AgroLife Scientific Journal - Volume 11, Number 2, 2022
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

EXPERIMENTAL RESEARCH ON HARVESTING SPECIES OF MEDICINAL PLANTS GROWN ON SMALL AREAS

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Abstract

The operation of harvesting medicinal plants is one of the important factors, which influences the quality of plant material and thus its value. In order to optimize the cultivation technologies and to adapt them to the local conditions, INMA Bucharest has developed and tested a multifunctional equipment for the mechanized harvesting of medicinal plants (annual and perennial), cultivated on small and medium areas. This equipment, of small capacity, equipped with interchangeable working parts, performs the harvesting operation by cutting, at a certain height from the ground. The paper presents the results obtained when testing the experimental model of Multifunctional equipment for harvesting medicinal and aromatic plants in the crops of three species of medicinal plants, grown on small areas. Determining for each crop some qualitative working indices (average working height, cutting degree, collecting degree, losses, etc.) as well as some energy indices (working speed, hourly fuel consumption, working capacity, etc.) allows the evaluation of the technical and working performances of the Multifunctional equipment for harvesting medicinal and aromatic plants.

Key words*: mechanized harvesting, medicinal plant, equipment.*

INTRODUCTION

Medicinal plants are an important source of bioactive compounds, micro and macro elements, which have special effects on human health. Therefore, they are used in both classical and traditional medical practice to treat certain specific conditions, for preventive purposes or for both (Noila, 2020; Jamshidi-Kia et al., 2018).

In the last 15-20 years, the population of developed countries has shown an increased interest in the use of medicinal plants, while for 80% of the population of developing countries, they are the only method of treatment. Thus, approximately 87.5% of the world's population uses these species, cultivated or from spontaneous flora, for medical purposes. The manufacture of medicines and their use in other fields (cosmetics, food, etc.) have led to a continuous increase in demand for these plant resources (Sanchez et al., 2020; Awuchi, 2019).

The cultivation of medicinal plants requires specific knowledge in the field of cultivation technologies, the use of special machines/ equipment, as well as the existence of ways of valorisation, in conditions of quality and safety. These reasons have led to a drastic reduction in the areas cultivated with these species in many European countries (Ivanovic et al., 2014).

In Romania, the areas cultivated with medicinal plants have registered a strong decline in recent years (Table 1 according to MADR).

Table 1. Evolution of the areas cultivated with medicinal plants (thousand hectares) and of the yield (thousand tons) during the period 2014-2019

Years Specification	2014	2015	2016	2017	2018	2019
Area	3.2	3.2	4.4	3.2	1.8	1.7
Yield	4.2	4.2	5.6	4.1	2.2	1.9

Table 1 shows the corresponding yields, whose oscillating evolution was influenced primarily by the size of cultivated areas, species and varieties used each year (Dumitru et al., 2020).

To these are added environmental factors and crop types, which mainly influence the content

of active substances in the plant material obtained, hence its quality (Yuan et al., 2020; Liu et al., 2016).
Characteristic for medicinal plants is that only certain parts of the plant are rich in bioactive substances. It is important that their harvest be carried out at the time and conditions dictated by the cultivation technology specific to each plants. The operation must be performed in a short time, regardless of the procedure applied: (manually or mechanized), in order to obtain a quality plant material (Zheng et al., 2018; Pajic et al., 2016).
Access to information on the latest developments in the field of harvesting of these species, as well as their acquisition, can be difficult and expensive for some growers of medicinal plants. Harvesting equipment is primarily classified according to the useful part of the plant being collected (rhizomes, bulbs, leafy stems, flowers or parts thereof, fruits or seeds, etc.). There are many companies around the world producing medicinal plant harvesters, some using modern, complex or innovative technical solutions (self-propelled, electrically operated machines, joystick control, etc.). In Europe, manual harvesting can be expensive, although it results in higher quality products when performed by qualified personnel (Martinov et al., 2007).
Harvesting is an important operation in cultivation technologies for these species, and its mechanization involves the use of machines adapted to cultivated areas. Worldwide there are concerns also for the realization of equipment for small areas (Mohamed et al., 2020; Niemiec et al., 2018; Radwan et al., 2015).
In Romania, among the most cultivated medicinal plants are: Lavender (*Lavandula angustifolia* Mill., family Lamiaceae), Hyssop (*Hyssopus officinalis* L., family Lamiaceae) and Basil (*Ocimum basilicum* L., family Lamiaceae).
Genus *Lavandula* is spread around the Mediterranean Sea, in southern Europe, northeastern Africa, the Middle East, southwestern Asia and southeastern India. For cultivation there are dozens of subspecies, varieties, local populations and hundreds of hybrids, belonging to about 30 species of the genus (Camen et al., 2016).
This plant has a long history of traditional use in medicine, cosmetics, etc., to which are added the many biological effects of its essential oil. (Lopez et al., 2018).
Hyssop (*Hyssopus officinalis* L., fam. Lamiaceae) is a perennial herbaceous plant, which has a pleasant smell. Although originating in the Mediterranean and Caspian Sea regions, the plant grows naturally also in Southern Europe, the Middle East, Central Asia, North Africa and North America. In many countries, the plant is cultivated and used due to its medicinal or culinary properties (Stan et al., 2019; Aćimovića et al., 2019).
Genus Melissa is a perennial plant, characterized by a lemon-like scent, cultivated and used for its aromatic, medicinal and melliferous properties. It is widespread in central and western Asia, southern Europe, especially in the Mediterranean basin. The species (*Melissa officinalis* L., family Lamiaceae) is the most cultivated worldwide, being naturalized in many parts of the world (Adel-Naime et al., 2020).
The paper presents the experimental research on mechanized harvesting of Hyssop, Lemon balm and Lavender species, cultivated on small areas, using the multifunctional equipment for harvesting medicinal and aromatic plants (experimental model).

