Estimation of economic demandingness of the technologies used for cultivation of legume-cereal intercrops under conditions of organic farming

Stanovení ekonomické náročnosti technologie pěstování luskovino-obilné směsky v podmínkách ekologického zemědělství

Jaroslav JÁNSKÝ[1], Jiří POSPÍŠIL[2]

[1]Faculty of Regional Development and International Studies, Mendel University in Brno, Czech Republic
[2]Faculty of Agronomy, Mendel University in Brno, Czech Republic

Abstract: The paper analyses the machinery costs associated with the performance of the individual operations when growing and harvesting the legume-cereal intercrops (LCI). For this purpose, a database of costs associated with the individual operations concerning the LCI growing has been created. This database is continuously updated in such a way that it enables to estimate variable costs associated with the individual LCI growing and harvesting operations. The authors followed up and analysed the process of growing and harvesting the LCI as a fodder crop and preserving the harvested material in the form of haylage and silage or for grain (both wet and dry). The analysed data were obtained in the course of the individual operations of machinery used in the individual technologies of establishing and growing of the LCI under the conditions of organic farming.

Key words: economic demandingness of LCI growing; variable costs; growing technologies; harvesting

Abstrakt: V příspěvku jsou analyzovány náklady na stroje při provádění jednotlivých operací pěstování a sklizně luskovino-obilné směsky (LOS). K tomuto účelu byla vytvořena databáze nákladů na jednotlivé operace pěstování LOS, která je průběžně aktualizována tak, aby bylo možné stanovit variabilní náklady na jednotlivé technologie pěstování a sklizně LOS. V souladu s metodickým postupem řešení jsou sledovány při pěstování a sklizeň na zeleno komoditní výstupy senáž a siláž a při pěstování a sklizni na zrno – suché a vlhké zrno. Zdroje dat byly získány pro stroje nasazené v jednotlivých technologiích zakládání porostu a pěstování LOS ve vybraných ekologických podnicích.

Klíčová slova: ekonomická náročnost pěstování luskovino-obilné směsky (LOS), variabilní náklady LOS, technologie pěstování a sklizně LOS

Under the conditions of organic farming, the arable land is used above all for growing cereals. At present, the share of cereal crops is approximately 55% of the total harvested area. The second position is occupied by fodder crops grown on arable land (32%). The legume-cereal mixtures (LCI) are grown on arable land and (regarding the character of their production) they participate in both groups of the aforementioned organic crops.

An evaluation of economic aspects of the cultivation of these crops enables, together with the calculation of the associated costs, to estimate either profits or losses of the individual farms. Gross margins that are used for the coverage of fixed costs and profits when evaluating economic aspects of the LCI growing may be considered as an advantageous criterion enabling to optimize the production programme especially from the viewpoint of the short-term (operational)

Subproject A/CZ0046/1/0024 was financed by the EEA Financial Mechanism, the Norwegian Financial Mechanism, and the state budget of the Czech Republic through the Research Support Fund.

decision making. However, this method has also a certain disadvantage; it does not involve the share of fixed expenses and for that reason, it also does not enable to evaluate the final profit per production units so that it is not possible to define their prices. This can sometimes lead (above all from the viewpoint of the long term planning) to wrong decisions (Kavka et al. 2006).

The estimation of direct costs per unit production enables also to compare not only different crops but also the individual growing technologies used within the framework of one farm. The estimation and knowledge of direct costs also enables to evaluate the effects of the applied technologies.

When evaluating the final economic parameters, the following facts should be taken into account (Lieber et al. 1991):

– If the gross margin covering fixed costs is positive and the overall profitability of crop growing negative , then the corresponding technology may be economically advantageous only from the short-term point of view;
– From the long-term point of view, only growing of those crops can be economically advantageous, which have pre-requisitions of profit generation and which show a positive overall profitability of production.

