Agrovoc descriptors: vitis vinifera, varieties, pruning, plant training, buds, grape must, quality, crop yield, chemical composition, carbohydrate content, sugars, acids, climatic factors

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Influence of crop load on yield and grape quality of cv. `Chardonnay`

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ABSTRACT

In the research we tried to define proper crop load for cv. `Chardonnay` (*Vitis vinifera* L. cv. `Chardonnay`) trained on the 1.7 m high cordon trellis in the Vipava Valley. The experiment was designed as a block trial. Three levels of crop load were employed and inspected for their influence on yield and grape quality: normal crop load with 20-30 buds per vine, lower crop load with 20 buds and higher crop load than normal with 40 buds per vine. Bearing wood at the normal and higher than normal crop load was canes with 8-10 buds per cane and at the lower crop load longer spurs with 4-5 buds per spur. The lower crop load resulted in lower yield/vine together with higher must sugar content, its lower acids content and higher pruning weight. The extent of differences was strictly dependent on the climatic conditions in each year of the experiment. The normal crop load showed its great variability in the research results. The grape quality was quite high in all three treatments. Satisfactory must sugar content was obtained with the normal or even higher crop load. The proposed number of buds at winter pruning is approximately 40-45 buds/kg of pruning weight. Normal Ravaz index for defined conditions is between 7-10. In spite of the fact that the weather conditions in each year of the experiment appear to have had the strongest impact on the must acids content, the problem of its additional decrease should be taken into consideration when the lower crop load is applied.

Key words: grapevine, Chardonnay, crop load, grape quality, cordon trellis

IZVLEČEK

VPLIV OBREMENITVE NA PRIDELEK IN KAKOVOST GROZDJA SORTE `CHARDONNAY`

V poskusu smo proučevali primerno obremenitev za sorto `Chardonnay` (*Vitis vinifera* L.) na 1,7 m visokem kordonu v vinorodnem okolišu Vipavska dolina. Poskus je bil zasnovan v bločni zasnovi. Ugotoviti smo želeli vpliv treh različnih osnovnih obremenitev na pridelek grozdja in lesa ter kakovost grozdja in sicer pri normalni obremenitvi z 20-30 očesi na trs, pri nižji z 20 očesi in višji z 40 očesi na trs. Rodni les so pri normalni in višji obremenitvi predstavljali šparoni z 8-10 očesi na šparon, pri nižji pa daljši rezniki s 4-5 očesi. Nižja obremenitev je vplivala na zmanjšanje pridelka na trto skupaj z zvišanjem sladkorne stopnje in znižanjem vsebnosti skupnih kislin v moštu ter zvišanjem količine porezanega lesa ob

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zimski rezi. Obseg razlik med različnimi obremenitvami je bil odvisen od klimatskih razmer v posameznem letu poskusa. Normalna obremenitev je dala najbolj spremenljive rezultate. Kakovost grozdja je bila sorazmerno visoka pri vseh treh obremenitvah. Zadovoljivo vsebnost sladkorja v moštu smo dosegli z normalno ali celo z višjo osnovno obremenitvijo. Primerno število puščenih očes pri zimski rezi je 40-45 očes/kg porezanega lesa. Normalne vrednosti za Ravaz indeks so med 7-10. Pri nižji obremenitvi od normalne je potrebno upoštevati znižanje količine skupnih kislin v moštu, čeprav se je izkazalo, da na njihovo vsebnost najmočneje vplivajo vremenske razmere v posameznem letu.

Ključne besede: vinska trta, Chardonnay, obremenitev, kakovost grozdja, kordon

1 INTRODUCTION

The adjustment of the optimum crop load in order to achieve expected wine quality is still the most discussed viticulture matter. It is difficult to propose proper number of buds per vine for a defined soil type, climatic conditions, scion/rootstock combination and trellis. Therefore permanent necessity for such investigation is always present, especially in regions where these connections are poorly understood. It is also widely believed by the vine growers that high-yielding vines produce lower-quality wines. This thought should be considered carefully as it depends primarily on fertility and quality of the cultivar and growing conditions of the vineyard (Winkler et al., 1974; Smart and Robinson, 1991).

