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Original Article

Quantitative assessment of soil condition, basic environmental factors and productivity of *Linum usitatissimum* in the steppe zone of Kazakhstan using the remote sensing method

Avaliação quantitativa da condição do solo, fatores ambientais básicos e produtividade de *Linum usitatissimum* na zona de estepe do Cazaquistão, a partir do método de sensoriamento remoto

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Abstract

The influence of environmental factors, such as lack of water and uneven rainfall, depletion of nutrients in the soil and reduced soil fertility, planting patterns and plant density, uneven growth stages, are the main limiting factors that hinder the growth of agricultural production in arid regions. The aim of the study was to assess the potential of Sentinel-2 to quantify soil conditions, which can improve the understanding of spatiotemporal dynamics in organic agriculture in the steppe zone of Kazakhstan and improve productivity management of *Linum usitatissimum*. In the course of the research, the influence of individual factors of the general environmental impact, such as the influence of humidity, meteorological conditions, the content of individual nutrient components of the soil on the yield, was studied. The meteorological conditions in this region in 2021 and the data of agrochemical analysis of the soil on which the oilseed crop was grown were evaluated. Sentinel-2 satellite images were used to determine the NDVI and GNDVI indices. A high content of nitrate nitrogen (12.3-16.2 mg/kg), a very low level of available phosphorus (3-10 mg/kg), and a high content of potassium (289-420 mg/kg) were found in the soil. A low content of humus (2.68-3.31%) and sulfur (1.1-4.9 mg/kg) was found. A study of the NDVI growth index showed that the highest value was reached by the period of July 20, 2021. After this period, a decrease in the vegetation index was observed. In conditions of severe drought, this change occurred earlier than under favorable conditions, and correlated with low flax yield (1.6-6.9 c/ha). This study demonstrates the potential of Sentinel-2 for quantifying soil conditions, which not only improves our understanding of spatial-temporal dynamics and environmental components in organic agriculture in the steppe zone of Kazakhstan, but also improves the management of *Linum usitatissimum* productivity.

Keywords: organic agriculture, steppe zone, oilseed flax, vegetation index, basic ecological assessment.

Resumo

A influência de fatores ambientais como: falta de água, chuvas irregulares, depleção de nutrientes no solo, redução da fertilidade do solo, padrões de plantio, densidade de plantas, estágios de crescimento irregulares são os principais fatores limitantes que dificultam o crescimento da produção agrícola em regiões áridas. O objetivo deste estudo foi avaliar o potencial do Sentinel-2 para quantificar as condições do solo, o que pode melhorar a compreensão da dinâmica espaço-temporal na agricultura orgânica na zona de estepe do Cazaquistão e aprimorar o manejo da produtividade de *Linum usitatissimum*. No decorrer da pesquisa, a influência de fatores individuais do impacto ambiental geral – tais como a influência da umidade, das condições meteorológicas, do teor de componentes nutrientes individuais do solo no rendimento – foi analisada. As condições meteorológicas nessa região em 2021 foram avaliadas e os dados de análise agroquímica do solo em que a oleaginosa foi cultivada. Imagens de satélite Sentinel-2 foram utilizadas para determinar os índices NDVI e GNDVI. Um alto teor de nitrogênio nitrato (12,3-16,2 mg/kg), um nível muito baixo de fósforo disponível (3-10 mg/kg) e um alto teor de potássio (289-420 mg/kg) foram encontrados no solo. Foi encontrado baixo teor de húmus (2,68-3,31%) e enxofre (1,1-4,9 mg/kg). Um estudo do Índice de crescimento do NDVI mostrou que o maior valor foi alcançado no período de 20 de julho de 2021. Após esse período, observou-se diminuição do Índice de vegetação. Em condições de seca severa, essa mudança ocorreu mais cedo do que em condições favoráveis, e correlacionou-se com a baixa produção de linho (1,6-6,9 c/ha). Nesse sentido, este estudo demonstra o potencial do Sentinel-2 para quantificar as condições do solo, o que não apenas melhora nossa compreensão da dinâmica espaço-temporal e dos componentes ambientais na agricultura orgânica na zona de estepe do Cazaquistão, mas também melhora o manejo da produtividade do *Linum usitatissimum*.

Palavras-chave: agricultura orgânica, zona estepária, linho oleaginoso, índice de vegetação, avaliação ecológica básica.

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1. Introduction

Oilseed flax (Linum usitatissimum L.) - a fibrous dicotyledonous plant of the linseed family (Linaceae), is a potentially economically profitable and very valuable raw material. This plant is known as common flax or flaxseed and is known to have a long history of cultivation in agriculture. Common flax is grown in many countries and is a raw material for the production of fiber, food and medicinal mixtures. Flax products are also used for other purposes. It should be emphasized that new developments in the technology of using flax products with higher added value could be considered as products of the intensification of organic farming methods (Mikelsone et al., 2011; Saleem et al., 2020; Naik et al., 2020).