Similarly as in case of other crops, also when evaluating the economic aspects of the LCI growing, it is not possible to reach the acceptable results without consideration their subsequent use. Expenses associated with the production of feedstuffs are an important cost item and for that reason, it is necessary to reach high yields of nutrients per hectare and to produce and preserve fodder crops with the minimum losses and costs (Jánský 2007). There is a general requirement which concerns the production of all feedstuffs: it is necessary to assure a satisfactory performance of farm animals on the base of a maximum intake of roughage and a minimum consumption of concentrates. This can be reached with feedstuffs containing high concentrations of nutrients and dry matter.

Recently, the legume-cereal mixtures are grown mainly as cash crops in the Czech farming and their use for feeding animals is markedly reduced. The aim of this paper is to evaluate the economic demandingness of growing the LCI under the conditions of organic farming.

The paper presents the results of a subproject called "Utilizing legume-cereal intercropping to increase self-sufficiency with animal fodder and maintain soil quality on organic farms in the Czech Republic", ref. No. A/CZ0046/1/0024, which is funded from the Research Support Fund of the National Training Fund, o.p.s.

OBJECTIVES AND METHODS

When solving this subproject, the authors used the results of monitoring and evaluation of technical and economical parameters that were investigated on five selected organic farms within the period of 2006–2008. The calculation of production costs was based on data about the LCI growing technologies used within this sample of farms within the period of several years (i.e. dressing and liming, tillage operations, sowing, treatment in the course of growing season, harvesting, and transportation of the main product, and of by-products).

The result of this study was the estimation of the variable machinery costs (diesel oil consumption and labour consumption were monitored with regard to the individual operations while the repair costs were estimated on the base of the results of a statistical analysis of the whole set of organic farms and calculated per hectare).

When evaluating the economic demandingness of the LCI growing, all expenses were strictly differentiated as variable and fixed.

Variable costs occur directly within the framework of the production process and they are directly proportional to the extent of production. When evaluating the value of the LCI production, the whole period of growing was taken into account, i.e. from the first tillage operation before sowing to the harvest period and the transportation of the final product.

The level of fixed costs corresponds with those calculated for conventional farms situated in the potato-growing region. These data originated mostly from the surveys performed within a set of the selected natural and legal bodies and were obtained by the authors of this study. Besides, they were also confronted with the statistical data published by the Research Institute of Agricultural Economics (Poláčková et al. 2010) and the Research Institute of Agricultural Engineering (Kovářová et al. 2002).

The total costs per unit of production do not involve storage costs. In the case that the LCIs were used with regard to their individual components (e.g. grain and straw), the calculations involved also costs associated with the harvest of by-products (i.e. straw removal and/or crushing).

The total costs per 1 ton of the LCI production are dependent on the total costs per hectare and on the obtained yields. Besides the machinery costs, they are influenced also by the material inputs. In this context, above all the costs of seed materials are important. When producing the LCI on organic farms, the intensity of fertilisation is restricted only to manuring. The costs associated with plant protection are included into the machinery costs because only the mechanical methods of weed killing (i.e. harrowing) are being used. The use of these methods seems to be necessary for obtaining the expected yields and for the maintenance of soil fertility; this was documented also in studies performed in other organisations.

The costs of seed materials are not influenced by the growing technology and it can be said that they are fully dependent on the possibilities of their purchasing from the suppliers.

Machinery costs (Pospíšil 2008) are determined by the set up of machine aggregates performing the individual operations which take into account both technical parameters and the price level of repairs and maintenance, fuels, lubricants and wages of operators (personal expenditures). Material costs were analysed as follows:

– Prices of the essential materials (seeds)
– Prices of the auxiliary materials (strings, foils etc.).

Costs of manuring and liming were calculated separately (this is carried in the period of four years).

RESULTS AND DISCUSSION

Direct costs associated with the individual technological operations from sowing to harvesting the LCI were followed up on several selected organic farms. The obtained results were used for the creation of a database containing the costs of the individual operations. This database is continuously updated in such a way that it is possible to estimate and evaluate variable costs associated with the individual technologies of growing and harvesting of the LCI. This means that we can monitor the costs of technologies of growing the LCI for silage and/or haylage, preserved in clamps, and stored in big bales on the one hand and harvesting the LCI for grain (both wet and dry) on the other. Orientational costs of the model technological procedures of growing, harvesting, and transportation of LCI are presented in Tables 1–4. These tables characterise not only the individual working operations, but also their variable and fixed costs expressed in CZK per hectare.

