# Performance of three mechanical harvesting systems for olives in Portugal

Almeida, A.[1] Peça, J.[2]; Pinheiro, A.[2]; Dias, A.[2]; Santos, L.[3]; Reynolds, D.[4] Lopes, J.[5]

(1) Escola Superior Agrária de Bragança, Apartado 1172, Bragança, Portugal e-mail: acfa@ipb.pt
(2) Universidade de Évora, Apartado 94, Évora, Portugal
(3) Departamento de Olivicultura da E.N.F.V.N., Elvas, Portugal
(4) R&O, Monte da Granja, Estremoz, Portugal
(5) Dir. Regional de Agricultura de Trás-os-Montes, Mirandela, Portugal

**Abstract**

Three mechanical harvesting systems for olives have been tested in field trials in the two main Portuguese regions of olive production: Trás-os-Montes and Alentejo. These tests took place in traditional olive orchards with 100 to 150 trees per hectare.

In the three systems, olives were harvested with the same trunk shaker and were collected manually (system I); with a tractor mounted rolling canvas (system II); with an inverted umbrella (system III).

Results are revealed in terms of working rates. The main factors that influence the systems performance are discussed.

**Key words**: olives / mechanical harvesting / performance

## 1. Introduction

Olive production assumes in Portugal and in the Southern European countries in general high economic value that justifies studies to solve the production difficulties. One of those difficulties is the high cost of traditional manual harvesting system, because labour is becoming more difficult to find and it is expensive.

Mechanized harvesting is one answer for this problem. Tree shakers are now widely accepted among growers, in spite of being unable to detach 100% of the production.

## 2. Material and Methods

Field trials carried out in Portugal in eleven traditional olive orchards (sites) over three years. Traditional olive orchards vary from 100 to 150 trees per hectare. Six of the olive orchards are in Trás-os-Montes region and five are in Alentejo region. A total of 2535 trees were used in the field trials.

In Trás-os-Montes there are three main cultivars: Cobrançosa, Verdeal and Madural, whereas in Alentejo, Galega is the main cultivar.

The mechanical harvesting systems studied are based on a trunk shaker mounted on the front loader of a 60kW four wheel drive tractor. Three different systems were used to collect olives detached:

In system I (Fig 1) the olives detached are collected on a 10m × 10m canvas placed under the canopy projection, and moved by four labourers. In a parallel row, a second group was placing another canvas under the next tree to be shacked. A second tractor and trailer was standing by to collect the olives when canvas became too heavy, as well as to provide transport to the processing unit.

*Figure 1* - System I

In system II (Fig 2) the olives detached are collected on a rolling canvas catching frame mounted on a second tractor. Two labourers are necessary to support the canvas movement. The canvases are made by two 4m × 8m separate parts, laid down on either side of the tree.

*Figure2* - System II

In system III (Fig 3) the olives detached are collected by a 9m diameter inverted umbrella linked to the tractor front-end-loader under the trunk shaker frame. The inverted umbrella can store temporarily 200/250 kg of olives in a collecting tray. Under the collecting tray a lead may be hydraulically open to allow discharge of the olives.

The experimental design was a randomized complete block with three treatments (system I, II and III) and three replications.

*Figure 3* - System III

**Measurements:**

- The following time in seconds, were taken:

**Tvt -** medium value of time per tree for trunk shaking (in systems I, II and III);

**TDV -** medium value of time to move the tractor/shaker unit, from one tree to next (in systems I, II and III);

**TDeP -** medium value of time to unroll the canvas and lay it under each tree (in system II);

**TEP -** medium value of time to roll up the canvas (in system II);

**TPAt -** medium value of time during which the canvas is under each tree (in system II);

**Tdaz -** medium value of discharging time of the inverted umbrella (in system III).

**Na** -Number of trees between discharges (in system III).

- The mass of the olives harvested by the shaker was measured. The mass of olives remaining on the trees was evaluated by manual picking from a sample of trees selected by randomization.

