IMPACT OF BUD LOAD ON THE YIELD COMPONENTS AND COMPOSITION OF THE BERRY OF CHARDONNAY ON SPUR CORDON IN ISTRIA, CROATIA

L'EFFET DU NOMBRE DE BOURGEONS LAISSÉS À LA TAILLE SUR LES COMPOSANTS DU RENDEMENT ET LA COMPOSITION DE LA BAIE DU CHARDONNAY AU TAILLE COURTE EN ISTRIE, CROATIE

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SUMMARY

The investigation was conducted from 2009 to 2012. on cv. Chardonnay in the productive vineyard. Training system was Istrian spur cordon, an unilateral spur cordon with upward positioned shoots, which characteristics were investigated in the agroecological conditions of Istria (Croatia), in a continuity of ten years.

Two bud loads of 16 buds and two bud loads of 32 buds per vine were investigated in this study, with a total of four treatments. Lower bud loads were represented with vines having eight arms with one spur containing two buds or two spurs containing one bud. Higher bud loads were represented with vines having eight arms with two spurs containing two buds or four spurs containing one bud. Each treatment had three repetitions of five vines. The experimental design was randomized blocks design.

Yield, number of bunches per vine, cluster weight, sugar content and titratable acidity in must were mostly different among different vegetation seasons.

Within the same year yield and the number of clusters per vine were mostly higher on vines with a bud load of 32 buds. Bud fruitfulness and cluster weight were generally higher on vines with a bud load of 16 buds. Sugar content, titratable acidity and pH value of must varied vary slightly among different treatments.

Based on the results of this four years experiment it can be concluded that the Istrian spur cordon, combining different bud loads, can be successfully applied to Chardonnay in Istria in the production of targeted grape quality.

RÉSUMÉ

L'investigation a été menée de 2009 à 2012 sur cv. Chardonnay dans le vignoble productif. Système de formation était le cordon au taille curte d'Istrie, un cordon unilatérale, dont les caractéristiques ont été étudiées dans les conditions agro-écologiques de l'Istrie (Croatie), dans une continuité de dix ans.

Deux chargements de 16 bourgeons et deux chargements de 32 bourgeons par pied de vigne ont été étudiés dans cette étude, avec un total de quatre traitements. Les chargements en bourgeons inférieurs étaient représentés avec des pieds ayant huit bras avec un courson contenant deux bourgeons ou deux coursons contenant un bourgeon. Les chargements plus élevées étaient représentés avec des pieds ayant huit bras avec deux coursons contenant deux bourgeons ou quatre coursons contenant un bourgeon. Chaque traitement a eu trois répétitions de cinq pieds de vignes. Le dispositif expérimental était randomisé blocs.

Le rendement, le nombre de grappes par pied, les poids moyenne de la grappe, la teneur en sucre et en acidité titrable étaient différentes plupart parmi les differents saisons de végétation.

Dans le même année le rendement et le nombre de grappes par pied de vigne étaient généralement plus élevé sur les vignes avec le charge de 32 bourgeon par pied. La fécondité des bourgeons et le poids moyenne de la grappe étaient généralement plus élevés dans les vignes avec une charge de 16 bourgeon par pied. La teneur en sucre, l'acidité titrable et le pH du moût varié très légèrement entre les différents traitements.

Sur la base des résultats de cette expérience de quatre ans, il peut être conclu que le cordon au taille curte d'Istrie, en combinant différentes charges bourgeon, peuvent être appliquées avec succès à Chardonnay en Istrie dans la production de la miré qualité du raisin.

Key Words: Bud load, Chardonnay, Yield components, Spur cordon
Mots clés : Chargement, Chardonnay, composantes du rendement, cordon au taille courte

INTRODUCTION

Viticulture and enology are the most important agricultural productions in Istria. According to Croatian viticultural register from year 2011, there are 2780 hectares of vineyards in Istria that are in system of agricultural incentives. The most common cultivars in Istria are: Istrian Malvasia, Merlot, Teran, Cabernet Sauvignon, Refošk and Chardonnay. After Istrian Malvasia (1530 ha), Chardonnay is the most widespread white grapevine cultivar in Istria, planted on 121 ha.

