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Evaluation of a towed over-the-row harvester for super high-density olive groves[1]

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Abstract
This paper reports the results of tests carried out in a super-intensive olive grove using the new towed model of the harvester produced by the Pellenc Company. Unlike the self-propelled harvesters commonly used in olive groves, this machine needs of a tractor of suitable power for its displacement and for the feeding of hydraulic control and electrical devices necessary for the operation (shakers groups, conveyor, proximity probes, etc.). The obtained results of tests carried out showed that the performance of the towed Pellenc CV5045 is in line with those obtained with the common self-propelled over-the-row harvesters. The tested machine, coupled to tractor and governed by hydraulic devices, that control its alignment with respect to the soil and vegetation, has a less easy manoeuvrability than the corresponding self-propelled model, so requiring a considerable experience and attention of the tractor driver.

Keywords: towed over the row harvester, super high density olive groves, harvesting efficiency

Introduction
The actually fruit farming techniques tend towards the crop intensification, increasing plant density and reducing the size of trees. This development is driven by some main factors as the varietal innovation, the new types of training systems, the employment of irrigation and especially the mechanical harvesting (Connor et al., 2014). The reasons for this general trend of fruit training systems are based on the labour costs reduction, thanks to the mechanization of cultivation operations joined to the workplaces safety increase. In this connection, the super high-density olive grove (super-intensive), with over 1,200 trees per hectare, is characterized basically by a strong reduction of production costs thanks to the full mechanization of all agricultural practices, from planting to harvesting (Camposeo et al., 2008). Really, among the olive field operations, the harvesting is the second most expensive of the entire crop cycle, after pruning, so its mechanization is critical to the profitability of the olives (Vivaldi et al., 2015). In the super-intensive olive groves, the non-stop mechanical harvesting, is operated by over-the-row self-propelled machines, which allow a significant increase in labour productivity amounted to 1800-3000 kg/h-worker (Arrivo et al., 2007). As known, the entire operation is realized by two workers, one driving the straddle harvester and the other one picking the olives to the harvesting zone, allowing to collect one hectare in few hours. Furthermore, the non-stop mechanical harvesting carried out in these super-intensive groves allow to achieve the mains objectives of mechanization: a) maximum harvesting output; b) minimal damage to the fruits and vegetation; c) minimum total cost.
On the other hand, the aforesaid over-the-row self-propelled machines provide extreme functionality and the highest quality product in each ripening time, clean and almost completely free from impurities. The unit cost of harvesting may reach an incidence of 0.03 € per kg of oil extracted, clearly less value than the cost incidence of mechanical harvesting with trunk shaker with umbrella, considered for the olive intensive cultivation

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the best management solution (Clodoveo et al., 2014).
Basically these olive harvesters are constituted by (Rius and Lacarte, 2010): a) the head for olives detachment; b) the olive collection system and transportation to the accumulation hopper; c) the olive accumulation into a hopper; d) the system for eliminating leaves and impurities; e) the complementary elements. The head for olives detachment, placed inside the straddle frame, consists of a horizontal shaking device which acts on both of the plant sides, so producing a direct unstable dynamic action on the drupes and the ensuing their detachment by inertia.
This paper reports the results of tests carried out in a super-intensive olive grove using the new towed harvester model produced by the Pellenc Company. Unlike the self-propelled harvesters commonly used in olive groves, this machine needs of a tractor of suitable power for its displacement and for the feeding of hydraulic control and electrical devices necessary for the operation (shakers groups, conveyor, proximity probes, and so on).

Materials and methods

The towed over-the-row harvester

The over-the-row harvester manufactured by the Pellenc brand model CV5045 (Fig. 1), is the towed version of the self-propelled Pellenc 4560. It is then a new machine available on the market, whose peculiarity is just the need of a tractor for its working. The Pellenc CV5045 is linked to the draw-bar of the tractor and a hydraulic system driven by the tractor PTO (800 rpm) allows to control and adjust the movements and the trim of the machine (Fig. 2a).

