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Mechanical harvesting of oil olives by trunk shaker with a reversed umbrella interceptor

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Abstract: Trunk shakers are primarily used for the mechanical harvesting of oil olives in intensive orchards. The objective of this trial was to determine the efficiency of mechanical harvesting of olives with a self-propelled trunk shaker with a reversed umbrella interceptor (model F3, SICMA, Catanzaro, Italy), from adult trees of two autochthonous cultivars, 'Ortice' and 'Ortolana', growing in southern Italy with 6 × 6 m spacing and trained to the vase system. The main characteristics of the trunk shaker were: an engine power of 77 Kw (105 CV), a very-high-frequency vibrating head (1800-2000 vibrations/min), a self-braking system and a 6-meter diameter umbrella opening. The worksite consisted of two workers one for maneuvering the harvesting machine and the other for handling the olives. Mechanical harvesting was carried on 30 November 2006 when the fruits of 'Ortice' and 'Ortolana' had a weight and detachment force around 2.8 g and 3.1 N and 3.8 g and 4.6 N, respectively, and the fruit drop was around 14% and 10%, respectively. Both cultivars had a good production (26.06 and 21.18 kg/tree). The mechanical harvesting yield (percentage of mechanically harvested olives) was very high, reaching values around 97% in both cultivars. Moreover, the low number of workers, the reduced time for the operation (2.5 min/tree), the good yield/tree and the high quantity of harvested fruit allowed a very high work productivity to be obtained: around 302 kg/h/worker for 'Ortice' and 246 kg/h/worker for 'Ortolana'. The quality of the oils extracted from the harvested olives met the requirements set by European law for extra virgin olive oils. The results indicate that the use of a trunk shaker with a reversed umbrella can be an efficient solution for mechanical harvesting of the 'Ortice' and 'Ortolana' cultivars in southern Italy.

1. Introduction

Harvesting is one of the most important operations of the whole cultivating cycle in olive production, both in order to obtain high quality oils and to reduce costs (Tombesi, 1990; Famiani *et al*., 1998; Cicek, *et al*., 2010; Ferguson *et al*., 2010). The aim of this trial was to evaluate the efficiency of a trunk shaker with a reversed umbrella interceptor for the mechanical harvesting (Visco *et al*., 2008; Farinelli *et al*., 2012 a, b) of two autochthonous cultivars, 'Ortice' and 'Ortolana', in southern Italy.

2. Materials and Methods

The experiment was carried out in 2006 in a commercial olive grove, belonging to the "Uliveto" farm, located in southern Italy (41°15' N, 14°38' E) (Province of Benevento). Adult trees of two autochthonous cultivars, 'Ortice' and 'Ortolana' (Di Vaio *et al*., 2013), trained to the vase system and planted at a spacing of 6 x 6 m were studied. The olive grove had a slope of less than 3% and was drip irrigated. Pruning was carried out annually and fertilization and pest management were carried out according to local standard practices. For the mechanical harvesting, carried out on 30 November, a self-propelled machine, "F3" model with three traction wheels and a reversed umbrella interceptor manufactured by SICMA (Catanzaro, Italy), was used (Fig. 1). The main characteristics of the trunk shaker were: an engine power of 77 Kw (105 CV), a very-high-frequency vibrating head (1800-2000 vibrations/min), a self-braking system and a 6-m diameter umbrella opening. The work force consisted of two workers, one for maneuvering the harvesting machine, the other for handling the olives. During drupe maturation, periodically on three samples of 100 olives per date, the following parameters were determined: olive detachment force, coloration (Jaén index between 0 and 7), fresh weight, pulp firmness (with a manual penetrometer with a 1.0 mm diameter plunger on the equatorial zone of fruit) and oil content (determined using a Soxlhet extractor). On four trees per cultivar, at the

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Fig. 1 - Mechanical harvesting of olives with a trunk shaker with a reversed umbrella interceptor.

beginning of ripening, eight small branches were labeled (two per cardinal point) and the fruit was periodically counted up to harvesting time in order to estimate fruit drop. Mechanical harvesting was carried out on 10 trees/cultivar and the drupes were weighed. After harvesting, undetached olives were harvested by hand and weighed. The ratio between mechanically harvested olives/total olives on the canopy, expressed as percentage, was used to determine the mechanical harvesting yield (%). The trunk cross-sectional area (at about 0.5 m above the ground) and canopy width (W), height (H) and volume [Volume = $((W/2)^2 \times 3.14 \times H) \times 2/3$] were measured/calculated on each of the harvested trees. Work productivity was calculated and expressed as the amount of harvested olives/h/worker. In both cultivars, after mechanical harvesting, 100 kg of olives were collected and micro-milled to obtain two samples of mono-variety oils, on which free acidity, peroxide number, spectrophotometric indices and sensorial characteristics (by panel test) were determined.

