ASSESSMENT OF LINSEED HARVEST EFFICIENCY

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Abstract

The change in variety composition in favour of oil-varieties of flax brought about even a change in harvest practices in favour of combine harvesters. Post- harvest residues, mainly in the form of stalks, are usable material from the technical and energy point of view. The most often used form is pressing into the form of bales. In cases, when the material obtained in this way cannot be rationally used, the carried out operations will have a negative effect on overall costs expended to crop growing. The subject of realized research was to determine parameters of different types of flax stalk processing into the form of bales and compare them to the alternative of their crushing and incorporation into the soil. The experiments were carried out at the following varieties: Recital, Oural, Amon, Flanders and Baikal. Levelized costs for harvest fluctuated in a wide range 461 CZK/t up to 3,420 CZK/t.

Key words: flax, energy consumption, bioenergy, harvest costs, combine harvester, pressing.

INTRODUCTION

Flax is a traditional crop of the Czech rural areas. In the past the flax fibre varieties were dominated on the Czech fields. Flax was perceived primarily as a technical crop, but it had also significance as a part of food and in crop rotation as well. According to ČANDOVÁ ET AL. (2011) the sown areas of flax have been gradually decreased since 1992. Currently the main application area for the use of flax is food production. That is why there are grown in the Czech Republic at the present time only oil varieties of flax.

The change of varietal composition and method of final use brought about also the change in method of harvest. During the harvest of fiber varieties the emphasis was put on assurance of quality and usable length of stem. To the harvest there were used the flax pullers. In the conditions of the Central Europe there were by NEUBAUER ET AL. (1989) most frequently used the trailed types of flax pullers integrated with wheeled tractor.

With the growing of oil-varieties there has been gradually abandoned the harvesting method using the flax puller and the flax is harvested in more effective way by means of combine harvesters. Nowadays, the primary product is by CHAUHANET ET AL. (2009) and BJELKOVÁ ET AL. (2012) flax seed, which is usable in food industry and other fields. The flax stem can be used to the production of short fibre, but in the practice it is used as a rule in energy production or, where it is possible, incorporated into the soil. Other possibility is an industrial use, for example in paper production. For the mentioned kinds of use there are not an obstacle shorter length of harvested stem, which enables a reduction of mass flow through the threshing mechanism and elimination of risk of its blockage. At very short length of stem, and therefore low yield, itis however its processing less profitable.

The harvest of flax by means of combine harvester is according SOUČEK AND BLAŽEJ (2012) effective, but put increased demands on the state of crop stand .It is also necessary the quality and uniform desiccation by FROMET (1993) and PRAŽAN ET AL. (2015) and low water content at the time of harvest by NILSSON (2005).

The aim of described research is to determine the effect of different technology of stalks harvest and cultivated variety on harvests efficiency.

MATERIALS AND METHODS

During the research there were determined the yields of individual parts of five linseed varieties as well as energy and exploitation parameters of harvest operations. All the data were obtained by measuring in operational and pilot plant conditions. The studied varieties were: Recital, Oural, Amon, Flanders and Baikal. The yields of individual parts of plants have been determined within the pilot plant experiment in site of Lukavec. Parameters of harvest were laid down by measuring in pilot plant and operational conditions in sites Lukavec, Morkovice, Šumperk, Loštice, Bludov a Bohutín.

In order to evaluate and compare the crop stands were harvested by combine harvester (Wintersteiger) and residual stalks were harvested and processed in four variants:

- 1-by pressing into round bales (CASE JX 1100 U + KRONE VARIO PACK Multi-cut 1500)
- 2- by pressing into gigant square bales (Massey Ferguson 8460 + Hesston 4880)
- 3- by pressing into small square bales (ZETOR 5211 + CLAAS Markant 50)
- 4- stem was disintegrated during the harvest by crusher connected to combine harvester and subsequently incorporated into the soil by disc harrows (CASE 7230 + FARMET4,6 m).

Harvest losses ranged around 5%. During the harvest there wasn´t harvested a part of plants comprising the root and part of stem attributable to the stubble (about 15 cm).

The yield of individual parts of plants was determined by conversion from gravimetrically specified quantity of dry matter in average sample. This average sample was established for all varieties from the results of cultivation trials lasting for 5 years in order to reduce the risk of their influencing by weather.

