ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 64 33 Number 1, 2016
http://dx.doi.org/10.11118/actaun201664010291

THE ECONOMIC ANALYSIS OF SEMI-MECHANISED HARVESTING OF LEMON BALM

Vladimír Mašán[1], Tomáš Kopta[2]

[1] Department of Horticultural Machinery, Faculty of Horticulture, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic
[2] Department of Vegetable Growing and Floriculture, Faculty of Horticulture, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

Abstract

MAŠÁN VLADIMÍR, KOPTA TOMÁŠ. 2016. The Economic Analysis of Semi-mechanised Harvesting of Lemon Balm. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 64(1): 291–296.

In recent years area for cultivation of *Melissa officinalis* is ranged around 40 ha. Low production could be also caused by less intensive use of machinery. Aerial parts could be fully harvested by mechanisation, but in case of small growers using of special machinery is not economic. The majority of growers harvest manually and this type of harvest represents up to 80% of the costs associated with the cultivation. The less expensive alternative of harvest by a hedge trimmer is evaluated in this article. The goal is to compare two ways of harvest (manual harvest and hedge trimmer harvest) of lemon balm aerial parts in production practise. According to results of experiments were calculated and determined boundaries of effective use of hedge trimmer in production of lemon balm in comparision to manual harvest and fully mechanised harvest. Obtained data shown an increase of harvest performance in case of hedge trimmer (0.0425–0.0525 ha.hr^{-1}) compared to manual harvest (0.0185–0.0216 ha.hr^{-1}). According to calculations, we can say that effective use of hedge trimmer (including purchase price) is from 0.37 ha at planting surface and 0.48 ha at planting rows. Results could also be used for other MAP crops with similar harvest technology as for lemon balm (for example *Mentha* spp., *Origanum* spp., *Achillea* spp.).

Keywords: lemon balm, hedge trimmer, semi-mechanised harvesting, economy

INTRODUCTION

In long term observations global production of medicinal and aromatic plants (MAPs) is stable in production volumes, possibly with slight increase in some years. But only less than than 60–90% of production comes from MASPs purpose of cultivation (Schippmann *et al*., 2003). In comparison with other crops it is caused by specific demands of growing, harvesting and post-harvest treatment, which corresponds to their special use (Prošková, Abrahamová, 2007), but also lack of mechanization (Burg, Zemánek, Mašán, 2012).

The production of MAPs in the Czech Republic after decrease in 2008 is gradually stabilized around 4 thousand ha. In 2010 the area increased to 7,864 ha and the increase continued in 2011 to 8,588 hectares and in 2012 the area cultivated decreased at 7,225 hectares. In 2010 the production of MAPs was 5,605 tons with low yield 0.71 t.ha^{-1}. In 2011 production of MAPs was around 7061 tons, with yield 0.82 t.ha^{-1}. The most important MAPs were milk thistle, caraway seeds, poppy seeds and ergot. The survey of foreign trade of the Czech Republic shows that a group of MASPs has a significant negative balance, which means that own production cannot meet the demand.

Cultivation trends are influenced by ransom prices of MAPs, which are determined by the processors of raw materials, world market price and availability of raw materials for import. The unstable prices limit the investment options (for example: founding new cultivation areas, higher quality mechanization) which could increase the yield of already cultivated crops. Therefore, the main trend of the last years is the implementation of good production practices, including post-harvest

treatment and storage of both conventional as well as organic farming (Tošovská *et al*., 2012).

Lemon balm – *Melissa officinalis* is a crop suitable for cultivation in the conditions of the Czech Republic. In recent years (2000–2012), the reported area of Lemon balm cultivation in the Czech Republic is about 40 ha (Štolcová, 2003). The leaves and young flowering shoots are antispasmodic, carminative, diaphoretic, digestive, febrifuge, sedative, and tonic. Furthermore, the effects of lemon balm are antibacterial, anti-inflammatory, antiviral and antioxidant (Kresánek, Kresánek, 2008). Aerial part, particularly the leaves contain 0.1–0.3% essential oil, consisting primarily of citral, citronellal (up to 25–50%), geraniol, linalol, nerol and eugenol. Other active compounds are phenolic and triterpenic acids and about 4% of tannins (Hornok, 1992; Valíček, 2005). Further among the bitter substances can be found slime, flavonoids, organic acids and minerals (Janča, Zentrich, 1995).