Work rates (WR) were computed from the following expressions:

$$\text{System I} \rightarrow \text{WR} = \frac{3600}{\text{TVt} + \text{TDV}} \qquad \text{System II} \rightarrow \text{WR} = \frac{3600}{\text{TDeP} + \text{TPAt} + \text{TEP} + \text{TDE}}$$

System III → $WR = \frac{3600}{TVt + TDV + \frac{Tdaz}{Na}}$

## 3. Results

Table 1 show the work rates results, per system and site

*Table 1*- Work rates by system, in trees per hour.

| | System I | | System II | | System III | |
|---|---|---|---|---|---|---|
| | **Mean value** | Standard deviation | **Mean value** | Standard deviation | **Mean value** | Standard deviation |
| Site 1 | **57** | 3,6 | **43,5** | 1,3 | **36** | 1,8 |
| Site 2 | **90,1** | 16,6 | **50,8** | 5,3 | **47** | 3,6 |
| Site 3 | **58,3** | 6,7 | **44,5** | 3,3 | **52** | 4,5 |
| Site 4 | **41** | | **36,5** | 13,4 | **41,3** | 10,6 |
| Site 5 | **37,5** | 3,5 | **27** | 5,6 | **22** | |
| Site 6 | **82,5** | 13,4 | | | **73,5** | 10,6 |
| Site 7 | **36** | 5,6 | **35,5** | 3,5 | **33,5** | 3,5 |
| Site 8 | **39** | 4,6 | **47,3** | 4,6 | **34** | 4 |
| Site 9 | **80,3** | 9,3 | **63,7** | 5 | **42,3** | 8,6 |
| Site 10 | | | **38** | 7,1 | **26** | 5,7 |
| Site 11 | **46,5** | 7,8 | **42,5** | 0,7 | **36** | 2,8 |

**Comparison of work rates of the different systems in the same olive orchard**

Considering that when growers decide to mechanize olives harvesting, they adopt system I as starting point, progressing then to system II or system III, the work rates of these two systems were computed in percentage of the work rate of system I. Results are shown in Table 2.

Table 2- Comparing systems – mean values

| | Work rate of system II in % of work rate of system I | Work rate of system III in % of work rate of system I |
|---|---|---|
| Mean value | **0,84** | **0,75** |
| Standard deviation | 0,17 | 0,14 |

**Shaker efficiency**

Shaker efficiency was measured by the ratio of mass of olives detached by the shaker and the mass of olives produced in the olive orchard. Results are presented in Table 3. Sites 5 and 6 do not include data, due to severe weather conditions. Results of sites 1, 2 and 3 were measured in trees used in the three systems.

Table 3- Shaker detachment capacity.

| | **System I** | **System II** | **System III** |
|---|---|---|---|
| Site 1 | 67% | 67% | 67% |
| Site 2 | 87% | 87% | 87% |
| Site 3 | 71% | 71% | 71% |
| Site 4 | 73% | 70% | 41% |
| Site 5 | 92% | | |
| Site 6 | 92% | | |
| Site 7 | 84% | 73% | 77% |
| Site 8 | 79% | 72% | 72% |
| Site 9 | 80% | 80% | 74% |
| Site 10 | | 77% | 67% |
| Site 11 | 96% | 90% | 89% |

## 4. Discussion and conclusions

Work rates have a great interval between the minimum and maximum values. Some factors are responsible for that: the heterogeneity in the traditional olive orchards, the different soil conditions that interfere with the equipment evolution and the labour quality.

System I has a better performance, followed by system II, being System III the slowest. However system I has a great dependence on labour and its quality. With inefficient labour, this advantage may be strongly diminished. An efficient labour, moving the canvas can improve the work rate. Systems II and III have lower performance and are more affected by the soil conditions. For these two systems, it is important that soil conditions allow a good capacity to sustain traffic of heavy equipment.

The shaker efficiency results are between 70% and 80% of olive production detached, what is in accordance with Giametta (1986), Tombesi (1990), Martin (1994), Ferguson *et al.* (1994) e Sierra (1996). In system III, site 4 the result is much lower 41%, because the tree crown conditions turn necessary to shake secondary branches, not possible with the inverted umbrella. In this site, was necessary to shake trunk and secondary branches, to get results of 73% for system I and 70% for system III.

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