

# Evolution of factors affecting mechanical olive harvesting

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## Abstract

Harvest efficiency is defined as the percentage of fruits harvested by total production. The percentage of fruits harvested is less than 100% when working with trunk shakers to detach olives. It is important to increase the percentage of fruits harvested in order to increase farmer's income. This objective can be achieved knowing the evolution of the main factors affecting fruit detachment. Fruit removal force (FRF), fruit weight (P) and the ratio between them are important for harvest efficiency. Field trials took place for two years (2013-2014) in Vilarça Valley, northeast Portugal in an olive orchard with 'Cobrançosa Transmontana' cultivar. It was adopted a mechanical harvesting system based on a trunk shaker to detach fruits, and an inverted umbrella to collect fruits. Elementary operation times were measured in seconds to evaluate work rates. FRF and P were measured in the ripening period, to evaluate their evolution. In this paper are presented the preliminary results of the ratio FRF (fruit removal force)/fruit weight evolution during the ripening period (P) and the results of the equipment work rate (trees h<sup>-1</sup>). The ratio FRF/P has predominantly descendant values in the weeks before harvest, from 140 to 80 as a result of a FRF downward variation from 4.9 to 2.94 N and an upward variation of P from 0.0294 to 0.0637 N. The FRF/P ratio stabilizes the decline in the last week of November just before harvesting, registering in some cases a slight increase in consequence of FRF increase higher than P increase (contrary to the tendency of previous weeks). Equipment work rate showed values between 40 and 57 trees h<sup>-1</sup>, confirming previous results.

**Keywords:** olive harvest mechanization, trunk shaker, efficiency, fruit removal force, fruit weight

## INTRODUCTION

Mechanical olive harvesting systems adopting trunk shakers are common in main production areas. With this kind of equipment it is detached less than 100% of the production, usually 70 to 90% (Michelakis, 2002). To avoid the consequent loss of 10 to 30% of production, growers usually adopt traditionally hand harvesting to detach olives remaining on the tree after the trunk shaker work, which increase costs.

It is important to improve mechanical harvesting efficiency, considered as the percentage of fruit removed from the total crop on the tree (Ferguson, 2006), in order to get better farmers net return. To achieve this objective, factors affecting mechanical olive harvesting must be known. Main factors that influence the efficiency of mechanical olive harvesting related to the orchard are tree shape, canopy density, pruning methods and the cultivar (Ferguson, 2006). Among the factors linked to the cultivar, fruit removal force (FRF), fruit weight (P) and the ratio between them are important for harvest efficiency (Tombesi, 1990; Ferguson, 2006, Farinelli et al., 2012). These factors affect the efficiency of mechanical harvest and can be also used as an indicator of when to begin and finish harvest season (Ferguson, 2006).

Preliminary results of fruit removal force (FRF), fruit weight (P) and the ratio between

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them, measured in field trials are presented in this paper. Work rates of harvesting system applied on the trees  $\text{h}^{-1}$  are presented too.

### MATERIALS AND METHODS

Field trials took place in Vilarica Valley (northeast of Portugal) in 2013 and 2014 in an irrigated olive orchard with 'Cobrançosa Transmontana' cultivar. Olive orchard has 300 trees spaced at  $7 \times 7$  m (Figure 1).



Figure 1. Experimental olive orchard.



Figure 2. Mechanical harvesting equipment.

The mechanical harvesting system is based on a trunk shaker mounted on the front loader of a 60-kW four wheel drive tractor to detach olives. Olives detached are collected by a 9-m diameter inverted umbrella linked to the tractor front-end-loader under the trunk shaker (Figure 2). The inverted umbrella can store temporarily from 200 to 250 kg of olives in a collecting tray. Under the collecting tray a lead may be hydraulically open to allow discharge of the olives.

To evaluate harvesting system work rate, elementary time in seconds were taken: medium time per tree for trunk shaking; medium time to move the tractor/shaker unit from one tree to the next one; medium discharging time of the inverted umbrella collecting tray; number of harvested trees between discharges.

To evaluate fruit removal force (FRF) and fruit weight (P) five repetitions were used. The olive orchard was divided in 30 plots with 10 trees each. Five of the plots were selected by randomization. Measurements were made in 10 olives around each tree crown of the five selected plots, each plot as a repetition. Harvest was performed in the first week of

December in 2013 and in the last week of November in 2014.