The specific energy obtained were determined from yield and calorific value of individual parts of linseed selected varieties.

$$Q^t_{i\,ha} = n_{i\,part} . Q^t_{i\,part} \quad \text{(MJ)} \qquad (1)$$

where: n_{ipart} yield of analysed part (t/ha)

$Q^t_{i\,part}$ calorific value of analysed part(MJ/kg)

Exploitation parameters of operations were determined by means of time record and the GPS. The consumption of diesel fuel was determined by means of flow meter built into the energy device, possibly by method of full tank.

Into the values of consumption of diesel fuel and need of work there is included the transport distance, which was for all of variants 2,5 km.

Consumed energy W_e was determined as total consumed direct energy W_{sp} (consumed in form of diesel fuel) related to the yield.

$$W_{sp} = m_{pal} . Q^t_{i\,pal} \quad \text{(MJ)} \qquad (2)$$

where: m_{pal} weight of consumed fuel (kg)

$Q^t_{i\,pal}$ calorific value of consumed fuel (MJ/kg)

$$W_e = \frac{W_{sp}}{m_s} \quad \text{(MJ/t)} \qquad (3)$$

where: m_s weight of processed dry material (t)

Levelized costs for particular alternatives of harvest were determined on the basis of measured values by calculation in expert system Agrotekis, which is as expert system freely available on the website www.vuzt.eu. The calculation of levelized costs comes from total costs, which are determined as the sum of fixed and variable costs:

$$N_C = N_f + N_v \quad \text{(CZK)} \qquad (4)$$

where: N_f fixed costs (CZK)

N_v variable costs (CZK)

Levelized costs were determined by calculation as unit costs:

$$N_j = \frac{N_C}{n_j} \quad \text{(CZK/t)} \qquad (5)$$

where: n_j yield (t)

Obtained data were evaluated by ANOVA, using the PC software Statistica CZ v12.

RESULTSAND DISCUSSION

All the varieties were harvested by combine harvester Wintersteiger Seed Universal after previous desiccation of crop stand by the Roundup. The yields of individual parts of monitored varieties of harvested plants are illustrated on the Fig. 1.

For the harvest of flax stem there were selected the alternatives with pressing into the round bales, large square bales, small square bales and the alternative without harvest with crushing in the course of harvest and subsequent incorporation into the soil by disc harrows. Thus, there were available for comparison 4 alternatives of harvest.

On the Fig. 2 there are shown values of specific consumed energy and need of work related to1 hectare of crop stand.

At conversion of consumed direct energy in form of diesel fuel on yields of selected varieties of flax it is possible to express specific energy consumed to 1 tonne of weight. For better comparison the values were related to 1 tonne of harvested seed. The values converted into dry matter are shown graphically on the Fig. 3.

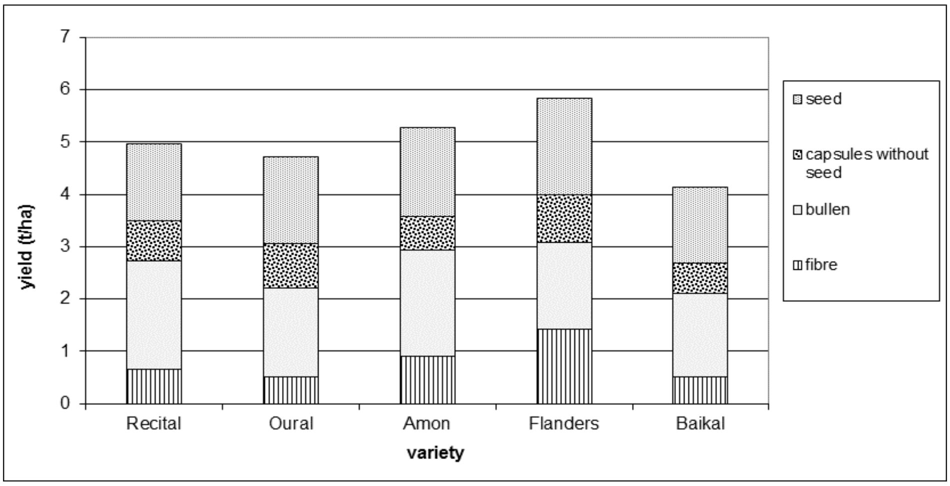

Fig. 1. – Yield of individual parts of linseed selected varieties during the harvest by combine harvester (site of Lukavec, given in dry matter)

