INFLUENCE OF THE PRODUCTION COSTS OF WINTER RAPE SEEDS ON THE VALUE OF THE PRODUCED BIODIESEL

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Abstract. The article presents an analysis and economic evaluation of the production technology of winter rape and processing of the obtained seeds into biofuel. The experiments were conducted on farms, which use different technologies of field preparation for sowing. Economic efficiency of biodiesel from winter rape was calculated with consideration of the rape seed production costs and its processing into biodiesel. The conducted experiments prove that the production of biodiesel may be profitable if not only biofuel is sold but also straw, rape cake and glycerine.

Key words: biodiesel, economic efficiency, glycerine, production cost, rape cake, winter rape

Introduction

Raising costs of plant production in agricultural farms and environmental benefits, including a possibility of limiting the greenhouse gases emission are the basic arguments for expanding the production and using biodiesel. A possible demand for cultivation area in case of expanding the use of biofuel is a significant environmental factor. It may result in increasing the number of work places and it may lead to development of the agricultural products market at the same time. However, cultivation of plants for bioenergy purposes may result in a risk of food prices increase, disappearance of biological variety or it may also result in formation of endemic species. Biofuel production guarantees their biodegradability and diversification in the fuel sector. The future of biofuels depends on their profitability, which on the other hand depends on mutually related factors. A high cost of production of plants negatively affects the production profitability. The biodiesel production requires maintaining low prices of output materials (rapeseeds) for its production from the economic point of view. However, this is difficult to obtain unless a technology of the plant production is selected appropriately. Production of raw material means all costs incurred from the moment of soil pre-treating for sowing to cropping. During the production of winter rape we cannot influence the outside determinants such as costs of work, taxes, grants or the state policy and a current state of economy. Moreover, atmospheric condition of a particular year, weather anomalies or cataclysms influences the production of raw material. All these factors influence the costs related to the biofuel production and the relation between the raw material production and the final price of biofuels. A farmer should

play a significant role since the course of the raw material production will greatly affect the final price of the product. For this reason, all technology innovations, energy-saving agricultural machines, new plant varieties, new generation fertilizers, which allow for lowering the production costs should be systematically introduced for use. The purpose of the research was to carry out an economic analysis and evaluation of the winter rape production technology, processing the obtained rape seeds into biodiesel and calculation of economic efficiency of the biodiesel production from winter rape [Dobek 2008; Šařec et al. 2009].

Material and methods

The research was conducted between 2006/07–2008/09 in family agricultural farms which are occupied with the plant production of the west pomeranian voivodship. Comparable technologies were used in the farms under study. Triple fertilizing and spraying was carried out, one-stage cropping was applied and differences included the application of different technologies of farming and sowing. The first farm has a total area of 32 hectares. The Agricultural Farm (hereinafter called ZR-1) cultivated winter rape in the researched years on the area ranging from 6 hectares to 14 hectares. Soils, which constitute the farm, are the medium soils of a very good and good rye complex of IVa and IVb soil valuation class. The applied technology of cultivation consisted in ploughing and a full set of post-harvesting tilling operations. After fore-crop harvesting a skimming with the use of a disc harrow was carried out. Sowing ploughing was performed before sowing and the tilt was prepared with a cultivation unit. Winter rape was sowed with a universal sowing unit at 2 cm depth. A doze of sowing in the first year was 5 $kg \cdot ha^{-1}$, in the second and the third it was 4,5 $kg \cdot ha^{-1}$. The obtained crop from the winter rape production was ranging from 3,4 t ha^{-1} to 3,9 $t \cdot ha^{-1}$. The second farm has a total area of 46 hectares. The Agricultural Farm (hereinafter called ZR-2) cultivated winter rape on the area ranging from 12 hectares to 26 hectares. Soils, which constitute the farm are the medium soils of a very good and good rye complex of IVa and IVb soil valuation class. A traditional technology of soil cultivation was applied in the winter rape production, that is a pre-sowing ploughing was carried out and then only harrowing. Winter rape was sowed with a cultivation and sowing unit at 2 cm depth. A doze of sowing in the first year was 3.5 $kg \cdot ha^{-1}$, in the second 3.5 $kg \cdot ha^{-1}$ and in the third it was 3 $kg \cdot ha^{-1}$. The obtained crop from the winter rape production was ranging from 3.6 t ha^{-1} to 4.1 $t \cdot ha^{-1}$. The last farm has a total area of 78 hectares. The Agricultural Farm (hereinafter called ZR-3) cultivated winter rape on the area ranging from 19 hectares to 32 hectares. Soils, which constitute the farm, are the medium soils of a very good and good rye complex of IVa and IVb soil valuation class. A simplified technology of soil cultivation was applied in the winter rape production, that is skimming was carried out and then sowing with a cultivation and sowing unit. Winter rape was sowed at 2 cm depth. A doze of sowing in the first year was 3 $kg \cdot ha^{-1}$, in the second and the third was 2.5 $kg \cdot ha^{-1}$. The obtained crop from the winter rape production was ranging from 3.6 t ha^{-1} to 4 $t \cdot ha^{-1}$.

