

ACCOUNTING FOR ENERGY COSTS FOR CULTIVATING CERTAIN AGRICULTURAL CROPS IN NORTHERN MUGHAN

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Abstract

The large-scale challenges facing agricultural production have become significantly more complex. In accordance with the long-term comprehensive program for the development of the agricultural sector of Azerbaijan, its structure is changing and improving, and new forms of organization of production - agricultural and agro-industrial enterprises and associations - are being widely developed.

This article examines a multifactorial approach to the intensification of agricultural production. Along with further expansion of the agricultural technology base (machinery, fertilizers, pesticides, irrigation, etc.), it aims to ensure more efficient use of soil and climate resources, biological inputs (species, varieties, breeds, agro-zoocenoses), advanced technologies, and new forms of production planning and organization in Northern Mughan. Energy consumption for cultivating cotton, winter wheat, corn, barley, and alfalfa on average over two years (2022-2023) at a private farm in the Saatli district of Northern Mughan is presented.

As a result of the research, we can note that alfalfa cultivation is the most efficient method, and for every 1 MC of anthropogenic energy consumed, 4.9 MC of energy is returned at harvest. For silage corn, this figure is slightly lower, at 3.96 MC per 1 MC consumed; for barley, 2.87 MC; and for winter wheat, 2.06 MC. For cotton, this ratio approaches 1 MC.

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1. Introduction

Soil, as an integral part of the natural complex, is a vital source of energy and material well-being for humanity. Further increase in agricultural production is possible only through proper, highly efficient and economical use of land, which is the main means of production in agriculture. This requires an understanding and in-depth analysis of climatic conditions that affect all aspects of agricultural production [1, 2].

The large-scale challenges facing agricultural production have become significantly more complex. In accordance with the long-term comprehensive program for the development of the agricultural sector of Azerbaijan, its structure is changing and improving, and new forms of organization of production - agricultural and agro-industrial enterprises and associations - are being widely developed.

A multifactorial approach to the process of intensification of agricultural production, further expansion of the technogenic base of agriculture (machinery, fertilizers, pesticides, irrigation, etc.)

is planned to ensure more efficient use of soil and climate resources, biological means of labor (species, varieties, breeds, agrozoocenoses), advanced technologies, new forms of planning and organization of production, achievements of world science and practice. "Only on the basis of comprehensive, integrative intensification can we achieve sustainable growth of agricultural production with a relative decrease in the specific consumption of resources (material, energy, labor)" (A.A. Juchenko, 1963) [5].

2. Material and method

The following factors were used to calculate direct energy costs: 43 MC/kg for fuel; for human energy costs, the FAO work intensity scale was used, from the lightest work (2.5 cal/min) to the heaviest work (15 cal/min).

Indirect energy costs for technological operations were calculated using the formula [9, 10]:

$$E_1 = \frac{\text{Weight of mechanism} \times 63,7 \text{ MC}}{\text{Lifetime of the mechanism} \times \text{depreciation} \times F} \quad (1)$$

Here, E_1 - is the machine energy.

F - is the ideal mechanism utilization factor.

The study used data from farm flow charts.

The following formula was used to determine the energy costs of agricultural production:

$$E_1 = \sum_{j=1}^m aj + \sum_{i=1}^n b_i + \sum_{k=1}^p ck \quad (2)$$

Where: E_1 - is the total energy consumption for crop cultivation; a - is the energy consumption for machine production and delivery to the workplace; b - is the energy consumption for the production and delivery of mineral fertilizers; c - is the energy consumption spent on agricultural practices.

The relative efficiency coefficient of anthropogenic energy use (r) is calculated by the following formula:

$$r = \frac{E_2}{E_1} \quad (3)$$

Here E_2 - is the chemical energy of the useful product.

Field measurements of agricultural machinery usage and fuel and lubricants in production conditions were also conducted. These data were compared with technical maps for agricultural machinery on the farm.

3. Analysis and discussion

The main principle of research is to develop practical proposals based on the development of fundamental sciences, along with the development of fundamental sciences. Currently, every study devoted to the study of living natural objects, especially their complexes, emphasizes the importance of studying the cycles of matter and energy. However, the level of understanding of these two fundamental components of the development of natural components remains disproportionately variable. Until now, researchers have devoted their main efforts to the study of the cycle of matter. However, although researchers clearly understand the need to study the cycles of matter and energy, the energy aspect of natural transformations has been studied very little.

It can be said that the general direction of scientific natural science is a systematic approach, where energetic factors also play an important role. This is, first of all, the theory of the biosphere of V.I. Vernadsky, which determines the interaction of living and non-living, geological and their relationship with the cosmic factor - the incoming radiation energy of the sun, and the theory of biogeocenoses of V.I. Sukachev, which defines new ways of understanding the processes of material-energy interaction in the biosphere [4].