Data were submitted to analysis of variance (ANOVA) using MSTA-C software and mean separation was performed by the Multiple Range Duncan test at the 5% significance level. Moreover, the standard errors (SE) of the means were also calculated.

3. Results and discussion

During maturation, the cv. Ortice was resistant to drupe detachment, which decreased at the beginning of November until reaching 309.17 g at harvest time. The cv 'Ortolana', instead, followed a rather constant course, and at harvest time reached 455.83 g (Fig. 2 and Table 1). Pulp firmness decreased constantly during maturation, reaching

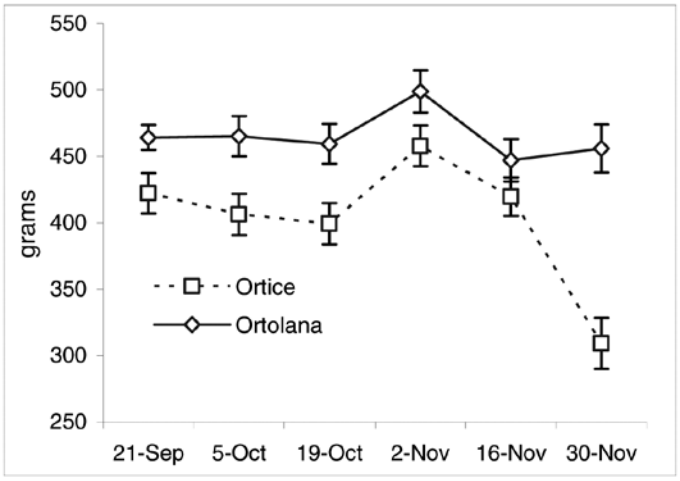

Fig. 2 - Evolution of olive detachment force during maturation (mean ± standard error).

Table 1 - Characteristics of trees and fruit at harvest, machine efficiency and work productivity (mean ± standard error)

	cv. Ortice	cv. Ortolana
Olive weight (g)	2.79 a±0.06	3.77 b±0.01
Olive detachment force (g)	309.17 a±19.30	455.83 b±18.20
Olive detachment force/olive weight (N/g)	1.11 a±0.08	1.21 a±0.09
Pulp firmness (g/mm^2)	267.00 a±5.11	231.58 b±0.45
Drupe coloration - Jaèn index (0-7)	2.10 a±0.05	4.35 b±0.17
Fruit drop (%)	13.95 a±2.27	10.36 a±2.49
Canopy volume (m^3)	47.34 a±2.35	56.31 b±1.56
Trunk cross section area (cm^2)	1587.31 a±337.96	613.43 b±172.04
Total olive yield per tree (kg)	26.06 a±7.72	21.18 a±5.02
Olives mechanically harvested per tree (kg)	25.17 a±7.21	20.49 a±5.03
Productive efficiency of tree (kg/m^3)	0.37 a±0.17	0.25 a±0.13
Mechanical harvesting yield (%)	96.58 a±1.15	96.74 a±0.88
Work productivity (kg/h/worker)	302.04 a±18.01	245.88 a±14.10

In each row, means with the same letter are not significantly different by Duncan multiple range test (P<0.05).

values of 267.00 g/mm^2 and 231.58 g/mm^2 for 'Ortice' and 'Ortolana', respectively (Fig. 3 and Table 1). At harvest, the accumulation of oil in the drupe was 26.09% in 'Ortice'

