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Research on increasing adaptive capacity of vines to climate change - treatments with kaolin and zeolite

(preliminary results)

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Introduction

- **Global climate warming** affects the phenological stages of the vine, especially the ripening of the grapes, which induces significant changes in their quality.

- These changes refer to **an increase in sugars**, **a decrease in organic acids** (especially malic acid) and **anthocyanin content in the berry**.

- Temperature also has a complex effect on the development of flavors and certain flavor precursors.

- In order to reduce these biochemical changes in berries with a negative effect on the quality of grapes, the raw material for obtaining high-quality wines, it is imperative to find **innovative technological solutions in the short term**, so that climate changes do not affect the typicality and quality of the wines obtained.

The justification of the theme

The research aims to analyze environmentally friendly technological solutions, in order to reduce the negative effects on the quality of grapes, in the context of global climate changes, **by applying treatments with natural clay-based products (CAOLIN AND ZEOLITE)**, which cause a partial closure of stomata, a reduction in photosynthesis and water loss through transpiration.

Materials and methods

Plant material and experimental conditions

The experiment was carried out **during the vegetation period of the year 2022** in the experimental vineyard located in the southern part of Romania, at the University of Agronomic Sciences and Veterinary Medicine Bucharest (N Lat.: 44° 47' 07"; E Long.: 26° 07' 28"; alt. 87 m).

The plantation where the experiment took place was established in 1994, with **Fetească regală** variety, clone 21 Bl, grafted on Kober 5 BB rootstock, spaced by 2.2 m (inter-row) and 1.2 m (intra-row), with a density of 3787 plant ha^{-1}.

The vines are trained as **bilateral cordon with a spur pruning system and loading of 12 buds/m^2** and the support system is of the vertical monoplane type. The plantation is located on a plane surface with reddish preluvosol soil and rows direction N-S. Phytosanitary treatments against to control diseases and pests have been applied in accordance with local standard practice.

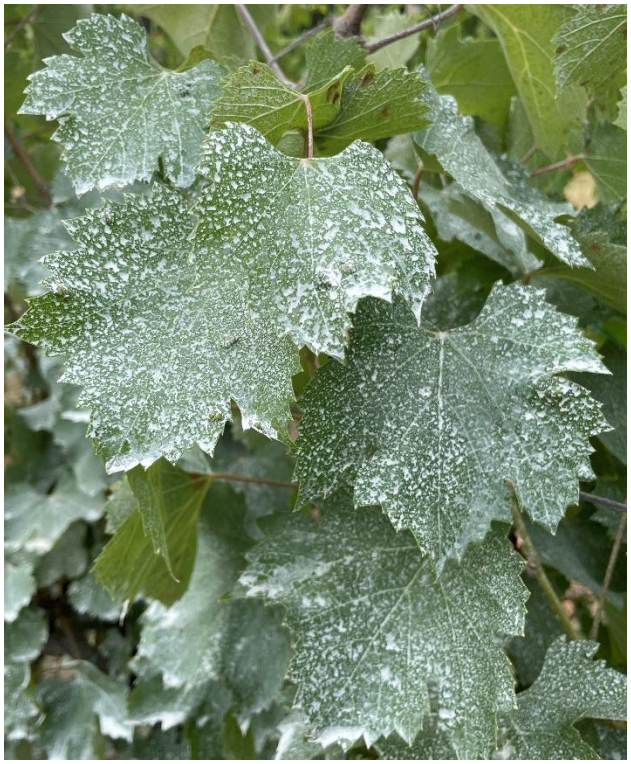
Canopy management techniques used in research

On three spaced rows, three intervals were selected (3 repetitions of 10 vine), on which foliar treatments were applied with kaolin and zeolite, of different concentrations (3% and 5%), and spray were carried out on August the 05th 2022 (DOY 217). The application of antiperspirant treatments was done when the grapes entered the vine when the berries have 15-16°Brix.

→ **Control (C)** - untreated control vines.

