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PRELIMINARY RESULTS OF HEDGE MECHANICAL PRUNING PERFORMED WITH NERO DI TROIA WINEGRAPE CULTIVAR

RÉSULTATS PRÉLIMINAIRES DE TAILLE MÉCANIQUE EN HAIE RÉALISÉE SUR LE CÉPAGE DE CUVE NERO DI TROIA

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Abstract :

Traditional winter pruning is labor consuming and has a high cost for grape-growing farms. In order to reduce this cost, mechanical pruning was experimented at a commercial farm located in a Controlled Appellation of Origin area (D.O.C.) of Southern Italy, on the local winegrape variety 'Nero di Troia'.

Vines were trained to spur pruned VSP, with 7 two-bud spurs and thus 14 buds per vine. In winter, a plot was mechanical pruned - hedge pruned - by cutting the stems below the first couple of wires that maintain their vertical position. As a result, each spur had 8 buds in the first year, thus the bud number per vine was 56. In the second year the spur number increased, and the average bud number per vine rose to 73. The aim of the present work was to study the effect of this alternative pruning method on Nero di Troia canopy geometry and structure, grape yield, berry composition and wine phenol content of winegrape grown in Southern Italy, in comparison to the traditional pruning.

Data collected during the second year of treatment showed that the mechanical pruning method experimented in this trial increased the canopy density and the grape yield, without inducing a sensible penalization of the grape and wine composition. 'Nero di Troia' produced a higher number of small berries per cluster that proved to have a greater content of several phenol compounds. It is necessary to extend this trial over several years more and to deepen the study of sanitary satus of berries and wine quality through sensory analysis.

Keywords:

Winegrape, semi-arid environment, "Nero di Troia", phenols, mechanical pruning, hedging

Résumé :

La taille d'hiver traditionnelle requiert un emploi important de main-d'œuvre et donc est une opération très coûteuse pour l'entreprise viticole. Pour réduire ce coût, la taille mécanique a été testée sur un cépage local, le 'Nero di Troia', dans une exploitation commerciale localisée dans l'aire de l'appellation d'origine contrôlée (AOC) « *Castel del Monte* » en Italie méridionale.

La forme de conduite de référence prévoyait une taille ~~courte~~ à 7 coursons de deux yeux, soit 14 bourgeons par cep selon une conduite en VSP (vertical shoot positioning). En hiver la parcelle expérimentale a été taillée mécaniquement – taille en haie - au dessous du premier niveau de fils releveurs. La première année chaque courson avait en moyenne 8 yeux, soit 56 bourgeons par cep; l'année suivante le nombre de coursons a augmenté jusqu'à atteindre 73 yeux par cep. L'objectif de cette étude était de comparer cette taille à la taille traditionnelle en vérifiant ses effets sur la géométrie et la structure de la canopée, le rendement du cep, la composition de la baie et la teneur en phénols du raisin et du vin. Les données de la deuxième année ont montré que la taille mécanique a augmenté la densité du feuillage et le rendement sans pénalisation sensible de la composition du raisin et du vin. Suite à la taille mécanique, les baies par grappe étaient plus nombreuses et plus petites avec une teneur supérieure pour plusieurs composés phénoliques. Il reste à poursuivre cet essai sur plusieurs années et à approfondir l'étude de l'état sanitaire du raisin et de la qualité sensorielle du vin.

Mots clés :

Cépage à raisin de cuve, environnement semi-aride, Nero di Troia, phénols, taille mécanique, taille en haie.

INTRODUCTION

Traditional hand winter pruning is one of the major costs for the farm since it is time consuming and because the cost of the labor in many grape-growing regions.

In the *Castel del Monte* Controlled Appellation of Origin area of Southern Italy (Apulia region), about 12 working days per hectare are necessary to prune a typical vineyard trained to spur-pruned vertical shoot positioned system, that corresponds to a total cost of about 500 euros per hectare. Farmers are thus interested in testing alternative mechanical methods for winter pruning.

