ISSN print: 1224-5984
ISSN online: 2248-3942

Rom Biotechnol Lett. 2022; 27(2): 3398-3406
doi: 10.25083/rbl/27.2/3398.3406

Received for publication: January.10, 2022
Accepted: April, 11,2022

Original paper

Performance of fungus-tolerant grapevine cultivars in different production systems

Fungus-tolerant grapevine cultivars

DRAGOSLAV IVANIŠEVIĆ[1], MLADEN I. KALAJDŽIĆ[1]*, PREDRAG BOŽOVIĆ[1], NEMANJA BRZAKOVIĆ

[1]Department of Fruit growing, Viticulture, Horticulture and Landscape architecture, Faculty of Agriculture, Trg Dositeja Obradovića 8, Novi Sad 21000, Serbia

Abstract

Several fungus-tolerant grapevine cultivars have been created and have already found their place in vineyards in Serbia and Hungary. The aim of this work was to investigate the differences in yield, grape quality and wine sensory properties obtained in two different production systems of pathogen-tolerant white grapevine cultivars Backa and Panonia over the 2015-2018 period. The paper showed differences in harvest parameters between the Conventional and NoPes&MinFert (without use of pesticides and mineral fertilizers) production systems. Fruitfulness and bud tolerance to low temperatures in these production systems were also examined. The results suggest that grape quality obtained by NoPes&MinFert was at the same level as that achieved by conventional methods, while the yield loss in NoPes&MinFert was on average <20% compared to the conventional system. Although the number of inflorescences per node and yield were higher in conventional production, NoPes&MinFert production showed satisfied yield that exceeded 10 t/ha. Wine sensory analyses showed that production NoPes&MinFert achieved better wine score compared to the wines derived from the Conventional production.

Keywords fungus tolerant cultivars; yield; grape quality

To cite this article: IVANIŠEVIĆ D, KALAJDŽIĆ MI, BOŽOVIĆ P, BRZAKOVIĆ N. Performance of fungus-tolerant grapevine cultivars in different production systems. Fungus-tolerant grapevine cultivars. *Rom Biotechnol Lett.* 2022; 27(2): 3398-3406 DOI: 10.25083/rbl/27.2/3398.3406

*Corresponding author: MLADEN KALAJDŽIĆ, e-mail: mladen.kalajdzic@polj.uns.ac.rs

Introduction

Application of the synthetic fungicides is a common practice in the conventional grape production. According to PETERLUNGER & al [1] viticulture in Europe accounts 3% of the total agricultural land and applies 65% of all fungicides used in whole agriculture. Due to increasing concern for the human health and the protection of the environment, nature friendly production systems should be applied instead of conventional.

In last few decades, organic viticulture has been intensively promoted (BARTOLUCCI [2]; MEISSNER & al. [3]) but it seems without success (MASSON & al. [4]). Most producers are reluctant to grow grapes organically due to the need to comply with integrated pest management schemes (GEIER [5]). Also, limiting factors in organic production is yield reduction by 8 to 16% (GUESMI & al., [6]).

On the other hand, organic viticulture enhances microbial diversity (HENDGEN & al. [7]) and floral diversity (NASCIMBENE & al [8]). Moreover, organic vineyards have been shown to host consistently richer communities of both vascular plants and butterflies compared to their conventional counterparts (PUIGMONTSERRAT & al. [9]). In organic production the grape quality is enhanced and without fungicides residues, compared to conventional (CRINNION [10]). Also, organic products have better nutritional and sensory characteristics (GRANATO & al. [11]), and higher antioxidant activity (TASSONI & al. [12]).

However, organic viticulture approaches are very strict and in many cases difficult to apply.

Cultivars such as Merlot and Chardonnay are very sensitive to pathogens and therefore alternative cultivars should be cultivated.

The main goal of grapevine breeding stations around the world is creation of cultivars that are resistant to fungal diseases while yielding adequate grape quality (PETERLUNGER & al. [1], TÖPFER & al. [13]). Resistant grapevine cultivars can be grown without use of pesticides or, in some years, require only a small portion of the fungicide applications that are necessary for cultivating traditional cultivars. Grapevine breeding in Serbia has been conducted since the middle of the 20th century, aiming to develop grape cultivars with improved grape quality, higher yield and enhanced tolerance to stress factors. As a result, several new grapevine cultivars suitable for organic production have been created. Some fungus tolerant cultivars such as Backa and Panonia have already found their place in vineyards in Serbia, Hungary, and some other countries.