MATERIALS AND METHODS

In order to support small farmers, cultivators of medicinal plants, INMA Bucharest has designed and developed an experimental model of Multifunctional Equipment for Harvesting Medicinal and Aromatic Plants - EMR. This is a low-power, easy-to-operate equipment that can also work in aggregate with a tractor, preferably a low-power one. It also has the possibility of being equipped with interchangeable active parts.
The field of use of EMR refers to the harvesting of many species of medicinal and aromatic plants belonging to different botanical families, which are collected in the form of *herba* (consisting of stem, leaves and flowers or stem and leaves) by cutting at different heights from the ground.
The experimental model of *Multifunctional Equipment for Harvesting Medicinal and*

Aromatic Plants, coupled to the tractor - EMR consists of a mower (with a straight or curved knife) installed on an assembled chassis, which supports a sack-type container for collecting the harvested material together with its support, the left/right plant lifters, as well as the drawbar for connecting to the tractor.

The mowers used for this experimental model are of the portable type, intended for harvesting tea leaves. The mower equipped with a knife with straight oscillating blades has a cutting width of 1.2 m, and for the one equipped with an oscillating knife with curved blades, the cutting width is 1 m (measured horizontally). Both types of mowers are powered by an air-cooled, two-stroke spark-ignition engine (capacity: 46 cm^3, maximum power: 2.2 kW). The same engine operates a fan, each model is equipped with, which acts as a blower, performing pneumatic transport and directing the harvested material in the collecting bag.

The assembled chassis, with rolling possibilities, is made up of removable subassemblies, made of metal profiles, so that it can be transported and assembled/disassembled easily.

The assembled bag support has the role of supporting and implicitly of protecting the collecting bag against aggressive contact with the stems of the plants left after harvesting. It was made of Polyplan PVC, a material resistant to abrasion, environmental factors, it is waterproof and easy to maintain, being mounted on the lower shield of the mower and anchored to the frame, by means of straps.

The bag, made of a polyester-based material, is the collecting system of the equipment and is mounted so that the harvested plant material is directed by the air flow inside it. It has a tubular shape, with an elastic system at the front, so that it can be attached to the clamps mounted on the rear contour of the mowers. In the middle area, it is provided with a cut-out covered with mesh, intended to evacuate the air, which transports the plants. It is not sewn on the back side, so its useful length can be adjusted by tying, in the appropriate section, depending on the characteristics of the *plant material* being collected.

The description of the equipment can be completed with several features. The number of rows harvested at one pass is 1-2, depending on the cultivation technology. The working height (manually adjustable) is between 150 ... 550 mm, for the straight blade mower and between 150 ... 650 mm, respectively, for the curved blade mower (measured at the side ends of the cutting blade). The front track gauge is 1682 mm and the rear track gauge is 1450 mm and the wheelbase is 1828 mm. The overall dimensions (LxWxH) are: 3783x1760x1418 mm (with the swivel wheels facing backwards and the drawbar in a horizontal position). The mass of the equipment is approx. 90 kg. The operating staff consists of 1 or 2 operators.

The tests were performed at SCDA Secuieni, Neamţ County, in July, in organic crops of Hyssop (*Hyssopus officinalis* L.), Lemon balm (*Melissa officinalis* L.) and Lavender (*Lavandula angustifolia* Mill.), species belonging to Lamiaceae family.

The biometric data of the crops studied are presented in Table 2.

Table 2. Biometric data of medicinal plant crops - SCDA Secuieni

Characteristic	Species		
	Hyssop *Hyssopus officinalis* L.	Lemon balm *Melissa officinalis* L.	Lavender *Lavandula angustifolia* Mill.
Variety	Local population "de Ciorani" (crop year VI)	Local population "de Secuieni" (crop year II)	Codreanca (crop year IV)
Row spacing [cm]	70	70	100
Plant spacing/row [cm]	50	50	50
Bush average height [cm]	59.6	48.5	69.5
Bush average diameter [cm]	55.75	68.75	70
Flower stem height [cm]	40	-	29.7
Total area of the plot [ha]	0.034	0.015	0.19

For Hyssop and Lavender, the harvesting time was in the flowering phenophase. The Lemon balm is harvested several times a year, throughout the vegetation period. In July it was sufficiently developed for the second harvest.

