Research on planting density of ‘Sangiovese’ and ‘Cabernet Sauvignon’ varieties

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Abstract

This research was undertaken to improve knowledge of ‘Sangiovese’ and ‘Cabernet Sauvignon’ production behaviour at different planting densities in a vineyard trained to horizontal spur cordon and located on Tuscan coastal area. The trial was conducted during a four year period (1997-2000) in a vineyard set up in 1994, comparing four planting distances (2.8 x 1.2; 2.0 x 1.5; 2.5 x 1.0; 2.0 x 0.75) at a density ranging from a minimum of 2976 to a maximum of 6667 vines/ha. ‘Cabernet Sauvignon’ was more vigorous, produced smaller clusters, had higher bud fertility, a lower yield and Ravaz index than ‘Sangiovese’. The must of ‘Cabernet Sauvignon’ had less titratable acidity and higher pH and total soluble solids content than ‘Sangiovese’. In general yield and production of wood per square meter were positively related to the increase in planting density, while pruning wood per linear meter showed an opposite trend. In ‘Sangiovese’ both inter-row and along the row spacing had a marked influence on yield and vegetative performance while in ‘Cabernet Sauvignon’ the effect of the spacing along the row seems to be prevailing. The results of this research indicate that in the Tuscan coastal area, planting density had no significant influence on grape quality in both cultivars.

1. Introduction

The choice of appropriate planting density results from a compromise between the need for mechanical access in order to carry out crop management practices and the achievement of an adequate qualitative level of the product. In Italy there is increasing interest in evaluating factors that have a positive influence on grape quality, with special emphasis on higher planting densities (Pisani, 1990). It is in fact widely believed that by increasing the number of vines per unit of area and reducing the quantity of production per vine, more elevated grape quality can be achieved. Therefore the possibility of adopting higher planting densities than those traditionally used has been investigated (Di Collalto et al., 1987; Intrieri, 1987; Bandinelli et al., 1993; Di Collalto and Cesari, 1994; Loreti et al., 1994). However, interpretation of the results has proved rather complex, partly due to the heterogeneity of the pedoclimatic environments, partly also because of the multiple intrinsic factors involved, such as grapevine variety, rootstock, crop management techniques, spatial arrangement of the canopy and extent of exposed leaf area (Scalabrelli, 1995; Carbonneau, 1996; Calò et al., 1999; Valenti et al., 1999a,b; Scalabrelli et al., 2001).
According to various authors the concept of planting density does not have an absolute meaning as far as quality is concerned; adjustment of grapevine physiological balance to the pedoclimatic potential of the environment would appear to be a more appropriate concept (Intrieri, 1995; Calò et al., l.c.). In this perspective, the choice of a particular planting arrangement should be considered as a means to

adapt the vigour of the given variety to the potential of the ecosystem (Calò et al., l.c.), limiting the need for operations such as topping, shoot thinning, bunch thinning, etc. (Intrieri, l.c.). It is therefore difficult to give general indications valid for all zones and all grapevine varieties. A case by case approach, choosing for each environment condition the planting arrangement that is most suitable to optimise quality, is necessary (Valenti et al., l.c.).

The present research was therefore undertaken to improve knowledge of 'Sangiovese' and 'Cabernet Sauvignon' production behaviour at different planting densities in the Tuscan coastal area environment, specifically in the DOC zone 'Monteregio di Massa Marittima' (province of Grosseto) where cv. 'Sangiovese' is traditionally grown and 'Cabernet Sauvignon' has been recently introduced.

2. Material and methods

Trials were conducted in a 0.8 ha experimental vineyard set up in 1994 at the municipality of Massa Marittima (province of Grosseto). The vineyard was established at four planting density with 'Sangiovese' clone 'SS-F9-A5-48' and 'Cabernet Sauvignon' clone 'R4' grafted on '420A' (Table 1). Vines were trained to horizontal spur cordon supported on wire at 80 cm from the ground, leaving a number of buds per ha as reported in Table 1. Experimental plot soil had a loamy-clayey-sandy texture, with sub-alkaline pH, negligible quantities of active and total limestone and low organic matter content (Table 2). Climatic conditions during the period April-September are summarised in Table 3.

