Scientific Papers. Series B, Horticulture. Vol. LXIX, No. 2, 2025
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

TECHNOLOGICAL SOLUTIONS TO REDUCE THE DISTURBING EFFECT OF CLIMATE CHANGE IN THE DEALU MARE VINEYARD

Marian ION, Liliana PÎRCĂLABU, Cristian BURLACU

Research and Development Institute for Viticulture and EnologyValea Călugărească,
2 Valea Mantei Street, Valea Călugărească, Prahova, Romania

Corresponding author email: alexandrinalster@gmail.com

Abstract

The researches were carried out in the Valea Calugareasca viticultural center in a vineyard with the Cabernet Sauvignon variety. The experimental device included as an experimental factor the soil maintenance system (black field, permanent grass with herbs from spontaneous flora, lawn, phacelia, white clover and vetch). The viticultural climate, characterized by a high heliothermic regime, against the background of reduced water resources and the technological variants experienced had a differentiated impact on the quantity and quality of grape production. The soil maintenance variants with Phacelia and vetch ensured significant differences in production, +1.052 kg/vine and +0.924 kg/vine, respectively. The deviation from the optimal content of the sugar of 12.0-12.8% was registered in the case of the soil maintenance variant with Phacelia, vetch and white clover. The leaf area required to produce one gram of grape in the conditions of maximum sugar accumulations was between 11.05 cm^2/g grape (the soil maintenance system variant by phacelia) and 9.92 cm^2/g grape (the soil maintenance system variant as black field).

Key words*: climatic change; grapevine; phacelia; white clover; grape production.*

INTRODUCTION

In order to mitigate the disruptive effect of climate change in recent years, a series of agro-technical solutions have been experimented with, aimed at conserving water in the soil and reducing water loss through transpiration. These solutions focused on optimizing soil maintenance systems.

As a prolonged monoculture, the viticultural ecosystem generates a wide range of inconveniences, such as accentuated soil erosion on sloping terrain,with the loss of the fertile topsoil layer; reduction of soil organic matter content; degradation of the soil's physical, chemical, and biological properties, properties that form the basis of its fertility; the appearance of anthropogenic soil compaction phenomena, through the use of mechanical aggregates during wet periods; mineral nutrition imbalances, which generate high sensitivity to pathogens (diseases, pests, frost, drought, etc.) (Abad et al., 2021).

The soil is the foundation of life, and the quantity and quality of production depend on its health. The annual or permanent vegetal cover, achieved by grassing the space between plant rows, constitutes one of the most important and practical measures for improving soil structure and organic matter, and for conserving and enhancing soil biodiversity (Zehetner et al., 2015).

Long-term grassing can constitute an 'ecological buffer,' which shelters and feeds the beneficial fauna in vineyards (predatory mites from the family Phytoseiidae, wasps from the family Trichogramma) (López-Piñeiro et al., 2013; Likar et al., 2017; Irvin et al., 2016).

Different soil maintenance systems, each with their advantages and disadvantages, generates in time differentiated effects on the soil, the plant and the environment, in the production of grapes obtained and, in their quality, and sanogenity (Kliewer, 2005).

Studies conducted by various researchers have highlighted different values for the foliar area/yield ratio depending on the variety (Iacono, 1994; Murisier, 1996). For red wines, under the conditions of the Midi-Pyrenees viticultural zone, the optimal value of this ratio was 2 m^2/kg (Dufourcq et al., 2002). The quantity and quality of grapes depend on the productivity of photosynthesis, which in turn depends on the foliar area.

MATERIALS AND METHODS

In order to establish the singular effect of the factors under study on the vegetative development of the grapevine, the yields obtained, and their quality, the experimental design was organized in a plot with the Cabernet Sauvignon variety, following the model of monofactorial experiments arranged in randomized blocks.

The experimental factor under study was the soil maintenance system, with its gradations:

a_1 - black field (Mt); a_2 - permanent grass with herbs from spontaneous flora; a_3 - lawn (40% *Lolium perenne*, 33% *Festuca rubra* and 27% *Poa pratensis*); a_4 - phacelia; a_5 - white dwarf clover and lawn (40% *Lolium perenne*, 33% *Festuca rubra* and 27% *Poa pratensis*); a_6 - vetch and lawn (40% *Lolium perenne*, 33% *Festuca rubra* and 27% *Poa pratensis*). All these soil maintenance systems aim to replace the currently practiced soil maintenance system, namely the black field, which consists of performing autumn and spring plowing, five mechanical inter-row hoeings and four manual row hoeings.