Despite the deep research in all these areas, the general picture of the interactions in the processes of matter and energy transformation on the Earth's surface remains largely unclear. A systematic approach to the study of natural objects makes the use of energy (thermodynamic) criteria and data particularly necessary. The study of the transformation and migration of substances involves the identification and description of extremely complex systems, since the material composition of plants, animals, soils and other areas is represented by various chemical compounds. Even the transition to the use of elemental composition in the study of matter only partially reduces the difficulties of this problem.

In the transition to the use of energy concepts and criteria in the study of biosphere processes, we first gain the ability to describe the processes occurring in the biosphere in their most general form, in their essential essence, and to evaluate them in individual quantitative units such as calories or joules. Then, and more importantly, we are able to discover new aspects of ecosystem processes. Here it is worth recalling the cascade nature of energy transfer and matter circulation, first identified by Lotke and Macfaill, where substances can be returned to the ecosystem many times in each period, while each part of the energy passes only once and is irreversibly lost at each stage of the food chain [2].

In addition, the energy approach allows us to detect and quantitatively study phenomena and processes that are still unclear only at the material level. Based on the laws of thermodynamics, we can identify important relationships in these flows and, as a result, more fully substantiate rational methods for controlling these processes. However, to achieve this, it is necessary to detect energy flows throughout the entire complex of interconnected components of the biosphere.

Agricultural systems can be viewed as ecosystems of which humans are an integral part, as well as as human-controlled chemical engineering processes in which sunlight, carbon dioxide, nitrogen, phosphorus, genetic information, etc. are used to produce carbohydrates and other nutrients. "Humanity is currently facing a critical challenge: to feed the world's growing population. So far, the task of increasing agricultural production has been solved by expanding cultivated areas and improving agricultural practices, increasing fertilizer use, and restoring wetlands and saline lands."

"However, the need to move to a new strategy, which can be formulated as a requirement to ensure the most complete and beneficial use of

solar energy, is becoming increasingly clear. Photosynthesis, by which plant substances are formed, is a crucial link in this process" [6,7]. Therefore, in the work on the scientific foundations of programming high agricultural productivity in developing countries, it is understandable that the first task is to create conditions for the maximum possible use of solar energy accumulated in the plant mass of agricultural plants during photosynthesis. At the same time, FAR does not fully reveal the picture of energy transformations in agrobiocenoses. Since only FAR is used in photosynthesis processes, it uses only a fraction of the FAR. Therefore, there is a need for a more complete coverage of energy transformations in the processes of biomass formation. To cover these processes, biogeoenergy and soil energetics are used. These studies can be widely diversified, covering all elements of biogeocenoses: the layer of the atmosphere above the earth's surface, plants, soils, subsoil resources, microorganisms and wildlife. "Biogeoenergetics aims to reveal all the pathways of energy transfer and forms of solar energy transformation in soil-plant complexes and to determine the relationships in this cycle, the influence on which will ensure the most productive use of solar energy by soil-plant systems" [5].

The transition from the extensive path of development to the intensive path of development and, above all, the emergence of a qualitatively new means of interaction between man and nature - machine technology - is due to the fact that the latter, in comparison with the natural factors available to man at that time, became a more powerful means of influencing nature in order to obtain the necessary material goods, which led to an increase in labor productivity and, as a result, the amount of goods produced. "Technology developed because humanity, in the limited space of the world, was looking for ways to increase the production of goods that were important to it, and did not find them. While developing technology in every way, expanding and intensifying this process of interaction between society and nature, people continued to proceed from the fact that a number of important natural resources - water, air, land, etc. - are, on the one hand, a "gift", free, and on the other hand, practically inexhaustible, and therefore, supposedly, there is no need to worry about them" [3, 4, 8].

Thus, the transition to intensive interaction with nature has led to ecological problems.

It is known that energy resources are divided into non-renewable (coal, oil, gas, oil shale, nuc-

lear energy) and renewable (forest, hydropower, tidal and wave energy, etc.). Renewable energy resources have an advantage over non-renewable energy resources, since their use causes environmental pollution. It should also be noted that calculations show that "by 2050, all economically viable fossil fuel reserves will be exhausted. If we assume that future geological development and an increase in the production coefficient will lead to an increase in existing reserves, for example, by 8 times, then in this case these reserves will be exhausted not in 2050, but in 2110, that is, not in 30 years, but in 140-150 years."

