

## **A trade-off between economics and environment requirements on energy crops vs. food crops in Romanian agriculture**

Reception of originals: 03/08/2018  
Release for publication: 07/01/2018

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### **Abstract**

The paper investigates the opportunity of replacing traditional cultivated area with grains, with the energetic plants as sunflower, rapeseeds and soybean as energy crops in Romania, under efficiency criteria, by including into research aspects regarding the environmental and policy support aspects. The main aim of the research is to identify the opportunity and efficiency of replacing cereals with energy crops by a multilevel approach. In this context, gross margins, profit, cost per unit, variable and material costs and profit margin are calculated for energy crops and compared with equivalent outputs from grain production: corn, wheat, and barley. The results indicate that energy crops are more efficient than grain crops in cultivation and generating revenues which influence the agricultural paradigm shifting under these conditions. Threshold prices and yields are calculated for underpinning the decision of replacing grains with energy crops. The research is designed as a framework in helping farmers in decision making process regarding the choices on the structure of production, assuming that they will switch to energy crops only if expected returns from the energy crops are higher than returns from growing conventional crops.

**Keywords:** variable cost. Material cost. Marginal profit. Price threshold. Energy crops.

### **1. Introduction**

The higher pressure of economic activities on the environment has imposed a dramatically change in agricultural systems in transitional economies. In recent years, the life support system, including the climate and the way on doing agriculture has experienced numerous and different policy transformations in order to become not only economic efficient but also environmentally friendly. In this larger context, increased CO<sub>2</sub> emissions resulting from

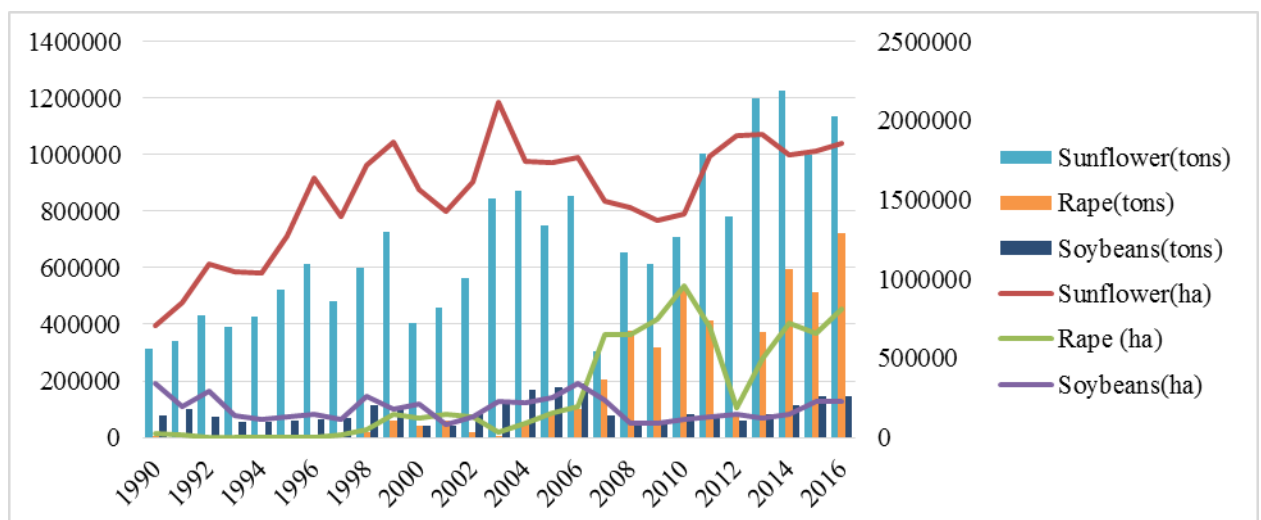
human activities and industrialization moved the focus on biofuels production obtained from energy crops.

Energy crops are plantations established so that the harvested biomass can be used for energy purposes (Krasuska and Rosenqvist, 2012). The increased use of energy from renewable sources, together with energy savings and increased energy efficiency, constitute important objectives of the European Union, as they are declared in Directive 2009/28/EC. The same official document set up the 2020 target of the share of energy from renewable sources in gross final consumption of energy in Romania to 24%, while its level in 2005 was 17.8%. Other studies (Chirila, 2013) show that renewable energy units will cover 16.8% of production by 2035. Reports (International Energy Agency, 2008, p.161) show that most of the biomass consumed in 2030 still comes from agricultural and forest residues, but a growing share comes from purpose-grown energy crops, mainly for making biofuels. In 2015, the avoided fossil fuel consumption reduced greenhouse gas emissions by 1.5 Gigatonnes, or 13% of total CO<sub>2</sub> emissions from fuel combustion (International Energy Agency, 2016).

Given these objectives, biofuels production and consumption are encouraged worldwide. Biomass fuels are considered clean because the CO<sub>2</sub> emanation from the burning is much smaller (Dobre and Bran, 2015). Biomass is the only renewable energy source that can substitute for fossil fuels in all forms: heat, electricity and liquid fuels (Kasmioui and Ceulemans, 2012). Dobre and Bran (2015) argued that the vegetal waste or secondary products from agricultural activities, which mostly remain chaotically over the soil, represent important sources of energy, because their content in cellulose.