Cv. `Chardonnay` is a world spread grapevine cultivar grown on 130.000 ha worldwide and also planted in all three wine growing regions in Slovenia. Its great capability to adapt to different soil and climatic conditions makes it very popular and frequently planted. But it has also some drawbacks such as its sensibility to powdery mildew (*Oidium tuckeri* Berk.), grey mould (*Botrytis cinerea* Pers.), grapevine fanleaf degeneration (GFLV), both types of grapevine yellows *Flavescence dorée* and *Bois noir*, Esca (*Phellinus igniarius* (L. ex Fr.) Quél., *Stereum hirsutum* (Willd. ex Fr.) S.F. Gray) and also to millerandage in some regions. In the Vipava Valley cv. `Chardonnay` is planted on 5 % of approximately 2.500 ha of viticulture areas. According to the l´ENTAV classification clones 76 and 95, planted in the experiment vineyard, belong to the group B of the clones with average production and quality (Boidron, 1994; Wolpert et al., 1994; Crespan and Colugnati, 2001; Bettiga, 2003).

The relationship between the crop level and the wine quality was widely investigated and reviewed (Winkler et al., 1974). A few research results are also available for some wide spread and locally grown cultivars in Slovenia (Koruza and Lokar, 1994; Čuš et al., 2003). Two major measures are employed for evaluating the crop load; leaf area to yield ratio and yield to pruning weight ratio which is more practical for field measurements (Bravdo et al., 1984; Smart and Robinson, 1991; Gal et al., 1997). Crop load expressed as yield to pruning weight ratio (kg/kg) is often highly correlated with yield to leaf area ratio (g/cm^2), providing a biological rationale for the relevance of crop load and wine quality relations (Naor et al., 2002). Adjustment of crop load can be done by means of pruning severity, shoot thinning early in the season and cluster thinning (Reynolds, 1989; Schalkwyk et al., 1995; Palliotti and Cartechini, 2000). The influence of different crop loads on grape and wine quality for different

cultivars and different wine growing regions has been extensively described and reviewed (Bravdo et al., 1985; Murisier and Zufferey, 1996; Carbonneau, 1997).

Therefore the aim of the research was to evaluate the effect of different levels of crop load on the grape quality of cv. `Chardonnay` in the lower Vipava Valley.

2 MATERIALS AND METHODS

The experiment was conducted in a seventeen-year old vineyard in the Vipava Valley wine growing district (AV Kromberk, Biotechnical Faculty) during the three growing seasons (2001-2003). The cultivar inspected was cv. `Chardonnay`, clones 95 and 76, planted in rows and grafted on SO4 rootstock. The spacing between rows and planting sites in the vineyard was 2.6 x 2.6 m. Two vines were planted per site. Vines were trained to a ´Casarsa´ trellis with 1.7 m high cordon with the normal crop load of three free hanging yielding canes per vine with 8-10 buds/cane. The vineyard was permanently green covered and no-tillage system was used. According to the climatic conditions (data not shown) the year 2001 could be considered as exceptional for this region with enough rainfall and very favourable weather conditions during the grape ripening, the year 2002 as quite normal with a lot of rainfall in August, and 2003 as extremely hot and dry.

The experiment was designed as a block trial with main factor of crop load expressed as the number of buds per vine fixed at winter pruning. Three levels of crop load were employed. The first treatment marked with 20-30 was 2-3 yielding canes per vine with 10 buds per cane. The second one labelled with 40 was a higher crop load than normal with 4-5 yielding canes with 8-10 buds per cane. The third treatment marked with 20 was a lower crop load than normal with 4-5 longer spurs with 4-5 buds per spur. The names of the treatments represent the number of buds per vine. The rows in the vineyard represented blocks in the experiment and they were four, two for each clone. The influence of the clones on the results was not evaluated in this experiment. In a single block three plots with 10 vines per plot were chosen and the treatment for each plot was allocated randomly.