The aim of the present study was to investigate the effects of Conventional and NoPes&MinFert production systems on productive characteristics of grape cultivars Backa and Panonia in the 2015-2018 period.

Material and methods

The experiment was performed, at the Experimental field of University of Novi Sad, Faculty of Agriculture situated in Sremski Karlovci (45º10´ N, 20º10´ E), 150 m, above sea level during four consecutive seasons (2015-2018), on the two Serbian wine grape cultivars: Backa (VIVC number 21272) and Panonia, (VIVC number 23765) which are less susceptible to fungal diseases. Backa (Petra x Bianca), released in 2004, is highly vigorous cultivar with mid-compact bunches. Wines made of Backa are light bodied wines, Panonia (one Hungarian tolerant genotype -((Kunbarat x Traminer) x Bianca) x Riesling), also released in 2004, is less vigorous compared to Backa with loose bunches. Moreover, Panonia has ideal shoot positioning in the canopy with small laterals. Panonia has full body wines similar to Riesling.

The vines were pruned to a modified Guyot (one arched cane of 12 buds and one spur of 2 buds), with an average of 14 buds per vine. Vines were planted in 2000 with 2.8 m space between rows and 1.6 m separation between pair of vines in a row. Rows had an East-West orientation.

Two production systems were performed:

NoPes&MinFert–without use of pesticides and mineral fertilizers; Grass mixture was established as cover crop in between the rows. Every second row was ploughed. Weeds in between the vines were controlled mechanically.

Conventional- pesticides and mineral fertilizers were applied as is usual in modern viticultural practice. Grass mixture was established as cover crop in between the rows. Every second row was ploughed. Weeds in between the vines were controlled by Glyfosav, herbicide produced by the company Chemical Agrosava (Belgrade, Serbia). The average amount of 50 kg N, 50 kg P and 70 kg K per hectare was applied each autmun.

The experiment was designed as a randomized complete block, in which a total of 24 vines of each cultivar/production system combination (Backa/NoPes&MinFert, Backa/conventional, Panonia/NoPes&MinFert and Panonia/conventional) were grouped into 3 blocks of 8 vines.

The climate conditions at the experimental site, including mean monthly air temperatures (°C) and mean monthly precipitation (mm) for the period 2015-2018 are presented in Figure 1.

Phenological observations

Three key phenological stages of the grapevine were examined. BBCH scale was used to identify the development stage.

BBCH-07- the beginning of budburst i.e. the date when green shoot tips became visible; BBCH-60- the beginning of flowering i.e. the date when first flower hoods were detached from the receptacle; and BBCH-80-the beginning of veraison i.e. the date when berries begun to develop cultivar-specific color (COMBE [14]).

Fruitfulness parameters

In the season 2015 fruitfulness of the nodes and shoots on 10 vines per combination cultivar/production were evaluated. Percentage of the nodes that arose in the shoot/s were calculated by dividing number of the bud-bursted nodes with total nodes. The number of inflorescences per node and number of inflorescences per shoot were recorded when the shoot's length was approximately 15-20 cm.

Harvest parameters

Yield was determined at harvest by weighing all the grapes. Average cluster weight was obtained by dividing the weight of all clusters in replicate with the number of clusters.

$$\text{Average cluster weight (g)}=\frac{\text{Weight of all clusters(g)}}{\text{Number of clusters}}$$

After crashing, the sugar content in the must was measured with Oechsle hydrometer. Titratable acidity was measured by titration of grape juice sample (10 ml) against 0,1 M NaOH, in the presence of bromothymol blue as an indicator, until changing color of the indicator. The *Botrytis* incidence was determined by visual assessment of the health status of the clusters at harvest time, expressed as percentage of infected clusters.

Tolerance to low winter temperatures

The bud tolerance to low winter temperatures was examined under laboratory conditions. Samples of 10 canes (one-year old wood, with 10 nodes) were collected three times during the winter 2017/2018 (end of December, end of January and middle of February). The canes were stored in cold chamber for 24 h at -5 °C. After that, the temperature was decreased for 3 °C each hour, until the temperature reached -21 °C. After 12 hours the cold chamber was turned off. The canes were left until the temperature in cold chamber reached the room temperature (CINDRIĆ & al. [15]) and after 7 days the bud assesion was performed. The buds exposed to low temperatures were classified in three categories: alive, partially alive and frozen.

Microvinification and wine sensory analysis

From each replicate, grapes were destemmed and crushed. The liquid phase was separated and 10 mg L^{-1} SO_2 was added. Then the liquid phase was left for one day and then racked before being inoculated with *Saccharomyces cerevisiae* (Uvaferm BDX). Fermentation was conducted in 5 L glass fermenters. After the end of fermentation, the wines were racked in the bottles.