Another source of ethanol is lignocellulose biomass. Studies in the field (Bran and Vasile, 2017) show that it has reduced costs and high availability. Krasuska and Rosenqvist (2012) found that Willow and Miscanthus are produced with lower costs compared to grains (triticale) and that the economics of perennials are less susceptible to changes in agricultural inputs prices compared to annual crops. Biofuels use has also cons, since new studies linked their production to rising food prices (Andrei et al. 2016) and showed their potential contribution to monoculture and deforestation (Mitchell, 2008; Timilsina, 2010). The same results found Taheripour and Tyner (2013), who observed that the production of biofuels from dedicated energy crops shifts existing marginal cropland-pasture to crop production and also causes moderate deforestation. They argue that the largest land use change is generated from growing switch grass as a biofuel feedstock while the lowest land use change is generated from Miscanthus for bio-gasoline production.

Energy crops production is developing in Romania under multiple policy requirements, both from inland and Eu-27 environmental and agricultural policy implements. The massive financial support in promoting biofuels and renewables has determined a massive agricultural paradigm change. According to Bran and Chipurici (2015), the vegetal biomass is obtained on large areas in Romania, due to favourable pedoclimatic and relief conditions. They are currently subsidized by European and national funds, encouraging, as such, their use for green energy. Statistical data show that rape, sunflower and soybean, as main energy crops in Romania, are cultivated on 17% of arable land, meaning 1.6 million hectares (Figure 1). The area under sunflower increased almost three times, in the period 1990-2016, up to 1,039,823 hectares from 394,741 hectares. Rape was cultivated on 455,953 hectares in 2016, 35 times more than its area in 1990. The area under soybean was 127,266 hectares in 2016, down from 190,228 hectares in 1990.



**Figure 1: Production and area under sunflower, rape and soybean in Romania, 1990-2016 (tons, ha)**

**Source: authors based on INS, (2017)**

An overview of the agricultural output shows that the production of sunflower was 2,032,340 tons, in 2016, which leads Romania among the top five producers of sunflower. Reports (FAO, 2010, p.14) show that, in 2010, Argentina, Ukraine and the Russian Federation accounted for 52% of the world production of sunflower.

Due to renewable energy importance in global and local economies, the idea of studying the energy crops efficiency issued from empirical observations of the fact that, since early 2000, the areas cultivated with energy crops have continually increased, in Romania (Andrei et al.

2016). This leads to the question whether increases in land used for energy crops are determined by their efficiency. In pursuing this question, economic data regarding revenues and expenses of energy crops are analysed.

The aim of this paper is to assess the economics of energy crops in Romania, namely rape, sunflower and soybean under 2017 market conditions, trying to answer the questions how efficient are energy crops. Moreover, because they compete with grains for the same arable areas, another objective of this paper is to compare the economic efficiency of energy crops and cereals.

The relevance of the research lies in the need of finding the answer to the question whether it is feasible to replace grains with energy crops. The potential supply of energy crops when they are competing with conventional crops is determined by their efficiency. Farmers will switch to energy crops only if expected returns from the energy crops are higher than returns from growing conventional crops.

The final goal is to emphasize the opportunity to set up energy crops, helping farmers in their decisions making related to the structure of production. The three crops have been selected because they are the most commonly cultivated on arable land in Romania, among other energy plantations (Bran and Chipurici, 2015), and furthermore, in Europe, where biodiesel is widely used, and it is made from extracted vegetable oil using crops such as rapeseed, soybean, oil palm, and sunflower (Naylor et al.2007). The efficiency of energy crops is assessed by using the revenue and expenditure budgets, under conditions express in farming system.

The research is structured on five main sections, starting with introduction in which is presented the main transformation reviled in literature and agricultural practice. Section 3 includes a description of the materials and methodology, where is designed the assumptions from which the starts and fundamentals our calculations. Part 4 presents the results of the experimental section. A comparative analysis of economic efficiency of energy crops and grain crops is undertaken. Section 5 presents the assessment of economic efficiency of shifting grains to energy crops with the final goal of underpinning the decision of replacing one crop to another. Marginal profits, prices and yields' thresholds are calculated. Finally, conclusions are detailed in Section 6.

## **2. A Brief Literature Review on Economic Efficiency Analysis in Contemporary Agriculture**

Analysing the economic efficiency in agricultural sector has represented an important topic of research in the literature, both by the arguing indicators` system of analysis, and also designing the theoretical and practical models, applicable in at farms` management decision of production. In the classical approach, economic efficiency has its roots in the microeconomics theory suggesting that inputs can be combined optimally to allocate scarce resources, allowing firms to maximize profits subject to a cost constraint or to minimize costs subject to an output constraint; both will result with an input allocation that is efficient or optimal (Mechri et al.2017). Marion (1986) considers efficiency as a characteristic of performance, alongside equity, transaction costs, market access, and price and revenue stability.

