Anna Kuczuk

COST- AND ENERGY – RELATED DETERMINANTS FOR CONVENTIONAL AND ORGANIC CULTIVATION OF WINTER WHEAT

Anna Kuczuk, dr – Politechnika Opolska, Opolski Ośrodek Doradztwa Rolniczego w Łosiowie

adres korespondencyjny:
Wydział Mechaniczny
ul. Prószkowska 76, 45-758 Opole
e-mail: a.kuczuk@po.opole.pl

KOSZTOWE I ENERGETYCZNE UWARUNKOWANIA UPRAWY KONWENCJONALNEJ I EKOLOGICZNEJ PSZENICY OZIMEJ

STRESZCZENIE: Różnice w nakładach i kosztach oraz energochłonności produkcji rolnej w systemach ekologicznym i konwencjonalnym są zasadnicze. W artykule dokonano analizy i porównania kosztochłonności i energochłonności obu systemów na przykładzie uprawy pszenicy ozimej. Wśród różnic pomiędzy oboma typami upraw zauważa się średnio wyższe koszty całkowite produkcji, przychody, a także wyższą efektywność ekonomiczną w produkcji konwencjonalnej. Na wyniku tym zaważył zwłaszcza duży udział kosztów materiałów produkcyjnych. Także w tej grupie gospodarstw średnia energochłonność produkcji była znacznie wyższa. W gospodarstwach ekologicznych obserwuje się niższe plonowanie związane głównie z ekstensywną jakością produkcji, w kompleksowej ocenie obu systemów produkcji należy jednak brać pod uwagę także jakość wytworzonej żywności ekologicznej oraz jej znaczenie dla jakości środowiska przyrodniczo-rolniczego.

SŁOWA KLUCZOWE: kosztochłonność produkcji, energochłonność skumulowana, rolnictwo ekologiczne, rolnictwo konwencjonalne, pszenica ozima

Introduction

Competitiveness in agriculture extorts various actions aimed to reduce cost and energy intensity in production. This production area to a large extent depends on external conditions, which makes its planning harder. Nevertheless, operations aimed to reduce cultivation energy intensity allow not only lowering their costs, but also having positive impact on environment. It is important to determine the weight of individual components in accumulated energy intensity of production. This makes it possible to affect its size in a more planned way.

In recent years one may observe increasing interest of consumers in food produced in an organic system. Also, its production is successively growing – it is an extensive method implemented with considerable or complete elimination of mineral fertilisers and chemical plant protection agents. Involved procedures lower cost and energy intensity of production, but also considerably reduce crop. Therefore, a very important issue is to know crop cost and energy intensity indexes in organic production. This constitutes very valuable information at production planning stage.

The purpose of this article is to compare accumulated cost and energy intensity of winter wheat production in selected conventional and organic farms located in Opolskie Voivodeship.

Cultivation in both farm types differs considerably. Conventional cultivation makes use of mineral fertilisers and chemical plant protection agents. Several farms from each group were taken for comparison purposes, all with alike conditions of cultivation carried out in the same years.

When analysing presented results, one should take into account the fact that nutritional parameters are important properties of organic food. Therefore, economic calculation in organic agricultural production should be subordinated to the desired quality of obtained organic farming products.

This study is the continuation of the previous analyzes enclosed in[1], expanding on the chosen elements of the economic bills concerning the winter wheat production in demonstrative, ecological and conventional farms, as well as the connection between the energy consumption of a production and its energetic effects.

The studied farms and research methods

The comparison of selected organic and conventional farms regarding accumulated cost and energy intensity of winter wheat production was performed on

[1] A. Kuczuk, *Porównanie energochłonności skumulowanej produkcji pszenicy ozimej w uprawie ekologicznej i konwencjonalnej*, "Journal of Research and Applications in Agricultural Engineering" 2013 t. 58(4), s. 29-33.

the basis of detailed information obtained from five conventional farms and three organic farms located in Opolskie Voivodeship. Data and information required for the analysis of conventional farms were acquired from Opole Agricultural Advisory Centre in Łosiów. They were taken from plant production cost-effectiveness sheets for winter wheat. In the case of organic farms, the information was acquired and production cost-effectiveness sheets were filled out following direct interviews with farm owners.

