Influence of tree's structure on the efficiency of the mechanical harvest of olives

Catania P., Piraino S., Salvia M., Vallone M.
University of Palermo. Dept. I.T.A.F., Mechanics Section
Viale delle Scienze, ed.4 – 90128 Palermo, ITALY.
Tel. 0039 0917028147, Fax 0039 091484035, p.catania@unipa.it

Abstract

This study represents an analysis about the influence of the structure of the plant and the drupes' position on the efficiency of the mechanical harvest of olives. The aim is to study the eventual correlations between some geometrical characteristics of the plants and the harvest efficiency.
The experimental tests were carried out in an olive grove sited in Castelvetrano, province of Trapani; the variety was Nocellara del Belice, the plants "globe" shaped.
Some morphological surveys were carried out on a sample of trees. The mechanical harvest was performed with a trunk shaker provided with an upside down umbrella. After the harvest, the residual production was quantified for each bud in order to evaluate the harvest efficiency.
The results showed that, in order to have a harvest efficiency higher than 80%, the geometric and morphologic parameters of the plants have to be: length of the main branch from 2 to 3 m, distance of the bud from the central axe of the tree from 1.30 to 2.30 m, height of the bud from the ground from 1.90 to 2.85 m, length of the fructiferous bud from 0.25 to 0.40 m. The above mentioned values are certainly to be referred to orchard having a regular lay out of planting of 6.00 x 7.00 m and mean circumference of the canopy about 10 m.

Keywords: mechanical harvest, olives, efficiency.

Introduction

In the modern olive growing the mechanization of the harvest is very important both to reduce the costs of production and to assure the quality of the oil.

Till today it's very difficult in Italy to mechanize the harvest of olives because a great number of orchards doesn't allow the use of the machines for several reasons: the irregular positioning of the plants, the slope of the plots, the large dimensions of the trees [Antognozzi E., Cartechini A., Tombesi A., Paliotti A. (1990), Paschino F., Mura R. (1997)].

Today the mechanical harvest of olives is greatly developing in the new orchards also due to their gradual modernization allowing the introduction of more and more efficient machines able to increase work capacity and productivity and considerably decrease the use of manpower [Amirante P., Pipitone F. (2000)].

Then, the design of new machines is not sufficient in order to improve the harvest efficiency, but it's fundamental that the orchard would be suitable for the best use of the machines and the structure of the plants would optimize the final result.

This study represents an analysis about the influence of the structure of the plant and the drupes' position on the efficiency of the mechanical harvest of olives.

The morphology of the tree is very important in the harvest with trunk shakers because it considerably influences the transmission of vibrations from the machine to the fruit in order to cause its detachment [Altieri G. (2001)]. Moreover, the geometry of the plants considerably varies inside the orchard and every tree has its characteristic frequency depending on its morphological, mechanical and dynamical properties [Formato F., Romano (2003)].

The aim of the study is to study the eventual correlations between some geometrical characteristics of the plants and the harvest efficiency.

Materials and methods

The experimental tests were carried out in an olive grove sited in Castelvetrano, province of Trapani, western Sicily, about 10 ha large, 200 m above sea level, with plants 10 years old having a lay out of planting 6.00 x 7.00 m. The variety was Nocellara del Belice, the plants "globe" shaped, planked at 0.65-0.85 from the ground level, 4.00 m high on average, having mean circumference of the canopy about 10 m (fig.1).

Figure 1. Typical plant of the site test

Fifty plants morphologically representative of the orchard were casually chosen and some morphological surveys were carried out. Taking into account that the distribution of the stresses to detach the drupes depends on the dimensions of the fructiferous buds and particularly on its point of insertion on the main branch, the following parameters were defined and surveyed (fig.2):

- length of the main branch (*parameter A*) as the sum of the length of the internodes ($L_{1,2} \ldots L_{n-1,\ n}$);
- distance (D) of the point of insertion of the bud from the central axe of the tree (*parameter B*);

- height (H) from the ground of the point of insertion of the bud (*parameter C*);
- length of the fructiferous bud (*parameter D*).

Then, the number of drupes was quantified for each bud.

The mechanical harvest was performed with a trunk shaker provided with an upside down umbrella (table 1).

Table 1. Technical characteristics of the machines used during the tests

Diameter of the holding member on the trunk [mm]	Machine total weight [kg]	Head weight [kg]	Diameter of the intercepting member [m]
50 – 550	1540	320	7.00

The following parameters were fixed during the tests: the height of the hooking point of the vibrating head (0.6 m from the ground), the direction of the arm bringing the pliers (orthogonal to the direction of the row), the rotation speed of the eccentric masses and, then, the vibration intensity.

After the harvest, the residual production was quantified for each bud in order to evaluate the harvest efficiency.

