., Potarzycki, J., Łukowiak, R., Przygocka-Cyna, K., & Szczepaniak, W. (2022). Soil fertility clock-crop rotation as a paradigm in nitrogen fertilizer productivity control. *Plants*, 11(21), article number 2841. doi: 10.3390/plants11212841.

[12] Hnatkivskyi, B., Poltavets, A., & Havrylchenko, O. (2022). Analysis of the current state of organization of land use management in agricultural enterprises. *Baltic Journal of Economic Studies*, 8(4), 50-57. doi: 10.30525/2256-0742/2022-8-4-50-57.

[13] Jain, S., & Tembhurkar, A.R. (2022). Sustainable amelioration of fly ash dumps linking bio-energy plantation, bioremediation and amendments: A review. *Journal of Environmental Management*, 314, article number 115124. doi: 10.1016/j.jenvman.2022.115124.

[14] Kaldybekov, A.B., Bektanov, B.K., Rsymbetov, B.A., Bazarbaev, S.O., & Dzhanteliev, D.T. (2022). Features of water and nutritional regimes of gray-brown soils in seasonal pastures of the desert zone of the South-Eastern Balkhash region. *Herald of Science of S. Seifullin Kazakh Agro Technical Research University*, 2(113), 55-65. doi: 10.51452/kazatu.2022.2(113).1076.

[15] Kang, L., Zhao, R., Wu, K., Huang, Q., & Zhang, S. (2021). Impacts of farming layer constructions on cultivated land quality under the cultivated land balance policy. *Agronomy*, 11(12), article number 2403. doi: 10.3390/agronomy11122403.

[16] Kazlauskas, M., Šarauskis, E., Lekavičienė, K., Naujokienė, V., Romaneckas, K., Bručienė, I., Buragienė, S., & Steponavičius, D. (2022). The comparison analysis of uniform-and variable-rate fertilizations on winter wheat yield parameters using site-specific seeding. *Processes*, 10(12), article number 2717. doi: 10.3390/pr10122717.

[17] Kenenbaev, S.B., Ramazanova, S.B., & Gusev, V.N. (2023). State and prospects of mineral fertilizers use in agriculture of Kazakhstan. *SABRAO Journal of Breeding and Genetics*, 55(3), 886-895. doi: 10.54910/sabrao2023.55.3.23.

[18] Khosravi, K., Rezaie, F., Cooper, J.R., Kalantari, Z., Abolfathi, S., & Hatamiafkoueieh, J. (2023). Soil water erosion susceptibility assessment using deep learning algorithms. *Journal of Hydrology*, 618, article number 129229. doi: 10.1016/j.jhydrol.2023.129229.

[19] Koza, M., Schmidt, G., Bondarovich, A., Akshalov, K., Conrad, C., & Pöhlitz, J. (2021). Consequences of chemical pretreatments in particle size analysis for modelling wind erosion. *Geoderma,* 396, article number 115073. doi: 10.1016/j.geoderma.2021.115073.

