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Improvement Of The Technology Of Corn Cultivation Based On The Current State Of Fertility Of Saline Soils Of The Shaulder Irrigation Massif

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ABSTRACT

As a result of the conducted soil research, the morphological and chemical properties of the soils of the Shaulder irrigated massif and adjacent territories were determined. A soil map and a map of soil cover degradation (scale 1:100000) were compiled using remote sensing materials.

Maps of the content of humus, nitrogen, phosphorus and potassium in soils were compiled and the current state of soil fertility was assessed. It has been established that almost all soils of 90 peasant farms need nitrogen, phosphorus and potash fertilizers, and the recommended doses of fertilizers must be applied strictly according to the cartogram.

For the rational and effective use of agricultural land on saline soils of the Shaulder irrigation massif of the Turkestan region, along with the differentiated application of mineral fertilizers, it is also very important to use innovative technologies for preserving and increasing soil fertility and the productivity of grain corn. As a result, it will be possible to preserve the saline irrigated lands of farmers, and not remove them from arable land, given that the highest population density in Kazakhstan is in the Turkestan region, 17 people per 1 m^2.

Keywords: soil cover, soil degradation map, soil salinity, soil fertility, cartograms of humus, nitrogen, phosphorus and potassium content.

INTRODUCTION

Since ancient times, the soils of the alluvial plains of the Syr-Darya have been used for irrigation. In the southern regions, irrigation leads to a significant increase in yield. However, under conditions of an arid climate, negative consequences are possible for the ecological state of the soils of both irrigated lands and the surrounding territories. The dynamism of soil formation conditions determines the need to assess the current state of the soil cover.

In this regard, it is important to present information not only from the point of view of discrete characteristics of soil properties, but also reflecting the peculiarities of their spatial distribution, i.e. compilation of soil maps. The complex nature and informational richness of modern soil maps, created on the basis of geographic and genetic classification, make it possible to use their various information layers to compile soil assessment maps [1,2]. Evaluation maps, based on the contours of soil maps, inherit a certain accuracy and reliability inherent in the latter.

The development of ecological-geographical mapping is currently taking place in two main directions: the actual ecological and through the "greening" of most sections of thematic mapping [3, 4].

The maps of anthropogenic impacts reflect the factors of impact, the response reactions of soils to them and their result (maps of dehumification, secondary salinization, pollution with heavy metals, etc.). An example is the World Map of Anthropogenic Soil Degradation [5], where each type of degradation process is assessed according to four levels of intensity (from weak to extreme) and the degree of distribution (in% of the area). A map "Anthropogenic changes in soils" of a scale of 1:20 million, which is similar in content, is given in the inset to the "Soil map of the Russian Federation and adjacent states" [6].

At present, the Republic of Kazakhstan has accumulated a lot of experience in compiling digital soil and assessment maps created on their basis, which was predetermined not only by the increased technical and computer software, but also by the rich heritage of geographic and genetic research and the continuity in methodological approaches to the study of soil cover that has survived to this day. [7, 8]. However, to solve specific tasks for the effective use of territories, it is necessary to create an information base for specific land use objects due to the variety of soil formation conditions in Kazakhstan.

One of the main degradation processes limiting soil fertility in dry areas in different countries of the world, including Kazakhstan, is soil salinization. Changes in soil salinity are most often the result of anthropogenic impact.

The accumulation of salts in areas that could potentially be used in agriculture is a worldwide problem, covering 340 million ha worldwide [9]. Areas subject to natural salinization occupy much more area than salinized as a result of irrigated agriculture [10-13].

Close groundwater and saline soils are already affecting crop production in many irrigated regions of Central Asia [14].

The current environmental stress in agriculture necessitates the development of measures aimed at maintaining the sustainability of agro-ecosystems, an important stage of which should be the rational management of soil fertility, focused on optimizing the humus state of soils [15, 16].

Modern high-intensity farming is possible only on soils with a high level of fertility and scientifically substantiated doses of fertilizers. The productivity of agricultural crops, the state of agrochemical parameters of soils largely depend on the volume of application of organic and mineral fertilizers, the formation of a positive or deficit-free balance of humus and nutrients. A prerequisite for increasing the efficiency of the use of mineral fertilizers is the application of fertilizers strictly in the calculated doses for the planned yield of agricultural crops with an optimal ratio of all macroelements [17].

