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ANALYSIS OF POSSIBILITIES OF REDUCING THE QUANTITY OF MINERAL FERTILIZER APPLICATION USING DIFFERENT TYPES OF ORGANIC FERTILIZERS IN CARDINAL GRAPE VARIETY

SUMMARY

This paper presents the results of a three-year study (2010–2012) on the influence of different types and combinations of fertilisers on the agro-biological, economic and technological characteristics of the Cardinal variety of grapes. The study was carried out in the experimental vineyard of the Biotechnical Faculty in Podgorica to explore the possibility of reducing the use of mineral fertilisers by applying various organic fertiliser sources.

Ten variants of fertilisation were applied: control (500 kg ha^{-1}, NPK 8:16:24), cattle manure (25 t ha^{-1}), poultry manure (10 t ha^{-1}), peat (12 t ha^{-1}), combination of 75% mineral fertiliser and 25% cattle manure, combination of 75% mineral fertiliser and 25% poultry manure, combination of 75% mineral fertiliser and 25% peat, combination of 50% mineral fertiliser and 50% cattle fertiliser, combination of 50% mineral fertiliser and 50% poultry manure, and combination of 50% mineral fertiliser and 50% peat.

The results demonstrate the possibility of using organic fertilisers to partially replace mineral fertilisers. The application of 50% mineral fertiliser and 50% organic fertilisers produced the best results in terms of grape yield and the physical and chemical characteristics of bunches and berries of the Cardinal variety..

Keywords: Grapes, Cardinal, mineral fertilizer, organic fertilizer.

INTRODUCTION

Production of table grapes is an important part of the economy of Montenegro. This branch of plant production is mostly present in Podgorica vineyard region. Due to very favourable climate, in this region are ideal conditions for cultivation of table varieties of different epochs of ripening. Cardinal, which is distinguished by large and beautiful bunches and berries, but also with very pleasant aroma, is the most common among the table grapes. Due

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to the above mentioned characteristics, a significant part of produced grapes is exported.

Cardinal variety originates from California, and was developed by crossing varieties Flame Tokay and Ribier. It is widespread in almost all countries of the world, especially in Spain, Italy, Romania and Mexico (Mirošević, 2008). The area under this variety in Montenegro is about 180 ha (Savić, 2007). Particularly good results are achieved in regions where at the time of maturation there are no abundant precipitation and where during winter there is no danger of low temperatures (Cindrić, 2000).

Fertilization is one of the most important agro technical measures in the production of grapes, significantly influencing the yield and quality of grapes (Delgado et al., 2004). In conventional agricultural production, fertilization is based on mineral-rich synthetic fertilizers, since it is the most efficient and quickest compensation of the deficit of certain nutrients. However, it should be kept in mind that their long-term and uncontrolled application can cause certain environmental problems (soil, water and air pollution), but also lead to deterioration of the soil structure and reduction of soil microflora (Korać, 2011). In addition, the excess of minerals, especially nitrogen fertilizers, leads to the accumulation of harmful residual substances (nitrates and nitrites) in grape berries and leaves (Abd El-Wahab, 2011; Montasser et al., 2003). These problems can be partially mitigated by application of organic fertilizers that in the past represented the standard method for vineyard fertilization. Since organic fertilizers contribute significantly to preserving natural resources, but also to reducing ecosystem degradation, their use in modern viticulture becomes increasingly important (Francis and Daniel, 2004). In comparison with mineral fertilizers, organic fertilizers (manure, compost, green manure, worm compost and other organic sources of nutrients) are less important in the fertilization of vineyards due to chemical bound of nutrition elements with organic matter from which they are gradually released during the mineralization process (Džamić, 2000). However, the real significance of organic fertilizers is far greater, as soil structure, air, water and heat regimes are substantially improved with their usage, soil is enriched with microorganisms and pH is reduced (Abbas et al., 2012; Sial et al., 2007). Due to all above mentioned, but also possible negative effects that can be caused by the uncontrolled use of mineral fertilizers, organic fertilizers are a very important source of support for the production of safe raw materials, suitable for export (Ghobrial, 2006).