Research on Chardonnay production characteristics has begun in 1985 by planting 400 vines in experimental field of the Institute of Agriculture and Tourism in Poreč. Good experimental results as well as growing popularity lead to rapid expansion of Chardonnay across Istria.

The most common training system in Istrian viticulture, and also in Chardonnay growing is double Guyot. The vineyard where this experiment was conducted, planted in 1994, was the first one in Istria with spur pruning applied, as a pruning type which enables larger use of mechanization. Our research began in 1997, when this vineyard came to full maturity and has been ongoing since then (Gluhić et al, 2005., Peršurić et al, 2009a, Peršurić et al, 2009b). Čuš (2004) reported that with cane pruning significant differences in yield per vine, soluble solids content and must titratable acidity were due to different number of buds per vine.

The aim of this research was to determine the impact of two different bud loads (45712 and 91424 buds per hectare) on spur cordon, obtained with spurs containing one or two buds, on yield components and composition of the berry of Chardonnay (*Vitis vinifera* L.) vines.

MATERIAL AND METHODS

Experimental vineyard is located 10 km from the sea, 170 m above sea level with southern sun exposure and 3 % slope. Row and vine spacing were 2.8 x 2.5 m with two vines planted at the same place (0.2 m next to each other). That makes 2857 vines per hectare. Vineyard was planted in 1994, with Chardonnay clone R8 grafted on Kober 5BB. The soil was typical red Mediterranean soil (*Terra rossa*).

Istrian spur cordon has one cordon, about 1m long, wrapped around the basal wire 0.9 m above the soil. On each cordon, there are 8 laterally positioned arms with different number of spurs and buds per arm. 0.4 m above the basal wire are two parallel sustainable wires placed 30 cm apart from each other. The particularity of this training system is early shoot trimming at 50-70 cm length, before or at the beginning of bloom. This leads to improvement of fruit set (especially under bad weather conditions) and more uniform shoot growth along the cordon. Also, it causes early growth of lateral shoots situated on the top of the primary shoot (2 or 3 per shoot) that leads to early development and beginning of assimilation. Being on the top of the primary shoot, it enables them all day long sun exposure. Moreover, distance of sustainable wires enables less canopy density which is positive for canopy microclimate and photosynthetic assimilation.

Two bud loads (16 and 32 buds per vine, or 45712 and 91424 buds per hectare), combined with two spur types (one or two buds per spur) were investigated in this study, resulting in a total of four treatments. Lower bud loads (LBL) were represented with vines having eight arms with one spur containing two buds or two spurs containing one bud, with a total of 16 buds per vine. Higher bud loads (HBL) were represented with vines having eight arms with two spurs containing two buds or four spurs containing one bud, with a total of 32 buds per vine. Randomized complete block design was used. Each treatment contained three replicates with five vines.

Time of harvest was earlier than usual in this region since grapes were used for sparkling wine production. Targeted grape composition was soluble solids from 16 to 18 Babo, titratable acidity from 8 to 10 g/L expressed as tartaric acid and pH from 3.1 to 3.3 Targeted yields were form 10 to 12 tons per hectare.

Cluster weight, number of clusters per vine and yield per vine were measured in harvest. Other yield parameters were obtained based on these measurements. Total soluble solids were measured and expressed as Babo, titratable acidity were assessed with neutralization with NaOH and expressed as g/L of tartaric acid and pH value was assessed with the pH meter. Data were analyzed within each year by the analysis of variance (ANOVA). Duncan’s multiple range test was used for post hoc comparison of significant treatment means.

RESULTS AND DISCUSSION

Results obtained from this research are shown in Table I, for each year separately. Climatic conditions in research area are shown in Figure 1. And Table II.

Figure 1 shows the 30-year average (1983-2012) of monthly temperature and precipitation. Total yearly rainfall was 863 mm, while mean yearly temperature in 30-year average was 13.5 °C. Data show that this winegrowing area is, due to temperature and precipitation, very convenient for vine growing.

