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Estimating Costs of a Chestnut Mechanical Harvester

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Abstract

In some European chestnut producing regions, harvest is mostly manually. However, due to the difficulty to find available labour, a significant number of producers are changing harvesting procedures, adopting mechanical systems.

There is not reliable information about costs associated to this harvesting system. This information can assume great importance for producers decision.

To contribute for the performance assessment of harvesting equipment based on a vacuum harvester, field trials to evaluate work rates has been carried out in Northeast of Portugal.

With the data collected it is possible to estimate associated costs and contribute for a better understanding of the feasibility of this procedure.

To evaluate the equipment work rate, time for each elementary operation was measured.

Work rate is presented by the ratio worked area / time.

Costs are computed under international standards for agricultural machinery management.

In environmental conditions and agriculture systems in the geographical area were field trials took place, vacuum harvesters can reduce harvesting time and associated costs. It can be an answer to the lack of labour required for manual harvesting.

Despite the need for further studies, this seems to be a good solution for lack of manpower problem. It is also necessary to change some agricultural practices in the field to improve the harvesting machines performance, such as soil management.

Keywords: mechanization, fruit harvesting, performance.

1. Introduction

Usually in chestnut (*Castanea sativa*) producing regions, harvest is manually, collecting from the soil previously fallen chestnuts.

With the aging of the rural population and the exodus of young people to other regions and activities, it is difficult to find available labor. Harvest mechanization is one solution to this problem.

Answering to this demand in the last years different chestnut harvesting systems became available in the market.

These harvesting systems can reduce harvesting time through better work rates and enabling to harvest in the optimal timing, improving fruit quality.

Reducing manpower needs is another goal that can be achieved.

To contribute for the performance assessment of harvesting equipment based on one of harvesting systems available, field trials to evaluate work rates has been carried out in Northeast of Portugal.

With the data collected associated costs was evaluated.

The harvesting system studied is based on a self-propelled vacuum harvester.

Results of the study are presented. They can contribute for a better understanding of this procedure feasibility.

2. Materials and Methods

Field trials took place in Northeast of Portugal in November 2018 and 2019 in chestnut orchards with altitudes between 800 and 900 meters, with a slight slope (up to 5%) of the cultivar Judia, with 25 to 35 years of age, spacing 9/10 m x 10/11 m (Figure 1). Soil is not mobilized. Grass cover is maintained.

The mechanical harvesting system studied is based on a self-propelled 74 kW vacuum harvester (Figure 2) (*Facma Cimina 380).* Harvesting width is 3 m. Chestnuts sucked from the soil, are temporarily stored in an adapted trailer (Figure 2) with a capacity of approximately 1,500 kg, pulled by the harvesting equipment.

The equipment collected fruits in the area between tree lines in three or four parallel strips depending on the distance between rows. After the last of these passages, the equipment proceeded to the next inter row area. Tests were performed using two different harvesting methods. In field tests I, chestnuts are harvested during the three or four trips and in the turns within each inter row. In field tests II, chestnuts are harvested during the three or four trips between rows, but not during each inter row. There is an interruption in the harvest between the turns between the tree lines, both in tests I and tests II. Field I tests were carried out in the beginning of the harvesting season, with a reduced amount of debris on the soil. Field tests II took place in a late stage of the season, in a repeated harvesting in the same place (double harvest), with a significant amount of debris (leaves, branches and burrs) on the soil. It is on the trailer indicated referred before (Figure 2) that the chestnuts harvested are removed from the orchard.

Figure 1. Orchard were field trials took place

Figure 2. Harvesting equipment and adapted trailer

This harvesting system needs one operator.

To evaluate the equipment work rate, time for each elementary operation was measured in minutes with a chronometer: harvesting time; inoperative time; turning time within two rows (during which harvesting continues) and turning time for switching between rows (during which harvesting stops). Inoperative time refers to the interruption of work to clear the product flow in the internal equipment parts.

Working rate is evaluated in ha h^{-1}.

Costs are evaluated following methodology proposed by Fidalgo et al (2006), Ortiz-Cañavate et al (2003), Hunt (1983); Edward (2015).

According to this methodology, agriculture machinery costs can be divided into two categories: annual ownership costs, which occur regardless of machine use, and operating costs, which vary directly with the amount of machine use. The true value of these costs cannot be known until the machine is sold or worn out. But the costs can be estimated by making a few assumptions about machine life, annual use, and fuel and labor prices.

The following assumptions were taken to evaluate costs:

A total of 250 hours $year^{-1}$ of work is assumed to be the average within the harvesting season, which spreads from mid-September till end of November.

