ENERGY-ECOLOGICAL EFFICIENCY OF AGROECOSYSTEM OF WEST KAZAKHSTAN

Khalel KUSSAINOV* — *Doctor of Economics, Professor, Aktobe Regional University named after K. Zhubanov, Aktobe, Kazakhstan, Kusainov-x@mail.ru, https://orcid.org/0000- 0001-9601-771X*

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Abstract. The negative balance of the reproduction of soil energy indicates a deep ecological and energy crisis in agriculture. Analyzed: indicators of the use of biological factors, such as solar energy and the energy of soil fertility, affect the ecological and economic efficiency of agricultural production; the efficiency of using solar energy and the coefficient of its efficiency. The required level of productivity has been determined to maintain the annual deficit-free soil balance in the western region of Kazakhstan. The necessity of state regulation to determine the critical threshold of the yield level to compensate for the deficiency of soil energy at the expense of other sources of organic matter has been substantiated. For the modernization and ecological optimization of agriculture, a bio-energetic model of individual crop rotations was built, which also includes indicators of crop yield, the degree of mineralization of soil organic matter and some other standard indicators.
Keywords: solar energy, energy of soil fertility, ecological economic efficiency, soil and energy balance, ecological optimization of agriculture, bioenergy model.
JEL codes: Q14, Q40, Q15

Аңдатпа. Топырақ энергиясының ұдайы өндірісінің теріс сальдосы ауыл шаруашылығындағы терең экологиялық-энергетикалық дағдарысты көрсетеді. Биологиялық факторларды пайдалану көрсеткіштері, мысалы, күн энергиясы және топырақ құнарлылығының энергиясы ауыл шаруашылығы өндірісінің экологиялық және экономикалық тиімділігіне әсер етеді; күн энергиясын пайдалану тиімділігі және оның тиімділік коэффициенті талданған. Қазақстанның батыс аймағындағы жыл сайынғы тапшылықсыз топырақ балансын сақтау үшін қажетті өнімділік деңгейі анықталды. Топырақ энергиясының тапшылығын органикалық заттардың басқа көздері есебінен өтеу үшін шығымдылық деңгейінің шекті шегін анықтауды мемлекеттік реттеудің қажеттілігі дәлелденді. Ауыл шаруашылығын жаңғырту және экологиялық оңтайландыру үшін жеке ауыспалы егістердің биоэнергетикалық моделі салынды, оған сонымен қатар дақылдардың өнімділігінің көрсеткіштері, топырақтың органикалық заттарының минералдану дәрежесі және кейбір басқа да стандартты көрсеткіштер кіреді.
Түйін сөздер: күн энергиясы, топырақ құнарлылығының энергиясы, экологиялық экономикалық тиімділік, топырақ-энергетикалық баланс, экологиялық ауыл шаруашылығын оңтайландыру, биоэнергетикалық модель.
JEL кодтар: Q14, Q40, Q15

Аннотация. Негативный баланс воспроизводства почвенной энергии свидетельствует о глубоком экологическом и энергетическом кризисе земледелия. Анализируются: показатели использования биологических факторов, как солнечная энергия и энергия почвенного плодородия воздействует на эколого-экономическую эффектность сельскохозяйственного производства; эффективность использования солнечной энергии и коэффициент её полезного действия. Определен необходимый уровень продуктивности для поддержания ежегодного бездефицитного баланса почвы в западном регионе Казахстана. Обосновано необходимость государственного регулирования для определения критического порога уровня урожайности для компенсации дефицит почвенной энергии за счет иных источников органики. Для модернизации и экологической оптимизации сельского хозяйства построена биоэнергетическая модель отдельных севооборотов, которая также включает показатели урожайность сельскохозяйственных культур, степень минерализации органического вещества почвы и некоторые другие нормативные показатели.
Ключевые слова: солнечная энергия, энергия почвенного плодородия, эколого-экономическая эффектность, почвенно-энергетический баланс, экологическая оптимизации сельского хозяйства, биоэнергетическая модель.
JEL коды: Q14, Q40, Q15

Introduction

Assessment of the efficiency of agricultural production in the context of applying the principles of a green economy is updated by analyzing the degree of ecological and energy feasibility of this agro-ecological system.