The production costs included operating costs of the used machines, devices and tractors, costs of materials and raw materials, costs of fuel, costs of human labour [Muzalewski 2009] and costs of processing rape seeds into biodiesel. Calculations included only indirect

costs. At the calculation of the production costs of biodiesel, post-productive remnants (straw, rape cake and glycerine) were not included in one variant and in the second variant these remnants were included in the income.

Results of the research

When analysing total production costs of winter rape in the farms under study: ZR-1, ZR- 2 and ZR-3, it may be stated that the lowest total production costs of rape seeds per one hectare were obtained in the farm ZR-3, where an average value in the researched years was 2400.9 PLN·ha^{-1}, while the highest in the farm ZR-1, where total average costs were 2919.2 PLN·ha^{-1} (Table 1). When analysing the structure of the production costs of seeds, the costs of materials and raw materials participated the most. The lowest costs occurred in the farm ZR-2 and amounted to 1370 PLN·ha^{-1}, what constitutes 55.17% of the total costs and the highest in the farm ZR-3 - an average value amounted to 1536.8 PLN·ha^{-1}, what constitutes 64.01% of the total costs. The operating costs of machines and devices had also a significant position (Table 1), which amounted on average to1045.4 PLN·ha^{-1} (35.81%) in case of the ZR-1 farm, 764.1 PLN·ha^{-1} (30.77%) in the ZR-2 farm and 521 PLN·ha^{-1}, (21.7%) in the ZR-3 farm. While, investigating the operating costs of machines and devices (Table 2) used for particular treatments, it may be stated that in the production of winter rape the highest total costs occurred in the ZR-1 and ZR-2 farms and related to farming. They amounted on average in the ZR-1 to 526.1 PLN·ha^{-1} (50.32%) while in the ZR-2 to 437.2 PLN·ha^{-1} (57.21 %). It was different in case of the ZR-3 farm where the highest costs occurred at one-stage harvesting and amounted to 182.1 PLN ha^{-1} (34.95%). Whereas, taking into consideration that the farm applied simplifications in farm cultivation, the costs of cultivation were lower and amounted to 127.2 PLN·ha^{-1}, what constitutes 24.41%).

Table 1. Average structure of winter rape production costs in the agricultural farms under study in 2006/07-2008/09

Specification	Agricultural facility					
	ZR-1		ZR-2		ZR-3	
	PLN·ha^{-1}	%	PLN·ha^{-1}	%	PLN·ha^{-1}	%
Costs of materials and raw materials	1495.4	51.23	1370.0	55.17	1536.8	64.01
Operating costs of machines and devices without costs of fuel and human labour	1045.4	35.81	764.1	30.77	521.0	21.70
Costs of fuel	275.7	9.44	273.0	10.99	307.7	12.82
Costs of human labour	102.6	3.51	76.1	3.06	35.4	1.47
Total costs	2919.2	100	2483.2	100	2400.9	100
Income from production	4092.2		4360.2		4070.0	
Economic efficiency of plant production	1.40		1.76		1.70	

Source: authors' own calculations

The calculations, which were carried out prove that the costs of human labour participated the least in the total costs of production. They amounted to 102.6 PLN·ha^{-1} (3.51%) for the ZR-1 farm, 76.1 PLN·ha^{-1}, (3.06%) for the ZR-2 farm and 35.4 PLN·ha^{-1} (1.47%) for the ZR-3 farm. However, production of one ton of rape per a mass unit of the obtained crop was the highest in the ZR-1 farm (789 PLN·t^{-1}), while they were lower in the remaining farms and amounted to 637.8 PLN·ha^{-1} (19.2% less) in the ZR-2 farm and 649.8 PLN·ha^{-1} (17.6% less) in the ZR-3 farm. In case of the production of rapeseeds, production efficiency was ranging from 1.40 in the ZR-1 to 1.76 in the ZR-2 what proved profitability of the seeds production.