The state of the agrochemical properties of soils most objectively reflects the nature of agricultural production. The scientifically grounded use of mineral and organic fertilizers, adherence to the technology of cultivation of agricultural crops are the main factors that allow to purposefully influence the process of reproduction of soil fertility. Considering that under conditions of intensive land use, there is a significant change in soil properties, it is necessary to carry out agrochemical monitoring, primarily of arable soils. Agrochemical monitoring of soils will make it possible to objectively assess the soil fertility of the farm and see in which direction the agronomic service of an agricultural enterprise should work more constructively [18].

Based on the foregoing, the main purpose of the work was to study and assess the current state of low-productive secondary saline soils of the Shaulder irrigated massif of the Turkestan region and give recommendations for recovering their fertility.

The optimal level of soil fertility is determined by such a combination of its main properties and indicators, at which all vital factors for plants can be used most fully and the possibilities of cultivated crops can be realized.

The main indicators of soil fertility, based on the generalization of numerous scientific studies, include the following agrochemical properties of soils: humus, nitrogen, phosphorus and potassium content.

Based on the foregoing, the establishment of the causes of dehumification, regulation and optimization of the humus state of irrigated soils and basic nutrients is of paramount importance, is relevant and guarantees an increase in soil fertility and obtaining stable yields.

OBJECTS AND METHODS

The soil survey site is located in the central part of the Turkestan region between 42 31/ and 43 02/ north latitude and 68 00/ and 68 43/ east longitude. Its length from north to south reaches over 57.60 km, from west to east - about 51.75 km, and the total area is 300 thousand ha. In addition to the Shaulder irrigation massif, it captures the adjacent territories.

The general bioclimatic conditions for the formation of the soil cover of the test site are determined by its confinement to the foothill zone of low-grass semi-savannas [19], which is the first step in the spectrum of vertical zoning of the Western Tien Shan and Karatauridge.

The main part of the site is confined to the ancient alluvial plain of the Syr-Darya riverat the confluence of the Arysriver.The plain is characterized by a flat relief, complicated by meandering depressions (traces of ancient channels), as well as by separate massifs of hilly sands. The main components of the soil cover are the soils of semi-hydromorphic and hydromorphic moistening regimes: meadow and meadow-serozem soils, which form complexes and combinations with meadow, common and flat saline lands. The highest surfaces of the ancient alluvial plain, where at present groundwater does not affect the soil formation processes, are occupied by light gray soils, which often, due to their genesis, in the lower part of the profile bear the features of the hydromorphic stage of development that took place in the past. Salinityinthesesoilsisalsoresidual.

The modern valley of the Syr-Darya is formed mainly by a floodplain meadow terrace and has a typical alluvial meso- and micro-relief (oxbows, flat-bottomed depressions, riverbed banks, separate sandy hillocks). The structure of the soil cover is characterized by heterogeneity with a wide distribution of soils of varying degrees and character of salinity. The soil cover of the floodplain terraces is mainly represented by floodplain meadow tugai and forest-meadow soils; on the above floodplain terraces, complexes of meadow light saline soils with meadow and ordinary saline lands are prevalent. Boggy and meadow-boggy soils are formed in oxbows.

The main concept that determines the methods of obtaining factual material, as well as its processing is the genetic approach, and until now it is the basic one in solving both theoretical and applied problems of soil science [20, 21].

At the stage of route field studies, morphological methods were used to ensure the reliability and validity of field diagnostics of soils, soil mapping, and characteristics of the main morphological properties of soils [22].

The use of instrumental methods is associated with laboratory analytical studies of selected samples [23].

The work related to scaling cartographic materials and space images, decoding space images and drawing up a colorful layout of the map were carried out in the MapInfo program. The main method for processing space information is indirect indication decoding [24, 25].

To determine the degree of soil degradation, paired sections were laid on undisturbed and anthropogenically transformed soils in order to determine changes in morphological and chemical properties.

Work on compiling a map of the humus content in soils and assessing their current humus state was carried out by conducting a traditional ground soil survey of the study object in accordance with Guidelines for conducting ... (1979) [26]. To determine the coordinates of the points of soil sampling, the global positioning system “Garmin 62s” was used in tandem with the “ASUS” netbook; soil sampling sites were mapped directly during field work using Map Info professional software. Then the selected soils were analyzed in the laboratory for the content of humus and basic nutrients using the methods detailed in the manual for general soil analysis [23]. Then the obtained analytical data were subjected to variational-statistical processing. Statistical processing of the obtained data was carried out by the generally accepted methods of mathematical statistics described [27-30] using the program of the analysis package "Excel-97" and "Atte Stat" and calculated the average "background" content of humus and basic nutrients.