Due to the high economic value of oilseed flax, the demand for this product is constantly growing. This leads to a constant increase in the acreage of flax. In the period 2018-2019, the sown area of oilseed flax in the world was about 3.04 million hectares (Çoban et al., 2021; Gao, 2020).

The Republic of Kazakhstan plays a key role in organic agriculture in Central Asia. According to the world statistics of organic farming development (Mikelsone et al., 2011), the area of organic farming in Kazakhstan in 2018 was about 192 thousand hectares. In terms of organic farming area, Kazakhstan ranks 37th out of 181 countries. At the same time, among Asian countries, the country ranks 6th in terms of organic farming area (FiBL, 2015; Inbusiness.kz, 2020).

In terms of regional coverage, the main areas of organic production are concentrated in Kostanay, Akmola, Almaty and North Kazakhstan regions, as well as in small areas in Karaganda and Aktobe regions. The largest territory where organic products are produced is located in Kostanay region (Medvedeva, 2020; Nugmanov et al., 2016).

In total, 12070 tons of organic flax seeds worth 10586 thousand euros were exported from Kazakhstan in 2021. Biological properties that ensure high productivity of oilseed flax include high drought tolerance, low transpiration coefficient and high adaptability to the arid conditions of Northern Kazakhstan.

It should be noted that the influence of environmental factors, such as lack of water and uneven rainfall, depletion of nutrients in the soil and reduced soil fertility, planting patterns and plant density, uneven growth stages, are the main limiting factors that hinder the growth of agricultural production in arid regions. To overcome problems that are unpredictable and lead to instability of the system's homeostasis (sudden meteorological disasters, biotic and abiotic stresses, and other environmental impacts), it is necessary to create three-dimensional information models that describe the growth and reproduction of agricultural crops and help predict negative factors, develop measures, and minimize damage in accordance with modern requirements. The construction of predictive models of agricultural yield that take into account the influence of environmental factors is currently a mandatory requirement for rational land use (Abuova et al., 2020; Bhattacharya, 2021; Cui et al., 2022).

Remote sensing technology has made significant progress since the 2000s. The main directions of technology development include the following areas:: 1) development of military technologies with subsequent implementation in civilian applications for analyzing the environment, land, ocean and air atmosphere; 2) sequential conversion of sensors of analog signals of photographic systems into systems based on sensors that convert the energy of various parts of the electromagnetic spectrum into electronic signals; 3) shooting from an airplane is converted into monitoring technologies from unmanned aerial vehicles. spacecraft and satellite systems. Remote sensing today is a complex multi-component system that includes satellite sensors for monitoring, evaluating, and recording electromagnetic radiation reflected or emitted by the Earth and its surroundings. The received signals are further processed and evaluated (Acharya and Thapa, 2015; Levin, 1999).

The ESA Sentinel-2 Project for Agriculture (Sen2-Agri), led by the Catholic University of Louvain and supported by ESA, has worked to develop and build an open source information processing system and to then automatically download all the data and images from the Sentinel-2 and Landsat-8 systems that were collected over the course of during the growing season. It should be noted that the information was obtained almost in real time from four different nationwide products. At the same time, the resolution accuracy was up to 10 meters. The following types of work were performed: 1) monthly temporary cloud-free synthesis of surface reflection coefficient indicators in ten Sentinel-2 ranges with a resolution of 10 or 20 m, depending on the control band; 2) evaluation of monthly arable land masks with a resolution of up to 10 meters, which were provided during the agricultural season for the purpose of mapping annual arable land; 3) preparation of maps of the five main areas of agricultural activity. types of agricultural crops and early indicators of the area for crops that were provided in the middle and end of the season; 4) an assessment of the state of vegetation was carried out, which described the dynamics of crop development during the seven-day period and in cloudless weather (Bontemps et al., 2015; Zhou et al., 2021).

It should be noted that the ESA Sentinel-2 (Sen2-Agri) project was guided by information requests that were identified by key international stakeholders.

In agriculture, it is very practical to provide high effective radiometric resolution to accurately model crop energy, detect health problems at an early stage of plant growth, detect subtle changes in soils, and map moisture and organic matter content. Improving the quality and accuracy characteristics of the equipment leads to high information quality of images. This makes it possible to evaluate information in an automated way using high-precision measurements (Lin and Liu, 2022; Wang at al., 2020; Yuzugullu et al., 2020).

Of course, phosphorus and nitrogen are important nutrients for plant growth. Timely introduction of phosphorus and nitrogen into the soil is a key factor in increasing crop yields (Lin et al., 2019; Liu et al., 2020; Wang et al., 2014).

Usually, farmers strive to keep the leaves of the crop dark green. However, this leads to low efficiency of fertilizer use and excessive application. It should be noted that the spectral properties of leaves should be used in a more rational way (Bhat et al., 2017; Mukherjee and Singh, 2020; Zhang et al., 2022).

