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Technical and economic analysis of alternative pruning systems in high dimensions olive trees in Calabria

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Abstract. Oliviculture in Calabria accounts for 30% of the agricultural gross regional production. On the Gioia Tauro plain, located in the province of Reggio Calabria, the oliviculture area is extended over more than 20,000 hectares. The olive trees in this area are characterised by a remarkable growth with trees reaching and often exceeding 25 metres in height. In these extreme conditions all the cultural operations are technically and economically complex. Particularly complex are the pruning operations, normally done with traditional methods, which are dangerous for the operators, who have to climb the trees to make the cuts with chain saws. The objective of this study is to encourage the use of mechanical systems, specifically truck-mounted telescopic platforms, to secure operators and lower the pruning costs. They were therefore analysed two operating systems, the traditional and the mechanical, comparing the working capacity of different yards. The results have been encouraging although the machines utilised can be rationally introduced only on large farms, while the small farms have to rely on cooperatives of services or on contractors.

Key words: pruning systems, agricultural mechanisation, economic analysis.

INTRODUCTION

Italy, with 1.19 million hectares of oliviculture areas and 3.17 million tonnes of olives produced, is the third nation in the world by extension, preceded by Spain and Tunisia respectively with 2.01 and 1.65 million hectares, and the second world producer, preceded only by Spain with 8.01 millions of tonnes of olives (Faostat, 2011). In Italy, olive production is mainly concentrated in the southern regions and in Calabria, where the oliviculture area represents 16% of the national one, the production of olives represents 30% of the agricultural gross regional production.

In Gioia Tauro plain, located in the province of Reggio Calabria, the oliviculture area is extended over about 20,000 hectares, mainly in small or very small farms with low investment capacity and high labour requirements because of low mechanisation levels. The olive-oil produced in the area is mainly lampante virgin olive oil of low quality mostly used in the industrial market. The olive trees belong to the 'Sinopolese' and 'Ottobratica' cultivars, which in this area are characterised by a remarkable growth, perhaps unique in the world, with trees reaching and often exceeding 25 metres in height: a real 'forest of olive trees' (Fardella, 1995). Unfortunately, although the landscape is impressive due to the majesty of these trees, the rational management of these plants is problematic because of the particularly labour-intensive

and physical effort required for the operation of cultivation. Among them, particularly complex are the resulting pruning operations, which influence the quality of the product and its high cost. The traditional local skilled workers, less equipped than modern 'tree climbers', climb these trees upto and over 20 metres with only the help of billhooks and ropes, in order to perform the pruning. The dangerous conditions in which the pruning operations are performed and the high cost of pruning, determine a low availability of skilled labour in this area and the tendency to minimise this practice, which is abandoned in some cases, but is usually done every ten years with drastic cuts and significant removal of wood mass. For these reasons, in most of the old olive-groves, there is a luxuriant growth of the crowns that creates a barrier to the passage of sunlight in the lower areas of the trees, altering the microclimate and encouraging phytopathologies difficult to control, also because of their large size.

In order to explore feasible solutions for the pruning operations for farmers in this area, the objective of the study is to compare traditional pruning with alternative mechanised systems, based on truck-mounted telescopic platforms. The used methodology quantifies the yard operating capacity and the labour productivity in these alternative pruning systems. Moreover, an economic analysis is conducted, showing the curves of the operating costs of the analysed systems.

MATERIAL AND METHODS

The tests have been conducted in a particular olive-growing area in Calabria, the 'Gioia Tauro Plain', in order to analyse the traditional and mechanised pruning systems.

The traditional pruning

The traditional pruning system was analysed in a farm in the 'Gioia Tauro Plain' (Table 1), where the olive trees, of 'Ottobratica' and 'Sinopolese' cultivar are secular with a height ranging from 20 to 26 m (Fig. 1). The average diameters of the crown are 16 m, with a planting density of 50 plants / hectare. In the farm observed the harvest is carried out from the ground from natural fruit drop, since the size of the normal olive harvest machine-shakers doesn't suit for the structure of these plants.

