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MECHANIZED HARVESTING OF LEAFY PARSLEY CROPS IN THE REGION OF SOUTH BANAT

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Abstract: So far, many types, styles and sizes of mowing equipment has been developed and introduced in the agricultural practice. Therefore, leaf crops harvesting seems to be easier to mechanize with respect to other cultivars. However, keeping the leaf matter clean and loaded into a dryer without contaminants limits the kind of mechanization that can be used.

In this paper is given a general review of Parsley (*Petroselinum crispum)* crops properties, possible benefits of its applications and basic principles of mechanized growing technology. In addition a simplified agroeconomical calculation of the production costs against possible income from sold vegetables, based on current prices expressed in euros is also provided. This way, the production of Parsley herbs is justified from medical, nutritive, culinary and economical points of view.

Finally, results of testing three harvesters of different design, applied for collecting and preparation of parsley leaves at parcels in the region of south Banat (North Serbia) are presented and analysed. Measurements comprehended following working parameters: harvester velocity, loss of acquired crop and cutting lengths distribution of parsley leafs.

Key words: *mower, leaf harvester, herb, cutting, losses.*

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INTRODUCTION

Parsley (*Petroselinum crispum)*

Parsley (*Petroselinum crispum)(Petroselinum crispum* (Mill.) Nyman ex A.W. Hill) belongs to the family *Apiaceae* and is one of the most popular herbs. Parsley is a biennial herb that is cultivated extensively. However, in some countries, like California, Belgium, France, Germany and Hungary parsley grows as an annual plant. Different parts of parsley herb are used, including its ripened fruits (also known as seeds), leaves as well as the other parts that grow above the ground.

Different parts of Parsley crops have found a number of possible applications, including medicinal, nutrient, as well as culinary.

So far, the leaves, fruits and root of this herb have been used in traditional medicine. However, the parsley is also used in conventional medicine. Fruits (seeds) of parsley are basically applied in the form of a stomachic or carminative. Roots of this crop are used in the form of a diuretic. Compared to the leaves of the plant, the fruits of parsley possess a very strong diuretic action and can be used in place for celery seeds (*Apium graveolens*) for treating arthritis, rheumatism, and gout..

Although people do not consume parsley in enough amounts, this herb is an excellent natural resource of pro-vitamin A (carotene), vitamin B1, vitamin B2, vitamin C, iron as well as other valuable minerals [6]. For instance, the fresh leaves of parsley are extremely nourishing and may be deemed to be a natural vitamin as well as mineral supplement in their individual capacity.

Parsley has been also used for culinary purposes. Today this herb is extensively cultivated throughout the world in the form of a nourishing herb. The leaves of parsley are harvested anytime between spring and autumn - the growing season of the plant [9].

Parsley is propagated by its seeds, which germinate extremely sluggishly [1]. Parsley grows best in extremely rich and well-drained soil and can endure pH range between 4.9 and 8.2. In the first year of their growth, parsley plants have a solitary leaf rosette [5]. If the Parsley herbs are grown primarily in order to produce fruits (seeds), the plants should be kept in the ground till their second growth season, when they actually bloom and produce seeds [8] [10].

Recent harvesting solutions for leafy parsley

The mechanization of leafy herbs and medicinal plants production is less developed with respect to production of other plant species in horticulture. The harvest is a particular problem, even for those plants that are harvested by machines designed for other plant species. A typical example is the leafy plants such as peppermint, lemon balm, thyme, sage, nettles, marjoram, parsley and other leafy vegetable plants.

Depending on the crop quality, multiple harvests of parsley are possible either by machine or manually. Under conditions of dry land farming, harvest could be performed three times per harvesting season. If irrigation is proprely applied, even four harvests per season are possible. For multiple harvests, Parsley plants should be cut at least 3 cm above the crown. In general, machine-harvested fields are mechanically chipped in a way to provide cutting plane in the range between 2.5cm and 7.5 cm above the crown, and after cutting transported to dehydrators.

Cutting, combing, stripping, vibration and threshing are different functions used for the detachment of the very wide range of aerial parts found in the diverse commodities to be harvested.

Cutting action is applied mainly to the leafy parsley, and any other green or similar plant parts. Each of these products needs multiple harvests for maximum yield specified to be sold at fresh market. In all cases, they have to be cleanly removed and handled softly for minimum leaf loss. Cutting is the most effective removal method, but it is also used in combination with other harvesting systems

Figure 1. Ploeger - MKC 4TR parsley stripping unit

Among the others, the Ploeger MKC 4TR power unit [4] represents a possible contemporary solution in the area of parsley harvesting, Fig. 1. It possess 6 meters wide parsley stripping element, equipped with cutting units directly after stripping device. The stripped parsley is conveyed into the container while the cut stems are transported onto the track path to avoid diseases and to create a uniform second grow of the crop. The stripping unit is delivered with a special platform, which facilitates transport of the stripping unit from one field to the other. This platform can be easily lifted by the hook lift system on the backside of the MKC 4TR power unit.

