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The impact of some innovative technological solutions on the quantity and quality of the grape production

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ABSTRACT

The experiment, carried out during 2018-2019 in Valea Calugareasca viticultural center, aimed to establish some innovative technological solutions concerning the vine phytosanitary protection, soil maintenance system and vine fertilization able to provide an increase of quantity and quality of grape production. The cultivars taken into study were 'Merlot' and 'Fetească albă'. Compared to the classical technological solutions, the new solutions experimented on were the integrated protection system, the soil mulching and the permanent grassing as soil maintenance systems and the mineral and foliar fertilization at the level of DoEXP. The results obtained showed the positive influence on grape production induced by the soil mulching with marc compost, the integrated protection system and the mineral fertilization. These increases were differentiated according to the cultivar and the interaction between the technological solutions applied. Regarding the impact of the new technological solutions on grape quality, we can notice a significant positive effect on the anthocyanin content (in case of 'Merlot' cultivar) and only a minor effect on the sugar content and total acidity of the grapes. The use of permanent grassing, as a soil maintenance system, had a negative impact on vine productivity and grape quality, especially during the drought years. The only positive effect was an increase in the must acidity.

Keywords: innovative solutions, pest control, soil maintenance system, fertilization system.

INTRODUCTION

Viticulture of the last decades was marked by permanent concerns regarding the development of the most efficient culture systems that would create increased possibilities for the expression of productivity and quality characteristics of vinifera cultivars and also allow, using maximum efficiency of the technological inputs, the realization of an appropriate production in terms of quantity, but also terms of quality and economy. These new technologies have to be accessible price-wise and easy to use for the farmers (Hafner, 2004; Fregoni, 2005; Ranca, 2005; Jackson, 2008). Special importance is also given to the problems related to the protection of viticultural ecosystem (an existing tendency to adapt the new technologies to the ecological system) as well as ~~for~~ to finding new technological solutions to adapt them at the disturbing effect of the actual climatic changes (Teil and Barrey, 2009; Șerdinescu*et al.*, 2013; Ruggero, 2019). For many years, on a global level, the experimented technological solutions were oriented to maximize the effects of phytosanitary protection, soil maintenance system and fertilization, in order to increase the grape's production~~s~~. For this reason, our research were focused on finding new innovative technological solutions in these directions for obtaining an increase in both the productivity and quality of grape production, ensuring at the same time the protection of the viticultural ecosystem.

MATERIALS AND METHODS

Research was carried out in Valea Calugareasca viticultural center, in two experimental plots cultivated with 'Merlot' and 'Fetească albă' cultivars. There were studied three experimental factors which have an important impact on vine growth and productivity and the grapes quality. These factors were: ***A-the plant protection system***, with two variants: a_1- chemical protection and a_2–integrated protection; ***B-the soil maintenance system***, with three variants: b_1-bare soil, b_2- permanent grassing (on the interval between rows) and b_3- soil mulching; ***C-the fertilization system***, with three variants: c_1- unfertilized, c_2- mineral fertilization (at the level of DoEXP) and c_3- foliar fertilization. It resulted in a multifactorial experiment of type 2x3x3, with 18 experimental variants, located in the experimental field according to the method of split plots. Each experimental plot had a number of 15 vines. To realize the permanent grassing of soil it was used the perennial grasses from spontaneous flora and for the mulching system, it was used the grape pomace as mulch. Mineral fertilization was performed annually, in spring, with the DoEXP of $N_{75}P_{100}K_{135}$, calculated according to the soil fertility and the foliar fertilization was performed three times during the growing season using Cropmax and Amalgerol as foliar fertilizers. To establish the influence of the innovative technological solutions on productivity and quality of the harvest achieved determinations regarding the grape yield, the sugar content (g/L) and the total acidity (g/L tartaric acid) in must at the harvest time. The gluco-acidimetric index was calculated, based on the sugar content and the total acidity values. In case of Merlot cultivar was established also the content in anthocyanin in the grape skin, using the colorimetric method. The experimental data obtained were interpreted based on the interactions between the experimental factors (AxB, AxC and BxC), using the medium values by factors. The placement of the experiment according to the method of split plots allowed us to establish the singular influence, as well as the interaction influence of the experimental factors on the grape production and quality. The chemical protection system (a_1), the bare soil system (b_1) and the unfertilized system (c_1) were considered as control.