A structure has been developed and a geographically referenced electronic database of the main indicators of effective soil fertility has been created. To solve this group of problems, 1:25000 scale soil-reclamation and soil-agrochemical surveys of the territories of the study object were carried out, which provided for the systematic selection of soil samples and their analysis, and the input of the obtained analytical data into an electronic database.

The database of the information system of the research object includes geographically referenced (longitude, latitude) analytical data on the content of humus, the degree of soil salinity, and the content of mobile forms of phosphorus and potassium.

When using space methods, the methodology of Pankova and Mazikov [31] was taken as a basis, supplemented by the works of her students Rukhovich [32] and Konyushkova [33]. We also used our own experience of previous works [34-39].

RESULTS AND DISCUSSION

The carried out soil studies made it possible to establish the basic patterns of formation and structure of the soil cover of the Shaulder irrigation massif and adjacent territories. Based on the analytical data obtained, a systematic list of soils was compiled and a complete description of their morphological, chemical, and physicochemical properties was given. The determination of the taxonomic belonging of the soils of the study area and the compilation of a systematic list was carried out on the basis of generally accepted principles of classification and diagnostics of soils [40], previously developed classification constructions and cartographic works [19], as well as the authors' own research. The division of soils was carried out up to and including clan; the systematic list consists of 24 names, 5 of which were identified for the first time in this territory. These are northern desertifiedserozem, saline, meadow and meadow-boggy drying, flat salt lands. The formation of these soils is associated with a decrease in the level of groundwater, mainly due to anthropogenic factors.

Based on the studies carried out, taking into account retrospective data and using remote sensing materials, a soil map of 1:100000 scale was compiled. The map legend corresponds to the systematic list of soils. The attributive information for each contour also reflects the structure of the soil cover in the form of various soil combinations (complexes, combinations, spots) indicating the percentage of components in the contour.

Studies have shown that most of the soils of the surveyed territory are largely transformed as a result of anthropogenic impact, in some places retaining their main diagnostic features, and sometimes acquiring others. Particularly negative consequences include the formation of secondary salt marshes from once arable soils.

Anthropogenic transformation of soils is mainly associated with the use of land for irrigation. In the lower part of the profile of arable soils, the particle-size distribution becomes heavier, the carbonate-illuvial horizon shifts inward, the thickness of the humus horizon increases with a significant depletion of it in organic matter in the arable horizon. The manifestation of these general regularities depends not only on the duration of irrigation, but also, to a large extent, on the type of soil, determined by the whole complex of soil formation conditions. A change in the water regime leads to a displacement into the depth of the carbonate-illuvial horizon and the washing out of water-soluble salts from the profile [41].

In addition, irrigated agriculture is accompanied by total destruction of the soil cover associated with the arrangement of the irrigation network (water intakes, canals, irrigation ditches, etc.). During the construction of canals, the underlying rocks, mostly highly saline, are brought to the surface. Salts washed away from the embankments by sediments become a source of additional salinization of the adjacent strip. In addition, along the canals, extensive flooding zones are formed due to infiltration, as a result of which the water and salt regime of soils changes with concomitant secondary salinization.

A high population density with an absolute predominance of rural, among other things, implies high grazing pressure on the soil cover. The morphological structure of the soils of degraded pastures is characterized by overcompaction, a decrease in the thickness of sod horizons for heavy soils by particle-size distribution, and their destruction with the formation of eolian landforms on light ones. Studies have shown that intensive grazing causes the loss of up to 30% of the humus content, 20-50% of plant nutrients, and up to 10% of the absorption capacity. In addition, an increase in the amount of water-soluble salts and carbonates is observed in the surface horizons [41].

To assess the current state of the soil, field studies were carried out, which included the establishment of sections on virgin and disturbed soils as a result of anthropogenic impacts with further analytical examination of the selected samples.

In accordance with the regulatory documents of the Republic of Kazakhstan on the protection of land resources [42-44] and taking into account the regional peculiarities of the formation of the soil cover of the surveyed territory, the following criteria for determining the degree of soil degradation were identified (Table 1).