Time of cultivating at one place is around 5 years (Valíček, 2005) possibly up to 6–8 years (Hornok, 1992). Vârban *et al.,* (2010), recommends planting in rows as the most profitable in the distance of 0.60 m between rows and 0.30 m distance between plants in the row with a density of 5.5 plants.m^{-2}. Tobeh *et al.* (2013), recommends for surface planting density of 16–20 plants.m^{-2}. Both authors also pointed out the fact that reducing the density of planted plants positively affects the amount of substances contained in the plant, however the yield of compounds per hectare will be decreased.

According to Hornok (1992) and Valíček (2005), the whole aerial part is harvested in the first year only once, in the next years usually twice in vegetation. The first harvest is recommended before flowering, others around mid-September. Dachler (1989) recommends in the first year two harvests, in subsequent years, three to four. After the harvest should be around 40 to 50 mm high stubble (Hornok, 1992; Valíček, 2005). Melissae herba during the harvest turns brown very quickly, so it is recommended to speed up the harvest process (Azizi *et al*., 2009).

All experiments were realised during vegetation period in year 2013 and the research was focused at verifying the economic efficiency of the deployment of small mechanization in the cultivation of MAPs. This paper compares the partially mechanized harvest by hedge trimmer with manual harvest of lemon balm.

MATERIALS AND METHOD

The aim of experiment is to compare manual and semi-mechanised harvest of lemon balm (*Melissa officinalis* L.) according to economic analysis of each type of harvest. Another purpose is to evaluate efficacy of each type of harvest and compare those type of harvest according to terms of costs structure.

The main goal of this article is to determine such a size of cultivating area, when the use of hedge trimmer become economic. And according to results compare economic use of hedge trimmer and economic use of full mechanised harvest.

Lemon balm was selected as model crop because technology of cultivation and harvest is similar to few other species (for example *Mentha* spp., *Origanum* spp., *Achillea* spp.), which are also cultivated in conditions of Czech republic.

Two years old plants were harvested during experiment. Spacing of plants in case of surface planting were 0.4 × 0.4 m and in case of row planting: 0.6 m between rows at 0.4 m plants in row. Evaluated was the first among two harvests intended for harvesting of aerial parts. The aerial parts of lemon balm were harvested before flowering as recommended by Kresánek, Kresánek (2008).

The harvest was monitored for both types of planting (means surface and row). In case of surface planting aerial parts were cutted, place at pile and then loaded on the loading area of the trailer. Cutting was performed over the entire width of the field. The cut width were determined by the length of the hedge trimmer bar. In case of row planting, fabrics were layed down between rows, so aerial parts fell down on it during harvest and then were brought out of rows and loaded on the loading area of the trailer.

Experiment were focused on comparision of harvest by hedge trimmer and manual harvest by hand-held shears. The measurements were run at the experimental fields of Faculty of Horticulture MENDELU in Lednice (Czech Republic) and by private growers in ČR and SR in the vegetation period in year 2013.

For experimental measurement the hedge trimmer STIHL HS81R was used. The machine was during the entire measurement in a good technical condition corresponding to normal wear and tear. Before the measurement was adjusted and checked. Hedge trimmer throughout the season showed no significant wear neither no technical faults.

Variants

Variant A) hedge trimmer harvest: one worker was cutting lemon balm by hedge trimmers and two workers harvested and loaded cutted aerial parts.

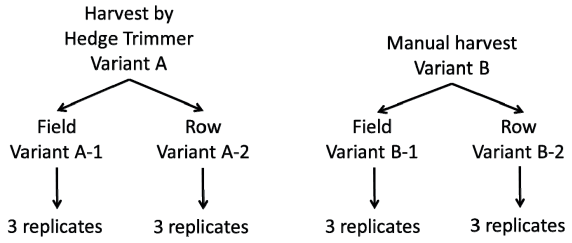
Variant B) manual harvest: all three workers were cutting by hand-held shears, harvesting and loading aerial parts simultaneously.

Subvariant 1) harvest of field planting.

Subvarinat 2) harvest of row planting.