Table 1. Characteristics of the olive grove under traditional pruning

Cultivar	Ottobratica and Sinopolese	
Age	Secular	
	Mean	*s.d.*
Tree height (m)	22.95	2.82
Crown diameter (m)	15.87	0.68
Trunk diameter (m)	0.96	0.07
Tree density (trees ha^{-1})	50	-

The equipment through which the operators perform the traditional pruning consists of billhooks, hatchets and chain saws, respectively used to cut branches with a diameter of 3–4 cm, 10 cm and more than 10 cm. The pruning can be performed simultaneously on two or three trees, depending on the number of work units of the yard which usually consists of a foreman (who coordinates the operations from the

ground) and 4 or 6 pruner specialists (2 per tree). In the farm tested, the yard consisted of seven work units (1 + 6), working simultaneously on three trees.

Figure 1. Typical olive-grove in 'Gioia Tauro Plain' and an example of traditional pruning.

The mechanised pruning

The tests were carried out in two olive farms in the 'Gioia Tauro Plain', A and B (Table 2), in which two yards were prepared with the support of two truck-mounted telescopic platforms (Fig. 2). Both yards were composed of two skilled workers: the first one, on the ground, who was assigned to the controls of the machine, giving directions about the pruning cuts to be performed; the second was carrying out the pruning from the platform.

Table 2. Characteristics of the olive grove under mechanised pruning

Cultivar Age	Farm A Ottobratica and Sinopolese Secular		Farm B Ottobratica and Sinopolese Secular	
	Mean	*s.d.*	*Mean*	*s.d.*
Tree height (m)	25	1.27	26	1.35
Crown diameter (m)	20	0.53	19	0.74
Trunk diameter (m)	0.92	0.06	0.95	0.09
Tree density (trees ha-1)	33	-	33	-

The machines are two self-propelled four-wheel drives, with a diesel engine and power of 61.5 kW in yard A and 84.0 kW in yard B. The first machine had a telescopic arm with a maximum working height of 11 m and a gate-person platform with a control panel for lifting and moving. The second machine, along with the telescopic arm of 11 m, had another articulated prolongation of 9 m, which increased the levels of extension and flexibility; the platform, however, had no supplementary commands for the articulated prolongation, lowering the performances of this second machine.

A   B

Figures 2. Telescopes arms used in the yard A (left) and in the yard B (right) in full extended position.

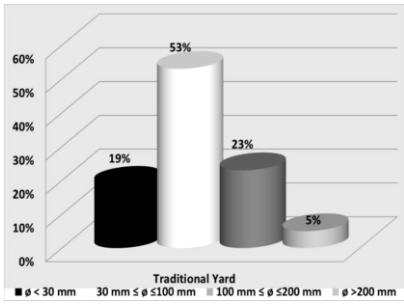
In yard A, the machine proceeded along the inter-row, stopping next to each tree; the pruner performed the cut in the explorable part of the crown (about 50%). The pruning was completed with the passage of the machine in the inter-row next to each tree.

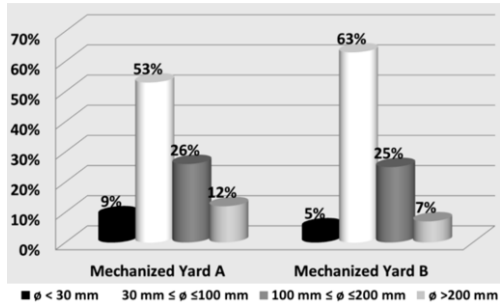
In yard B, because of the greater flexibility of movement of the platform, the vehicle was placed at the centre of four trees and the pruner, from this position, performed the pruning of about half of each tree crown, which was completed later, when the machine was positioned in the next row.

RESULTS AND DISCUSSION

For the reasons previously expressed, in the studied farms the pruning is usually done every ten years, so the cuts made are necessarily very drastic, and the wood mass removed is very significant.

The subdivision by classes of diameter of cut branches in the considered yards (Fig. 3) shows us the pruning's magnitude.

A 

B 

Figures 3. Percentage of the cuts breakdown by classes of diameter in the tests performed in the traditional and mechanised way, in yards A and B.

The operating capacity of the yards, due to the magnitude of cuts, was generally very low. In particular, in the traditional yard it has been of 1.20 trees h^{-1} and the labour productivity of 0.17 trees (h w^{-1}), (worker), while the timber removed is about 840 kg h^{-1}. In the two mechanised yards (A and B) the operating capacity was respectively of 2.06 and 1.60 trees h^{-1}, considering that the workforce was made up only of two workers, showing the productivity of the two yards increase to 1.03 and 0.82 trees $(h\ w)^{-1}$, and the mass of the cut timber equal to 694 and 639 kg h^{-1} (Table 3). From the reliefs it also is apparent that yards A and B took 16 and 20 hours to work on one hectare, while the traditional yard took 83 hours in the same area.