Wine sensory analysis was performed five months after the end of fermentation by five trained academic staff members of the Faculty of Technology and Faculty of Agriculture from the University of Novi Sad. Buxbaum method was used to score the wine samples (0-20 points), assessing appearance (maximum 2 points), color (2), aroma and bouquet (4) and other characteristics, such as sugar, acidity, and astringency (scoring maximum of 12 points in total for these traits related to taste). All samples were presented to each assessor at the same time. The order of sample presentation was completely randomized, and individual samples were identified by assigning each a random number. Bread cubes were provided to cleanse the palate between samples during evaluation.

Statistical analyses

Statistical analyses (multifactorial ANOVA) were performed using *R* software. Duncan's test was used to test the significance of differences ($p < 0.05$) among the mean values of measured parameters. Graphs were generated using the *ggplot2* package.

Results

Weather conditions varies among the years (Figure 1). In general, summers were hot and dry, particularly in 2015 and 2017. Precipitation amount was the highest in May and June; cumulative precipitation value for these months was the highest in 2016 (268 mm).

Phenological stages, including beginning of budburst, flowering, veraison and harvest date differed among cultivars (Table 1). However, different production systems did not affect the phenology and harvest date, therefore grapes from both NoPes&MinFert and conventional plots were harvested same day.

Conventional production of Panonia had a higher percentage of the nodes that arose in the shoot/s compared to

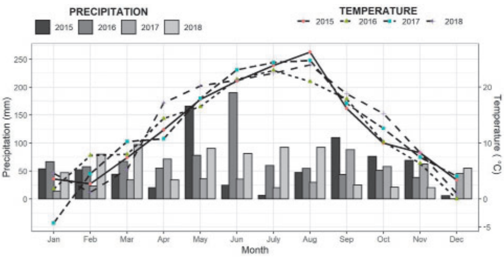


Figure 1. Variations of weather conditions among the years.

Table 1. Dates for the beginning of the main phenological stages and harvest (2015-2018).

Year	GDD* (°C)	Cultivar	Beginning of bud-burst	Beginning of flowering	Beginning of veraison	Harvest date
2015	1925	Backa	8 April	19 May	15 July	31 August
		Panonia	8 April	19 May	15 July	31 August
2016	1740	Backa	2 April	22. May	14 July	05 September
		Panonia	1 April	20. May	03 July	05 September
2017	1880	Backa	27 March	25 May	18 July	23 August
		Panonia	25 March	25 May	18 July	23. August
2018	2074	Backa	3 April	06 May	8 July	20 August
		Panonia	2 April	06 May	7 July	20 August
2015-2018	1904	Backa	4 April	18 May	13 July	29 August
		Panonia	3 April	17 May	9 July	29 August

*GDD- Growing Degree Days is a temperature derived index using average temperatures above a 10 °C base (April - October)

Table 2. Shoot fruitfulness of Backa and Panonia in NoPes&MinFert and conventional production systems in 2015.

Cultivar	Production system	Nodes that arose in the shoot (%)	Number of developed shoots		Number of fruitful shoots		Fruitful shoots (%)	
			Spur	Cane	Spur	Cane	Spur	Cane
Backa	NoPes&MinFert	85.1 ^{ab}	2.0	7.2 b	1.7	6.0 ^{b}	86.7	83.4 ^{b}
	Conventional	94.9 ^{a}	1.8	9.0 a	1.8	8.6 ^{a}	100.0	96.2 ^{a}
Panonia	NoPes&MinFert	75.8 ^{b}	1.8	6.5 b	1.7	5.4 ^{b}	95.8	86.4 ^{b}
	Conventional	88.1 ^{a}	1.7	6.6 b	1.6	5.8 ^{b}	85.8	89.7 ^{ab}

Different letters in superscript indicate significant difference among the mean values (Duncan's test, $p<0.05$).

Table 3. Number of inflorescences per node, shoot and fruitful shoot depend on the production system in 2015.

Cultivar	Production system	Number of inflorescences		
		per node	per shoot	per fruitful shoot
Bačka	NoPes&MinFert	1.19 ^{c}	1.47 ^{b}	1.74 ^{b}
	Conventional	1.69 ^{a}	1.67 ^{ab}	1.73 ^{b}
Panonia	NoPes&MinFert	1.44 ^{b}	1.84 ^{a}	2.11 ^{a}
	Conventional	1.73 ^{a}	1.92 ^{a}	2.16 ^{a}

Different letters in superscript indicate significant difference among the mean values (Duncan's test, $p<0.05$).

