Sito, S.[1], Vesna Očić [2], V. Kušec [3], B. Šket [4]
Natalija Brečko [4], K. Ciler [5], Tatjana Glogovšek [1]

Preliminary communication

Working performances of carrot root extraction machines

Abstract

This paper presents results of field measurements of working performance and fuel consumption evaluation in various operating conditions. Three versions of carrot extraction machines (Dewulf, Europa 2000 and Asa lift) at three locations and two varieties of carrots (Maestro F1 and Mello Yello F1) was. In optimum soil conditions, fuel consumption ranged from 8.4 to 12.5 L/ha, while in heavy operation conditions for extraction machines fuel consumption increased significantly for 65%. The performance of carrot extraction in optimal soil conditions was on average between 3-4 t/ha. In unfavorable soil conditions (soil sodden, mud or too dry soil) working effects up to 70% and this has direct negative consequences on the overall carrots production costs.

Keywords: *carrot, extraction machine, tractor, working performances, fuel consumption*

Introduction

Vegetable production in the Republic of Croatia amounts to 70 000 ha, which is only 4.8% of the total processing area. In Croatia, 70% of vegetables are produced on family farms, of which only 3% is the production of vegetables in protected areas (greenhouses and PVC tunnel) (www.mps.hr).

The annual production of vegetables is around 370 000 tons, which is not sufficient for Croatian needs. One of the most important vegetable cultures in Croatia is the carrot which should be given greater significance and modernized her cultivation in the future.

Carrots are an outlandish plant prone to cross with wild relatives. Pollinated by wind and insects. Carrot fruit is a schizocarp consisting of two crescent shape mericarps. Carrot seed has an elongated oval shape with visible ribs with small spines. Carrot seeds can keep germination in optimum storage conditions for up to 3 years (Matotan, 2004).

Rooted vegetables give its best yield in winter, under the frost, in the dark and humidity conditions. It is unbelievable that soil is giving the people who do not have a large choice of food at that time, such rich in vitamins and minerals. It is mainly low in calories, rich in fiber as well as in vitamin C.

Carrots achieve an optimal root size at about 450 roots per m^2 if they are ideally arranged across the entire surface. However, so arranged carrots cannot be mechanically extracted with a machine, so in practice, the carrot is planted in rows or in the beds (Brčić, 1991).

When the peaks of the leaves, especially the lower one, begin turning into yellow, the carrot comes to a standstill phase and is ready for harvest. At this time, the process of gathering assimilates in the root is finished and the root is rich in sugars, beta carotene and has the best taste. This is the technological maturity which is the most suitable for drying and storing. But carrots can also be digged before their technological maturity, which is important if carrots are sold in the laces.

1 prof.dr.sc. Stjepan Sito, doc.dr.sc. Vesna Očić, Tajana Glogovšek, mag.ing.agr., Sveučilište u Zagrebu, Agronomski fakultet, Svetošimunska cesta 25, Hrvatska
2 mr. sc. Vlado Kušec, Visoko gospodarsko učilište u Križevcima, Ul. Milislava Demerca 1, Križevci
3 mag. Branko Šket, Natalija Brečko, univ.dipl.ekon., Šolski centar Šentjur, Cesta na kmetijsko šolo 9, Šentjur, Republika Slovenija
4 Krešimir Ciler, dipl. ing. agr., Srednja poljoprivredna škola, Ul. Gjure Prejca 2, Zagreb
Autor za korespondenciju: ssito@agr.hr

Figure 1. Drill machine (Source: Glogovšek, 2016)
Slika 1. Sijaćica za povrće (Izvor: Glogovšek, 2016)

Carrots can be harvested in single-phase or two-phase. Single-phase process extraction involves machines whose working parts raise roots together with the earth, and picker, who works on the principle of endless tracks, catch leaves and extract the roots. The leaves are then removed from the root and the root is transported to the container by the transport system. Two-phase harvest involves removing the leaves and then the lifter enters the soil and extract the root (Matotan, 2004).

On smaller excavation areas a lifter with an endless belt can be used. Firstly, it is necessary to remove the green mass and after the passage of the extraction machine the carrot root should be picked up by hand (Čuljat et al.,1997).

The harvest time is adjusted according so sufficient root strength to avoid cracking and breaking during removal and processing (Lešić et al., 2004).

The usually carrot yield is between 35 to 50 t/ha. The late varieties and hybrids which are intended for storage and processing, have a higher yield (Matotan, 2004).

According to Lešić et al. (2004), carrot yield depends on breeding purpose, row spacing, number of plants per m2 and the amount of seed (kg/ha).