At the harvest the yield per vine was weighed, the number of clusters per vine was counted and the sample of 100 berries per vine was taken. The samples of berries were analysed for must sugar and acids content. Sugar content was measured with a Digital vine refractometer WM-7 (Atago, Japan) in degrees Oe (^{o}Oe) and must acids content was deduced by titration with 0.1 M NaOH to the pH 8.2 endpoint.

During the dormant season, vines were pruned on a vine-by-vine basis. One-year-old canes were separated from the old wood and were weighed. The pruning weights are reported with the data from the previous growing season.

Data were statistically analysed using the multifactor analysis of variance and means were separated using the Duncan's multiple range test at a significance of $p \leq 0.05$.

3 RESULTS AND DISCUSSION

Yield per vine. The crop load significantly influenced the yield per vine in all three years. In 2001 (Figure 1), the treatment 20 with 3.9 kg/vine significantly differed from the treatments 20-30 and 40 with yields of 5.4 and 5.7 kg/vine, respectively. In the other two years all three treatments were grouped in three significantly different groups: in the year 2002 (Figure 2) by turns from lower to higher crop load the yield ranged from 4.1, 5.1 to 5.8 kg/vine, and in 2003 (Figure 3) in the same order of the crop load the yield was 3.5, 3.8 and 5.0 kg/vine. Interestingly, in 2002 the yield per vine for the treatment 20-30 changed in the opposite way from the other two

treatments, what was not true in the very dry year 2003. In this year the yield per vine decreased in the three treatments but surprisingly again, the most severe decrease was observed in the treatment with normal crop load. Altogether the yield per vine at the normal crop load was most unstable and unpredictable in comparison with the other two treatments.

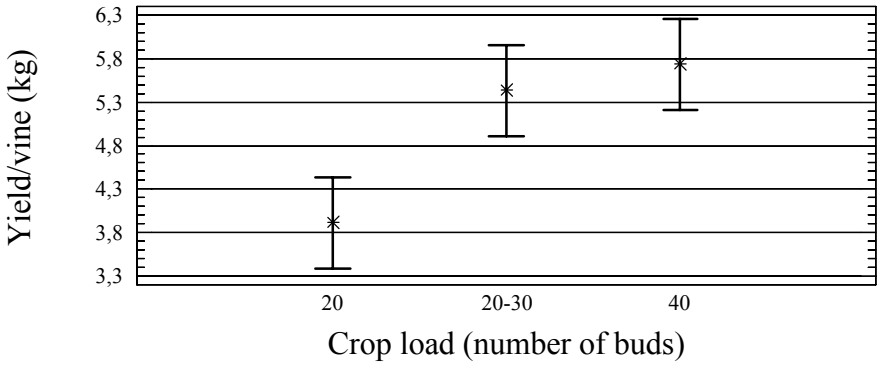

Figure 1: Means and confidence intervals (95 %) for yield per vine at three levels of crop load in 2001

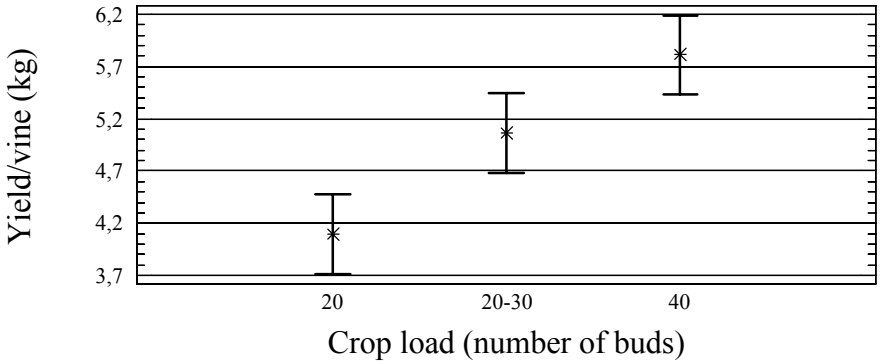

Figure 2: Means and confidence intervals (95 %) for yield per vine at three levels of crop load in 2002