In the analysed conventional farms (marked K1 to K5), winter wheat cultivation area ranged from 1 ha up to 6 ha. Natural and production conditions for the plant cultivation were alike, mainly in class IIIa or IIIb soils. For farms K1, K3 and K4, the analysis covered production in years 2011 and 2012. In case of farms K2 and K5, acquired data concerned only year 2011. In the studied conventional farms, own stock of machines was used primarily. Further information concerning these farms is provided in Table 1. In the case of organic farms (marked E1 to E3), data from years 2011-2012 were taken as well.

Both conventional and organic farms were located in the same administrative districts. The purpose of this selection was to make sure that all farms had as close as possible soil and climatic conditions. Farm E1 was characterised by commodity production and was standing out from among the other organic farms with the area taken for winter wheat cultivation. General information concerning winter wheat cultivation in organic farms is given in table 1.

In computations of accumulated energy used for plant growing, the examiners took into account its expenditure for preparing field for cultivation, that's fertilisation and liming[2], unit energy expenditures for work of machines (taking into account fuel consumption) and equipment incurred in connection with cultivation, sowing, plant maintenance, crop, transportation and grain cleaning[3]. If straw was not ploughed in a farm, then energy expenditure incurred for its pressing and transportation was determined.

The types of employed machines and equipment were specified for some of the analysed farms, which allowed estimating accumulated energy used for their work. For other farms, in their estimates the examiners used machines and equipment characterised by the same or similar masses and outputs[4] so as to ensure that comparison of both production methods was unbiased as much as possible.

Accumulated energy intensity was also calculated for applied mineral fertilisers and manure per weight of NPK constituents and unit accumulated energy expenditures appertaining to them[5]. In the case of conventional farms, the rese-

[2] Z. Wójcicki, *Metodyczne problemy badania energochłonności produkcji rolniczej,* „Problemy Inżynierii Rolniczej" 2005 nr 1, s. 5-12; idem, *Poszanowanie energii i środowiska w rolnictwie i na obszarach wiejskich*, Warszawa 2007.

[3] Z. Wójcicki, *Metodyka badań postępu technologicznego w gospodarstwach rodzinnych*, Warszawa 2008.

[4] P. Pruszek (red.), *Poradnik PROW. Przepisy ochrony środowiska, normatywy i wskaźniki funkcjonujące w produkcji rolniczej*, Brwinów 2006.

[5] P. Pruszek (red.), op. cit.; *Z.* Wójcicki, *Poszanowanie energii i środowiska…*; Z. Wójcicki, *Metodyka badań postępu….*

Table 1

Characteristics of winter wheat cultivation in the studied conventional and organic farms

Specification	K1		K2	K3		K4		K5	E1		E2		E3	
	2011	2012	2011	2011	2012	2011	2012	2011	2011	2012	2011	2012	2011	2012
Crop area [ha]	2	2	1	1	1	5	6	2	18,74	29,33	1,50	1,75	7,50	7,13
Soil valuation classes	III b	III a	III a	III a	III a	III a	IV a	III b	III a, III b, IV a, IV b, V, VI	III a, III b, IV a, IV b, V, VI	III b	III b	II, III a	II, III a
Variety	Jaga	Jenga	Bogatka	Kobra	Bogatka	Bogatka	Zyta	Juliusz	Zyta	Zyta	Almari	Almari	No name	No name
Forecrop	winter rape	winter wheat	winter rape	spring barley	corn	spring barley	sown pea	winter rape	buck-wheat	buck-wheat	red clover + oats with field pea	red clover + oats with field pea	pea + potatoes + vegeta-bles + oats with field pea	pea + potatoes + vegeta-bles
Weed, disease, and pest control	chemical	chemical	chemical	chemical	chemical	chemical	chemical	chemical	crop rotation, mechani-cal weeding	crop rotation, mechani-cal weeding	crop rotation, mechani-cal and manual weeding	crop rotation, mechani-cal and manual weeding	crop rotation, mechani-cal weeding	crop rotation, mechani-cal weeding
Mineral/ natural fertilisa-tion* N/P/K [kg ha^{-1}]	119/96/96	130/40/60	170/92/90	134/60/75	134/50/75	64/0/0	60/40/40	174/72/72	0	0	87/16/70	38/10/43	0	0
Crop [dt ha^{-1}]	83.10	64.00	75.00	55.00	55.00	64.00	45.00	85.00	32.02	39.72	40.0	22.86	40.0	21.04