Agricultural systems constantly face the challenge of controlling phosphorus levels. At the same time, the following interrelated questions arise. This is the depletion of phosphorus reserves and the deterioration of the environment due to excess phosphorus. Excessive phosphorus content can be dangerous for freshwater systems. On the other hand, agricultural production should be provided with phosphorous fertilizers that need it (Asadi et al., 2020; Grant et al., 2004; Martens et al., 2022).

We must emphasize that organic farming is quite attractive from the point of view of providing the population with high-quality food products. At the same time, the negative impact of chemically synthesized products on the environment and human health is reduced. This significantly improves the environmental situation. Organic farming contributes to the development of small and medium-sized businesses and increases the export potential of agricultural products.

Therefore, the search for new ways of greening agriculture at the lowest cost, one of which is the transition to an organic farming system, is of great interest.

One of the methods used to improve crop management and production is the use of various remote methods based on satellite images from space, air and unmanned aerial vehicles, which are used all over the world. These methods make it possible to evaluate soil fertilization, determine the content of organic matter, water and salt, as well as the vegetation of agricultural crops (Mzid et al., 2022; Nasiri et al., 2022; Pu et al., 2022). Satellite methods have certain advantages: data acquisition covers large geographical areas, including hard-to-reach ones, and also provides constant time resolution for creating time series, short re-viewing time, and provides free data (Angelopoulou et al., 2020). Based on remote analysis data, management decisions can be made that ensure higher agricultural productivity. Moreover, remote sensing methods can be used as a tool to support certification of organic crops based on biochemical and biophysical differences between fields (European Network for Rural Development, 2021; Wei et al., 2022).

The aim of the study was to assess the potential of Sentinel-2 to quantify soil conditions, which can improve the understanding of spatiotemporal dynamics in organic agriculture in the steppe zone of Kazakhstan and improve productivity management *Linum usitatissimum*.

2. Materials and Methods

2.1. Site characteristics

The research was conducted on ordinary chernozem soils, the first natural and climatic zone of Kostanay region in 2021. The research area was a production field (Fedorovsky district of the region), where flax was cultivated using technology on an area of 200 hectares. Analytical work was carried out in an accredited testing laboratory of Zarechnoye Agricultural Experimental Station LLP (accreditation certificate number KZ. T. 11. 2311 dated 12.3.2020 in accordance with ISO 17025).

In the experimental region under study, according to long-term observations (Kostanay Branch of the Republican State Enterprise “Kazhydromet”), the annual precipitation rate is 340 mm. The total amount of precipitation during the warm period, including April-October, was 71.2% of the annual total. In the second half of summer, there is more precipitation (RSE “Kazhydromet”, 2023).

In the reporting year 2021, the amount of precipitation for the period (October-September) was 322.6 or 94.9% of the annual norm (Table 1). Considering the moisture supply of agricultural crops for the growing season of 2021, it is worth noting that most of the precipitation fell in the second decade of July (88.9 mm - July 11-12, 21), while in May only 5.5 mm fell. Such conditions created significant difficulties in sowing at the optimal time, since the seeds did not have enough moisture to produce friendly shoots. Light precipitation in June affected the appearance and development of cultivated crops. In August, the amount of precipitation was only 15.4% of the long-term average.

It should be noted that our analysis of the relationship between grain yield and the amount and time of precipitation showed that in the northern region of Kazakhstan, its height (among other factors) was determined by precipitation in June-July, and grain quality was determined by precipitation in August-September. In the first case, more precipitation in June-July led to an increase in yield, in the second case, less precipitation and a higher temperature at the end of ripening and harvesting led to an improvement in the technological qualities of grain (Table 2).

As for the average daily air temperature, it is worth noting that in May, the excess over the long-term norm was 6.3°C, and in other months of the warm period of 2021, it was close to the long-term average values (Table 3).

In addition, we monitored weather conditions in the study area in 2021 using the Caipos automatic weather station (Figures 1 and 2).

On the production field of the Metelitsa peasant farm (Fedorovsky district, Kostanay region), oilseed flax was grown using organic technology on an area of 200 hectares. Productivity zones were analyzed at this site based on vegetation zones identified in recent years using satellite images (Figure 3).

The experiment process is as follows

1) analysis of the productivity zones of oilseed flax plants and drawing up an appropriate map;
2) conducting an agrochemical survey in the coordinate system;
3) creating a map of the distribution of batteries within the boundaries of the studied area;
4) monitoring the vegetation index of oilseed flax under organic farming conditions.

Agrochemical monitoring of agricultural land soils was carried out in accordance with the Rules for conducting an agrochemical soil survey (No. 4-1/147 of 27.02.2015).

The selection of elementary plots was carried out using the following methods: All-Union Production and Scientific Association on Agrochemical Service of Agriculture, (1982), Derzhavin and Bulgakov (2003), Sychev et al., (2007). Soil samples were taken using the grid method over the entire cell (elementary section) in a zigzag pattern with geographical reference. The area of the elementary plot is 25 ha.