The difference between the yield in the highest and the lowest crop load was quite stable in the three years and ranged from 1.8 kg/vine in 2001 to 1.5 kg/vine in 2003 that resulted in an average difference of 5.000 kg/ha at given planting density. If the normal crop load is compared with the highest one the difference between the treatments increased from 0.3 kg/vine in 2001 to 1.2 kg/vine in 2003. Consequently the difference between the normal crop load and the lowest one was decreased in the same period, from 1.5 kg/vine in 2001 to 0.3 kg/vine in 2003.

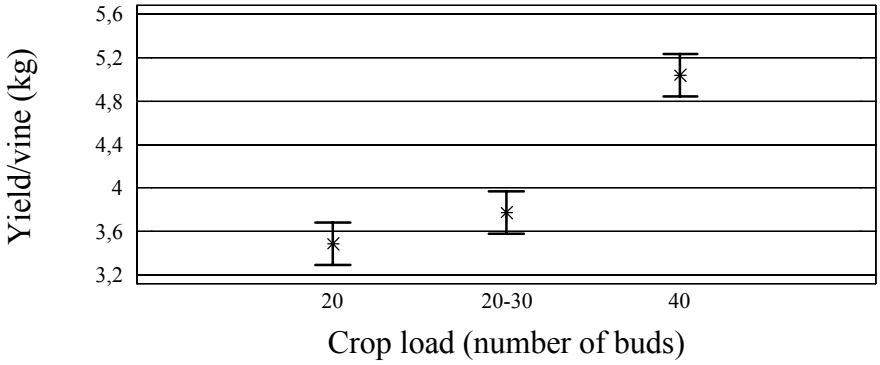

Figure 3: Means and confidence intervals (95 %) for yield per vine at three levels of crop load in 2003

Must sugar content. In 2001 the values for the must sugar content (Figure 4) ranged in the opposite way than the values for the yield per wine. At the lower crop load a higher value of the must sugar content was achieved (100.3 ^{o}Oe) and it significantly differed from the values in the other two treatments; namely, 95.4 ^{o}Oe for the normal and 92.1 ^{o}Oe for the highest crop load. In the next year (Figure 5) the values for all three treatments were lower but there were no significant differences between the treatments although the treatments grouped in different groups compared to the yield per vine. The treatments ranged in the same order with regard to the crop load as in 2001 with values 92.0, 90.1 and 89.6 ^{o}Oe from the lower to the higher crop load. The differences between them were less distinctive than in 2001. In 2003 the differences were higher again but not statistically different (Figure 6). If we compare the absolute differences among the treatments in 2003 with those from 2001 the values are almost the same. The must sugar content for crop load of 40 buds/vine was 92.4 ^{o}Oe, for 20-30 buds/vine the content was 97.8 ^{o}Oe and for 20 buds/vine it was 99.6 ^{o}Oe. The values were very close to those from 2001.

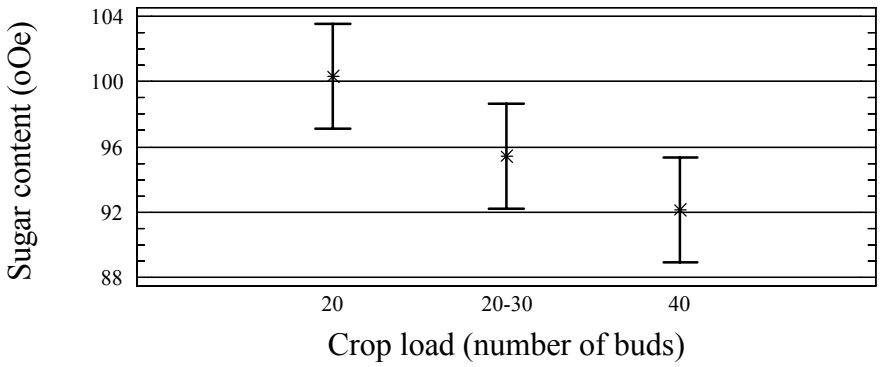

Figure 4: Means and confidence intervals (95 %) for must sugar content at three levels of crop load in 2001