* In case of organic farm E2, natural fertilisation with manure took place. In case of K4 farm, fertilisation with manure took place in the second year.

Source: A. Kuczuk, *Porównanie energochłonności skumulowanej produkcji pszenicy ozimej w uprawie ekologicznej i konwencjonalnej*, "Journal of Research and Applications in Agricultural Engineering" 2013 vol. 58(4), s. 29-33.

archers also computed expenditures of accumulated energy concerning applied plant protection agents[6]. Labour expenditure was taken into account for each farm type.

Winter wheat growing costs include the following: operating costs for employed machines, equipment and means of transport, fuel costs, costs of materials (sowable material, manure and mineral fertilisers, plant protection agents), and labour costs. They were calculated in the same way as in the work[7], based on the following dependence:

$$Kc = \Sigma KM + \Sigma KP + \Sigma KMAT + \Sigma KR, [PLN \cdot ha^{-1}] \quad (1)$$

where:
ΣKc – total winter wheat production costs $[PLN \cdot ha^{-1}]$,
ΣKM – sum of costs incurred for the use of machines, equipment and means of transport,
ΣKP – sum of costs incurred for fuel,
ΣKMAT – sum of costs for materials used,
ΣKR – total labour costs.

The above values are the sum of direct outlays for production, and indirect outlays estimated to reach 33% of direct outlays.

When assessing accumulated energy intensity of winter wheat production, it has been assumed that its total value is contained in the sum of the same constituents, as specified above. It may be given using the following formula:

$$EC = \Sigma EM + \Sigma EP + \Sigma EMAT + \Sigma ER, [MJ \cdot ha^{-1}] \quad (2)$$

in which, in the same way as above, individual components take into account accumulated expenditures objectified in machines, equipment, means of transport and parts for repair (ΣEM), accumulated energy expenditures in consumed fuel (ΣEP), energy intensity for the manufacture of materials used up in the production (seeds, mineral fertilisers and manure, plant protection agents – ΣEMAT), and totalled equivalent energy intensity of labour (ΣER).

Individual components were determined on the basis of data concerning the kind and type of employed machines and equipment, their work time, unit indexes of operating and repair costs[8], and according to conversion factors for products and agents used in agriculture into conventional accumulated energy intensity units[9].

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[6] Z. Wójcicki, *Poszanowanie energii i środowiska…*, op. cit.
[7] K. Sławiński, *Analiza energochłonności produkcji żyta ozimego w gospodarstwach ekologicznych*, „Inżynieria Rolnicza” 2011 nr 4(129), s. 243-249.
[8] M. Marks, P. Makowski, *Ocena efektywności energetycznej dwupolowych członów zmianowania ugór – pszenica ozima*, “Acta Scientarium Polonarium. Agricultura” 2007 nr 6(4), s. 25-32.
[9] Z. Wójcicki, *Poszanowanie energii i środowiska…*, op. cit.

Discussion of results

While analysing data contained in table 2 and in figure 1, we may see that average total cost per 1 ha of crop was approximately 44% higher for the studied conventional farms than in the case of organic farms (PLN 3735.58 and PLN 2595.67, respectively).