Winter pruning is recognized as one of the most important cultural practices since it represents the main crop regulation method. Nevertheless, it is well-known that the number of buds left on vine induces several compensative responses either in terms of sprouting buds and shoot growth, that determine the canopy size and structure, or in terms of bunch number per vine, bunch and berry mass, etc., which exert a direct influence on the vine yield and the grape quality (Jackson *et al.*, 1984; Clingeleffer *et al.*, 2000; Heazlewood *et al.*, 2006).

Many trials have been conducted to study the effects of the pruning level on vine growth and berry composition as related with methods of mechanical pruning. This wide literature shows that the responses change considerably according to the variety, the intensity of pruning, the environmental conditions and the methods of vineyard management (McCarthy and Cirami, 1990; Schultz *et al.*, 2000; Archer and van Schalkwyk, 2007; Carbonneau *et al.*, 2007).

The aim of the present research is to experiment a method of mechanical pruning in the *Castel del Monte* D.O.C. area and to assess the physiological, quantitative and qualitative responses of the main local variety Nero di Troia, which is the basic cultivar to produce *Castel del Monte* red wines.

MATERIALS AND METHODS

The trial is run in the semi-arid environment of Southern Italy (Corato, Bari province), at "Torre Santa" farm. The vineyard is located at 41°05' N lat. 16°20' E long., 356 m a.s.l. on a shallow, gravel, sandy-loam soil, with sub-alkaline reaction and low organic matter content. The annual mineral nutrition consists of about 0.4 t ha-1 of mineral-organic fertilizer (N,P,K 6-8-15). A seasonal irrigation volume of about 550 m3 ha-1 is applied.

Cv. Nero di Troia is grafted onto 34 E.M. rootstock, planted 1.00 m (within row) x 2.30 m (between rows) apart, trained to VSP system and spur pruned with 7 two-bud spurs per vine. The cordon is positioned at 0.80 m above the soil; two couples of wires are utilized to maintain the vertical shoot position: their heights above the cordon are 0.30 m and 0.70 m, respectively. The last trellis wire is at 1.10 m from the cordon.

In winter 2006, a plot of 360 vines started to be mechanically pruned – hedge pruning - by using a pre-pruner machine (Binger-Seilzug, Bingen, Germany). The cut was done a little below the first couple of wires; as a result it was obtained, in average, 8 buds per spur and 56 buds per vine. An adjacent plot of 360 traditionally hand pruned vines was individuated in order to compare the effects of the two pruning methods. The two treatments were indicated as "traditional pruning" (TP) and "alternative pruning" (AP). The same treatments were repeated the following year in the same plots. The canopy was topped (one time) after shoots overcoming the last trellis wire.

In 2008, two years after starting to compare the two treatments, some measurements were taken in each plot in order to assess: bud load, canopy geometry and structure, canopy light interception, yield components and berry composition, wine phenol composition.

Bud load was measured after winter pruning, on ten single-vine replications per treatment, by counting the bud number per vine.

Canopy geometry and structure were assessed in early September, during grape ripening, according to Smart and Robinson (1991). At 50 row positions, canopy height, canopy top-width and basal-width were measured; these data were used also to estimate the exposed leaf surface, the canopy volume and their ratio. By applying the point quadrat method, the following parameters were assessed in the cluster zone: leaf layer number, percentage of gaps, percentage of interior leaves and of interior clusters. On the ten single-vine replications, the number of main shoot per vine was also counted.

Canopy light interception was evaluated in a cloudless day, at the above mentioned positions, by measuring the photosynthetic photon flux at the top, middle and bottom portions of the East side of the canopy; measurements were taken at the external surface as well in the centre of the canopy. The photosynthetic photon flux available at the West canopy side was also measured. Measurements were taken between 10:30 and 12:30 solar time (fully lighted East side), by means of a solar bar (AccuPAR LP-80, Decagon Dev. Inc. Pullman, WA, USA).

Grapes were harvested in mid October, according to the farm decision. All clusters of the ten single-vine replications of each plot were harvested, weighted and counted.