The abundance of solar energy is essential for life on Earth and is considered a driving force beyond geochemical, biochemical, and zoological factors. Over the past century, some of the solar energy stored as fossil fuels has been used by humans. This fossil energy has led to unprecedented intensification in technology, education, and social life. As existing fossil fuel reserves are depleted and a significant portion of fossil fuel energy is stored in hard-to-reach reserves, humans are entering a new phase of evolution and interactions within the biosphere.

The purposeful use of the energy produced in agriculture includes industrial nitrogen fixation, "the extraction of phosphorus, potassium, sulfur, limestone and other minerals", irrigation, and requires the supply of industry and the transportation of agricultural products.

Thus, since the relationship between the combustion of the energy produced and the subsequent energy extraction in agriculture is only marginal, it is impossible to compare them.

Figure 1 shows a general diagram of energy consumption in agricultural production (crop production). The left side of the figure represents renewable (natural) energy resources, and the right side represents anthropogenic energy (embodied energy + human labor energy). Agronomic measures are designed to act as catalysts.

Thus, it is clear that all types of fuel and energy resources used by humanity are used both directly and indirectly in the process of agricultural production.

In modern developed countries, 22% of total energy consumption is spent on agriculture (in the USA this figure reaches 17%), that is, on food production. 1/3 of this energy is consumed directly in production, and 2/3 in agro-industrial complexes. About 70% of the energy directly consumed in agriculture comes from mineral fertilizers, pesticides, agricultural tractors and machines ("embodied energy"). About 30% comes

from fuel, energy and seeds, and a small part from the energy of human labor; thus, as US agriculture has strengthened, the share of manual labor has fallen from 12,500 kcal to 4,900 kcal.

Referring to literature sources, a graph (Figure 1) was constructed that reflects the relationship between the energy consumed for agricultural needs of agricultural systems in eight countries and the energy returned in the form of crops (crop production) and livestock products, as well as the energy efficiency coefficient (upper part of the figure).

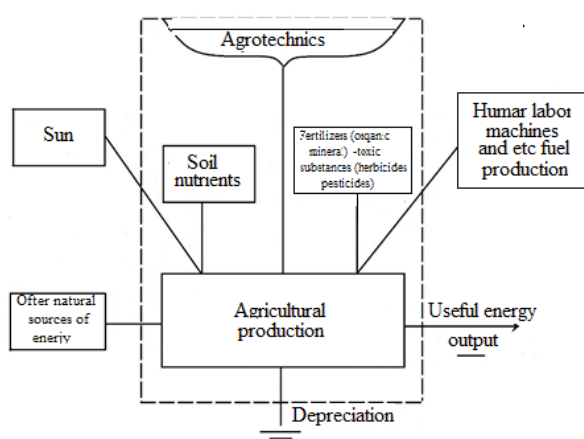
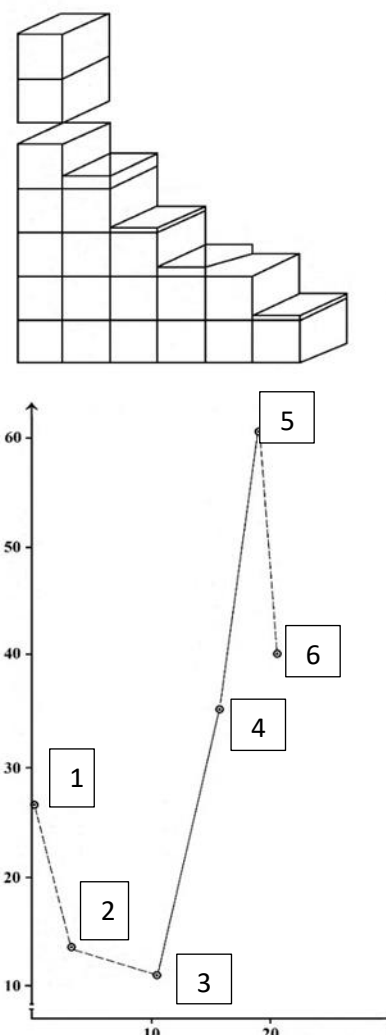


Figure 1. Scheme of energy costs in agricultural production

Analyzing the literature, we can note that as agricultural production intensifies, its unit costs increase and the efficiency ratio decreases. For example, in the Congo Basin, for every calorie of energy expended in slash-and-burn agriculture, 65 calories are returned in the form of crops. In this case, the cultivation technology is very primitive, simple. Energy consumption is mainly associated with the use of human labor.