Average economic effectiveness of production in the studied organic farms is distinctly lower (1.36). This result is primarily affected by clearly higher crops and receipts in conventional farms (economic effect: 1.62). As a result of lower production outlays (total costs), organic farms E1 and E3 have economic effectiveness comparable to conventional farms. In organic farm E2, operating costs for machines and equipment were higher compared to E1 and E3. This resulted from the costs of fertilising with manure, and also from less efficient field works in cultivation area (1.5 ha and 1.75 ha) of farm E2. Straw bringing and pressing costs were high as well. Straw was used in that farm for litter, and its value only slightly exceeded management costs. Another reason for poor result in the farm was that 1/3 of total winter wheat crops area got wet in 2012. This fact caused negative economic result of winter wheat cultivation in that farm. The farm incurred production costs for cultivation in the area of 1.75 ha, while area of harvest was only 1.20 ha.

While analysing the structure of costs provided in figure 1, we see that in the case of conventional farms, prevailing costs (on average) were those for materials, primarily fertilisers and plant protection agents (54%). Whereas, machinery and equipment operation costs were prevailing in the case of winter wheat production in organic farms. On average, they constituted more than 50% of total costs in these farms. Also in this group of farms, the cost of labour and fuel consumption[10] was slightly higher compared to conventional farms.

[10] Data on fuel prices for the years 2011-2012 (in terms of every month) were obtained from Opole Agricultural Advisory Centre in Łosiów: M. Ucinek, *Koszty podstawowych działalności produkcji roślinnej i zwierzęcej. Kalkulacja dla użytku słuzbowego,* Łosiów, 2011, 2012.

Table 2
Costs, income, profits and economic effectiveness for winter wheat cultivation [PLN·ha-1] in the studied organic and conventional farms

Specification	Costs, income, profit and economic effectiveness [PLN · ha-1]									
	K1	K2	K3	K4	K5	Average K1-K5	E1	E2	E3	Average E1-E3
Machinery and equipment operating costs	1080.15	1732.34	935.90	1894.90	1124.65	1353.59	1461.91	1610.66	1310.44	1461.00
Fuel cost	236.82	353.10	276.39	331.18	278.83	295.27	123.91	381.84	288.81	264.85
Material cost	1871.58	2473.80	2198.49	1601.06	1964.86	2021.96	385.55	1493.18	314.37	731.03
Labour cost	49.88	0.00	53.20	156.94	63.84	64.77	78.13	202.54	135.66	138.78
Total cost	3238.42	4559.24	3463.99	3984.09	3432.18	3735.58	2049.50	3688.22	2049.28	2595.67
Income	6631.61	6339.00	4977.50	5159.29	7184.20	6058.32	3443.52	4000.12	3162.40	3535.35
Profit	3393.19	1779.76	1513.52	1175.20	3752.02	2322.74	1394.02	311.90	1113.12	939.68
Economic effective-ness	2.04	1.39	1.44	1.34	2.09	1.62	1.68	1.04	1.58	1.36

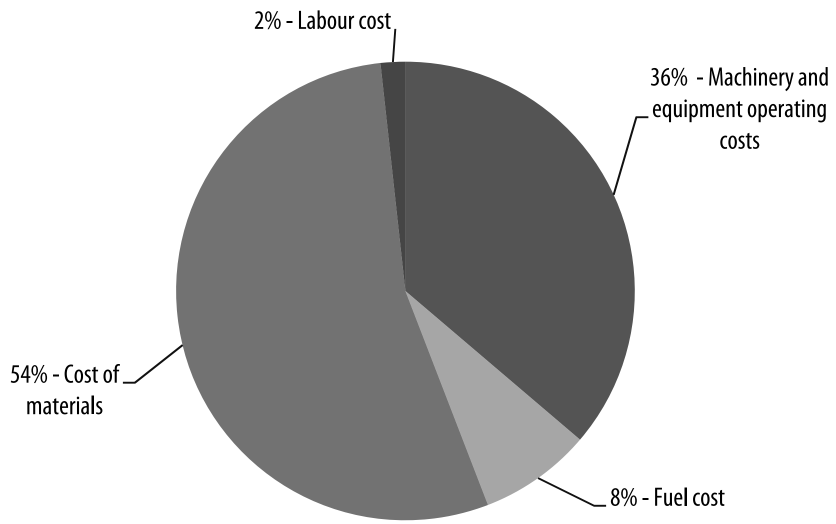
Table 3 contains calculation results concerning accumulated energy intensity for winter wheat production in the studied agricultural farms – conventional and organic. In case of a two-year research, the specified values are averaging values from the whole period.