Table 1. Distribution of precipitation over the periods of the year in comparison with the long-term value.

Year	Total precipitation, mm			
	In just one year (October-September)	Cold period (November-March)	Warm period (April-October)	Growing season (May-August)
Multi year value	340.0	98.0	242.0	162.0
2021	322.6	124.7	187.8	128.1

Table 2. Precipitation distribution by months of the growing season, mm.

Year	May	June	July	August
Long term rate	36.0	35.0	56.0	35.0
2021	5.5	13.7	103.5	5.4

Table 3. Average daily air temperature, °C.

Year	April	May	June	July	August	September
Long term norm	5.3	13.7	20.0	20.9	18.9	12.5
2021	6.3	20.0	20.8	21.3	22.2	11.1

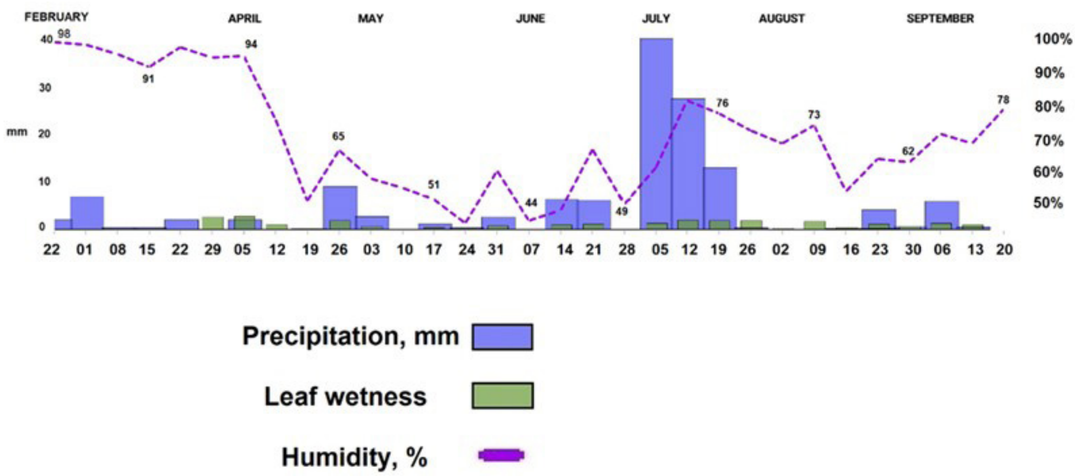

Figure 1. Precipitation schedule for 2021.

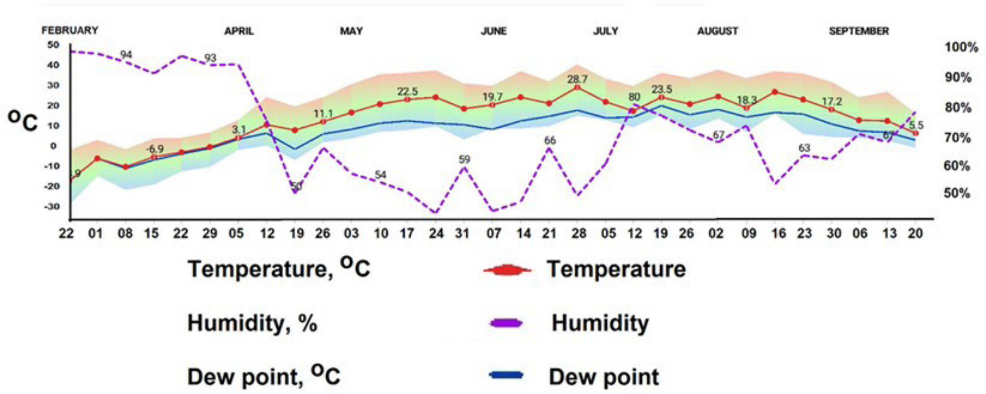

Figure 2. Graph of temperature regimes for 2021.

Figure 3. Sample collection points, 2021.

Agrochemical analyses were carried out in accordance with the following regulatory documents: GOST 26205-91. The soil. Determination of mobile compounds of phosphorus and potassium by the Machigin method in the modification of the TsINAO; GOST 26423-85. The soil. Preparation of water extract and determination of its pH; GOST 26213-91. The soil. Determination of organic matter by the Tyurin method in the modification of the TSNAO; GOST 26951-86. The soil. Determination of nitrates by ionometric method; GOST 26490-85. The soil. Determination of mobile sulfur by the TsINAO method (Gosstandart of the USSR, 1985, 1986a, b, 1991, 1992a, b).

In the study area, the climate is sharply continental, characterized by cold, low-snow winters and hot, dry summers. In spring, there is prolonged cold weather. The region is characterized by an earlier cold snap in autumn. Precipitation is typical for this region in late summer. This distinguishes it from other arid regions. The region is also characterized by high insolation, sharp temperature differences between day and night, low humidity values, rather low cloud cover, and frequent winds. These environmental and weather factors cause intense evaporation of moisture. This is 2-5 times the amount of precipitation. The end of May and most of June are particularly dry. It should be noted that during this period, spring crops are in the phase of entering the tube, the phase of the formation of tubules.