The analyzed viticultural climate parameters were: average, minimum and maximum air temperature, precipitation, solar radiation and relative humidity. For the collection of biological material, what represents the reserve of beneficial entomofauna in vineyards, Barber traps were used which capture both beneficial and harmful fauna. The determination and systematic classification of the collected species allows the evaluation of beneficial entomofauna and the appreciation of its role in the vineyard ecosystem, as a natural factor limiting the development of certain pest species.

Grapes were harvested at technological and phenological maturity and analyzed for soluble sugar content and total acidity. The influence of foliar area size on the quantity and quality of grape production was established.

The following analyses were performed: sugar content - determined by refractometry (OIV, 2021a); total acidity - determined by titration with NaOH (OIV, 2021b), gluco-acidimetric index = sugar ratio/total acidity (expressed in g/l tartaric acid); vegetative biomass of the vines hub (foliar area).

RESULTS AND DISCUSSIONS

From a climatic perspective, the year 2024, overall, can be considered a year with high heliothermal resources against a backdrop of low water resources, especially during the early-ripening and maturation phase of grapes. A specific characteristic of the year 2024 was the very high temperatures recorded during the summer months, both in the air, where they frequently exceeded 35ºC and even 40ºC, and at the soil surface, where temperatures of 50ºC and even over 60ºC were frequently recorded. Also, the time interval during which these temperatures were present often exceeded 20-26 days. The high thermal regime, which was accompanied by high values of actual insolation, ensured a normal development of the grapevine plants and good grape ripening (Table 1).

Table 1. The 2024 climatic parameters regarding average, minimum, and maximum temperatures

Month	Average temperature, °C	Minimum temperature, °C	Maximum temperature, °C
January	0.9	-11.2	16
February	7	-5.2	20.4
March	8.3	-1.8	27.5
April	15.2	1.9	31
May	16.8	6.6	29.5
June	25.5	13.7	37.7
July	26.9	14.2	39.5
August	26	14.5	36.6
September	19.7	8.2	35.1

The above-average thermal regime throughout the summer months did, however, lead to a decreased air hygroscopicity of 67.5% (Table 2).

Table 2. The 2024 climatic parameters regarding precipitation, air hygroscopicity, and sunshine duration

Month	Rainfall, mm	Higroscopicity, %	Real sunshine hours
January	59.9	81.8	151.8
February	16.8	77.4	163.1
March	48.6	75.8	215.8
April	63.9	66.1	273.1
May	47.1	64.1	274.9
June	29.5	56.4	339.4
July	54	55.4	344.9
August	23.3	52	333.9
September	86.7	65.4	286.2

The precipitation regime observed during the January to September period was markedly distinct from that of the preceding year, exhibiting a deficit in annual totals (304.0 mm),

yet displaying variations throughout the vine's growing season.
The lowest precipitation levels were recorded in the summer months (May, June, July, and August), resulting in a reduction of the soil's immediate water reserves. The insufficient soil water reserves, in conjunction with the exceptionally high air temperatures, led to the widespread manifestation of grape shriveling in vineyard plantations during September.
The severe decrease in soil humidity, manifested since the early-ripening period, it positively influenced sugar accumulation in the grapes, especially when factoring in the above-average thermal regime. A negative impact on grape production was observed, attributed to the phenomenon of berry withering, which arose from the loss of a greater quantity of water through transpiration than was replenished by soil water absorption.
Soil management systems induced differentiated effects on grape yields, with the highest grape production being obtained in the case of the soil management system with phacelia and vetch with lawn, 3.212 kg/vine hub, also 3.084 kg/vine hub. The lowest grape production was recorded when soil maintenance was carried out through permanent grass with herbs from spontaneous flora and lawn, 2.100-2.120 kg/vine hub, (Table 3).