Table 1 - Determination of the degree of soil and land degradation

Indicators	Degradation degree				
	0	1	2	3	4
Decrease in the content of physical clay by an amount,% of the initial	< 5	5-15	16-25	26-32	> 32
Decrease in the power of the soil profile (A + B),% of the initial	< 3	3-25	26-50	51-75	> 75
Decrease in the humus reserves in the soil profile (A + B),% of the initial	< 10	10-20	21-40	41-80	> 80

Deflationary load of the infertile layer, cm	< 2	2-10	11-20	21-40	> 40
Projective cover of pasture vegetation,% of the zonal	> 90	71-90	51-70	11-50	< 10
The content of the sum of salts in the upper fertile layer (%): - with the participation of soda - for other types of salinization	< 0,1 < 0,1	0,1-0,2 0,1-0,25	0,2-0,3 0,3-0,5	0,31-0,5 0,51-0,8	> 0,5 > 0,8
Increase in the content of exchangeable sodium (in% of CEC): - for soils, containing <1% sodium - forothersoils	< 1 < 5	1-3 5-10	3-7 10-15	7-10 15-20	> 10 > 20

The degree of soil degradation was determined based on the results of an analytical examination of selected samples, taking into account the factors and criteria of soil degradation, which made it possible to draw up a map of soil degradation based on a soil map of the surveyed area. The use of the soil map as the basis for any assessment maps, in this case, degradation, is a condition for obtaining reliable information. It is well known that different types of soils exhibit different responses to similar types of impact. ThesoildegradationmapisshowninFigure 1.

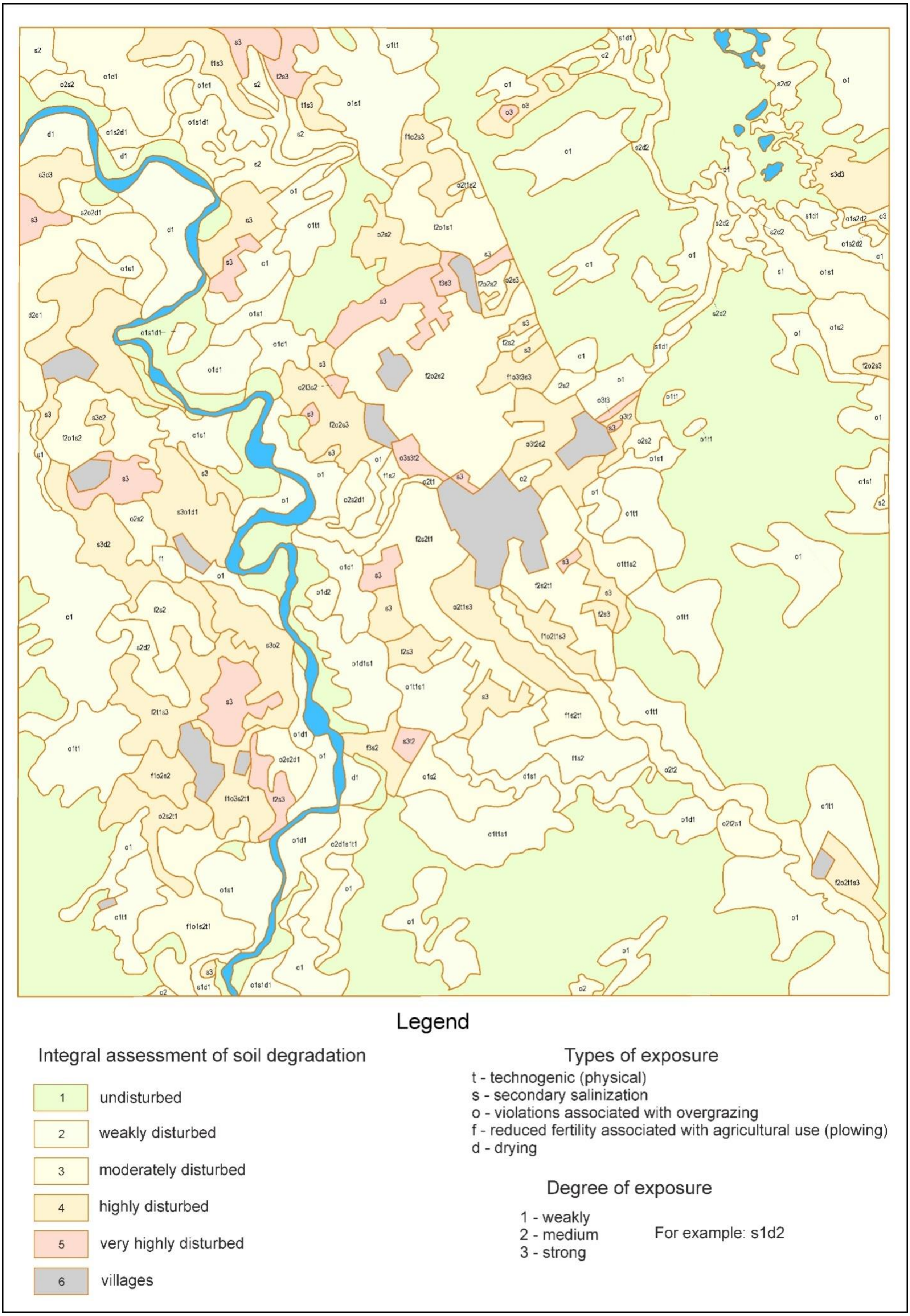
Legend
Integral assessment of soil degradation
1 undisturbed
2 weakly disturbed
3 moderately disturbed
4 highly disturbed
5 very highly disturbed
6 villages
Types of exposure
t - technogenic (physical)
s - secondary salinization
o - violations associated with overgrazing
f - reduced fertility associated with agricultural use (plowing)
d - drying
Degree of exposure
1 - weakly
2 - medium
3 - strong
For example: s1d2