The resulting performance includes preparing machines and workers, cutting, picking, loading melissae herba and cleaning.

Both variant were measured three times, so total of 12 measurements were performed. Measurement conditions was minimal area of 0.1 ha for one replication. Measurements were run in the same climate and conditions. The scheme of arrangement of experiment is represented by Fig. 1.



1: *The scheme of arrangement of experiment*

The measurements were performed according to Czech Technical Standard (ČSN 47 0120 – Agricultural and forestry machines and tractors. Time measuring methods and operating indices determination) and Abrham *et al.* (1996). Attaching a hedge trimmer was assessed on the basis of time frames. Then achieved performance of workers W_{07} (ha.hr^{-1}) was calculated from data obtained by measurement.

Technical-economic Parameters

It was necessary to determine extent of deployment of hedge trimmer in one year (hr.y^{-1}). Extent annual deployment hedge trimmer (hr.y^{-1}) were obtained from machinery users and ranged between 30–75 hr.y^{-1}. Performance (ha.hr^{-1}) was determined on the basis of three replicates. Payroll costs for workers were 8.00 €.hr^{-1} including health and social insurance. The economic evaluation is based on the methodology of Abraham (1996). Costs were modeled for the predicted depreciation period of 3 years. Counted with the cost of running machines, the cost of preparing the machine, fuel and service. The purchase price of the machine was 580.00 €.

Statistical Analysis

Obtained data were evaluated by ANOVA, specifically Two-way between groups ANOVA, using the PC software Statistica CZ v12.

RESULTS AND DISCUSSION

The average harvest time of Melissae Herba in surface planting using the hedge trimmer (Variant A-1) was 2.36 hr compared with manual harvest (Variant B-1) 5.40 hr. The average harvest time in row planting using the hedge trimmer (Variant A-2) was 1.92 hr compared with manual harvest (Variant B-2) 4.64 hr. Tab. I and Tab. II represent number of hours in each replication and performance W_{07}.

The measurements shown an increase of the efficiency of the collection using the hedge trimmer at surface planting by 128.8% and in row planting by 141.6%. Fig. 2 shows comparing methods of harvesting and planting type and their influence on work time.

The average efficiency of harvest was in case of hedge trimmer: Variant A-1 0.0425 ha.hr^{-1} and Variant A-2 0.0525 ha.hr^{-1}. The average efficiency of harvest was in the case of manual harvest: Variant B-1 0.0185 ha.hr^{-1} and Variant B-2 0.0216 ha.hr^{-1}. We can say that increase of efficiency was statistical significant in case of hedge trimmer in both variants (field and row). In case of manual harvest there was no statistical significance. Statistically significant was the influence of hedge trimmer on increasing of efficiency of harvest in both types of planting (field and row).

The harvest using hedge trimmer was evaluated also from an economic point of view. Cost structure is illustrated in Tab. III.

The cost of using hedge trimmer, which is further used in all economic calculations is 400 €.ha^{-1}. Tab. IV and Tab. V described calculating of costs for both type of harvest.

The cost of harvesting Melissae Herba in case of surface planting by using a hedge trimmer (Variant A-1) was 776.5 €.ha^{-1} and in case of manual harvest (Variant B-1) was 1297.3 €.ha^{-1}. We can say on the basis of comparison of two variants of the harvest, that in case of surface planting economic effect reflected on 0.37 ha.y^{-1}, which represents 8.7 hr.y^{-1}. A total of 1.11 ha represented 26.20 hours.