Considering that most vineyards are built on skeletal, mostly infertile soils of the southern part of Montenegro, they are growing and yielding under conditions of insufficient essential nutrition elements. The application of mineral and organic fertilizers is one of the most important agro technical activities in the production of this important culture. Mineral and organic fertilizers complement each other in maintaining fertility of the soil and can be replaced according to the nutrient content (Popović, 2007).

The possibility of using organic fertilizers in order to increase growth and development, as well as for improving of yield and nutritional status of the vines, was examined by many researchers (Zafar et al., 2012; Popović, 2007; Kassem and Marzouk, 2002 and Omar, 2005). Although this is not a new idea, there is still not enough information about the impact of organic fertilizers on the yields and quality of table varieties in Montenegro. For these reasons, experiments have been set up with the aim of examining the influence of the reduced quantities of mineral fertilizers in the fertilization of Cardinal using various sources of organic fertilizers in the conditions of the Montenegrin vineyard region.

MATERIAL AND METHODS

In the period 2010-2012 the influence of various organic fertilizers, and mineral fertilizer (NPK 8:16:24), as well as influence of these various combinations on the agro-biological and economical and technological characteristics of the Cardinal variety was analysed in the Podgorica vineyard region. The experimental vineyard of the Biotechnical Faculty was used for this research.

The experiment was carried out in the early grape variety Cardinal, grafted on rootstock Kober 5BB. The vineyard was planted in 2005, with 2.50 m between and 1.2 m within row distance. The vine form is double horizontal cordon, about 80 cm high. The research involved 300 vine plants. Short pruning was applied with two long cordons with five buds and two cordons with two buds. The experiment was performed in three repetitions with 10 vine plants each. The fertilization was carried out in the furrows at a depth of 25 cm during the winter grape period in the last week of January and was applied in the following variants: V1 (control variant) - 100% mineral fertilizer (500 kg / ha NPK 8:16:24) ; V2 - cattle manure 25 t ha-1; V3 – poultry manure, 10 t ha-1; V4 - peat, 12 t ha-1; V5 - 75% mineral and 25% cattle manure; V6 - 75% mineral and 25% poultry manure; V7 - 75% mineral fertilizer and 25% peat; V8 - 50% mineral and 50% cattle manure; V9 - 50% mineral and 50% poultry manure and V10 - 50% mineral fertilizer and 50% peat.

The following parameters were followed:

- Grape yield was obtained by weighing harvested grapes on each vine plant, and the bunch weight was determined from the ratio of yield and number of bunches. After harvest, the average weight (g) of berries was measured.

- Sugar content in grape juice is determined aerometrically (Oeschle must balance), and proportion of the total acid in the grape juice by neutralization of acids and their salts with n/10 NaOH solution using bromothymol blue indicator.

During the studied period, the highest temperatures were measured in 2012, both on an annual basis and during the growing period. The average temperature of the vegetation period in this year was 23.4°C and was slightly higher compared to 2011 (23.1°C) and significantly higher than 2010 when it was 21.7°C. The Podgorica vineyard region is characterized by a high Winkler index, which in the years of experiment was > 2300, > 2 600, > 2 600, in 2010, 2011 and

2012, respectively. The amount of rainfall in the vegetation period was 771.7 mm in 2010, 309.8 mm in 2011 and 911.6 mm in 2012 (Monstat, 2013).

Analysis of the results was performed using analysis of variance for completely random block design using LSD test for paired comparisons on two levels of significance: 0.05 and 0.01.

RESULTS AND DISCUSSION

Bunch weight is essentially a biological feature of a variety that depends on the agro ecological conditions of the production area to a large extent (Cindrić, 2000). In the three-year average (Table 1), the lowest weight of bunches had variants with individual application of organic fertilizers V2, V3 and V4 (200 g, 205 g and 209 g, respectively), and the highest weight had the variant V10 in which combination of 50% of mineral fertilizer and 50% peat was applied - 265 g. Statistical data processing has shown that all variants with a combination of mineral and organic fertilizers have a significantly higher weight of bunches than the variants with individual application of organic fertilizers or variant with mineral fertilizers. The positive impact of combined use of organic and mineral fertilizers on the bunch weight is also reported by Abd El Wahab 2011.