Each treatment had 4 replications. Within each block, 6 representative plants were marked so as to be utilised throughout the four-year period 1997-2000 for determinations of: bud fertility, bunch weight, grape production and weight of pruning wood (per vine, per area unit and per linear meter of row). Ravaz index was also calculated by ratio between grape production and pruning wood. In addition, at harvest berries were sampled in order to determine total soluble solids (°Brix), titratable acidity, pH, as well as total polyphenols and anthocyanins content according to the Glories (1997) method.

The data were analysed by MANOVA and two-by-two differences were tested by applying Tukey's multiple range test. SPSS software was used. Different lower-case or capital letters indicate statistically different values ($p<0,05$) among 'Cabernet Sauvignon' and 'Sangiovese' planting densities respectively. The '*' symbol indicates statistical differences ($p<0,05$) between the averages of 'Cabernet Sauvignon' and 'Sangiovese' characteristics.

3. Results and discussion

The interrelations between microclimate, grapevine variety, training system, competition between vines, all play a role in modifying grapevine behaviour; therefore they can to some extent account for the influence of planting density on agronomic results (Ollat et al., 1994; Carbonneau 1993) and the frequently discordant data reported in the literature. In our experimental system, the interactions between planting density and growth year, planting density and grapevine variety, grapevine variety and growth year, were all found to be highly significant (Tables 4 and 5).

'Sangiovese' showed lower bud fertility (Figure 1) than 'Cabernet Sauvignon', as well as greater bunch size (Figure 2) and higher productivity per vine (Figure 3). In contrast, wood production per vine (Figure 4) and mean shoot weight (Figure 5) were lower in 'Sangiovese' than in 'Cabernet Sauvignon'. These differences in grape and

wood production led to a considerably higher Ravaz index in ‘Sangiovese’ (Figure 6). However, ‘Cabernet Sauvignon’ achieved higher must total soluble solids content (Figure 7), higher pH (3,42 vs. 3,31) and lower titratable acidity (Figure 8).
Planting density influenced in different way all growth and production parameters measured on ‘Sangiovese’ and ‘Cabernet Sauvignon’ confirming that the influence of planting density is strongly dependent on the vigour of the particular grapevine variety (Jackson and Lombard, 1993).
Bud fertility (Figure 1) of ‘Cabernet Sauvignon’ was higher at the 4000 vines per hectare density and more contained at the 6667 vines/ha densities, while in ‘Sangiovese’ no statistically significant differences were observed. On the latter cultivar bunch size (Figure 2) was inversely related to the inter-row spacing, being higher at the 2976 and 4000 planting densities which had larger inter-row distances (2.8 and 2.5 m respectively). In ‘Cabernet Sauvignon’ the differences were less pronounced, and bunch size was lower only at the density of 4000 vines/ha.
In ‘Sangiovese’ yield (Figure 3) and wood (Figure 4) production per vine decreased, as expected, with increasing number of vines per hectare, while in ‘Cabernet Sauvignon’ the yield was inversely related to the vine spacing along the row and the pruning weight decreased only at closer spacing (1.00 and 0.75 m) along the row.
Analysing the effect of different spacing on vigour level it can be noted that in both cultivars it was mainly affected by the inter-row spacing (Figure 5), being the mean shoot weight highest at the density of 4000 and 2980, respectively spaced between the rows by 2.5 and 2.8 m.
As regards the Ravaz index, no statistically significant differences among the 4 treatments were observed for ‘Sangiovese’ (Figure 6), while for ‘Cabernet Sauvignon’ the lowest value observed at wider spacing (2976 vines per hectare) indicate a vine balance more oriented towards vegetative activity. Yield (Figure 9) and wood production (Figure 10) per area unit were found to be more elevated at the highest planting density in both cultivars, although in ‘Sangiovese’ the higher bunch weight occurred at the larger spacing had a compensatory effect on yield per area unit. This effect was not observed in ‘Cabernet Sauvignon’. Moreover on the latter cultivar wood production per linear meter of cordon was inversely related to the row spacing (Figure 11). On the other hand, grape production per linear meter along the row (Figure 12) did not differ in ‘Cabernet Sauvignon’ while in ‘Sangiovese’ was highest at the lower planting density (2976 vines/ha), having the widest inter-row spacing (2.80 m).
These results suggest that in our experimental system, the effects of planting density were due to the combination of two distinct factors: the vine spacing along the row and the inter-row spacing. Although spacing along the row is often considered to be the main factor influencing the balance of the plant, it should be kept in mind that inter-row spacing is not only responsible for a possible shading and for adjustment of production per area unit, but it can also influence inter-row soil water content (Hunter, 1998; Intrieri, l.c.; Valenti et al., l.c.). Therefore, our data suggest a direct relationship between vigour and inter-row spacing. A possible explanation is that the greater quantity of linear meters of canopy in densities with closer inter-row spacing, and consequently the greater quantity of leaf surface exposed, may have constituted a vigour-limiting factor due to the greater transpiration demand precisely at a period of low summer rainfall.
The influence of planting density on must characteristics was less marked. In general, no variation in total soluble solids content (Figure 7), pH and titratable acidity (Figure 8) was observed. It is worth noting that planting density exerted no