Figure 1. Towed olive harvester CV5045 built by Pellenc

The harvesting unit is constituted by two set of shakers. The first one, composed of 13 pairs of shakers, is positioned in the lower front part of the tunnel; the second one, instead, composed of 15 pairs of shakers is placed in the upper rear part of the tunnel (Fig. 2b). This arrangement of the shakers allows to improve the detachment of drupes from the plant. Really, entering the tunnel during the machine advancement, the plant is immediately come into the lower shakers (Fig. 2c); in the next step, completely entered the tunnel and regained its standing position, the plant is come into the upper shakers (Fig. 2d). An electronic control panel enables instant adjustment of operating parameters relating to shaking (amplitude, frequency, opening, acceleration); this peculiarity of the machine is useful inside olive groves where it is not possible to keep constant the advancement speed and, therefore, it is necessary to change the shaking frequency in order to obtain a uniform work. The machine is also equipped with a peculiar cleaning system made of shakers and grid separators, which produce the expulsion of extraneous material. Finally, an extractor attends to remove leaves and other impurities. The harvested product falls down in two stainless steel tanks (each of 1,700 L) located at the sides of the machine; these tanks through overturning tip in turn the olives in a trailer towed by the tractor for transport.

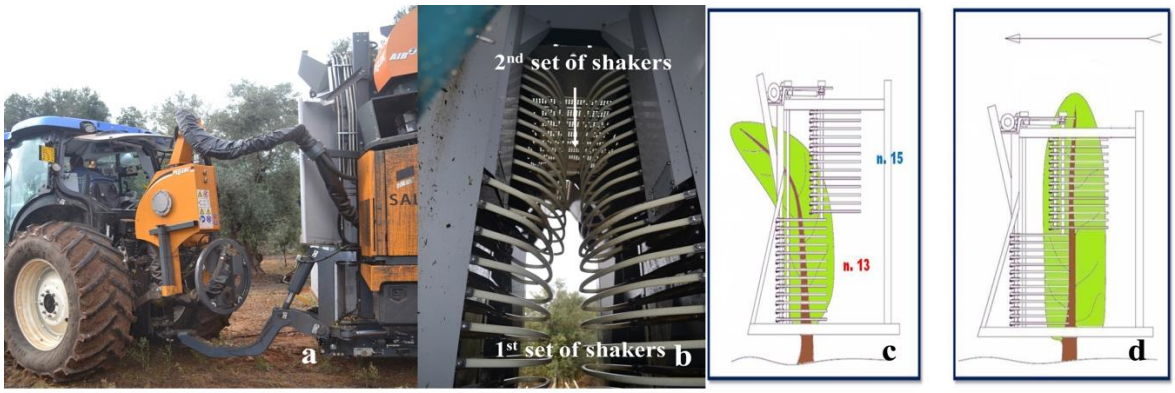

Figure 2. a. Hydraulic system to control the trim of the machine; b. Set of shakers; c. Plant into the lower shakers; d. Plant into the upper shakers.

Field tests

Experimental harvesting tests were carried out in a super high-density olive grove ("Arbequina" cultivar) of 4 years old, located on a farm in the territory of Cassano (Bari province – Apulia – Italy). The trees were planted with a layout of 4.0 m x 1.5 m, giving a density of 1667 plants/ha. The harvesting trials, carried out using the tractor New Holland T7-210 (155 kW), were targeted to evaluate the performance of the machine in terms of operating capacity and harvesting efficiency.

Results and discussion

The obtained results show that the performance of the towed Pellenc CV5045 machine is in line with those obtained with the common self-propelled over-the-row harvesters (Table 1). Really the harvesting has required 10 h and the yield has been 11600 kg/ha, taking into account that the cost for hiring the machine has been 400 €/ha. The harvesting efficiency has been next to 97-98%, then higher than those reported for intensive installations in which the harvest is carried out with olive harvester shakers, tree shaker with umbrella (95%) and single cone (91%) (Arrivo et al., 2001). Moreover, the damage observed on the trees due to the machine harvesting operations, expressed in percentages of broken vegetative axes, were approximately 1.2%, similar to shaker harvester (1.1%). The average forward velocity (1.7 km/h) has been mainly conditioned by the canopy, whose sizes were in any case compatible with the ones of the tunnel of the machine, and by the amount of the pendulous production.