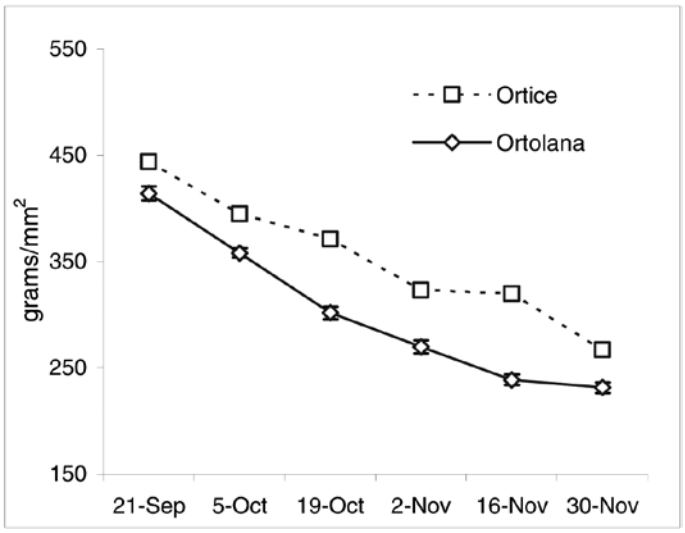

Fig. 3 - Evolution of pulp firmness during maturation (mean ± standard error).

and 16.51% in 'Ortolana' (Fig. 4). Olive pigmentation, scored according to the Jaén index, differed for the two cultivars: 2.10 in 'Ortice' and 4.35 in 'Ortolana' (Table 1). Both cultivars had good production (26.06 and 21.18 kg/tree) (Table 1), and the productive efficiency was 0.37 and 0.25 kg of olives/m^3, respectively (Table 1). The canopy volume of the trees was 47.34 m^3 for 'Ortice' and 56.31 m^3 for 'Ortolana'. Pre-harvest fruit drop increased during the entire period, reaching values of 13.95% for 'Ortice' and 10.36% for 'Ortolana' at harvest time (Fig. 5 and Table 1). At harvest fruit weight was 2.79 g for 'Ortice' and 3.77 g for 'Ortolana' (Table 1). The ratio between the olive detachment force and weight decreased throughout the ripening period and was 1.11 and 1.21 N/g at harvest (Fig. 6 and Table 1). In general, fruit characteristics and ripening patterns were similar to those reported by Di Vaio *et al*. (2013) for the same cultivars.

Despite the high canopy volume of the trees, the mechanical harvesting yield (percentage of mechanically harvested olives) was very high: 96.58% and 96.74% for the 'Ortice' and 'Ortolana' cultivars, respectively (Table 1). These high values are likely due to the relatively low olive detachment/weight ratios at the time of harvesting, which were close to one. Indeed, Farinelli *et al*. (2012 a) reported a significant negative relationship between the olive detachment/weight ratio and the mechanical harvesting yield obtained with a trunk shaker. The same authors observed that high mechanical harvesting yields are obtained when the ratio is less than 2. In this regard, it can be noted that in the present work, for both cultivars, the olive detachment/weight ratio, as a result of the medium weight and the medium/low detachment force of the olives, was less than 2 for the entire ripening period. This indicates that mechanical harvesting could be carried out efficiently

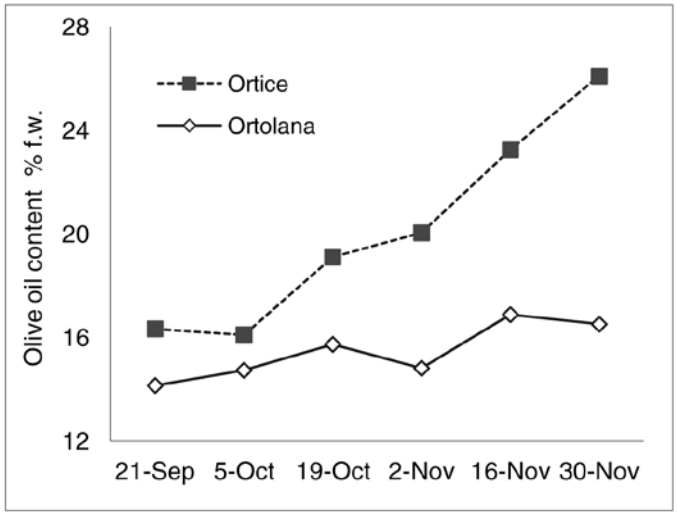

Fig. 4 - Evolution of olive oil content (% f.w.) during maturation.