In this regard, it should be emphasized

* *Corresponding author: K. Kussainov, Kusainov-x@mail.ru*

that the main energy factors of agricultural production were, are and will remain in the foreseeable future solar energy, soil energy potential and anthropo-technogenic energy.

Based on the calculations carried out, the ratio of the energy of each factor in the conditions of Western Kazakhstan, respectively, is approximately 630: 300: 1. In other words, every year in the agriculture of the region for 1 unit of energy of anthropogenic origin, consumed in the production process, there are 630 units of incoming solar energy; in this case, respectively, the total potential of soil energy in the amount of 300 units is involved.

Each of these factors has its own ecological functions in the process of energy functioning and reproduction of agro-ecological systems. It should be emphasized that the direction and efficiency of the implementation of these functions has a direct economic interpretation. So, any increase in the efficiency of using solar radiation or soil energy, which does not require additional costs of technogenic resources, leads to an increase in the efficiency of the entire agriculture. And vice versa, ecologically unjustified agriculture, accompanied by the degradation of the soil cover and soil energy potential, leads to a decrease in productivity, agricultural productivity, makes it necessary to attract ever increasing amounts of technogenic energy, which ultimately results in a sharp decrease in the overall efficiency of the industry.

The energy of the sun (photosynthetic energy) is the only external planetary source that, in a broad sense, generally determines the flow of energy to the Earth's surface and the very possibility of the functioning of all biological systems.

Soil energy is traditionally referred to as the secondary energy factor of agro-ecosystems. It is traditionally considered as the fundamental ecological basis of biological systems based on photosynthesis of organic matter. Any alternative energy sources that enable the functioning of agriculture in the near future are, in principle, impossible.

Man-made energy is the only social factor fully regulated and controlled by man. The limiting social aspects of such governance are economic motivations. At the same time, the ecological factors of the existence of society also in all cases have a certain economic basis. Efficiency, ecological feasibility, and the degree of reproduction of the energy of soil fertility and testifies to the level of perfection and ecological development of civilization.

Methods and Materials

The analysis of indicators of the use of biological energy of solar energy and energy of soil fertility, revealed the possibility of assessing the ecological and economic efficiency of agricultural production in western Kazakhstan.

Published data indicate that the annual input of solar energy in the region is 2.1-2.2 x 107 MJ / ha. It is well known that in the process of photosynthesis, up to 95-98% of organic matter is formed. At the same time, it is believed that certain limitations determine the fact that only about 40% of direct solar radiation actually participates in photosynthesis *(Bulatkin, 2019; Lebedko, 2020; Kussainov, 2000; Machneva, 2019; Sadanov, 2019; Khlestkina, 2020).*

The structure of effective photosynthetically active radiation (PAR) under the conditions of western Kazakhstan is presented in Table 1. As you can see, during the active period of agricultural work in the region - from May to October - more than 70% of the total PAR is received.

The analysis of the dynamics of the efficiency of using solar energy was carried out by us according to such an indicator as the efficiency of the PAR or the coefficient of its efficiency (efficiency of the PAR), determined by the ratio of the energy of the crop and the incoming effective PAR.

Table 1 – PAR inflow in western Kazakhstan during a calendar year, MJ / m2

Month	Value
January	55
February	90
March	150
April	220

May	295
June	320
July	315
August	270
September	210
October	125
November	65
December	35
Total for the year	2150

The table was compiled by the author

Let us consider the regularities of the dynamics of the efficiency of the use of solar radiation, adhering to the differentiation with respect to individual, most characteristic (as we have already established in the process of analyzing the dynamics of productivity and costs) chronological stages of the development of agriculture in western Kazakhstan. These stages include the beginning and middle of the 50s, the middle of the 60s, the middle of the 70s, the middle of the 80s, as well as the end of the 90s. and early 2000s. The data obtained in this case are presented in Table 2.

First of all, it should be noted that throughout the entire study period, there was a fairly active dynamics of the studied indicator.