Table I. Chardonnay yield and grape quality parameters for years 2009 to 2012.

Composants du rendement et la composition de la baie du Chardonnay pour les années 2009 à 2012.

Year	Nr. of arms × spurs × buds = buds/vine	Yield / vine (kg)	Yield / ha (t)	Clusters/ vine	Bud fertility coefficient	Cluster Weight (g)	Soluble solids (°Babo)	Titratable acidity (g/l)	pH
2009.	**8×1×2= 16**	3,66 a	10,46 a	25,4 b	1,59 ab	147 a	16,5 a	8,0 a	3,28 a
	8×2×1= 16	3,63 a	10,37 a	27,4 b	1,71 a	131 ab	16,5 a	8,3 a	3,27 a
	8×2×2= 32	4,10 a	11,73 a	35,6 a	1,11c	116 b	16,4 a	8,0 a	3,28 a
	8×4×1= 32	4,66 a	13,31 a	38,9 a	1,21 bc	123 ab	16,3 a	8,1 a	3,24 a
2010.	**8×1×2= 16**	3,93 ab	11,24 ab	20,1 c	1,26 b	196 a	16,5 a	10,2 a	3,17 a
	8×2×1= 16	4,48 ab	12,80 ab	24,9 b	1,55 a	178 a	16,1 ab	10,5 a	3,14 a
	8×2×2= 32	5,21 a	14,89 a	28,8 a	0,90 c	181 a	15,6 b	10,3 a	3,12 a
	8×4×1= 32	3,51 b	10,01 b	21,0 c	0,66 d	171 a	16,6 a	10,5 a	3,14 a
2011.	**8×1×2= 16**	3,66 ab	10,45 ab	16,9 b	1,06 ab	209 a	17,7 a	9,2 a	3,29 a
	8×2×1= 16	3,21 b	9,16 b	19,1 ab	1,19 a	162 b	18,1 a	9,1 a	3,26 a
	8×2×2= 32	4,00 ab	11,42 ab	24,7 ab	0,77 b	165 b	18,1 a	9,1 a	3,22 a
	8×4×1= 32	4,62 a	13,20 a	28,6 a	0,89 ab	157 b	17,7 a	9,1 a	3,22 a
2012.	**8×1×2= 16**	2,49 a	7,12 a	21,4 b	1,34 ab	115 a	17,6 a	8,6 ab	3,18 a
	8×2×1= 16	2,72 a	7,78 a	23,9 ab	1,49 a	120 a	17,9 a	8,2 b	3,20 a
	8×2×2= 32	3,10 a	8,85 a	29,7 a	0,93 b	107 a	18,2 a	8,4 ab	3,20 a
	8×4×1= 32	3,17 a	9,05 a	28,6 ab	0,89 b	120 a	17,7 a	8,9 a	3,15 a

For each year and within the same column means followed by different letters are significantly different by Duncan's multiple range test.

Comparing each investigated year (Table II) with the 30-year average, significant deviations from the average can be identified. According to climatic conditions year 2009 was very good. Total rainfall (855.4 mm) were 8 mm less than average, with almost no rain in May and temperatures of 20 °C, which allowed good flowering. In September, before and during harvest there was slightly less rainfalls and temperature were above average, which was very convenient. During vegetation there was enough rainfalls, slightly less than the average. Average annual temperature was 14.5°C, 1°C above the average.

differences. Higher bud loads had more clusters, with a smaller cluster weight and smaller bud