It is very important for plants to quickly consume the moisture that is contained in the soil as a result of winter precipitation. Plants must absorb moisture before new precipitation occurs. In this region, climate factors vary greatly not only in different periods of the year, but also in different years. The factors differ in intensity and time of manifestation.

2.2. Determination of individual nutrient components

Determination of humus, mobile forms of nitrogen (NO_3 or $N\text{-}NO_3$) and phosphoric acid (P_2O_2 according to Chirikov) was carried out as described below in a soil layer of 0-40 cm on all crop rotation fields before sowing and before harvesting.

The Tyurin method was used as the main analytical method for determining the content of a substance. This method has already been modified in accordance with CSRIASA (Gosstandart of the USSR, 1992b). The method is based on the oxidation of organic matter with a strong solution of potassium dichromate and sulfuric acid. The content of trivalent chromium, is released during chemical transformations, equivalent to the substance. This method is also based on this use in photocolorimetric equipment. In this case, the tests were carried out using a photoelectric colorimeter of the KFK-Z OMZ (Manufactured by ZOMZ, Russian Federation)

The main method for determining the B nitrate nitrogen content is based on the most use-of-b ionometric sampling method (Gosstandart of the USSR, 1986b). During the method, nitrates extraction of nitrates with 1% potash solution at alum at mass of soil sample and soil and soil sample and the bulk solution of Instead of potassium alumalum can also be possible to use either a 1M solution of potassium sulfate. Further, the content of nitrates was determined with ITAN pH/RN ITAN/ISET (Russian Federation). This analyzer is equipped with a special electrode that is selective for nitrate anions.

The Chirikov method was used as the main method for monitoring the content of available phosphorus and potassium compounds. The method was modified in accordance with the requirements of CSRIASA (Çoban et al., 2021; FiBL, 2015; Gao, 2020; Inbusiness.kz, 2020; Nugmanov et al., 2016). The analytical method is based on the extraction of mobile compounds of potassium and phosphorus from the soil with 0.5 M acetic acid solution. In this method, the soil-to-plant ratio should be 1: 25. Phosphorus was determined as a blue phosphorus-molybdenum complex. The phosphorus content was determined using a photoelectric calorimeter of the KPK 3-01-ZOMZ type (ZOMZ, Russian Federation). The potassium content was determined using a photoelectric flame atomic absorption spectroanalyzer of the PFA 378 type (Unico-Sys, Russian Federation).

Maps of the spatial distribution of soil parameters based on the results obtained were compiled using the cross-platform geographic information system Quantum GIS by interpolation of a triangulated irregular network (TIN).

The range of values on that indicator was between -1 and +1. Maps of qualitative assessment content of nitrogen of the nitrogen content of plant leaves were obtained by Geoanalytica. Agro service generated from with data with a specific permission. The resolution time was 16 days. The Normalized Difference Red Edge Index (NDRE) was a single indicator from the Internet of photosynthetic activity from plant coatings used to estimate nitrogen concentrations in plant leaves using near infrared (750-1000 Nm) and extreme red (690-730 Nm) channels. This indicator is applicable for assessing depression and aging of vegetation. It is effective in estimating the most nitrogen content in the plant coming out of multispectral data, which is the extreme red and near-infrared spectral channels.

2.3. Soil sampling

Soil samples were taken using the grid method over the entire cell (elementary section) in a zigzag pattern with geographical reference. Within each of the selected productivity zones 20 sampling points are made in one combined sample by pricking the soil with a manual reed sampler to a depth of 20 cm

From the total area of the field, sampling points were selected on a 200-ha area of the Dew area, which was prepared as a site for growing oilseed flax using organic technology in production conditions. In accordance with the productivity zones, an agrochemical survey was conducted based on the map of productivity zones. Using data interpolation, maps of the probable distribution of food elements within the boundaries of the study area were compiled. At the 200-hectare demonstration site, soil samples were taken with reference to the zones of fertility and geographical reference, and the content of the main elements of plant nutrition was determined. The data obtained are shown in Table 4. Analysis of soil samples shows that almost all areas of the site had a high supply of nitrate nitrogen. Only in two of the studied sites, the intake of nitrate nitrogen into the soil was low. Mobile phosphorus reserves at the facility were very low in all areas. In general, there were never any problems with the content of potassium here; here its supply in all areas was at a high level.

2.4. Data analysis

Digital platforms of the geographic information systems Quantum GIS and SAS Planet were used to visualize the results of the agrochemical survey with reference in the coordinate system Quantum GIS and SAS Planet.

The data were statistically processed using the analysis of variance. The significance of differences between the variants was estimated at a probability level of 0.05. Statistical analysis was performed using Microsoft Excel 2003 and AGROS 2.11 software.