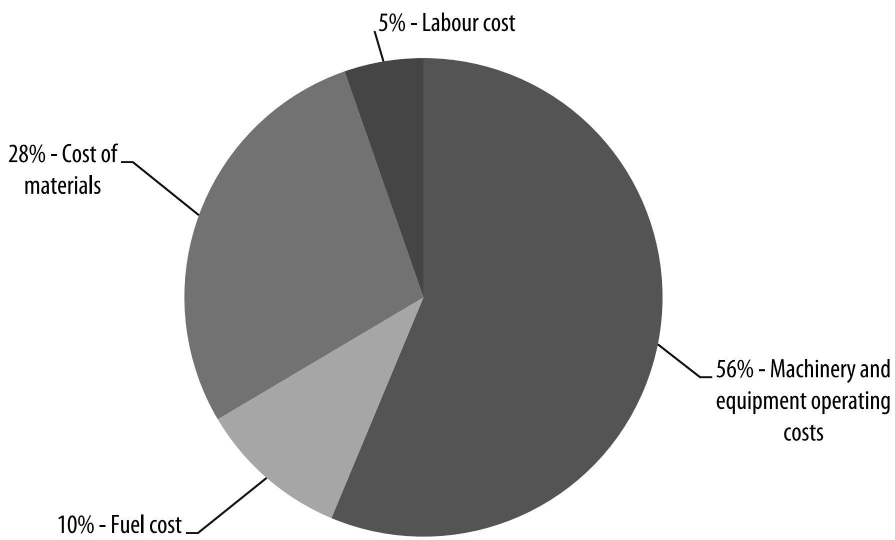
Table 3
Accumulated energy intensity of the winter wheat production [MJ·ha-1] in the studied organic and conventional farms

Specification	Accumulated energy intensity [MJ·ha-1]									
	K1	K2	K3	K4	K5	Average K1-K5	E1	E2	E3	Average E1-E3
Machines and equipment	2856	4 225	2 800	5094	3 942	3783	1 579	6 827	3 568	3991
Fuel	1344	2 004	1 569	1 949	1 583	1690	703	2 306	1 640	1550
Materials	14975	17 170	17 196	13227	20 298	16573	10 043	7 088	1 976	6369
Labour	973	1 450	1 635	1410	1 145	1323	509	1 688	1 186	1128
Total	20148	24849	23200	19492	26968	23369	12 834	17 909	8 370	13038

Source: A. Kuczuk, *Porównanie energochłonności skumulowanej produkcji pszenicy ozimej w uprawie ekologicznej i konwencjonalnej*, "Journal of Research and Applications in Agricultural Engineering" 2013 vol. 58(4), s. 29-33.

Figure 1
Average percent shares (in a group of farms) for individual components in production cost intensity, a) conventional farms; b) organic farms





Data provided in table 3 show that conventional farms had higher accumulated energy intensity for winter wheat production. Average result for this group of farms was 23369 MJ·ha^{-1}. In the case of organic farms, average value of accumulated energy was 13038 MJ·ha^{-1}, respectively. We can see that the difference in average energy expenditures was significant, reaching approximately 80%. For conventional farms, determined average value was 25% higher than energy expenditures in winter wheat production, as specified by Marks and Makowski[11].

When we compare values calculated for organic farms to available literature data, they are close to average values of accumulated energy expenditures in organic cultivation of winter rye, given by Sławiński[12]. Also, in another work[13], comparing energy expenditures for rye production in conventional and organic farms, it was specified that the difference in expenditures per 1 ha constituted 65% of outlays in an organic system. On the other hand, in the aspect of sustainable agricultural production, energy and material expenditures in much the same group of farms are approximately 22% lower than in the studied organic farms[14].