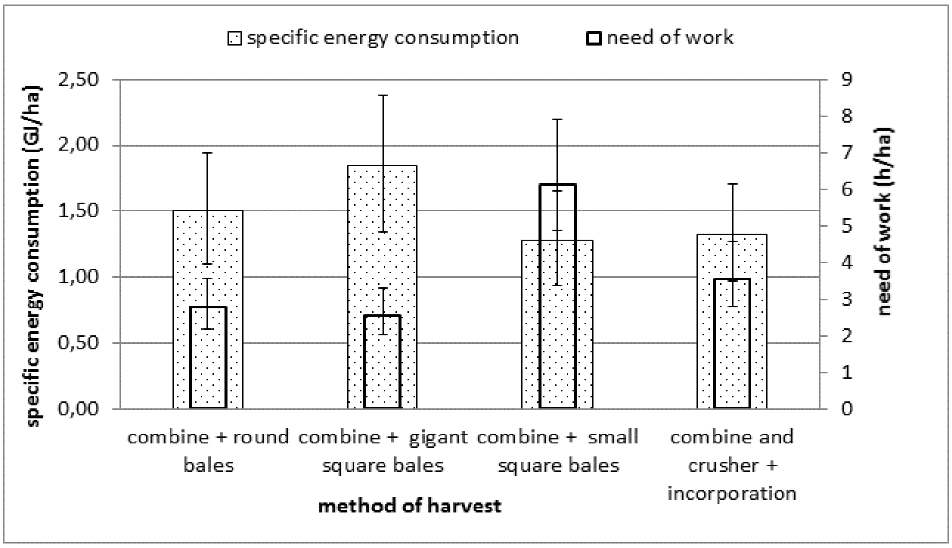

Fig. 2. – Specific consumed energy and need of work destined for harvest of selected alternatives of harvest

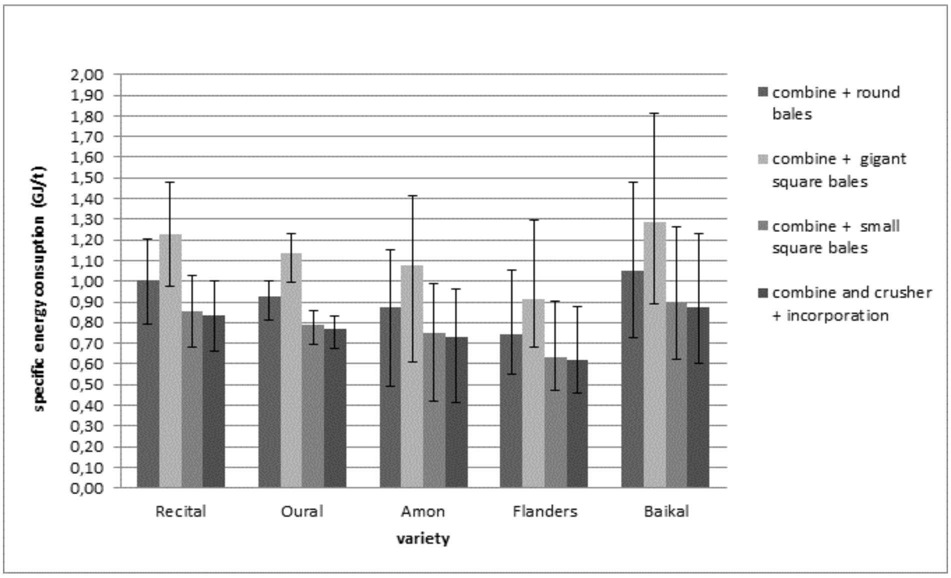

Fig. 3. – Specific consumed energy for evaluated harvest alternatives of linseed selected varieties related to 1 tonne of seed

In case of harvest of flax stem in form of bales there is a real possibility of its material or energy use. In order to quantify the energy contained in obtained mass of linseed there were gained the data by means of analytical analyses of with drawed samples and their yield. Average yields of individual parts of plants are graphically shown on the Fig. 1. The results of analyses of these parts of plants are shown in the Tab. 1.