appreciable influence on berry total anthocyanins and polyphenols content. Overall, however, 'Cabernet Sauvignon' was richer both in anthocyanins (891 $mg \cdot Kg^{-1}$ vs. 654 $mg \cdot Kg^{-1}$) and polyphenols (66 o.d. vs. 58 o.d.).

Several trials on planting density carried out in 'Sangiovese' and 'Cabernet Sauvignon' in 'Chianti Classico' area reported that at closer planting spacing the vegetative activity increased, according to the cultivar and the rootstock, with favourable effects on ripening and grape quality of 'Sangiovese', but not in 'Cabernet Sauvignon' (Di Collalto, 1992, Di Collalto and Cesari, l.c.). In the same area vegetative and productive behaviour in 'Sangiovese' planted at different spacing, were also related to the soil characteristics. In particular, in poor soils the best grape and wine quality were obtained with higher planting density, on the contrary middle density gave the best performances on more fertile soils (Bertuccioli et al., 2001; Scalabrelli et al., l.c.).

4. Conclusion

In the environment of the Tuscan coastal area 'Cabernet Sauvignon' was shown to be more fertile, more vigorous, earlier and less productive than 'Sangiovese'. These results confirm that the influence of planting density is strongly dependent on the particular grapevine variety. In 'Sangiovese' both inter-row and the row spacing had a marked influence on yield and vegetative performance, while in 'Cabernet Sauvignon' the effect of spacing along the row seems to be prevailing. As far as grape quality is concerned, since planting density appeared to have no significant effect either on anthocyanins and polyphenols content or on must chemical-physical characteristics it would be misleading to claim the existence of a direct correlation between planting density and grape quality.

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Table 1. ‘Sangiovese’ and ‘Cabernet Sauvignon’ experimental vineyard parameters.

Thesis	Distance between the rows	Distance on the row	Planting density	Linear meter of canopy/ha	Bud load/ha	m^2 of the leaf surface area/ha
1	2.80	1.20	2976	3571	37000	9643
2	2.50	1.00	4000	4000	40000	10800
3	2.00	1.50	3333	5000	45000	13500
4	2.00	0.75	6667	5000	50000	13500

Table 2. Soil properties of the experimental vineyard.

Physical	parameter (units) value	Sandy (%) 21.30	Loam (%) 36.20	Clay (%) 42.50	
Chemical	parameter (units) value	pH 7.27	Exange Cationic Capacity (meq) 24.4	Total limestone % <0.5	Organic matter (%) 1.35
Macroelements	Paramete r (units) value	Total Nitrogen (‰) 0.60	P_2O_5 available (ppm) 5	K_2O available (ppm) 72	

Table 3. Meteorological conditions recorded at Massa Marittima during the period April through September (avg 1997-2000).