The amount of costs of the essential and auxiliary materials is influenced above all by the seed material and technology of the preservation and/or storage of the harvested fodder. The average prices are presented in Table 5. This table contains also the average yields and the average prices of the seed material used when estimating the economic demandingness of the LCI growing. All prices are presented without the VAT.

The results presented in Tables 1–4 and in Figure 1 indicate that the energy consumption was increased when harvesting the LCI for silage. This was influenced above all by the type of the harvesting machinery and its year-round use (see Figure 2 presenting the shares of fixed costs in the total costs of the individual technologies). When comparing the costs of energy consumed for the LCI harvesting for grain, it is possible to see that the differences in the diesel oil consumption are negligible (Figure 3). However, when harvesting the LCI for wet grain, the labour costs were higher than in other cases. As far as the total costs are concerned, the labour consumption was also higher in the case of wet grain technology

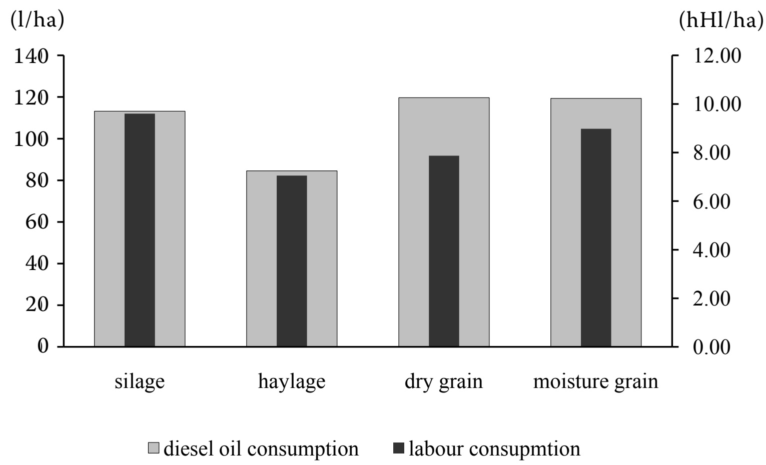

Figure 1. Consumption of energy and labour for the LCI-production according to the individual technologies

Source: own results

Table 1. Technology of the LCI harvest for silage

Name of operation	Technics	MJ	Harvested acreage	Performance (h/MJ)	Consumption of diesel oil (l/MJ)	Time consumption (h/MJ)	Diesel oil costs (CZK/MJ)	Labour costs (CZK/MJ)	Machinery fixed costs (CZK/MJ)	Machinery total costs (CZK/MJ)
Manuring	T 4 × 4, 110 kW – spreader – 10 t	hectare	0.25	0.5	28	2	173.25	50	150	373.25
Stubble breaking	T 4 × 4, 120 kW – Stubble ploughs 4 m	hectare	1.00	2.44	6.90	0.41	170.775	41	377	588.775
Ploughing	T 4 × 4, 90 kW – Ploughs 4 f	hectare	1.00	1.18	21.00	0.85	519.75	85	304	908.75
Harrowing	T 4 × 4, 70 kW – Harrows 8 m	hectare	2.00	4.00	4.70	0.25	232.65	50	214	496.65
Transportation of seed material	T 4 × 2, 65 kW – T. trailer 8–9 t	hectare	1.00	10.00	0.25	0.20	6.1875	20	300	326.1875
Loading of seed material	Manipulator	hectare	1.00	50.00	0.45	0.20	11.1375	20	450	481.1375
Sowing	T 4 × 4, 65 kW – Universal drill 6 m	hectare	3.00	2.86	3.50	0.35	259.875	105	418	782.875
Rolling	T 4 × 4, 75 kW – roller 6 m	hectare	1.00	3.45	3.40	0.29	84.15	29	372	485.15
Mowing and cutting	Forage harvesters > 200 kW	hectare	1.00	1.67	18.00	0.60	445.5	60	1 583	2 088.5
Transportation of chopped fodder	T 4 × 2, 65 kW – T. trailer 8–9 t	hectare	1.00	7.14	15.00	2.40	371.25	240	236	847.25
Compacting	Manipulator	hectare	1.00	1.49	12.00	0.85	297	85	450	832
Clamp covering	Manually	hectare	1.00	0.00	0.00	1.20	0	120	0	120
Sum		**hectare**	**x**	**x**	**113.2**	**9.6**	**2 571.525**	**905**	**4 854**	**8 330.525**