Figure 2. Carrot Maestro F1 before and after washing (Source: Glogovšek, 2016)
Slika 2. Mrkva Maestro F1 prije i poslije pranja (Izvor: Glogovšek, 2016)

Growing of vegetable crops is accounted by big share of working hours and per product unit in one of the most intensive branches of agriculture. High intensity means high initial costs and performance of all predicted technological operations in the optimal agrotechnical time. Such production is only profitable if modern technology and production technology is applied, from sowing and planting to harvesting. In this chain, agricultural technology has a considerable share, because it enables timely and quality execution of all operations in the most favorable agrotechnical terms.

The harvest in October, within the roots intended for longer storage, gives good results if the temperatures are not very low yet and the plants are still in good condition, lie with a part of the leaves, which makes it easier to harvest.

On the efficiency of harvester and on the quality of the picked root crops during the harvest can influence numerous factors; soil condition, soil moisture, soil type, planting density (sowing), operators education and experience (Knežević, 2001; Brkić & Jurišić, 2001; Ivančan et al., 1994).

The aim of this paper was to determine the working performance and the fuel consumption of carrot extraction machines Dewulf P3B (Figure 3), Europa 2000 and Asa lift, driven by three different tractors, during the extraction of orange carrot Maestro F1 and yellow carrots Mello Yello F1.

Figure 3. Machine for extraction Dewulf P3B (Source: Glogovšek, 2016)
Slika 3. Vadilica mrkve Dewulf P3B (Izvor: Glogovšek, 2016)

Materials and methods

During field measurements for this study three tractors (Hurlimann XA 86DT, New Holland TD 5050 and Hurlimann XT 910.4) and three carrots extraction machines (Europe 2000, Asa lift and Dewulf) were used. For the investigation two carrots varieties were used; orange colour (Maestro F1) and yellow colour (Mello Yello F1). The study was carried out in the northern part of Croatia (Varaždin County). Measurements included operating speed of carrot harvesters in different working conditons. The fuel consumption was measured by the volumetric method and the working speed was calculated using chronometer method. Carrot production costs are calculated taking into account the variable production costs, and the fuel cost per hour of machine work is defined as a product of fuel consumption per hour of work and average fuel prices. The price of subsidized fuel is 0.80 (€/L).

Results and discussion

Table 1 shows the technical characteristics of tractors used with carrot harvesters. It is noticeable that Hurliman XT 910 has a bigger power engine, but also greater weight in relation to the New Holland TD 5050 and Hurlimann XA 86DT.

Table 1. Tractor characteristics
Tablica 1. Obilježja traktora

Number of the family farm Naziv OPG-a	1	2	3
Tractor type Naziv traktora	Hurlimann XA 86 DT	New Holland TD 5050	Hurlimann XT 910,4
Engine power (kW)/Snaga motora (kW)	61 kW	60 kW	76 kW
Total weight-unballasted (kg)/ Masa-neopterećenja (kg)	3,160	3,880	4,280
Total mass-ballasted/ Najveća dopuštena nosivost traktora (kg)	5,000	6,000	6,000
Capacity of fuel tank (L)/ Volumen spremnika (L)	90	95	140
Road speed/ Transportna brzina (km/h)	40	40	40
Power take-off speed/ Br. okretaja priključnog vratila (min^{-1})	540	540,1000	540,1000
Hydraulic pump/ Hidraulična crpka (L/min)	50	80	58

Characteristics of the individual carrot varieties used in this study are shown in Table 2. The production costs of 1 ton are approximately equal and range around 80 euros. The purchase price of 1 ton of carrots after extraction ranged between 213 and 240 euros and the price after storage ranged on average around 290 euros. The yield of carrot roots for individual varieties is different, depending on the agrotechnics, irrigation, etc. and ranges from 35 to 75 t/ha.

Table 2. Production cost, prices and yield of carrot roots
Talica 2. Troškovi proizvodnje, cijene i prinos mrkve

Varieties/Sorte	Mello Yello F1	Maestro F1
Production cost (€/t)/ Trošak proizvodnje (€/t)	80	80
The price of carrot before storage (€/t)/ Cijena mrkve prije skladištenja (€/t)	213	240
The price of carrot after storage (€/t)/ Cijena mrkve nakon skladištenja (€/t)	267-333	293
Yields (t/ha)/ Prinos (t/ha)	45-75	40-55

Fuel consumption during the ˝harvest is highly variable and in optimum soil conditions ranged from 8.4 to 12.5 L/ha, while in disadvantaged operation conditions for carrot harvester fuel consumption increased significantly and range from 11.6 to 17.9 L/ha. The effective working time of carrot harvester was quite uniform ranges from 58 to 64%. The operating speed of the carrot harvester was from 1.2 to 3.5 km/h (Table 3).