Climatic data	T° min	T° max	T med	Degree days[1]	mm
Temperature	15.0	27.1	20.8	1976	
Rainfall					276
ETP					907
Teoric Water Deficit[2]					- 268

[1] = calculated according to Winkler et al. (1974).
[2] = calculated according Huglin (1986)

Table 4. Results of analysis of variance performed on vegetative and productive behaviour on 1997-2000: F of Fisher and their level of significance. D: density; wgt: weight; BF: bud fertility; C: cluster; Y: yield; P: pruning; MS: mean shoot.

Factors	BF	C wgt	Y · vine	Y · m^{-2}	Y · m	MS · wgt	P wgt · vine	P wgt · m^{-2}	P wgt · m	Ravaz
cv (A)	72.6**	402**	35.9**	31.4**	40.8**	19.3**	221**	190**	212**	177**
D (B)	7.41**	1.41	73.7**	6.90**	5.13**	11.0**	91.1**	22.0**	27.6**	1.63
Y (C)	57.2**	61.8**	32.2**	36.0**	37.6**	50.0**	5.24**	4.24**	80.5**	25.5**
AxB	3.65**	5.14*	11.4**	6.15**	7.82**	2.34**	12.0**	6.62**	9.99**	1.57
AxC	16.3**	8.48**	6.31**	6.44**	5.56**	33.3**	19.7**	17.9**	15.0**	15.7**
BxC	3.88**	1,13	1.80	2.71**	6.59**	2.97**	3.09**	2.84**	16.9**	2.86**
AxBxC	4.00**	1,16	2.08*	1,81	1.60	1.50**	3,10**	2.43**	3.99**	1.37

Table 5. Results of analysis of variance performed on several must parameters on 1997-2000: F of Fisher and their level of significance. cv: cultivar; Den: density; TSS: total soluble solids; TA: titratable acidity; Ant: total anthocyanins; Poly: total polyphenols.

Factors	TSS	pH	TA	Ant	Poly
cv (A)	41.8**	50.5**	9.79**	75,80**	6,63**
Den (B)	0,68	0.59	0,21	1,76	1,28
Year (C)	5,59**	49.2**	225**	0,70	1,50
AxB	0,82	1.97	0,21	0,88	0,74
AxC	4.04	11.0**	2.25	0,20	1,32
CxB	1.75	1.87	0,98	0,88	0,27
AxBxC	0.29	0,95	0,79	0,67	0,48