The need of studying the economic efficiency in agriculture emerges from the limited nature of inputs from agricultural and industrial sources, as well as the cost of labor which require measures to maximize their conversion into products, namely to reduce specific consumption per unit of output and to increase outputs (quantity and value of products) per unit of input consumed.

As a general approach (Ion, 2005; Vasilescu et al., 2010), the subject of economic activity is essentially the individual who lives animated mainly by maximizing profits (Ion, 2005). In Malthusianism doctrine, the central idea is that efficiency and development are dependent on population growth (Dolan, 2000). The maximization of profit had been introduced by the Marginalists (Muresan et al.2001). Economic efficiency is addressed by the theory of end-use or marginal utility, on marginal productivity theory of production factors and production functions in neo Keynesianism (Muresan et al.2001).

When the efficiency of production is measured in agriculture, the restrictions that do not allow for maximum profit in any circumstances, such as environmental and energy restrictions, should be also considered. For these reasons, the economic criteria, correlated with the energy and environmental criteria must be taken into account in assessing economic efficiency (Ion, 2005).

Voicu (2000) argues that, in agriculture, a high level of economic efficiency can be achieved not by increasing the volume of resources, but by changing their structure and increasing their conversion into products. Numerous studies have demonstrated this and have shown that crop

rotations increase yield sustainability (Struik and Bonciarelli, 1997, Herzog et al. 2006) or it was proved the causality between production cost and price (Kovačević et al., 2017).

In this paper, changes in the structure of production are considered as methods of increasing efficiency, and not the supplementary allocation of factors. For assessing the economic efficiency, farmers can use a system of indicators: profit, marginal profit, gross margin, cost per unit, and variable cost per unit, material cost per unit, rate of profit, and rate of the economic return. Dobre (et al. 2012) claim for using gross margin for assessing economic efficiency in Romanian exploitations, most of them producing for self-consumption and, as a consequence, they do not register profit.

In some situations, additional or aggregate indicators are needed. For example, when measuring economic efficiency of organic crops compared to conventional crops, Sipiläinen (et al.2008) argued that enhancement of environmental quality such as biodiversity and other environmental amenities are not recognized as a positive output. They consider that this ignorance may create biases in traditional efficiency scores. The authors used an aggregate indicator, namely the crop diversity index, as an indicator of environmental output in a comparison of efficiency of conventional and organic crop farms. Kelly et al. (1996) used marginal value for assessing economic efficiency in agriculture. According to their research, a farm reaches economic efficiency when the marginal value of the inputs is equal to their respective unit costs. When the marginal value is higher, the farm can earn higher profits by increasing the production, when the marginal value is lower, the farm should reduce its production to increase its profits.

The methods to measure technical efficiency are classified into two main groups (Mechri et al. 2017; Ceyhan, 2017): parametric and non-parametric, depending on whether they rely on assumptions on the functional form of the production frontier. As regards the first group, Sadoulet and de Janvry (1995) proposed to distinguish three families of parametric methods: engineering approaches, average production functions and stochastic production frontiers. The production or profit functions are estimated using econometric techniques applied to cross-sectional or panel data at the farm level.

As regards the second group of methods, Charnes et al. (1978) introduced Data Envelopment Analysis as a non-parametric method. It consists in determining a frontier that envelops all the input-output data, with observations lying on the variant defined as technically efficient. The method uses on farm-level data on outputs and inputs. The frontier of production is constructed by identifying iteratively the “best” variant. Mathematically, the process of

establishing the production frontier can be presented as a problem of linear optimization, often used in research for establishing the structure of production (Voicu and Dobre, 2003). For optimizing the structure of production, the authors recommend the following methods: the partial budget, the matrix of profit, the method of variants and the linear programming. Non-parametric methods are often used for agricultural efficiency assessment (Arnade, 1994; Perdomo and Mendieta, 2007; Ion and Turek Rahoveanu, 2012).

The current study uses non-parametric methods, namely the matrix of profit, and indicators calculated based on farm-level data on outputs and inputs. It aims to establish which crop is more efficient in terms of profit, marginal profit, gross margin, cost per unit, variable cost per unit, material cost per unit, rate of profit, and rate of the economic return. The assessment is made for taking the decision whether it is more efficient to switch from grain crops to energy crops, under the climate change condition and higher demand for energy crops.

### 3. Materials and Methods

The economics of energy crops are analysed based on the budgets of income and expenditures, for the period 2015-2017. They are presented in Table 1, for sunflower, rape and soybeans. The assumptions made for the base case calculations derive from information provided by farmers about energy crops production, i.e. yields, labour costs, fertilization, chemical control and output prices.

