POLISH JOURNAL OF NATURAL SCIENCES
Abbrev.: Pol. J. Natur. Sc., Vol 27(4): 353–358, Y. 2012

THE ANALYSIS OF ENERGY CONSUMPTION IN LINK OF ROTATION: WINTER RYE – POTATO IN SYSTEM OF ORGANIC AND CONVENTIONAL FARMING

Kazimierz Sławiński, Robert Bujaczek

Department of Agricultural Engineering
Koszalin University of Technology

Key words: conventional farming, energy consumption, link of rotation, organic farming, potato, winter rye.

Abstract

The study was conducted in 2008–2010, in north-western Poland, in 10 organic farms and 10 conventional farms. Potato crop of early varieties was in these farms; growing structure every year. In all farms a forecrop for potato was winter rye grown for grain. Cultivation was carried out in similar natural and productive conditions, mainly on soils of class IIIa and IVb.

Productivity of link of rotation: winter rye – potato depends mainly on potato yielding.

In organic farming rye has a definitely higher energy efficiency rate than potato. In conventional farming there was a higher energy efficiency rate in potato growing.

In comparison to conventional system, the organic farming of link of rotation: winter rye – potato is characterized by lower accumulative energy profit (by 50%), a definitely lower energy efficiency rate and higher energy consumption.

The effectiveness of technologies in the organic system should not be limited to a single crop, but considered in a whole production process.

ANALIZA NAKŁADÓW ENERGETYCZNYCH ZMIANOWANIA: ŻYTO OZIME – ZIEMNIAK W SYSTEMIE ROLNICTWA EKOLOGICZNEGO I KONWENCJONALNEGO

Kazimierz Sławiński, Robert Bujaczek

Katedra Agroinżynierii
Politechnika Koszalińska

Słowa kluczowe: rolnictwo ekologiczne, rolnictwo konwencjonalne, ziemniaki, zmianowanie, zużycie energii, żyto ozime.

Address: Kazimierz Sławiński, Koszalin University of Technology, ul. Racławicka 15-17, 75-620 Koszalin, Poland, phone: + 48 (94) 347 84 93, e-mail: agromarketing@poczta.onet.pl

Abstrakt

Badania przeprowadzono w latach 2008–2010 w północno-zachodniej Polsce, w 10 gospodarstwach ekologicznych i 10 gospodarstwach konwencjonalnych. Każdego roku uprawiano ziemniaki odmian wczesnych. Przedplonem było żyto ozime uprawiane na ziarno. Uprawa została przeprowadzona w podobnych warunkach naturalnych i produkcyjnych, głównie na glebach klasy IIIa i IVb. Stwierdzono, że wydajność zmianowania: żyto ozime – ziemniak zależy głównie od plonowania ziemniaków. W ekologicznej uprawie żyto ma zdecydowanie wyższy wskaźnik efektywności energetycznej niż ziemniaki. W rolnictwie konwencjonalnym wyższy wskaźnik efektywności energetycznej stwierdzono w uprawie ziemniaka. W porównaniu z systemem konwencjonalnym rolnictwo ekologiczne w zmianowaniu żyto ozime – ziemniak charakteryzuje się niższym skumulowanym zyskiem energii (o 50%), zdecydowanie niższym wskaźnikiem efektywności energetycznej i większym zużyciem energii.

Introduction

According to many authors, crop production in organic farming system is characterized by lower energy consumption than in a conventional system (LÖTJÖNEN 2003, PETERSEN et al. 1999, PISKIER 2009, REGANOLD et al. 2001). However, as DALGAARD'S research indicates (2003), due to lower crop yields in organic farming systems, energy efficiency is similar to that achieved in conventional system. The report of FOSTER et al. (2006) shows that in the system of organic farming the energy efficiency rate of crops may also have a value less than 1 (below the energy efficiency threshold). Also HILL (2009) indicates that organic farming does not always consumes less energy than conventional farming- it all depends on the employed technology.

