Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 14, Issue 3, 2014
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ECONOMIC ANALYSIS OF SELECTED OPTIONS OF STRAW USE DEPENDING ON HARVESTING TECHNOLOGY

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Abstract

Post-harvest straw deserves particular attention among agricultural raw materials. It can be intended for sale, applied as litter material in animal husbandry or used in field fertilization. To a lesser extent it can be used for fodder production, covering mounds of roots and tubers and the production of insulation materials in horticulture and building construction. Using surplus straw directly for energy generation, including production of pellets and briquettes, should also be considered rational. Several applications were analyzed. The main purpose of the research is to determine the profitability level of winter wheat cultivation and of energy use of the straw obtained. Among others, they included situations in which obtained straw was used in the production of pellets, in fertilization after prior grinding and mixing with manure or used for direct sale. For our calculations, the costs/ha of wheat cultivation and then straw collection were estimated. The comparative analysis of various options of wheat straw utilization shows the highest profitability in the option of selling the straw and mineral fertilization.

***Key words*:**, *biomass, economic calculations, wheat, straw*

INTRODUCTION

Energetic crops constitute an increasingly high proportion of arable crops cultivated on farms [2]. Those plants have high energetic value, high yielding of biomass and widespread use in power generation. Among agricultural raw materials straw deserves particular attention [1]. For many years straw remained in the field and was burned by farmers. Recently however decreasing tendency to use straw in that way has been observed [6]. Application of chemical fertilizers and plant protection products leads to increases in the yields of grain and straw [3]. Therefore a problem arises how to utilize surpluses which can be used directly for energy production [5].

Biomass used as a renewable energy source has a huge impact on the operation of business entities. It enables sustainable development of a country, ensuring energy security, economical and rational use of fuels and energy, growth of competition and it counteracts negative impacts of natural monopolies [8].

MATERIALS AND METHODS

The main objective of the research is to determine the profitability level of winter wheat cultivation and of energy use of the straw obtained from the wheat in the Lower Silesia region. The research provides economic calculation of wheat production profitability using a simple cost-sharing method in the form of simplified calculations. The calculations use prices of year 2012. In order to estimate the profitability of straw, four possible options for straw use are presented including production costs. The subject of research in all the options is the content of different macroelements and the possibility of balancing the shortages of those elements. Cost calculation of straw biomass production has been conducted in the following options:

1. The final collection of organic matter and nutrients in the form of straw is compensated by manure and mineral fertilizations.
2. The final collection of minerals is balanced with mineral fertilization.
3. Straw remains in the field and after being supplemented with a nitrogen fertilizer it is ploughed.
4. Straw remains in the field without fertilization.

The paper also presents graphs of the dependency of farmer's income on the costs of straw transport in the 'loco' farm and 'loco' company variants. The result of the analysis is the presentation of the farmer's direct surplus taking into account the value of his production and incurred production costs.

RESULTS AND DISCUSSIONS

As shown in Fig.1, the highest percentage of costs connected with wheat cultivation is related to mineral fertilizers, which account for 42% of all the costs.

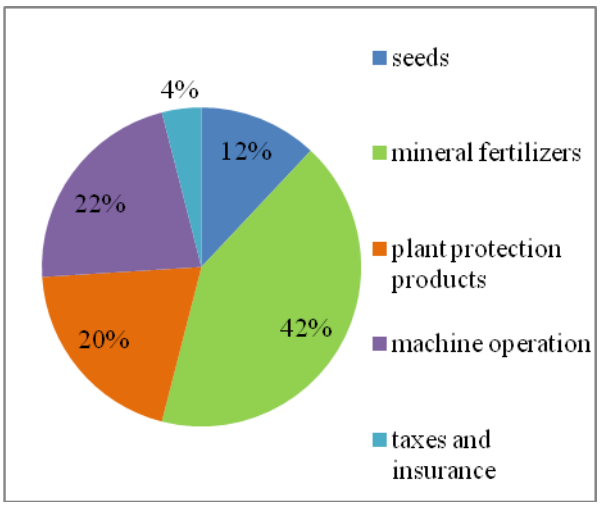

Fig. 1 Cost structure for wheat production per hectare
Source: Author's calculations based on the table of costs of using machines after [7]

The second group 4 of highest costs of cultivation per hectare is connected with agrotechnical operations. Wheat requires very good soils. It yields the best on heavy soils which are present to a sufficient degree in the Lower Silesia soil structure. Following the data in Table 1 and calculating the following options:
profitability of wheat cultivation it is assumed that an average yield per hectare is 55q (q=quintal=100kg) and the price is 95 PLN·q^{-1}.