**Table 1: Revenues and expenditures of energy crops, 2015-2017 (euros hectare-1)**

Elements	Sunflower			Rape			Soybeans		
	2015	2016	2017	2015	2016	2017	2015	2016	2017
A. Revenues	833.3	911.8	858.1	833.3	850.0	806.5	1170.0	1232.3	1148.4
B. Total expenditure	813.4	772.5	794.6	806.5	755.9	798.9	1102.5	1102.9	1050.4
I. Variable expenditure	756.9	710.9	740.9	742.0	696.7	739.6	968.5	971.0	927.6
1. Total materials	411.0	395.0	392.8	369.6	387.0	372.7	572.1	602.9	513.0
Seeds	21.5	21.5	19.4	68.8	68.8	68.8	160.0	169.5	160.0
Fertilizers	66.8	50.8	50.8	162.7	180.0	165.9	200.0	230.0	150.0
Pesticides	322.6	322.6	322.6	138.1	138.1	137.9	212.0	203.3	202.9
Other materials	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2. Mechanized works	314.8	284.7	318.0	346.9	276.5	340.9	353.0	320.6	372.9
3. Logistics	12.3	11.8	11.8	10.8	12.2	11.2	17.0	19.9	16.5
4. Other variable expenditure	18.7	19.4	18.3	14.6	21.0	14.8	26.4	27.5	25.1
II. Fixed expenditure	56.6	61.5	53.7	64.5	59.3	59.3	134.0	131.9	122.9

1. Labour	11.7	21.5	11.1	20.1	25.0	15.1	81.0	79.0	64.5
2. Management	15.0	15.5	14.7	14.9	16.8	14.8	22.0	22.0	20.1
3. Other fixed expenditure	29.9	24.5	27.9	14.6	17.5	14.6	31.0	30.9	38.3

Source: authors own calculation based on farm's accountancy

The methods of optimizing the structure of production by replacing cereals with energy crops are the matrix of profit (Voicu and Dobre, 2003). The final goal is to underpin the decision referring to the structure of production, based on economic efficiency. The marginal profit ( $M_p$ ) is the difference between gains ( $G$ ) and losses ( $L$ ), as described below:

$$M_p = G - L$$

$$G = R_1 + E_0$$

$$L = E_1 + R_0, \text{ meaning that:}$$

$$M_p = (R_1 + E_0) - (E_1 + R_0),$$

where:

$R_1$ =revenues of the crop introduced into structure

$E_0$ =expenditure of the crop replaced

$E_1$ =expenditure of the crop introduced into structure

$R_0$ =revenues of the crop replaced.

The decision of replacement is done if gains are higher than losses:  $M_p > 0$ , meaning that:

$$(R_1 + E_0) > (E_1 + R_0).$$

The levels of marginal profit for different variants of replacements are presented in Table 3 (Matrix of profit), Section 4. The variants chosen are those which bring the highest level of marginal profit per hectare:

$$V.O. = \max(M_p)$$

In dynamics, because prices and yields change from one year to another, the revenues, expenditure and marginal profits are modifying, as well. There are threshold levels of prices and yields that prohibit the replacements of one crop to another. Two situations are considered:

- variable prices and constant yields;
- variable yields and constant prices.

In the first situation, variable prices, the price of the crops introduced into structure varies. The threshold prices under which the crops introduced into the structure become less competitive compared to the crops which are replaced are calculated using the formula:

$$P'_1 = \frac{(R_1 - M_p)}{Y_1}, \text{ where:}$$

$P'_1$  = threshold price for the crop introduced into the structure.

The threshold price of the replaced crop over which the replacement is not feasible, because it becomes more competitive compared to the crop introduced into the structure, is calculated using the formula:

$$P'_0 = \frac{(R_0 + M_p)}{Y_0}, \text{ where:}$$

$P'_0$  = threshold price for the crop replaced from the structure.

In the second situation, threshold yields are calculated for both crops: the ones introduced into the structure and the ones replaced. The formula is:

$$Y'_1 = \frac{(R_1 - M_p)}{P_1}, \text{ where:}$$

$Y'_1$  = threshold yield for the crop introduced into the structure.

The threshold yield of the replaced crop is calculated using the formula:

$$Y'_0 = \frac{(R_0 + M_p)}{P_0}, \text{ where:}$$

$Y'_0$  = threshold yield for the crop replaced from the structure.

The threshold prices and yields of the replaced crops and the crops introduced into the structure are summarized in Table 4, Section 4.

#### 4. Analysis of Economic Efficiency of Energy Crops and Grains

Economic efficiency can be expressed in different ways, using a complex system of indicators. Among them, ones of the most popular are profit, as difference between revenues and expenditure, gross margin, as difference between revenues and variable expenditure, cost per unit, variable cost per unit, material cost per unit, rate of profit, as profit share in total revenues, and rate of the economic return, as profit share in total expenditure. The calculations of economic efficiency for energy crops are presented in Table 2.