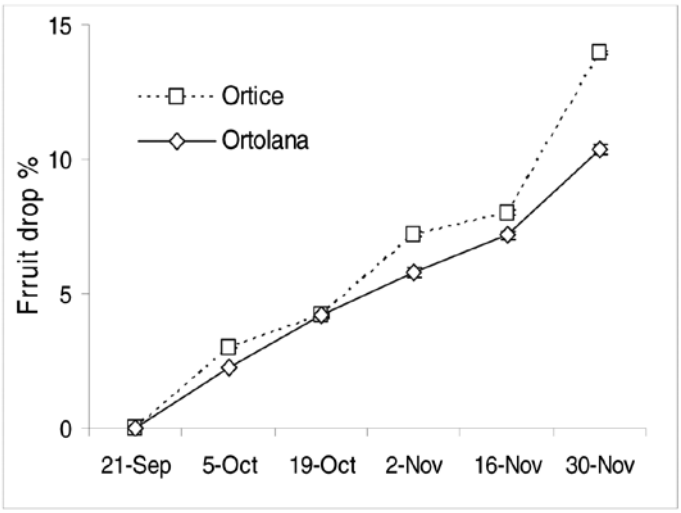

Fig. 5 - Evolution of pre-harvest fruit drop during maturation.

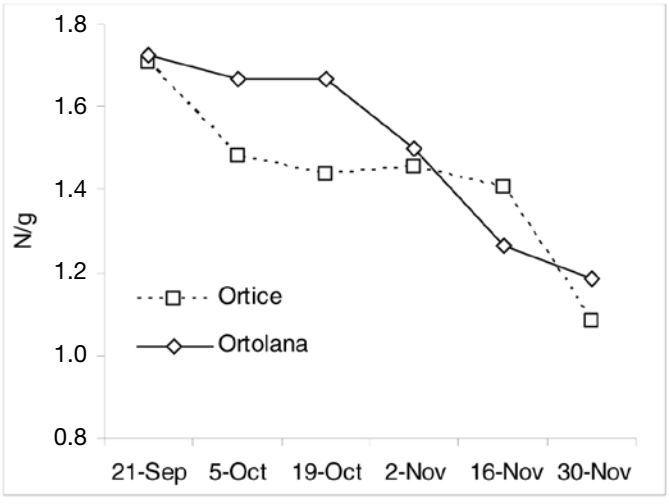

Fig. 6 - Evolution of the ratio between olive detachment force and drupe weight during maturation (mean ± standard error).

Table 2 - Quality indices of oils obtained from cv. Ortice and Ortolana olives mechanically harvested with a trunk shaker (mean±standard error)

Cultivar	Acidity % oleic acid	Peroxide value meq O_2 Kg^{-1}	UV			Defects at panel 0-5
			K232	K270	Δk	
Ortice	0.52±0.04	8.2 b±0.13	1.967±0.065	0.145±0.014	-0.003±0.000	0±0.00
Ortolana	0.46±0.02	6.5 b±0.14	1.824±0.032	0.155±0.036	-0.005±0.000	0±0.00

during the entire ripening period. At the farm level, this allows for flexibility, also considering that oil quality changes during olive ripening and so oils with different characteristics can be obtained by modulating harvesting time (Inglese *et al*., 2011). Moreover, the low labour requirement (only two workers), the reduced time for operation (about 2.50 min/tree, which included the approach to the tree and attachment of the shaker to the trunk, opening of the reversed umbrella, shaking and closing the reversed umbrella), the good yield/tree and high quantity of harvested fruit allowed very high values of work productivity to be obtained: about 302.04 kg/h/worker for 'Ortice' and 245.88 kg/h/worker for 'Ortolana' (Table 1). This result highlights the importance of a good yield/tree in determining high work productivity and therefore the economic convenience of using machines for olive harvesting (Famiani *et al*., 1998). The oil quality indices (acidity, peroxide number, spectrophotometric indices and sensorial characteristics by panel test) reported in Table 2 show that all analytical and sensory evaluations of the oils from the two cultivars met the requirements set by law for extra virgin olive oils (EC Regulation n. 2568, 1991). Therefore, the use of the trunk shaker with interceptor allowed high quality oils to be obtained.

In conclusion, the results of the present study show that the trunk shaker with the reversed umbrella interceptor, which allows for high harvesting yields and high labour productivity, can be considered an interesting solution for mechanical harvesting of the autochthonous cultivars 'Ortice' and 'Ortolana' in southern Italy.

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