The efficiency of agricultural production can be measured in energy consumption. In the organic farming system the energy efficiency rate is highly dependent on the applied technology and the crops obtained (HILL 2009, SŁAWIŃSKI 2010). According to SZEPTYCKI and WÓJCICKI (2003), the efficiency of energy inputs in agriculture is influenced, among others, by: the type of production and its intensity, the level of mechanization, applied technology and production organization. The effectiveness of technology should be considered in the link of rotation which is of particular importance in the system of organic farming, because the effect of organic fertilization and applied agronomic treatments lasts several years. The evaluation of effectiveness cannot be limited to the analysis of individual treatments but it should be considered comprehensively in the full-scale production process. The aim of the study was the analysis of energy consumption in link of rotation: winter rye – potato in system of organic and conventional farming.

Material and Methods

The study was conducted in 2008–2010, in north-western Poland, in 10 organic farms and 10 conventional farms. Potato crop of early varieties was in these farms' growing structure every year. In all farms a forecrop for potato was winter rye grown for grain. Cultivation was carried out in similar natural and productive conditions, mainly on soils of class IIIa and IVb. In the conventional system, pre-sowing rye was fertilized with ammonium phosphate. Additional seeding with nitrogen and potassium fertilizers was taken in the spring. Weeds were fought by a single herbicide spraying. It was used a double foliar nutrition of rye with a solution of urea and magnesium sulphate, and simultaneously anti-hatching regulator, fungicide and insecticide. Pre-sowing potatoes were fertilized with manure at 30 t ha^{-1}. In further growing they were sprayed seven times with chemical substances against weeds, pests and diseases, including foliar nutrition with a solution of urea and magnesium sulfate.

In the ecological system rye in spring was fertilized with manure in an amount of 10 000 l ha^{-1} and basalt powder at 600 kg ha^{-1}. Potatoes were fertilized with manure at 30 t ha^{-1} in the autumn. The cultivation of potatoes consisted of five earthings up (alternately with harrowing) and double spraying with biological insecticide Novodor with the moment of appearing of larvae of Colorado potato beetle.

Farms were self-sufficient in terms of equipment including means of mechanization and did not use the services from outside. Energy consumption of materials and energy value of crop was defined in megajoules (MJ) based on rates of specific energy consumption (WÓJCICKI 2000). Energy efficiency rate (E_{ee}) was calculated from the relation between energy value of crop (P_e w GJ ha^{-1}) and energy expenditures incurred for its formation (N_e w GJ ha^{-1}). The collected data was presented as a 3-year average and was reduced to the area of 1 ha. While estimating the productivity, plant crops were converted into cereal units (*Katalog norm*... 1999).

Results

One of the methods to evaluate crop rotation or its part, is to express the productivity of crops in conventional conversion units, e.g. in cereal units. According to the productivity, organic link of rotation: winter rye – potato is far less productive than the conventional system. While organic farming achieved on average 90 c.u. ha^{-1}, in the conventional system it was 160 c.u. ha^{-1} (Table 1). In both analyzed systems, this value depended mainly on the productivity of potato.

Table 1

Productivity of link of rotation: winter rye – potato in the organic and conventional farm (the average in the years 2008–2010)

Crop	Organic		Conventional	
	winter rye	potato	winter rye	potato
Main crop [t ha^{-1}]	2.15	18.7	3.2	35.4
Secondary crop [t ha^{-1}]	1.89	–	2.1	–
[c.u. ha^{-1}]	24.3	65.5	35.2	123.9
Link of rotation [c.u. ha^{-1}]	89.8		159.1	

In the analyzed production systems, potato growing involves the need to incur more than 2.5 times higher energy expenditures than in the cultivation of rye. Bulb yield, however, carries a large energy potential, that determines the energy productivity of analyzed link of rotation. Comparing energy value of crop to the expenditures incurred on its formation, it was found that in organic farming, rye is characterized by definitely higher energy efficiency rate than potato (Table 2). In the conventional system, potato was characterized by a higher rate of energy efficiency. Rye grown in the organic system and potato in conventional farming had also low (compared to other crops) rate of energy consumption, amounting to 0.44. In both the organic and conventional systems, the cultivation of winter rye was associated with higher (comparing to potato) energy consumption per unit [MJ c.u.$^{-1}$].