NoPes&MinFert counterpart (Table 2). In the conventional production of Backa, the number of developed shoots and number of fruitful shoots were significantly higher compared to all other treatments.

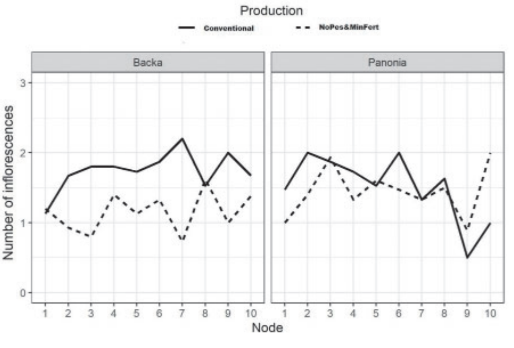


Figure 2. Comparison between number of inflorescences per node in a vine treated through conventionally methods and NoPes&MinFert.

Conventional production system of booth cultivars had significantly higher number of inflorescences per node compared to NoPes&MinFert production (Table 3). NoPes&MinFert production of Backa had significantly lower number of inflorescences per shoot (irrespectively to its fruitfulness) compared to booth production systems of Panonia. Panonia had more inflorescences per fruitful shoot compared to Backa, while no difference was observed between production systems.

In booth cultivars the number of inflorescences per node was higher in a vine treated through conventionally methods compared to NoPes&MinFert (Figure 2). In conventional production of Backa number of inflorescences per node showed an increase from the beginning (1) until the node number 7. Then, the slight decrease in number of inflorescences per node was observed. In NoPes&MinFert production system of Backa number of inflorescences per node showed higher variation.

Table 4. Yield and grape quality of Backa and Panonia in NoPes&MinFert and conventional production systems, in 2015-2018 years.

Cultivar	Production systems	Yield (kg m^{-2})	Cluster weight (g)	Total soluble solids (%)	Titratable acidity (g l^{-1})	*Botrytis* sp. incidence (%)
			2015.			
Backa	NoPes&MinFert	0.86 ^{b}	269.9 ^{a}	21.47	6.07	0.0
	Conventional	1.41 ^{a}	163.3 ^{b}	20.73	6.53	0.0
Panonia	NoPes&MinFert	0.97 ^{b}	240.3 ^{a}	23.97	8.37	0.0
	Conventional	1.43 ^{a}	220.0 ^{ab}	24.13	7.97	0.0
			2016.			
Backa	NoPes&MinFert	1.90 ^{ab}	270.0 ^{a}	22.4	7.27	0.33
	Conventional	1.66 ^{ab}	266.7 ^{a}	19.2	7.83	3.00
Panonia	NoPes&MinFert	1.54 ^{b}	156.7 ^{b}	24.9	9.43	0.00
	Conventional	2.14 ^{a}	223.3 ^{ab}	23.2	8.76	2.33
			2017.			
Backa	NoPes&MinFert	1.90 ^{a}	313.3 ^{a}	21.36	6.13	0.33
	Conventional	1.28 ^{bc}	326.7 ^{a}	23.86	5.67	0.00
Panonia	NoPes&MinFert	1.54 ^{ab}	186.7 ^{b}	24.13	7.83	0.00
	Conventional	0.77 ^{c}	190.0 ^{b}	27.06	6.90	0.00
			2018.			
Backa	NoPes&MinFert	1.18 ^{b}	253.3 ^{b}	21.53	5.80	3.33
	Conventional	2.19 ^{a}	356.7 ^{a}	21.40	5.63	0.00
Panonia	NoPes&MinFert	1.05 ^{b}	241.7 ^{b}	25.63	6.93	0.00
	Conventional	1.13 ^{b}	195.0 ^{b}	25.10	7.63	0.00
			2015-2018 (average)			
Bačka	NoPes&MinFert	1.46	276.4	21.69	6.32	1.00
	Conventional	1.63	278.3	21.29	6.41	0.75
Panonia	NoPes&MinFert	1.27	206.3	24.67	8.15	0.58
	Conventional	1.37	207.1	24.86	7.81	0.00

Different letters in superscript indicate significant difference among the mean values (Duncan's test, $p<0.05$). If the interaction (Year x Cultivar x Production) was not obseved multiple comparisons was not performed; the effects of other factors are present in Table 5.

Table 5. Statistical significance of the folowing experimental factors: year, cultivar and production system.

