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COMPARATIVE RESEARCH REGARDING THE ENERGY EFFICIENCY OF WHEAT CROP, IN ECOLOGICAL AND CONVENTIONAL CULTIVATION SYSTEMS

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Abstract

Due to the importance of the winter wheat crop, in ensuring the food needs of the population, and for increasing the average and total production, it is necessary to ensure a high economic efficiency of the use of energy in agriculture, by increasing the degree of mechanization in production processes, the development of irrigations, the substantial increase in the quantities of chemical fertilizers used, the creation of new varieties and hybrids that are more productive and of higher quality, increases direct and indirect energy consumption. In order for this share not to increase, given the substantial growth in agricultural production, it is necessary to apply a complex of measures that ensure, along with the increase in the economic efficiency of energy use, a minimum energy consumption per unit of product or per unit area. Conserving soil and preventing soil degradation has become imperative in our efforts to ensure food security, protect biodiversity and maintain healthy ecosystems. The purpose of establishing this experiment was to compare the results regarding the production achieved in the wheat crop, the expenses incurred, the incomes achieved and the profitability of the crop both in ecological and conventional systems. In the conventional system, the incomes were higher so, the yields were higher. The energy efficiency of the two culture systems analyzed was another aspect studied. For realize one unit of product it was consumed 0.108 kwh in conventional system while, in organic variant it was consumed 0.184 kwh, witch mean a better energetic efficiently for conventional one.

Key words: *wheat, culture technology, conventional system, ecological system, energetic efficiency*

INTRODUCTION

Due to the importance of the autumn wheat crop, in ensuring the food needs of the population, in addition to increasing the average and total production, it is also necessary to ensure a high economic efficiency of the use of energy, and the calculation methods used allow to determine the contribution of the various treatments to increase production and improve energy indicators, given that the economic profitability of crops within agricultural holdings differs depending on the volume of production factors used and their influence on production obtained [4, 6]. The areas cultivated with grain corn was 3.3 million ha, absolute record being recorded in 1992 [17]. Conventional farmers should be encouraged to switch to organic farming, and organic farmers should be properly rewarded for the public goods they deliver, producing quality food while protecting nature [3]. Increased support for organic farming is a smart public policy tool to ensure that the next CAP will contribute to the green agreement and the goals of the Fork and Biodiversity Farm strategies [13,14]. Achieving 25% organic land in the EU by 2030 will only be achievable if Member States devote a much larger share of the CAP budget to organic conversion and maintenance than is currently the case in most countries(Ecological Agriculture) [3,12,14]. Mechanization creates environmental risks because it does not differ from the conventional one in terms of fuel for agricultural work [2].

A study carried out and published by the European Commission concluded the comparison made between the two agricultural models - organic and conventional - to see which is more profitable [22, 23].

Following research, it has been proven that organic farming brings slightly higher incomes in some cases [23]. When factoring in the upfront costs of pesticides, fertilizers or fuel to get the crops, organic farming has some advantages [4]. It turns out that mechanization creates environmental risks, because it does not differ from the conventional one in terms of fuel for agricultural works [7, 18]. The main conclusion of the study is the existence of small differences between the two agricultural models when it comes to invested capital, but the expenditure is aimed at obtaining certifications and investing in special equipment [2,19].

Organic farming is a management system of agricultural production that favors renewable resources and recycling and does not harm the environment [13].

Several surveys and studies have attempted to analyze and compare conventional and ecological agricultural production systems.

Organic farming is less harmful because ecological farms do not consume or release synthetic pesticides into the environment, because their use would result in damage to the soil, water and wildlife, terrestrial and aquatic; ecological farms support ecosystems. The beneficial action of the tillage system on a crop factor must keep the other factors at an acceptable level [20, 21], so that the increase of agricultural production, the decrease of fuel consumption or the increase of the soil production capacity can be possible through economic optimization solutions [1, 7, 16, 18]. Compliance with the rules and principles for the production of organic crops are regulated by national legislation. The control of the entire technological process of obtaining such a product is done by inspection and certification organizations [22].

The common wheat crops produced in organic agriculture conditions revealed the superior quality of the crop in terms of nutritional value, as well as the absence of compounds that can negatively influence the quality of the harvest [13]. Another important problem arises, namely the fact that in ecological agriculture the allocated resources are small, which can cause low productivity [9,11]. The seeds quality is another important factor for the success of the harvest, their genetic and somatic value being decisive [8,17]. Ecological agriculture, with reduced inputs, requires a lower amount of energy compared to agriculture in conventional system, which can determine the saving of allocated energy and the decrease of carbon emissions on a large scale [9, 13].