→ **Kao** - kaolin sprayed treatment:
V 1 – 3%
V 2 – 5%

→ **Zeo** - foliar treatment with Romanian natural zeolite:
V 3 – 3%
V 4 – 5%



Leaves gas exchange parameters

- the intensity of photosynthesis (A) (µmol CO_2 $m^{-2}s^{-1}$),
- the intensity of transpiration (E) (mmol H_2O $m^{-2}s^{-1}$),
- the stomatal conductance (g_s) (mol H_2O $m^{-2}s^{-1}$),
- the intercellular concentration of carbon dioxide (CO_2i) (µmol CO_2 mol^{-1}).

The treatments were performed on August 12 and 19, between 10:00 and 12:00 a.m. on each vine, 3 replicates (in each replica, one not sick and fully grown leaf per treatment was sampled), using a portable system for photosynthesis LCpro-SD ADC BioScientific equipped with an infrared gas analyser.

Quantitative and qualitative parameters examine in research

The grapes were harvested on the date of September 02, 2022. At harvesting, for control and each experimental variant, they were made the following determinations:

- grape weight – grams
- berry weight – grams
- yield – kg/vine

- sugar content – ºBrix
- titratable acidity – g/L tartaric acid

Sugar concentration in grapes was measured by using an Atago digital refractometer. The results were expresed in ºBrix. Titratable acidity was determined by titrating with 0.1 N NaOH using an Pellet digital biurette, and expresed as g/L tartaric acid.

Statistical analysis

The reported data of leaves gas exchange parameters represent the mean ± standard error (SE). Statistically significant differences between variables were assessed using one-way analysis of variance (ANOVA). Then, the paired-samples Student T test (2-tailed) were accomplished and the significant differences among variants have been considered at P≤0.05. Tables were constructed using Microsoft Excel 2013.

Results and discussions

1. Results regarding the evolution of temperature and precipitation during the vegetation period of the year 2022

Month	T min (ºC)	T max (ºC)	T med (ºC)	Rainfall (mm)
April	3,83	18,90	11.37	72.1
May	9,06	25,55	17.31	52.2
June	14,33	29,83	22.08	32.3
July	16,23	→ 32,94	→ 24.58	24.7
August	17,19	→ 33,32	→ 25.26	29.4
September	10,43	25,37	17.90	56.2
October	5,26	21,94	13.60	8.8
Average	10.91	26.84	18.87	
Total				119

2. Results regarding analyzed physiological parameters

Table 1. Physiological parameters regarding gas exchange to Fetească regală variety, treated with four different canopy management, in the climatic conditions of the year 2022

Indicators	C	Kao 3%	Kao 5%	Zeo 3%	Zeo 5%
	12.08.2022				
A (µmol CO_2 m^{-2} s^{-1})	9.93±6.35	8.92±9.69 a A	7.46±1.84 a B	10.10±5.10 a B	13.39±3.93 a A
E (mmol H_2O m^{-2} s^{-1})	4.80±2.16	3.00±3.16 a A	3.17±1.07 a A	2.56±1.29 a A	4.60±2.03 a A
gs (mol H_2O m^{-2} s^{-1})	0.10±0.06	0.12±0.17 a A	0.05±0.02 a B	0.06±0.04 a B	0.10±0.05 a A
CO_{2i} (µmol L^{-1})	386±16.80 a(*)	308±55.19 a A	338±19.92 a B	295±34.70 b B	342±29.67 b B
	19.08.2022				
A (µmol CO_2 m^{-2} s^{-1})	14.46±7.49	13.71±3.05 a A	12.61±2.16 a A(*)	21.06±0.64 a A (*)	21.38±2.64 a A
E (mmol H_2O m^{-2} s^{-1})	5.75±2.14	4.45±0.68 a A	5.49±0.85 a A	4.20±0.65 a A	5.60±0.78 a A
gs (mol H_2O m^{-2} s^{-1})	0.18±0.10	0.11±0.04 a A	0.14±0.02 a A(*)	0.24±0.04 a A(**)	0.22±0.04 a A
CO_{2i} (µmol L^{-1})	406±12.01 b	410±19.76 a A	425±17.77 a A(*)	487±14.43 a (*) A(**)	438±17.78 b A(*)

Legend: A = Net photosynthesis; E = Transpiration rate; gs = Stomatal conductance; CO_{2i} = Intercellular CO_2 concentration

The data are shown as means ± SE. The significant differences (P<0.05) between variants are indicated by different letters in the row: in capital letters, the differences between periods within the same applied treatment; in small letters, the comparisons by TTEST within the same period, with the control.