3. Results and Discussion

The data obtained are shown in Table 4. Analysis of soil samples shows that almost all areas of the site had a high supply of nitrate nitrogen. Only in two of the studied sites, the intake of nitrate nitrogen into the soil was low. Mobile phosphorus reserves at the facility were very low in all areas. In general, there were never any problems with the content of potassium here; here its supply in all areas was at a high level.

Cartograms of nutrient distribution at the production site were compiled on the basis of agrochemical soil analysis using the QGIS interpolation plugin and the triangulated irregular network (TIN) method (Figures 4-6).

Table 4. Content of basic nutrients in the soil layer 0-20 cm, 2021.

	Contains mg / kg of soil											
sampling point	**no_3**	**offers**	**P_2o_5**	**supply[1]**	**k_2O**	**supply[1]**	**pH**	**feed[1]**	**x**	**feed[1]**	**humus, %**	**Supply[1]**
1	15.1	maximum	6	very low	420	very high	8.54	alkaline	4.8	low	3.15	minimum
2	13.8	average	8	very low	392	high	8.56	alkaline	4.9	low	2.68	minimum
3	4.0	very low	3	very low	351	high	8.67	alkaline	1.3	very low	3.31	minimum
4	5.5	minimum	5	very low	302	high	8.61	alkaline	2.0	very low	2.85	minimum
5	14.1	average	4	very low	392	high	8.48	Slightly alkaline	1.8	very low	2.92	minimum
6	16.2	high	5	very low	392	high	8.58	alkaline	2.0	very low	2.85	minimum
7	15.5	maximum	8	very low	682	very high	8.47	slightly alkaline	4.8	low	3.14	minimum
8	12.3	average	4	very low	289	elevated	8.55	alkaline	1.8	very low	2.75	minimum
9	15.1	maximum	3	very low	354	high	8.58	alkaline	2.7	very low	2.85	minimum
10	12.6	average	6	very low	384	high	8.57	alkaline	1.1	very low	2.94	minimum
11	14.5	medium	10	low	406	very high	8.68	alkaline	1.2	very low	2.94	low

[1]The nutrient content is characterized as very low/low-grade/medium/high/high/ultra-high in accordance with the recommendations of the Ministry of Agriculture and Food of the Russian Federation (1994) on classification.

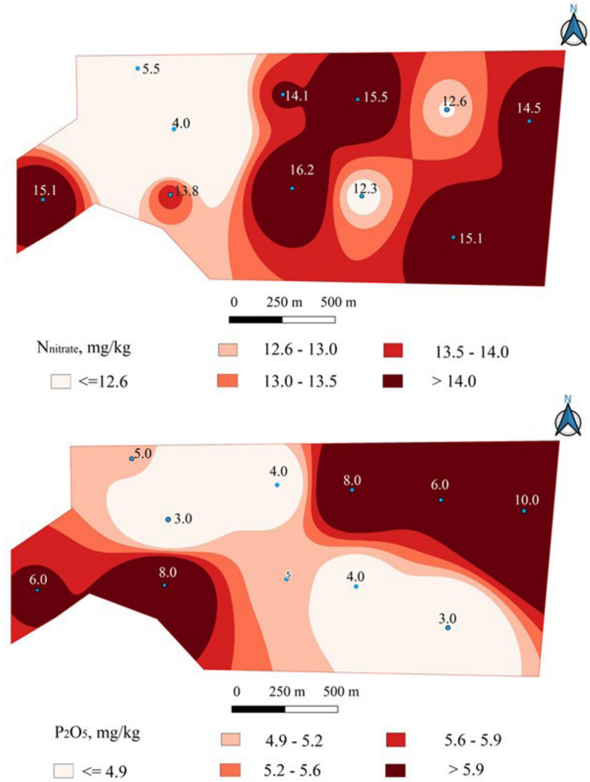

Figure 4. Nitrogen nitrate and mobile phosphorus content, 2021.

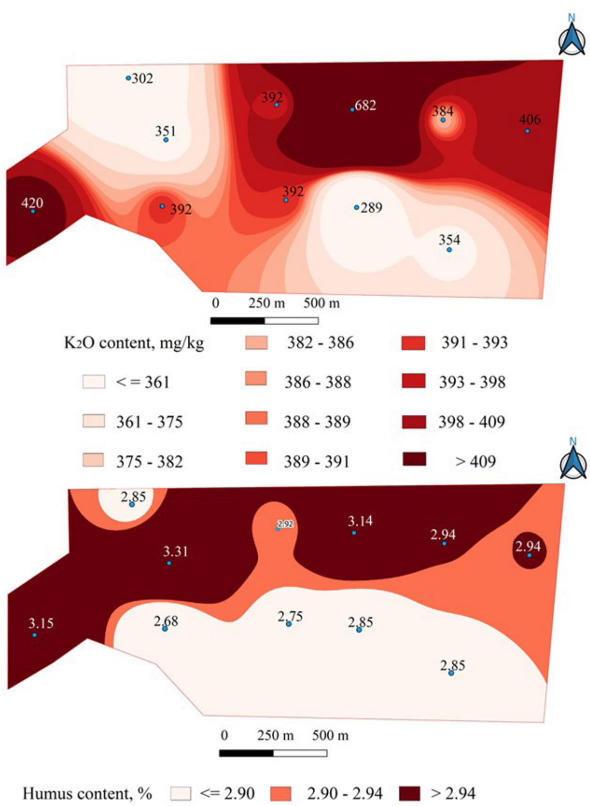

Figure 5. Map of the distribution of exchangeable potassium and humus, 2021.