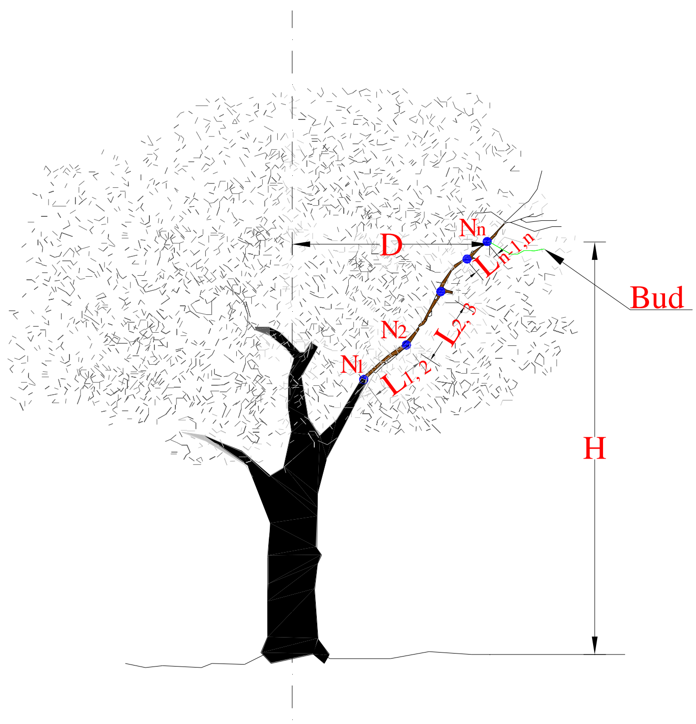

Figure 2. Surveys performed on the plant

The data were arranged in classes homogeneous in range and number of surveys (table 2, 3, 4 and 5) that were statistically analysed and the mean compared with

Duncan's multiple comparison procedure (p = 0.05) using the software Statgraphics Plus, Manugistics.

Table 2. Classes of the parameter A

Class	Main branch length [m]
1	0.60 – 1.50
2	1.51 – 1.84
3	1.85 – 2.08
4	2.10 – 3.00

Table 3. Classes of the parameter B

Class	Distance from the axe [m]
1	0.10 – 0.90
2	0.95 – 1.15
3	1.16 – 1.35
4	1.36 – 2.35

Table 4. Classes of the parameter C

Class	Height from the ground [m]
1	1.00 – 1.70
2	1.71 – 1.90
3	1.91 – 2.15
4	2.16 – 2.85

Table 5. Classes of the parameter D

Class	Bud length [m]
1	0.25 – 0.40
2	0.41 – 0.50
3	0.51 – 0.60
4	0.61 – 0.90

Results

Table 6 shows the mean values of the harvest efficiency obtained for the classes of the *parameter A*. It emerges that the highest values were found in the classes 3 (83.2%) and 4 (96.4%) and statistically significant differences among all the classes; moreover, the efficiency increases going from class 1 to class 4.

Table 6. Results of Duncan's multiple comparison procedure for the main branch length

Class	Harvest efficiency [%]		
	Mean	Standard deviation	Coefficient of variation
1	45.7 a	17.68	38.68%
2	70.8 b	11.12	15.70%
3	83.2 c	8.70	10.45%
4	96.4 d	6.08	6.30%

Note: different letters in the column denote statistically significant differences at the 95% confidence level.

In particular, the main branch (*parameter A*) determines an higher value of harvest efficiency with length more that 2 m; in fact, the harvest efficiency shows a 13% increase going from 2 to 3 m length. The lowest efficiency (45.7%) was obtained for length going from 0.60 to 1.50 m.

In table 7 the mean values of the harvest efficiency for the *parameter B* are reported; it shows that the efficiency increases going from class 1 (61.2%) to class 4 (82.9%); statistically significant differences were found between the classes 1-2, 1-3, 1-4, 2-3 and 2-4.

Table 7. Results of Duncan's multiple comparison procedure for the distance of the bud from the central axe of the tree

Class	Harvest efficiency [%]		
	Mean	Standard deviation	Coefficient of variation
1	61.2 a	23.73	38.80%
2	70.5 b	16.20	22.97%
3	79.7 c	20.87	26.19%
4	82.9 cd	21.67	26.13%

Note: different letters in the column denote statistically significant differences at the 95% confidence level.

The distance of the fructiferous bud from the central axe of the tree influences the harvest efficiency; the highest values were obtained with distances more than 1 m. In fact, the efficiency shows a 25% increase going from distances lower than 1 m to distances higher than 1 m. The lowest value (61.2%) was found in class 1.

Table 8 shows the mean values of the harvest efficiency for the *parameter C*. It comes out that the highest values were obtained in class 3 (82.4%) and class 4 (79.9%); statistically significant differences were found between the classes 1-3, 1-4, 2-3 and 2-4.

The height of the fructiferous bud from the ground influences the harvest efficiency that shows the highest value with a height more than 1.90 m; in fact, the efficiency has a 12% increase going from 1.90 to 2.85 m. The lowest efficiency (66.1%) was found in class 1.

Table 8. Results of Duncan's multiple comparison procedure for the height from the ground of the bud

Class	Harvest efficiency [%]		
	Mean	Standard deviation	Coefficient of variation
1	66.1 a	24.67	37.31%
2	67.1 a	19.59	29.18%
3	82.4 b	17.53	21.29%
4	79.9 b	21.56	27.00%

Note: different letters in the column denote statistically significant differences at the 95% confidence level.