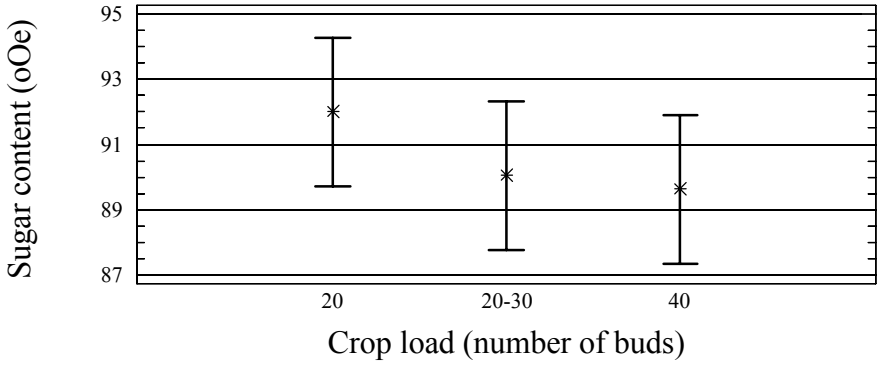

Figure 5: Means and confidence intervals (95 %) for must sugar content at three levels of crop load in 2002

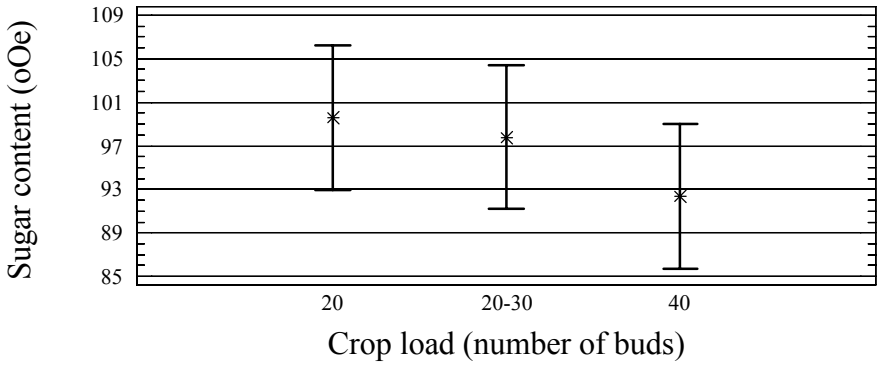

Figure 6: Means and confidence intervals (95 %) for must sugar content at three levels of crop load in 2003

Must acids content. The must acids content was not significantly different among the treatments in any of the experimental years. In 2001 (Figure 7) it was lowest in the treatment 20-30 with 4.5 g/l, followed by 4.7 g/l in the treatment 20 and 4.8 g/l in the

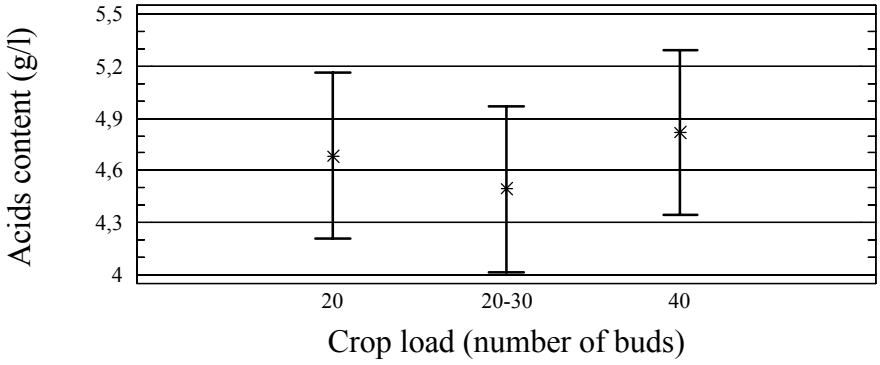

Figure 7: Means and confidence intervals (95 %) for must acids content at three levels of crop load in 2001.