RESULTS AND DISCUSSIONS

Analyzing the obtained data, we can notice that the experimental factors, in their interaction, had a different influence on grape production (Table 1). Considering the singular effect of factor A (medium values) it is found that the integrated protection (a_2) ensured an increase of the grape production of 22.0% (0.52 kg/vine) in the case of 'Merlot' cultivar and of 18.8% (0.28 kg/vine) in case of Fetească albă' cultivar, as compared to control (chemical protection).
Analyzing the effect of factor B (medium values B) we can notice a positive effect on the grape production of the mulching system (b_3), which ensured an increase of 32.8% (0.81 kg/vine) in case of 'Merlot' cultivar and of 17.9% (0.28 kg/vine) in case of 'Fetească albă' cultivar as compared to control (bare soil system). This positive effect is the result of the better conservation of water in soil during the summer drought periods ensured by the soil mulching. The use of permanent grassing of soil caused a reduction of grape production due to the competition on the use of water resources exerted by spontaneous flora used for soil grassing. Concerning the singular effect of the fertilization system (factor C), the medium values show the favorable influence of mineral and foliar fertilization on the grape

production, as compared to control. The mineral fertilization (c_2) ensured an increase of grape production of 28.3% (0.65 kg/vine) in case of 'Merlot' cultivar and of 24.6% (0.36 kg/vine) in case of 'Fetească albă' cultivar, as compared to control (unfertilized). The foliar fertilization (c_3) ensured smaller increases, of only 13.5% (0.31 kg/vine) in case of Merlot cultivar and of 13.5% (0.15 kg/vine) in case of 'Fetească albă' cultivar.

Table 1. Influence of the experimental factors on grape production (kg/vine)

Interaction AXB

Factor A	Factor B			Medium value A
	b_1 bare soil	b_2 permanent grassing	b_3 soil mulching	
'Merlot' cultivar				
a_1 - chemical protection	2.24	1.99	2.84	2.36
a_2 - integrated protection	2.71	2.21	3.72	2.88
Medium value B	2.47	2.10	3.28	2.62
'Fetească albă cultivar				
a_1 - chemical protection	1.42	1.27	1.78	1.49
a_2 - integrated protection	1.70	1.72	1.89	1.77
Medium value B	1.56	1.49	1.84	1.63

Interaction AXC

Factor A	Factor C			Medium value A
	c_1 unfertilized	c_2 mineral fertilization	c_3 foliar fertilization	
'Merlot' cultivar				
a_1 - chemical protection	2.06	2.70	2.32	2.36
a_2 - integrated protection	2.54	3.19	2.90	2.88
Medium value C	2.30	2.95	2.61	2.62
'Fetească albă' cultivar				
a_1 - chemical protection	1.36	1.69	1.42	1.49
a_2 - integrated protection	1.57	1.95	1.79	1.77
Medium value C	1.46	1.82	1.61	1.63

Interaction BXC

Factor B	Factor C			Medium value B
	c_1 unfertilize d	c_2 mineral fertilization	c_3 foliar fertilization	
'Merlot' cultivar				
b_1- bare soil	2.93	3.61	3.29	3.28
b_2- permanent grassing	1.78	2.37	2.14	2.10
b_3- soil mulching	2.18	2.84	2.40	2.47
Medium value C	2.30	2.95	2.61	2.62
'Fetească albă' cultivar				
b_1- bare soil	1.60	2.06	1.84	1.84
b_2- permanent grassing	1.41	1.55	1.52	1.49
b_3- soil mulching	1.37	1.85	1.46	1.56
Medium value C	1.46	1.82	1.61	1.63

Analyzing the influence of the binary interaction between the experimental factors (AxB, AxC, BxC) on the grapes production we can notice the following aspects: in case of the interaction AxB factors the integrated protection system (a_2) ensured the highest production to the all variants of soil maintenance system and the soil mulching (b_3) ensured the highest production for both the protection systems; in case of the interaction AxC the integrated protection system (a_2) ensured the highest production to the all variants of soil fertilization and the mineral fertilization system (c_2) ensured the highest production for both the protection systems; regarding the interaction BxC we can mention that the soil mulching (b_3) ensured the highest production to the all variants of soil fertilization and the mineral fertilization (c_2) ensured the highest production to the all variants of soil maintenance system.