Tab. 1. – Average results of analysis of individual parts of linseed

	combustion heat	calorific value	ash	carbon	nitrogen
	(MJ/kg)	(MJ/kg)	(%)	(%)	(%)
seed	26.76	18.07	3.99	48.01	2.86
capsules	18.92	12.28	3.95	48.03	0.82
bullen	18.24	11.77	1.96	49.02	0.77
fibre	16.73	10.65	4.60	47.70	0.79
roots	17.97	11.57	6.32	46.84	0.50

The calorific value, basic energy indicator, is the highest in the seed, however the seed isn´t used to the energy purposes. The calorific value is mainly influenced by analytic composition and by water content.

The amount of specific energy obtained by individual parts of plant sis shown on the Fig. 4.The values were obtained by conversion of calorific value into the yield per hectare of cultivated area. These values range from 44 up to 63 GJ/ha.

The specific energy obtained during the harvest with use of combine harvester ranged from 43 up to 63 GJ/ha.

In order to evaluate the technology it is important to know economic point of view. As the main indicator for particular alternatives of technological processes at selected varieties there were calculated levelized costs related to 1 tonne of produced dry matter of material. These levelized costs were calculated from real costs for operation of machinery, depreciations of machinery wage costs and material costs (fuel, lubricants, preparations for desiccation of crop stand etc.).

In case of utilization of harvested post-harvest residues it would be possible to reduce the costs for harvest of seeds to the values shown in the graph on Fig. 5 (alternative with harvest of flax stem). The costs are mentioned in comparison with alternative with crushing and subsequent incorporation of flax stems into the soil by disc plough -harrow.

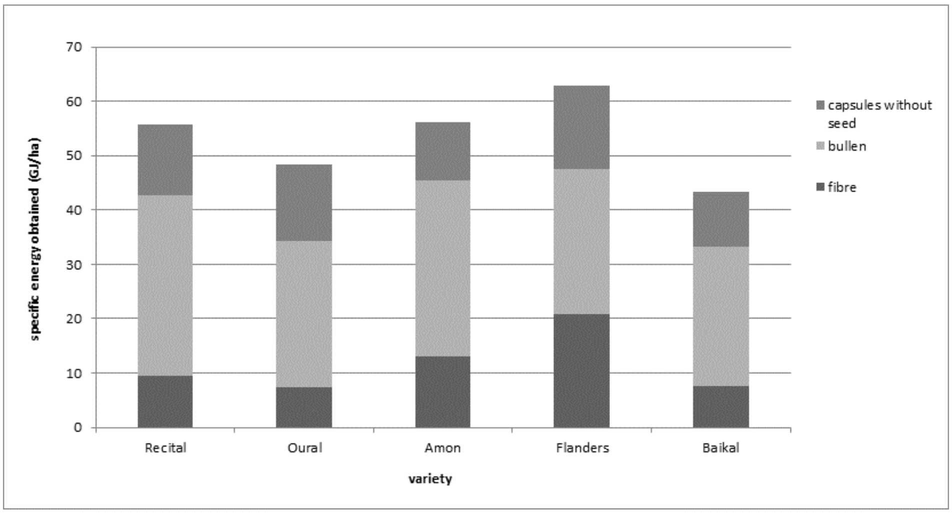

Fig. 4. – Calorific value and dry matter content of samples of linseed selected varieties–the whole plants