In Mexico, the energy efficiency ratio drops sharply from 128.8 to 4.1 when wheat is grown, because in many cases oxen were used as draft animals. Economically developed countries also tend to have stable energy efficiency ratios for cereal crops, ranging from 2 to 5 calories per unit input. However, even here, when you look closer, different nuances emerge. For example, the energy efficiency of corn cultivation in Hungary is 3.5, while in Azerbaijan it is 3.0. This difference may seem insignificant. However, as Figure 3 shows, with almost the same costs incurred, productivity in Hungary is about 1.5-2 times higher than in Azerbaijan.

Thus, current methods of intensification of agricultural production are associated with high energy costs.



Relate energy consumption to energy returned as productivity. 1. Mexico; 2. Mexico (biofuels potential); 3. India; 4. Azerbaijan; 5. Great Britain; 6. United States of America

Figure 2. Energy savings of winter wheat cultivation

In accordance with the research plan, a survey was conducted on cotton, winter wheat, corn, barley and alfalfa crops on farms in Northern Mughan, and direct and indirect energy costs were measured. Direct costs include fuel, electricity and the energy content of the workforce. Indirect costs include energy costs for the extraction and processing of ore, coal, gas, oil and other raw materials, as well as energy used in the production of agricultural machinery, fertilizers, plant protection products and irrigation systems.

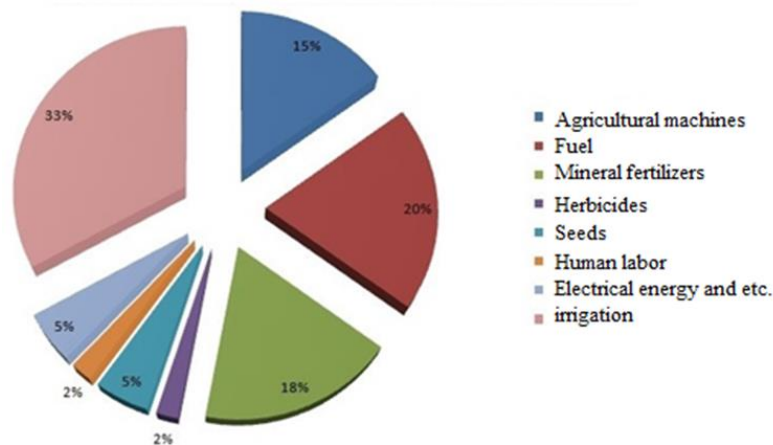


Figure 3. Structure of energy consumption in crop production in the arid climate of the Kura-Aras lowland of Azerbaijan

Table 1
Technical energy consumption in the conditions of auxiliary experimental farm in Saatli district (Northern Mughan), MC

Energy consumption	Cotton	Winter wheat	Corn	Barley	Alfalfa
Machines	7334	3900	4900	3250	3550
Fuel	11050	5000	5600	4350	4800
Nitrogen	8400	4050	4400	2800	-
Phosphorus	1900	750	870	600	870
Potassium	1090	150	505	255	-
Herbicides	1050	750	500	420,5	-
Irrigation	16700	10600	11362,5	8750	9000
Seed	2850	1380	1520	1616	80
Electrical energy	500	320	320	320	200
Transportation	675	600	600	600	600
Human labor	1000	355	600	350	290
Other expenses	1100	975	1050	950	915
Sum of expenses	53649	28830,5	32377,5	24261,5	20305
Product (MC/ha)	55431	59211	127265,2	69565,8	99539,3
Coefficient "r"	1,04	2,06	3,96	2,87	4,91

In addition to these energy costs, the production costs of mineral fertilizers and herbicides are also taken into account. The energy equivalents of nitrogen, phosphorus and potassium fertilizers include the extraction of raw materials, the operating costs of enrichment equipment, plant and processing plant equipment, and the energy spent on transporting raw materials and fertilizers by rail. The energy equivalents for irrigation systems include the entire period of earthworks and technical work required to create these systems.

Figure 3 shows the structure of energy costs in agricultural production in Azerbaijan, calculated using data from the Central Statistical Office.

Research to identify and account for anthropogenic energy flows in various agrophytocenoses at an agricultural experimental farm in the Saatli district of Northern Mughan.

Table 1 shows the energy consumption for the cultivation of cotton, winter wheat, corn, barley, and alfalfa over an average of two years.

Studies show that cotton cultivation is the most energy-intensive production technology. The total energy consumption in the first year was 53,560 MC/ha and in the second year was 53,738 MC/ha. The free energy yield (fiber) for 2022 and 2023 was 55,737 MC/ha and 55,125 MC/ha, respectively.

Alfalfa cultivation is the least energy-intensive technology, with costs of 20,630 MC/ha and 19,980 MC/ha during the study years, and free energy productivity (yield) of 99,650 MC/ha and 99,428 MC/ha.

