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VALUE ANALYSIS OF HARVESTING SYSTEMS FOR OLIVES

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Abstract: *Automation of olives harvesting is an important part of precision agriculture, in order to provide economic efficiency and high reliability (if possible, low or/and precision maintenance). This paper focuses on the logistics and functional analysis, complete with value analysis of the harvesting systems used in olive orchards. The work required a state-of-the-art study and presents the method used for value analysis and identification of the base functions for olive harvesting equipment. We used several criteria for future life cycle (technical, technological, manufacturing, exploitation, maintenance, recycling, etc.) and costs. Based on the study, steps were identified as the main necessary logistic and value functions. The results (functions) have been split into two categories: essential functions and supporting functions, which interact inside the harvesting system. The analysis of olive logistics took the following into consideration (in correlation with harvesting processes particularities): orchard types, olive varieties, and core product of post-harvesting technology. The strictly necessary functions were identified for the minimum cost without diminishing quality, reliability and performance of the harvesting equipment. The results will be used for the optimization of a viable solution, which could be implemented in different specified conditions of olive orchards.*

Key words: *olives harvesting, value analysis, optimization.*

1. INTRODUCTION

Modern agriculture is based on both economic efficiency and high reliability, which also applies to an olive orchard. Therefore, when we create olive orchards, we need to carry out a study about all the technological process of the final products which includes them, the soil, as well as the harvesting methods. As shown in the previous study [1], today traditional olive orchards are preferred, although they have lower productivity (kg/ha) compared to intensive or hyper-intensive orchards, due to the fact that much larger varieties of olives can be cultivated, which include table olives and oil olives [2].

It is essential to carry out an analysis study about the estimated olive orchard establishment costs, the maintenance cost (pruning, fertilizing, orchard maintenance, weed-control, and social costs), the harvesting costs and all other costs up to the final product.

Olive fruit production and oil quality are essential criteria for the determination and improvement of the harvesting methods.

The functions necessary for a minimum cost with the highest efficiency can be identified through logistical analysis of olives and considering the particularities of harvesting processes (such orchard type, olive variety, primary product of post-harvesting technology). All without diminishing the quality of the olives, and at the same time providing reliability and performance of harvesting equipment [1], [3].

2. EXPERIMENTAL WORK

This method is based on our three-year study carried out in Greece on olive orchards in Halkidiki and Thessaly regions during the olive harvest seasons. This study was conducted between 2015 and 2017, on over 200 relevant locations.

In this study, we collected all the data that influence the olive harvesting process. We divided these data into three broad categories, namely identification, separation from the tree,

and intermediate storage of olives during harvesting, see Figure 1.

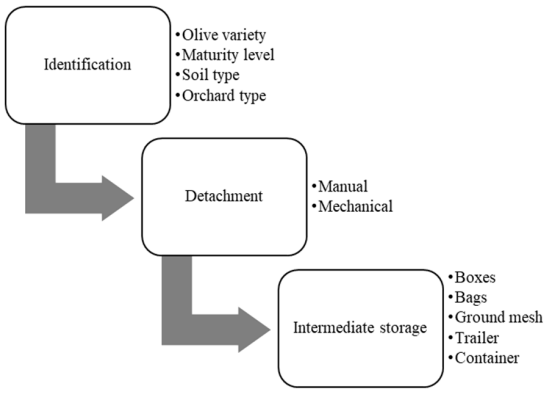

Fig. 1: Functional principle for olive harvesting systems.

This study shows the factors that influence and determine the quality and the productivity of the olives.

Our study indicates that in this region of Greece there are three types of orchards, the traditional, the traditional-modern and the hyper-intensive. Also, the study indicates the costs for implementing these types of orchards, Table 1.

Table 1

Cost of the new orchard (ha).

Activity	Orchard cost (€/ha)		
	Traditional	Traditional - modern	Hyper - intensive
Soil preparation	-	5.000	5.000
Supporting system	-	-	10.000
Growing	-	1.500	7.500
Irrigation system	-	5.000	20.000
Harvest equipment	0...150	150… 100.000	30.000… 150.000

Based on these data, we focused on three types of orchards: the traditional, the traditional-modern and the hyper-intensive. For these three types of orchards we created an analysis of functional principles for olive harvesting systems [4], as in Figure 2, and based on this analysis we determined the final costs and the efficiency of the olive orchards.