Factor	Yield (kg m-2)	Cluster weight (g)	Sugar (%)	Titratable acidity (g l^{-1})	*Botrytis* sp. incidence (%)
Year	**	*	**	**	**
Cultivar	**	**	**	**	*
Production system	ns	ns	ns	ns	ns
Year x Cultivar	**	**	ns	ns	ns
Year x Production system	**	*	**	ns	**
Cultivar x Production system	ns	ns	ns	ns	ns
Year x Cultivar x Production system	**	**	ns	ns	ns

*, **, ^{ns} indicate significant at $p < 0.05$, 0.01, or non significant, respectively.

In conventional and NoPes&MinFert production systems of Panonia, number of inflorescences showed an increase from the base until second and third node, respectively. Then, in booth production systems of Panonia a slight decrease in number of inflorescences was detected.

In 2015, both Backa and Panonia, had significantly higher yield in the conventional compared to the NoPes&MinFert production (39 and 32 %, higher respectively) (Table 4). In 2016 in the conventional production of Panonia the yield was 28% higher compared to NoPes&MinFert production. In 2018, Backa showed 46% higher yield in the conventional compared to the NoPes&MinFert production, while no difference was observed for Panonia. Moreover, Backa showed higher yield compared to Panonia.

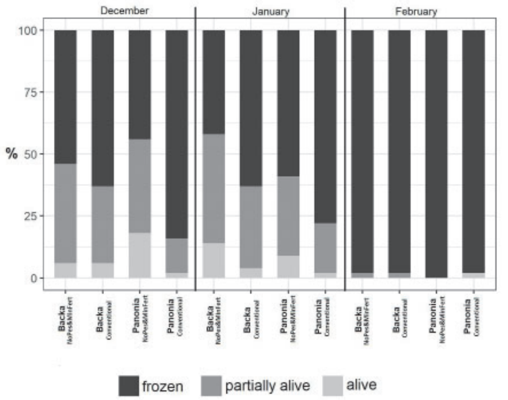
In the seasons 2015 and 2018, Backa had significantly higher cluster weight in the conventional compared to NoPes&MinFert production. The highest cluster weight was recorded in the conventional production of Backa in 2018. On average, Backa had 70 g heavier clusters compared to Panonia.

The cultivars showed satisfied tolerance to the incidence of *Botrytis* sp.(Table 4). However, Backa was more sensitive particularly in the organic production during 2017 and 2018, while in 2016 both cultivars were more sensitive in conventional production.

In 2016, higher sugar percentage was recorded in the NoPes&MinFert production. Contrary, in 2017 both Backa and Panonia had higher sugar percentage in the conventional compared to NoPes&MinFert production. Panonia accumulated significantly higher sugar in the grape juice (24.8%) compared to Backa (21.5%).

Titratable acidity varies particularly among the seasons and between cultivars. Thus, the highest titratable acidity (8.32 on average) was observed in 2016, while the lowest in 2018 (6.5 g l^{-1}). During the experiment Panonia had significantly higher titratable acidity (7.98 g l^{-1}) compared to Backa (6.37).

Both cultivars, Backa and Panonia, had less frozen buds in NoPes&MinFert compared to conventional production (Figure 3.). The highest difference in frozen buds between



Comparison between frozen buds of cultivars Backa and Panonia in NoPes&MinFert and conventional production.

Table 6. Total wine score of Backa and Panonia in NoPes&MinFert and conventional production systems, in 2015-2018 years.

Cultivar	Production systems	Color	Clarity	Aroma	Taste	Total score
			2015.			
Backa	NoPes&MinFert	2.0	2.0	3.3	10.6	17.9
	Conventional	2.0	2.0	3.0	10.1	17.1
Panonia	NoPes&MinFert	2.0	2.0	3.2	10.2	17.4
	Conventional	2.0	2.0	2.9	10.2	17.1
			2016.			
Backa	NoPes&MinFert	2.0	2.0	3.0	11.2	18.2
	Conventional	2.0	2.0	3.0	10.9	17.9
Panonia	NoPes&MinFert	2.0	2.0	3.3	11.4	18.7
	Conventional	2.0	2.0	3.3	11.3	18.6
			2017.			
Backa	NoPes&MinFert	2.0	2.0	3.4	10.7	18.1
	Conventional	2.0	2.0	3.5	10.5	18.0
Panonia	NoPes&MinFert	2.0	2.0	3.4	10.9	18.3
	Conventional	2.0	2.0	3.3	10.6	17.9
			2018.			
Backa	NoPes&MinFert	2.0	2.0	3.2	10.8	18.0
	Conventional	2.0	2.0	3.2	10.7	17.9
Panonia	NoPes&MinFert	2.0	2.0	3.1	11.3	18.4
	Conventional	2.0	2.0	3.1	11.1	18.2
			2015-2018 (average)			
Backa	NoPes&MinFert	2.0	2.0	3.2	10.9	18.1
	Conventional	2.0	2.0	3.1	10.8	17.9
Panonia	NoPes&MinFert	2.0	2.0	3.2	10.8	18.0
	Conventional	2.0	2.0	3.2	10.5	17.7