Cereal crops occupy a medium position in energy intensity. The costs of cultivating winter wheat during the study years were 27,251 MC/ha and 30,410 MC/ha; for corn, these costs were

29,840 MC/ha and 34,915 MC/ha; for barley, 24,586 MC/ha and 23,937 MC/ha. The free energy productivity was as follows: for winter wheat, 59,922 MC/ha and 58,500 MC/ha; for silage corn, these costs were 126,392 MC/ha and 128,138.4 MC/ha; for barley, 69,729.1 MC/ha and 694,025 MC/ha.

The main part of energy costs in irrigated agriculture falls on irrigation measures. Thus, for cotton it is 31% (on average over 2 years), for winter wheat 36.8%, for corn 35%, for barley 36%, for alfalfa 44.3%. On average, this figure for all crops was 36.6%.

The total share of mineral fertilizers and chemical plant protection products used (in percent) was 23.2% for cotton; 19.8% for winter wheat; 19.4% for silage corn; 16.8% for barley; and 4.3% for alfalfa.

The use of agricultural machinery and fuels and lubricants is also a major energy consumption item. The share of these energy costs is: for cotton - 34.3%; for winter wheat - 30.9%; for silage corn - 32.4%; for barley - 31.3%; for alfalfa - 41.1%.

Energy intensity is a good indicator of labor intensity. Here the following are found: the most labor-intensive process is cotton cultivation - 1000 MC/ha; The least labor-intensive process is alfalfa cultivation, 290 MC/ha; cereals occupy an intermediate position, with costs ranging from 350 MC/ha (barley) to 600 MC/ha for corn.

Interesting conclusions can be drawn from the relative efficiency estimates (the "r" coefficient) of various agricultural crops.

4. Conclusion

In conclusion, we note that alfalfa cultivation is the most efficient method, and for every 1 MJ of anthropogenic energy consumed, 4.9 MC of energy is returned at harvest. For silage corn, this figure is slightly lower, at 3.96 MC per 1 MC consumed; for barley, 2.87 MC; and for winter wheat, 2.06 MC. For cotton, this ratio approaches 1 MC.

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ŞİMALİ MUĞAN ŞƏRAİTİNDƏ KƏND TƏSƏRRÜFATI BİTKİLƏRİNİN BƏCƏRİLMƏSİ ÜÇÜN ENERJİ XƏRCLƏRİNİN UÇOTU

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Xülasə. Kənd təsərrüfatı istehsalının qarşısında duran genişmiqyaslı çətinliklər xeyli mürəkkəbləşib. Azərbaycanın kənd təsərrüfatı sektorunun inkişafı üçün uzun müddətli kompleks proqrama uyğun olaraq, onun strukturu dəyişir və təkmilləşir, istehsalın təşkilinin yeni formaları - kənd təsərrüfatı və aqrar-sənaye müəssisələri və birlikləri geniş şəkildə inkişaf etdirilir.

Təqdim olunan məqalədə kənd təsərrüfatı istehsalının intensivləşdirilməsinə çoxfaktorlu yanaşma araşdırılır. Kənd təsərrüfatı texnologiyası bazasının (maşın, gübrələr, pestisidlər, suvarma və s.) daha da genişləndirilməsi ilə yanaşı, Şimali Muğanda torpaq və iqlim ehtiyatlarından, bioloji mənbələrdən (növlər, sortlar, cinslər, aqrozoosenozlar), qabaqcıl texnologiyalardan və istehsalın planlaşdırılması və təşkilinin yeni formalarından daha səmərəli istifadəni təmin etmək məqsədi daşır. Şimali Muğanın Saatlı rayonundakı fərdi təsərrüfatda orta hesabla iki il (2022-2023 illər) ərzində pambıq, payızlıq buğda, qarğıdalı, arpa və yonca becərilməsi üçün enerji sərfiyyatı təqdim olunur.

Tədqiqatların nəticəsi olaraq qeyd edə bilirik ki, yonca becərilməsi ən səmərəli üsuldur və sərf olunan hər 1 MC antropogen enerji üçün məhsul yığımında 4,9 MC enerji qaytarılır. Siloslu qarğıdalı üçün bu rəqəm bir qədər aşağıdır, sərf olunan 1 MC üçün 3,96 MC; arpa üçün 2,87 MC; və payızlıq buğda üçün 2,06 MC təşkil edir. Pambıq üçün bu nisbət 1 MC-ə yaxınlaşır.

Açar sözlər: aqroenergetika, texnoloji enerji, Şimali Muğan, kənd təsərrüfatı bitkiləri, becərmə.