Popović, T., Raičević, D., Pajović-Šćepanović, R., Matijašević, S. (2023): The influence of different vine loads with fertile buds on the agrobiological, economical and technological characteristics of the cardinal variety in the agro-ecological conditions of Podgorica subregion. Agriculture and Forestry, 69 (1): 93-103. doi:10.17707/AgricultForest.69.1.08

DOI: 10.17707/AgricultForest.69.1.08

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THE INFLUENCE OF DIFFERENT VINE LOADS WITH FERTILE BUDS ON THE AGROBIOLOGICAL, ECONOMICAL AND TECHNOLOGICAL CHARACTERISTICS OF THE CARDINAL VARIETY IN THE AGRO-ECOLOGICAL CONDITIONS OF PODGORICA SUBREGION

SUMMARY

The paper presents the results of a two-year study of the influence of different vine loads with fertile buds on the agrobiological, economic and technological characteristics of the Cardinal variety. The research was carried out in the vineyard of the Biotechnical Faculty in Podgorica subregion. Four different vine loads with fertile buds were applied: 8, 12, 16 and 18 buds. The results of the research showed that the applied loads had a significant impact on the examined parameters of the Cardinal variety. The obtained results on the average yield of grapes show that the lowest value of this parameter was the variant with a load of 8 buds - 1.45 kg m^{-2}, while the highest grape yield was recorded for the variant with a load of 16 buds (2.03 kg m^{-2}). V1 variant had the highest average bunch (386 g) and berries (7g) weight, while V4 had the smallest bunch (285 g) and berries (5.95 g) weight. The quality of the grapes also varied significantly under the influence of the vine load. The highest sugar content in must was recorded in the variant with a load of 8 buds - 15.79%, and the lowest in the variant with 18 buds - 14.30%. The acid content did not differ significantly between the tested variants. V4 variant had the highest - 4.30 g/l, and V1 and V3 variants - 4.05 g/l measured the lowest acid content.

Keywords: Cardinal, yield, bunch weight, berry weight, grape quality

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Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.
Recieved:02/02/2023 *Accepted:16/03/2023*

INTRODUCTION

Thanks to the Mediterranean climate in Podgorica vine region, the conditions are ideal for growing table grape varieties of all maturity periods. Such favourable climatic conditions allow grape varieties of very early and early maturing to be the first to be placed on the market, which provides significant financial effects (Savić, 2016). The backbone of the table grape assortment in Montenegro is the very early table variety Cardinal, which is characterized by large and attractive bunches and berries, but also a very pleasant aroma, resulting in exporting of large grape quantities (Popović, 2020). The variety was created in California by Elmer Snyder and Frank N. Harmon and, according to them, it was created by crossing the Flame Tokay x Ribier variety. However, genetic analyses revealed that this variety was created by crossing the varieties Alfons lavalee and Queen of the vineyards, which was confirmed by Ibanez et al. (2009), *Cipriani et al.* (2010), Lacombe *et al.* (2013), and Crespan *et al.* (2017). Cardinal is cultivated in many countries around the world, especially in the USA, Italy, France, Algeria, and Israel (Božinović, 2010). It is grown on an area of 180 ha in Montenegro (Savić, 2007). In regions where there are no heavy rains in the ripening period and where winters are mild without the risk of low temperatures, it gives particularly good results (Žunić, 2017).

In the technology of viticulture production, winter pruning is one of the most important ampelotechnical measures that maintain the cultivation form of vines, regulate the vegetative and reproductive potential and indirectly affect the quantity and quality of the grape yield (Mirošević *et al*., 2008). With this ampelotechnical measure, the aim is to ensure a high-quality yield of grapes on the vines, in such way that the yield does not threaten the productive capacity of the vines during the decades of exploitation of the vineyard (Mijatović *et al*., 2018).