NS non-significant; *significance at P ≤ 0.05; **significance at P ≤ 0.01; ***significance at P ≤ 0.001

Leaves gas exchange parameters - results

The intensity of photosynthesis (A) (µmol CO_2 $m^{-2}s^{-1}$)

► they have registered differences between periods, for the same treatment applied: Kao 5% 0.038* and Zeo 3% 0.035*

The intensity of transpiration (E) (mmol H_2O $m^{-2}s^{-1}$)

► all comparisons made were non-significant

The stomatal conductance (g_s) (mol H_2O $m^{-2}s^{-1}$)

► they have registered differences between periods, for the same treatment applied: Kao 5% 0.021* and Zeo 3% 0.0001**

The intercellular concentration of carbon dioxide (CO_2i) (µmol CO_2 mol^{-1})

► comparing the control with the experimental variants, within the same period, differences were recorded as follows:

- Control vs Zeo 3% - 0.037* (for 12.08.2022) and 0.015* (for 19.08.2022)
- Control vs Zeo 5% - 0.024* (for 12.08.2022)

► they have registered differences between periods, for the same treatment applied: Kao 5% 0.024*, Zeo 3% 0.003** and Zeo 5% 0.029*.

3. Results regarding quantitative and qualitative parameters of the grape harvest

Table 2. Grapes quantitative and qualitative parameters at harvesting time for Fetească regală variety, 2022

Indicators	C	Kao 3%	Kao 5%	Zeo 3%	Zeo 5%
	02.09.2022				
Bunch weight (g)	81.80±6.45	81.15±1.51	75.35±11.99	78.00±8.99	77.30±12.79
Berry weight (g)	1.79±0.12	1.84±0.03	1.73±0.12	1.88±0.10	1.99±0.10
Yield (kg/vine)	3.21±0.32	3.40±0.32	3.45±0.19	2.98±0.19	3.81±0.80
Sugar content (ºBrix)	26.40±0.26	25.67±0.40	24.57±0.31	**22.70±0.53**	***23.43±0.21***
Titratable acidity ($g.L^{-1}$ tartaric acid)	5.35±0.32	5.13±0.18	5,15±0.48	5.20±0.12	5.11±0.12

The data are shown as means ± SE.

Discussions

- In this study the values of the four indicators studied in the vine treated with kaolin and zeolite were similar to those of the control vine, in agreement with the results obtained by Glenn et al. (1999; 2010) and Kerns and Wright (2000).
- Brilliant et al. (2016) argued that kaolin and zeolites have different effects (low or no different than the control) on net photosynthesis due to climate variations.
- Moreover, other studies have shown that kaolin treatments do not affect photosynthesis or plant development, but minimize the negative effects of water stress and photoinhibition caused by excessive solar radiation (Glenn et al., 1999; Kerns and Wright, 2000; Lobos and et al., 2015).

Conclusions and recommendations

- The results obtained are of great interest, since it allows a better understanding of these treatments as a measure to protect grapevines from the severe droughts and the high sun exposure in the recent times.

- The assessment of kaolin and zeolites treatments efficiency in climate change through multiple-based approaches (physiological, biochemical) revealed regulation of heat stress responses and tolerance mechanisms, and improved summer stress responses and photochemistry modulation under stress conditions.

- From a climate change perspective, comparative studies should be further explored under controlled and field conditions to elucidate the advantages of particle film application on other varieties production and quality.