Justifiability of Parsley (*Petroselinum crispum)* production

Republic of Serbia does not possess the statistic's records on the parcel areas under the parsley. However, estimated value is about 2700-3000 *ha* [2]. In addition, varieties selection of parsley cultivar is very poor.

Although production of leafy parsley is not widespread in Serbia, results of simplified calculations presented in Tab. 1, [3] justifiy the investements neccessary for production of crops of this kind.

Table 1. Calculation of parsley leaf production

Materials and operations	*Measurement unit*	*1 ha*	*Price (Euro)*	*Costs (Euro/ha)*
1. Material				
Seeds of parsley	*kg*	*10*	*30,00*	*300,00*
Livestock manure	*t*	*30*	*20,00*	*600,00*
Water for irrigation	*l*			*100,00*
TOTAL /1/				*1000,00*
2. Work of tractor				
Plowing at 25 cm	*working day*	*0,6*		
Discing	*working day*	*0,3*		
Distribution of manure	*working day*	*1,0*		
Plowing of manure	*working day*	*0,5*		
Sowing	*working day*	*0,1*		
Interrow cultivation	*working day*	*1,0*		
Mowing the leaves of parsley	*working day*	*1,0*		
Other works	*working day*	*1,0*		
TOTAL /2/		*5,5*	*90,00*	*495,00*
3. Manual work				
Distribution of manure	*working day*	*12*	*15,00*	*180,00*
Sowing	*working day*	*2*	*15,00*	*30,00*
Loading / unloading	*working day*	*5*	*15,00*	*75,00*
Hoeing, weeding	*working day*	*20*	*15,00*	*300,00*
Collecting raw materials from field	*working day*	*10*	*15,00*	*150,00*
TOTAL /3/				*735,00*
TOTAL COSTS /1+2+3/				*2230,00*

MATERIALS AND METHODS

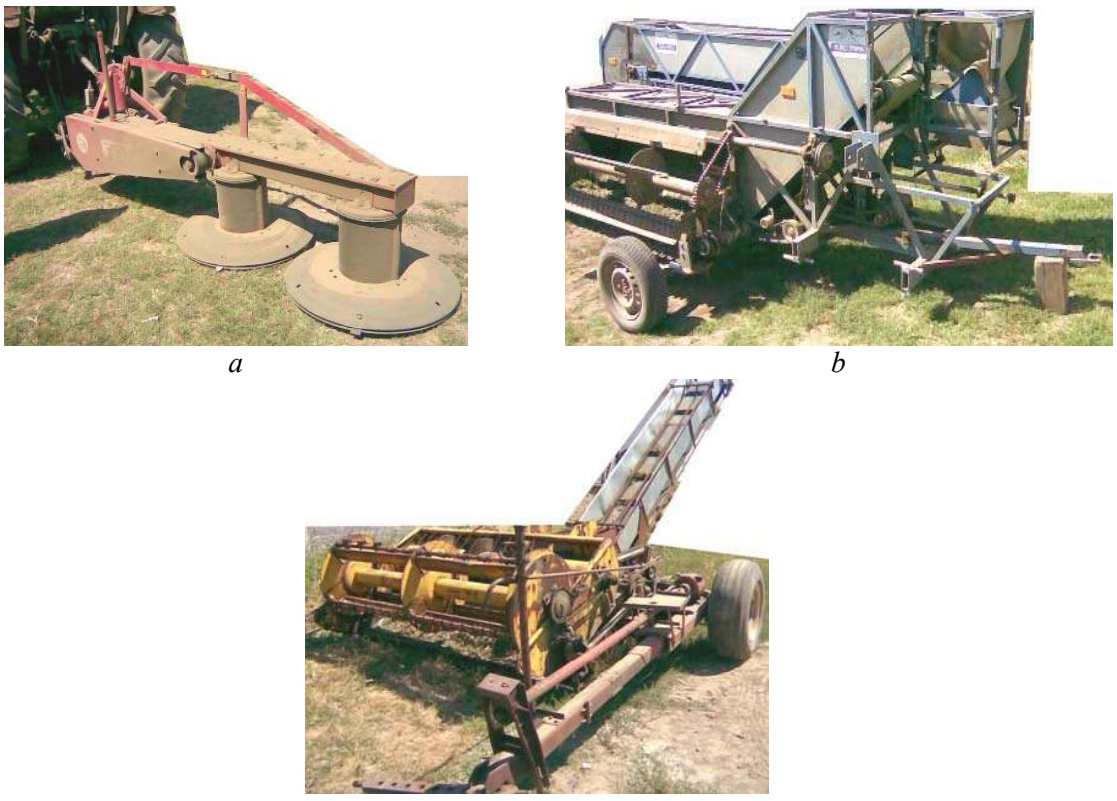
This paper presents results of testing three systems, commonly used in Serbia for mechanized harvesting of parsley leaves. The experiments were conducted during the second decade of the June 2012 in the region of the South Banat in north-east Serbia. Rectangular experimental plot is placed on flat terrain between the villages Kovin and Bavanište, at altitude 78 *m*. The position of experimental parcel, which photograph is given in Figure 2, is spatially defined by its GPS coordinates: 44°48’ N and 20°53’ E.