The level of acidity (pH) in the selected soil samples was characterized as alkaline in almost all areas. The low sulfur content in this area is most likely due to insufficient application of mineral fertilizers, since the use of mineral fertilizers is not provided for in organic farming. In addition, a low humus supply was noted at the test site.

In the period of plant growth development at the test site, the vegetation index of flax plants (Figure 7).

In the course of this work and the study of the vegetation index NDVI, it was found that the highest value was reached on July 20 (the beginning of the third decade of the month). After this period, a decrease in the vegetation index was observed. It is also worth noting that in the conditions of acute drought in 2021, this change occurred earlier than it occurs under favorable conditions, and could indirectly indicate low crop yields. Since at the peak of moisture consumption, there was an acute shortage of soil moisture, and the situation was aggravated by high temperatures and atmospheric drought.

Subsequently, the yield was determined for all observed points in this area, and the data are summarized in Table 5, and a structural analysis of the plants was performed.

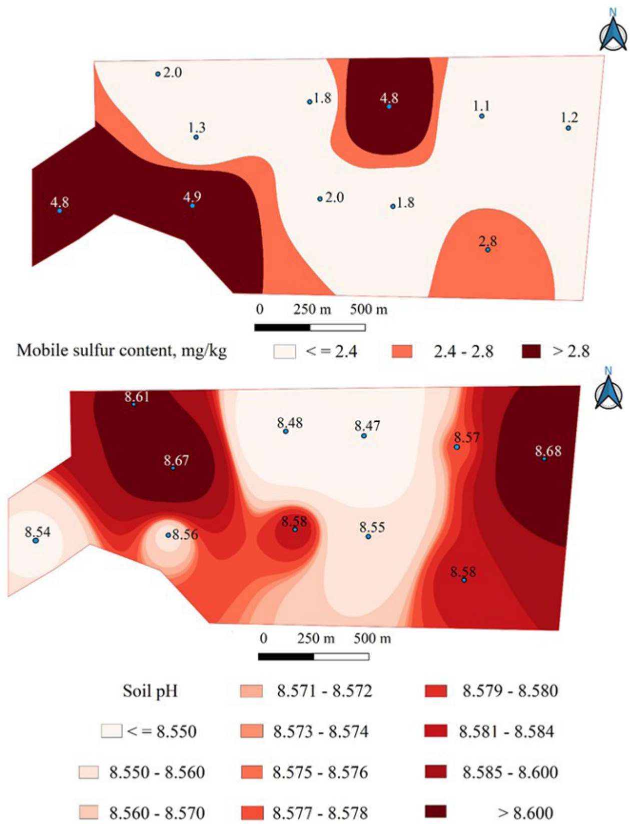

Figure 6. Map of mobile sulfur and pH distribution within the boundaries of the designated area, 2021.

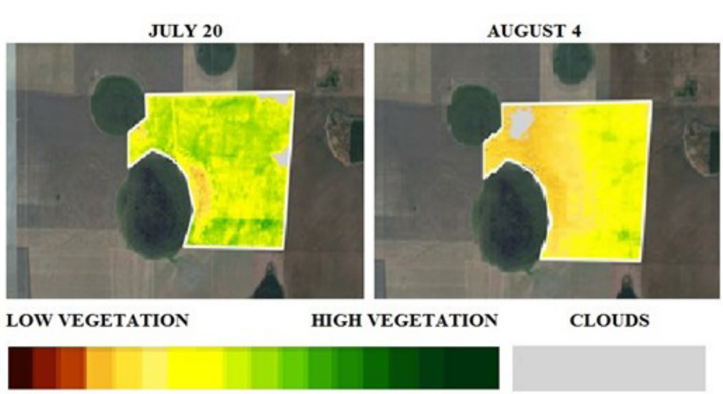

Figure 7. Monitoring of the NDVI (Normalized Difference Vegetation Index) index during the growing season of oilseed flax in the Metelitsa farm.

Table 5. Structural analysis of oilseed flax plants, 2021.