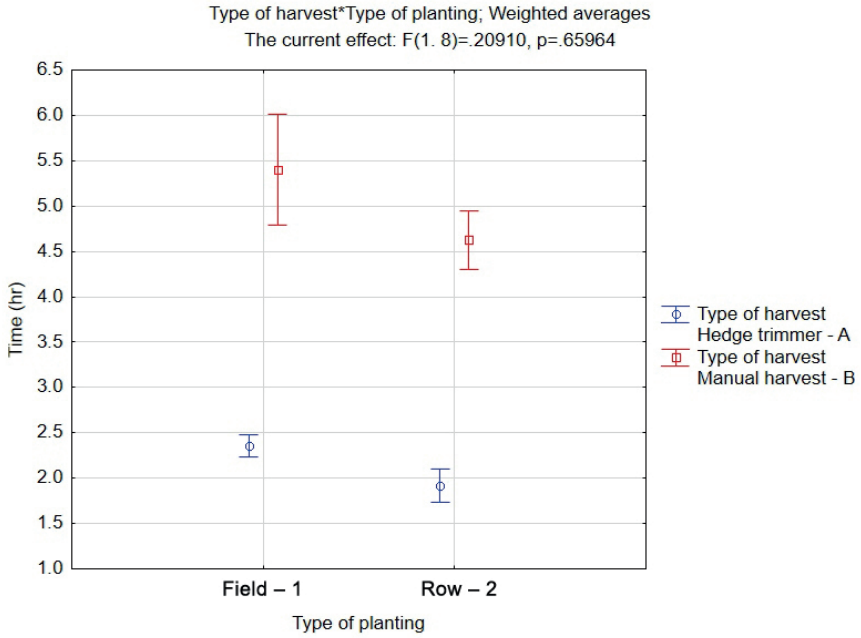
The cost of harvesting Melissae Herba in case of row planting by using a hedge trimmer was: Variant A-2 704.7 €.ha^{-1} and in case of manual harvest: Variant B-2 1111.1 €.ha^{-1}. We can say on the basis of comparison of two variants of the harvest, that in case of row planting economic effect reflected on 0.48 ha.y^{-1}, which represents 9.06 hr.y^{-1}. Overall, the 1.43 ha, represented 27.19 hours.

I: *Field planting – number of hours in each replication and performance W07*

Measured on 0.1 ha	1. repeat (hr)	2. repeat (hr)	3. repeat (hr)	Average (hr)	W_{07} (ha.hr^{-1})	W_{07} (m^2.hr^{-1})	Elaborateness (hr.ha^{-1})
Variant A-1	2.60	2.20	2.28	2.36	0.0425	425.00	23.53
Variant B-1	5.28	4.40	6.52	5.40	0.0185	185.00	54.05

II: *Row planting – number of hours in each replication and performance W07*

Measured on 0.1 ha	1. repeat (hr)	2. repeat (hr)	3. repeat (hr)	Average (hr)	W_{07} (ha.hr^{-1})	W_{07} (m^2.hr^{-1})	Elaborateness (hr.ha^{-1})
Variant A-2	1.80	2.28	1.68	1.92	0.0525	525.00	19.05
Variant B-2	5.08	4.00	4.80	4.64	0.0216	216.00	46.30



2: *Comparing methods of harvesting and planting type and their influence on work time*

III: *Cost structure Hedge trimmer STIHL HS 81 R*

Purchase price 580.00 € Engine performance – 0.75 kW Average fuel consumption – 0.75 l.hr^{-1}						Costs (€.ha)			
Annual deployment (hr.y^{-1})	Depreciation (€.hr^{-1})	Fuel (€.hr^{-1})	Repairs and materials (€.hr^{-1})	Wage (€.hr^{-1})	Costs (€.hr^{-1})	for performance – W07 (ha.hr^{-1})			
						0.035	0.040	0.045	0.050
30.00	6.44	0.59	0.91	8.00	15.94	456.00	**400.00**	354.00	319.00
50.00	3.87	0.59	1.35	8.00	13.80	394.00	345.00	307.00	276.00
75.00	2.58	0.59	1.82	8.00	12.99	371.00	325.00	289.00	260.00

Note: Amortization period – 3 years, average fuel consumption on the basis of measurements, repairs and materials were obtained from machinery users.

IV: *Comparing the costs of harvesting melissae herba at field planting*

Harvested area 1.0 ha	Harvest by Hedge Trimmer	Manual harvest
Performance (ha.hr^{-1})	0.0425	0.0185
Time (hr)	23.5	54.0
The cost of the hedge trimmer including payroll operator (€)	400.0	
Wage (€)	2.0 × 23.5 × 8.0	3.0 × 54.0 × 8.0
The total cost (€.ha^{-1})	776.5	1297.3
Difference (€ha^{-1})	520.8	