Figure 1. The soil degradation map

The realities of the present time make it possible to combine soil genetic research with agro-reclamation. The latter, due to their focus on a specific result, largely enrich knowledge of the essence of the processes.

To assess the current state of soil fertility, on the basis of a soil map, lands of 90 farms with soils of varying degrees of salinity and an area of 1500 ha were selected, where soil-agrochemical survey was carried out.

As the results of the obtained data show, soils of 99.0% or 1485.4 ha of the surveyed territory have very low humus content, which indicates the degradation of these soils, associated, among other things, with dehumification (Table 2).

Table 2 - Grouping of soils by humus content

№ of group	Humus content	Humus, %	Area, ha	% of area
1	Very low	< 2,0	1485,4	99,0
2	Low	2,1 – 4,0	14,6	1,0
Total	-	-	1500,0	100,0

Also, the content of the main nutrients of easily hydrolyzable nitrogen, mobile phosphorus and exchangeable potassium was determined. As it is known, nitrogen is a part of proteins, enzymes, nucleic acids, chlorophyll, vitamins, alkaloids. The level of nitrogen nutrition determines the size and intensity of the synthesis of protein and other nitrogenous organic compounds in plants.

To assess the shares of each soil group from the total surveyed area, graphs of the distribution of soil groups for all studied properties were compiled. The data on the content of easily hydrolyzable nitrogen are shown in Figure 2.