**Table 2: Economic efficiency of energy crops**

Elements	M.U.	Sunflower			Rape			Soybeans		
		2015	2016	2017	2015	2016	2017	2015	2016	2017
A. Revenues (A=H*J)	euros ha <sup>-1</sup>	833.3	911.8	858.1	833.3	850.0	806.5	1170.0	1232.3	1148.4
B. Total expenditure	euros ha <sup>-1</sup>	813.4	772.5	794.6	806.5	755.9	798.9	1102.5	1102.9	1050.4
C. Variable expenditure	euros ha <sup>-1</sup>	756.9	710.9	740.9	742.0	696.7	739.6	968.5	971.0	927.6
C1. Material expenditure	euros ha <sup>-1</sup>	411.0	395.0	392.8	369.6	387.0	372.7	572.1	602.9	513.0
D. Gross margin (D=A-C)	euros ha <sup>-1</sup>	76.5	200.9	117.1	91.4	153.3	66.8	201.5	261.3	220.8
E. Profit (E=A-B)	euros ha <sup>-1</sup>	19.9	139.4	63.4	26.9	94.1	7.6	67.5	129.3	98.0
F. Rate of profit (F=E/A*100)	%	2.4	15.3	7.4	3.2	11.1	0.9	5.8	10.5	8.5
G. Rate of economic return (G=E/B*100)	%	2.4	18.0	8.0	3.3	12.4	0.9	6.1	11.7	9.3
H. Yield	tons ha <sup>-1</sup>	2.5	2.5	2.5	2.5	2.5	2.5	3.0	3.0	3.0
I. Cost (I=B/H)	euros t <sup>-1</sup>	325.4	309.0	317.9	322.6	302.4	319.6	367.5	367.6	350.1
J. Variable cost (J=C/H)	euros t <sup>-1</sup>	302.7	284.4	296.4	296.8	278.7	295.9	322.8	323.7	309.2
K. Material cost (K=C1/H)	euros t <sup>-1</sup>	164.4	158.0	157.1	147.9	154.8	149.1	190.7	201.0	171.0
J. Price	euros t <sup>-1</sup>	333.3	364.7	343.2	333.3	340.0	322.6	390.0	410.8	382.8

Source: own calculation based on data in Table 1 and farm's accountancy

Among the crops studied, sunflower brings the highest profit per hectare, 139.4 euros ha<sup>-1</sup>, in 2016, followed by soybeans and rape, in the same year. In terms of gross margin, among the energy crops, soybeans return the highest value of 261.3 euros ha<sup>-1</sup>, in 2016. It is followed by sunflower and rape. The highest rate of profit returns sunflower, 15.3%, then rape and soybean. The rate of economic return has the highest value for sunflower, 18%. The lowest cost per unit is registered by rape, 302.4 euros t<sup>-1</sup>, then sunflower and soybean. The variable cost is lowest for rape, in 2016. The values of material costs are lowest for rape, in 2015. We may conclude that sunflower is the most efficient crop in terms of profit, rate of profit and rate of economic return, rape is efficient in costs (total, variable and material) and soybeans in gross margin.

n dynamics, the highest values of economic efficiency indicators are registered in 2016. For all crops, the values of profit, gross margin, and rates of returns increased in 2016, and then

they dropped in 2017. Increases in values of profit and gross margin were caused by growth in prices. From 2015 to 2016, the levels of prices grew to 109% for sunflower, 102% for rape, and 105% for soybeans. This situation led to increases in competitiveness, although the costs remained unchanged or slightly decreased. An analysis between costs and prices is needed to better understand the changes in competitiveness from one year to another. Thus, Table 3 comprises the main statistical indicators that explain the relations between energy crops' costs and prices.

**Table 3: Statistical indicators for relations between energy crops' costs and prices**

Crop	Element	MV	Variance	St.Dev	Std.Err	CV%
Sunflower	price/ total cost	1.094899	0.004166	0.064546	0.037266	5.895194
	price/variable cost	1.18056	0.005744	0.075789	0.043757	6.419762
	price/material cost	2.173537	0.013186	0.11483	0.066297	5.283086
Rape	price/ total cost	1.055732	0.002454	0.049542	0.028603	4.692662
	price/variable cost	1.144537	0.003035	0.05509	0.031806	4.813306
	price/material cost	2.204778	0.00141	0.037545	0.021677	1.702911
Soybean	price/ total cost	1.090582	0.000527	0.022957	0.013254	2.10501
	price/variable cost	1.238405	0.000621	0.02492	0.014387	2.01225
	price/material cost	2.109083	0.008359	0.091429	0.052786	4.335005

Source: own calculation based on data in Table 2

Among the energy crops studied, strong correlations between prices and costs have been found in the case of sunflower, followed by soybeans and rape. The price of sunflower is strongly correlated to sunflower variable cost (-0.9994) and total cost (-0.9867), but less correlated to material cost (-0.6630). It means that, besides the material cost, other variables of the operating (variable) cost, such as mechanized work and logistics, are better correlated to price.

The price of rape is strongly correlated to variable cost (-0.7623), but less correlated to total cost and material cost. This leads to the conclusion that, besides the variable cost, other variables of total cost, namely the fixed cost, are less correlated to price. It also means that, besides the material cost, other variables of the operating costs, namely the mechanized work and logistics, are stronger correlated to price.

The price of soybeans is strongly correlated to material costs, and less correlated to total and variable costs. This claims that, besides the variable costs, other variables of the total costs, namely the fixed costs, are stronger correlated to price; and, besides material costs, other variables of the operating costs, namely the mechanized work and logistics, are less correlated

to price. The values of covariance (Table 3) show direct relations between prices and costs for soybeans and indirect relations between prices and costs for sunflower and rape.