The optimal vine loading with fertile buds for each variety must be in accordance with its biological characteristics. The accurate loading of the vines with fertile buds is achieved on the basis of knowledge of the vegetative potential of the vines, the agroecological growing conditions and the quality of the grape yield to be achieved (Vujović, 2013). Leaf size and leaf area, movement and fertility of buds, cane growth, yield, quality of grapes, etc. depend a large extend on the optimal vine loading with fertile buds (Pejović, 1982). If, during pruning, the vines are burdened with a large number of buds, the quality of the grapes will decrease, and the vines will be overburdened (Milosavljević, 1998). Excessive load on the vines with fertile buds also leads to delayed and uneven ripening of the grapes (Prculovski, 2019). In the case of insufficient loading, there is a stronger occurrence of infertile shoots, flower shedding, more intensive bud growth, higher sensitivity to diseases and pests, as well as weaker resistance to low winter temperatures (Karoglan *et al*., 2017). That is why it is necessary to establish the optimal load of grapevines with fertile buds in each wine-growing region for all varieties and cultivation forms in accordance with the technology of grape production that will give the most desired production results.

The aim of this study was to examine the influence of different vine loading with fertile buds on some biological and technological characteristics of the dominantly grown table variety Cardinal in the agro-ecological conditions of Podgorica subregion.

MATERIAL AND METHODS

The study of the impact of different vine loading with fertile buds on the agrobiological, economic and technological characteristics of the Cardinal variety was carried out in 2017 and 2018. The tests were carried out in the experimental vineyard of the Biotechnical Faculty in Podgorica (latitude 42° 26′ 78″ N and longitude 19° 12′ 57″ E). The Cardinal variety was grafted onto Berlandieri x Riparia Kober 5 BB, and the vineyard was planted in 2005 with a planting distance of 2.5 m between rows and 1.2 m between vines in a row. The training system of the vine is a two-arm horizontal cordon with a tree height of about 80 cm. Short and mixed pruning was applied. During the research, the experimental vineyard was irrigated with a drop-by-drop system. The tests were carried out on 120 vines, that is, in three repetitions with 10 vines each.

The trial included the following variants:

V1 - 8 buds (4 spurs with 2 buds each)
V2 - 12 buds (4 spurs with 3 buds each)
V3 - 16 buds (2 spurs with 3 buds each and 2 long spurs with 5 buds each)
V4 - 18 buds (2 spurs with 3 buds each and 2 canes with 6 buds each)

During the two-year study, the following parameters were monitored:

-The grape yield was obtained by weighing the harvested grapes from each vine, and the bunch weight was determined from the ratio of the yield achieved and the number of bunches.

-After the grape harvest, the length and width of the bunch and the berry were measured, as well as the average weight of the berry.

-The sugar content in the grape juice was determined hydrometrically (with Oechsle hydrometer), and the proportion of total acids in the grape juice was determined by neutralization of all acids and their salts with an n/10 NaOH solution with the indicator bromthymol blue.

-Data from the meteorological station in Podgorica were used in the analysis of the climatic conditions of Lješkopolje.

-Processing of the obtained results was carried out by analysis of variance for a completely random block system. Testing was performed using the LSD test for pairwise comparisons at two significance levels: 0.05 and 0.01.

RESULTS AND DISCUSSION

Climate conditions

The meteorological conditions that prevail in the production regions have a great influence on the height and quality of the yield of the vine (Mirošević and

Karoglan-Kontić, 2008). Of all climatic factors, air temperature exerts the most dominant influence on the growth of the vine, its fertility, as well as on the height and quality of the grape yield.

Based on the data from Table 1, lower temperatures were measured in 2017, both on an annual level and during the period. The average annual air temperature in the first year of the research was 16.8ºC, which is 0.8º lower than in 2018. The average temperature in the vegetation period in this year was 22.7ºC and was 1.1º lower than in the second year of the research. The vegetation sum of temperatures was higher in 2018 and amounted 5105.1ºC. In the studied period, the Winkler index was high and amounted > 2700 in 2017 and > 2900 in 2018, respectively.