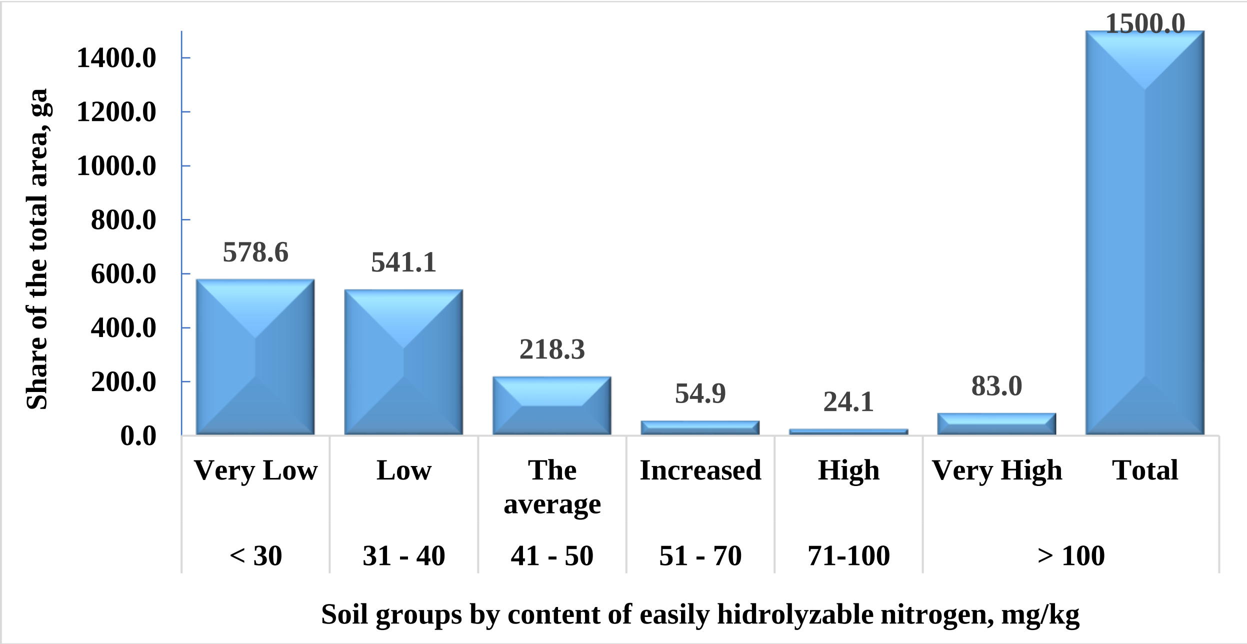

Figure 2 - Distribution of soil groups according to the degree of availability of easily hydrolyzable nitrogen

The figure shows that the soils of 578.6 ha (38.6%) of the lands of these farms contain less than 30 mg of easily hydrolyzable nitrogen per 100 g of soil and are classified as “very low”. In the soils of 541.1 ha (36.1%) of lands, the content of this form of nitrogen is low and amounts to 31-40 mg/kg of soil, 218.3 ha (14.6%) of lands have an average gradation with a content of 41-50 mg/kg soil.

Thus, almost all soils (89.2%) of 90 peasant farms need nitrogen fertilizers, and only 10.8% of the area (162 ha) have an optimal content of this form of nitrogen and do not require nitrogen fertilization.

Phosphorus plays an extremely important role in energy metabolism in plant organisms. With a lack of phosphorus, the metabolism of energy and substances in plants is disturbed.

According to the content of mobile forms of phosphorus, as can be seen from Figure 3, of their average "background" content, a large share is occupied by the groups of soils "medium" and "increased", respectively, 645.5 ha (43.0%) and 307.5 ha (20.0%) of the surveyed area. Such a variegated content of mobile phosphorus in soils requires leveling the background of the content of this element, i.e. it is necessary to apply the recommended doses of fertilizers strictly according to the cartogram.

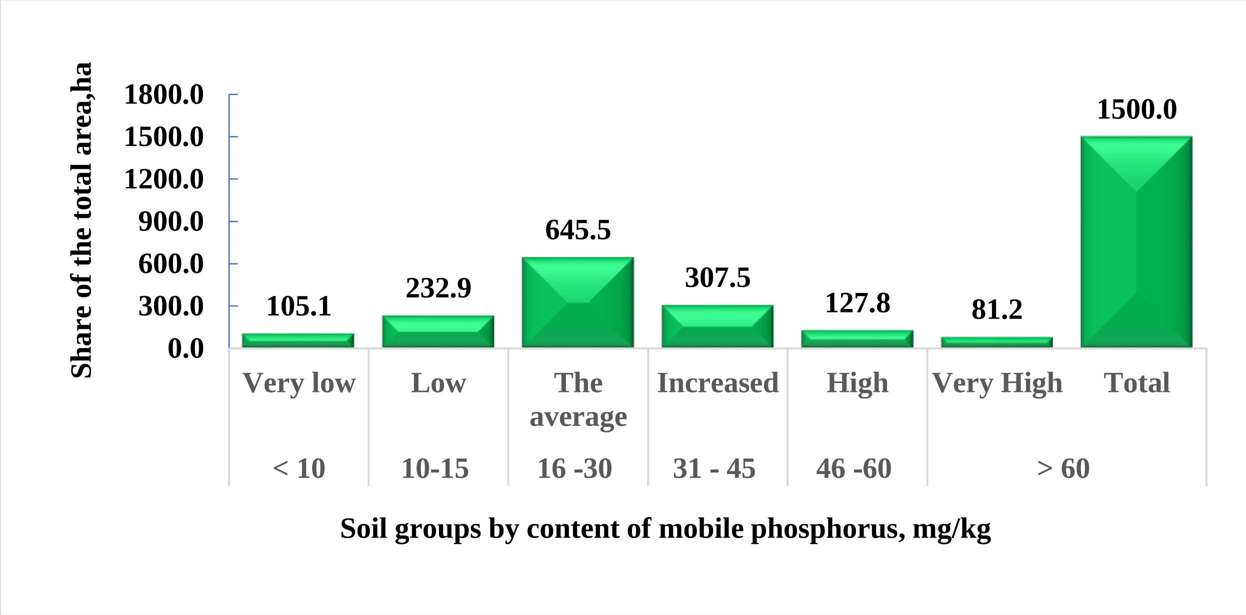

Figure 3 - Distribution of soil groups according to the degree of availability of mobile phosphorus