Table 2. Average values of mechanisation means operating costs for the winter rape production in the agricultural enterprises under study in 2006/07-2008/09

Specification	Unit	Agricultural facility					
		ZR-1		ZR-2		ZR-3	
		PLN·ha^{-1}	%	PLN·ha^{-1}	%	PLN·ha^{-1}	%
Costs of farming	PLN·ha^{-1}	526.1	50.32	437.2	57.21	127.2	24.41
Costs of fertilizing	PLN·ha^{-1}	27.4	2.62	30.1	3.94	37.9	7.27
Costs of sowing	PLN·ha^{-1}	50.4	4.82	41.8	5.47	92.5	17.75
Costs of care	PLN·ha^{-1}	60.6	5.80	32.8	4.29	81.3	15.60
Costs of harvesting	PLN·ha^{-1}	381.0	36.44	222.3	29.09	182.1	34.95
Total operating costs of units	PLN·ha^{-1}	1045.4	100	764.1	100	521.0	100

Source: authors' own calculations

On the basis of the research which were carried out, it may be stated that in the production of biodiesel from rape seeds, its costs of processing are high and amount to about fifty percent of the total costs of the biofuel production. In processing the rape seeds produced in the farms under study, an average percentage participation in the costs of the biodiesel production was 2738 PLN·ha^{-1}, that is 48.4% for the ZR-1 farm, while for the ZR-2 and ZR-3 farms it was respectively 2886 PLN·ha^{-1} (53.75%) and 2738 PLN·ha^{-1} (53.28%). Figure 1 presents a percentage structure of the biodiesel production costs in the farms under study.

Assuming that the value of biodiesel is equal to indirect costs of production and including sale of the post-production remnants (straw, rape cake, glycerine), the biodiesel production may be profitable (Table 3). An average value of efficiency of the biodiesel production in the researched farms was between 1.43 in the ZR-1 farm and 1.47 in the ZR-2 and ZR-3. Values of this coefficient prove profitability of the production.

Whereas, while analysing the process of the biodiesel production in different variants, it may be stated that the most advantageous variant is one that includes the value of the sold biofuel and remnants such as straw, rape cake and glycerine on the side of incomes; the value of biodiesel amounted to 2.16 PLN·dm^{-3} in the ZR-1 farm, 2.12 PLN·dm^{-3} in the ZR-2 farm, and 1.82 PLN·dm^{-3} in the ZR-3 farm without taxes. If we include obligatory taxes then the price of biofuel will be respectively 3.44 PLN·dm^{-3}, 3.38 PLN·dm^{-3} and 2.92 PLN·dm^{-3}. The price of biofuel in case when the post-production remnants are not sold

(straw, rape cake and glycerine) is the worst variant. The price of such biofuel was (without taxes) 3.76 PLN·dm^{-3} in the ZR-1 farm, 3.38 PLN·dm^{-3} in the ZR-2 farm and 3.41 PLN·dm^{-3} in the ZR-3 farm. If we include obligatory taxes then the price of the produced fuel will be respectively 5.84 PLN·dm^{-3}, 5.27 PLN·dm^{-3} and 5.31 PLN·dm^{-3} (Table 4).