Fig. 1

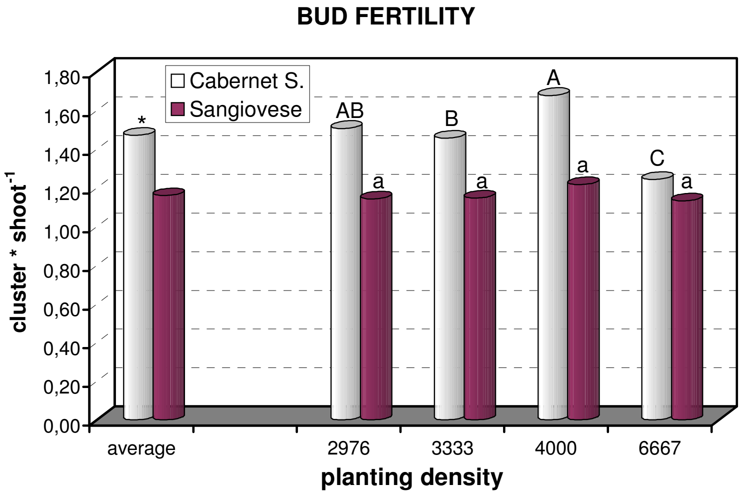


Fig. 2

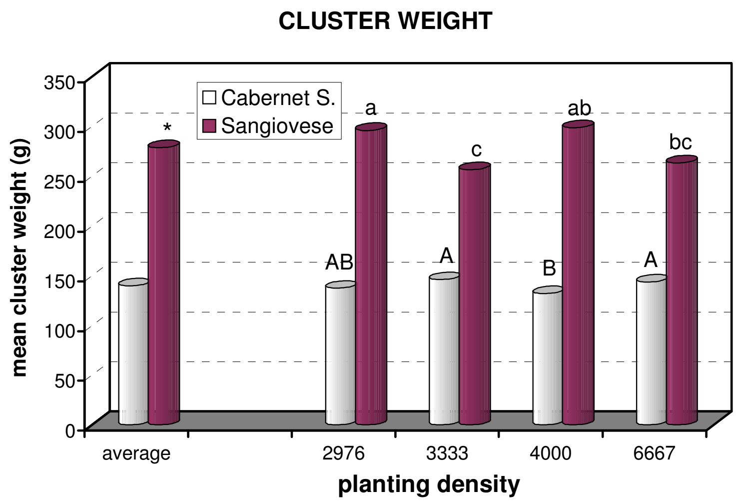
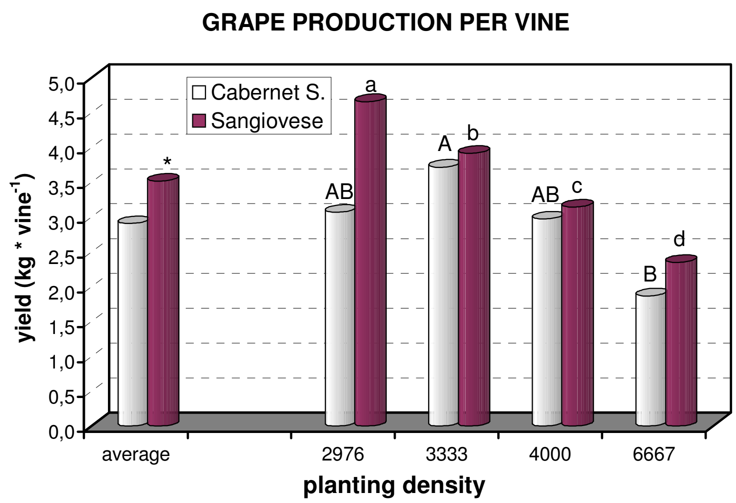


Fig. 3



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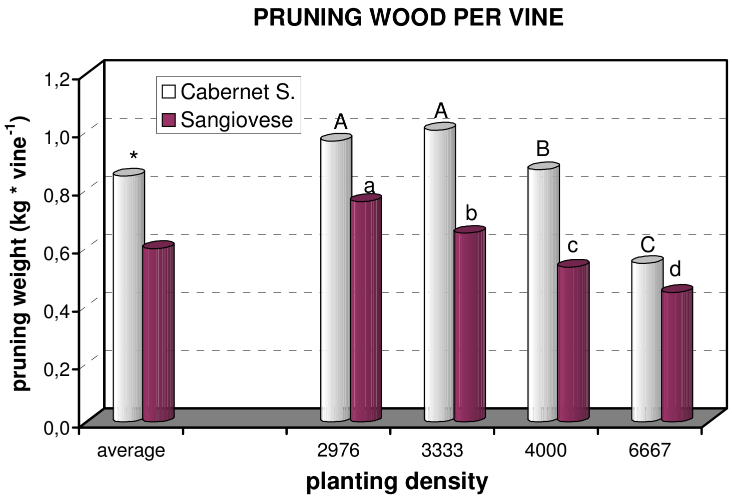

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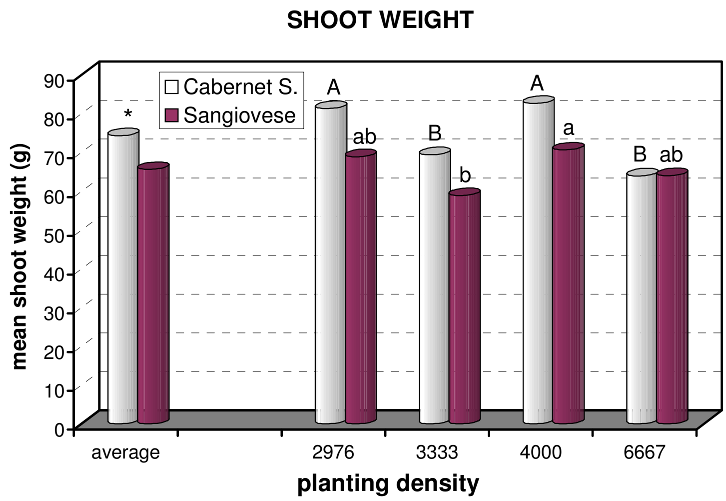