A *b*

Figure 2. Experimental plot: a) plan view and b) crop

Cultivar of leafy parsley "*Domaći lišćar*" was growed on the experimental plot, using the following technological operations:

1. primary tillage;
2. presowing preparation (as for alfalfa);
3. sowing, performed in late February and early March, at a depth of 2 cm, and at 25 cm row spacing;
4. crop protection:
   - spraying of herbicides (late march);
   - spraying against of sorghum (early may);
   - fertilization after emergence and
   - leaf harvesting (starts in mid–June).



a *b* *c*

Figure 3. Tested machines: a) mower "SIP ROTO 165", b) harvester-mower "Euro Prima NB 2004" and c) silage harvester "Pobeda KS-69/A"

The leaf humidity was 70.8-78.3 % during the harvesting process, which involved cutting plants, collection and transport to the drier [7]. Parsley leaves were mowed by tractor MTZ 820 aggregated by three different harvester systems:

- mounted (carried) rotary drum mower, Mower "SIP ROTO 165"
- mounted (carried) harvester-mower for leafy vegetables "Euro Prima NB 2004";
- adapted trailed forage harvester, Silage harvester "Pobeda KS-69/A".

Machines used are presented in Figure 3, while their technical characteristics are given in Table 2.

Table 2. The characteristics of harvesting machines

TECHNICAL DATA	*Mower SIP ROTO 165*	*Harvester-mower Euro Prima NB 2004*	*Silage harvester Pobeda KS-69/A*
Hitch	*Mounted at 3 points*	*Mounted at 3 points*	*Trailed at single point*
Cutting device	*Rotational knives on drums*	*With double cut scythe*	*Conventional, with single cut*
Working width (mm)	*1650*	*1800*	*2200*
Weight (kg)	*392*	*1100*	*1200*
Transport width (mm)	*1340*	*2000*	*2200*
Transport length (mm)	*2850*	*5300*	*5200*
Maximal height (mm)	*1110*	*1900*	*3500*
Max. no of P.T.O. shaft rotations (min^{-1})	*540*	*540*	*540*
Required tractor power (kW)	*22*	*60*	*48*
Working speed (km h^{-1})	*12-15*	*2-5*	*4-7*
Mowing capacity (ha h^{-1})	*2*	*0,5*	*1*

Parameters of the herb samples were determined by manual separation of samples acquired at the operational harvesting length of 1m. Forward speeds of all three harvesters were recorded during harvesting, as well as the loss.

RESULTS AND DISCUSSION

Experimental harvesting of parsley leaves was performed by three harvester systems:

1. Harvesting of Parsley leafs by the first system (mounted rotary drum mower "SIP ROTO 165") assumed cutting the plants with rotary blades and disposing the swath on land. In the next phase, cutted mass was collected manually by forks, and put into the trailer. Consequently, this system was the most unfavorable with respect to other two tested systems. Mass losses reached the highest values, because the product leaves after cutting fell down to the ground surface and manually collecting led to occurrence of non picked-up mass on the soil (ground) surface. This, except major losses, implies higher costs of manual workforce, while reducing the quality of the collected mass that comes into contact with the surface of the plot and thus polluting.
2. The second system, mounted harvester-mower "Euro Prima NB 2004", cuts leaves mass with double cuts, reducing the possibility of obstruction on the cutter bar. Finally, conveyor belt, which is built in the trailer and aggregated on the back side of the combine, inserts the cut off the mass in the trailer. Main disadvantage of this design is related to the fact that there is no ability to change the speed of conveyor. Consequently, in the case of higher mass density, an obstruction of conveyor belt may occure.

3. The third system for collecting leaf Parsley, adapted trailed forage harvester "Pobeda KS-69/A", arised after modifying the basic construction of forage harvester. There were two kinds of modifications, done in order to use the machine in parsley harvesting: (a) transport rollers (which deliver mown mass up to the cutter), cutter and conveying tube were removed; (b) the elevator, belt conveyor with laths (which delivers mown mass to the trailer) were added. This way, the adapted machine cuts mass by classical oscillatory cutting bar with a movable operating body. The belt conveyor, aggregated at the back side of the combine, transports the cut off mass and inserts it in the trailer. Under various operating conditions, the inmproved design of this harvester showed stable work, exposing the least disparities of operational characteristics from the optimal values and had a minimum of malfunction when compared to other two tested machines.