Buxbaum method was used to score the wine samples (0-20 points), assessing appearance (maximum 2 points), color (2), aroma and bouquet (4) and other characteristics, such as sugar, acidity, and astringency (scoring maximum of 12 points in total for these traits related to taste).

production systems was observed in Panonia at the end of December 2017 (44% necroted buds in NoPes&MinFert compared to 84 in Conventional production). Moreover, both cultivars showed the lowest cold hardiness at the end of the winter. In the February 2018, in NoPes&MinFert production of Panonia all bud categories (primary and secondary) in the winter buds were damaged.

The wines of booth cultivars achieved higher score in the NoPes&MinFert production compared to the conventional counterpart (Table 6). There were no differences among the treatments in the scores for wine color and clarity and each wine achieved a maximum (2 points) for these traits. The wine of Backa had a slightly better scores for and taste in the NoPes&MinFert compared to conventional production. The taste of the wine of Panonia, which is simmilar to the wine of its ancestor Riesling, achieved higher score in the NoPes&MinFert compared to the conventional production.

Discussion

Production without use of pesticides and mineral fertilizers - NoPes&MinFert, was similar to organic viticulture practices. Higher percentage of developed shoots and fruitfull shoots in conventional compared to NoPes&MinFert production, results in higher number of inflorescences per node. Our results are in agreement with (DÖRING & al. [16]) who found that organic production, had significantly lower growth and yield compared to integrated system. The lower yield in NoPes&MinFert compared to conventional production can be the result of the significantly lower cluster weight in the organic system and aligns with the findings reported by DÖRING & al. [16]. Moreover, it could be the result of lower bunch compactness (MEIßNER [17]). DÖRING & al. [18] posted that a decrease in soil moisture content under organic and biodynamic viticulture is likely to be responsible for the lower yield. However, POOL & ROBINSON [19] did not observe any differences in the number of berries/clusters and the average cluster weight between different management systems. It is speculated that difference in yield between conventional and organic production may be due to yield losses due to pests. Meta-analysis of 362 paired sets of organic–conventional yield data, noting that organic yields are on average 80% of conventional yields, but variation is substantial (21% standard deviation) (DE PONTI & al. [20]). In that research, authors also observed that the organic yield gap significantly differed between crop groups and regions (DE PONTI & al. [20]).

In a number of experiments (TASSONI & al. [12]; DÖRING & al. [16]) the grape juice sugar concentration of organically managed vines was almost same as that of conventionally managed vines. In our experiment the effect of production system on sugar concentration in the grape juice was inconclusive and depends on the interaction of weather conditions during the season (year) and cultivar. Titratable acidity in the grape juice was not affected by the production system which is in agreement with DORING & al. [16].

Our results for Backa and Panonia are supported by those obtained by DANNER [21], who observed a higher *Botrytis* sp. incidence in the production without spraying compared to conventional production. Conversely, some authors (PIKE [22], MEIßNER [17]) reported lower incidence of *Botrytis* sp. in organic vineyards. However, PIKE [22] conducted the experiment in Australian climate conditions where the disease pressure is low. In our experiment, the lower number of developed shoots could results in lower canopy density and better aeration around clusters which prevents *Botrytis* incidence (IVANIŠEVIC & al. [23]. Backa and Panonia are early ripening cultivars (end of the August) that can be harvested before the onset of unfavorable weather conditions in September and October.

NoPes&MinFert production showed higher bud freezing tolerance compared the conventional production. Enhanced tolerance to low temperatures in organic production can be related to lower yield. WAMPLE & WOLF [24] observed that Chardonnay had a greater freezing tolerance in the low than in the high crop load vines. CINDRIĆ & al. [15] observed that in the conditions of North Serbia (Vojvodina) majority of the cultivars have the highest tolerance to low temperatures in the last decade of January and in the middle of February. However, some cultivars tolerant to fungal diseases are the most susceptible to low temperatures in the middle of February (CINDRIĆ & al. [15]), as it was the case in our study.