For each species, the height and working regime were determined following preliminary tests. The harvesting operation was carried out in the morning, after the dew had risen until noon, and then, in the afternoon, after 17.00 until sunset. The equipment was fitted with the straight blade mower for harvesting Hyssop (Figure 1) and Lemon balm (Figure 2), and respectively with the curved blade mower, suitable for the globular shape of the bushes, for harvesting Lavender (Figure 3).

Figure 1. Hyssop harvesting

Figure 2. Lemon balm harvesting

Figure 3. Lavender harvesting

Tests were performed according to the methodology developed by INMA Bucharest.
In order to evaluate the quality of the process, several qualitative working indices and energy indices are determined and calculated.
For this, 3 areas were delimited for each crop, placed on the diagonal of the plot (with a length of 1 m and a width equal to the working width).
After passing the multifunctional equipment for harvesting medicinal plants over the delimited areas, the following were determined by weighing:
- m_{colcut} - *herba* mass (inflorescences/plants) cut and gathered in the collecting bag [g];
- m_{cut} - *herba* mass (inflorescences/plants) cut that did not reach the collecting bag [g];
- m_{uncut} - *herba* mass (inflorescences/plants) uncut, consisting of whole and partially cut plants left in the field (cut by hand after passing the equipment to be weighed) [g];
- m_{tot} - *herba* total mass (inflorescences/plants) possible to be harvested from a certain area, representing the sum of the partial masses presented above [g].

$$m_{tot} = m_{colcut} + m_{cut} + m_{uncut} \text{ [g]} \quad (1)$$

The cutting degree is determined by calculation, using the formula below.

$$deg_{cut} = \frac{m_{colcut} + m_{cut}}{m_{tot}} x100 \text{ [\%]} \quad (2)$$

The colectting degree and losses were also expressed as a percentage (%), in relation to the total mass as well.

$$deg_{col} = \frac{m_{colcut}}{m_{tot}} x100 \text{ [\%]} \quad (3)$$

$$losses = \frac{m_{cut} + m_{uncut}}{m_{tot}} x100 \text{ [\%]} \quad (4)$$

Each index represents the arithmetic mean of the three values corresponding to each marked area, for which three repetitions were performed.
The working width represents the average value of 5 determinations, performed at equal intervals on a considered working length of 25 m. The working height represents the average value of the determinations performed in 10 points.
For the other indices, 3 (three) determinations were performed for each crop, so that for each of them, the final value considered represents the arithmetic mean of the corresponding determinations.

RESULTS AND DISCUSSIONS

The results obtained in the test under operating conditions of the experimental model of multi-functional equipment for harvesting medicinal and aromatic plants are presented in Table 3.
In the case of Lemon balm harvesting, in order not to damage the crop, the tractor was abandoned, the equipment being manually directed on the row. Based on the experimental results obtained, of which the cutting degree between 88.4%-94.9%, the collecting degree between 87.1-93.2% and the losses between 6.8%-12.9%, it is found that the multifunctional equipment for harvesting medicinal and aromatic plants has achieved satisfactory harvesting of the studied species.

Table 3. Test results

Name of qualitative working indices and energy indices	U. M.	Hyssop	Lemon balm	Lavender
Number of rows harvested	-	2	2	1
Cutting height	Mm	172	200	330
Working width	M	1.18	1.1	0.73
Cutting degree	%	93.7	88.4	94.9
Collecting degree	%	92.3	87.1	93.2
Losses (uncollected cut plants + uncut plants)	%	7.7	12.9	6.8
Working speed	Km h^{-1}	1.53	1.33	1.65
Fuel consumption (mower)	l h^{-1}	1.54	1.61	1.48
Working capacity	ha h^{-1}	0.18	0.146	0.12
Fuel consumption per area unit	l ha^{-1}	8.55	11.02	12.33

CONCLUSIONS

The experimental results obtained demonstrate the efficiency of the *Multifunctional technical equipment for harvesting medicinal and aromatic plants EMR*, for harvesting perennial species of medicinal plants, with spiciform inflorescence grown on small areas.
It can be operated either in aggregate with a tractor or it can be manually directed on the row. It can also be equipped with interchangeable working parts, chosen according to the characteristics of the crop.
In order to achieve useful technical systems for small producers of medicinal plants, as well as to obtain quality production, the multifunctional equipment can be an important premise.
Also, the mechanized harvesting of medicinal and aromatic plants, performed with this equipment, can significantly contribute to the economic efficiency of these crops grown on small and medium-sized areas, and possibly to the long-awaited relaunch of this sector.

ACKNOWLEDGEMENTS

This paper was supported by one funding source the NUCLEU Programme, carried out with the support of ANCSI, Project PN 5N/07.02.2019 "Research on the superior valorisation of some new plant species cultivated in Romania".
The paper was supported by a grant of the Romanian Ministry of Agriculture and Rural Development, Funding contract no. 25.1.2/27.09.2019, project ADER 25.1.2: "Research on the development and testing of technical equipment for harvesting medicinal and aromatic plants, used in small farms".
This paper is financed by Ministry of Research, Innovation and Digitalization through Program 1-Development of the national research-development system, Subprogram 1.2.-Institutional performance-Projects for financing excellence in RDI, Contract no. 1PFE/30.12.2021

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