Information in table 3 also indicates that energy intensity in materials used for production was the prevailing component of accumulated energy intensity in conventional farms, constituting from 69.10% (K2) up to 75.27% (K5). This result was connected primarily with using mineral fertilisers, especially nitric, and sowable material. Also in other works, e.g. Dobek[15], Marks and Makowski[16] et al[17], the share of materials in production energy intensity is much the same.

The remaining part of energy load was generated mainly by machinery and equipment operation, and fuel consumption involved. Accumulated energy values were ranging from 4190 MJ·ha^{-1} (K1) up to 7043 MJ·ha^{-1} (K4), respectively. This means that maximum diversification was just above 2853 MJ·ha^{-1}.

In order to illustrate the problem more thoroughly, the following Fig. 2 shows the structure of shares in individual accumulated energy intensity components for winter wheat cultivation in the studied farms. It is visible, that in conventional farms highest accumulated energy intensity concerned materials used for production (71% on average), whereas in the case of organic farms the share of this production component in accumulated energy intensity was much lower

[11] M. Marks, P. Makowski, op. cit.

[12] K. Sławiński, op. cit.

[13] K. Sławiński, *Porównanie energochłonności uprawy wybranych gatunków roślin towarowych gospodarstwie ekologicznym i konwencjonalnym*, "Journal of Research and Applications in Agricultural Engineering" 2010 t. 55(4), s. 99-101.

[14] J. Sawa, B. Huyghebaert, Ph. Burny, *Nakłady energetyczno-materiałowe w aspekcie zrównoważonej produkcji rolniczej*, „Inżynieria Rolnicza" 2006 nr 13, s. 417-422.

[15] T. K. Dobek, *Ocena efektywności ekonomicznej i energetycznej produkcji pszenicy ozimej i rzepaku ozimego wykorzystanych do produkcji biopaliw*, „Inżynieria Rolnicza" 2007 nr 6(94), s. 41-48.

[16] M. Marks, P. Makowski, op. cit.

[17] J. Kurek, *Badania nakładów materiałowo-energetycznych w gospodarstwach rodzinnych*, „Problemy Inżynierii Rolniczej" 2011 nr 2, s. 29-38; B. Szwejkowska, S. Bielski, *Ocena energetyczna produkcji nasion soczewicy jadalnej* (*Lensculinaris Medic.*), "Annales Universitatis Marie Curie-Sklodowska Lublin-Polonia" 2012 vol. LXVII(3), Sectio E, s. 54-60.

(49% on average). On the other hand, organic farms had higher values of accumulated energy intensity for employed machines and equipment and labour. This most often proves the need to ensure higher frequency of mechanical and manual measures in field works related to organic cultivation.

Figure 2
Average percent shares (in a group of farms) for individual components of production energy intensity, a) conventional farms; b) organic farms