Five replications of 100 berries per treatment were sampled in order to assess, on their must, concentration of total soluble solids, pH and titratable acidity expressed as tartaric acid.

Moreover, ten clusters per treatment were sampled in order to assess the single berry weight and the number of berries per class of weight: < 1.0 g, 1.1-1.5 g, 1.6-2.0 g, 2.1-2.5 g, 2.6-3.0 g, 3.0-3.5 g, > 3.5 g. On 25 berries per each class and treatment, the longitudinal and traversal diameters were also measured.

From berries of each of the 5 central classes, the content of total skin polyphenols and flavonoids (both expressed as (+) catechin), anthocyanins (expressed as malvidin monoglucoside), proanthocyanidins (expressed as cyanidin chloride), and flavans reacting with vanillin (expressed as (+) catechin) was analyzed according to Di Stefano and Cravero (1991). Moreover, the same analyses, with the same method, were performed on five berry samples taken from the grape mass of each of the two pruning treatments.

One hundred kilograms of grapes were wine processed according to a protocol already described (Suriano and Tarricone, 2006). Three replications per treatment were performed. The concentration of the same phenol compounds tested in berry skin was analyzed in the young wines (in December), according to Di Stefano and coll. (1989).

Data were statistically analyzed by ANOVA. The standard error was also calculated.

RESULTS AND DISCUSSION

Bud load, canopy geometry and structure

In comparison to the traditional pruning (TP), the alternative method of mechanical pruning (AP) experimented in this trial increased, after two years, the bud number per vine from 14 to 73 (+420%) and the shoot number per vine from 24 to 35 (+46%). Thus the traditionally pruned vines gave 1.7 main shoots per bud, while the alternative pruned vines gave about 0.5 main shoots per bud. Hence, approximately 45% of dormant buds were "blind" in mechanical pruned vines, possibly as a compensative effect for the higher vine bud number (Heazlewood *et al.*, 2006).

The increase of buds and shoots per vine scarcely modified the canopy height (-11%) and the canopy top-width (+11%), as well as the exposed canopy surface area (-9%), while the canopy basal-width increased by 30% (fig. 1). As effect of the enlargement of the basal-width, the vine canopy volume augmented in AP, but only by 5%; the ratio between the exposed canopy surface area and the canopy volume declined by 15%, indicating a certain degree of loss in "energy efficiency" of the whole canopy.

The number of leaf layers in the cluster zone passed from about 3.0 (TP) to 4.5 (AP), and the gap percentage, which was already as low as 8% (TP), became almost zero (AP). As a result, the percentage of internal organs sensibly rose: the internal leaves passed from 28% (TP) to 45% (AP) and the internal clusters passed from 57% (TP) to 83% (AP). The increase of internal clusters was quite high (+47%) pointing out this parameter as sensitive to the rise of the bud and the shoot number per vine (fig. 2).

All differences found between the two treatments were statistically significant ($p \leq 0.05$), except for the canopy volume.

Canopy light interception

Maximum photosynthetic photon flux available in the ambient at the time of measurements was 1940 μmol m^{-2} s^{-1}.

