Vineyards Mechanical Pruning

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ABSTRACT

It has been adopted in different wine regions for various economic, labour and winemaking reason. In this paper the results of the research activity on mechanized pruning of three wineyards (and their economic aspects): Sangiovese by spur pruned cordon, Cabernet Sauvignon trained by simple curtain and Trebbiano Romagnolo trained by GDC are presented. A mechanical pruning with only the shortening of vine-shoots, and a combined system comprising mechanical pruning (shortening of the vine-shoot) followed by manual labour (spurs were thinned out manually), were compared to the manual pruning. The mechanized pruning presents some advantages in the working times as well as in the operations costs with a reduction of times of over 90%, and a reduction of costs of 80% in respect to the manual pruning. Generally, the completely mechanical pruning allows to increase, in a considerable way, spurs and buds; it, also, allows to control the production by the cut height and it is characterized by the high presence of small bunches. This research activity results show the advantages of mechanical pruning in respect to that manual, allowing to obtain good results. In addition, the different mechanization levels allow to satisfy the requirements of different vineyards conditions.

Keywords: Mechanical pruning, vineyards, manual labour, Italy.

1. INTRODUCTION

In Italy, despite 30 years of research, there has been a difficulty in finding a practical application of mechanically pruning vineyards during the winter. Only in the last decade, the high increase of labour costs, the lower availability of skilled workers, and the strong public boost to vineyard modernization has led to a significant increase in specialized machinery in this sector. Some pruning techniques, carried out, only by mechanical means that involve specific operating

Luigi Pari, Fabio Pezzi. "Vineyards Mechanical Pruning". International Commission of Agricultural and Biological Engineers, Section V. Conference "Technology and Management to Increase the Efficiency in Sustainable Agricultural Systems", Rosario, Argentina, 1-4 September 2009.

actions on foliage (minimal pruning or pruning zero) (Clingeleffer, 1984) (Possingham, 1996), resulted in not being suitable enough to solve the needs of European and Mediterranean viticulture, even if they are used in Australia and in some other countries.
In our country, the mechanical pruning (also called hedging) consists of cutting vine shoots close to the permanent cordon by oscillating disks or bars, which are aided by pruning devices. As any manual finishing is considered in this method, it is possible that growing and problems production occur by changing the renewal, the spurs placing and the buds load (Brancadoro et al, 1997) (Intrieri et al, 1995). In Italy, a system that combines mechanical pruning (shortening of the vine-shoot) to hand finishing (manual labour), is preferred in order to better monitor the buds load and to correctly stimulate their renewal (Poni, 2004). The hand finishing can occur released by the pruners (operators action from ground in a subsequent phase) or directly linked to the pruning yard (operators on a wagon equipped with security, positioning and promotion systems, such as air compressed distribution to move pneumatic scissors). With these different possibilities of mechanically pruning vineyards, a comparison test was done, in order to obtain information on the technicalities, the economics, and the quality of their work.

2. MATERIALS AND METHODS

2.1 Vineyards

The tests were conducted in Romagna, close to the experimental farm "Terre Naldi" of Faenza. For some years, different techniques were applied on the same plots, whereas in the last year, surveys on the performance of the machines in usage, as well as on the plants growth, were carried out. The tests were conducted on three vineyards, which had three mechanical training: Sangiovese trained to spur pruned cordon (SPC); Cabernet Sauvignon trained to simple curtain (SC); and Trebbiano Romagnolo trained to GDC (GDC).

2.2 Setting of tests

Within each of the three training systems, the following prunings were carried out: (1) Manual pruning (m) in which operators proceeded on foot and used manual scissors; this choice of pruning consisted of six spurs every meter of permanent cordon, which had 4 buds per spur on Trebbiano and 3 buds on Sangiovese and Cabernet; (2) mechanical pruning (M) only with the pruners. In order to control the load of the total gems and to stimulate an appropriate renewal, the shortening cut was close to the ground (grazing), and in this way we had spurs with 3 buds on Trebbiano and 1 or 2 and spurs with 1 or 2 buds on Sangiovese and Cabernet; (3) mechanical pre-pruning and subsequent hand finishing (M + m), which had operators that proceeded on foot and who used manual scissors; these actions mainly concerned the thinning/pruning of spurs, which was carried out in a similar way to the manual proceeding; and finally, (4) simultaneously mechanical pre-pruning and hand finishing (M + w); this method had a wagon facility with two operators equipped with pneumatic scissors, similar to the mechanical pre-pruning and subsequent hand finishing (M + m).