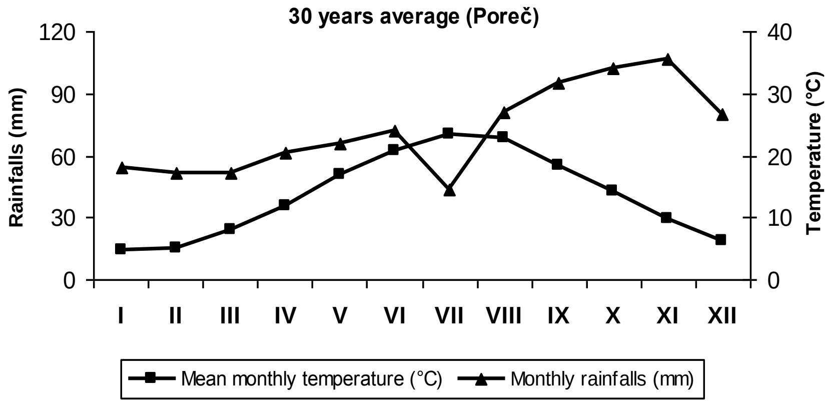

Figure 1 - Monthly rainfall and mean monthly temperature in 30 years period (1983-2012) for weather station Poreč

Précipitations mensuelles et température moyenne mensuelles en 30 années période (1983-2012) en Poreč

Yield characteristics (Table I) show that it was a very good winegrowing year. Yields per vine, with smaller bud load (45712 buds per 1 ha) were less than 4 kg, and with higher bud load (91,424 pupa) above 4 kg, but these differences were not statistically significant. Yields per 1 ha ranged from 10.4 to 13.3 tones, with no statistically significant

fertility coefficient. Bud fertility for both LBL and HBL was higher in treatments with 1 bud per spur, which was not expected. Yield quality was the same in all bud load treatments.

In year 2009, twofold higher bud load did not provide, for practical use, higher yields but neither lower yield quality. These results are not similar to

Table II Monthly rainfall and mean temperature at Poreč weather station for period 2009-2012.

Précipitations mensuelles et la température moyenne en Poreč pour le période 2009-2012.

Year	2009.		2010.		2011.		2012.	
Month	Rainfalls (mm)	Mean temperature (°C)	Rainfalls (mm)	Mean temperature (°C)	Rainfalls (mm)	Mean temperature (°C)	Rainfalls (mm)	Mean temperature (°C)
I	84.7	5	138.7	4.1	6.5	4.9	16.1	4.5
II	60.3	5.6	127.1	5.8	18.8	5.3	25.8	1.9
III	76.5	8.6	43.4	7.6	60.1	8.5	0.5	9.8
IV	45.0	14.0	44.3	12.9	22.7	13.6	55.1	12.6
V	2.5	19.1	121.0	16.8	15.7	17.9	102.5	16.5
VI	61.3	21.1	92.7	21.2	52.4	22.0	18.6	23.1
VII	38.4	24.5	44.1	24.9	133.6	23.3	2.2	26.1
VIII	69.3	24.6	74.5	22.3	0.0	24.1	3.8	25.1
IX	30.5	20.4	214.2	18.2	44.7	21.6	145.5	20.0
X	73.5	13.3	90.6	13.1	117.1	13.1	76.8	15.0
XI	169.8	11.6	269.3	11.2	16.3	9.2	79.9	11.9
XII	143.6	6.5	138.7	5.0	26.5	7.8	94.6	5.6
Total/average	**855**	**14.5**	**1399**	**13.6**	**454**	**14.3**	**621**	**14.3**

those provided by Čuš (2004), where significant differences in yield, depending on the bud load, were observed. Also, LBL had lower yield per vine as well as higher soluble solids and lower total acidity in must. This was certainly influenced by very good climatic conditions.

Year 2010 (Table II) was very rainy and with 1398.6 mm of rainfalls it is the year with the most rainfall in Istria measured in the past 30 years. Considering rainfalls, March, April, July and August were within the average. All other months were extremely above the average. Major problem was excessive amount of rain in September, before and during the harvest, which caused a lot of rotten grapes for later varieties. Those problems were avoided by earlier harvest time for Chardonnay in this experiment. Mean annual and monthly temperatures were not significantly different than the average.

HBL treatment (8x4x1=32) was not taken under consideration since results were not as expected and therefore cannot be explained (Table I). Other HBL yield per vine was up to 30 % higher than LBL treatments, with slightly lower soluble solids and equal titratable acidity as well as pH. Besides total acidity, these results are similar to those provided by Čuš (2004). HBL treatment resulted in 15 to 40 % higher number of clusters per vine and 13 to 72 % lower bud fertility coefficient. Single cluster weight, although very high for all treatments, was not significantly different between treatments.