[20] Kuanova, L., Bekbossinova, A., & Abdykadyr, T. (2023). Assessment of the sustainable development of regions: The case of Kazakhstan. *Eurasian Journal of Economic and Business Studies*, 3(67), 122-135. doi: 10.47703/ejebs.v3i67.310.
[21] Kunanbayev, K., Churkina, G., Filonov, V., Utebayev, M., & Rukavitsina, I. (2022). Influence of cultivation technology on the productivity of spring wheat and the humus state of southern carbonate soils of Northern Kazakhstan. *Journal of Ecological Engineering*, 23(3), 49-58. doi: 10.12911/22998993/145459.
[22] Lal, R. (2020). Soil organic matter content and crop yield. *Journal of Soil and Water Conservation*, 75(2), 27A-32A. doi: 10.2489/jswc.75.2.27A.
[23] Li, H., Zhang, Y., Sun, Y., Liu, P., Zhang, Q., Wang, X., Wang, R., & Li, J. (2023). Long-term effects of optimized fertilization, tillage and crop rotation on soil fertility, crop yield and economic profit on the Loess Plateau. *European Journal of Agronomy*, 143, article number 126731. doi: 10.1016/j.eja.2022.126731.
[24] Makenova, S.K., Alipbeki, O.A., Tatarintsev, V.L., Inkarov, D.S., Asanova, G.A., & Muzyka, O.S. (2023). Issue on land degradation in Kazakhstan. *Herald of Science of S. Seifullin Kazakh Agro Technical Research University*, 2(117), 261-272. doi: 10.51452/kazatu.2023.2(117).1406.
[25] Malakhov, D., Batyrbayeva, M., & Vitkovskaya, I.A. (2022). A new method for land degradation assessment in the arid zone of Republic of Kazakhstan. In *Environmental degradation in Asia: Land degradation, environmental contamination, and human activities* (pp. 135-161). Cham: Springer. doi: 10.1007/978-3-031-12112-8_7.
[26] Peixoto, D.S., de Castro Moreira da Silva, L., de Melo, L.B.B., Azevedo, R.P., Lemos Araújo, B.C., de Carvalho, T.S., Guimarães Moreira, S., Curi, N., & Montoani Silva, B. (2020). Occasional tillage in no-tillage systems: A global meta-analysis. *Science of the Total Environment*, 745, article number 140887. doi: 10.1016/j.scitotenv.2020.140887.
[27] Pinto, A.P., Faria, J.M.S., Dordio, A.V., & Carvalho, A.P. (2023). Organic farming – A sustainable option to reduce soil degradation. In *Agroecological approaches for sustainable soil management* (pp. 83-143). Hoboken: Wiley Blackwell. doi: 10.1002/9781119911999.ch5.
[28] Rau, A., Koibakova, Y., Nurlan, B., Nabiollina, M., Kurmanbek, Zh., Issakov, Y., Zhu, K., & Dávid, L.D. (2023). Increase in productivity of chestnut soils on irrigated lands of Northern and Central Kazakhstan. *Land*, 12(3), article number 672. doi: 10.3390/land12030672.
[29] Rayichuk, L., Draga, M., & Boroday, V. (2023). Product environmental footprint and bread industry. In *Baking business sustainability through life cycle management* (pp. 15-27). Cham: Springer. doi: 10.1007/978-3-031-25027-9_2.
[30] Shah, K.K., Modi, B., Pandey, H.P., Subedi, A., Aryal, G., Pandey, M., & Shrestha, J. (2021). Diversified crop rotation: An approach for sustainable agriculture production. *Advances in Agriculture*, 2021, article number 8924087. doi: 10.1155/2021/8924087.
[31] Shah, S.T., Ullah, I., Basit, A., Sajid, M., Arif, M., & Mohamad, H.I. (2022). Mulching is a mechanism to reduce environmental stresses in plants. In *Mulching in agroecosystems: Plants, soil & environment* (pp. 353-376). Singapore: Springer. doi: 10.1007/978-981-19-6410-7_20.
[32] Sharma, S., Kaur, G., Singh, P., Alamri, S., Kumar, R., & Siddiqui, M.H. (2022). Nitrogen and potassium application effects on productivity, profitability and nutrient use efficiency of irrigated wheat (*Triticum aestivum* L.). *PLoS ONE*, 17(5), article number e0264210. doi: 10.1371/journal.pone.0264210.
[33] Smagulova, Sh., Yermukhanbetova, A., Akimbekova, G., Yessimzhanova, S., Razakova, D., Nurgabylov, M., & Zhakupova, S. (2022). Prospects for digitalization of energy and agro-industrial complex of Kazakhstan. *International Journal of Energy Economics and Policy*, 12(2), 198-209. doi: 10.32479/ijeep.12859.
[34] Tokbergenova, A., Kiyassova, L., & Kairova, Sh. (2018). Sustainable development agriculture in the Republic of Kazakhstan. *Polish Journal of Environmental Studies*, 27(5), 1923-1933. doi: 10.15244/pjoes/78617.
[35] Turebayeva, S., Zhapparova, A., Kekilbayeva, G., Kenzhegulova, S., Aisakulova, Kh., Yesseyeva, G., Bissembayev, A., Sikirić, B., Sydyk, D., & Saljnikov, E. (2022). Development of sustainable production of rainfed winter wheat with no-till technologies in Southern Kazakhstan. *Agronomy*, 12(4), article number 950. doi: 10.3390/agronomy12040950.
[36] United Nations. (2013). *The III-VI national communication of the Republic of Kazakhstan to the UN framework convention on climate change (UNFCCC)*. Astana: LLP Print house "Forma Plus".
[37] Zhang, W.P., Fornara, D., Yang, H., Yu, R.P., Callaway, R.M., & Li, L. (2023). Plant litter strengthens positive biodiversity-ecosystem functioning relationships over time. *Trends in Ecology & Evolution*, 38(5), 473-484. doi: 10.1016/j.tree.2022.12.008.
[38] Zhu, R., Yu, Y., Zhao, J., Liu, D., Cai, S., Feng, J., & Rodrigo-Comino, J. (2023). Evaluating the applicability of the water erosion prediction project (WEPP) model to runoff and soil loss of sandstone reliefs in the Loess Plateau, China. *International Soil and Water Conservation Research*, 11(2), 240-250. doi: 10.1016/j.iswcr.2023.01.003.
[39] Zhumagulova, M.K., Bakenova, Zh.B., Kairova, G.N., Kazibaeva, S.Zh., Urazaeva, M.B., & Roslan, I. (2022). Influence of mineral fertilizers and bioproducts on the agrochemical properties of dark chestnut soil and quality of apple fruits in the conditions of the South-East of Kazakhstan. *Annals of Forest Research*, 65(1), 7737-7746.