So, in general, the efficiency of the PAR increased from (beginning - mid-50s) to 0.5 (mid-60s), 0.6 (mid-70s) and 0.7% in the mid-80s. x years. The overall growth was, as we can see, 150%. The agricultural crisis of the 90s - early 2000 led to a sharp deterioration in the efficiency of solar energy use to the level of the beginning - mid-50s, i.e. before the start of active development of virgin and fallow lands (Table 2).

Table 2 – The efficiency of using PAR in agriculture in the West Kazakhstan region

Time periods	Efficiency, PAR, %
Beginning 50s	0,3
Mid 50s	0,3
Mid 60s	0,5
Mid 70s	0,6
Mid 80s	0,7
End 90s-early 2000	0,3

The table was compiled by the author

It should be recognized that, to a large extent, the dynamics of the PAR energy efficiency indicators was also characterized by discrete fluctuations caused, as we have already noted, by the influence of extreme weather conditions in certain years.

Results (classification)

Consequently, the data obtained give us sufficient grounds to believe that the more than 2-fold increase in the efficiency of photosynthesis and the use of solar energy in general in crop production in the West Kazakhstan region is a direct result of the intensification of agriculture in the mid-50s - 80s and in particular, the general growth in the use of man-made costs in production. Such a qualitative transformation of agriculture determined the general increase in the efficiency of agricultural production by the period of the 70-80s.

Based on these patterns, we believe that the prospects for agriculture in the region are in the growth of the efficiency of using solar energy. At the same time, the factors that determine such growth should be based primarily on a biological rather than on a technogenic nature, which will make it possible to achieve truly intensive development. These factors are new varieties and breeds of animals, soil-saving farming systems and certain technologies in crop production, the widespread use of science-intensive ("high") technologies.

At the same time, we believe that the development of national agriculture should provide for both the qualitative and quantitative growth of its technical potential. These factors include the creation and implementation of modern, more productive and resource-saving technology, the optimal use of chemicalization and protection means, etc. It should be emphasized once again that progress in agriculture is unthinkable without the creation of appropriate economic incentives that could determine the appropriate motivation for active entrepreneurship, innovation, and justified economic risk.

In this regard, it is advisable to focus on the following circumstance. If we analyze the data obtained once again, it should be recognized that the factor of the qualitative transformation of agricultural production in the economic sense was quite noticeable in the region during the 50-80s. At this time agricultural productivity grew faster than the dynamics of costs. Recall that in this case, production increased 6.8 times, while costs - less than 5 times.

The problem of preserving soil fertility arose simultaneously with the emergence of active farming. At the same time, modern agriculture provides for the alienation of a significant amount of energy from agroecosystems in the form of basic and valuable by-products. At the same time, the process of mineralization (decomposition) of soil organic matter is sharply accelerated, which upsets the stability of the balance in the negative direction.

As shown by the results of our ecological and energy analysis, traditional farming in Kazakhstan does not ensure the proper preservation of soil fertility. Apparently, taking into account world experience, such problems are universal for all agricultural regions, regardless of the degree of technogenic intensification of production, both for extensive low mechanized agriculture and the industrial agrarian sphere. It should be emphasized that it is this circumstance that is the main one in the process of developing further optimization measures in the national agriculture.

Soils that are prone to water and wind erosion are characterized by extremely low fertility. On such deflated soils, the yield is 60-70% lower than on non-deflated soils. Unfortunately, the area of such lands has a steady tendency to increase. Soil fertility studies indicate that practically all soils used in agriculture on the territory of the West Kazakhstan region need to replenish the reserves of organic matter and improve their agrophysical properties.

The value of the internal energy of soil organic matter is a universal indicator for assessing potential fertility. This methodology provides for the analysis of the efficiency and reproduction of soil energy potential through the ratio of the processes of synthesis and decay of organic matter. This ratio for a certain period of time characterizes the humus regime of the soil and is considered the main parameter of the intensity of the accumulation or mineralization of organic matter.

Thus, the ecological perfection of the farming system and the efficiency of the reproduction of the potential of soil fertility are assessed by the achieved degree of maintaining a deficit-free energy balance of the soil.