The research focuses on farmers' decisions to choose between different crops, when establishing the structure of production. Under the climate change and increased CO<sub>2</sub> emissions conditions, energy crops' cultivation is encouraged worldwide. But energy crops need to be cultivated on arable land and compete with grains cultivated for ensuring food security. Farmers will switch to energy crops only if expected returns from the energy crops are higher than returns from growing grains. Thus, a comparative analysis of economic efficiency of energy crops and cereals is needed. The arable cultivated area in Romania is over 8 million hectares. Statistics (National Institute of Statistics database) show that the main crops cultivated in 2016 are:

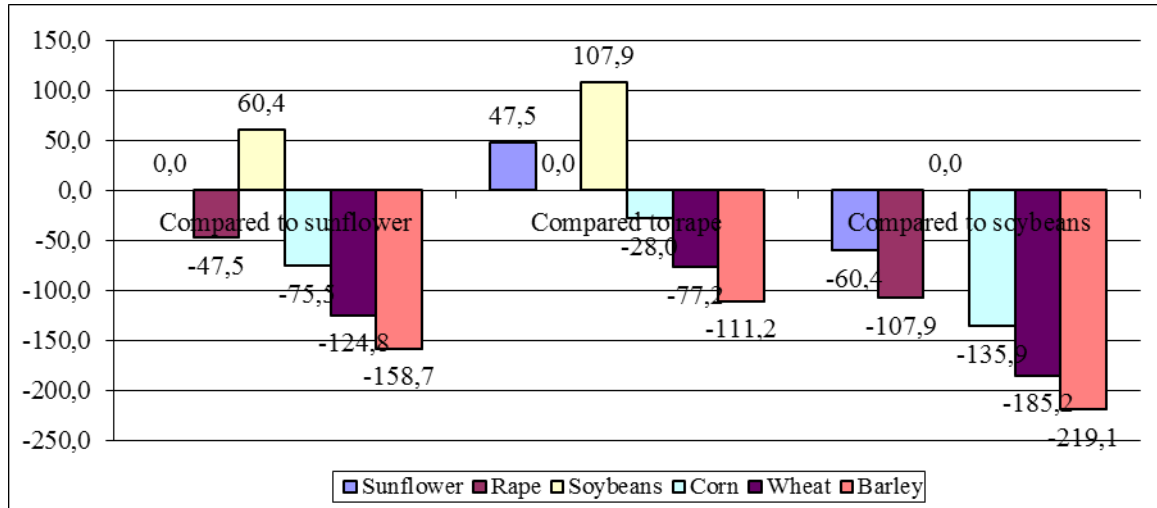
- corn (2,497,000 hectares),
- wheat (2,112,000 hectares),
- sunflower (1,016,000 hectares),
- barley (487,000 hectares), and
- rape (471,000 hectares).

We consider useful to compare energy crops efficiency with economic efficiency of corn, wheat, and barley because we assume that farmers will potentially divert land from current traditional crops, wheat, corn, barley, to energy crops, if the returns over variable costs for energy crops are more than the returns over variable costs for traditional crops (gross margin). Specialists (Dobre et al. 2012) consider that gross margin is more appropriate compared to profit for assessing economic efficiency in Romanian exploitations, because most of them produce for self-consumption and not for the market and, as such, they do not register profit. The gross margins from energy crops production are compared with cereals cultivated for grain and their representation is illustrated in Fig. 5.

Energy crops are more competitive than cereals (Figure 5). Barley is the least efficient culture; differences in gross margins are over 100 euros ha<sup>-1</sup> compared to energy crops. The differences of gross margin of wheat compared to energy crops are between 77 euros ha<sup>-1</sup> and 185 euros ha<sup>-1</sup>. The differences of gross margin of corn compared to energy crops are between 28 euros ha<sup>-1</sup> and 135 euros ha<sup>-1</sup>.

Compared to sunflower, only soybean crop is more competitive, and compared to rape, sunflower and soybeans crops are more competitive, while compared to soybeans, no crop is

competitive. We may conclude that soybeans crop is the most competitive, in terms of gross margin, and energy crops are, generally, more efficient than cereals.



**Figure2: Gross margins for corn, wheat and barley cultivated for grain compared to gross margins of sunflower, rape and soybean cultivated for energy (euros ha-1)**

Source: authors own calculation based on Table 2

### 5. Assessment of Economic Efficiency of Replacing Grains with Energy Crops

The comparative analysis of economic efficiency of energy crops and grains found that energy crops are more efficient than grains; therefore the economic efficiency of replacing grains with energy crops needs to be assessed. In order to decide the opportunity of replacing one crop to another, the marginal profit is calculated in the matrix of profit (Table 4).