Table 3. Influence of soil maintenance systems on Cabernet Sauvignon grape production

Graduation	Grape production kg/vine	The average weight of a grape g
a_1 - black field	2.160	93.12
a_2 - permanent grass with herbs from spontaneous flora	2.100	88.64
a_3 - lawn	2.120	92.58
a_4 - phacelia	3.212***	97.84
a_5 - white dwarf clover and lawn	3.028**	93.64
a_6 - vetch and lawn	3.084**	96.68

The analysis of production differences determined by soil management systems indicates that, in comparison with the control (black field), all other soil management systems induced statistically significant positive production differences (distinct and highly significant). The largest production differences were recorded in the case of soil maintenance through phacelia seeding (+1,052 kg/vine hub) and through seeding with vetch and lawn, and white dwarf clover and lawn (+0.924 kg/vine hub), and +0.868 kg/vine hub, respectively.
Regarding the average weight of 100 berries, the soil maintenance systems, compared to the control (black field), induced differences of +14.8 g in the case of soil maintenance with phacelia, +4.8 g with the soil maintenance system using vetch and lawn, and only +1.8 g with the soil maintenance system using white dwarf clover and lawn. When soil maintenance was conducted through permanent grass with herbs from spontaneous flora and lawn, the differences compared to the control (black field) were negative, at -11 g and -5.6 g, respectively (Table 4).

Table 4. Influence of soil maintenance systems on the average weight of 100 berry in the Cabernet Sauvignon variety

Graduation	Weight of 100 berry g
a_1 - black field	129.8
a_2 - permanent grass with herbs from spontaneous flora	118.4
a_3 - lawn	124.2
a_4 - phacelia	144.6
a_5 - white dwarf clover and lawn	131.6
a_6 - vetch and lawn	134.6

As a primary observation, it results that permanent grassing of inter-row spaces and lawn represent the technological interventions through which the competition exerted by perennial grasses in the utilization of water and mineral substances on the grapevine is most prominently manifested. An extended period of drought, combined with an elevated temperature regime and air hygroscopicity below 40%, during the phase of rapid shoot and grape development, resulted in a sharp decrease in photosynthesis. Under these conditions, shoot growth was significantly reduced (by more than 50% in sensitive varieties), a pronounced weakening of the vines was observed, and an early cessation of berry growth occurred (berry weight, in most varieties, is 40-50% lower).
Regarding the sugar content of the grapes, the same trend is observed as in the case of grape production, with the soil maintenance system

using phacelia and vetch with lawn showing 276.7 g/l sugars and 266.1 g/l sugars, respectively. In the case of soil maintenance through permanent grass with herbs from spontaneous flora and lawn, the sugar content decreased by 1.3 to 4.7% (Table 5).

Table 5. Influence of soil maintenance systems on Cabernet Sauvignon grape quality

Graduation	Sugar content, g/l	Total acidity, g/l tartaric acid
a_1 - black field	245.9	3.46
a_2 - permanent grass with herbs from spontaneous flora	234.3	3.59
a_3 - lawn	242.8	3.52
a_4 - phacelia	276.7	2.88
a_5 - white dwarf clover and lawn	252.3	3.38
a_6 - vetch and lawn	266.1	3.32

Changes occurring in the viticultural climate have led to an increase in sugar accumulation in grapes, against the backdrop of a drastic reduction in total acidity. This caused the glucoacidimetric index to take on high values, ranging from 65.26 (soil maintenance system with permanent grass with herbs from spontaneous flora) to 96.08 (soil maintenance system with phacelia) (Table 6).

Table 6. Influence of soil maintenance systems on Cabernet Sauvignon grape quality

Graduation	Gluco-acidimetric index
a_1 - black field	71.07
a_2 - permanent grass with herbs from spontaneous flora	65.26
a_3 - lawn	68.98
a_4 - phacelia	96.08
a_5 - white dwarf clover and lawn	74.64
a_6 - vetch and lawn	80.15

The values obtained are far above those optimal for producing typical and high-quality wines. The must acidity decreased slightly depending on the soil maintenance systems, in parallel with a slight increase in sugar accumulation in the grapes.

The specific climatic conditions of 2024 led to good sugar accumulation in grapes and a reduction in total acidity, regardless of the soil maintenance system. The size of the foliar area influences vegetative growth, grape production, sugar accumulation in berries, as well as other 'noble' compounds (anthocyanins, aromas, etc.). Recent research has emphasized the importance of the foliar area required to produce one gram of grapes (cm^2/g) and the optimal values of this indicator, compatible with maximum sugar accumulation in berries.