treatment 40. The range in the other two years (2002 and 2003) was the same as the range for the yield per vine, it means that the low crop load influenced the low acids content and the higher crop load maintained the acids content slightly higher. The values in 2002 (Figure 8) were almost one fold higher than in 2001 and 2003 and ranged from 8.3 g/l in the treatment 20, 8.5 g/l in the treatment 20-30 and 8.6 g/l in the treatment 40. The results in 2002 were the consequence of the different climatic conditions in this year. The year 2003 was very dry what resulted in very low must acids content (Figure 9). With 20 buds/vine only 3.8 g/l must acids was maintained, followed by 4.0 g/l at the 20-30 buds/vine and 4.3 g/l at the 40 buds/vine.

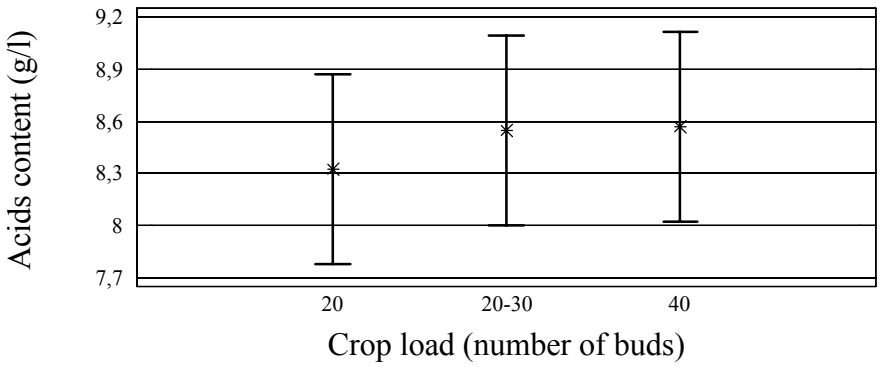

Figure 8: Means and confidence intervals (95 %) for must acids content at three levels of crop load in 2002

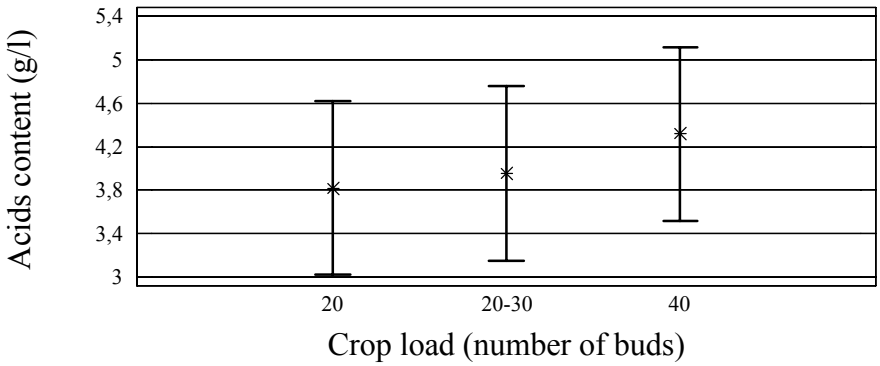

Figure 9: Means and confidence intervals (95 %) for must acids content at three levels of crop load in 2003