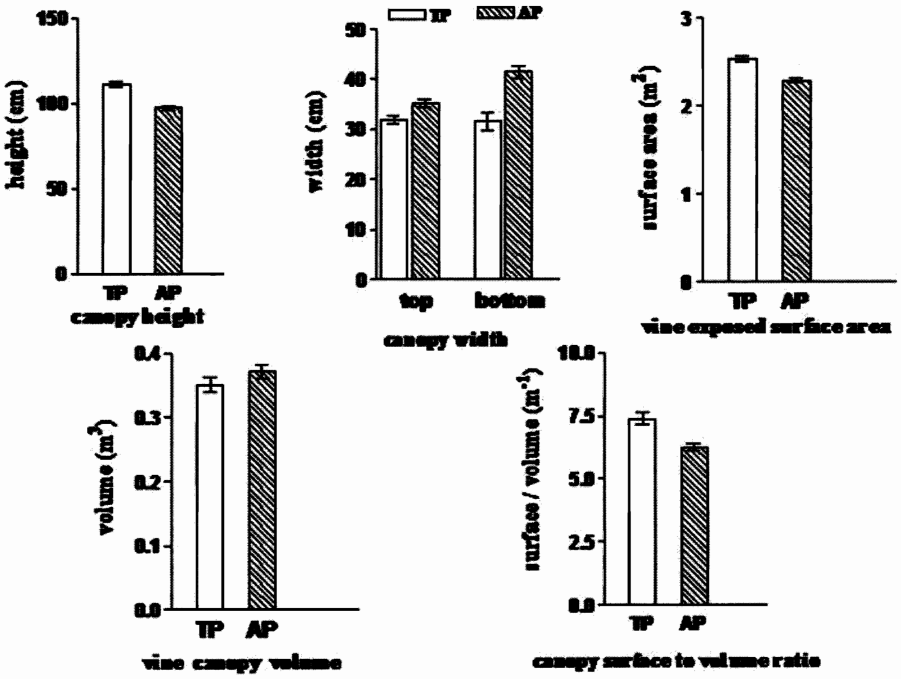

Figure 1 - Canopy geometry
Figure 1 - Géométrie de la plante

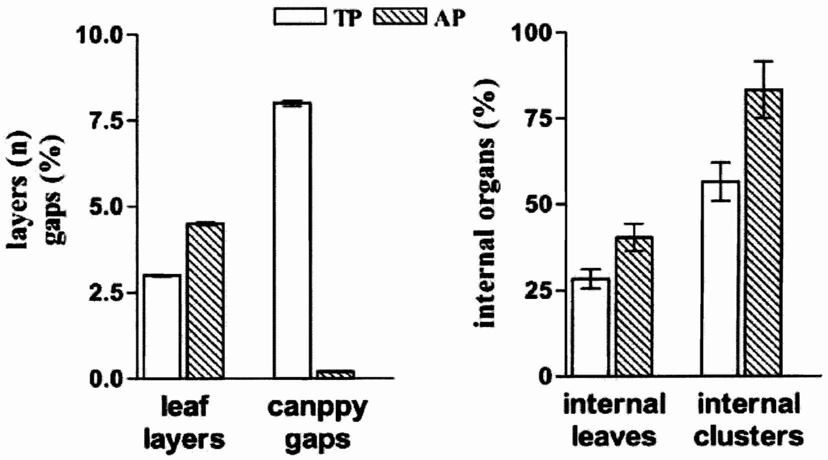

Figure 2 - Canopy structure
Figure 2 - Structure de la plante

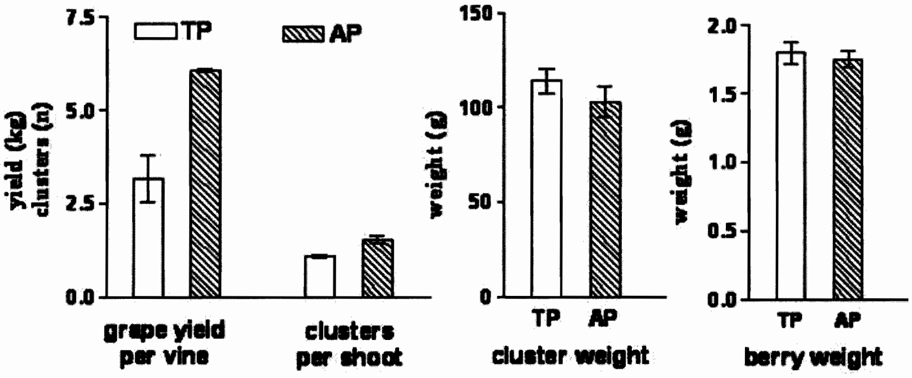

Figure 3 - Yield components
Figure 3 - Paramètres de rendements à la récolte

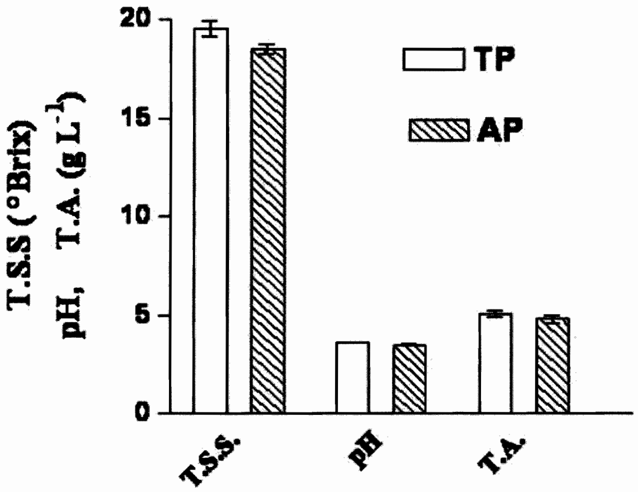

Figure 4 - Berry composition (technological parameters)
Figure 4 - Composition de la baie

Average PPF intercepted by the external canopy surface of vines in the two plots was about 1200 ÷1100 µmol m^{-2} $s^{-1,}$ without any relevant difference among canopy portions (top, middle or bottom). Due to leaf light absorption, PPF available in the centre of the canopy interior was only 4÷5% of that intercepted by the external surface, independently from the pruning treatment.

On the West canopy side, where only diffused radiation was available at the time of measurement, the PPF was 10% of that found at the East side, either in TP or AP treatment.

On the whole, the chance of light interception per unit of canopy surface area did not change between the two treatments.

Yield components and berry composition

The grape yield was about 3 kg in traditionally pruned vines; alternative pruned vines showed a higher yield, as it commonly occurs with mechanical pruning methods leaving a greater bud number per vine (Clingeleffer, 1984; Reynolds, 1988; Archer and van Schalkwyk, 2007). In the present trial, the grape yield was almost doubled (fig. 3). This result seemed equally ascribable to the higher shoot number per vine and to the greater shoot fertility (number of clusters per shoot) showed by AP vines (~1.7 vs. 1.1), which may be interpreted as a compensative effect for the high bud blindness.