**Table 4: Matrix of profit for sunflower, rape and soybean replaces**

Element	Symbol	Sunflower	Sunflower replaces			Rape	Rape replaces			Soybean	Soybean replaces		
			Corn	Wheat	Barley		Corn	Wheat	Barley		Corn	Wheat	Barley
Revenues	R0	x	860.2	688.2	774.2	x	860.2	688.2	774.2	x	860.2	688.2	774.2
	R1	858.1	x	x	x	807	x	x	x	1148.4	x	x	x
Expenditures	E0	x	846.5	672.5	761.3	x	846.5	672.5	761.3	x	846.5	672.5	761.3
	E1	794.6	x	x	x	799	x	x	x	1050.4	x	x	x
Yield	Y0	x	5000	4000	4000	x	5000	4000	4000	x	5000	4000	4000
	Y1	2500	x	x	x	2500	x	x	x	3000	x	x	x
Price	P0	x	0.172	0.172	0.194	x	0.172	0.172	0.194	x	0.172	0.172	0.194
	P1	0.343	x	x	x	0.323	x	x	x	0.383	x	x	x
Marginal profit	Mp	x	49.7	47.8	50.6	x	-6.2	-8.1	-5.3	x	84.2	82.3	85.1

Source: authors own calculation based on data in Table 2

From the economic point of view, only sunflower and soybeans are more efficient to replace the cereal crops, because in the case of rape, the marginal profit resulted from substitution has negative values. The maximum value of the marginal profit is 85.1 euros ha<sup>-1</sup>, when soybean replaces barley:

$$V.O.= \max (M_p) = \max (49.7; 47.8; 50.6; -6.2; -8.1; -5.3; 84.2; 82.3; 85.1) = 85.1 \text{ euro ha}^{-1}$$

The other two crops remaining to be replaced are corn and wheat. The maximum level of marginal profit is 84.2 euros ha<sup>-1</sup>, corresponding to soybeans replacing corn:

$$V.O.= \max (M_p) = \max (49.7; 47.8; -6.2; -8.1; 84.2; 82.3) = 84.2 \text{ euros ha}^{-1}$$

But soybeans crop has been already introduced into the structure. The two remaining crops which must be introduced are sunflower and rape. Under these circumstances, the maximum level of marginal profit is 49.7 euros ha<sup>-1</sup>, corresponding to the situation in which sunflower replaces corn:

$$V.O.= \max (M_p) = \max (49.7; 47.8; -6.2; -8.1) = 49.7 \text{ euros ha}^{-1}$$

The remaining crop needed to be replaced is wheat. The maximum level of marginal profit is 82.3 euros ha<sup>-1</sup>, corresponding to soybean replacing wheat:

$$V.O.= \max (M_p) = \max (47.8; 82.3) = 82.3 \text{ euros ha}^{-1}$$

The total marginal profit resulting from the replacement of grains with energy crops is 217 euros ha<sup>-1</sup>.

The results of shifting crops change from one year to another, because the competitiveness of energy crops in comparison to common cereals is greatly affected by prices on the commodity agricultural markets (Krasuska and Rosenqvist, 2012). Moreover, the agricultural prices volatility is high. Farmers will be switching between conventional crops based on relative expected returns, which are governed by expected prices for different crops, yield and production cost structure for energy crops compared to that of conventional crops (Kumarappan, 2011). As mentioned before, two situations are considered: variable prices and variable yields. In the first situation, variable prices, the price of the crops introduced into the structure varies, namely the prices of sunflower and soybeans.

Sunflower replaces corn. The threshold price of sunflower is 0.323 euros kg<sup>-1</sup>. The initial price was 0.343 euros kg<sup>-1</sup>. If the price goes under 0.323 euros kg<sup>-1</sup>, then the replacement is not efficient, because corn is more attractive to be cultivated compared to sunflower.

Soybeans replace wheat and barley. The threshold price of soybeans replacing wheat is 0.355 euros kg<sup>-1</sup>. The initial price of soybean was 0.383 euros kg<sup>-1</sup>. If the price goes under 0.355 euros kg<sup>-1</sup>, then the replacement is not feasible, because wheat becomes more efficient

compared to soybeans. The threshold price of soybeans replacing barley is 0.354 euros  $\text{kg}^{-1}$ . The initial price of soybean was 0.383 euros  $\text{kg}^{-1}$ . If the price goes under 0.354 euros  $\text{kg}^{-1}$ , then the replacement is not feasible, because barley becomes more efficient compared to soybeans.

It was also calculate the threshold prices for the replaced crops, over which the replacement is not feasible. In the case of sunflower replacing corn, the threshold price for corn is 0.182 euros  $\text{kg}^{-1}$ . The initial price was 0.172 euros  $\text{kg}^{-1}$ . If the price of corn goes above 0.182 euros  $\text{kg}^{-1}$ , corn becomes more competitive compared to the sunflower.

Wheat is replaced by soybeans. The threshold price for wheat is 0.192 euros  $\text{kg}^{-1}$ . The initial price was 0.172 euros  $\text{kg}^{-1}$ . If the price of wheat increases over 0.192 euros  $\text{kg}^{-1}$ , then the replacement of wheat with soybeans is not feasible, because wheat becomes more competitive compared to soybeans. In the case of soybeans replacing barley, the threshold price for barley is 0.214 euros  $\text{kg}^{-1}$ . The initial price was 0.194 euros  $\text{kg}^{-1}$ . If the price of barley goes above 0.214 euros  $\text{kg}^{-1}$ , barley becomes more competitive compared to the soybeans and the replacement is not feasible.