Table 1. Production income from winter wheat per hectare

Specification	Unit	[Amount ·ha^{-1}]	Value in PLN
Price of 1 Quintal of Grain	[PLN·q·(100kg)$^{-1}$]		95
Grain Yield	q(100kg)	55	
Value of Grain Yield	PLN		5225
Grain	q(100kg)	2.5	490.5
Mineral Fertilizers	PLN		1800
Plant Protection Products	[PLN·ha^{-1}]		882.2
Total Direct Costs	PLN		3172.7
Direct surplus	PLN		2052.3
Shallow Ploughing	h(hour)	2	57
Harrowing	H	0.5	19
Fertilization	H	0.5	14
Sowing Tillage	H	2.5	200
Sowing	H	1	50
Late fertilizing (N)	H	1	25
Spraying	H	0.5	50
Grain transport	H	0.7	40
Combine harvesting	H	0.8	270
Taxes and insurance	PLN		180
Indirect Costs	PLN		905
Total Costs	[PLN·q^{-1}]		4077.70
Production Income	PLN		1147.30
Single area payment	Ha	1	710.57
Supplement to the area payment	Ha	1	274.23
Production Income			2132.10

Source: Author's study

With such assumptions, the direct surplus was 2052.3 PLN and the direct costs were slightly

over 3000 PLN. The total income including indirect costs exceeded 2000 PLN. Table 2 shows profitability calculation for winter wheat straw. It was assumed that 36 bales of straw can be obtained from 1 hectare and the price of one bale is 25 PLN. The calculation also considered all the costs connected with collecting the straw from t4888he field. The overall direct surplus from selling the straw amounted to 667.93 PLN·ha^{-1}.

Table 2 .Calculation of straw profitability per hectare in 2012

Straw	Unit	Value
Total number of straw bales	Item	36(7150 kg)
Unit Price	[PLN·bale^{-1}]	25
Income	PLN	900
Straw Pressing	PLN	124.46
Loading	PLN	30.69
Straw Transport	[PLN·h^{-1}]	76.92
Total Costs	[PLN·h^{-1}]	232.07
Transport Costs	[PLN·km^{-1}]	3.85
Income from Straw	PLN	744.85
Direct Surplus	PLN	667.93

Source: Author's study

The structure of costs incurred on straw and grain production was also evaluated. The calculation was based on the income from selling individual crops. Knowing the income, it was possible to estimate the overheads which were then reflected in the production of one ton of wheat (Table 3). According to former research, straw yield to grain yield relation is about 0,46 [1]. In my calculation grain yield is 8000 kg, so proportion is 0,89 and then overheads 0,17.

Table 3. Calculating production overheads for straw and wheat grain

Straw Value [PLN]	900
Grain Value [PLN]	5225
Overheads	0.17
Value of grain production costs [PLN]	900
Value of straw production costs [PLN]	155.02

Source: Author's study based on [4].

Straw can be used for multiple purposes. Therefore, considering the income from its sale, a profitability calculation of several options was conducted depending on the straw use.

Option 1 - Straw removed from the field - fertilization supported with manure

The costs of labour for two operators have been included in operational costs. Table 4 presents quantitative content of the most important macroelements constituting the straw. The total yield of straw obtained from one hectare of wheat is 7150 kg.

Table 4. The content of macroelements in the collected straw

Element	Percentage of elements in straw	Straw yield [kg]	Mineral content in the straw [kg·ha^{-1}]
N	0.6	7150	45.8
P_2O5	0.1		7.9
K_20	1.1		83.7
Mg	0.1		6.4
Ca	0.3		19.3

Source: Author's study based on [10]

Based on that amount, the quantities of NPK, Mg and Ca were estimated. In order to supplement fertilization, mineral fertilizers were used in the form of ammonium nitrate and potassium salt. Costs of fertilization are calculated in Table 5. It has been assumed that one manure spreader should carry a load of 3000 kg.