Any form of energy can be transformed into another, energies are storable and transferable in different ways [5, 7]. The quantification of energy spent in the agricultural production process is highly complex. In the specialized literature, there is no unanimous opinion regarding the coefficients of equalization of the forms of energy, as well as on the grouping of the types of energy used in agriculture [2, 5, 8]. The energy consumed to obtain agricultural production (Ec) includes a whole series of expenses and was structured as follows:

-direct active energy or direct external energy (human energy, energy mechanics, etc.);

- indirect active energy, necessary for the production of goods consumables in a single production process (seeds, pesticides, chemical fertilizers etc.);

- passive energy, necessary for the production of fixed assets (machinery, constructions etc) used in agriculture.

From the total energy consumed to obtain the vegetable agricultural production, active energy consumption holds the largest share [10]. The consumption of passive energy, being distributed over the years of use of the respective fixed assets, on works and cultures, etc., has a smaller influence on the total energy consumption.

In this context, the purpose of the paper is to comparatively analyze the winter wheat yield and production carried out in conventional versus ecological system in close relationship with expenses, incomes and profitability and also to assess the energy consumption, in order to find out which agro-system is more efficient from this point of view.

MATERIALS AND METHODS

The study carried out in the Experimental Field of the Research and Development Station for Pomiculture Băneasa during the period 2020/2021 (Map 1).

Map 1. Experimental plots
Source: Research and Development Station for Pomiculture, SCDP Baneasa.

The experimental site was located on a flat land (below 3%), with southern exposure, the soil type being typical preluvosol, formed on loess, well supplied with humus.Particle size analysis to determine the soil content of dusty clay and sand revealed a high percentage of clay ranging from 32.4% in the upper horizon 0-20 cm, 33.4% at depth 20-40 cm and 39.4% at depths greater than 40 cm. The loamy-clayey texture results in low nutrient mobility and poor soil water permeability. Apparent density at depth 0-20 cm 1.53 g/cm3 medium, high at 20-40 cm 1.50 g/cm3. Low total porosity throughout the depth of the profile. The degree of soil compaction ranges from 16%, the soil is moderately compacted to 18% at depths greater than 40 cm, heavily compacted, pH in the surface horizon of 5.27.Humus content 2.46, Nt 0.135, PAL 59, KAL 105 and C/N ratio 12.4.

Base saturation 72%, hydrolytic acidity 5.89, sum of exchange bases 15.18.

To achieve the objectives, a monofactorial experience was carried out where

a1: Conventional agriculture

a2: Organic farming

The size of the experimental plot was 480 m^2 (16x30) and that of the harvestable plot was 176 m^2 (8x22), following the elimination of the edges.

A protective strip was provided around the experiences having the working width of a seeder. The seeder used to sow the experimental plots was the D9 seeder from Amazone, with a working width of 4 m, for wheat. The biggest energy consumers are soil work, especially plowing, the basic work of the soil, this consumption being influenced by the structure, texture and humidity of the soil. The highest indirect energy consumptions are those related to the application of chemical fertilizers.

For these reasons, the possibilities of cultivation using direct seeding or basic works that do not involve turning a furrow are also evaluated from an economic point of view. The economic profitability of the crops within the agricultural holdings differs depending on the volume of the production factors used and their influence on the production obtained [12,15]. The purpose of establishing this experiment was to compare the results regarding the production achieved in the wheat crop, the expenses incurred, the incomes achieved and the profitability of the crop both in ecological and conventional systems. Another aspect followed was the energy efficiency of the culture systems.

Comparisons between fuels

Historically, mankind has generally obtained energy by consuming fossil fuels, so comparing fuel sources in terms of the amount of unit energy they contain helps with this calculation.

1 kg of anthracite (4% moisture) = 36MJ = 10 kWh

1 m3 natural gas = 39 MJ = 10.8 kWh

1 liter of petrol = 34 MJ = 9.4 kWh

1 liter of diesel = 40 MJ = 11.1 kWh

1 liter of liquefied petroleum gas = 41 MJ = 11.4 kWh

1 liter of fuel oil = 44 MJ = 12.2 kWh

By comparison, 1kg of renewable fuel such as woody biomass typically contains 4.2 kWh. 1 liter of diesel contains approximately 18% more energy than 1 liter of petrol.