The cluster and berry weight, which were respectively 114 g and 1.8 g in TP vines, slightly decreased in AP vines (-10% and -5%). Also this behavior has been widely observed, as reported by the above mentioned Authors, and compensate for the greater vine yield.

In comparison to the Nero di Troia shoot fertility (1.5), cluster weight (250 g) and berry weight (2.5 g) that we commonly observe in the *Castel del Monte* area, values found in this trial were lower, likely due to the severe drought conditions that occurred during the 2007 and 2008 grapevine vegetative period.

Although the vine productivity was very different between the two treatments, little changes in berry composition were observed as concerns the "technological" parameters. In comparison to total soluble solids (19.5 °Brix), pH (3.6) and titratable acidity concentration (4.5 g L-1) of grapes from TP treatments, grapes from AP treatments showed only a 5% of reduction (fig. 4).

By analyzing the berry distribution among the seven classes of weight considered in this trial (fig. 5), it was an evident tendency of AP grapes to have a higher incidence of berries weighting 1.0-2.0 g (52% of total number and 44% of total weight), while in TP grapes prevailed berries weighing more than 2.0 g (70% as total number and 50% as total weight). In both treatments, the berry weight was strongly correlated to the berry diameter; the regression coefficient between the two parameters (r2) was as high as 0,97 for TP ($p < 0{,}0001$) and 0,95 for AP ($p < 0{,}0001$), thus the weight may be considered as a good indicator of the berry size which, in turn, may affect the must composition. The reduction of berry size is known to increase the skin/pulp ratio and thus the must phenol concentration and the wine quality (Singleton, 1972; Ojeda *et al.*, 2002).