Source: own calculation

Table 2. Technology of the LCI harvest for haylage

Name of operation	Technics		Harvested acreage	Performance (h/MJ)	Consumption of diesel oil (l/MJ)	Time consumption (h/MJ)	Diesel oil costs (CZK/MJ)	Labour costs (CZK/MJ)	Machinery fixed costs (CZK/MJ)	Machinery total costs (CZK/MJ)
Manuring	T 4 × 4, 110 kW – spreader 10 t	hectare	0.25	0.50	25	2	154.69	50.00	150	354.69
Stubble breaking	T 4 × 4, 75 kW – Cultivators 3 m	hectare	1	1.82	6.9	0.55	170.78	55.00	1 250	1475.78
Ploughing	T 4 × 4, 90 kW – Ploughs 4 f.	hectare	1	0.83	18.5	1.2	457.88	120.00	304	881.88
Sowing	T 4 × 4, 80 kW – Cultivator Mounted Seed Drills 3 m	hectare	1	2.22	11.5	0.45	284.63	45.00	250	579.63
Loading of seed material	T 4 × 4, 80 kW – front. loader	hectare	1	20.00	0.27	0.05	6.68	5.00	35	46.68
Transportation of seed material	T 4 × 2, 65 kW – T. trailer 8–9 t	hectare	1	100.00	0.15	0.01	3.71	1.00	11.2	15.91
Mowing	T 4 × 4, 75 kW – mower 3.2 m	hectare	1	2.50	5	0.4	123.75	40.00	186	349.75
Raking	T 4 × 2, 80 kW – rotor rakes 6.3 m	hectare	1	2.86	3.6	0.35	89.10	35.00	192	316.10
Baling	T 4 × 2, 75 kW – Round balers 1.6 m	hectare	1	1.05	5.7	0.95	141.08	95.00	320	556.08
Wrapping of big bales	T 4 × 2, 75 kW + wrapping machine	hectare	1	12.50	0.2	0.08	4.95	8.00	245	257.95
Loading of big bales	T 4 × 4, 80 kW – front. Loader	hectare	1	12.50	3.5	0.56	86.63	56.00	35	177.63
Transport of big bales	T 4 × 2, 65 kW – T. trailer 8–9 t	hectare	1	50.00	2	0.2	49.50	20.00	33	102.50
Storage of big bales	T 4 × 4, 80 kW – front. Loader	hectare	1	12.50	2.24	0.25	55.44	25.00	35	115.44
Sum		**hectare**	**x**	**x**	**84.56**	**7.05**	**1 628.80**	**555**	**3 046.2**	**5 230.00**