RESULTS AND DISCUSSIONS

According to Table 1, soil works are the link that consumes the most energy and fuel, the costs amounting to 1,897.7 Lei/ha out of a total of 3,852.8 Lei/ha, the difference being claimed by the crop maintenance works and the necessary phytosanitary products. Complex fertilizers N:P:K +SO3+ Zn were applied in a dose of 200 kg/ha pc, for the basic fertilization.

The seed used was the Avenue variety with a rate per hectare of 200 kg/ha. This variety has been preferred by many farmers due to its qualities: very good production potential, medium-sized plants, with very good tolerance to falling, good tolerance to brown rust and Fusarium wilt, very good winter tolerance. very high power twinning (the brothers have an erect habit), ideal precursor for early sowing of rapeseed, recommended to be cultivated in all cultivation areas, but especially in the south and south-east of Romania due to the fact that it reaches flowering (not maturity) before the arrival of very high temperatures.

It has good baking qualities: G% 26-28; P% 12-12.5; W 200-250; MH 73-75 kg/hl. The seed treatment was carried out with the product Amiral Proffy 6 FS and Nuprid AL 600 FS. Fertilization, in the spring, was carried out with urea, 100 kg/ha pc. To combat weeds, the herbicide Omnera was applied in a dose of 0.75 l/ha. In April, we intervened for the treatment of diseases and pests, as well as the application of a foliar fertilizer with the products Falcon Pro, 0.7 l/ha, Cypeguard Max, 0.05 l/ha and Microfert U in a dose of 3 l/l/ha.

The next phase fertilization was carried out in April with ammonium nitrate, 100 kg/ha. In May, another phytosanitary treatment was applied using the products Microfert Alga 3 l/ha, Mizona 0.6 l/ha and Faster Delta 0.3 l/ha. The climatic conditions of the year favored the attack of foliar diseases and pests, necessitating the application of another phytosanitary treatment with the products Nativo Pro 325 SC 0.6 l/ha and Afinto 0.14 l/ha. The total technological expenses incurred for the establishment of wheat cultivation in the conventional system amounted to 3,852.8 lei/ha.

Wheat culture in conventional system

Planned production - 8,000 kg/ha. The previous culture was the rapture.

The consumptions in the first part of the vegetation (unfinished production) are identical, the applied works being approximately the same, with the same amount of diesel fuel consumed (Table 2).

In the second part of the vegetation, the expenses related to the application of the programmed technology are higher in the ecological culture system, expenses generated by the higher price of phytosanitary products used to fight diseases and pests, but also of fertilizing products.

To combat diseases and pests, the Aminotop MN and Aminotop Ultra products were applied along with Alggreen, Buster and Sticker bio. The seed treatment was carried out with Bio SSP, Freya Seed, Germino seed products. A soil treatment was also carried out with N-Bacter products, Country Terra Clean+P+Fix+Roots.

Table 1. Technological sheet of the wheat crop cultivated in conventional system

Indicator	Diesel consumption Liters	Expenses Lei	Total technology expenses Lei
Stubble-turning 8-12cm	5.6	88.5	88.5
Disk 15cm	5.6	88.5	119.3
Fertilized equipment serviced			10.5
Fertilize	1.2	33.8	313.8
Plowgh	20.5	362.3	362.3
Disk 15cm	5.6	88.5	88.5
Combinator	4.0	56.3	156.3
Treat the seed with insecto-fungicides	0.9		129.8
Seed transport	2.58	3.75	7.3
Sowing	5.0	119.3	584.2
Serviced seeders	-	-	5.9
Total unfinished production	**50.9**	**841.0**	**1,843.6**
Fertilized with solid fertilizers	1.2	33.8	270.4
Foliar fertilizer + phytosanitary treatment	1.0	27.8	173.0
Herbicide	1.21	35.6	266.4
Transport	0.9	7.8	8.0
Insecticide treatment	1.7	41.9	135.1
Fungicide treatment	1.7	41.9	230.5
Harvesting	10.4	800	800.0
Transportation 5 km away	5.0	60	117.0
Straw balling	4.0	-	8.8
Total finished production	**27.1**	**1,056.7**	**2,009.2**
TOTAL GENERAL	**78.0**	**1,897.7**	**3,852.8**

Source: Own calculation.

Fertilization was carried out with Bio Ostara N, 100 kg/ha, Bio Ceres NPK, with doses of 200 kg/ha simultaneously with the work to be discussed.

Wheat culture in ecological system

Planned production - 5,000 kg/ha. The previous culture was the rapture (Table 2).