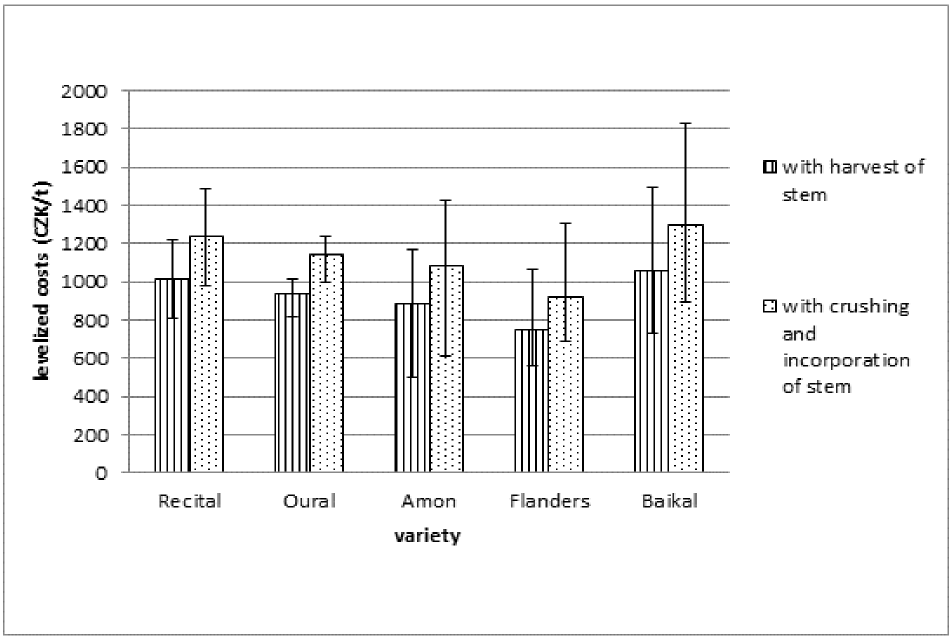

Fig. 5. – Levelized costs for harvest of seeds of linseed selected varieties after deduction of costs for harvest of flax stem (related to the weight of dry matter of harvested seed)

Levelized costs for harvest of flax stem reach the values shown in graph on the Fig. 6.

However, at the present time the flax stem is in practice the commodity, which is marketable only with difficulties, therefore the levelized costs are often expressed as the total costs for harvest related to the yield of seed. Values of levelized costs expressed by this way for all variants are shown in graph on the Fig. 7. In these data there are included all the costs originated in connection with harvest and transport to the storage site (it was taken into account the distance of 2,5 km).

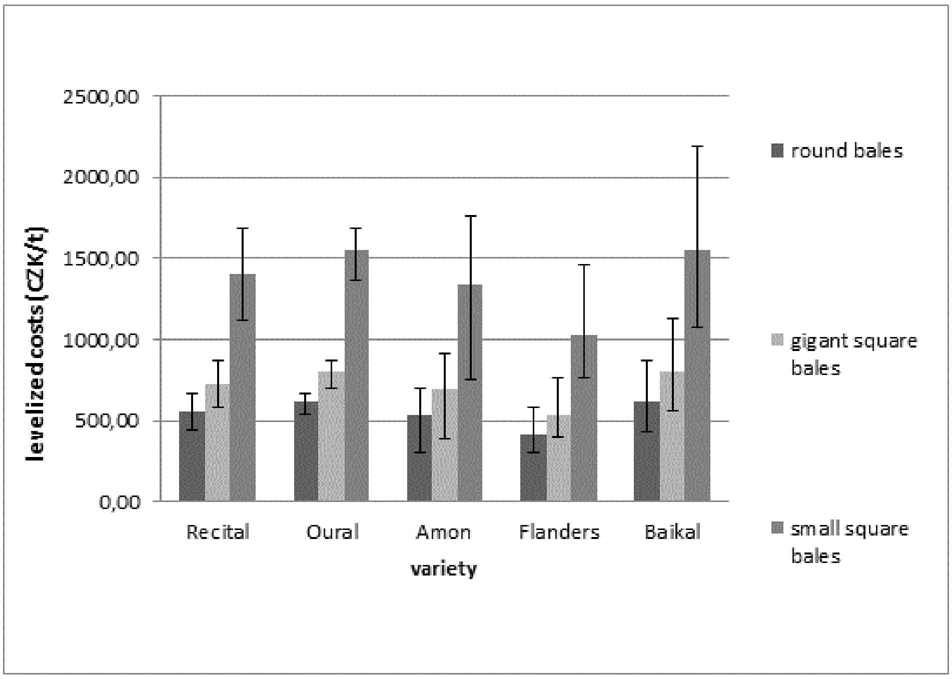

Fig. 6. – Levelized costs for harvest of flax stem of linseed selected varieties (related to the weight of dry matter of harvested flax stem)

