The fruit detachment force:fruit weight ratio can be used to predict the harvesting yield and the efficiency of trunk shakers on mechanical olive harvesting

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Introduction

In olive producing countries, trunk shakes are the main machines to mechanize olive harvesting in intensive olive groves in order to lowering the cultivation costs. For a convenient use of these machines the harvesting yield, which represents the percentage of detached olives with respect to the total present on the canopy, should be equal to or higher than 85%, which is considered the breakeven point for mechanical olive harvesting with trunk shakers. Although there are investigations that have evaluated the effects of several factors, such as cultivars, tree training system, fruit characteristics, on the efficiency of trunk shakers, very few have regarded the quantification of the effects of tree characteristics, such as the volume of the canopy, growth habit and canopy density. Moreover, there are no studies that have been able to establish harvesting indexes to individuate the best harvesting time with trunk shakers in order to obtain high harvesting yields. The aim of this research was to assess the importance of tree characteristics, namely canopy density and size and growth habit on the harvesting yield obtainable with trunk shakers and to establish if the fruit detachment force:fruit weight ratio can be used as an index to establish the best time to harvest olive with a trunk shaker.

Material and methods

From 2004 to 2007, an investigation was carried out in Central Italy, by using adult (20-year-old) average-sized trees of several olive cultivars (Arbequina, Frantoio, Kalamata, Leccino, Manzanilla de Sevilla, Moraiolo, Picholine, Picholine Marocaine, Sorani), characterized by differences in all the studied factors: canopy density – CD (sparse, medium and dense), growth habit – GH (spreading, dropping and erect), tree vigour – TV (weak, medium and strong), fruit detachment force (FDF) and weight (FW). The trees were located in the olive germplasm collection of the University of Studies of Perugia in Central Italy (http://apps3.fao.org/wiews/olive/oliv.jsp). Trees were trained according to the vase system and spaced m 5 x 5 m. Pruning was applied every two years. Mechanical harvesting was applied in different dates, depending on the years, of November, which represents the period of harvesting in the considered area. At the time of harvesting the fruit detachment force was measured and samples were collected to determine fruit weight. The values of fruit detachment force and weight were also used to determine their ratio (FDF/FW). The mechanical harvesting yield (MHY) was calculated by making the ratio between the fruit harvested by trunk shaker and the total yield per tree. All collected data were statistically analysed using Principal Component Analysis (performed by Simca -P 8.0 Umetrics) and correlated by SigmaPlot. 2002.

Photo 1 – Olive germplasm collection

Photo 2 – Satellite photos.

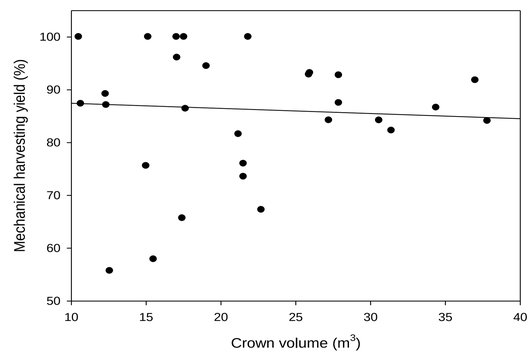

Figure 1 – Correlation between mechanical harvesting yield and crown volume.

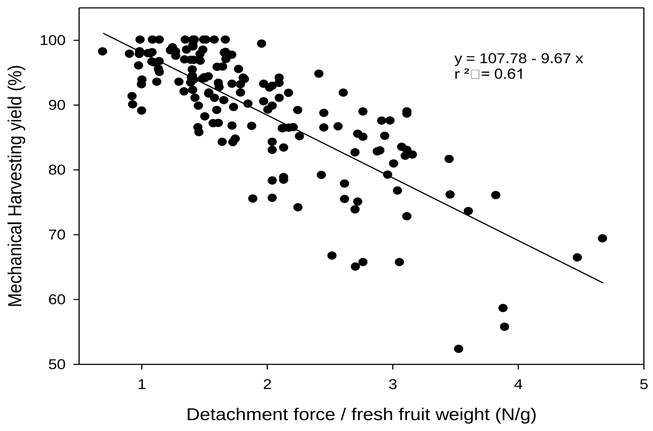

Figure 2 – Linear correlation between mechanical harvesting yield and detachment force/ fresh fruit weight.