In the second situation, in which the yields are variable, the threshold yields of the crops introduced into the structure are calculated.

Sunflower replaces corn. The threshold yield for sunflower is 2355  $\text{kg ha}^{-1}$ . The initial yield was 2500  $\text{kg ha}^{-1}$ . If the yield decreases down 2355  $\text{kg ha}^{-1}$ , then the replacement is not feasible, because sunflower is less competitive compared to corn.

Soybeans replace wheat and barley. The threshold yield for soybeans replacing wheat is 2785  $\text{kg ha}^{-1}$ . The initial yield was 3000  $\text{kg ha}^{-1}$ . If the yield decreases down 2785  $\text{kg ha}^{-1}$ , then the replacement is not feasible, because soybeans is less competitive compared to wheat.

The threshold yield for soybeans replacing barley is 2777  $\text{kg ha}^{-1}$ . The initial yield was 3000  $\text{kg ha}^{-1}$ . If the yield goes down 2777  $\text{kg ha}^{-1}$ , then the replacement is not feasible, because soybeans is less competitive compared to barley. The threshold yields of the replaced crops are also calculated. In the case of sunflower replacing corn, the threshold yield for corn is 5289  $\text{kg ha}^{-1}$ . The initial yield of corn was 5000  $\text{kg ha}^{-1}$ . If the yield goes above the threshold, then corn becomes more efficient compared to sunflower and the replacement is not feasible.

When soybeans replace wheat, the threshold yield for wheat is 4478  $\text{kg ha}^{-1}$ . The initial yield of wheat was 4000  $\text{kg ha}^{-1}$ . If the yield goes above the threshold, then wheat is more competitive compared to soybeans and the replacement is not feasible.

Barley is replaced by soybeans. The threshold yield for barley is 4440 kg ha<sup>-1</sup>. The initial yield of corn was 4000 kg ha<sup>-1</sup>. If the yield increases above the threshold, then barley is more competitive compared to soybeans and the replacement is not feasible. All the considerations above are summarized in Table 5, showing the range of crops' prices and yields between which farmers will switch to energy crops.

**Table 5: Prices and yields' thresholds of substitution**

Threshold	Sunflower replaces corn when		Soybean replaces wheat when		Soybean replaces barley when	
	sunflower higher as	corn lower as	soybean higher as	wheat lower as	soybean higher as	barley lower as
Price (euros kg <sup>-1</sup> )	0.323	0.182	0.355	0.215	0.354	0.215
Yield (kg ha <sup>-1</sup> )	2355	5289	2785	4478	2778	4440

Source: authors own calculation based on data in Table 4

## 5. Conclusions

This paper has investigated the economics of sunflower, rapeseeds and soybean as energy crops in Romania, trying to answer the questions how efficient are energy crops compared to grains? And is it efficient to replace cereals with energy crops? Gross margins, profit, cost per unit, variable and material costs and profit margin are calculated for energy crops and compared with equivalent outputs from grain production: corn, wheat, and barley. During the research it found that, among the energy crops studied, sunflower is the most efficient crop in terms of profit, rate of profit and rate of economic return, rape is efficient in costs (total, variable and material) and soybeans in gross margin.

Prices are strongly correlated to variable costs for sunflower and rape and to material costs for soybeans, meaning that fixed costs are less correlated to prices, their values being constant over time and acting as a buffer for prices' volatility. We also found that energy crops are more efficient than grain crops and it is feasible to replace corn with sunflower and wheat and barley with soybeans, from the economic point of view and under specific restrictions of prices and yields' thresholds.

When choosing the structure of production, farmers, as any other economic agents, consider the economic efficiency of each crop. But other aspects, such as the assurance that a bio

power facility will be built to procure those crops, as indicated in Choinière (2004), should be looked at. Overall, food security and environment should be considered, in a wider context. Our research showed that energy crops are more efficient than grain crops, meaning that, based only on economics, farmers will choose to cultivate energy crops. But, energy crops require agricultural areas, which opens discussions about the competition food versus fuels (Tomei and Helliwell, 2016), with negative implications related to possible food shortages and increases in food prices. The recent increase in biofuels production has displaced land that could have been used for growing food. However, two of the commodities most often associated with food crisis, wheat and rice, are not major sources of biofuel feedstock (International Energy Agency, 2008, p.174).

We consider that new areas of unused agricultural surfaces should be identified for establishing energy crops, without jeopardizing food security in Romania. Statistics (National Institute of Statistics, 2017) show that out of the total arable land of 9,395,303 hectares, 8,234,437 hectares have been cultivated, remaining 1,160,866 hectares out of crop. This area could be utilized for energy crops. Furthermore, in order to avoid the competition for land, residue-based biofuel production should be considered (Carriquiry et al. 2011). The crops considered are corn, sorghum, barley, rice, wheat, and sugarcane.

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