When constructing a general balance of the reproduction of the soil energy balance, we used the difference between the input of energy flows (in the form of actual volumes of humified organic matter of plant residues and organic fertilizers) and their standard losses (energy of humus mineralization in the soil) per 1 ha of arable land. This approach has been fundamentally tested and recommended for studies of changes in the content of soil organic matter in intensive farming under production conditions. At the same time, most researchers suggest abstracting from calculations of humus losses due to erosion *(Alkhasov, 2020).*

The construction of such a balance involves the analysis of outgoing and incoming energy vectors. The factor of mineralization of soil organic matter should be considered such a negative (outgoing) vector. The positive (incoming) factors of the soil energy balance should include the intake of organic matter in the form of plant residues, agricultural crops, green manure, as well as traditional and non-traditional types of organic fertilizers.

Table 3 shows some of the energy characteristics of modern technologies in crop production, published in the scientific press and which, in our opinion, can be used as standard indicators in the analysis of the ecological and energy efficiency of agriculture in Kazakhstan. Analyzing the given tabular data, they show that the ecological character of modern agriculture has a generally negative energy orientation in relation to maintaining a deficit-free balance of soil energy potential. This point of view is based on the fact that in most cases the required yield at the current technological level of agriculture for most crops is unattainable even in theoretical terms.

Table 3 – Ecological and energy characteristics of growing major crops

Crops	Intensity of mineralization of soil organic matter, t / ha / thous. MJ / ha	Coefficient of humification of plant residues	Compensating energy volumes of plant residues, which, taking into account the humification coefficient, should enter the soil	Yield level required to maintain a deficit-free balance of energy soil potential, t / ha
Winter wheat and rye	0,70/ 16,1	0,20	80,7	4,2
Barley	0,70/16,1	0,22	73,3	5,4
Peas	0,80/ 18,4	0,23	80,2	6,7
Corn for grain	1,56/36,0	0,20	180,0	11,8
Silage corn	1,47/33,9	0,17	199,3	89,0
Sunflower	1,39/ 32,0	0,14	228,8	11,2
Annual herbs	0,70/ 16,1	0,22	73,3	20,0
Perennial herbs	0,60/13,8	0,25	55,3	7,2
Black steam	2,20/50,0	-	210,0	-

The table was compiled by the author

The data in Table 4 make it possible to judge the extent to which the required level of productivity has been achieved in modern agriculture in Western Kazakhstan to maintain an annual deficit-free soil energy balance.

Table 4 – The level of ecologically sound productivity of the main agricultural crops in the West Kazakhstan region

Cultures	Average(70-80s)		Small indicators	
	Productivity, t / ha	Degree of realization of the required yield, %	Productivity, t / ha	Degree of realization of the required yield, %
Winter wheat	1,2	29	2,6	62
Winter rye	1,0	24	1,8	43
Spring wheat	1,0	20	2,0	40
Spring barley	1,1	20	2,0	37
Peas	0,7	10	1,1	16
Millet	1,1	20	2,0	36
Oats	1,1	21	2,2	42
Silage corn	8,0	9	16,0	18
Annual herbs	7,5	38	11,0	55
Perennial herbs	6,7	93	8,1	113

The table was compiled by the author

As you can see, even the highest indicators are clearly insufficient from an environmental point of view. In this case, from 18% (when growing corn for silage) to 62% (when growing winter wheat) of the annually consumed soil energy was reproduced. If we take into account the average yield indicators, then the degree of realization of ecologically necessary productivity was most often from 10 to 30%.

It should be emphasized that the most significant influence on the achievement of a deficit-free balance of the use of soil fertility energy was and is still exerting motivation for an all-round increase in the yield of agricultural crops. Until now, this has been done most often without any environmental focus. We believe that the factor of productivity can be rightfully attributed to the decisive factors in achieving an expanded reproduction of the energy potential of soil fertility. Obviously, this is how this aspect should be viewed in the future.

Government regulation is needed to create the "ideal" agriculture of the future. A certain level of productivity should become a critical threshold, otherwise, when conducting low-productive agriculture, the farmer must necessarily compensate for the shortage of soil energy at the expense of other sources of organic matter. Such agriculture will objectively have significantly lower efficiency, firstly, due to low yields, and secondly, due to the increased costs of using organic fertilizers, which will determine economic motivation to achieve high productivity and, consequently, economic efficiency. Only such a combination of administrative and economic levers can ensure the real global environmental safety of agriculture, which is the goal of the national project for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021-2025.