Such undesirable climatic conditions as in 2010 can cause multiple problems. These results show that LBL yield was average to high, while HBL yield was excessively high. However, must quality was good for all treatments, considering target product which is sparkling wine. It leads to conclusion that LBL is more suitable under such climatic conditions.

Year 2011 (Table II), was the year with the least rainfall (454 mm) in the past 30 years. Because of the average rainfall in June and especially heavy rainfall (threefold above the average) in July, there was no major drought damage. Therefore, it is regarded as a very good winegrowing year.

Those conditions affected grape production positively, as shown in Table 3. Yield per hectare ranged between 9 and 10 tones and between 11 and 13 tones (for LBL and HBL, respectively). Must quality showed no difference between treatments, being optimal for target production (sparkling wine). Treatment 8x1x2=16 had less clusters per vine but higher cluster weight. LBL treatments showed 19 to 54 % higher bud fertility coefficient compared to HBL, which was similar result as in past years. Also, bud fertility coefficient was higher in treatments with one bud per spur. That did not result in higher yield per vine or per hectare. These results are similar as reported in Čuš (2004). Overall, HBL is more suitable for drier climatic conditions, such as during year 2011.

In year 2012 (Table II) frequency and severity of rainfall (621 mm) as well as temperatures above the average during the growing season, made it a poor winegrowing year. Compared to the 30-year average, year 2012 had less rainfall during first three months. In June, July and August there was almost no rainfall (compared to average 190 liters of rain during those three months), with high average daily temperatures. Average monthly temperatures for these months were also above the 30-year average.

Table I shows no significant difference in yield parameters between LBL and HBL treatments although HBL resulted in slightly higher number of clusters per vine. Cluster weight also didn't show any significant difference between treatments whereas bud fertility coefficient was 44 to 67 % higher for LBL treatments. There was no statistical difference between must quality parameters among treatments. Slightly higher TA values in HBL treatments don't have any practical value. Besides must TA values, our results do not confirm those obtained by Čuš (2004). Although must quality in 2012 was overall considered to be very good, lower yield parameters qualify 2012 as not satisfactory for grapevine production. Under such conditions, different bud loads didn't have any effect on yield parameters.

Some results from this research didn't confirm those found in literature on this subject (Čuš, 2004), such as that higher number of buds per vine causes lower cluster weight, higher yield/vine, lower soluble solids and higher titratable acidity. Čuš (2004) concluded that the differences between treatments were dependent on climatic conditions, which our results confirmed only for years 2010 and 2011. According to the same author, climatic conditions and not vine load had the greatest impact on must acidity, which is identical to results found in our research. Our results were significantly impacted by environmental conditions in our area, which confirms those obtained by Čuš (2004) who concluded that the climatic conditions during research have the greatest influence on yield components and must composition.

CONCLUSIONS

Based on results obtained from 4 very different years in terms of climatic conditions, we conclude that Istrian spur cordon showed good results in all years investigated and therefore can be successfully applied in Istrian Chardonnay production, combining diverse bud loads. In years with rainfalls higher than in 30 years average during the vegetation season, lower bud load (~45000 buds/ha) can be expected to produce satisfactory yield as well as grape quality. In good climatic conditions with average rainfalls during the vegetation season and with target yield between 11 and 13 t/ha, higher bud load (~90000 buds/ha) is recommended to obtain good grape quality. Under dry weather conditions and with rainfalls lower than in 30 years average during the vegetation season, higher bud load has no effect on improving yield so lower bud load is more adequate. Bud fertility is improved by lower bud load per vine and often with leaving only one bud per spur. The number of clusters per vine is usually higher under higher bud load per vine but it is not necessary followed by higher yield per vine. Cluster weight is often higher under lower bud loads but it isn't always statistically different from higher bud loads.

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