Number of bunches - The lowest number of bunches per vine plant had variants with individual application of organic fertilizers in the three-year average - V2 and V3 (17.4, 17.6), while highest bunch number was found in variants V10 and V7 (18.7). All the studied varieties of fertilization had a significantly higher number of bunches than variants V2 and V3. A significantly higher number of bunches was determined in variants V10 and V7 in comparison with variant V1.

Grape yield as an absolute indicator of fertility, and depends on a large number of factors, among which the most important are the biological specificity of the variety, the plant nutrition and ecological conditions that prevail in production area (Popović, 2012). The highest yield of grapes was measured in variants V10, V7 and V9 (5.0 kg/vine, 4.8 kg/ vine and 4.7 kg/vine), while the lowest yield was found for variant V2 - 3.5 kg/vine. Fertilizer variant with mineral fertilizer (V1), yielded 4.2 kg/vine. In the three-year average on all variants with combined application of fertilization, a significantly higher yield was obtained in variants where organic fertilizers were applied individually. The variance analysis showed that the variants V10 and V7 had significantly higher yields of grapes compared with the variant on which only mineral fertilizer was used (V1).

The yield of grapes in the examined years was within the limits indicated by Cindrić, 2000; Božinović, 2010; Dardeniz, 2014 et al.

Average berry weight – All studied fertilizers significantly influenced the average berry weight of the Cardinal varieties. In the three-year average, the lowest weight of berry had variants with the use of 100% organic fertilizers (V2 -

5.7 g, V3 - 5.8 g and V4 - 5.9 g). A significant increase in the weight of the berries was found in vines fertilized with 50% mineral and 50% organic fertilizers (V10 - 6.7 g, V9 - 6.4 g). The positive effect of combined application of organic and mineral fertilizers on this vine property is due to the higher content of organic matter in the soil, as well as to improved structure and physical properties of the soil (Abd El Wahab, 2011 and Gamal, 1992).

Tab. 1. Influence of organic and mineral fertilizers on yield and physical characteristics of bunches and berries.

Variant	Number of bunches				Bunch weight (g)				Yield (kg/vine)				Berry weight (g)			
	2010	2011	2012	2010-12	2010	2011	2012	2010-12	2010	2011	2012	2010-12	2010	2011	2012	2010-12
V1	18.1	18.1	18.3	**18.2**	233	230	235	**233**	4.2	4.2	4.3	**4.2**	6.0	6.1	6.2	**6.1**
V2	17.0	17.4	17.8	**17.4**	184	196	220	**200**	3.1	3.4	3.9	**3.5**	5.5	5.6	6.0	**5.7**
V3	17.3	17.6	18.0	**17.6**	193	200	222	**205**	3.3	3.5	4.0	**3.6**	5.6	5.8	5.9	**5.8**
V4	17.5	17.9	18.2	**17.9**	197	204	225	**209**	3.4	3.7	4.1	**3.7**	5.7	5.9	6.1	**5.9**
V5	18.1	18.0	18.5	**18.2**	238	248	260	**249**	4.3	4.5	4.8	**4.5**	6.4	6.0	6.2	**6.2**
V6	18.4	18.5	19.0	**18.6**	240	253	255	**249**	4.4	4.5	4.9	**4.6**	6.2	6.2	6.4	**6.3**
V7	18.7	18.6	18.9	**18.7**	251	257	262	**257**	4.7	4.7	5.0	**4.8**	6.4	6.3	6.6	**6.4**
V8	17.0	18.3	19.3	**18.2**	228	255	269	**251**	3.9	4.7	5.2	**4.6**	5.7	6.5	6.8	**6.3**
V9	17.3	17.9	19.7	**18.3**	232	260	267	**253**	4.0	4.8	5.3	**4.7**	5.8	6.5	7.0	**6.4**
V10	16.6	19.3	20.1	**18.7**	241	275	280	**265**	4.0	5.3	5.6	**5.0**	6.0	6.9	7.1	**6.7**
ẋ	17.6	18.2	18.8	**18.2**	224	238	250	**237**	3.9	4.3	4.7	**4.3**	5.9	6.2	6.4	**6.2**