Table 5. Cost calculation for manure fertilization

Item	Cost [PLN·h^{-1}]	Time (h)	Total cost [PLN]
Spreader	32.02	0.3	9.6
U 3512 Tractor	32.62		9.8
U 2812 Tractor	28.19		8.5
Loader	2.5		0.8
Total			28.6

Source: Analysis based on [7].

To carry out manure fertilization the following machines should be used: the tractor Ursus 3512 with a spreader and the tractor Ursus 2812 with a front loader.

A required dose of minerals is presented in Column 2. It corresponds to the NPK amount in the straw collected from the field. In order

to supplement the shortage of these elements manure was applied. Considering the full coverage of the phosphorous requirement, the amount of almost 2633 kg of manure should be applied per hectare. Such a dose however does not fully cover the demand for nitrogen and potassium (Table 6).

Table 6. Mineral balance after removing straw from the field and supplementing the field with a proper amount of manure

Mineral	Mineral content in the straw [kg·ha^{-1}]	Content of pure NPK component in manure [kg·t^{-1}]	Required manure dose in [kg]	Mineral balance [kg]
Nitrogen	45.8	5	9160	Shortage 39
Phosphorus	7.9	3	2633	Full dose
Potassium	83.7	7	11957	Shortage 65.27

Source: Author's study based on chemical composition of fertilizers

The calculation of the expenditures is presented in Table 7.

Table 7. Cost of mineral supplementation after manure fertilization

Cost of Additional Fertilization	Unit Price in [PLN·q^{-1}]	Amount of Mineral [kg]	Cost of Mineral Fertilization [PLN]
Ammonium Nitrate	139.0	39.0	54.2
Potassium Salt	201.6	81.9	165.2
Total Cost of Mineral Fertilization			219.4
Total Cost of Manure Fertilization [PLN]			28.6
Total Costs			248
Value of Straw [PLN]	900		
Income [PLN]	652		

Source: Author's study based on input prices in 2012

As a result of using that option the farmer generates an income of 652 PLN. Such a solution is pro-ecological because the shortage of minerals which have been lost in straw collection is supplemented through manure fertilization and mineral fertilizers.

Option 2 - Straw removed from the filed - mineral fertilization

In this calculation the shortage of NKP elements is supplemented exclusively by mineral fertilization. Fertilization includes the use of ammonium nitrate, potassium salt and Polifoska 6. The result of income calculation in this option is higher than in manure fertilization and amounts to 658 PLN, which is shown in Table 8.

Table 8. Costs of mineral fertilization

Cost of Fetilization	Unit Price in [PLN·q^{-1}]	Amount of Mineral [kg]	Cost of Mineral Fertilization [PLN]
Ammonium Nitrate	139.0	45	62
Potassium Salt	201.6	84	164
Polifoska 6	196	7.9	16
Total Cost of Mineral Fertilization [PLN]			242
Value of Straw [PLN]	900		
Income [PLN]	658		

Source: Author's study based on market prices in 2012

Option 3 - Straw remains in the field supplemented with urea

It was assumed in this calculation that straw remains in the field.

For a quicker decomposition of harvest residues, fertilization with urea was used (Table 9).

In this situation the whole amount of NPK remains in the soil.

The results of the calculation are presented in Table 9. In this option the farmer does not benefit financially from straw production.

However the positive aspect of this option is the creation of humus layer in the soil from the harvest residues.

Table 9. Economic calculation for the option: Straw remains in the field

Cost of Fertilization	Unit Price [PLN*dt^{-1}]	Amount of Mineral [kg]	Cost of Mineral Fertilization [PLN]
Urea	169	100 kg	169
Production Loss [PLN]	-169		

Source: Study based on [9].

The costs incurred by the farmer result from the purchase of urea.

Option 4 - Straw remains in the field

No mineral fertilization is applied.