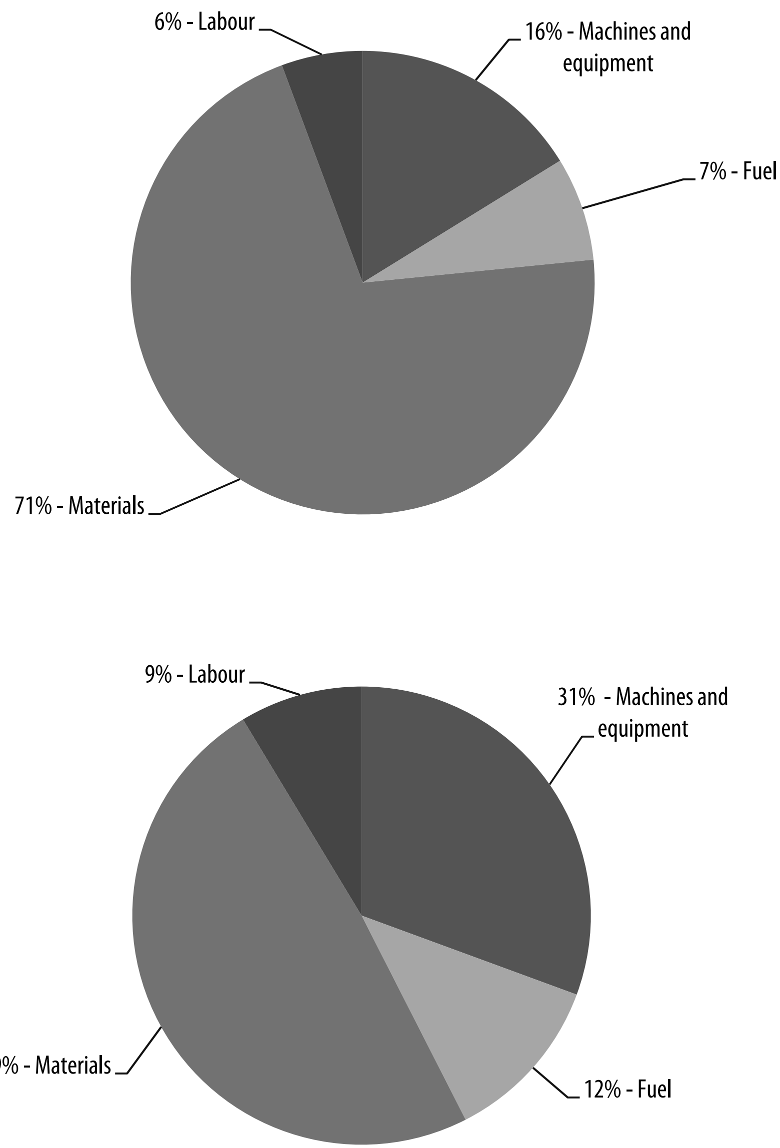


Table 4
Further production indexes for the studied organic and conventional farms

Specification	Farms									
	K1	K2	K3	K4	K5	Average K1-K5	E1	E2	E3	Average E1-E3
Crop [GU·ha-1]	74	75	55	54,5	85	68,7	35,9	31,4	30,5	32,60
Energy efficiency [GU/GJ of accumulated energy)	3.64	3.02	2.37	2.64	3.15	2.96	2.80	1.72	3.71	2.74
[Nutritional MJ · ha-1]	78927	80483	59021	58484	91214	73625.8	38492	33728	32740	34987
Nutritional MJ/MJ of accumulated energy	3.9	3.24	2.54	2.83	3.38	3.18	3.00	1.85	3.98	2.94
Total cost [PLN/dt]	44.67	60.79	62.98	77.51	40.38	57.27	57.75	121.04	76.31	85.03
Total cost/nutritional MJ [PLN/MJ]	0.0416	0.0566	0.0587	0.0722	0.0376	0.0534	0.0538	0.0859	0.1128	0.0842
Total cost/MJ of nutritional energy in straw [PLN/MJ]	0.0230	0.0313	0.0324	0.0399	0.0208	0.0295	0.0297	0.0623	0.0393	0.0438
Energy efficiency for MJ of nutritional and fuel energy in straw/MJ of accumulated energy	7.06	5.86	4.60	5.12	6.12	5.75	5.43	3.35	7.21	5.33

Table 4 shows further indexes that characterise production in the studied farms from cost and energy point of view. The difference in obtained crops for farm groups is clearly visible. Average crop in conventional farms was 68.7 $dt\cdot ha^{-1}$, and in organic: 32.6 $dt\cdot ha^{-1}$, which was twice less. This difference resulted from an extensive organic production and lack of application of chemical fertilisers and chemical plant protection agents. This translates into the value of nutritional energy in flour (nutritional MJ) obtained from grain crop. Nevertheless, if we look at energy efficiency representing the ratio between the number of obtained grain units (GU) and GJ of energy expenditure (accumulated energy intensity)[18], it may be stated that close values are received for both production types. In the case of conventional farms, average values of this index reached 2.96 GU/GJ, and for organic farms: 2.74 GU/GJ. As a result, there are slight differences in average volume of produced nutritional energy per unit of accumulated energy expenditures. If we take energy efficiency as the sum of nutritional energy from grain and fuel energy contained in straw per 1 MJ of accumulated energy expenditures, then, on average, it is 5.75 for conventional farms and 5.33 for organic farms.