Parameter	Number of bunches		Bunch weight		Grape yield		Berry weight	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2010-2012	0.470	0.633	11.165	15.047	0.409	0.671	0.409	0.551

Sugar content in must - Optimal mineral nutrition is essential for achieving higher carbohydrate content in grape. Potassium and phosphorus have highest importance of all macronutrients, and nitrogen and in specific optimal limits (Popović, 2007). Table 2 presents the results demonstrating that the applied fertilizers in all the studied years significantly influenced the chemical composition of the berries, that is, the content of sugar and acids in the must. In the three-year average, the variant with cattle manure had the lowest content of sugar - 14.12%, while the highest content was measured in the V10 variant - 14.94% and V9 - 14.80%. All the examined fertilizer combinations had significantly higher sugar content compared to variant V2, and variants V10 and V9 had higher amount of sugar compared to the variant fertilized with poultry

manure (V3) and peat variant (V4). The results of the study are in line with the results by Omar (2005), demonstrating in seedless variety Thomson seedless a significant increase in sugar content in must in combined use of mineral and organic fertilizer.

Table 2. Influence of organic and mineral fertilizers on chemical characteristics of berries

Variant	Sugar content (%)				Acid content (g/l)			
	2010	2011	2012	2010-12	2010	2011	2012	2010-12
V1	14.35	14.55	14.83	**14.58**	4.18	4.00	3.88	**4.02**
V2	13.87	14.12	14.37	**14.12**	4.65	4.38	4.22	**4.42**
V3	13.97	14.31	14.60	**14.31**	4.55	4.39	4.10	**4.34**
V4	13.96	14.54	14.70	**14.44**	4.40	4.23	4.00	**4.21**
V5	14.41	14.62	14.82	**14.62**	4.25	3.97	3.90	**4.04**
V6	14.53	14.73	14.62	**14.57**	4.32	4.02	3.85	**4.06**
V7	14.64	14.87	14.90	**14.80**	4.13	3.92	3.75	**3.93**
V8	14.00	14.77	15.17	**14.60**	4.30	4.10	4.02	**4.14**
V9	14.13	14.80	15.27	**14.80**	4.38	4.18	4.13	**4.23**
V10	14.23	15.13	15.37	**14.94**	4.22	3.99	3.97	**4.06**
Average	14.20	14.57	14.86	**14.57**	4.33	4.11	3.98	**4.14**

Parameter	Sugar content		Acid content	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2010-2012	0.438	-	0.289	-

Acid content in must is an important indicator of the quality influencing the taste and harmony of the grapes (Popović, 2012). Due to the specific pedological and climate conditions, the grapes produced in the southern parts of Montenegro are characterized by high sugar content and low acid content. In a three-year average, a statistically significant increase in acidity was found in variants with the individual application of organic fertilizers (V2 - 4.42 g/l, V3 -

4.34 g/l, V4 - 4.21 g/l). The smallest content was measured in the V7 variant - 3.93 g/l. El-Shenawy and Fayed (2005) had similar results in the variety Crimson seedless and Abd-El Wahab (2011) in the Red Globe variety.

CONCLUSIONS

Based on a three-year study of the fertilization of Cardinal variety with different types and combinations of organic and mineral fertilizers in the agro ecological conditions of Podgorica vineyard, it can be concluded:

-The highest yields of grapes, bunch and berry weight had fertilization variant in which mineral and organic fertilizers were combined in a ratio of 50% + 50%.
-All variants of combined application of organic and mineral fertilizers have had a positive effect on the content of sugar and acids in grape must.
-Given the very small number of available information related to the fertilization of grape vines with organic fertilizers, these studies should continue in the following period.

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