Measurements of the fruit removal force from the shoots were made with a modified dynamometer Chatillon Model DPP – 2.5 kg produced by John Chatillon & Sons, Inc., North Carolina, USA (Figure 3). Measurements of fruit weight were made with an analytical balance Mettler PC 2000 (Gemini BV Laboratory, The Netherlands).

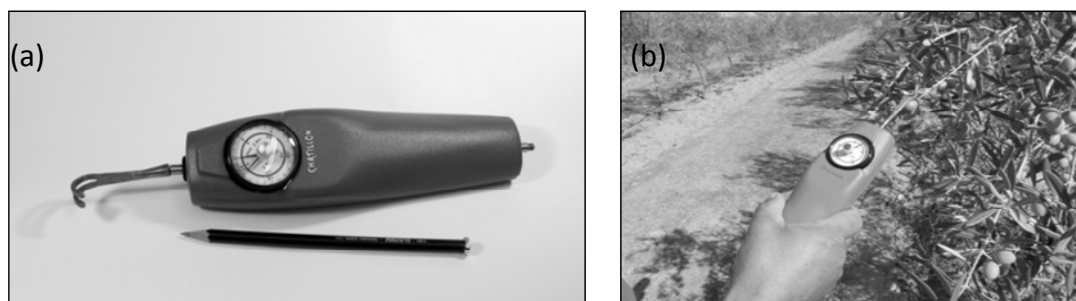


Figure 3. Dynamometer to measure fruit removal force (a) and measuring of fruit removal force in an olive orchard (b).

### RESULTS AND DISCUSSION

Figure 4a-f shows the evolution of FRF/P ratio during the ripening period, in the main representative repetitions. This ratio has predominantly descendant values in the weeks before harvest, from 140 to 80 as a result of a FRF downward variation from 4.90 to 2.94 N and an upward variation of P from 0.0294 to 0.0637 N. The FRF/P ratio stabilizes the decline in the last week of November, just before harvest, registering in some cases a slight increase in consequence of FRF increase higher than P increase (contrary to the tendency of previous weeks).

More experiments are needed to understand the unexpected FRF/P ratio values obtained two weeks before harvesting, registered in the same field trials (Figure 4a, b, d). Future studies can establish a relation between FRF/P ratio and harvest efficiency (considered as the percentage of fruit removed from the total crop on the tree).

Harvesting yields equal to or higher than 85% are considered the breakeven point for mechanical harvesting of olives with trunk shakers (Farinelli et al., 2012). The establishment of a FRF/P ratio value related to the referred breakeven point, allow using FRF/P as a useful indicator of the most appropriate period of time for harvesting with trunk shakers.

The elementary time tree<sup>-1</sup> in seconds used to compute equipment work rate is presented in Figure 5. Work rate values are presented in Table 1.

Time to move equipment between the trees assumes a great importance, showing that good conditions to move equipment have better chances to improve the work rate. Work rate values obtained in this study confirm the previous results of Almeida et al. (2007).

Table 1. Work rate values (trees h<sup>-1</sup>) of the equipment for mechanical olive harvesting.