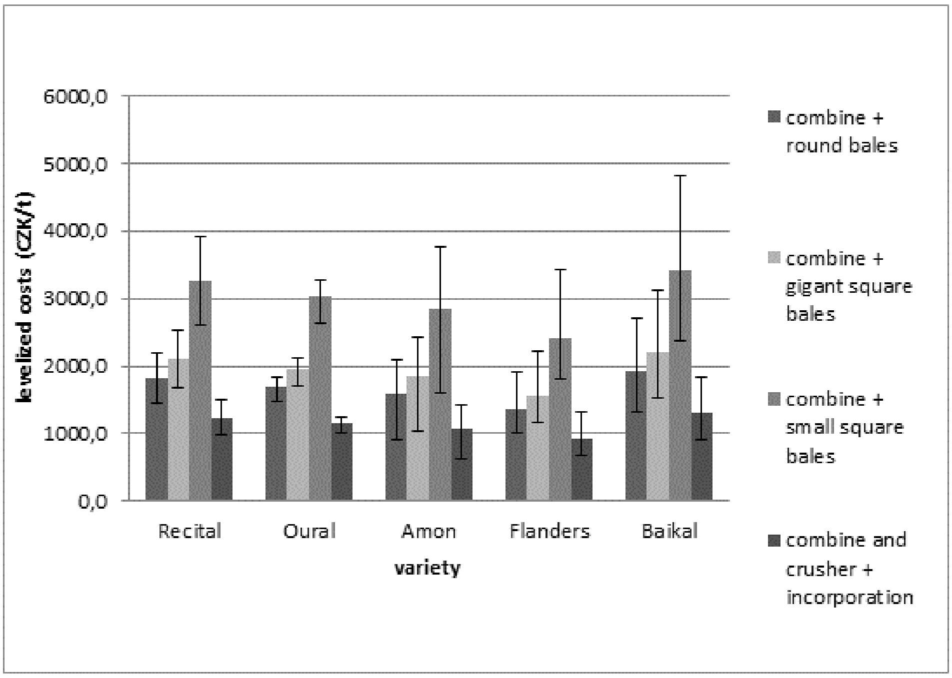

Fig. 7. – Levelized costs for seeds production of selected varieties of linseed (related to the weight of dry matter of seed, including harvesting of stem)

Within the pilot plant experiments there were evaluated five varieties of linseed. There were the following varieties: Recital, Oural, Amon, Flanders and Baikal. From the yield point of view it was achieved in trial site Lukavec the best results in case of the variety Flanders (2.02 t/ha seed, 3.47 t/ha stem), the worst result was reached at the variety Baikal (1.43 t/ha seed, 2.31 t/ha stem).

Specific consumed energy calculated from the consumption of diesel fuel range from 1.28 GJ/ha (pressing of small square bales) up to 1.84 GJ/ha (pressing of giant square bales).From energy consumption point of view the technology of flax stem pressing into the small square bale sis more efficient, than crushing and incorporation of this flax stem into the soil.

The calorific value of plant parts used for energy production at water content up to 20% ranged from 10.65 up to 12.28 MJ/kg, which are the values comparable to the work of ČANDOVÁ ET AL. (2009). Energy, which can be obtained in the form of post-harvest residues (stem + empty capsules) at monitored varieties in case of monitored varieties from 43 GJ/ha (Baikal variety) up to 63 GJ/ha (Flanders variety).

The share of delivered direct energy makes 2 - 4% of obtained energy.

From the obtained results it is obvious, that the amount of levelized costs for harvest of flax seed in case of placing of flax stem on market range for particular varieties from 751 CZK/t of dry matter (Flanders) up to 1.061 CZK/t of dry matter (Baikal). In case of crushing and incorporation of flax stem into the soil by disc plough-harrow the costs increased by 20-25% and range from 919 CZK/t of dry matter up to 1.298 CZK/t of dry matter.

Levelized costs for the harvest of flax stem are therefore in the wide range. Under the given yields of flax stem the lowest levelized costs were achieved in case of harvest using the round bales (410 CZK/t up to 619 CZK/t). At pressing into the large square bales the levelized costs were higher and ranged from 534 CZK/t up to 807 CZK/t. The highest costs from 1.031 CZK/t up to 1.557 CZK/t were determined in case of pressing into the small square bales. The comparison of results from the varietal point of view the lowest costs were determined at Flanders variety, on the contrary the highest costs in case of Oural variety. It was mainly caused by the yield of flax stem, which was the highest at Flanders variety and the lowest at Oural variety.