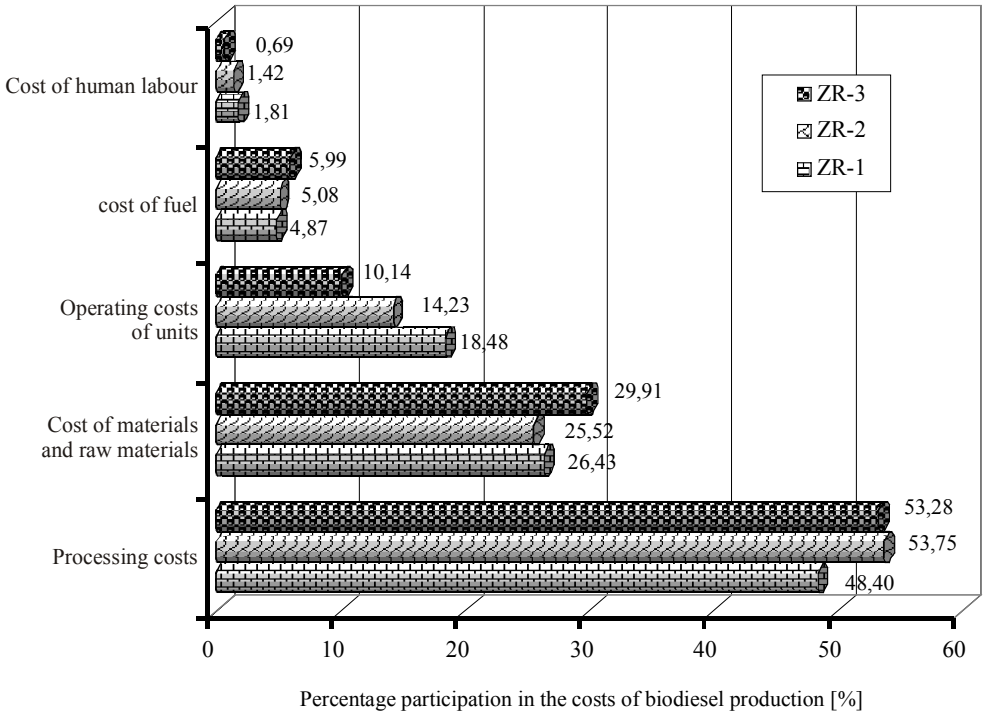

Fig. 1. Percentage structure of biodiesel production costs in the agricultural farms under study

Table 3. Average production costs and the processing costs of winter rape crop into biodiesel in the agricultural facilities under study in 2006/07 - 2008/09

Item number	Specification	Unit	Agricultural facility		
			ZR-1	ZR-2	ZR-3
1	Costs of plant production	PLN·ha^{-1}	2919.1	2483.2	2400.9
2	Costs of processing into biofuel	PLN·ha^{-1}	2738.0	2886.0	2738.0
3	Total costs (pos.1 + pos.2)	PLN·ha^{-1}	5657.2	5369.1	5138.9
4	Biofuel value	PLN·ha^{-1}	5657.2	5369.1	5138.9
5	Value of straw, meal and glycerine	PLN·ha^{-1}	2405.0	2535.0	2405.0
6	Total income (pos.4 + pos.5)	PLN·ha^{-1}	8062.1	7904.1	7543.9
7	Economic efficiency of biofuel production (pos.6/pos.3)	–	1.43	1.47	1.47

Source: authors' own calculations

Table 4. Average production costs of biodiesel in the agricultural facilities under study in 2006/07--2008/09

Item number	Specification	Unit	Agricultural facility		
			ZR-1	ZR-2	ZR-3
1	Obtained biodiesel	$kg \cdot ha^{-1}$	1369	1443	1369
		$dm^3 \cdot ha^{-1}$	1506	1587	1506
2	Price of the produced biodiesel[1]	$PLN \cdot dm^{-3}$	3.76	3.38	3.41
3	Price of the produced biodiesel[2]	$PLN \cdot dm^{-3}$	2.16	2.12	1.82
4	Price of biodiesel with taxes[3] (counted from position 2)	$PLN \cdot dm^{-3}$	5.84	5.27	5.31
4	Price of biodiesel with taxes[3] (counted from position 3)	$PLN \cdot dm^{-3}$	3.44	3.38	2.93
5	Price of diesel oil[4]	$PLN \cdot dm^{-3}$	4.98		

[1] - without incomes from sale of straw, meal and glycerine
[2] - with incomes from sale of straw, meal and glycerine
[3] -with taxes and profit margin of a distributor as for conventional fuel
[4] - average price as on 01 September 2011