To evaluate the annual total costs it was assumed a purchasing price of 72,320 € for the harvester more 2,000 € for the trailer (a total of 74,320 € for equipment purchasing cost, including taxes). Equipment salvage value estimated as 10% of purchasing cost. An expected economic life time of 10 years for both equipment.

Fuel costs were also assumed as follows: fuel consumption: 7.5 L $hour^{-1}$; fuel cost: 1.3 € L^{-1}. Considered 250 hours $year^{-1}$ of work.

Labour costs were also assumed as follows: cost $year^{-1}$ $person^{-1}$: 9,000 €; social and insurance cost increase: 20%; person total hours $year^{-1}$: 2,000. Work hours for this equipment: 250 hours $year^{-1}$.

Ownership costs (also called fixed costs) include depreciation, interest (opportunity cost), taxes, insurance, and housing.

Depreciation is a cost resulting from wear, obsolescence, and equipment age. To estimate annual depreciation, economic life and salvage value need to be assumed (see assumptions).

Depreciation was computed by the following equation Eq (1):

$$Depreciation = \frac{purchase\ cost - salvage\ value}{economic\ life} \quad (1)$$

Interest, taxes, insurance, and housing was not considered in this study because these items presume a high level of subjectivity.

Operating costs (also called variable costs) include repairs and maintenance, fuel, lubrication, and operator labor.

Repair costs for a particular type of machine vary widely from one geographic region to another because of soil type, terrain, climate, and other conditions. Within a local area, repair costs vary from farm to farm because of different management policies and operator skill.

Because all these factors and their variability, the best data for estimating repair costs are records of owners past repair expenses: 350 € year^{-1} in average for this particular equipment.

Fuel consumption was estimated by records of owners (see assumptions). Actual fuel cost L^{-1} was assumed.

Labour cost was computed by the following equation Eq (2), considering assumptions referred previously:

$$Equipment\ annual\ labour\ cost = \frac{Total\ annual\ labour\ cost \times 1.2}{Total\ annual\ hours} \times 250\ hours \qquad (2)$$

The sum of the indicated items represents the equipment annual cost. Equipment cost per hour was calculated considering 250 hours year^{-1} of harvesting work.

3. Results and Discussion

Figure 3 shows kg of chestnut harvested hour^{-1} and Figure 4 the work rate results in tests 1 and 2.

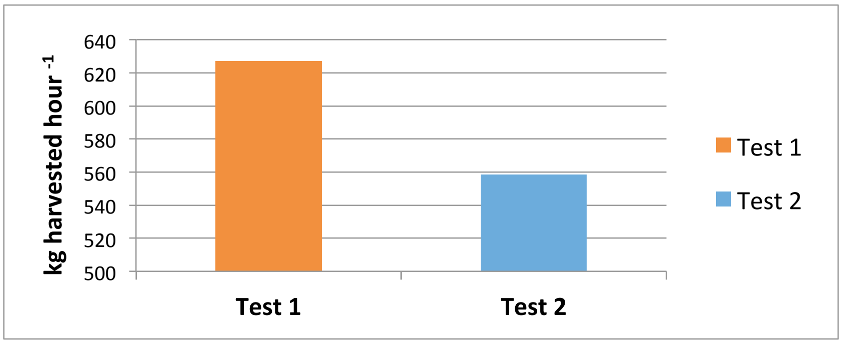

Figure 3. Chestnuts harvested kg h^{-1}

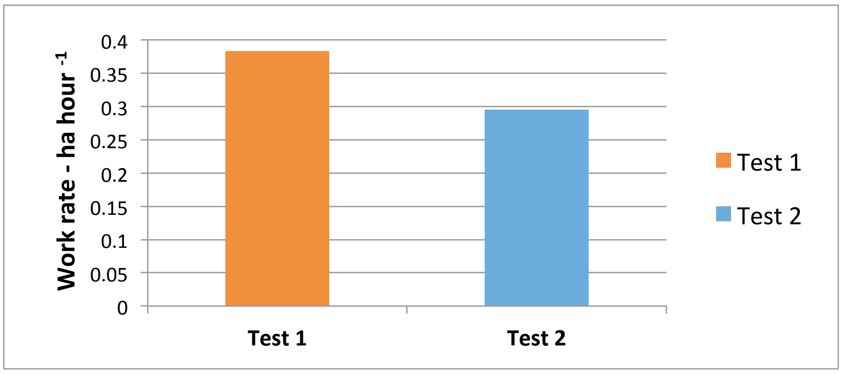

Figure 4. Work rate ha h^{-1}

Field tests 2 took place in a late stage of the season with a significant amount of debris (leaves, branches and burrs) on the soil. This is the reason why in this double harvesting the amount of chestnut harvested is lower. The work rate is lower in consequence of an increase of inoperative elementary time, necessary to clean the chestnut flow inside the equipment (Figures 5 and 6).