The farmer's income then equals zero. He does not incur any additional costs.

Having estimated the income obtained from selling the straw, a relationship was defined between an income obtained from selling the straw and the costs connected with the transport and collection of the straw. Three variants are considered here:

Variant 1: the farmer presses the straw, a company loads and transports it
Variant 2: "loco" farm,
Variant 3: "loco" company.

Figures 2 shows the relationship between the distance and the income obtained from selling the straw.

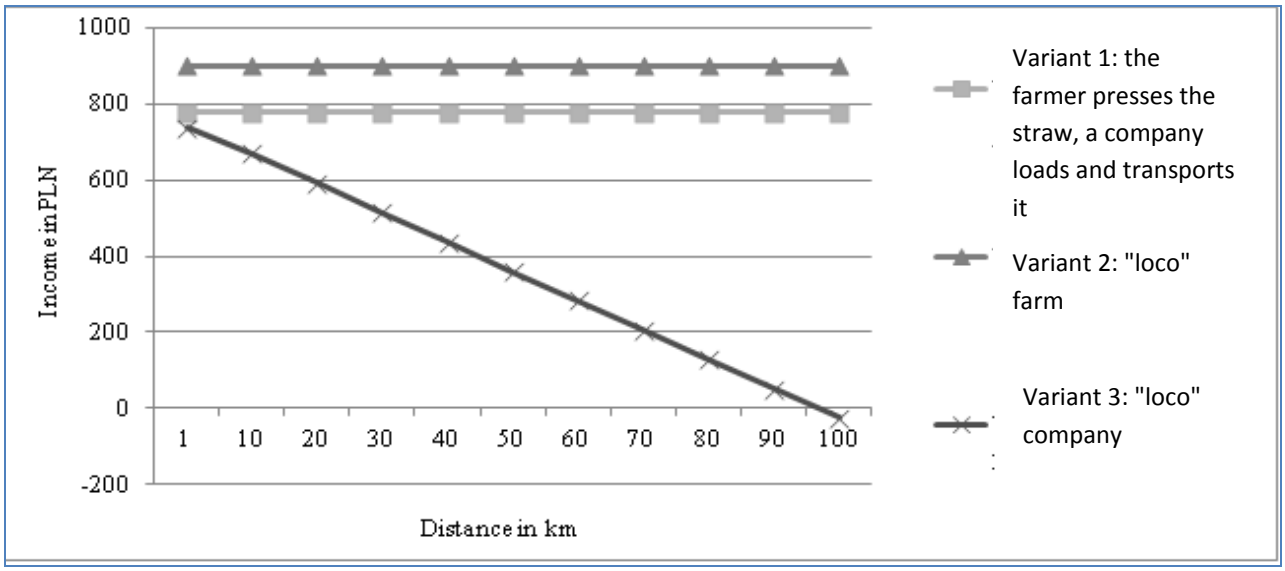

Fig. 2. Multi-variant analysis of farmer's income changeability depending on the distance of straw transportation
Source: Author's study

In the first variant the farmer presses the straw and a company loads it and transports on its own. Then the income is constant and amounts to 775 PLN. The highest profitability for the farmer is obtained in the 'loco' farm variant because then the farmer does not bear any costs connected with straw collection. Then the income is 900 PLN. The farmer receives the lowest possible income in the 'loco' company variant, where he incurs the total costs of straw collection.

Estimation of the 'loco' company variant shows that the threshold distance which ensures the farmer's income is 95 km. Beyond that distance the farmer makes a loss.

CONCLUSIONS

The comparative analysis of various options of wheat straw utilization shows the highest profitability in the option of selling the straw and mineral fertilization in order to balance the NPK minerals. The structure of expenditures on wheat cultivation per hectare shows significant prevalence of costs connected with mineral fertilization and applied plant protection products. In energetic use of straw, the most profitable variant is 'loco' company because the farmer does not bear any costs connected with collecting the

straw from the field. The primary objective of modern farm is to minimize costs and maximize benefits through the use of modern means of production. The straw obtained by farmers can be used in many ways and generates some economy profits. This article presents the calculation of chosen options on the basis of adopted assumptions.

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