The analysis of the use of losses and reproduction of soil organic matter energy in agriculture of the West Kazakhstan region made it possible to draw the following conclusions:

As can be seen from the data presented in Table 5, in general, it can be argued that the fundamental indicators are conservative. In particular, the negative balance of the reproduction of soil energy traditionally took place throughout the entire second half of the 20th century and the beginning of 2000. This pattern practically did not change. It has not changed at the present time. The negative balance of soil energy in different years ranged from 13.1 to 15.1 thousand MJ per 1 hectare of arable land and was 3-4 times higher than the volume of incoming energy.

According to our calculations, in the agriculture of western Kazakhstan in the second half of this century, only 21 to 320% of the soil energy consumed by agriculture was restored. Non-renewable losses ranged from 68 to 79%, respectively. Thus, out of 4 units of consumed soil energy, 3 units are annually consumed irretrievably. At the same time, for the production of 1 unit of energy in the form of the main product in the agriculture of the region, an average of 173-1 units of anthropotechnogenic energy is required, as well as approximately the same amount, from 1.2 to 1.5 units, in different years - the energy of soil fertility. Such data are undoubtedly ineffective and indicate a deep ecological and energy crisis in agriculture in the West Kazakhstan region. This circumstance is one of the main reasons for the current crisis in agricultural production. Moreover, it can legitimately be attributed to the main global world contradictions of modern agriculture.

Table 5 – The balance of the energy potential of the soil in the agricultural landscapes of the West Kazakhstan region (excluding the effect of erosion), thousand MJ per hectare of arable land

Periods	Loss of soil energy	Energy input to the soil in the form of:		Balance (-; +)
	Energy of mineralized soil organic matter	Plant residues	Organic fertilizers	
1950	18,5	3,7	0,1	-14,7
1955	19,1	4,2	0,1	-14,8
1960	20,3	5,1	0,1	-15,1
1970	20,2	5,8	0,2	-14,2
1980	20,5	6,2	0,3	-14,0
1990	20,0	5,9	0,3	-13,8
1998	18,9	4,8	0,1	-14,0
2000	19,2	5,3	0,2	-13,7
2010	19.1	5,5	0,2	-13,4
2018	19.0	5,7	0,	-13,1

The table was compiled by the author

The analysis of the components of this balance shows that due to the yield of agricultural crops in the agriculture of Kazakhstan, from 20 to 30% of the annually mineralized energy of soil fertility is restored, while due to the use of organic fertilizers - only from 0.5 to 1.5%. As can be seen from the data in Table 5, such a ratio was generally traditional for agriculture in western Kazakhstan in the second half of the 20th century.

It should be recognized that the latest crisis in the national agricultural sector has led to some deterioration in the energy balance of the reproduction of soil fertility potential. A decrease in crop yields and the use of organic fertilizers led to an increase in the negative balance compared to the indicators of the early 90s. At the same time, the level of reproduction of soil energy decreased from 31 to 26%.

The situation of a sharp imbalance in the reproduction of the energy of soil fertility in agriculture in Kazakhstan led to a decrease in the energy potential of the soil. The constant consumption of energy sources in the absence of a sufficiently complete and reasonable replacement of them leads to the degradation of the system (agroecosystem), which actually happens in practice. Therefore, the main condition for ecologically sound farming is simple reproduction of soil energy potential. It is on this basis that the ecologically optimal agriculture of the future should be modeled.

The bioenergetic model of individual crop rotations, constructed by us, includes such indicators as the yield of the main crops, the degree of mineralization of soil organic matter and some other standard indicators. In the course of the analysis, we used data from stationary studies (Table 6), which allow us to draw the following conclusions.