For the Cabernet Sauvignon variety, the soil maintenance option using phacelia sowing allows a foliar area of 3,548 m^2/vine hub to support the maturation of 3.212 kg of grapes, while a foliar area of 3,329 m^2/vine hub facilitates the maturation of 3.084 kg of grapes with the vetch and lawn seeding soil maintenance method (Table 7).

Table 7. Influence of soil maintenance systems on Cabernet Sauvignon grape production

Graduation	Foliar area square meters	Grape production kg/vine hub
a_1 - black field	2.142	2.160
a_2 - permanent grass with herbs from spontaneous flora	2.026	2.100
a_3 - lawn	2.094	2.120
a_4 - phacelia	3.548	3.212
a_5 - white dwarf clover and lawn	3.147	3.028
a_6 - vetch and lawn	3.329	3.084

The foliar area required to produce one gram of grapes, under conditions of maximum sugar accumulation at harvest, ranged from 11.05 cm^2/g grape (soil maintenance variant through phacelia) at a sugar content of 276.7 g/l must, to 10.79 cm^2/g grape (soil maintenance variant through vetch and lawn) at a sugar content of 266.1 g/l must (Table 8).

The foliar area required to produce one gram of grapes in the version maintained as a black field is 9.92 cm^2/g of grapes at a sugar content of 245.9 g/l of must.

From Tables 9 and 10, containing the analysis of samples from Barber traps, the situation of soil arthropod fauna can be observed.

Table 8. Influence of soil maintenance systems on the foliar area/production relationship of the Cabernet Sauvignon variety

Graduation	Area required for ripening one gram of fruit (square centimeter/g)
a_1 - black field	9.92
a_2 - permanent grass with herbs from spontaneous flora	9.65
a_3 - lawn	9.88
a_4 - phacelia	11.05
a_5 - white dwarf clover and lawn	10.39
a_6-vetch and lawn	10.79

The foliar area required to produce one gram of grapes in the version maintained as a black field is 9.92 cm^2/g of grapes at a sugar content of 245.9 g/l of must.

From Tables 9 and 10, containing the analysis of samples from Barber traps, the situation of soil arthropod fauna can be observed.

It can be observed that in the case of soil maintenance through phacelia, white dwarf clover and lawn, as well as in the variant with vetch and lawn, the beneficial soil entomofauna was improved, compared to the variants maintained through black field, permanent grass with herbs from spontaneous flora, and lawn variant.

Table 9. The situation of numerical abundance harmful soil arthropod fauna

	14.07.2024						20.09.2024					
	a_1	a_2	a_3	a_4	a_5	a_6	a_1	a_2	a_3	a_4	a_5	a_6
1. Ord. ORTHOPTERA	**1**	**1**	**1**					**2**				
Fam. Tettigoniidae	1	1										
Fam. Catantopidae			1					1				
Fam. Gryllidae								1				
2. Ord. HOMOPTERA	**1**	**7**	**2**	**1**	**2**	**2**	**1**	**3**	**2**		**1**	**1**
Fam. Iassidae		2		1	1			2				
Fam. Cercopidae									1			
Fam. Cicadellidae		5			1	1	1	1	1		1	1
Fam. Aphididae	1		2			1						
3. Ord. LEPIDOPTERA Fam. Geometridae												
TOTAL	**2**	**8**	**3**	**1**	**2**	**2**	**1**	**5**	**2**		**1**	**1**

Table 10. The situation regarding numerical abundance of useful soil arthropod fauna

	14.07.2024						20.09.2024					
	a_1	a_2	a_3	a_4	a_5	a_6	a_1	a_2	a_3	a_4	a_5	a_6
1. Ord. ARANEAE				**2**			**10**	**3**	**2**	**2**		**2**
2. Ord. DERMAPTERA Fam. Forficulidae *Forficula auricularia* L										2	2	3
3. Ord. HETEROPTERA Fam. Nabidae												
4. Ord. COLEOPTERA	**2**				**5**	**5**	**4**		**2**		**2**	
Fam. Carabidae	2				3	3	4				2	
Blitophaga undata Mull.							2					
Calosoma auropunctata L.					2	2						
Harpalus pubescens L.	2				1	1	2				2	
Fam. Staphylinidae									2			
Fam. Cerambycidae					2	2						
5. Ord. DIPTERA Fam. Sciaridae												
6. Ord. HYMENOPTERA		**1**	**1**	**4**	**1**	**1**		**1**	**4**	**38**	**17**	**18**
Suprafam. Chalcidoidea			1	1						2		
Suprafam. Ichneumonoidea												
Suprafam. Formicoidea		1		3	1	1		1	4	36	17	18
TOTAL	**2**	**1**	**1**	**6**	**6**	**6**	**14**	**4**	**8**	**40**	**21**	**23**

CONCLUSIONS

Current grapevine cultivation technologies practiced in viticultural ecosystems are oriented towards the maximum efficiency use of technological inputs in order to achieve sustainable grape productions in terms of quantity and quality, while ensuring durable protection of viticultural ecosystems.