2.3 Machines

A pruner equipped with an alternate movement mowing bar (an oscillating blade and a fixed counter blade) was fit to operate in three different training systems by changing the layout, orientation and number of bars used (Figure 1). This was an unilateral machine equipped with hydraulic controls and adjustments, which made two passages on each row. During operations of manual finishing conducted simultaneously by the operators transported on wagon, a facilitator wagon that was pulled by the tractor carrying the pruners, was utilized. The wagon was equipped with a delivery system for compressed air that was used for the pneumatic scissors functioning.

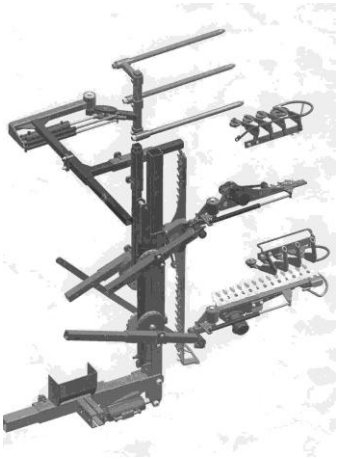

Figure 1. The pruner used in the tests (Tanesini Technology).

2.4 Evaluation of methods

The evaluation of the carried out methods involved: operating, qualitative, and economic parameters. In order to know the productivity of both mechanical system and manual labour, advancing speed and working times were surveyed. The results of the three training systems were determined by measuring the following entities: intensive pruning, given from comparing the weight of the removed wood in the considered method to that one removed in manual pruning; spurs and the load of buds per plant; renewal represented by the relation between spurs of one year and total spurs.
At the harvest time, the quantitative and qualitative characteristics of each method of production were determined considering as parameters the number and the average weight of bunches, the average weight of the berries, and sugar degree. Finally, according to the methodology for calculating, recommended by ASAE (Asae Standards, 1998), an economic evaluation using the parameters given in Table 1 was carried out.

Table 1. Parameters used for economical assessment

ECONOMICAL ELEMENTS	VALUES
List price – PL (€)	
- pruner preparation SPC	8500
- pruner preparation SC	4500
- pruner preparation GDC	5500
- wagon	2500
Residual value – VR (€)	10% PL
Physical length – N (h)	2000
Annual use – U (h/anno)	h/anno
Years of use - n	N/U (max. 12)
Fixed costs (€/anno)	Variabile
- depreciation	(PL-VR)/n
- interests	5% (PL+RV)/2
- costs	2% PL
Variable costs (€/h)	
- repairs	60% PL/N
- maintenance	1,3
- tractor with operator	25
- wage	13

3. RESULTS

3.1 Machine performance

The advancing speed of the pruner ranged from 0.54 to 1.40 km/h, whereas that of the pruners on ground ranged from 0.05 to 0.10 km/h. In both cases the lowest speed was recorded during pruning of the vines. The advancing speed of the machine was also affected by hand finishing in the same field (M + w), which limited the performance of the mowing bar. The time unit of work showed obvious differences from the manual technique (m) to the only mechanical one (M), in which although data was reduced, it always exceeded 90%, (Figure 2). The mechanical pre-pruning method and the manual finishing one (M + m and M + w) occupied a medium position with a reduced time variable from 42 to 68%.