Table 1. Average monthly, annual and vegetative air temperature (ºC)

Year	Months												Year average	Veg. Average	Veg sum
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII			
2017.	2,6	9,2	14,0	15,2	20,5	27,0	29,3	29,9	20,9	16,1	10,7	7,3	16,8	22,7	4862.8
2018.	7,4	7,4	10,2	19,2	22,8	25,4	27,5	28,9	24,2	18,9	12,8	6,7	17,6	23,8	5105.1
Average	5,0	8,3	12.1	17,2	21.65	26,2	28.4	29.4	22.5	17.5	11.7	7.0	17.2	23,2	4983.9

The results presented in Table 2 show that the amount of precipitation was quite uniform in the studied years. A slightly higher amount of precipitation during the growing season was recorded in 2017 - 424.4 mm, compared to 2018, when 366.4 mm of rain fell.

Table 2. Average monthly, annual and vegetative rainfall (mm)

Year	Months												Year average	Veg sum
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
2017.	84,6	222,0	115,7	106,5	79,8	13,0	33,2	30,8	110,6	50,5	365,2	358,2	1570,1	424,4
2018.	134,9	284,6	461,5	26,3	109,1	46,1	40,7	17,7	9,2	117,3	236,2	136,9	1620,5	366,4
Average	109.7	253.3	288.6	66.4	94.4	29.5	36.9	24.2	59.9	83.9	300.7	247.5	1595.3	395,4

The number of bunches per vine (Tab.3) depends on the method of pruning, the ecological cultivation conditions, but also on the applied agrotechnics (Cindrić, 2000). The lowest number of bunches per vine in the two-year average were measured in variants with 8 and 12 buds per vine (11.3 and 15.3, respectively) while the variety with 18 buds per vine was the one with the highest number of bunches (20.9). All load variants had statistically significantly higher number of bunches compared to the V1 variant.

Bunch size, as a very important parameter for the quality of table grapes, was determined based on the average weight, length and width of the bunch. The results of the research on the average weight of the bunch of the variety Cardinal are shown in table 3. In the two-year average, the variety V4 had the smallest average bunch weight - 285.0 g, while the variants V1-386 g and V2-362.5 g had the highest weight of the bunch. Statistical processing of the data showed that all

the variants with a lower vine load with fertile buds (8, 12 and 16 buds) had a significantly higher bunch weight compared to the variant with a load of 18 buds per vine. In all tested variants, the average bunch weight was higher in 2018, which is a consequence of higher amounts of precipitation in the period May-July, i.e. in the period when the berries grow intensively. The results are in accordance with numerous studies carried out on different grapevine varieties, in which an increase in the bunch weight was found in variants with a smaller number of bunches per vine (Kavoosi *et al*., 2009; Somkuwar and Ramteke, 2010; *Gil et al*., 2013; Prculovski *et al*., 2017).

The grape yield depends on a large number of factors such as the biological specificity of the variety, agrotechnical measures carried out in the vineyard as well as ecological conditions in the production areas (Popović, 2012). Based on the results shown in Table 3, obtained for the average grape yields in variants with different vine load, significant variations can be observed between the tested varieties.

Table 3. Bunch weight and yield of the Cardinal variety

Varijant	Number of bunches		2017-2018	Bunch weight (g)		2017-2018	Yield (kg/m^2)		2017-2018
	2017	2018		2017	2018		2017	2018	
V1	11.5	11.1	11.3	369.5	402.5	386.0	1.41	1.48	1.44
V2	15.4	15.2	15.3	350.1	375.0	362.5	1.79	1.90	1.84
V3	17.9	18.5	18.2	320.4	350.4	335.4	1.91	2.16	2.03
V4	21.1	20.7	20.9	264.5	305.5	285.0	1.86	2.10	1.98
Average	16.4	16.3	16.4	326.1	358.2	342.2	1.74	1.91	1.82

Parameter	Number of bunches		Bunch weight		Grape yield	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2017-2018	1.22	2.27	40.21	74.98	0.253	0.358