Potassium participates in the processes of synthesis and outflow of carbohydrates in plants, determines the water-holding capacity of cells and tissues, affects the resistance of plants to adverse environmental conditions and the susceptibility of crops to diseases.

As for exchangeable potassium (Figure 4), 565.7 ha (38.0%) of the surveyed area have a high content of this form of potassium, and 332.7 ha (22.0%) have an increased content, 272.8 ha (18.0%). %) very high and 328.8 ha (22.0%) medium and low content of exchangeable potassium, i.e. the latter require the application of potash fertilizers with a slight introduction to soils with a high content. Consequently, the content of exchangeable potassium in the soil of the surveyed farms is subject to the same regularity as that of mobile phosphorus, i.e. very variegated from low to very high, and here it is also necessary to apply potash fertilizers in accordance with the cartogram to level the background.

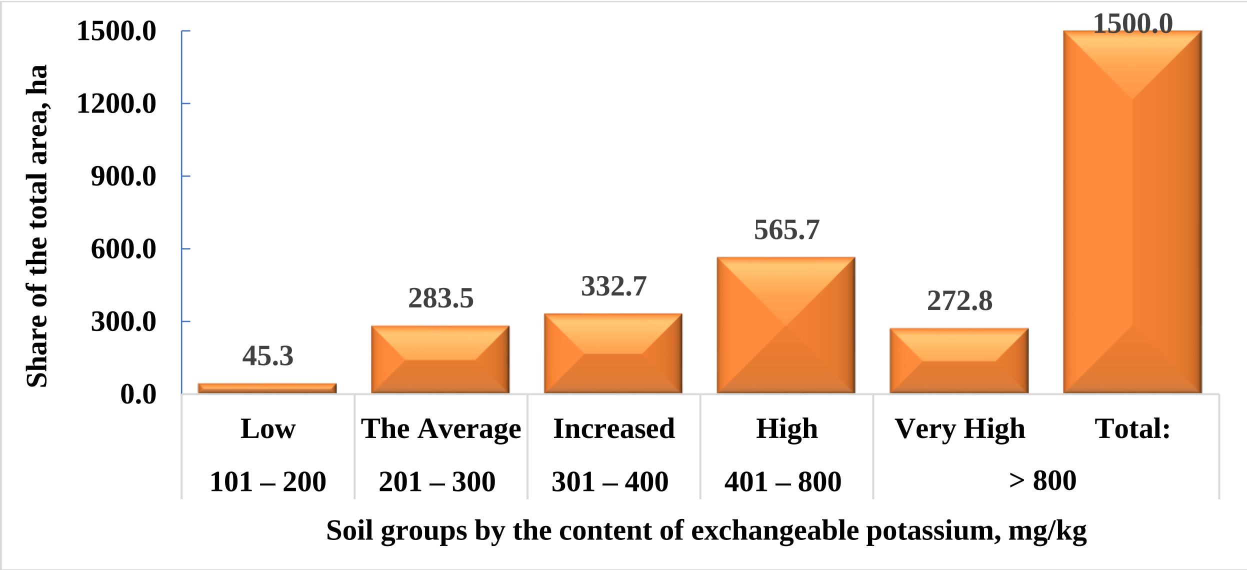

Figure 4 - Distribution of soil groups according to the degree of exchangeable potassium content

Further, using spatially coordinated analytical data using GIS technologies, geographically linked large-scale thematic maps of the main indicators of effective soil fertility were created. A map of the humus content, cartograms of the content of easily hydrolyzable nitrogen, mobile forms of phosphorus and potassium for all 90 farms on 1500 ha have been compiled. For example, we give them for the peasant farm "Tylegen" (Figure 5).