Table 2

Selected elements of the energy assessment of potato and winter rye production in the conventional and ecological farm (the average in the years 2008–2010)

Energy beam	Organic		Conventional	
	winter rye	potato	winter rye	potato
Energy expenditures [MJ ha^{-1}]	9 935	25 163	16 120	38 950
Energy value of main and secondary crop [MJ ha^{-1}]	22 743	45 034	32 580	88 500
Accumulative energy profit [MJ ha^{-1}]	12 808	19 871	16 460	49 550
Energy efficiency rate	2.29	1.87	2.02	2.27
Energy consumption rate	0.44	0.56	0.49	0.44
Energy consumption rate per unit [MJ j.z.$^{-1}$]	408.8	384.2	458.0	314.4

Total expenditures of energy, incurred for conventional cultivation of link of rotation: winter rye – potato, were nearly 57% higher than in the organic system. The energy value of obtained crop was definitely higher (78.6%), which has contributed to obtaining over 100% higher accumulative energy profit in conventional system. In organic cultivation of link of rotation: winter rye

– potato energy expenditures incurred to produce 1 cereal unit averaged 390,8 MJ c.u.$^{-1}$ and in the conventional cultivation 346.1 MJ c.u.$^{-1}$. Production of 1 cereal unit in a conventional system required only 88.6% of expenditures incurred in the organic system (Table 3).

Table 3

Selected elements of the energy assessment of link of rotation: winter rye – potato in the organic and conventional farms (the average in the years 2008–2010)

Energy beam	Organic	Conventional	Difference organic=100%
Energy expenditures [MJ ha^{-1}]	35 098	55 070	156.9
Energy value of main and secondary crop [MJ ha^{-1}]	67 777	121 080	178.6
Accumulative energy profit [MJ ha^{-1}]	32 679	66 010	202.0
Energy efficiency rate	1.93	2.20	114.0
Energy consumption rate	0.52	0.45	86.5
Energy consumption rate per unit [MJ j.z.$^{-1}$]	390.8	346.1	88.6

Conclusion

1. Productivity of link of rotation: winter rye – potato depends mainly on potato yielding.
2. In organic farming rye has a definitely higher energy efficiency rate than potato. In conventional farming there was a higher energy efficiency rate in potato growing.
3. In comparison to conventional system, the organic farming of link of rotation: winter rye – potato is characterized by lower accumulative energy profit (by 50%), a definitely lower energy efficiency rate and higher energy consumption.
4. The effectiveness of technologies in the organic system should not be limited to a single crop, but considered in a whole production process.

Translated by Kazimierz Sławiński

Accepted for print 24.09.2012

References

Dalgaard T. 2003. *On-farm fossil energy use*, Ecology and Farming, 32(9): .

Foster C., Green K., Bleda M., Dewick P. Evans B., Flynn A., Mylan J. 2006. *Environmental impacts of food production and consumption. A report to the Department for Environment, Food and Rural Affairs. Manchester Business School*. Defra, London.

Hill H. 2009. *Comparing energy use in conventional and organic cropping systems*. Sustainable Agriculture Information Service, pp. 1–8.

Katalog norm i normatywów. 1999. Wydanie III, SGGW, Warszawa.

LÖTJÖNEN T. 2003. *Machine work and energy consumption in organic farming*. Ecology and Farming, 32: 7–8.

PISKIER T. 2008. *Analiza efektywności energetycznej proekologicznych sposobów ograniczania zachwaszczenia pszenicy jarej*. J. Res. Appl. Agric. Engng., 53(4): 37–39.

PETERSEN C., DRINKWATER L.E., WAGONER P. 1999. *The rodale Institute Farming Systems Trial. The First 15 Years,* The Rodale Institute.

SŁAWIŃSKI K. 2010. *Porównanie energochłonności uprawy wybranych gatunków roślin towarowych w gospodarstwie ekologicznym i konwencjonalnym*. J. Res. Agric. Engng., Poznań, 55(4): 99–101.

SZEPTYCKI A., WÓJCICKI Z. 2003. *Postęp technologiczny i nakłady energetyczne do 2020 r*. IBMER, Warszawa, pp. 14–20.

REGANOLD J.P., GLOVER J.D., ANDREWS P.K., HINMAN J.R. 2001. *Sustainability of three apple production systems*. Nature, 410: 926–930.

WÓJCICKI Z. 2000. *Wyposażenie techniczne i nakłady materiałowo-energetyczne w rozwojowych gospodarstwach rolniczych*. IBMER, Warszawa, pp. 111–131.