By analyzing the index of total skin phenol content according to the five central classes of berry weight, which were the most represented in the bunches, it was evident a tendency of the lighter berries to accumulate more anthocyanins and flavans reacting with vanillin per kilogram of grapes; this effect was less evident for flavonoids (fig. 6). This tendency concerned, in particular, berries weighting from 1 to 2 grams. The occurrence of this type of berries ranged from 32% in TP to 52% in AP when calculated on

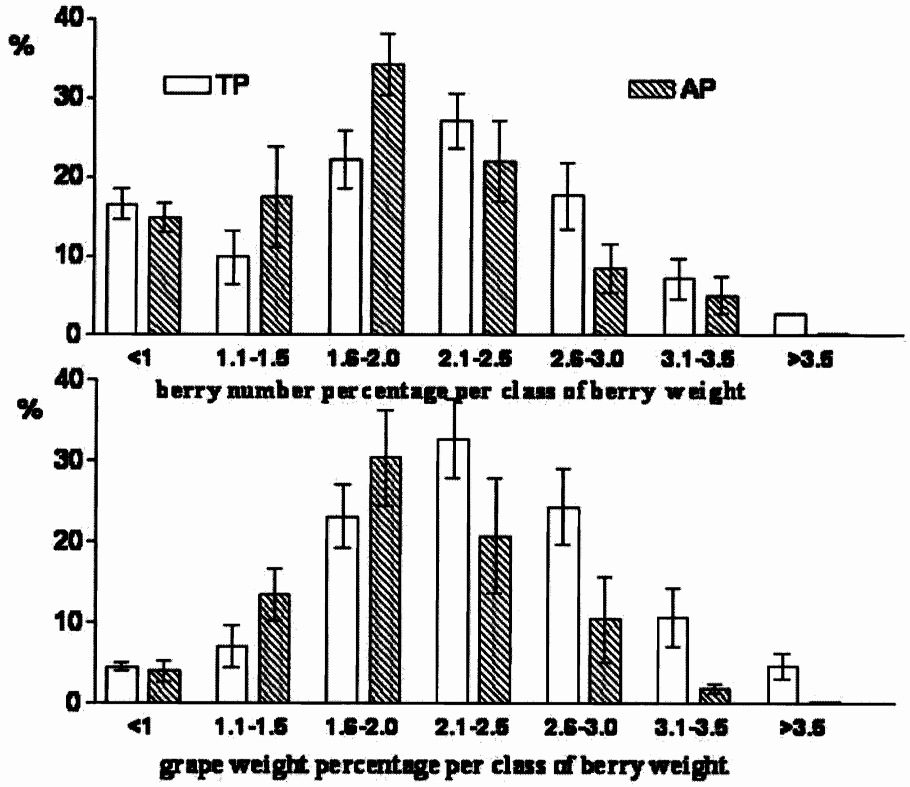

Figure 5 - Berry distribution per class of weight
Figure 5 - Distribution des baies par classe pondérale