V: *Comparing the costs of harvesting melissae herba at row planting*

Harvested area 1.0 ha	Harvest by Hedge Trimmer	Manual harvest
Performance (ha.hr^{-1})	0.0525	0.0216
Time (hr)	19.0	46.3
The cost of the hedge trimmer including payroll operator (€)	400.0	
Wage (€)	2.0 × 19.0 × 8.0	3.0 × 46.3 × 8.0
The total cost (€.ha^{-1})	704.7	1111.1
Difference (€ha^{-1})	406.4	

Using gatherers and fully mechanized harvest of MAPs seems to be economically advantageous around 30 ha of harvested area according to Pajic *et al*. (2007), but according to Stričík, Salamon (2007) over 36.9 hectares. Growers who use harvester states that economic deployment of harvester in cases of Basil (*Ocimum basilicum*) and Lemon balm (*Melissa officinalis*) ranged from 6 to 12 ha. Harvest efficacy of harvesters with the cutting bar ranged between 0.45–1.0 ha.hr^{-1}. But such a large areas are unattainable for small farmers.

Small farmers often have only basic mechanization, which can be used in the harvesting and transporting, or for soil cultivation. They cultivate different crops on area around 1.0 ha, often only around 0.3–0.7 hectares and the total cultivated area is around 3–5 hectares. With a such small area is the efficiency of the use of any special custom mechanization low, particularly that ones which are intended for a single operation, such as reaping machine. Therefore, the purchase of machinery must be based on its economic analysis (Stričík, Salamon, 2007).

The alternative form is renting of farm machinery from rental service, but this possibility is not real or interesting for lessors. That is also reason why growers harvest often manually, which is time-consuming and makes up to 80% of the cost of cultivation of MAPs (Pajic *et al*., 2007).

Shortening the time ROI is possible at an annual increase of deployment hedge trimmers planting larger areas, or the use of such a method of harvesting the crops of both *Mentha* spp. and others. The positive effect for small growers also lies in shortening of harvest and in option of timing of harvest during optimal conditions.

CONCLUSION

This article focuses on the economic efficiency of harvesting of MAP crops for small growers. Most authors examined a fully mechanised harvest on large areas. Compared with this approach, this paper examined a semi-mechanised harvesting of lemon balm by a hedge trimmer. The measurements shown that use of hedge trimmers for small growers could be economic alternative to manual harvest. Obtained data shown increase of harvest efficiency in case of hedge trimmer 0.0425–0.0525 ha.hr^{-1} in comparision to manual harvest 0.0185–0.0216 ha.hr^{-1}. So the use of the hedge trimmer seemed to increase the efficiency of the harvest in more than 128.8%. However for growers the economic efficiency of harvest is important. The measurements showed the costs around 400 €.ha^{-2} when using the hedge trimmer. According to results of term of costs analysis and after comparing of two types of harvest, we can say, that in case of surface planting is economic effect clearly visible at 1.11 ha, what means 26.20 hours. After three year amortization period, value for area is 0.37 ha.y^{-1} and value for time 8.73 hr.y^{-1}. In case of row planting the economic effect occure at 1.43 ha, what means 27.19 hours. After three year amortization period, value for area is 0.48 ha.y^{-1} and time 9.06 hr.y^{-1}. Results could be use also for other MAP crops with similar harvest technology as for lemon balm (for example *Mentha* spp.). Return on investment can be reached by using a hedge trimmer for subsequent harvests or by using on the other crops.

REFERENCES

ABRHAM, Z. et al. 1996. *Náklady na mechanizované práce v rostlinné výrobě*. Praha: Inst. Výchovy a vzdělávání MZe-ČR.

AZIZI, M., RAHMATI, M. and EBADI, M. T. et al. 2009. Studying effect of different drying methods on weight loss rate, essence content and camazolen percentage of chamomile (*Matricaria recutita* L.). *Iranian Journal of Medical and Aromatic Plants*, 25(2): 182–192.

BURG, P., ZEMÁNEK, P. and MAŠÁN, V. 2012. Moderní mechanizační prostředky pro sklizeň léčivých, aromatických a kořeninových rostlin. In: NEUGEBAUEROVÁ, J., KAFFKOVÁ, K. *18. odborný seminář s mezinárodní účastí Aktuální otázky pěstování léčivých, aromatických a kořeninových rostlin*. Brno: Mendelova univerzita v Brně, 45–51.