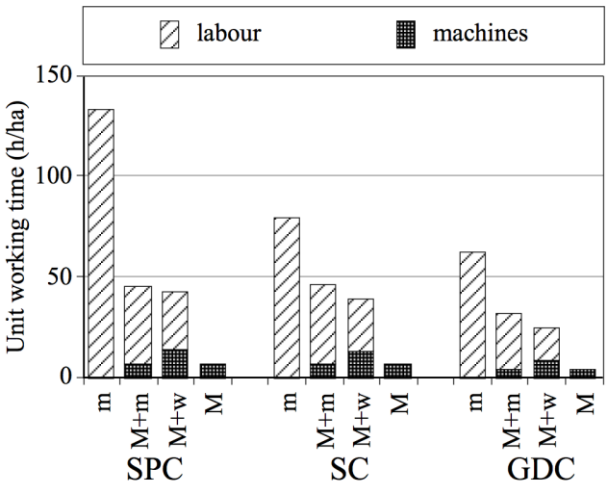

Figure 2. Unit working time on the three trained systems

3.2 Quality of the work and production

Table 2 presents the descriptors considered for the qualitative evaluation of pruning. Compared to the manual technique (m), the only mechanical one (M) gave a different pruning measurement in all three training systems examined, by a much lower wood elimination. The main difference concerned the density of spurs, which increased 122-163%; this caused an increased load of gems, which was partly affected by the age and length of the spurs. The two pruning systems varied significantly even in the renewal of the spurs. The two mechanical actions associated to hand finishing practice (M + m and M + w) led to a result similar to that of the only manual system. Finishing on the ground allowed for the same accuracy as compared to manual processing.

Table 2. Descriptors of the quality of pruning. In each line values with the same letter are not significantly different (p = 0.05 by Duncan test).

VINEYARD THESIS	Intensive pruning (%)	Total spurs (n/plant)	New spurs (%)	Buds (n/plant)
SPC - Sangiovese				
m	100 a	6,2 a	95,3 a	15,0 a
M+m	93,2 a	6,0 a	96,0 a	18,2 ab
M+w	78,0 b	8,5 b	89,0 b	24,8 b
M	51,3 c	16,3 c	66,9 c	55,0 c
SC - Cabernet S.				
m	100 a	6,7 ab	87,5 a	18,7 a
M+m	94,3 a	6,3 a	88,0 a	17,5 a
M+w	77,4 b	8,1 b	85,0 a	22,6 b
M	39,7 c	14,9 c	71,0 b	28,9 c
GDC - Trebbiano				
m	100 a	6,0 a	93,2 a	21,6 a
M+m	92,5 b	5,2 a	92,2 a	20,4 a
M+w	81,0 c	8,7 b	70,4 a	34,6 b
M	56,6 d	15,3 c	65,9 b	48,9 c

For vineyard production, a stabilization of the data gathered during these tests is pointed out (Table 3). For Trebbiano, a vineyard made of baseline buds with low fertility, the control of the total gems through the shortening of spurs, by mechanical means (M), caused a reduction in productivity compared to traditional pruning (m). On the contrary, on Cabernet and partially on Sangiovese grapes, which had fertile basal buds, the increase of buds, which was the maximum in the mechanical method (M), caused an increase in productivity apart from the length of the spurs. For the qualitative character of the harvested grapes, tests were carried out with the following trends: the inverse proportionality between productivity and average weight of the bunches and berries, which had values that decreased in the most mechanized process; and a reduction of the sugar degree when the productivity increases, which had a less obvious trend that promoted alcohol production per hectare.

Table 3. Data describing production - in each line values with the same letter do not show significant differences (p=0,05 Duncan test).