For all the experiments, the highest production, respectively 3.74 kg/vine in case of 'Merlot' cultivar and 2.21 kg/vine in case of 'Fetească albă' cultivar was obtained in case of the variant $a_2b_3c_2$ (integrated protection system, soil mulching system and the mineral fertilization).

The data regarding the influence of the experimental factors on the sugar content of the grapes are presented in table 2.

As a general point of view, one can notice that the experimental factors had a lower influence on the sugar content of the grapes as compared to the influence on grape production. Analyzing the singular effect of factors, A (medium values A) and B (medium values B) it is found that these factors had practically no obvious influence on the sugar content of the grapes. Only factor C (fertilization system) had a positive effect. Analyzing the medium values of factor C it is found that compared to the control (c_1), the mineral fertilization (c_2) ensured an increase of the sugar content of1.1% (2.7 g/L) in case of Merlot cultivar and of 3.9% (8.5 g/L) in case of 'Fetească albă' cultivar and the foliar fertilization (c_3) ensured an increase of 1.0% (2.2 g/L) and of 2.7% (5.8 g/L) for the same cultivars.

Analyzing the influence of the binary interaction between the experimental factors (AxB, AxC, BxC) on the sugar content of the grapes we can notice the following aspects: in case of the interaction AxB and AxC was not observed an obvious influence of one factor to the other factor. In case of the interaction BxC we can mention that the soil mulching (b_3) ensured the highest sugar content to all the variants of soil fertilization and the mineral fertilization (c_2) ensured the highest sugar content to all the variants of soil maintenance system.

The total acidity of the grapes (g/L tartaric acid) was not found an obvious influence determined by the experimental factors. Only in case of chemical protection system (a_2) and the use of permanent grassing as a soil maintenance system (b_2) one can mention a slight increase in the grape's total acidity.

Table 2. Influence of the experimental factors on the sugar content of the grapes (g/L)

Interaction AXB

Factor A	Factor B			Medium value A
	b_1 bare soil	b_2 permanent grassing	b_3 soil mulching	
'Merlot 'cultivar				
a_1 - chemical protection	241.5	243.4	241.7	242.2
a_2 - integrated protection	242.6	241.9	242.4	242.3
Medium value B	242.0	242.7	242.1	242.3
'Fetească albă' cultivar				
a_1 - chemical protection	224.4	222.0	223.4	223.3
a_2 - integrated protection	225.3	220.0	220.3	221.9
Medium value B	224.8	221.0	221.9	222.6

Interaction AXC

Factor A	Factor C			Medium value A
	c_1 unfertilized	c_2 mineral fertilization	c_3 foliar fertilization	
''Merlot' cultivar				
a_1 - chemical protection	240.7	243.1	242.7	242.2
a_2 - integrated protection	240.5	243.4	243.0	242.3
Medium value C	240.6	243.3	242.8	242.3
'Fetească albă' cultivar				
a_1 - chemical protection	219.9	225.2	224.7	223.3
a_2 - integrated protection	215.8	227.4	222.5	221.9
Medium value C	217.8	226.3	223.6	222.6

Interaction BXC

Factor B	Factor C			Medium value B
	c_1 unfertilized	c_2 mineral fertilization	c_3 foliar fertilization	
'Merlot' cultivar				
b_1- bare soil	240.7	242.7	242.8	242.0
b_2- permanent grassing	240.8	243.2	243.9	242.7
b_3- soil mulching	240.2	243.9	241.9	242.1
Medium value C	240.6	243.3	242.8	242.3
'Fetească albă' cultivar				
b_1- bare soil	223.9	225.8	224.9	224.8
b_2- permanent grassing	214.5	225.9	222.7	221.0
b_3- soil mulching	215.2	227.2	223.3	221.9
Medium value C	217.8	226.3	223.6	222.6

For this reason, the values of gluco-acidimetric index do not show high variability. In case of Merlot cultivar these values oscillated between 42.7 and 47.1 and in case of the Fetească albă cv. between 30.9 and 35.3 (Figure1and 2).