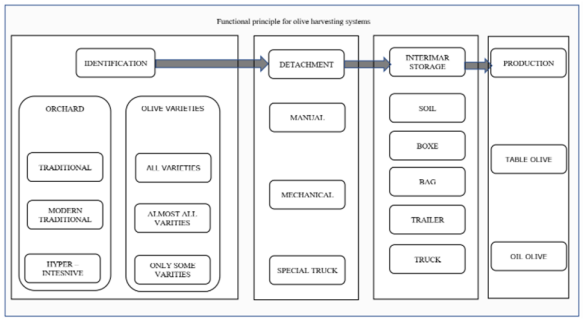

Fig. 2: Analysis of functional principles for olive harvesting systems.

This identification analysis allowed us to select the harvesting method for separating the olives from the trees, and subsequently the type of storage and destination of the olives for processing [5].

The traditional orchard was analyzed in the peninsula of Kassandra, the village of Polihrono in the autumn of 2015. This type of orchard is found in all regions of Greece and is the oldest type of olive orchard. Here man's intervention is minimal and they can be considered 100% organic orchards, therefore it is possible to obtain best table olive and oil quality from both black and green olives.

The traditional-modern orchard was analyzed in the peninsula of Kassandra in the village of Agia Anastasia in the autumn of 2016. High-quality olives can be obtained only if harvesting is done with manual devices followed by separation of black olives from green ones [6]. Also, with these devices, superior quality extra virgin oil can be obtained. If we use mechanical shaker devices, the quality of the olives is lower (due to the fact they have not reached the desired maturity level and because they are hit/damaged during the harvesting process) [7]. With these devices, the oil obtained is extra virgin superior quality, however it is inferior to manual methods.

The hyper-intensive orchard was analyzed in the region of Larissa, which is the only region in Greece where this type of plantation is found, in the experimental stage, in autumn 2017. The super-intensive plantation is commercially viable because of the high productivity and because it offers good quality olives. However, the resulting product is fit only for processing into olive oil, and its quality qualifies as extra

virgin, but it must be mentioned that this oil is inferior from the oils that result from other types of orchards.

Based on this study, we can make a comparison of orchard costs, as in Table 2 [8].

Table 2

Comparison of orchard costs per hectare of production.

Activity	Orchard		
	Traditional (Polihrono-2015)	Traditional – modern (Agia Anastasia-2016)	Hyper – intensive (Larissa-2017)
Workers (50€/worker)	20 (1000 €)	2 (100 €)	2 (100 €)
Rent harvest equipment (€)	-	1000	1200
Transportation warehouse (€)	50	150	150
Fertilizer (€)	250	250	250
Sowing soil (€)	100	100	100
Cutting branches (€)	100	100	100
Clean soil (€)	100	100	100
Irrigator (€)	-	100	100
Total costs/ha (€)	1600	1900	2100
Olive trees	200	500	2500
Harvesting duration	2-3 days	12 hours	7 hours
Total olive productions (kg)	4000	12000	16000

3. RESULTS AND DISCUSSIONS

The best method of harvesting, from a quality point of view, is the classic method (manual, with comb, bats or manual vibratory devices). The classic method is intended for both table olive and oil olive.

With the mechanical harvesting equipment, it is possible to harvest more trees in less time and use fewer workers. With mechanical harvesting equipment, care should be taken in order not to damage the olives, this damaging their quality and consequently that of final products. Also, certain types of machinery have the disadvantage that together with harvesting the olives harvest both vegetation and also hurt olives, which form wounds that can be affected by pathogens. Again, olives must be at the appropriate maturity stage, and tree shaping must be appropriate, see Table 3 [9].

Table 3

Comparison of orchard types.

	Orchard		
	Traditional	Traditional - modern	Hyper - intensive
Production [kg/ha]	200-4000	3000-12000	10000-22000
Olive variety	All	Most	Koroneiki Arbequina Arbosana
Oil olives	Yes – superior quality	Yes – good quality	Yes – good quality
Table olives	Yes – superior quality	Yes – superior quality	No
Life of orchard	>100 years	25-30 years	10-15 years

4. CONCLUSIONS

The analysis of harvesting systems is still in the research stage. In the past several years, more money has been invested in research into improving the quality and the quantity of olive products. This is because it involves seasonal work that requires a large number of specialists. Olive collectors must know the destination of the olives, namely table or oil olive. They need to know the ripening stages of olives, and the appropriate harvest time in order to obtain the highest quality. Mechanized elements can damage the health of workers because vibrations are transmitted to the human body, so injuries to the wrist, elbow, shoulder and spine may also occur [10], [11], [12].