Table 2. The technological sheet of the wheat crop grown in ecological system

Indicator	Diesel consumption Liters	Expenses Lei	Total technology expenses - Lei
Stubble-turning 8-12cm	5.6	88.5	88.5
Disk 15cm	5.6	88.5	119.3
Fertilized equipment serviced			10.5
Fertilize	1.2	33.8	355.3
Plowgh	20.5	362.3	362.3
Disk 15cm	5.6	88.5	88.5
Combinator	4	56.3	284.2
Treat the seed with insecto-fungicides	0.9	-	197.8
Seed transport	2.58	3.75	8.8
Sowing	5	119.3	370.6
Serviced seeders	-	-	5.9
Total unfinished production	**50.9**	**841.0**	**1,891.7**
Fertilized with solid fertilizers	1.2	80.8	519.3
Foliar fertilizer + phytosanitary treatment	1.0	7.8	332.5
Transport	0.9	27.8	33
Herbicide	1.39	11.0	298.8
Serviced crop treated equipment	0.9	8.8	27.8
Transport	0.9	7.8	8.0
Insecticide treatment	0.4	128.0	258.8
Fungicide treatment	1.7	141.9	274.0
Harvesting	10.4	600.0	600.0
Transportation 5 km away	5.0	60.0	117.0
Chopping vegetable scraps	4.0	89.0	181.0
Straw balling	4.0	-	8.8
Total finished production	**31.8**	**1,162.9**	**2,653.1**
TOTAL GENERAL	**82.7**	**2,004.0**	**4,544.8**

Source: Own calculation.

Energy efficiency analysis - Wheat conventional system
Total energy consumption
Diesel consumption (litres) xkw/l diesel
78x11.1=865.8 kw
Energy consumption/unit of harvested product
Total energy consumption: production (kg)
865.8:8,000=0.108 kwh
Energy efficiency analysis - Wheat ecological system
Total energy consumption
Diesel consumption (litres) x kw/l diesel
82.7x11.1=917.9 kw
Energy consumption/unit of harvested product
Total energy consumption: production (kg)
917.9:5,000=0.184 kwh.

Obtaining small productions in the wheat culture cultivated in the ecological system had a negative impact on the energy balance, the energy consumption for obtaining a unit of product being high, 0.184 kwh compared to 0.108 kwh in the wheat cultivated in the conventional system (Table 3).

Fuel consumption for the establishment and maintenance of the culture was higher in the ecological system, 82.7 l/ha compared to 78 l/ha consumption recorded in the conventional culture system. The energy consumption was, implicitly, higher, increasing the technological expenses.

Table 3. Energy efficiency of the analyzed systems

Indicator	Conventional system	Ecological system
Diesel consumption-l/ha	78	82.7
Diesel consumption-lei/ha	1,897.7	2,004.0
Total technological costs–lei/ha	3,852.8	4,544.8
Total energy consumption-kw/ha	865.8	917.9
Energy consumption/unit of harvested productkwh	0.108	0.184
Yield –kg/ha	8,000	5,000

Source Own calculation.

Of the active energy consumed, the most significant share was the consumption of direct active energy, and this, in turn, is largely determined by the fossil energy consumed (fuel consumption) for the movement of agricultural aggregates in the work process during which produces mechanical work [1, 6, 3]. Energy consumption with chemical fertilizers represented the highest share in indirect active energy expenses.

Out of the total amount of agricultural work performed to obtain agricultural production, the highest energy consumption (fuel consumption) is carried out during the execution of soil works. The basic work of the soil consumes the largest amount of mechanical energy, representing about 35% of the total energy consumed for the mechanized execution of works in plant production.

Whatever culture system we choose, its efficiency is important. As a result, in order to establish the economic efficiency of each culture system analyzed, as well as the comparison of the two, conventional and ecological, it was necessary to calculate some indicators such as the expenses incurred for the establishment of the crops, therefore, the production expenses, the unit cost per product unit, recorded income, realized profit and profit rate.

Production expenses
Total production expenses (lei/h) consisting of:
- direct expenses
- indirect expenses.

In order to calculate the expenses per hectare, the technological sheet of the experimental variants is drawn up, in which all the works are listed in chronological order and expressed in value.

Direct expenses can be grouped into constant expenses and variable expenses

a) constant expenses are those that were made for all variants equally and include:
- land preparation expenses (ploughing, harrowing, harrowing, seed bed preparation, sowing)
- expenses with the application of fertilizers and their cost
- expenses related to the maintenance of the culture and the transport of the harvest
- harvest expenses.

b) Variable expenses are those that have been differentiated on each variant depending on the treatment applied.