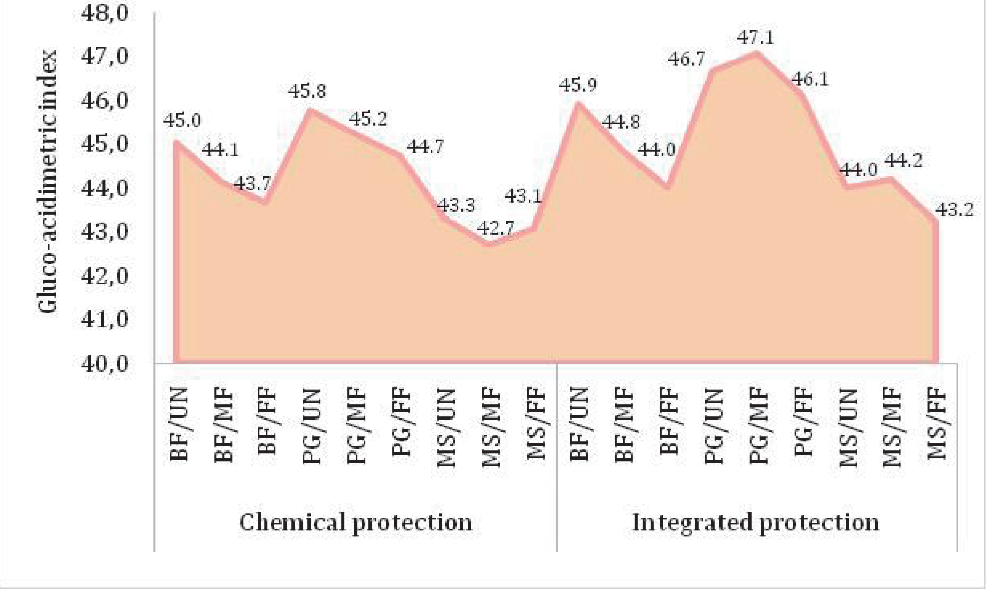

Figure 1. Influence of the experimental factors on the values of gluco-acidimetric index in case of 'Merlot' cultivar (BF-bare soil; PG-permanent grassing; MS-soil mulching; UN-unfertilized; MF-mineral fertilization; FF- foliar fertilization)

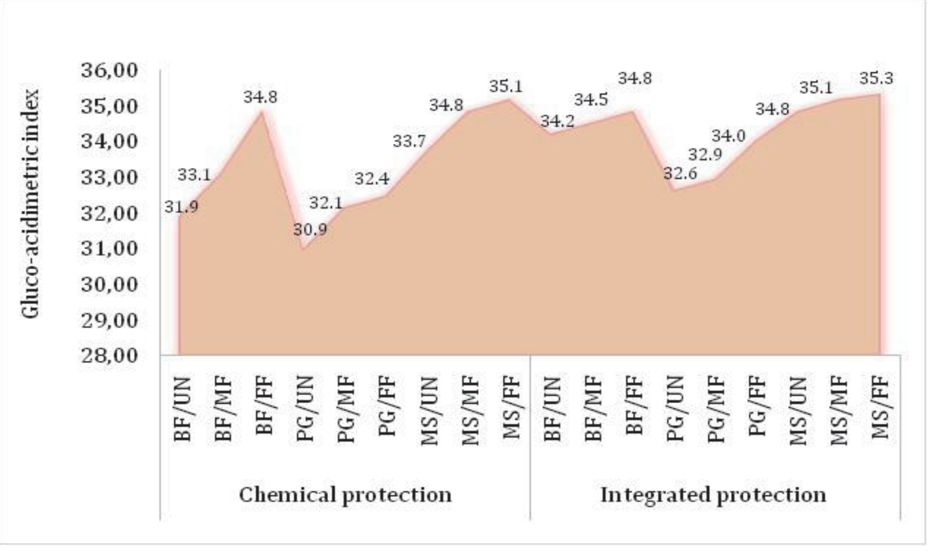

Figure 2. Influence of the experimental factors on the values of gluco-acidimetric index in case of the 'Fetească albă' cultivar (BF-bare soil; PG-permanent grassing; MS-soil mulching; UN-unfertilized; MF-mineral fertilization; FF- foliar fertilization)