In our study we observed enhanced wine aroma in the NoPes&MinFert production of Backa compared to conventional counterpart. Satisfied sensory properties of the organic wines, such as flavor intensity, wine body and a general acceptance were also observed in Italy (LANTE & al. [25]). Organic grapevines, grown with reduced pesticides, are more stressed by pathogens compared to conventionally grown grapevines and produce more aroma related compounds (MARTIN & RASMUSSEN [26]). In one study that presents differences between organic and conventional production in central Italy, organic wines had higher overall acceptance by the sensory panel (BENI & ROSSI [27]). Wines of Trebbiano and Sangiovese from the conventional production in the same study, were described as unbalanced and acidic, compared to the organic wines (BENI & ROSSI [27]). In our study, sugar-acid ratio in the grape juice was improved by the the NoPes&MinFert production system of Panonia (lower sugar and higher acidity–Table 4). Therefore, it seems that better sugar-acid ratio in the NoPes&MinFert production improves the wine balance which is particularly important in hot and dry seasons.

Conclusions

Findings yielded by the present study show that fungus-tolerant grape cultivars Backa and Panonia are suitable for the production without use of pesticides. Although the number of inflorescences per node and yield were higher in conventional production, NoPes&MinFert production showed satisfied yield that exceeded 10 t/ha. Moreover, NoPes&MinFert production showed enhanced bud tolerance to low winter temperatures compared to conventional counterpart. Grape chemical composition was similar in both productions while the wines from NoPes&MinFert production achieved higher score in the wine sensory analyses. Differences between cultivars in yield and grape chemical composition were also observed. The studied cultivars allow sustainable grape production in the moderately continental climate conditions.

Source of research fundings

the research was supported by The Ministry of Education, Science and Technological development of the Republic of Serbia and its project TR 31027 and Contemporary technology in organic viticulture - supported by Autonomous Province of Vojvodina, Provincial Secretariat for higher education and scientific research.

Acknowledgments

We are grateful to our professor emeritus Petar Cindric (creator of the cultivars Backa and Panonia), prof Nada Korać and dr Vlada Kovač. We are also grateful to enologist Siniša Ostojić for his support of this work.

References

1. E. PETERLUNGER, G. DI GASPERO, G. CIPRIANI, P. SIVILOTTI, L. ZULINI, M.T. MARRAZZO, D. ANDREETTA, R. TESTOLIN. Breeding strategy for the introgression of disease resistance genes into European grapevine. *Acta Hortic*., 603: 665-670 (2003).
2. R. BARTOLUCCI. Philosophical considerations in converting to organic vineyard production. *Am J Enol Vitic*, 43: 294-295 (1992).
3. G. MEISSNER, M.E. ATHMANN, J. FRITZ, R. KAUER, M. STOLL, H.R. SCHULTZ. Conversion to organic and biodynamic viticultural practices: impact on soil, grapevine development and grape quality. *OENO One*, 53(4) (2019).
4. J.E. MASSON, I. SOSUSTRE-GACOUNGOLLE, M. PERRIN, C. SCHMITT, M. HENAUX, C. JAUGEY, E. TEILLET, M. LOLLIER, J.F. LALLEMAND, F. SCHERMESSER, G. WESTHALEN. Trandisciplinary participatory-action-research from questions to actionable knowledge for sustainable viticulture development. *Humanit. Soc. Sci. Commun*., 8(24): 1-9 (2021).
5. B. GEIER. Organic grapes - More than Wine and Statistics. *The World of Organic Agriculture: Statistics & Emerging Trends 2016.* H. Willer, & M. Yussefi, (Eds.): International Federation of Organic Agriculture Movements (IFOAM), pp. 62-65. Bonn, Germany. (2006).
6. B. GUESMI, T. SERRA, Z. KALLAS. The productive efficiency of organic farming: the case of grappe sector in Catalonia. *SJAR*, 10(3): 552-566 (2012).
7. M. HENDGEN, B. HOPPE, J. DÖRING, M. FRIEDEL, R. KAUER, M. FRISCH, A DAHL, H. KELLNER. Effects of different management regimes on microbial biodiversity in vineyard soils. *Sci Rep*, 9393: 1-13 (2018).
8. J. NASCIMBENE, L. MARINI, M.G. PAOLETTI. Organic farming benefits local plant diversity in vineyard farms located in intensive agricultural landscapes. *Environ Manage*, 49: 1054–1060 (2012).
9. X. PUIGMONTSERRAT, C. STEFANESCU, I TORRE, J. PALET, E FABREGAS, J. DANTART, A ARIZZABALAGA, C FLAQUER. Effects of organic and conventional crop management on vineyard biodiversity. *Agr Ecosyst Environ*, 243 : 19-26 (2017).
10. W.J. CRINNION. Organic foods contain higher levels of certain nutrients, lower levels of pesticides, and may provide health benefits for the consumer. *Altern. Med. Rev.*, 15(1): 4–12. (2010).
11. D. GRANATO, T. MARGRAF, I. BROTZAKIS, E. CAPUANO, S.M. VAN RUTH. Characterization of conventional, byodinamic and organic purple grape juices by chemical marker, antioxidant capacity, and instrumental taste profile. *J. Food. Sci*, 80: C55-C65 (2015).
12. TASSONI, N TANGO, M. FERRI. Comparison of biogenic amine and polyphenol profiles of grape berries and wines obtained following conventional, organic and biodynamic agricultural and oenological practices. *Food Chem,* 139: 405–413 (2013).
13. R. TÖPFER, L. HAUSMANN, M HARST, E. MAUL, E. ZYPRIAN,. R. EIBACH. New horizons for grapevine breeding. *Fruit, vegetable and cereal science and biotechnology*. H. Slochowsky, & M.V. Hanke, (Eds.): Global Science Books, Isleworth, pp. 79-100. (2011).
14. B.G. COMBE. Growth stages of the grapevine: Adoption of a system for identifying grapevine growth stages. *Aust J of Grape Wine R*, 1(2): 104-110 (1995).