In practice the linseed growers are very often forced to harvest the flax stem from field also in case, that they haven´t any use for it. The reason can be for example a difficult way of its incorporation into the soil, unsuitability of its presence in soil for the subsequent crops or elimination of excessive occurrence of pests. In these cases it is necessary to express the levelized costs as the total costs for harvest of seed and stem expressed only for quantity of seed. Also in this case the lowest costs were determined at variant with pressing into round bales. These costs range from 1.353 up to 1.911 CZK/t. The costs are higher at pressing into giant square bales (1.566 up to 2.213 CZK/t) and the highest costs were determined at pressing into small square bales (2.422 up to 3.420 CZK/t). The lowest levelizedcosts were in this case again at Flanders variety a the highest ones at Baikal variety.

From the obtained results it is obvious, that efficiency of harvest can significantly influence the whole economy of linseed growing. Apart from the timeliness of harvest by NILSSON (2005) with previous quality desiccation by FROMET (1993), PRAŽAN ET AL. (2015) it is also important right choice of variety suitable for climatic conditions of certain locality and used harvest machinery.

CONCLUSIONS

The growing of linseed has its importance thanks to the production of dieteticly valuable and comprehensively usable flaxseed and stem, which can be utilized as the technical and energy feedstock. The linseed has also its importance for creation of crop rotation and soil protection. There is often mentioned its significance in relation to the area of organic farming and decontamination of infested soils.

Within the pilot plant experiments there were evaluated five varieties of linseed. From the yield point of view it was achieved in trial site Lukavec the best results in case of the variety Flanders, the worst result was reached at the variety Baikal. Levelized costs for the harvest of flax stem are in the wide range. In practice the linseed growers are very often forced to harvest the flax stem from field also in case, that they haven´t any use for it.

If it is suitable or necessary to harvest the flax stem, the most efficient method is pressing into the small round bales, eventually into giant square bales. Pressing into small square bales is from the energy point of view less demanding, but owing to very low performance, very costly.

In cases, when it isn´t probable a possibility of rational use of post-harvest residues and their incorporation into the soil don´t hinder subsequent cultivation operations it is suitable their disintegration by means of a crusher connected to combine harvester and subsequent incorporation into the soil. The advantage of this solution is possibility to connect operations of seed harvest and soil tillage.

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REFERENCES

1. BJELKOVA, M., NOZKOVA, J., FATRCOVA-SRAMKOVA, K., TEJKLOVA, E.: Comparisons of lin seed (Linumusitatissimum L.) genotypes with respect to the content of polyunsaturated fatty acids, CHEMICAL PAPERS, 66(10), 2012: p. 972 – 976. ISSN: 0366-6352.
2. ČANDOVÁ, D., SOUČEK, J., VACEK, O.: Properties of flax from energy recovery point of view (CZ), Agritech Science, 3 (3), 2009: p. 1-5. ISSN 1802-8942.
3. FROMET, MA.: Effect of desiccants on seedyield and plant dry matter in linseed, Linum-Usitatissimum, Annals of applied Biology, 122, 1993: p. 100 – 101.
4. CHAUHAN, M. P., SINGH, S., SINGHA. K.: Post Harvest Uses of Linseed, J HumEcol, 28(3), 2009: p. 217-219.
5. NEUBAUER, K. ET AL.: Machines for crop production (CZ), SZN, Praha, 1989. ISBN 80-209-0075-6.
6. NILSSON, D. B.: Svennerstedt, and C. Wretfors, 'Adsorption Equilibrium Moisture Contents of Flax Straw, Hemp Stalks and Reed Canary Grass', Biosystems Engineering, 91 (2005), 35–43 <http://dx.doi.org/10.1016/j.biosystemseng.2005.02.010>
7. PRAŽAN, R., ČEDÍK, J., SOUČEK, J., GERNDTOVÁ, I.: Swing booms with large working widths (CZ), Agritech Science, 9 (2), 2015: p. 1-5. ISSN 1802-8942.
8. SOUČEK, J., BLAŽEJ, D.: Linseed harvests parameters depending on the state of cutting mechanism. Research in Agricultural Engineering 58 (2), 2012: p. 46-49. ISSN 1212-9151.

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