Table 6 – Economic and ecological-energy efficiency of crop rotations per 1 ha of crop rotation area

Values	Crop rotations		
	4-field grain steam	**5-field grain steam**	**10-field grain-steam-herbal**
1. Grain yield, tones	0,9	0,9	0,5
2. Profitability, %	18	21	27
3. The total energy consumption, thousand MJ (with the recommended fertilization system	13,5	14,0	10,0
4. Energy productivity, thousand MJ / ha	14,8	15,3	18,9
5. Energy efficiency, rel.	1,1	1,1	1,9
6. Mineralization level, thousand MJ	25,0	23,0	18,3
7. Balance of soil energy potential, thousand MJ (-,+)	-20,1	-18,5	-8,1
8. Efficiency of PAR, % (for main products)	1,5	1,6	2,0

The table was compiled by the author

So, from the point of view of the priority of increasing grain production per unit of arable land, respectively, the highest indicators were obtained in grain-fallow crop rotations. At the same time, the increase in the share of grain crops in the crop rotation from 75 to 80% was not accompanied by an increase in grain yield. It seems important that the increase in the proportion of black fallows in crop rotations (from 10 to 25%) was practically ineffective (see Table 6).

At the same time, as we can see, all other criteria - both economic and environmental - were significantly higher in grain-steam-herb crop rotations.

So, in the latter case, there was an increase in profitability by 1.3-1.5 times; total energy costs in the production process decreased per unit area by 26-28%; energy productivity increased by 24-28%; the efficiency of technologies increased by more than 1.7 times; the level of mineralization, or, in other words, the loss of soil energy potential decreased by 20-27%; solar energy efficiency increased by 25-33%. At the same time, about 56% of the mineralized organic matter of the soil was reproduced annually in grain-steam-grass crop rotations, while in 4-5-field grain-fallow crops - only no more than 20% (see Table 6).

The ecological and economic assessment of the feasibility of various crop rotations is more indicative in the following comparison. So, for 1 unit of the main product in grain-fallow crop rotations, it was necessary to spend 1.1 unit of energy of anthropotechnogenic resources and from 1.5 to 1.7 units of soil energy, with 80% of the latter being lost forever. In crop rotations with the share of grain crops up to 40%, perennial grasses - 50%, fallow - 10%, the production of 1 unit of the main product required only 0.5 units of technogenic energy and less than 1 unit of soil energy. At the same time, only about 44% of the soil energy was irreplaceable.

As you can see, the differences are more than significant and allow us to draw some practical conclusions.

Discussion and conclusions

All of the above testifies, in particular, to the fact that the concentration of sown areas of grain crops and black fallows is a fundamentally erroneous direction in the development of agriculture. With all the need for the culture of black fallows in the conditions of agriculture in the region, the proportion of the latter should be much - almost 1.5-2 times less than at present in practice. The main task is to increase the productivity and efficiency of technologies, and, thus, the growth of productivity and production efficiency per unit area. Only on this basis is it possible to intensively develop agriculture in Kazakhstan.

How can the balance of soil energy be stabilized in modern agriculture? We believe that this is based on three main factors.

Factor 1. Yield growth

Due to this factor, it is impossible to fully compensate for the loss of organic matter in the soil, taking into account the real level of productivity. According to our calculations, at this time, the energy of plant residues in the process of growing crops in western Kazakhstan does not exceed 25-30% of the total energy balance. This indicator fluctuates significantly in different years, but such a ratio should still be considered fundamental.

As evidenced by the results of our research, with the implementation of an active, scientifically grounded agricultural policy aimed at increasing the efficiency of agriculture in every possible way, it is quite realistic to increase the productivity of agriculture in the West Kazakhstan region by 2.2-2.5 times. Moreover, to ensure the required level of competitiveness of the industry, there is simply no other way out.

This growth potential allows increasing the specific weight of the yield factor up to 65% of that required to achieve a positive energy balance. The main role in this will be played by the economic and technological aspects of the problem: the creation of motivations for the growth of production, the optimization of technologies, the improvement of resource and energy supply and the qualitative modernization of the technical state of the industry.

Factor 2. Improving the structure and culture of agriculture

The problem is to find the optimal ratio of crops in crop production, as well as ways to improve the culture of agriculture itself, which will ultimately lead to a decrease in the level of mineralization of soil organic matter and thereby ensure an increase in the ecological safety of agriculture.