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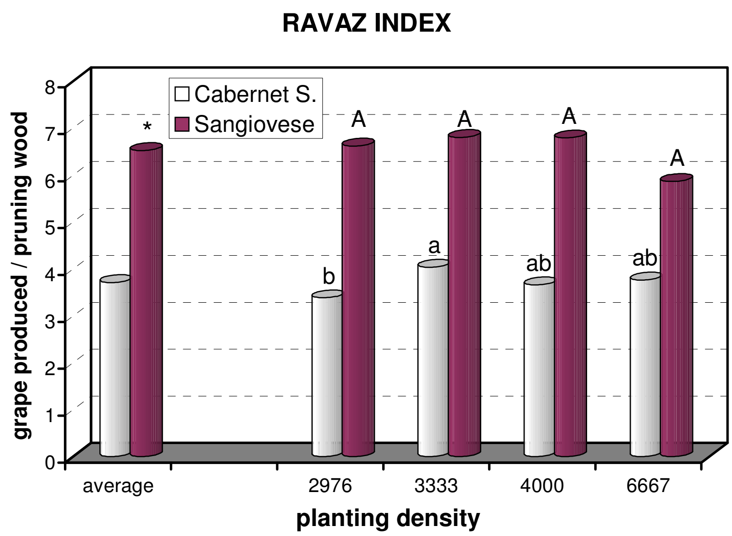

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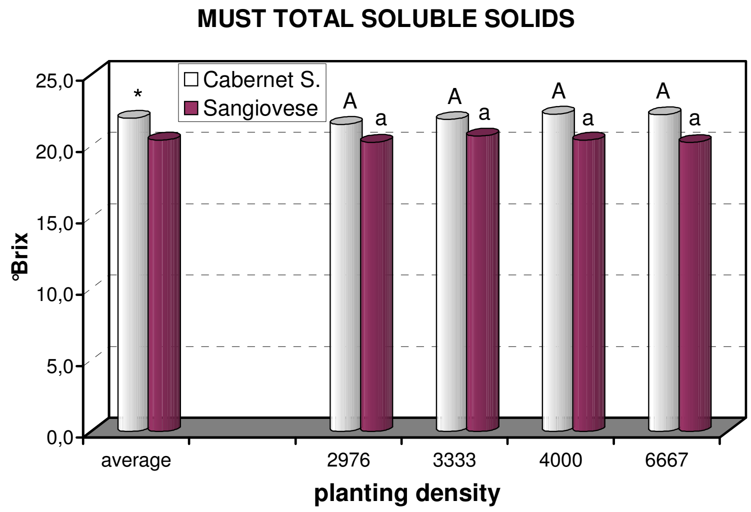