Average total cost per production unit reached 57.27 PLN/dt in conventional farms and 85.03 PLN/dt in organic farms, respectively. In the case of organic farms, the value of this calculation component was raised by costs in farm E2. This relation transfers linearly into average total cost of producing nutritional energy unit. It was 0.0534 PLN/MJ for the studied conventional farms and 0.0842 PLN/MJ for organic farms. In case of average total cost of producing nutritional energy in grain and fuel energy in straw, it was 0.0295 PLN/MJ for conventional farms and 0.0438 PLN/MJ for organic farms, respectively.

In case of the studied organic farms, the shares of taken into account components of accumulated energy expenditures differed much, and resulted both from applied agrotechnical measures and from the specificity of farms themselves. In case of farm E1, large area of winter wheat crop was combined with the need to use modern, high-capacity and aggregated machines. This caused relatively low unit expenditures related to machinery and equipment work and consumed fuel (2282 $MJ\cdot ha^{-1}$). On the other hand, during the studied period the farm had high energy expenditures for liming, which resulted in increased accumulated energy expenditures for production.

Own stock of machines in farm E2 was obsolete, not much aggregated, which caused the need for repeated runs of machines and relatively high number of machine-hours. This was also clearly visible in production costs. That was the only one among the studied organic farms, in which high share in energy expenditures was related to straw pressing and transportation (more than 50% of total energy expenditures involved in machinery and equipment operation and fuel consumption). This was due to carried out animal production. In the same farm, energy balance was also to a large extent burdened by fertilising with manure.

[18] Z. Wójcicki, *Efektywność energetyczna produkcji rolniczej w Polsce*, „Problemy Inżynierii Rolniczej" 2005 nr 4, s. 5-16.

Among the studied organic farms, farm E3 was characterised by lowest accumulated energy intensity of production. Its energy balance was not burdened by fertilising, liming, or straw management. On the other hand, energy expenditures related to work of other machines and equipment and consumed fuel did not cause any significant undermining of balance proportions, compared to other farms.

Conclusions

Completed studies on cost and energy intensity of accumulated winter wheat production in conventional and organic farms allowed formulation of the following conclusions:

Lack of chemical mineral fertilisers and chemical plant protection agents was the reason for obtaining lower crops in the studied organic farms. On average, for organic farms it reached 32.6 $dt \cdot ha^{-1}$, whereas for conventional farms it was almost twice higher – 68.7 $dt \cdot ha^{-1}$.

On average, total production cost for 1 ha of winter wheat for conventional farms reached 3735.58 PLN, and in the case of organic farms: 2595.67 PLN. However, taking into account much lower crop yield in organic farms, average cost per product unit was 57.27 PLN for conventional farms and 85.03 PLN for organic farms.

In conventional farms, prevailing costs were purchases of fertilisers and plant protection agents, and in organic farms: operating costs for machines and equipment.

At comparable winter wheat sale prices, average economic effectiveness was 1.62 in conventional farms and 1.36 in organic farms.

Lack of mineral fertilising and application of chemical plant protection agents in organic farms caused radical reduction of accumulated energy intensity for winter wheat cultivation. Average accumulated energy intensity in the studied organic farms reached 17909 $MJ \cdot ha^{-1}$, and in the case of conventional farms: 23369 $MJ \cdot ha^{-1}$.

On average, as a result of twice lower crop yield in the studied organic farms compared to conventional farms, production cost for unit of nutritional and fuel energy in straw was aproximately twice higher in organic farms.

Due to the differences in obtained winter wheat crops among the studied organic and conventional farms, and similar, twofold differences in energy expenditures, indexes specifying number of GU per unit of consumed accumulated energy, and thus the volume of produced nutritional energy per accumulated energy unit were very much the same for both farm types. In the case of conventional farms, average value of this index reached 2.96 GU/GJ, and in conventional farms: 2.74 GU/GJ.

The above relations translate into comparable, high energy efficiency in both farm types. On average, it was 5.75MJ of nutritional energy and fuel energy in straw per one MJ of accumulated energy intensity for conventional farms, and 5.33 MJ for organic farms.

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