Recall that the use of black vapors (and the need for this is currently practically not refuted) requires increased compensation for losses of biological energy. Maintaining a black fallow culture for 1 year is accompanied by almost 4 times more energy consumption of soil organic matter than, for example, in crops of perennial grasses.

Thus, there is a certain prospect for a reduction to possible limits of black fallows and crops, which are characterized by increased mineralization of soil organic matter, as well as an increase in the cultivated areas of perennial grasses. The experience of modern agriculture in western Kazakhstan shows that the above changes are potentially very limited and can only to some extent affect the overall solution to the problem. In general, according to the calculations carried out, due to the above optimization measures, it is possible to compensate for up to 15% of the energy losses of soil fertility.

At the same time, the positive role of the introduction of soil protection technologies, expanding the area of green manure crops, and reducing soil erosion through the implementation of a set of soil protection measures is very significant, i.e. factors that reduce the negative dynamics of the content of organic matter in the soil. According to the calculations, the potential for using the above measures will provide up to 5% of the renewable soil energy. It should also be emphasized that it is on the basis of such factors that the soil conservation agricultural policy is being built today in the leading countries of the world. This direction is reflected in the "Green Kazakhstan" national project.

Factor 3. Use of non-traditional sources of biological energy

The problem of reproduction of soil energy from traditional sources of organic matter - and this is primarily manure - lies both in the limited amount of this source itself, and in the relatively high economic costs of its introduction.

According to our calculations, at the moment, due to traditional types of organic fertilizers in the region, it is possible to compensate for no more than 2-3% of the annually consumed soil energy.

At the same time, there is a much more accessible and cheaper source of biological energy. This is a by-product of crop production, primarily grain straw. Now this source of organic matter is practically not used to maintain soil fertility in the region or is used on an extremely limited scale.

As the evidence of developed economic countries shows, the prevailing trend in intensive agriculture is an increase in the use of crop by-products in order to achieve an expanded reproduction of soil fertility. In particular, in countries such as the USA, Canada and others, it is recommended that at least 40% of by-products be used as organic fertilizer (Alpysbaev K.S., 2021), (Kaidarova L.K., 2020). It is believed that the use of this source of biological energy in global agriculture will continue to increase. Such forecasts are based on both environmental and economic aspects of the need to ensure a sustainable increase in the efficiency of agricultural production (Kantarbayeva S.M., 2020).

In the agriculture of the West Kazakhstan region, the energy of crop by-products is a rather significant source. So, according to our calculations, this figure is 1.3-1.5 times higher than the total amount of energy fixed in the main product. Despite such significant reserves, by-products are practically not used as organic fertilizers in the region's agriculture.

The factor of using crop by-products when achieving a deficit-free balance of soil fertility energy reproduction can potentially provide up to 7-9%, and in the future up to 12% of energy.

Thus, the presented results of analytical studies make it possible to assert about a real possibility to ensure the actual ecological safety of agriculture in the West Kazakhstan region. This level provides for:

- A simple reproduction of annual energy losses of soil organic matter;
- The fundamentally new agriculture, focused on global environmental and economic challenges to achieve sustainable, environmentally reasonable agriculture.

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БАТЫС ҚАЗАҚСТАН АГРОЭКОЖҮЙЕСІНІҢ ЭКОЛОГИЯЛЫҚ ЖӘНЕ ЭНЕРГЕТИКАЛЫҚ ТИІМДІЛІГІ

***Халел ҚҰСАЙЫНОВ**, Қ.Жұбанов атындағы Ақтөбе өңірлік университетінің профессоры, экономика ғылымдарының докторы, Ақтөбе, Қазақстан, Kusainov-x@mail.ru, https://orcid.org/0000-0001-9601-771X*

ЭКОЛОГО-ЭНЕРГЕТИЧЕСКАЯ ЭФФЕКТИВНОСТЬ АГРОЭКОСИСТЕМ ЗАПАДНОГО КАЗАХСТАНА

***Халел КУСАИНОВ**, доктор экономических наук, профессор Актюбинский региональный университет им. К.Жубанова, г. Актобе, Казахстан, Kusainov-x@mail.ru, https://orcid.org/0000-0001-9601-771X*