Generally speaking, the highest values of this index were registered in case of the variants with lower production and a higher sugar content in grapes. Concerning the content of anthocyanin in berries skin, we can notice that the experimental factors, in their interaction, had a differential influence on this content (Table 3).

Table 3. Influence of the experimental factors on the anthocyanin content of the grapes (mg/L)

Interaction AXB

Factor A	Factor B			Medium value A
	b_1 bare soil	b_2 permanent grassing	b_3 soil mulching	
'Merlot 'cultivar				
a_1 - chemical protection	719	793	905	806
a_2 - integrated protection	803	816	822	814
Medium value B	761	804	864	810

Interaction AXC

Factor A	Factor C			Medium value A
	c_1 unfertilized	c_2 mineral fertilization	c_3 foliar fertilization	
'Merlot' cultivar				
a_1 - chemical protection	799	812	805	806
a_2 - integrated protection	803	822	815	814
Medium value C	801	817	810	810

Interaction BXC

Factor B	Factor C			Medium value B
	c_1 unfertilized	c_2 mineral fertilization	c_3 foliar fertilization	
'Merlot' cultivar				
b_1- bare soil	754	769	760	761
b_2- permanent grassing	795	813	805	804
b_3- soil mulching	855	870	865	864
Medium value C	801	817	810	810

The data obtained indicate a very low influence of the plant protection system (Factor A) on the content of anthocyanin in grapes. On the contrary, the soil maintenance system (Factor B) and the fertilization system (Factor C) had an obvious influence on this content. Analyzing the singular influence of factor B (medium values B) we can notice an increase of the anthocyanin content with 13.5% (103 mg/L) in case of the mulching system (b_3) as compared to control (bare soil). The medium values of factor C indicate an increase of the anthocyanin content with 2,0% (16 mg/L) in case of the mineral fertilization (c_2) and with 1.2% (9.0 mg/L) in case of foliar fertilization (c_3) as compared to control (unfertilized).
If we consider the binary interaction between the experimental factors (AxB, AxC, BxC) on the anthocyanin content of the grapes we can mention the following aspects: in case of the interaction AxB the integrated protection system (a_2) ensured the highest anthocyanin content for all the variants of soil maintenance system and the soil mulching (b_3) ensured the highest anthocyanin content for both the protection systems; in case of the interaction AxC the integrated protection system (a_2) ensured the highest anthocyanin content for all the variants of soil fertilization and the mineral fertilization system (c_2) ensured the highest anthocyanin content for both the protection systems; regarding the interaction BxC we can mention that the soil mulching (b_3) ensured the highest anthocyanin content for all the variants of soil fertilization and the mineral fertilization (c_2) ensured the highest anthocyanin content for all the variants of soil maintenance system.

CONCLUSIONS

The innovative technological solutions studied within the experiment have influenced in an obvious way especially grape production, having a less influence on the quality characteristics of the grapes.
The use of an integrated plant protection system, the soil mulching system and ~~the~~ mineral fertilization (at the level of DoEXP) ensured the highest production in case of both studied cultivars.
Concerning the quality characteristics of the grapes (sugar content, total acidity and anthocyanin content) one can mention an obvious positive influence of soil mulching and of mineral fertilization on the anthocyanin content of the berries' skin and only a slow positive effect of mineral fertilization on the sugar content of the grapes. The total acidity of the grapes was not influenced in an obvious way by the experimental factors.
The use of permanent grassing, as soil maintenance system, had a negative impact on vine productivity and the grape~~s~~ quality, especially during the drought years, due to the competition on the use of water resources exerted by spontaneous flora used for soil grassing. The only positive effect was a slow increase of the must acidity.

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