Source: authors' own calculations

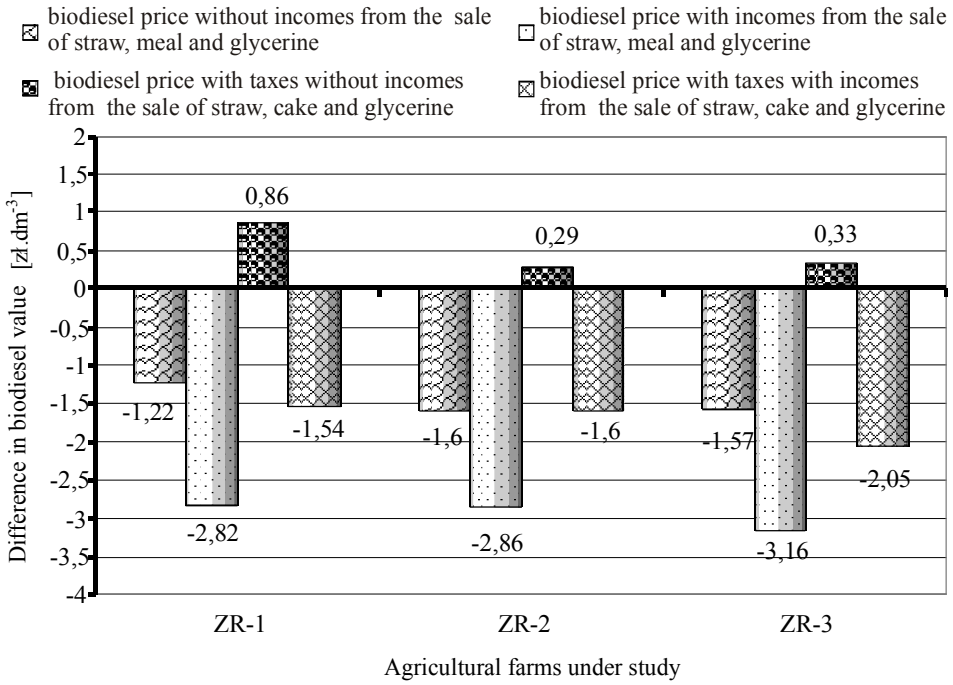

Fig. 2. Calculated differences between the price of the produced biodiesel in relation to the accepted variant of incomes calculation and the price of diesel oil

Whereas, comparing costs of the biodiesel production with the price of biodiesel oil, obligatory on 1 September 2011, it may be stated that in the calculated variants, only a variant in which only sale of biofuel was included in incomes and the obligatory taxes were included in the costs, the value of biodiesel calculated in this way was higher than the price of diesel oil. Figure 2 presents a difference between a calculated costs of producing biodiesel in relation to the accepted variant of calculating incomes and costs regarding the price of diesel oil. In the graph, the X-axis was assumed as an average price of diesel oil (value equals zero) while the Y-axis was assumed as differences between diesel oil and different variants of calculations of the biodiesel production price in the farms under study. The most significant difference (advantageous for biodiesel) was obtained in the variant without taxes and with incomes from the sale of straw, cake and glycerine and it amounted on average to 2.94 PLN·dm^{-3}. The most advantageous difference occurred in case of the ZR-3 farm and it was 3.16 PLN·dm^{-3}, and the lowest in the ZR-1 farm and it was 2.82 PLN·dm^{-3}. Only in the variant with taxes and without incomes from the sale of straw, cake and glycerine, a difference, advantageous for diesel oil, occurred. Thus, in the ZR-1 farm, biodiesel is more expensive than diesel oil of 0.86 PLN·dm^{-3}, in the ZR-2 farm – of 0.29 PLN·dm^{-3}, and in the ZR-3 – of 0.33 PLN·dm^{-3}.

Conclusions

1. The conducted research proves that the production of biodiesel in the agricultural farms under study may be profitable. The lowest costs of production occurred in the variant without taxes and including the sale of straw, cake and glycerine on the side of incomes. Thus, production of cubic decimetre of biodiesel in the ZR-3 farm cost 1.82 PLN·dm^{-3}, in the farm ZR-2 – 2.12 PLN·dm^{-3}, and in the farm ZR-1 – 2.16 PLN·dm^{-3} provided that not only biofuel is sold but also straw and post-extraction meal. It also relates to energy efficiency of the biodiesel production.
2. The biodiesel production is unprofitable when the post-production remnants cannot be sold and when the costs include obligatory taxes and surcharges for diesel oil. The highest costs of production occurred in the ZR-3 farm and amounted to 5.84 PLN·dm^{-3}, and the lowest in the ZR-3 farm – 5.27 PLN·dm^{-3}.
3. The Act of 25 August 2006 on bio components and liquid biofuels, implemented by the government (Dz.U. 2006 no. 169 item 1199) and on additional payments for agricultural production enable a farmer to produce biodiesel for his own needs what consequently lowers the agricultural production costs and allows for improvement of its profitability at the same time.

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WPŁYW KOSZTÓW PRODUKCJI NASION RZEPAKU OZIMEGO NA WARTOŚĆ WYPRODUKOWANEGO BIODIESLA

Streszczenie. W artykule przedstawiono analizę i ocenę ekonomiczną technologii produkcji rzepaku ozimego oraz przetworzenia uzyskanych nasion na biopaliwo. Badania przeprowadzono w gospodarstwach stosujących różne technologie przygotowania roli do siewu. Obliczono efektywność ekonomiczną biodiesla z rzepaku ozimego z uwzględnieniem kosztów produkcji nasion rzepaku oraz przetworzenia na biodiesel. Z przeprowadzonych badań wynika, że produkcja biodiesla może być opłacalna pod warunkiem sprzedaży nie tylko biopaliwa, ale także słomy, makuchu rzepakowego, a także gliceryny.

Słowa kluczowe: biodiesel, efektywność ekonomiczna, gliceryna, koszt produkcji, makuch rzepakowy, rzepak ozimy

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