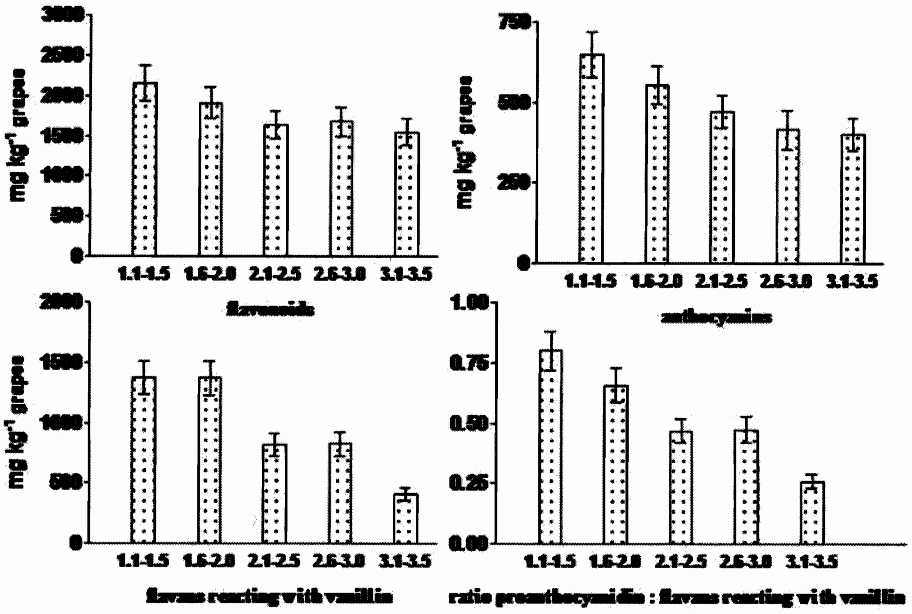

Figure 6 - Index of total phenol content in berry skin per class of berry weight
Figure 6 - Index des phénols dans la pellicule de la baie par classe pondérale de la baie

per number basis, and from 30% in TP and to 44% in AP when calculated on per weight basis. Variations of skin total polyphenol and proanthocyanidin concentration did not show a clear trend (data not shown). However, as a consequence of the lower ratio between the proanthocyanidins and the flavans reacting with vanillin, the heavier berries could have a potentially smoother taste.

When skin total phenol content was analyzed on berry samples taken from the grape mass, and was expressed on per berry basis which is useful to evidence to the physiological impact of the treatment on the synthesis of berry compounds (Ojeda *et al.*, 2002; Carbonneau *et al.*, 2003), the alternative pruning method resulted do decrease the anthocyanins by 3% and the total polyphenols, flavonoids, flavans reacting with vanillin and proanthocyanidins by about 15% respect to the traditional pruning method; the ratio between the two latter compounds did not change (fig. 7). A decrement of phenol content in grapes produced by mechanically pruned vines was expected because of the higher vine productivity and canopy shading. Nevertheless, compared to the yield

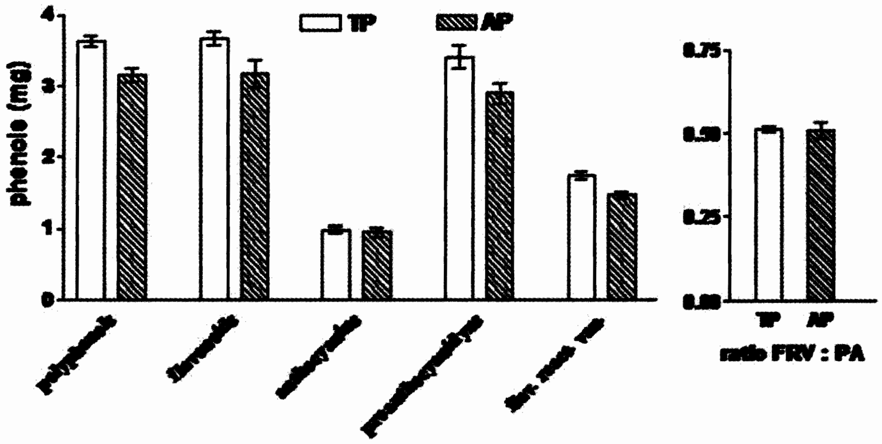

Figure 7 - Index of total skin phénol content per single berry
Figure 7 - Index de phénols totaux dans la pellicule, par baie.

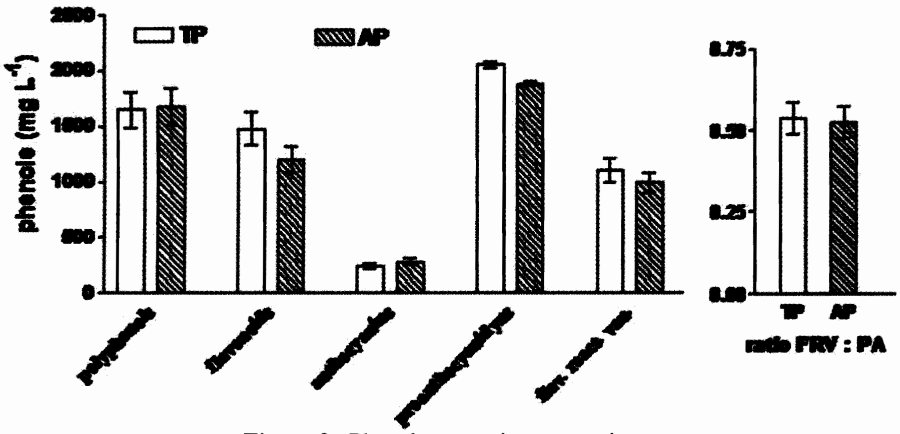

Figure 8 - Phenol content in young wines
Figure 8 - Teneur en phénols du vin jeune