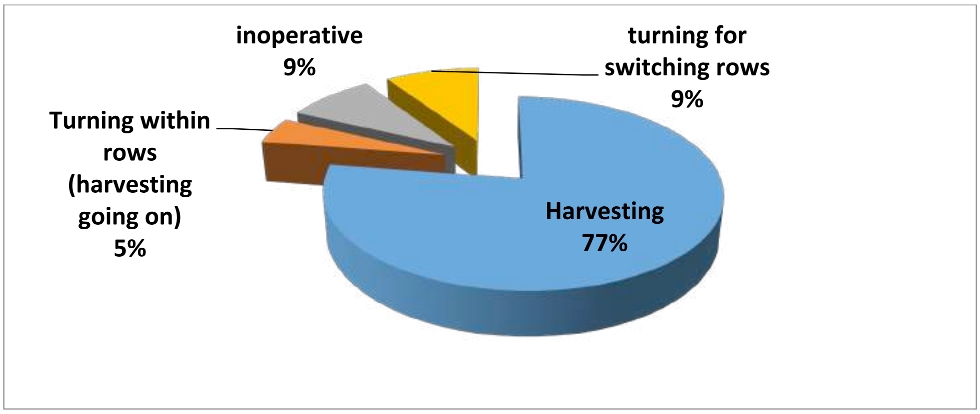

Figure 5. Test 1 – relative importance of elementary operations time.

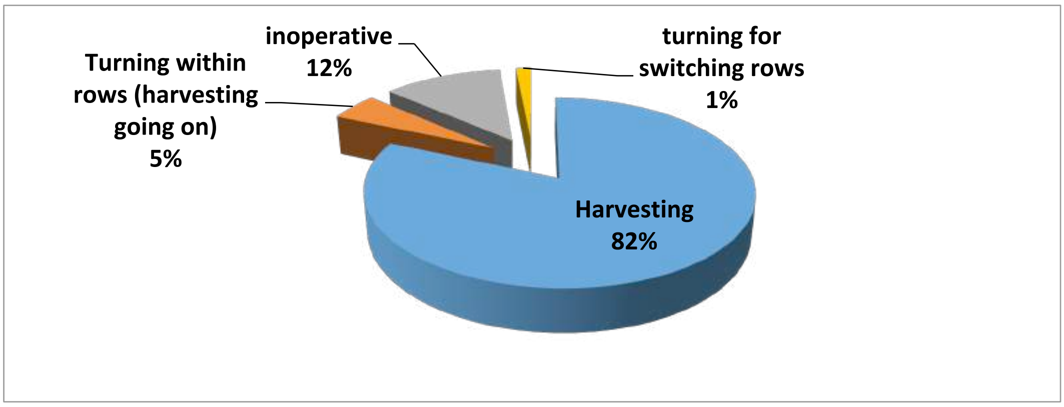

Figure 6. Test 2 – relative importance of elementary operations time.

In Table 1 are presented the annual costs computed under the assumptions mentioned in methods. Figure 7 represents relative percentage items costs.

Table 1. Annual costs for the harvesting system considered

Annual costs considered	Total costs year^{-1}
Depreciation	€ 6,689
Repairs and maintenance	€ 350
Fuel	€ 2,437
Labour	€ 1,350
total	€ 10,826

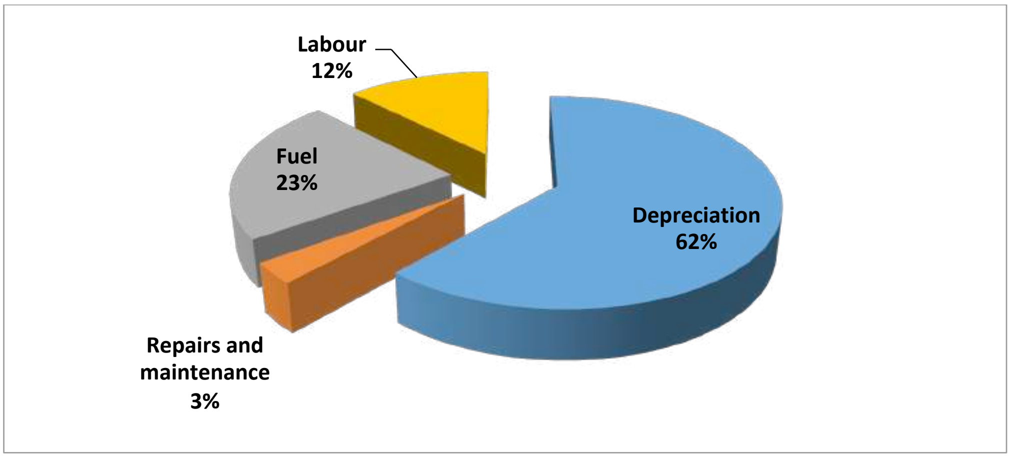

Figure 7. Relative importance of costs items considered.