Source: own calculation

Table 3. Technology of the LCI harvest for moisture grain

Name of operation	Technics		Harvested acreage	Performance (h/MJ)	Consumption of diesel oil (l/MJ)	Time consumption (h/MJ)	Diesel oil costs (CZK/MJ)	Labour costs (CZK/MJ)	Machinery fixed costs (CZK/MJ)	Machinery total costs (CZK/MJ)
Liming	T 4 × 4, 120 kW spreader semi-trailer 8 t	hectare	0.25	0.60	12.00	0.50	74.25	12.50	173.00	259.75
Manuring	T 4 × 4, 80 kW spreader semi-trailer 5 t	hectare	0.25	0.50	25.00	2.00	154.69	50.00	492.19	696.88
Stubble breaking	T 4 × 2, 75 kW – Cultivators 3.5 m	hectare	1.00	2.13	6.00	0.47	148.50	47.00	434.50	630.00
Ploughing	T 4 × 4, 180 kW – Ploughs 7 f.	hectare	1.00	1.00	21.00	1.00	519.75	100.00	1 023.75	1643.50
Smoothing and harrowing	T 4 × 4, 65 kW – skids 6 m	hectare	1.00	3.57	3.50	0.28	86.63	28.00	174.63	289.25
Sowing by seed combination	T 4 × 4, 110 kW – Seed Drills 4.5 m	hectare	1.00	2.00	10.00	0.50	247.50	50.00	603.50	901.00
Transportation of seed material	T 4 × 2, 50 kW – T. trailer 5–7 t	hectare	1.00	8.33	0.40	0.12	9.90	12.00	33.90	55.80
Loading of seed material	T 4 × 4, 60 kW – front. Loader	hectare	1.00	14.29	0.20	0.07	4.95	7.00	26.95	38.90
Harrowing	T 4 × 4, 110 kW – Harrows 12 m	hectare	1.00	5.26	1.70	0.19	42.08	19.00	107.08	168.15
Grain harvest	Combine harvesters > 200 kW	hectare	1.00	2.22	16.00	0.45	396.00	45.00	1 445.00	1 886.00
Grain transportation	T 4 × 2, 50 kW – T. trailer 5–7 t	hectare	1.00	2.50	12.00	0.40	297.00	40.00	346.00	683.00
Grain ensiling into sacks	Grain crusher and press the bag	hectare	1.00	2.50	5.00	0.40	123.75	40.00	1 763.75	1 927.50
Straw harvesting	T 4 × 2, 75 kW – Round balers 1.6 m	hectare	0.50	1.11	5.50	0.90	68.06	45.00	738.06	851.13
Loading of straw	T 4 × 4, 60 kW – front. Loader	hectare	0.50	16.67	0.40	0.50	4.95	25.00	42.95	72.90
Straw harvesting	T 4 × 2, 65 kW – T. trailer 8–9 t	hectare	1.00	50.00	0.23	0.60	5.69	60.00	76.69	142.39
Storage of big bales	T 4 × 4, 60 kW – front. Loader	hectare	1.00	16.67	0.40	0.60	9.90	60.00	82.90	152.80
Sum		**hectare**	**x**	**x**	**119.33**	**8.98**	**2 193.59**	**640.50**	**7 564.84**	**10 398.94**