DACHLER, M. and PELZMANN, H. 1989. *Heil- und Gewürzpflanzen*. Wien: Österreichischer Agrarverlag.

HORNOK, J. W. (ed.). 1992. *Cultivation and processing of medicinal plants*. Chichester: John Wiley.

JANČA, J. and ZENTRICH, J. 1995. *Herbář léčivých rostlin 3. díl*. 1. vyd. Praha: Eminent.

KRESÁNEK, J. and KRESÁNEK, J. 2008. *Atlas liečivých rastlín a lesných plodov*. Martin: Osveta.

LAIRD, S. A. and PIERCE, A. R. 2002. *The Rainforest Alliance Sustainable Botanicals Project: Report from the pilot project phase, August 2001-January 2002*. New York: Rainforest Alliance.

NEUGEBAUEROVÁ, J. 2006. *Pěstování léčivých a kořenových rostlin*. 1. vyd. Brno: Mendelova zemědělská a lesnická univerzita v Brně.

PAJIC, M., RAICEVIC, D., ERCEGOVIC, D. et al. 2007. Influence of exploatation charakteristics of harvester „NB 2003" on chamomile harvesting quality. *Acta Hort. (ISHS)*, 749: 253–258. [Online]. Available at: http://www.actahort.org/books/749/749_31.htm. [Accessed: 8. 7. 2014].

PROŠKOVÁ, J. and ABRAHAMOVÁ, M. 2007. *Analýza současného stavu pěstování léčivých, aromatických a kořeninových rostlin (LAKR) v ekologickém zemědělství ČR, příležitosti a konkurenceschopnost v tomto odvětví*. [Online]. Praha: Výzkumný ústav zemědělské

ekonomiky Praha. Available at: http://rac.uhlava.cz/index.php?page=140&id=594&lang=cz&sm=13&task=on. [Accessed: 10. 6. 2014].

SCHIPPMANN, U., CUNNINGHAM, A. B. and LEAMAN, D. J. 2003. Case study No. 7.: Impact of cultivation and gathering of medicinal plants on biodiversity: global trends and issues. In: *Biodiversity and the ecosystem approach in agriculture, forestry and fisheries*. [Online]. Rome, Italy: FAO Inter-Departmental Working Group on Biological Diversity for Food and Agriculture. Available at: http://www.fao.org/docrep/005/y4586e/y4586e08.htm. [Accessed: 8. 7. 2014].

STRIČÍK, M. and SALAMON, I. 2007. Investment rating with a combine harvester acquisition for chamomile flower picking. *Acta Hort. (ISHS)*, 749: 265–268. [Online]. Available at: http://www.actahort.org/books/749/749_33.htm. [Accessed: 10. 6. 2014].

ŠTOLCOVÁ, M. 2003. *Multimediální elektronická publikace – Léčivé, aromatické a kořeninové rostliny*. [Online]. Praha: ČZU Praha. Available at: http://etext.czu.cz/php/skripta/skriptum.php?titul_key=57. [Accessed: 10. 6. 2014].

TOBEH, A., MOGHANLU, F. and IMANI, A. 2013. Effect of different Planting and harvest dates on quantitative yield of Lemon balm as a medicinal plant. *International Journal of Agronomy and Plant Production*, 4(4): 839–847.

TOŠOVSKÁ, M. et al. 2012. *Situační a výhledová zpráva. Léčivé, aromatické a kořeninové rostliny*. [Online]. Praha: Ministerstvo zemědělství ČR. Available at: http://eagri.cz/public/web/file/188525/SVZ_2012_konecna_verze.pdf. [Accessed: 15. 5. 2014].

VALÍČEK, P. 2005. *Koření a jeho léčivé účinky*. 1. vyd. Benešov: Start.

VÂRBAN, D., SOCACIU, C., DUDA, M. et al. 2010. Research regarding the nutrition space, seeds germination and free compounds in Melissa officinalis L. species. *Hop and Medicinal Plants*, 18(1–2): 44–48.

Contact information

Vladimír Mašán: masan.vlado@gmail.com
Tomáš Kopta: tomas.kopta@mendelu.cz