The highest yield of grapes in the studied period were the variants with a load of 16 and 18 buds per vine (2.03 kg m^{-2} and 1.98 kg m^{-2}), while the lowest yield was the variety with 8 buds - 1.44 kg m^{-2}. Statistical data processing confirmed that all tested variants had a significantly higher yield compared to variant V1. Other differences did not reach the limit of statistical significance. The increase in total yield with the increase in the vine load with fertile buds is in agreement with the results obtained by Howell et al. (1991), Reynolds *et al*. (1994), Coban and Cara (2002), Popović *et al*. (2020), Sefo *et al*. (2020). The yields achieved in the examined years were at the level reported for the Cardinal variety by other authors (Avramov, 2001; Žunić, 2002, 2017; Božinović, 2010; Matijašević, 2021).

Tab 4. Length and width of bunches of the Cardinal variety

Variant	Bunch length (cm)		2017-2018	Bunch width (cm)		2017-2018
	2017	2018		2017	2018	
V1	22.7	23.1	22.9	12.1	12.5	12.3
V2	21.2	21.8	21.5	11.0	11.8	11.4
V3	20.4	20.8	20.6	10.4	11.0	10.7
V4	19.8	20.4	20.1	9.5	9.92	9.7
Average	21.0	21.5	21.2	10.7	11.3	11.0

	Bunch length		Bunch width	
Parameter	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2017-2018	1.847	3.444	1.068	2.003

As for the effect of the different vine load with fertile buds on the length and width of the bunches of the Cardinal variety (tab. 4), it was noted that the vines loaded with 8 buds had the greatest length (22.9 cm) and width of the bunches (12.3 cm), while the smallest length (20.1 cm) and bunch width (9.7 cm) was measured in the V4 variant.

Variant V1 had a statistically significantly greater length and width of bunches compared to variants V3 and V4, while the difference in this parameter compared to the variant V2 did not reach the limit of statistical significance. Similar results regarding the length and width of the bunch of the Cardinal variety were obtained by Matheou *et al.* (1995) and Kryeziu *et al*. (2017) in the agroecological conditions of Greece and North Macedonia.

Based on the data presented in Table 5, the berries of the Cardinal variety had the greatest length (25.1 mm) and width (24.2 mm) in the variant with the lowest vine load, while the smallest berries were in the variant with a load of 18 buds - 21.8 and 21.4 mm, respectively. Variant V1 had a very significantly longer berry length compared to V4 and V3 variants, and significantly longer compared to V2 variant. The difference in berry width was significant only between the V1 variety compared to V3 and V4 variants. Similar results were obtained by Somkuwar and Ramteke (2010), who state that an excessive number of bunches on the vine reduces the diameter of the berries, while a smaller number of bunches can increase the weight of the berries despite the reduction in yield (Ezzahouani and Williams, 2003).

In addition to the average length and width of the berry, the V1 variant had the highest berry weight (7g) in the two-year average, while the V4 variant had the smallest berry weight (6g). Despite the differences in berry weight, statistical data processing established that the different vine load with fertile buds did not significantly affect this characteristic of the berry of the Cardinal variety. The average weight of the berry during this research for all tested variants was 6.5 g and was within the limits stated for this variety by other authors: Matheou et al. (1995); Korać et al. (2012), Cindrić (2000) Popović et al. (2020).

The quality of table grapes is determined primarily by the appearance of the bunch and the berry, but also by the taste of the grape, which depends on the sugar and acid content, aroma, flesh consistency, skin thickness and many other

elements (Matijašević, 2009). The sugar content in the must, beside the variety, maturity degree and health conditions of grapes, climatic conditions in grape ripening phase, depends significant on production technology (Ranković-Vasić, 2011).