Source: own calculation

Table 4. Technology of the LCI harvest for grain

Name of operation	Technics		Harvested acreage	Performance (h/MJ)	Consumption of diesel oil (l/MJ)	Time consumption (h/MJ)	Diesel oil costs (CZK/MJ)	Labour costs (CZK/MJ)	Machinery fixed costs (CZK/MJ)	Machinery total costs (CZK/MJ)
Liming	T 4 × 4, 120 kW spreader semi-trailer 8 t	hectare	0.25	0.60	12.00	0.50	74.25	12.50	87.25	174.00
Manuring	T 4 × 4, 80 kW spreader semi-trailer 5 t	hectare	0.25	0.50	28.00	2.00	173.25	50.00	225.25	448.50
Stubble breaking	T 4 × 4, 135 kW – Cultivators 4.7 m	hectare	0.20	2.63	6.90	0.38	34.16	7.60	184.76	226.51
Ploughing	T 4 × 4, 180 kW – Ploughs 6 f.	hectare	0.80	1.18	21.00	0.85	415.80	68.00	789.80	1273.60
Smoothing and harrowing	T 4 × 4, 150 kW skids + harrows 9 m	hectare	2.00	5.00	3.50	0.20	173.25	40.00	528.25	741.50
Loading of seed material	Manipulator	hectare	1.00	100.00	0.19	0.01	4.70	1.00	130.70	136.41
Transportation of seed material	T 4 × 2, 50 kW – T. trailer 5–7 t	hectare	1.00	33.33	0.32	0.03	7.92	3.00	28.92	39.84
Sowing	T 4 × 4, 65 kW – Seed Drills 6 m	hectare	1.00	2.86	3.50	0.35	86.63	35.00	288.63	410.25
Rolling	T 4 × 4, 75 kW – roller 6 m	hectare	0.15	4.00	3.50	0.25	12.99	3.75	99.74	116.49
Harrowing	T 4 × 4, 120 kW Harrows 9 m	hectare	0.50	5.00	2.50	0.20	30.94	10.00	91.94	132.88
Grain harvest	Combine harvesters 150–199 kW	hectare	1.00	1.25	15.00	0.80	371.25	80.00	1496.25	1947.50
Grain transportation	Truck 8–10 t	hectare	1.00	16.67	9.00	0.06	222.75	6.00	248.75	477.50
Straw harvesting	T 4 × 2, 75 kW – Round balers 1.6 m	hectare	1.00	1.05	6.10	0.95	150.98	95.00	565.98	811.95
Loading of big bales	Self–propelled loader	hectare	1.00	12.50	2.00	0.20	49.50	20.00	189.50	259.00
Transportation of big bales	T 4 × 2, 50 kW – T. trailer 8–9 t	hectare	0.50	50.00	1.20	0.50	14.85	25.00	54.85	94.70
Storage of big bales	Manipulator	hectare	1.00	3.45	5.00	0.59	123.75	59.00	307.75	490.50
Sum		**hectare**	**x**	**x**	**119.71**	**7.87**	**1 946.96**	**515.85**	**5 318.31**	**7 781.12**

Source: own calculation

Table 5. Inputs and their prices as an average of 3 years according to individual technologies

		Silage	Haylage	Dry grain	Moisture grain
Yield	ton/hectare	16.70	7.00	3.10	2.55
Sowing rate	kilo/hectare	290.00	245.00	287.00	230.00
Price of diesel oil incl. lubricants (10%)	CZK/litre	24.75	24.75	24.75	24.75
Wages	CZK/h	100.00	100.00	100.00	100.00
Diesel oil price	CZK/litre	22.50	22.50	22.50	22.50
Seed material	CZK/hectare	5 200.00	2 700.00	2 895.00	2 750.00
Manure + lime	CZK/hectare	2 600.00	2 600.00	2 720.00	2 720.00
Foil, cord	CZK/hectare	1 670.00	1 600.00	500	970.00

Source: own calculation

(due to the increased fixed costs associated with the use of a crusher and a press).

The obtained results clearly indicate that the highest and the lowest values of consumption of both energy and labour were recorded in the case of the LCI ensilaging and harvesting for wet grain, respectively.

The results presented in these tables and figures also clearly indicate that material costs represent a substantial part of the direct costs: when growing the LCIs for green fodder and for grain, they represented 73% and 71% of total direct costs, respectively. This means that organic farmers should pay an increased attention to these costs in spite of the fact that it is rather difficult to control them because the prices of external inputs cannot be regulated by the farmers themselves.

As far as machinery costs in the individual technologies were concerned, the most expensive were the operations associated with the establishment of crops because they represented 35–47% of the total direct costs of growing the LCIs for green fodder and for grain, respectively. Harvesting was the second most demanding group of technological operations (32% and 49% of total direct costs of growing the LCIs for green fodder and for grain, respectively). Machinery costs were significantly influenced also by the age, performance, and the quality of the individual machines.

CONCLUSIONS

When evaluating costs recorded in the individual variants of the LCI growing , it is necessary to say that the selection of the individual machines and machine aggregation represents the most important factor of influencing the direct costs, namely with regard to the size of organic farms and to the area of the individual field blocks. As far as other factors