Average	Minimum	Maximum	Standard deviation
52.0	40.0	57.0	5.29

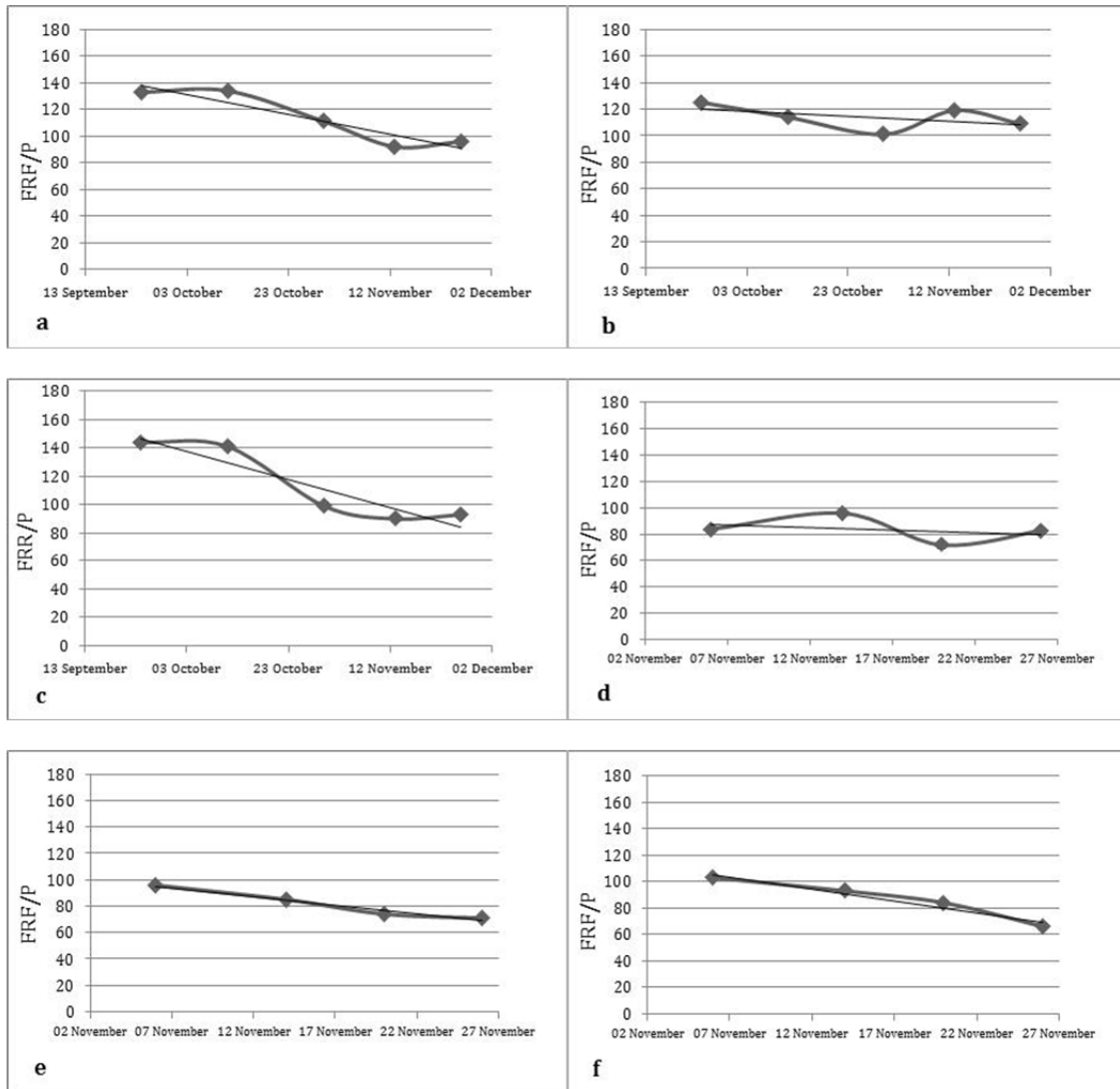


Figure 4. Evolution of FRF/P (fruit removal force/fruit weight) ratio during the ripening period of olive fruits in Vilarica Valley, Portugal: a) plot 1 in 2013; b) plot 2 in 2013; c) plot 3 in 2013; d) plot 1 in 2014; e) plot 2 in 2014; f) plot 3 in 2014.

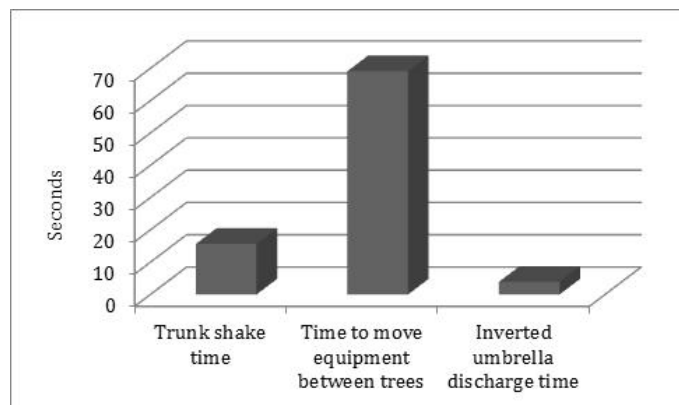


Figure 5. Elementary time per tree used to evaluate work rate of the equipment for mechanical harvesting of olive fruits in Vilarica Valley, Portugal.

## CONCLUSIONS

The evolution of FRF/P ratio during the ripening period can be used to measure the easiness of olives detachment. The ratio of FRF/P must be linked to yield harvested to establish a ratio value as indicator of the best period to harvest with high efficiency. This future study should be done on various cultivars and in different regions. Therefore, more field trials are needed to better understand the FRF/P ratio evolution.

## ACKNOWLEDGEMENTS

The authors want to thank to the Program PRODER Medida 4.1 N<sup>o</sup> 44663 for the financial support, to the farmer of Quinta do Carrascal – Viaz and personnel involved in the field trials allowing to get data presented.

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