Tab 5. Physical characteristics of the Cardinal variety berry

Variant	Berry length (mm)		2017-2018	Berry width (mm)		2017-2018	Berry weight (g)		2017-2018
	2017	2018		2017	2018		2017	2018	
V1	24.7	25.5	25.1	24.0	24.4	24.2	6.9	7.2	7.0
V2	22.9	24.1	23.5	22.8	23.6	23.2	6.6	6.9	6.8
V3	22.3	23.1	22.7	21.8	22.4	22.1	6.3	6.5	6.4
V4	21.4	22.2	21.8	21.5	21.3	21.4	5.8	6.2	6.0
Average	22.82	23.72	23.3	22.5	22.9	22.7	6.4	6.7	6.5

Parameter	Berry length		Berry width		Berry weight	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2017-2018	1.658	3.09	2.09	3.90	1.19	2.22

The results presented in Table 6, show that the application of different vine loads in the examined years had a significant effect on the sugar content in the grape juice. In the two-year average, the V1 variant had the highest sugar content - 15.79%, while the V4 variant had the lowest sugar content – 14,30%. Statistical processing of the data showed that the variant with the lowest vine load had a significantly higher sugar content compared to variants V3 and V4, while the difference compared to variant V2 did not reach the limit of statistical significance. Similar results were obtained by Pejović (1982), Maraš *et al*. (2012), and Popović *et al*. (2020) who obtained a higher content of sugar in grape juice in variants with a lower load of vines. All tested variants had a higher sugar content in 2018, which is a consequence of more favourable climatic conditions in this research year. Similar results were obtained by Vukosavljević *et al.* (2011) who found a higher sugar content in the years with higher mean vegetation temperatures.

The content of acids in grapes significantly determines the taste and harmony of grapes. Due to specific climatic conditions, grapes produced in the southern parts of Montenegro are characterized by high sugar and low acids content (Popović, 2012). In the two-year average (Tab. 6), the acid content did not differ significantly between the studied variants. The variant with the highest acid content was the one with a load of 18 buds per cane - 4.31 g/l, while the variants V1 and V3 had the lowest acid content, which was 4.05 g/l. These results are in agreement with the results of Popović (2020), while Korać (2012) and Božinović (2010) state higher values for the acid content in the must of the Cardinal variety, which is probably a consequence of the different agroecological conditions in which research was conducted.

Tab. 6. The effect of different vine loads on the chemical characteristics of the berries

Variant	Sugar content (%)		2017-2018	Acid content (g/l)		2017-2018
	2017	2018		2017.	2018.	
V1	15.45	15.60	15.79	4.00	4.10	4.05
V2	14.75	15.10	14.92	4.10	4.20	4.15
V3	14.30	14.80	14.55	3.95	4.15	4.05
V4	14.10	14.50	14.30	4.23	4.40	4.31
Average	14.65	15.00	14.89	4.07	4.21	4.14

Parameter	Sugar content		Acid content	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2017-2018	1.22	2.27	-	-

CONCLUSIONS

Based on the conducted research, it can be concluded:

•The average grape yield in the two-year period was the highest on vines loaded with 16 buds, while the lowest yield was achieved on vines loaded with 8 buds.

•The number of bunches varied significantly between the examined variants and ranged from 11.3 in the V1 variant to 20.9 in the V4 variant.

•The average weight of the bunch was between 285 and 386 g. The highest bunch weight had the canes loaded with the lowest number of buds, that is, the canes on which short pruning was applied. The greatest length and width of the bunch was measured in the variant with the lowest vine load with fertile buds.

•The average weight of the berries was the highest in the variants V1 -7.0 g and V2 - 6.8 g, while the smallest berries (6.0 g) was in the variant V4. The average berry length and width were also the highest in the variety with 8 bud load, while the lowest length and width were measured in berries of the V4 variant.

•In the two-year average, the V1 variant had the highest sugar content - 15.79%, while the V4 variant had the lowest sugar content- 14.30%. The sugar content of all tested variants was higher in 2018, which is a consequence of higher average air temperatures during the vine vegetation season.

•The content of acids in the wine was characteristic for the tested variety in the Podgorica vineyard. The highest content of acids (4.31 g/l) was found in the variant with the highest load of vanes.

•Based on all of the above, it can be concluded that for the production practice in the agro-ecological conditions of the Podgorica subregion, the optimum loading is 16 buds per vine because it enables obtaining high yields as well as good quality of grapes for the Cardinal variety.

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