Table 3. Efficiency, effective working time and operating speed of carrot harvester
Tablica 3. Učinak, efektivni radon vrijeme i radna brzina vadilice za mrkvu

Carrot harvest type/ Vadilica mrkve	Europa 2000	Asa lift Combi plus	Dewulf P3B
Effect on extraction in optimal soil conditions/ Učinak kod vađenja u optimalnim uvjetima tla (t/h)	4.1	3.2	3.8
Efficiency in optimal soil conditions (t/h)/ Radni učinak u optimalnim uvjetima tla (t/h)	1.2	0.9	1.1
Efficiency in disadvantaged soil conditions (t/h)/ Radni učinak u nepovoljnim uvjetima tla (t/h)	58	62	54
Effective working time in optimal conditions (%)/ Efektivno radno vrijeme u optimalnim uvjetima tla (%)	28	31	29
Average operating speed at harvest (km/h)/ Prosječna radna brzina pri vađenju mrkve (km/h)	1.2	3.5	1.8

The average costs of fuel consumption is between 6.72 and 10.00 €/h, depending on the type of carrot harvster (Table 4.)

Table 4. Fuel consumption during carrot harvesting
Tablica 4. Potrošnja goriva prilikom vađenja mrkve

Tractor type Tip traktora	Hurlimann XA 86DT	New Holland TD 5050	Hurlimann XT 910,4
Carrot harvester type/Tip vadilice mrkve	Europa 2000	Asa lift Combi Plus	Dewulf P3B
Fuel consumption in optimum conditions L/h/ Potrošnja goriva u u optimalnim uvjetima L/h	12.5	8.4	8.9
Fuel consumption in optimum conditions (L/h) Utrošak goriva u optimalnim uvjetima (L/h)	17.9	11.6	13.8
Cost of fuel consumption (€/h)/ Trošak potrošnje goriva (€/h)	10.00	6.72	7.12

The cost of fuel consumption of carrot harvester per 1 hour, significantly depends on the following factors: weather condition, condition of the soil, maintenance of tractor, control of the pneumatic pressure, operator's education and experience, type of carrot harvester etc.

Conclusion

The efficiency of Dewulf P3B and yield are lower in the harvest of carrot Maestro F1 variety, compared to the Mello Yello F1 variety. The effective harvesting time, which directly effects on the efficiency is quite uniform and ranges from 62 to 54%. On the efficiency and fuel consumption can influence numerous factors such as sowing density, timely sowing, varieties, carrot harvester performance, weather conditions and a good harvest organization.

References

Brčić J. (1991) Mehanizacija u povrćarstvu. Zagreb: Sveučilišna naklada d.o.o
Brkić, D, Jurišić, M. (2001) Strojevi i uređaji za vađenje šećerne repe. Udžbenik. Osijek: Sveučilište J.J.Strosmayera.
Čuljat. M., Barčić. J. (2007) Poljoprivredni kombajni. Osijek: Poljoprivredni institut Osijek.
Glogovšek, T. (2016) Radni učinci strojeva za vađenje mrkve. Diplomski rad. Zagreb: Agronomski fakultet Sveučilišta u Zagrebu.
Ivančan, S., Košutić, S., Gospodarić, Z. (1994) Stanje usjeva i opći uvjeti rada kao čimbenici kvalitete rada strojeva za vađenje korijena šećerne repe. Actual Tasks on Agricultural Engineering, Opatija, 225-234.
Knežević, D. (2001) Utjecaj brzine kretanja kombajna na učinkovitost vađenja šećerne repe. Magistarski rad. Zagreb: Agronomski fakultet Sveučilišta u Zagrebu.
Lešić R., Borošić J., Buturac I., Herak-Ćustić M., Poljak M., Romić D. (2004) Povrćarstvo. Čakovec: Zrinski
Matotan, Z. (2004) Suvremena proizvodnja povrća. Zagreb: Nakladni zavod Gobus.
http://www.mps.hr/default.aspx?id=5859 (Accessed: September 21th 2016)

Prispjelo/Received: 20.4.2019. Prihvaćeno/Accepted: 6.5.2019.

Prethodno priopćenje

Radni učinci strojeva za vađenje korijena mrkve

Sažetak
U radu su prikazani rezultati terenskih mjerenja radnih performansi i potrošnje goriva u različitim radnim uvjetima. Korištena su tri tipa strojeva za vađenje mrkve (Dewulf, Europa 2000 i Asa lift) na tri lokacije i dvije vrste mrkve (Maestro F1 i Mello Yello F1). U optimalnim uvjetima tla potrošnja goriva strojeva kretala se u rasponu od 8,4 do 12,5 L / ha, dok je u teškim uvjetima rada za strojeve za vađenje mrkve potrošnja goriva značajno porasla na 65%. Učinkovitost vađenja mrkve u optimalnim uvjetima tla kretala se u prosjeku između 3-4 t / ha. U nepovoljnim uvjetima tla (mokro tlo, blato ili suho tlo) radni efekti padaju do 70%, što ima izravne negativne posljedice na ukupne troškove proizvodnje mrkve.
Ključne riječi: *mrkva, stroj za vađenje (vadilica), traktor, radne performanse, potrošnja goriva*