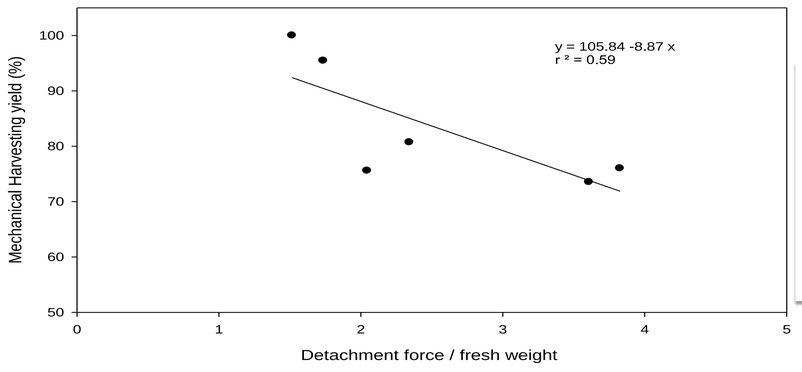

Figure 3 – Linear correlation between mechanical harvesting yield and detachment force/ fresh fruit weight in Moraiolo cultivar..

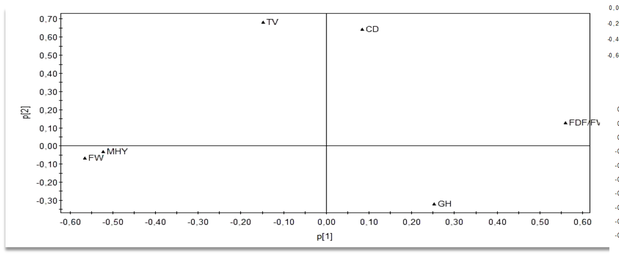

Figure 4 - Factor loadings for principal components (PC) PC1 and PC2, accounting for 77.4% of total between-groups variability (function 1 accounts for 46.0% and function 2 accounts for 31.4%): .

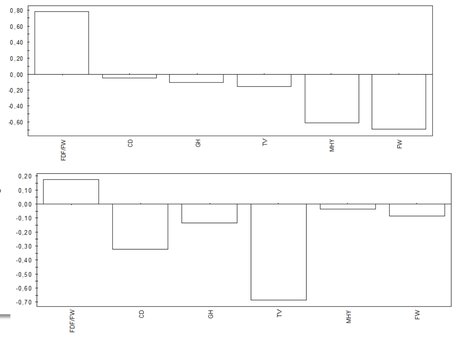

Figure 5. PCA. Weights of variables (in absolute value) for first two components: PC1 above; PC2 below.

Results

The tree crown volume ranged from 10 to 35 m^3 and didn't affect mechanical harvesting yield (Fig. 1). Fruit detachment force and weight were the most important factors affecting harvesting yield. The ratio between these two parameters resulted strongly and linearly related to the harvesting yield, explaining about 60% of the total variability (Fig. 2). This relationship was also found when a single cultivar was harvested at different FDF/FW ratios (Fig. 3). The results agreed with those obtained by PCA, that also showed that among the other considered factors only tree vigor and fruit weight had a high importance in determining the percentage of mechanically detached olives (Fig. 4 and Fig. 5). Furthermore the results showed that with trees with canopies around 8.000 m^3/ha, which are common in intensive olive orchards in Italy and other olive producing countries, it is necessary to have values of the fruit detachment force/fruit weight ratio equal to or lower than 2.3 to ensure harvesting yields equal to or higher than 85% (Fig. 2 and Fig. 3).

Conclusions

In conclusion, the results clearly demonstrated a linear relationships between the fruit detachment force/fruit weight ratio and the harvesting yield obtainable with trunk shakers and indicated that this ratio can be used as a powerful harvesting index to decide the best harvesting time to execute the mechanical harvesting with trunk shakers in intensive olive orchards.