Table 1 CV5045 harvester operational data

Forward speed (km/h)	1.7
Operating capacity (ha/h)	0.50
Workers (n)	2
Harvesting efficiency	97-98%
Losses on plant (%)	1.2

The high operating capacity in combination with the low number of employed worker highlights the high performance of the Pellenc CV5045, unlikely comparable with the ones pertinent to other harvester machines for olive groves. Really the evaluation of the machine's technical and economic feasibility should match also other equipment commonly used for mechanised harvesting in the super high density olive groves (Arrivo et al., 2001), even if the only machines that successfully can be employed in such plantations are the shaker rods, driven by pneumatic, electric or combustion motor

(Bellomo and D'Antonio, 2008). But the working capacity and the workers number of the Pellenc CV5045 so as the other self-propelled over-the-row harvesters remains the same even if the yield increases, whereas the same operative parameters pertinent to the shaker rods are clearly different and significantly conditioned by the ambient conditions. The tested model, coupled to tractor and governed by hydraulic devices, that control the alignment with respect to the soil and vegetation, has a less easy manoeuvrability than the corresponding self-propelled model, so requiring a considerable experience and attention of the tractor driver. Nevertheless, even if the self-propelled model, with the driver's cab and the collection module integrated into a single structure allows a high handling of the vehicle during the harvesting operations, the performance of the towed Pellenc CV5045 is quite equivalent to the harvesters commonly employed in super high density olive groves. Finally, the Pellenc CV5045 cannot be hauled on the road because it is fitted with one axle and the weight is about 11000 kg and then this machine has to be placed on a tow for its carriage.

Conclusions

The increase of the super high-density olive groves and the pertinent non-stop mechanized harvesting represents the changing process towards an olive-growing culture that is more and more introducing the use of technology. Actually two kinds of harvesting machines can be found on the market: the self-propelled and the one towed by a tractor. Clearly, further than the obvious technical differences between both harvesting methods, those differences are based on their mobility and handling capability (best in self-propelled) and their sale price (much lower for the towed ones). The towed Pellenc CV5045 olive harvester has been tested in an Apulian super-intensive olive grove and the obtained results allowed to assess its performance, totally equivalent to that of the self-propelled model. The harvested product was clean and almost there were no leaves or branches in the hopper, so pointing out that:

- the fan inside the machine clean the product efficiently;
- the cultivation system was suitable;
- the harvester was able to pass between the rows without causing any damage to the plants.

References

Arrivo A., Bellomo F. e D'Antonio P., 2007. Raccolta meccanica dell'oliveto superintensivo. L'informatore Agrario, 1, 68-71.

Arrivo A., Bellomo F., D'Antonio P. 2001. Limiti di convenienza per l'impiego delle machine operatrici, applicazione a machine mono e polifunzionali per la viticoltura. Riv. Ing. Agr. XXXII,3, 147-157.

Bellomo F., D'Antonio P. 2008. Using a grape harvester in super-intensive olive cultivation. J.of Ag. Eng., 1, 33-39.

Camposeo, S., Ferrara, G., Palasciano, M., Godini, A. 2008. Varietal behaviour according to the superintensive olive culture training system. Acta Hortic. 791, 171-274

Connor, D.J., Gómez-del-Campo, M., Rousseaux, M.C., Searles, P.S., 2014. Structure, management and productivity of hedgerow olive orchards: A review. Sci. Hortic. 169, 71-93.

Clodoveo M.L., Camposeo S., De Gennaro B., Pascuzzi S., Roselli L. 2014. In the ancient world virgin olive oil has been called "liquid gold" by Homer and the "great healer" by Hippocrates. Why is this mythic image forgotten? Food Research Intern. 62, 1062–1068.

Rius X., Lacarte J.M., 2010. The Olive Growing Revolution. The Super High Density System. Comgrafic Publisher. Barcellona, Spain.

Vivaldi G.A., Strippoli G., Pascuzzi S., Stellacci A.M., Camposeo S. 2015. Olive genotypes cultivated in an adult high-density orchard respond differently to canopy restraining by mechanical and manual pruning. Sci. Hortic. 192: 391-399.