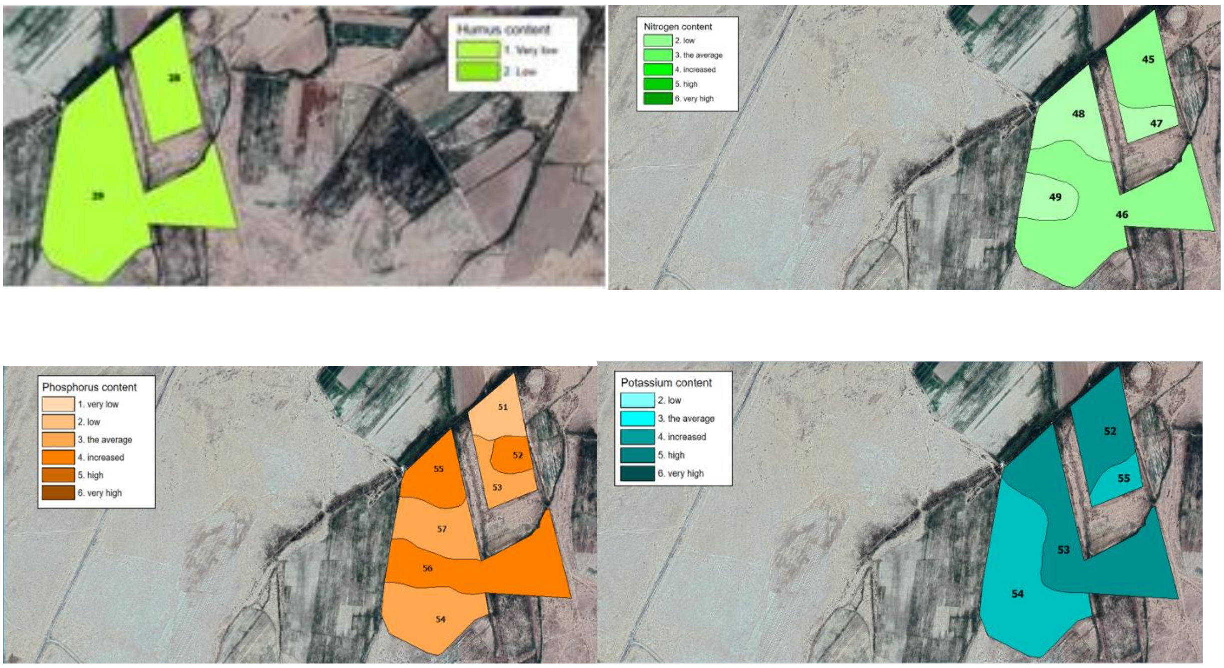

Figure 5 - Cartogram of the content of humus, nitrogen, phosphorus and potassium in soils of the peasant farm "Tylegen"

The diversity of soil fertility existing in the surveyed fields is very clearly shown in the presented cartograms. And, of course, it is already impossible not to reckon with it. If we do not take it into account further, then it will be impossible to achieve high indicators in increasing the productivity of these agrocenoses, because such variegation creates certain difficulties in the use of certain methods of increasing soil fertility.

Thus, the obtained cartograms allow coordinating the rates of fertilization for the planned harvest, taking into account the heterogeneity of the soil cover in terms of the content of mobile forms of nutrients in them. This enables the farmer to apply fertilizer only where it is needed, and not apply where it can be done without it. For this purpose, according to the obtained data on the content of easily hydrolyzable nitrogen, mobile phosphorus and exchangeable potassium in the soils of 1500 ha of land of 90 farms, according to the above cartograms, we calculated the doses of carbamide, ammonium nitrate, ammophos, superphosphate and potassium sulfate for the planned corn harvest (8 t/ha).

CONCLUSIONS

As a result of the conducted soil research, the morphological and chemical properties of the soils of the Shaulder irrigated massif and adjacent territories were determined. A soil map and a map of soil cover degradation (scale 1:100000) were compiled using remote sensing materials.

The main condition for the sustainable development of the agro-industrial complex and the source of its expansion is the preservation, reproduction of soil fertility, rational and efficient use of agricultural land. Based on the foregoing, for the rational and effective use of agricultural land on saline soils of the Shaulder irrigation massif of the Turkestan region, along with the differentiated application of mineral fertilizers, the use of innovative technologies for preserving and increasing soil fertility and the productivity of corn for grain is also very relevant. As a result, it will be possible to preserve the saline irrigated lands of farmers, and not to remove them from arable land, given that the highest population density in the Republic of Kazakhstan is in the Turkestan region, 17 people per 1 m^2 [45].

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