According these results, cost kg^{-1} chestnut harvested is €0.07 for test 1 and €0.08 for test 2. The increase of cost kg^{-1} in test 2 is consequence of work rate results. Despite the lower performance on double harvesting this procedure is necessary because fruits continuously fall from the trees over the ripening period.

The work rate of manual harvesting expected is 20 kg h^{-1} to 30 kg h^{-1} per person (Monarca D. et al 2003; Monarca D. et al 2014a).Considering a cost of € 7 h^{-1} per operator, it's reasonable to expect a cost € 0.24 to € 0.36 kg^{-1} for manual harvesting.

According mechanical harvesting results presented, a significant cost savings can be achieved (Figure 8).

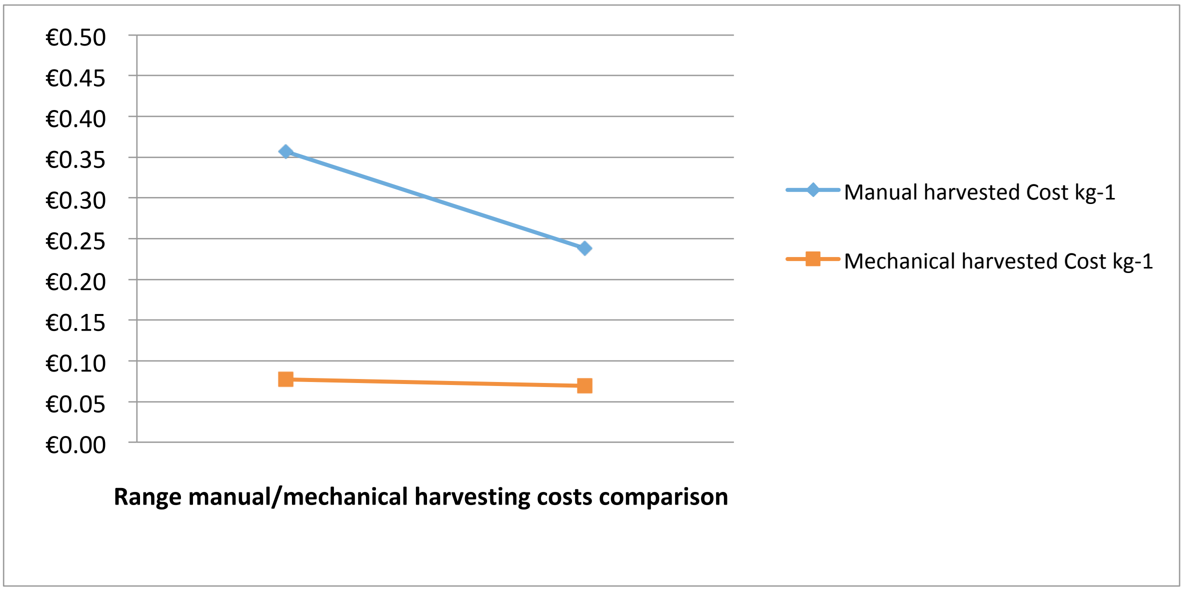

Figure 8. Comparing manual *vs* mechanical costs

4. Conclusions

The results show a work rate vacuum harvester higher, compared with manual harvesting work rate. With the harvesting system studied using a self-propelled vacuum harvester with one operator, it is expected to harvest 593 kg hour^{-1} person^{-1}. With manual harvesting it is expected to harvest 20 to 30 kg hour^{-1} person^{-1} (Monarca et al 2003 and 2014a). This advantage turns easier to match the optimum time to harvest with the area. The reduction in the time facilitates double harvesting procedure (harvest the same area twice), reducing the period of contact of the fruit with the soil, advantageous for the chestnut sanitary status.

The reduction of costs provided by mechanical harvesting is considerable, compared with manual harvesting.

It is possible to conclude that the chestnut mechanical harvesting studied it is possible to achieve considerable advantages:

It is a solution to the labor shortage for this operation.

Significant costs reduction.

Improvement of chestnut sanitary status.

Soil management is a relevant aspect for this operation. For the good suction of the fruits, they must be on an efficient cover of the soil. Soil must have a good grass covering, clean of inert and vegetal residues resulting from agricultural practices. Mechanical harvesting is not compatible with plowed chestnut groves.

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