Indirect expenses represent those expenses that do not participate directly in the production process and consist of the payment of the farm manager, CAS tax, crop protection, soil amortization, heated lighting [10].

The unit production cost (lei/t; lei/kg.), represents the value with which we obtain the product under concrete conditions. The production cost is calculated per ton of product, representing the total expenses related to the production obtained.

The total income per hectare is calculated by multiplying the production obtained with the production price (the price at which the production is sold).

V= Production x unit selling price

Cu = Cht/Qp

where:

Cu = the unit cost of production, in lei/t or lei/kg;

Cht = total expenses per ha, lei/ha;

Vps = the value of the secondary product, in lei/ha;

Qp = the quantity of the main products, in kg or t/ha;

The profit was calculated by making the difference between income and expenses

Profit rate (%) represents the ratio between profit and total expenses multiplied by 100

Rp (%) = (P/Cht)*100

where: P = profit, in lei/kg

Table 4. The economic efficiency of the studied systems

Indicator	Conventional System	Ecological System
Yield-kg/ha	8,000	5,000
Price /kg-lei	1.0	1.0
Income- lei/ha	8,000	5,000
Expenses-lei/ha	3,852.8	4,544.8
Profit- lei/ha	4147.2	455.2
Profit rate %	107.6	10.0
Unit cost/tone-lei/to	481.6	909.0

Source: Own calculation.

The profit rate of 107.6% means that the profit made is 107.6% of the initial costs or investment. Practically, for every lei invested, the company generated a profit of 0.76 lei, which indicates a very good financial performance (Table 4). The company managed to use its resources efficiently to generate profit. The high profit rate indicates a satisfactory demand for the products or services company, which is a positive sign in the long run

A high profit provides opportunities to reinvest in the business to support future growth. In general, a profit rate of 107.6% is a sign of success and financial health, but it is also important to look at the context in which this profit was achieved.

In the ecological system, a profit rate of 10% indicates that the profit made is 10% of the initial costs or investment. This suggests a positive financial performance, but less satisfactory than a rate of 107.6%. Although it is a positive result, there is room for improvement.

The business could look for ways to reduce costs or increase revenue to increase this ratio. A profit ratio of 10% suggests that the business is able to generate profit in a sustainable way. This profit can be used for reinvestment, which what could help the long-term growth of the business. In general, a 10% profit rate is a good sign, but it should be looked at in the wider context of the market and business strategy.

CONCLUSIONS

Conventional farming and organic farming are two different approaches to growing plants and raising animals. Conventional agriculture uses pesticides, herbicides and chemical fertilizers to maximize production and control pests. Its primary goal is to increase yields and maximize profit, often at a lower cost per hectare.

As an environmental impact, there may be negative effects on soil, water and biodiversity due to the intensive use of chemicals.

Organic farming uses a number of sustainable practices. Uses natural pest control methods and organic fertilisers, promotes crop and ecosystem diversity, which can lead to better resistance to disease and pests, focuses on producing higher quality food, often with less impact on the environment . The studied systems highlighted a higher profitability of the conventional culture system. The yields were higher, implicitly, the incomes were higher in the conventional system. The expenses incurred for the establishment of one hectare of wheat in the organic farming system were increased by 700 lei/ha compared to the conventional culture system. At the same time, the unitary cost for a unit of obtained product was 481.6 lei/ton in the conventional cultivation system and much higher, in the organic system, 909 lei/to. Regarding the energy efficiency, the fuel consumption was bigger, but insignificant, 4 l/ha, in the variant of organic culture. The energy consumed to obtain a unit of product was 0.108 kwh in the conventional agriculture system and 0.184 kwh in organic version.

suggesting a higher energy efficiency of the conventional system mainly due to the higher yields recorded in this system.

Each method has its advantages and disadvantages. Conventional farming can provide higher returns in the short term, while organic farming emphasizes sustainability and the long-term health of the environment. Increase in production energy consumption per kg of main production, for soil works, showed a decrease in energy effort per unit of product.

The ecological system did not obtain satisfactory results, possibly also due to the influence of climatic factors, the higher prices of ecological products used in the various technological links, therefore higher expenses. After the analysis of the two culture systems, it emerged that, for reduce the differences and balance the economic side, it is necessary to purchase phytosanitary products, at an advantageous price, to analyze the technological links that attract large expenses and try to adopt some less expensive but more effective technological options. The choice between the two ,depends on personal values, economic priorities and local conditions.

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