Average operational parameters of harvesting machines, determined under experimental cutting the Parsley leaves, are presented in the Table 3.

Table 3. Average operational parameters of harvesting machines

Parameter	*Type of harvesting machine*		
	Mounted rotary drum mower "SIP ROTO 165"	*Mounted harvester for leafy vegetables "Euro Prima NB 2004"*	*Adapted trailed forage harvester "Pobeda KS-69A"*
Constructive working width (m)	*1.65*	*1.80*	*2.20*
Realized working width (m)	*1.44*	*1.58*	*2.02*
Working speed (km h^{-1})	*11.34*	*1.16*	*2.37*
Cutting height (cm)	*8.31*	*5.53*	*7.28*
Losses (%)	*18.41*	*5.69*	*3.16*

Process of harvesting the Parsley leaves should facilitate further processing and drying of the cutted mass. In the final stage of processing the stems with leaves, complete mass is dried and leaves are separated from the stalk after drying. Therefore, the heat energy is consumed for drying stalks, which has no practical value.

Low stem cutting height, below 6 cm, characterised the second system (mower "Euro Prima NB 2004"with two knives), which is not recommended for the parsley. Rotary drum mower "SIP ROTO 165" generated a greater amount of cutting mass with respect to other tested machines, due to higher operating speeds. This system achieved the best cutting height in comparison to other two tested mowers, because of the better maintaining the configured cutting height.

Besides the amount of processed cutting mass, realized mass losses of mower at work is a key parameter to evaluate the quality of machine. Classic mower "Pobeda KS-69A" has achieved the lowest total mass loss (3.16 % of the average yield of green mass). The medium level of mass loss was evidenced when the harvester with two mower blades "Euro Prima NB 2004" was tested 5.69% in average. Rotary mower have achieved greater total losses with an average loss of 18.41 %. Rotary drum mower "SIP ROTO 165" achieved significantly greater losses with respect to other two harvesters. This was not caused by mowing, but was a direct consequence of utilization of other

hand operations that decreased the overall efficiency of harvesting process (mowing and manual collecting).

Machine with classic mower ("Pobeda KS-69A") achieved a satisfactory height level of stem cutting, but the operating speed was limited due to design of cutting device. This property, in addition to smaller working width, affects (decreases) the surface productivity, which was about 0.48 ha h^{-1} in average. Mower with two blades "Euro Prima NB 2004" achieved productivity of about 0.18 ha h^{-1}, while the drum rotary mower "SIP ROTO 165"achieved 1.63 ha h^{-1}.

CONCLUSIONS

For production conditions in Serbia, examined technical solutions for the harvesting of leafy parsley did not give satisfactory results. The first tested system, which demands manual (hand) operations (related to crop collecting) is especially inefficient and its application should be prevented in the future. Therefore, hit can be concluded that harvesting process must be completely mechanised and automated.

The future farm will be a multifunctional agricultural production unit, employing considerable technology and technological skills. The quality of the final product mostly depends on the harvesting method. Consequently, farm managers must persevere in continual extensive evaluation of existing harvester designs and in exploring the new possible solutions for machine's design.

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MEHANIZOVANA BERBA PERŠUNA U REGIONU JUŽNOG BANATA

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Sažetak: Do sada je razvijen i uveden u poljoprivrednu proizvodnju veliki broj tipova i konstrukcija mašina za košenje. Stoga se čini da je mehanizovanje žetve lisnatih useva lakše u poređenju sa ostalim kulturama. Ipak, očuvanje čistoće lisnatih useva i njihov utovar u sušare bez neželjenih kontaminanata ograničava vrstu opreme koja se može koristiti. U radu je prikazan opšti pregled opreme i postupaka za mehanizovano ubiranje peršuna (*Petroselinum crispum*). Na osnovu uprošćene ekonomske analize, zasnovane na tekućim cenama u Srbiji izraženim u evrima, potvrđena je opravdanost uzgoja ove poljoprivredne kulture sa ekonomske tačke gledišta. Konačno, prikazani su i analizirani rezultati uporednog testiranja tri kombajna različite kontrukcije, primenjene za sakupljanje i pripremu lišća peršuna na parcelama u regionu južnog Banata (severna Srbija). Merenjem su obuhvaćeni: brzina kombajna, gubici sakupljenog useva i raspodela dužina isečenih frakcija peršuna.

Ključne reči: *kosačica, kombajn za lišće, biljka, sečenje, gubici*

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