The largest production differences were recorded in the case of soil maintenance through phacelia (+1,052 kg/vine hub) and through seeding with vetch and lawn, and white dwarf clover and lawn (+0.924 kg/vine), and +0.868 kg/vine hub, respectively.

Regarding the sugar content of the grapes, the same trend is observed as in the case of grape production, with the soil maintenance system using phacelia and vetch with lawn showing 276.7 g/l sugars and 266.1 g/l sugars, respectively. In the case of soil maintenance through permanent grass with herbs from spontaneous flora and lawn, the sugar content decreased by 1.3 to 4.7%.

Compared to the control (black field), the variant with soil maintenance through phacelia, to ensure the ripening of a grape production of 3.212 kg, achieved a foliar area of 3,548 m²/vine hub. Under the conditions of 2024, in variants V5-white dwarf clover + lawn (40% *Lolium perenne*, 33% *Festuca rubra*, and 27% *Poa pratensis*), and V6-vetch + lawn (40% *Lolium perenne*, 33% *Festuca rubra*, and 27% *Poa pratensis*), a significant increase in beneficial arthropod fauna was observed, both underground and aboveground. A numerical abundance of beneficial arthropod fauna was recorded, especially those of the orders Coleoptera and Hymenoptera. The variant cultivated with phacelia had a positive effect on increasing the pollinator population.

REFERENCES

Abad, J., Hermoso de Mendoza, I., Marín, D., Orcaray, L., & Santesteban, L. G. (2021). Cover crops in viticulture. A systematic review (2): Implications on vineyard agronomic performance. OENO One, 55(2).

Dufourcq T. and Serrano E. (2002). Determination du rapport feuilles/fruits optimal pour quatre principaux cepages de la regions Midi-Pyrenees. Actes du colloque <<Gestion du rendement vers une recherche de la qualite>>. Station regionale ITV Midi-Pyrenees: 36-42

Iacono F., Bertamini M., Mattivi, A. (1994). Differential effects of canopy manipulation and shading. Note I Composition of grapeberries (Vitis vinifera L. cv. Cabernet Sauvignon). Wein-Wiss. 49, 220-225

Irvin, N. A., Bistline-East, A., & Hoddle, M. S. (2016). The effect of an irrigated buckwheat cover crop on grape vine productivity, and beneficial insect and grape pest abundance in southern California. Biological Control, 93, 72-83.

Likar, M., Stres, B., Rusjan, D., Potisek, M., & Regvar, M. (2017). Ecological and conventional viticulture gives rise to distinct fungal and bacterial microbial communities in vineyard soils. Applied Soil Ecology, 113, 86-95.

López-Piñeiro, A., Muñoz, A., Zamora, E., & Ramírez, M. (2013). Influence of the management regime and phenological state of the vines on the physicochemical properties and the seasonal fluctuations of the microorganisms in a vineyard soil under semi-arid conditions. Soil and Tillage Research, 126, 119-126.

Mark Kliewer W., Nick K. Dokoozlian (2005). Leaf Area/Crop Weight Ratios of Grapevines: Influence on Fruit Composition and Wine Quality, Am J Enol Vitic. 2005 56:170-181; **DOI:** 10.5344/ ajev.2005. 56.2.170.

Murisier F.M. (1996). Optimisation du rapport feuille-fruit de la vine pour favorise la qualite du raisin et sut acumulatioan des glucides et de reserves. These de doctorat. EPF Zurich, 132

Zehetner, F., Djukic, I., Hofmann, R., Kühnen, L., Rampazzo-Todorovic, G., Gerzabek, M. H., & Soja, G. (2015). Soil organic carbon and microbial communities respond to vineyard management. Soil Use and Management, 31(4), 528-533.