increment, the phenol decrement was not too much marked; the higher incidence of berries weighting 1-2 g in the grape mass could have exerted a partial compensative effect. Those observations point out the interest to repeat these analyses over more years and to check more precisely the real consequences on wine quality using sensory analysis, and also to pay attention to berry sanitary status.

Analyses performed on young wines showed that, at that point of their evolution, the wine obtained from the high producing mechanical pruned vines had same polyphenol concentration of the wine obtained by the traditionally pruned vines (fig. 8).

A tendency for a lower flavonoid (-19%) and a higher anthocyanin concentration (+18%) was observed, although these differences did not achieve a high level of statistical significance, ($p \leq 0,05$). An improvement of red color has been sometimes observed in wines of other red cultivars, possibly due to a higher skin/juice ratio of the berries, which were characterized by a lighter mass (Archer and Schalkwyk, 2007). Both proanthocyanidins and flavans reacting with vanillin were significantly lower in AP young wines, by -11% and -8% respectively; since these two compounds showed a similar decrease, their ratio did not change. This latter parameter is a good indicator of the flavanol polymerization level and thus of the tannin astringency (Cagnasso *et al.*, 2005-2006). Hence, the smoothness of the two wines might be quite similar.

Although all these behaviors should be better investigated, the observed tendencies seemed helpful to maintain a good quality in grapes produced by mechanical pruned vines, in spite of their high yield.

Further analyses to carry out at the end of the wine evolution will give a more complete information on the enological potential of the grapes produced by adopting the traditional and the mechanical pruning. Moreover, it should be also investigated the percentage of phenol extractability from berry skin into the must as well as the seed phenol contribute to the wine composition; both these aspects have not been analyzed in this paper.

CONCLUSIONS

The first results of the mechanical pruning experimented as an alternative to the traditional manual pruning seem to indicate that this method might be conveniently adopted, on a large scale, with Nero di Troia grown in the *Castel del Monte* area of Southern Italy, since it may increase the yield without inducing a sensible penalization of the grape quality.

This result could be interpreted as a consequence of some partial compensative effects, such as the greater bud number per vine vs. the greater bud blindness percentage, the greater bud blindness vs. the higher shoot fertility, the higher shoot fertility vs. the higher incidence of lighter and smaller berries which seemed characterized by a higher concentration of some, but not all, important phenol compounds. A deeper investigation including the assessment of the skin/pulp ratio according to the class of berry weight, the phenol extractability and the analysis of mature wines is necessary to provide more information.

Since only two years passed from when the alternative mechanical pruning has been applied, further investigation is in any case necessary to understand if the mechanical pruning method tested in this trial could be reliable over a long period. Results of more vintages should be examined since the "year effect" could exert a determinant influence on the grape and wine quality as related to different pruning treatments (Holt *et al.*, 2008).

At the moment, the loss of energy efficiency of the mechanically pruned canopies is moderate, and this parameter could be considered as a synthetic index of the global result.

It is very important to assess the influence that the progressive increase of the bud number per vine will have on the bud blindness, the canopy compactness, the grape yield, the berry phenol concentration and extractability, as well as to understand the possible interaction among these parameters and the different vintages. It will be also important to check, in the future, the sanitary status of the crop and the wine quality using sensory analysis as well.

Finally, a specific economical analysis to compare the costs of the manual and the mechanical pruning was not performed in this work; however, a preliminary calculation indicated that the mechanical method could reduce the pruning expenses by about 40%.

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