Fig. 8

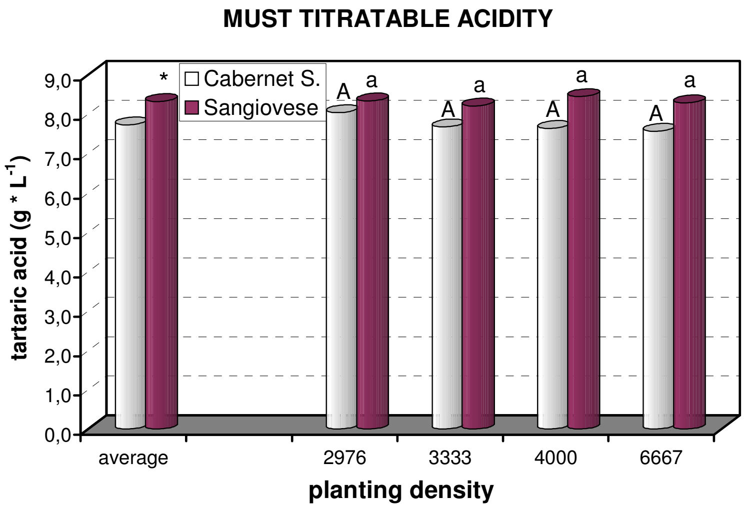

Fig. 9

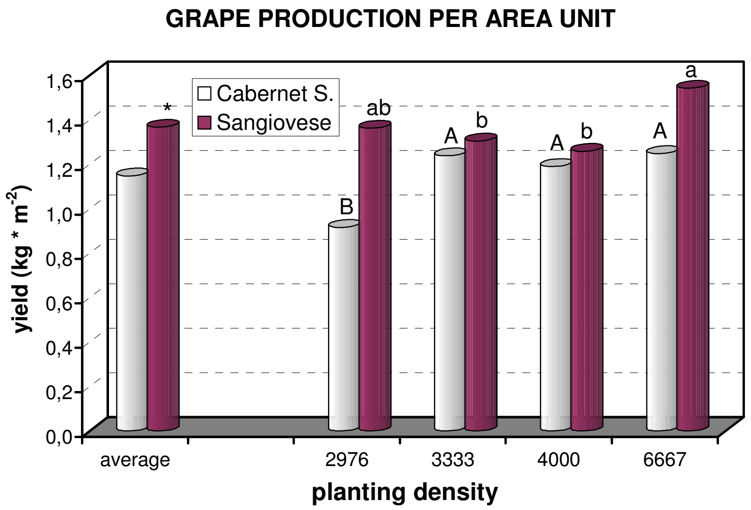

Fig. 10

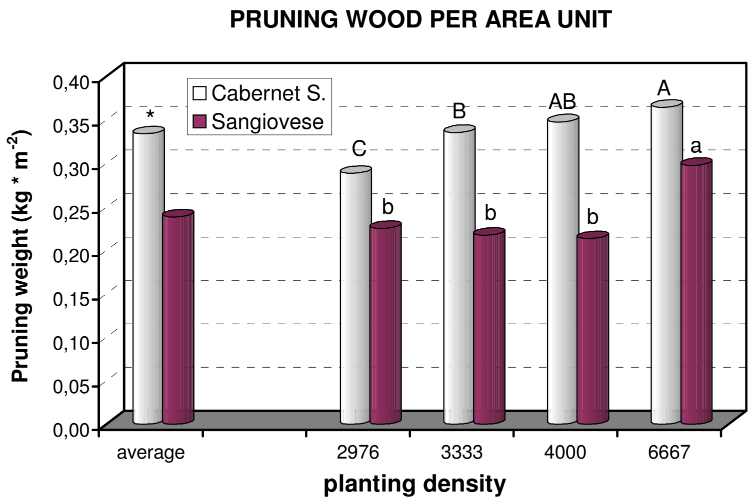

Fig. 11

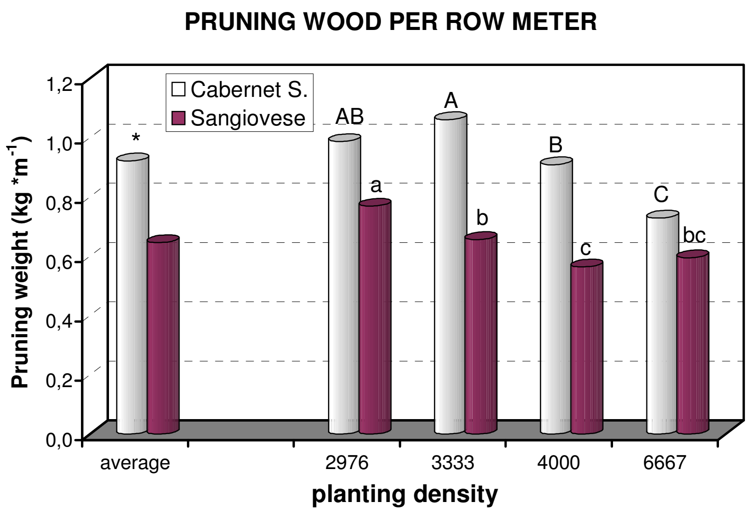

Fig. 12