Pruning weight. The range of the pruning weights in 2001 (Figure 10) was opposite to that for the yield per vine in the same year (Figure 1). As it was shown before in the most cases these two parameters are reciprocally interdependent. There were no significant differences between the treatments in any of the experimental years. The pruning weights in 2001 were 0.58 kg/vine in the treatment 40, 0.71 kg/vine in the treatment 20-30 and the highest value of 0.74 kg/vine in the treatment 20. In 2002 (Figure 11) the pruning weights in the treatments 40 (0.76 kg/vine) and 20 (0.83 kg/vine) were higher in comparison with 2001. The same was true for the yields per vine (Figure 1 and 2). In the treatment 20-30 the yield/vine diminished and the pruning weight increased to the highest value (0.86 kg/vine) in the same year. This

result is in some way consistent if we consider the changing of the yield/vine in the opposite direction than in the other two treatments. From the physiological point of view a year dependent decrease in yield at the normal crop load (20-30 buds/vine) had a stronger influence on the pruning weight in comparison with the crop load decrease to 20 buds/vine at the lower crop load (Figure 1, 2, 10 and 11). In 2003 the influence of the very dry conditions could be observed. The pruning weight and the yield/vine had smaller values if all three years are compared. The values ranged from 0.46 kg/vine for the normal, 0.48 for the higher and 0.56 kg/vine for the lower crop load.

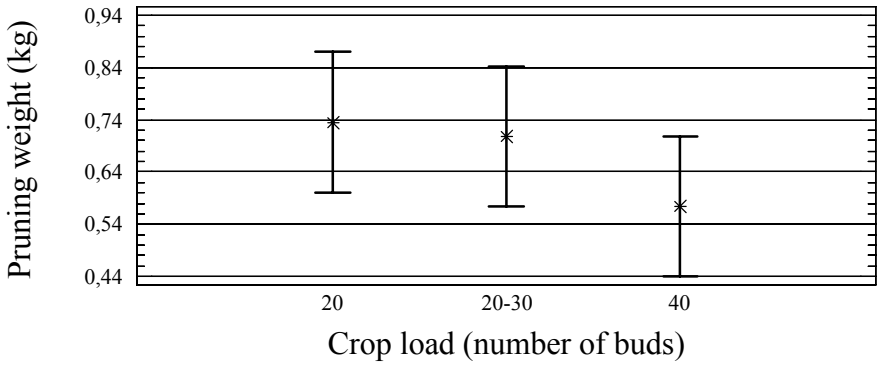

Figure 10: Means and confidence intervals (95 %) for pruning weight at three levels of crop load in 2001

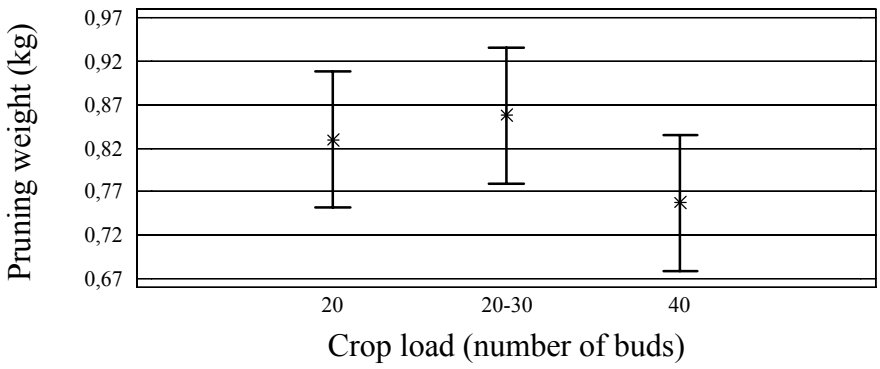

Figure 11: Means and confidence intervals (95 %) for pruning weight at three levels of crop load in 2002

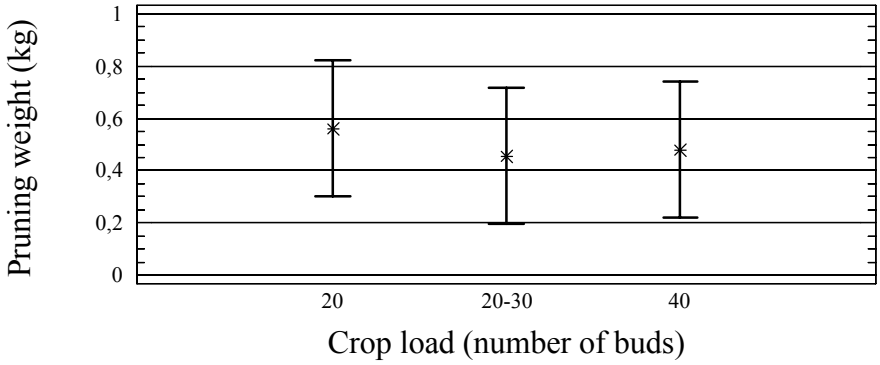

Figure 12: Means and confidence intervals (95 %) for pruning weight at three levels of crop load in 2003