Sampling location	Plant height, cm	Branching	Average number of boxes per plant	Average number of grains in 1 box	Weight of 1000 seeds, g	Yield, c / ha
1	28.1	3.6	9.0	6.4	6.1	4.9
2	29.8	3.4	8.2	6.6	5.6	1.6
3	27.9	3.2	9.7	6.1	5.7	3.3
4	30.2	3.0	9.0	6.6	5.6	5.6
2.7	5	33.6	3.3	11.6	6.5	6.1
3.2	6	26.8	4.1	7.4	6.7	6.0
2.6	7	27.1	3.8	8.6	5.9	3.9
8	31.0	3.8	10.7	6.7	6.1	5.4
9	31.5	2.5	7.0	6.0	6.1	6.9
10	29.1	3.6	7.6	6.0	5.7	4.1
11	25.4	3.7	7.8	6.5	6.2	5.2

Analysis of soil samples shows that in almost all areas of the test site, the soil was found to contain mainly high levels of nitrate nitrogen (12.3-16.2 mg / kg), very low levels of mobile phosphorus (3-10 mg/kg), and high levels of potassium (289-420 mg/kg). Low content of humus (2.68-3.31%) and sulfur (1.1-4.9 mg/kg) was noted.

The study of the vegetation index NDVI showed that the highest value was reached in the period of July 20, 2021. After this period, a decrease in the vegetation index was observed. In conditions of severe drought, this change occurred earlier than under favorable conditions and correlated with low yields of oilseed flax (1.6-6.9 centners / ha), since in the phase of peak moisture consumption, there was an acute shortage of soil moisture, and the situation was aggravated by high temperatures and atmospheric drought. This study demonstrates the potential of Sentinel-2 to quantify soil conditions, which not only improves our understanding of spatiotemporal dynamics in organic agriculture in the steppe zone of Kazakhstan, but also improves *Linum usitatissimum productivity management*.

In our previous works (Abuova et al., 2019; Ismuratov et al., 2020; Nugmanov et al., 2018), we applied remote sensing studies to various agricultural crops in Northern Kazakhstan. It was shown that remote sensing allows it to evaluate to evaluate potential for obtaining different soil and producing different various on and effect of different factors on crop performance. As part of the present work, we have obtained results that can be used to further develop organic farming approaches, as the influence of this spread in different soil properties on *linum usitatissimum* productivity has already been analyzed.

Scientists from Finland confirm in their research that when data is available for more years, as well beyond the limits of our test region, it is possible to gain a deeper understanding of the value dependence of the cost of preparing for sowing on growing conditions, which will further support the introduction of diversification with the help of farmers. This study highlights the opportunities available when you benefit from digitizing data, including through the use of digital technologies. The new method developed may allow the replacement of most currently used field experiments with very resource-intensive field data on the farm, which is based on Sentinel NDVI values obtained from Sentinel-2, at the field plot scale (Peltonen-Sainio et al., 2019).

Overall, according to the researchers, low total nitrogen levels in organic farming systems may offer the opportunity to produce flaxseeds and oils c that are high in omega-3 fatty acids and low in cyanogenic glycosides, with high yields. With yields, it's similar to normal farming. Since the high quality of the product can be maintained or even improved c by organic farming methods, suitable flaxseed suitable is suitable as an oil oilseed crop in organic farming, which allows you to diversify the rotation of the crop rotation (Klein et al., 2017).

4. Conclusions

At the production site, zones with low and high productivity zones of oilseed flax are identified. A map of the distribution of plant nutrition elements was compiled and the crop yield was determined within the study area. The average yield was 4.0 c / ha.

The possibility of using permitted phosphorus-containing fertilizers in organic farming, in order to optimize the phosphorus nutrition of plants, is considered.

As a result, a visual map of the location of zones in the field was obtained, which was supplemented by sampling and results of agrochemical data analysis. Such sampling has a number of advantages over grid sampling, which is not able to cover areas of heterogeneity throughout the field, as well as reveal the relationship between soil parameters and crop yields, which is crucial for organic farming.

Meteorological conditions in this region in 2021 and data from agrochemical analysis of the soil on which oilseeds were grown were estimated. Sentinel-2 satellite images were used to determine the NDVI and GNDVI indices.

The soil was found to contain high levels of nitrate nitrogen (12.3-16.2 mg / kg), very low levels of available phosphorus (3-10 mg/kg), and high levels of potassium (289-420 mg/kg). Low levels of humus (2.68-3.31%) and sulfur (1.1-4.9 mg/kg) were found. A study of the NDVI growth index showed that the highest value was achieved by the period of July 20, 2021. After this period, a decrease in the vegetation index was observed. Under severe drought conditions, this change occurred earlier than under favorable conditions and correlated with low flax yields (1.6-6.9 centners / ha). This study demonstrates the potential of Sentinel-2 to quantify soil conditions, which not only improves our understanding of spatiotemporal dynamics and environmental components in organic agriculture in the steppe zone of Kazakhstan, but also improves maximum productivity management. The study was limited to the analysis of *Linum usitatissimum* productivity, further research should be directed to the analysis of the productivity of other crops in the steppe zone of Kazakhstan using the remote sensing method.

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