Вплив ґрунтозахисних заходів на стан ґрунту та продуктивність рослин

Султан Асанбайович Кушербаєв
Магістр, викладач
Карагандинський державний університет імені академіка Є. Букетова
100024, вул. Університетська, 28, м. Караганда, Республіка Казахстан
https://orcid.org/0009-0007-1590-2524

Ізтілеу Аманжолули Аманжол
Доктор медичних наук, професор
Карагандинський державний індустріальний університет
101400, просп. Республіки, 30, м. Теміртау, Республіка Казахстан
https://orcid.org/0009-0004-2077-7201

Жанар Алписбаєвна Сейлханова
Кандидат медичних наук, доцент
Карагандинський державний університет імені академіка Є. Букетова
100024, вул. Університетська, 28, м. Караганда, Республіка Казахстан
https://orcid.org/0000-0002-7020-6595

Гульняз Білалова Дуанбекова
Кандидат медичних наук, доцент
Карагандинський державний університет імені академіка Є. Букетова
100024, вул. Університетська, 28, м. Караганда, Республіка Казахстан
https://orcid.org/0000-0001-7196-9159

Толганай Серіковна Каппарова
Магістр, викладач
Карагандинський державний індустріальний університет
101400, просп. Республіки, 30, м. Теміртау, Республіка Казахстан
https://orcid.org/0009-0005-8862-4364

Анотація. У Казахстані сільськогосподарські землі деградували протягом десятиліть, що призвело до загального зниження врожайності сільськогосподарських культур. Метою дослідження є проведення екологічної оцінки сучасного стану ґрунтів Казахстану для підвищення врожайності сільськогосподарських культур з використанням ґрунтозахисних методів. Під час проведення дослідження використовувалися такі методи: картографічний, аналізу і синтезу, систематизації, абстрагування, конкретизації, прогнозування. Під сільське господарство використовується 86 % земель Казахстану. Активне землекористування призвело до різних форм деградації, внаслідок чого налічується 90 млн га еродованих ґрунтів, з яких 29.3 млн га практично повністю розмиті. У 2023 році середня врожайність зернових культур становила 9.3 ц/га, олійних – 7.1 ц/га, овочевих – 275.4 ц/га. Зазначено, що врожайність зернових культур у 2023 році нижча на 28 %, ніж у попередньому періоді 2020-2022 рр., незважаючи на збільшення посівних площ. Посуха та деградація ґрунтів є основними причинами зниження врожайності зернових культур. Зазначено, що основними біологічними обмеженнями для виробництва зернових культур є ґрунтова посуха, суховії, деградація та екстремальні температури, особливо в богарних зрошуваних системах землеробства на посушливих землях, таких як південь Казахстану. У північній і центральній частині Казахстану угіддя сільськогосподарського призначення представлені чорноземами і каштановими ґрунтами, а на півдні бурими напівпустельними. Найбільші площі еродованих сільськогосподарських угідь розташовані в Алматинській, Атирауській і Туркестанській областях – понад 30 %, а найменші – в Акмолинській, Карагандинській, Костанайській і Північно-Казахстанській областях – 5 %. Для продуктивного вирощування зернових культур необхідний моніторинг ґрунту за основними рухомими елементами, які впливають на врожайність рослин. Середні значення для Республіки Казахстан становлять: вміст азоту – 37.5 мг/кг, фосфору – 16.8 мг/кг, калію – 419.5 мг/кг, гумусу – 2.8 %. Практична значущість дослідження полягає в розширенні та доповненні теоретичної бази досліджень у галузі деградації ґрунтів, а отримані результати пропонуються для комплексної екологічної оцінки ґрунтів Казахстану

Ключові слова: агрохімічний аналіз; природність; раціональне землекористування; гумус; азот; фосфор