4 CONCLUSIONS

The most common way of regulating the yield in a vineyard is the application of different number of buds per vine at winter pruning (Murisier and Ziegler, 1991). This agrees with the results of our experiment with cv. `Chardonnay` on a Casarsa trellis where important differences in yield/vine were obtained regarding to a different number of buds/vine left at winter pruning. The Casarsa trellis is one of the most used in the Primorska wine growing region and is nowadays considered to be a high productive but low grape quality trellis especially when high yielding cultivars are trained on it. Our results showed that high quality cultivars, i.e., cv. `Chardonnay`, could achieve good results even on this trellising system.

Interestingly, the normal crop load (20-30 buds/vine) of cv. `Chardonnay` at Casarsa trellis showed the greatest variability of the yield/vine and its dependency not only upon the pruning severity and the climatic conditions in each year of the experiment but also upon some in this experiment unexplainable conditions. The last was less obvious in the other two treatments. In general the productivity of the vines in the two treatments out of the three ranged according to the rainfall during the growing seasons of the experimental years (2002>2001>2003). The exception was the treatment with the normal crop load.

With the third treatment, i.e., the lowest crop load, we wanted to approach the Cordon speronato pruning system that is considered to improve the grape quality at Casarsa trellis. The results of our experiment also showed the shift to lower yield/vine together with higher must sugar content, lower acids content and higher pruning weight when this pruning system is compared to the normal and to the higher crop load. The grape quality was quite high for the all three treatments therefore the decision upon crop load and pruning system is strictly dependent on a vine grower's strategy of grape quantity/quality ratio at harvest. Satisfactory yield and must sugar content of cv. `Chardonnay` could be obtained with the normal or even slightly higher crop load at Casarsa trellis.

If the climatic conditions are considered together with the pruning severity the differences in the grapevine productivity will be more obvious in the years with more rainfall during the grape ripening (i.e. 2002) and less distinctive for the grape quality in the same conditions. If a dry growing season occurs (as in 2003) the differences in grapevine productivity will be smaller and the differences in grape quality will be higher. In the normal growing conditions (as in 2001) the differences will be quite high for the grapevine productivity and also for the grape quality. The research results showed that the regulation of the yield through pruning severity was strictly dependent on the year and therefore it is difficult for vine growers to predict it at winter pruning. This assumes a greater importance of crop load regulation in the years characterized by less and not more rainfall than normal. It is important to stress that the experiment was performed on a high quality cultivar with quite normal productivity which responds in different manner to pruning severity, as was already reported for a very productive cultivars (Čuš et al., 2003). It is also well known that cv. `Chardonnay` is very susceptible to drought stress that causes yield losses, possible disequilibria in must sugar/acid ratio and development of oxidative conditions in the produced vines. The proposed number of buds at winter pruning for satisfactory grape quality of cv. `Chardonnay` at Casarsa is approximately 40-45 buds/kg of cane pruning and slightly differs from the other wine growing regions (Smart and Robinson, 1991; Wolpert et al., 1994). Normal Ravaz index for cv. `Chardonnay` in the investigated conditions is between 7-10. If poor climatic conditions occur during the growing season the reduction in crop load via clusters thinning is necessary.

Although the weather conditions in each year of the experiment strongly influenced the must acids content, the problem of its further decrease due to a too low crop load should be considered very carefully. Therefore in warm conditions possible disequilibria in must sugar/acid ratio could be provoked at such early ripening cultivars as cv. `Chardonnay`.

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