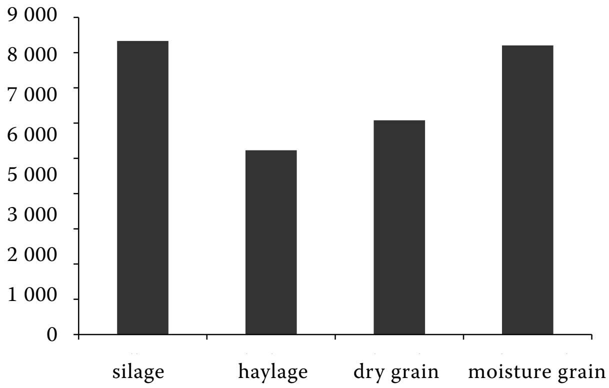

Figure 2. Machinery costs per hectare for the LCI-production according to the individual technologies

Source: own results

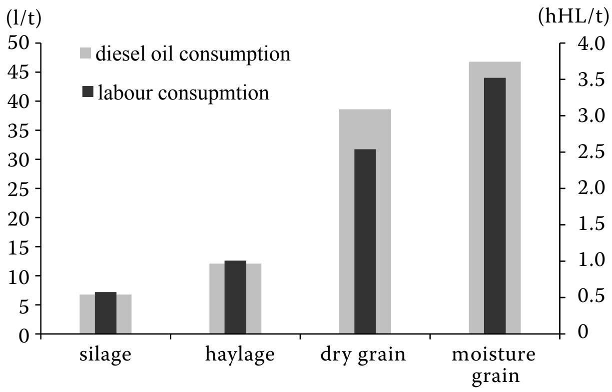

Figure 3. Consumption of energy and labour per one ton of the LCI-production according to the individual technologies and results obtained within the study period

Source: own results

are concerned, the following are also important: (1) acquisition value of the individual machines (it is reflected in fixed costs due to depreciations), and (2) their year-round performance. In the case that this parameter is lower than the recommended values, the machinery costs may be markedly increased and for that reason, it is worth consideration to evaluate the economic advantages of the contractor services. Under the conditions of organic farms, the LCI production is significantly influenced also by the agrotechnical operations. As compared with the conventional farms, lower expenses for the chemical protection of plants and for fertilisers are substituted by increased costs of the mechanical weed killing. Higher prices of inputs are also important and their impact on direct costs should not be neglected. Gross margin is not taken into account when analysing the economic demandingness of the LCI growing. On Czech farms, the LCIs are grown as intercrops; they are not traded, and for that reason, it not possible to estimate their market price. Regarding this fact, the gross margin is not used in the presented results.

REFERENCES

Farm Accounlancy Data Network – FAND (1989). An A-Z of metodology. Commission of the European Communities, Brussel, Luxembourg.

Jánský J., Živělová I., Křen J. Valtýniová S. (2007): Konkurenceschopnost ekologicky pěstovaných obilnin (Competitiveness of organically grown cereals). Acta Universitatis agriculturae et silviculturae Mendelianae Brunensis, LV: 33–45.

Kavka M. et al. (2006): Normativy pro zemědělskou a potravinářskou výrobu: technologické, technické a ekonomické normativní ukazatele (Normative for agricultural and food production: technological, technical and economic normative indicators). Ústav zemědělských a potravinářských informací, Praha; ISBN 80-7271-163-6.

Kovářová M., Abraham Z., Jevič P., Šedivá Z., Kociánová V. (2002): Ekonomika pěstování a využití nepotravinářských plodin (Growing economy and utilization of non-food crops). Výzkumný ústav zemědělské techniky, Praha; ISBN 80- 238-9955-4.

Lieber F. et al.(1991): Nauka o hospodaření zemědělského podniku (Theory of agricultural enterprise economy). ČIAE, Praha.

Poláčková J. et al. (2010): Metodika kalkulací nákladů a výnosů v zemědělství (Methodology of costs and revenues calculation in agriculture). Ústav zemědělské ekonomiky a informací, Praha; ISBN 978-80-86671-75-8.

Pospíšil J. (2008): Perspektivní technologie (Perspective technology). Zemědělec – týdeník moderního hospodáře, *13*:10–14.

Arrived on 11th June 2010

Contact address:

Jaroslav Jánský, Jiří Pospíšil, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic
e-mail: jansky@mendelu.cz, jiri.pospisil@mendelu.cz