Table 3. Results of the working yards

Pruning system	Yard	Yard workers (n)	Operating capacity yard				Labour productivity		
			trees h^{-1}	kg h^{-1}	h $tree^{-1}$	h ha^{-1}	trees h w^{-1}	ha h w^{-1}	kg h w^{-1}
Traditional		7	1.20	840	0.83	83.00	0.17	0.002	120
Mechanised	A	2	2.06	694	0.49	16.20	1.03	0.03	347
	B	2	1.60	639	0.61	20.00	0.82	0.025	319

The economic analysis was performed in order to quantify the costs of the operating hours of two mechanised yards, compared to the traditional one.

Table 4 and Fig. 4 show the parameters used and the curves of the operating costs of the tested yards, showing the limits of convenience for the acquisition of the machinery covered by the tests compared with the traditional yard.

Table 4. Parameters used for the financial analysis

PARAMETERS USED	***Yard A***	***Yard B***
• New value (€)	75,000	110,000
• Residual value (€)	7,500	11,000
• Interest rate	0.03	
• Rate of various expenses	0.02	
• Rate of repair and maintenance	0.06	
• Duration of physical activity (hours)	7,200	
• Economic life (years)	12	
• Power used* (kW)	39	
• Cost of Fuel (€/kg)	1	
• Cost of lubricant (€/kg)	3.5	
• Cost of skilled labor** (€/day)	160	
• Daily commitment of labor (hours)	8	
• Number of workers employed in the yard (n)	2	
FIXED COSTS	***Yard A***	***Yard B***
• Amortization Quota (€/year)	5,625	8,250
• Interest Quota (€/year)	1,238	1,815
• Share of various expenses (€/year)	1,125	1,650
TOTAL FIXED COSTS (€/year)	**7,988**	**11,715**
VARIABLE COSTS	***Yard A***	***Yard B***
• Share of repair and maintenance (€/h)	0.63	0.92
• Share of Fuel (€/h)	11.12	11.12
• Share of lubricant (€/h)	1.75	1.75
• Share of skilled labor (€/h)	50.00	50.00
TOTAL VARIABLE COSTS (€/h)	**63.49**	**63.78**
** (70% of nominal power)*		
*** (20 €/h)*		

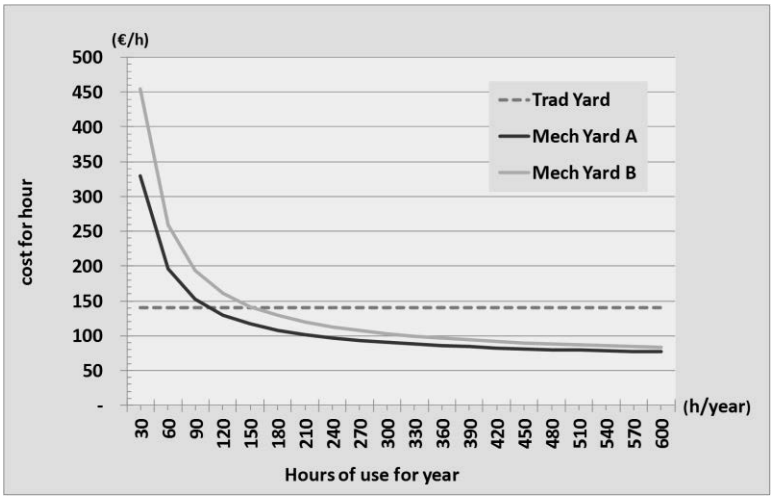


Figure 4. Costs analysis of the different yards.

CONCLUSIONS

The mechanical yards show higher operating capacities compared to the traditional ones. However, the economic analysis shows that the machines in question, due to the high initial investment, are better suited to large farms (with areas larger than 40 hectares), in which, because of their versatility and multi-functionality, these machines can also be used in other farming operations. The investment required for telescopic elevators is not sustainable for the small farms, which are prevalent in the area. In this case, a viable solution would be to turn to a cooperative of services or contractors, although this may result in the lack of timeliness of intervention and working turn-over. Another aspect of primary importance, in the mechanisation of the pruning of these particular trees, is related to higher safety for the workers employed in this operation which is often put off due to its dangerousness, with obvious negative effects on the quality of the product obtained.

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