VINEYARD THESIS	Bunches of grapes (n/plant)	Average mass of bunches of grapes (g)	Average mass of 100 grapes (g)	Productivity (t/ha)	Sugar (°brix)
SPC-Sangiovese					
m	20,1 a	610 a	306 a	36,78	21,0 a
M+m	21,3 a	602 a	301 a	38,47	21,0 a
M+w	22,5 a	591 ab	298 a	39,89	20,2 ab
M	22,4 a	580 b	245 b	38,97	18,8 b
SC-Cabernet S.					
m	21,1 a	260 a	102 ab	18,20	27,2 a
M+m	20,0 a	278 c	104 b	18,53	27,2 a
M+w	24,2 a	270 ac	101 ab	21,60	27,0 a
M	33,0 b	205 b	96 a	22,55	27,4 a
GDC-Trebbiano					
m	33,9 a	228 a	214 a	19,38	19,8 a
M+m	33,3 a	230 a	222 a	18,98	19,8 a
M+w	37,0 ab	220 a	218 a	20,35	18,9 a
M	39,0 b	164 b	220 a	15,99	18,4 b

3.3 Economic evaluation

The four methods showed a different cost of the pruning due to the cost of machinery and productivity observed in the three training systems. Table 3 lists the values (unit costs) that consider a vineyard of 10 ha. The mechanical pruning (M) method resulted in being the cheapest one (77-83% of saving according to the training system) compared to the manual one (m), which always involved a higher cost. The hand finishing techniques allowed cost savings, but were lower than that of the mechanical methods (27-53% for M + m and 23-46% for M + w). Under the same technique, using the same data to evaluate the influence of the three training system, lower costs and more in GDC in the Cabernet Sauvignon trained to simple curtain SC, respectively, were carried out.

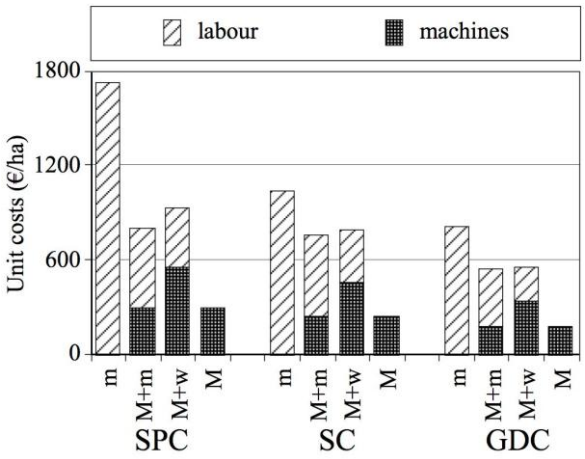

Figure 3. Unit costs supposed for the three training systems

Based on wide level annual analysis, we have established the minimum grapevine area convenient to purchase pruning machine and to perform mechanical operations, either integral or hand finishing.
The values in Table 4 show savings from small areas (from 0.7 to 2.8 ha) even considering the most expensive action, such as the wagon transporting workers, who do the hand finishing.

Table 4. Hand pruning cost and individuation of small areas for the convenience of purchasing farm machinery

Training system	Mechanical pruning	By hand cost (€/ha)	Minimum area to mechanize (ha)
SPC	M+m	1733	1,0
	M+w	1733	1,4
	M	1733	0,7
SC	M+m	1040	1,6
	M+w	1040	2,6
	M	1040	0,7
GDC	M+m	813	2,0
	M+w	813	2,8
	M	813	1,0

4. CONCLUSIONS

Based on these experimental tests, the mechanical pruning of the vineyards trained to permanent cordon attained results good enough to consider it a valid technique to apply in Italy as well. The techniques used for the three training systems (pruned cordon, simple curtain and GDC) represent three different ways of pruning, in which the man/machine relation is a key-role. The pruners that were used were operated properly in all test conditions, with good adaptability.
The compared ways of pruning differ in the following ways: intensive pruning, load of buds, number and position of spurs, and plant growth which in three years of testing had shown a

tendency towards an equilibrium, both for quantity and quality of production. A good capacity for renewal even in the most mechanized method is surveyed. The increased mechanization modifies the size and number of bunches and berries related to increased productivity (grapes and sugar) for vineyards with basal fertile buds. The most positive evaluations on mechanical pruning concern the economic aspect. A general profit is pointed out by the mechanical pruning or is supplemented by hand finishing even on a small vineyard (0.7-2.8 ha). The agronomic, economic and productive results show how the machines used for vineyard pruning today are an appropriate means to satisfy the Italian viticulture requirements.

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