15. P. CINDRIĆ, N. KORAĆ, V. KOVAČ. Sorte vinove loze, Prometej, Novi Sad. (2000).
16. J. DÖRING, M. FRISCH, S. TITTMANN, M STOLL, R. KAUER. Growth, yield and fruit quality of grapevines under organic and biodynamic management. *PLoS ONE*, 10(10): 1-28 (2015).
17. G. MEIßNER. Untersuchungen zu verschiedenen *Bewirtschaftungs systemen* im Weinbau unter besonderer Berücksichtigung der biologisch-dynamischen Wirtschaftsweise und des Einsatzes der biologisch-dynamischen Präparate. Justus-Liebig-Universität Gießen. (2015).
18. J. DÖRING, C. COLLINS, M. FRISCH, R. KAUER. Organic and biodynamic viticulture affect biodiversity and properties of vine and wine: A systematic quantitative review. *Am J Enol Vitic*, 70: 221-242 (2019).
19. R.M. POOL, J.A. ROBINSON. The SARE–Cornell organic grape project. *In* 3rd Organic Grape and Wine Production Symposium. Pool RM (Eds): pp. 7–14. (1995).
20. T. DE PONTI, B. RIJK, M.K ITTERSUM. The crop yield gap between organic and conventional agriculture. *Agr Syst*, 108: 1–9 (2012).
21. R. DANNER. Vergleichende Untersuchungen zum konventionellen, organisch-biologischen und biologisch-dynamischen Weinbau. PhD Thesis, Universität für Bodenkultur Wien. (1985).
22. B.P.A. PIKE. Effect of organic, biodynamic and conventional vineyard management inputs on grapevine growth and susceptibility to powdery mildew and *Botrytis* bunch rot. *Thesis*, School of Agriculture, Food and Wine. The University of Adelaide. (2015)
23. D. IVANIŠEVIĆ, M. KALAJDŽIĆ, M. DRENJANČEVIĆ, V. PUŠKAŠ, N. KORAĆ. The impact of cluster thinning and leaf removal timing on the grape quality and concentration of monomeric anthocyanins in Cabernet-Sauvignon and Probus (*Vitis vinifera* L.) wines. *OENO One*, 54(1): 63–74 (2020).
24. R.L. WAMPLE, T.K.WOLF. Practical consideration that impact vine cold hardiness. Proc. for the 4th Int. Symposium on Cool Climate. pp. 23-38 (1996).
25. LANTE, A. CRAPISI, G. LOMOLINO, P SPETTOLI. Chemical parameters, biologically active polyphenols and sensory characteristics of some Italian organic wines. *J Wine Res*, 15(3): 203-209 (2004).
26. K.R. MARTIN, K.K. RASMUSSEN. Comparison of sensory qualities of geographically paired organic and conventional red wines from the southwestern US with differing total polyphenol concentrations: a randomized pilot study. *Food Nutr. Sci,* 2: 1150–1159 (2011).
27. C. BENI, G. ROSSI. Conventional and organic farming: Estimation of some effects on soil, copper accumulation and wine in a Central Italy vineyard. *Agrochimica*, 53:145–159 (2009).