In table 9 the mean values of the harvest efficiency for the *parameter D* are reported; it shows statistically significant differences between the classes 1 (mean efficiency 81.2%) and 3 (70.2%) and 1 and 4 (69.9%).

Table 9. Results of Duncan's multiple comparison procedure for the length of the fructiferous bud

Class	Harvest efficiency [%]		
	Mean	Standard deviation	Coefficient of variation
1	81.2 a	21.14	26.05%
2	76.7 ab	22.95	29.92%
3	70.2 b	21.31	30.35%
4	69.9 b	21.30	30.47%

Note: different letters in the column denote statistically significant differences at the 95% confidence level.

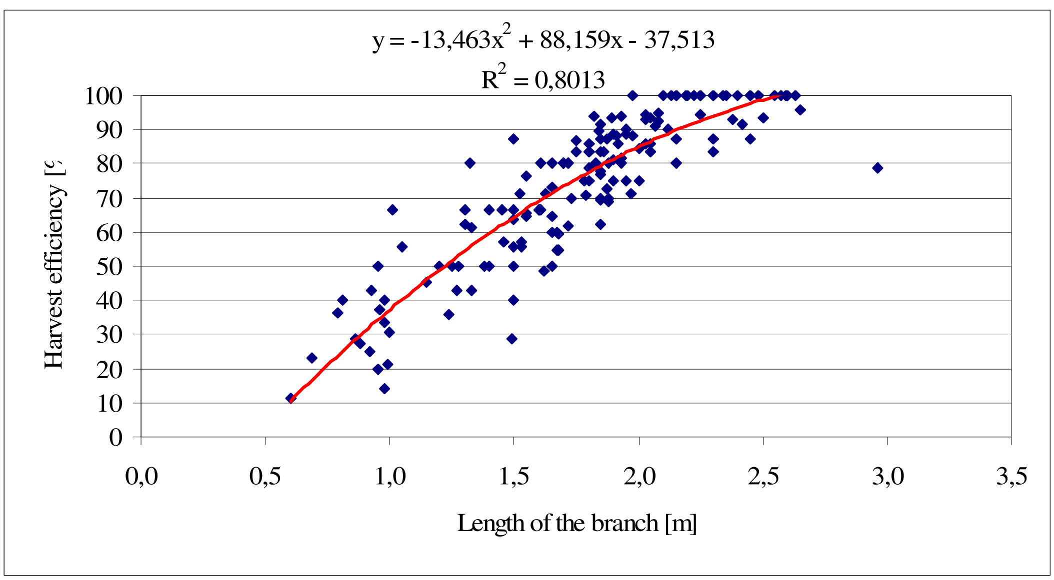

Figure 3. Correlation between the harvest efficiency and the length of the branch

The lower the bud length, the higher the efficiency; in fact, there is a 10% decrease of the efficiency going from 0.50 to 0.90 m. The lowest value of the efficiency was found in class 4.

Relating the values of the above mentioned *parameters* with the harvest efficiency, it was found a correlation only for the *parameter A* (fig. 3). The data are interpolated by an equation of the second order described, for the considered interval, by an increasing parabola having R^2 equal to 0.80.

Conclusions

The paper is a first contribution to the study of the influence of the geometric and morphologic characteristics of the olive tree on the mechanical harvest efficiency performed with trunk shaker.

Some interesting remarks can be drown. The four parameters taken into account influence the harvest efficiency for the variety Nocellara del Belice. In particular, in order to have a harvest efficiency higher than 80% it can be asserted that the geometric and morphologic parameters of the plants have to be:

- length of the main branch (*parameter A*) from 2 to 3 m;
- distance of the bud from the central axe of the tree (*parameter B*) from 1.30 to 2.30 m;
- height of the bud from the ground (*parameter C*) from 1.90 to 2.85 m;
- length of the fructiferous bud (*parameter D*) from 0.25 to 0.40 m.

The above mentioned values are certainly to be referred to orchard having a regular lay out of planting of 6.00 x 7.00 m and mean circumference of the canopy about 10 m.

References

Altieri G. (2001). Studio delle vibrazioni nella raccolta meccanizzata dell'olivo. Atti del Convegno POM "Riduzione del costo di produzione, miglioramento della qualità e tutela dell'ambiente nella filiera olivicolo olearia". Sciacca.

Amirante P., Pipitone F. (2000). Innovazioni tecnologiche per la raccolta meccanica delle olive. Informatore Agrario, 42, 105-109.

Antognozzi E., Cartechini A., Tombesi A., Paliotti A. (1990). La trasmissione della vibrazione e l'efficienza di raccolta in olivi della cv. Moraiolo. Genio Rurale, 5.

Formato F., Romano (2003) Vibrations analysis during the mechanical harvesting of olives. XXX CIOSTA CIGRV Congress, Torino.

Paschino F., Mura R. (1997). Razionalizzazione della struttura della pianta di olivo per il miglioramento della resa di raccolta con scuotitrici da tronco. Atti del Convegno AIIA, Ancona.