If the orchard is small and for a small family business, the best orchard is the traditional-modern, where we can use more types of harvesting methods, at various costs.

6. REFERENCES

[1]. Glavan, D.O., Babanatsas, T., Babanatis Merce, R.M.. *3D modeling of olive tree and simulating the harvesting forces*. 8th International Conference on Manufacturing Science and Education – MSE 2017 "Trends in New Industrial Revolution", vol 121, 2017.

[2]. Tucu, D., Filipovici, A.. *Controlled stems cutting module for SRC nurseries*. Actual tasks on agricultural engineering, proceedings. Book

Series: Actual Tasks on Agricultural, vol 42, Engineering-Zagreb, 397-404, 2014.
[3]. Tucu, D., Golimba, A.-G., Mnerie, D.. *Grippers design integrated in handling systems destinated to agriculture mechanization*. Actual tasks on agricultural engineering, proceedings. Book Series: Actual Tasks on Agricultural Engineering, vol 38, Zagreb, 447-454, 2010.
[4]. Cristea, C.. *The allocation of customers to warehouses optimization using genetic algorithms*, Acta Technica Napocensis, Series: Applied Mathematics, Mechanics and Engineering, Vol. 56, Issue I, March 2013, pp. 89-94.
[5]. Crisan, G. H., Filip, N.. *Buses fleet maintenance optimization, using computer simulation methods*, Acta Technica Napocensis, Series: Applied Mathematics, Mechanics and Engineering, Vol. 60, Issue III, September 2017, pp. 417-420.
[6]. Babanatis Merce, R.M., Babanatsas, T., Maris, S., Tucu, D., Ghergan, O. C.. *Study of an automatic olives sorting system. Actual tasks on agricultural engineering, proceedings*. Book Series: Actual Tasks on Agricultural Engineering, vol 46, Zagreb, 485-490, 2018.
[7]. Babanatsas, T., Glavan, D.O., Babanatis Merce, R.M., Maris, S.. *Modelling in 3D the olive trees cultures in order to establish the forces (interval) needed for automatic harvesting*. IOP Conference Series: Materials Science and Engineering, International Conference on Applied Sciences, vol 294, Hunedoara, Romania, 2018.
[8]. Apostolopoulos, K., Kaldis, P., Galatoulas, I.. *Agricultural Economics, Cost - Economic Outcome – Competitiveness*, Athens, 45-76, 2010.
[9]. Peri, C.. *Olive handling, storage and transportation*. Wiley-Blackwell, Italy, 2014
[10]. Arghir, M.. *Dynamics of human body subjected to vibrations on a vibrating plate*, Acta Technica Napocensis, Series: Applied Mathematics, Mechanics and Engineering, Vol. 60, Issue III, September 2017, pp. 337-342.
[11]. Mnerie, D., Tucu, D., Anghel, G. V. , Slavici, T.. *Study about integration capacity of systems for agro-food production*. Actual tasks on agricultural engineering, proceedings. Book Series: Actual Tasks on Agricultural Engineering, vol. 36, Zagreb, 617-622, 2008.
[12]. Biris, A., Gligor, C. A., Arghir, M.. *Modelling of mechanical hand-arm system under vibration action*, Acta Technica Napocensis, Series: Applied Mathematics, Mechanics and Engineering, Vol. 56, Issue III, September 2013, pp. 475-478.

ANALIZA VALORII SISTEMELOR DE RECOLTARE A MĂSLINELOR

Rezumat: Lucrarea presupune un studiu de ultimă oră și prezintă metoda utilizată pentru analiza valorii și identificarea funcțiilor de bază ale echipamentelor pentru recoltarea măslinelor. Am ținut cont de mai multe criterii (de tehnică, tehnologic, de producție, de exploatare, de întreținere, de reciclare etc.) și de costuri necesare recoltării. Pe baza etapelor studiului au fost identificate principalele funcții de logistică. Rezultatele au fost împărțite în două categorii și anume a funcțiilor esențiale și a funcțiilor de sprijin care interacționează în cadrul sistemului de recoltare. Analiza considerațiilor logistice de recoltare a măslinelor, în corelație cu particularitățile proceselor de recoltare cum ar fi tipul livezilor, soiul de măsline și produsul principal al tehnologiei post-recoltare au dus la identificarea funcțiilor strict necesare pentru costul minim, fără a diminua calitatea, fiabilitatea și performanța echipamentului de recoltare. Rezultatele vor fi utilizate pentru a optimiza o soluție viabilă, care ar putea fi implementată în diferite tipuri de livezi de măsline.

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