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DR. ETHEM İLHAN ŞAHIN
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EFFECTS OF SOIL AND FOLIAR FERTILIZING ON *AFUS ALI* GRAPEVINE BUDS' WINTER TEMPERATURE RESISTANCE AND CLUSTER CHEMICAL COMPOSITION

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ABSTRACT

The aim of this research was to determine the influence of soil and foliar fertilizing on the chemical composition of the clusters and the resistance of the clusters to low winter temperatures of grapevine cultivar *Afus Ali* grown in the Tikves vineyard area. In November, with the basic cultivation of the soil, the fertilizer NPK 10-20-30 was applied (500 $kg \cdot ha^{-1}$). Foliar fertilizing was performed with 0.4%, 0.8%, 1.2% and 1.5% solution of NPK fertilizer 18-9-27+2MgO + ME (1000 $mg \cdot kg^{-1}$Fe; 200 $mg \cdot kg^{-1}$ B; 150 $mg \cdot kg^{-1}$ Zn; 500 $mg \cdot kg^{-1}$ Mn; 56 $mg \cdot kg^{-1}$ Mo; 110 $mg \cdot kg^{-1}$ Cu). Four foliar treatments were applied during the vegetation: 15 days before flowering, 15 days after flowering, in the phase of grain growth and in the phase of verasion. In the soil samples, a neutral pH value was determined, medium fertility with available nitrogen and phosphorus as well as good fertility with available potassium. Different concentrations of foliar fertilizing had a positive influence on the chemical composition of the clusters and the resistance of the oaks to winter temperatures in which a significantly higher ($p<0.05$) content at all tested temperatures in all variants was obtained compared to the control area. In the clusters of the *Afus Ali* variety, higher ($p<0.05$) content of nitrogen (1.49%), phosphorus (0.69%) and potassium (1.12%), as well as the lowest percentage of frozen buds (5.80%) at a temperature of –15 °C, 9.00% frozen buds at a temperature of –18 °C and 17.87% frozen buds at a temperature of –21 °C was determined at the variant 4 (NPK 10-20-30 + 1.2% solution of NPK 18-9-27+2MgO+ME). The content of calcium (1.57%) and magnesium (0.40%) in the clusters was determined in variant 3 (NPK 10-20-30 + 0.8% solution of NPK 18-9-27+2MgO+ME).

Keywords: Grapevine production, foliar fertilizing, buds.

INTRODUCTION

Grapevine (*Vitis vinifera* L.) is one of the most economically important productive drought stress-adapted crops grown globally (Gambetta et al., 2020). The natural conditions for the cultivation of grapevines and the production of quality wines in the Republic of North Macedonia are almost ideal because Macedonia is known as a sunny and mountainous country that is recognizable by its Mediterranean and continental climate with warm sunny days and cooler nights.

Grapes are considered one of the most popular and favourite fruits globally for their excellent flavour, taste, and nutritional value. They are mainly consumed as fresh fruits, juice, raisins, and wine. Grapes consist of sugar in the form of monosaccharides (glucose and fructose) and various phenolic compounds. It also contains minerals such as potassium, magnesium, iron, and calcium as well as vitamins C, B12, and B6, which are nutritionally important. Achieving a balance between productivity and fruit quality is a major goal in viticulture, which is particularly a challenge considering the threats of climate change and weather variability (Bruwer, 2018; Armachius, 2022).

Fertilization is an important agrotechnical measure, where by applying optimal doses and types of fertilizers in an appropriate period, it is possible to significantly influence the development of the grapevine, and thus the production of high-quality grapes (Delgado et al., 2004).

Managing the nutritional requirements of the vineyard requires a visual assessment of the grapevines, growth habits, and the nutrient status of plant tissues and/or soil to develop an appropriate fertilizer program. Each vineyard may have a unique combination of soil type, grapevine age, canopy architecture, and cultivar, thus nutritional requirements vary among vineyards, even locations within a vineyard (Arrobas et al. 2014).

The grapevine, as a perennial crop, needs large amounts of nutrients that are used differently in different phenophases of development, so nutrition should be correlated with the phenophases of development.

The application of nutrients through the soil often does not give the expected results due to their unavailability for plants (unfavourable physical properties of the soil, due to drought) (Stojanova, 2019). Hence, for the successful cultivation of the grapevine and the production of high-quality grapes, foliar nutrition is important. With foliar nutrition, it is possible to have a preventive effect in certain phenophases of the grapevine's development, when the needs for nutrients are greater, and the root system is not able to absorb sufficient amounts of nutrients, so additional nutrition through the leaves is of great benefit to cluster development and grape quality (Stojanova, 2018; Colapietra and Alexander, 2006). Through foliar fertilizing, there is a high degree of uptake and utilization of nutrients by the plant, the antagonism between elements in the soil, the fixation of some of the elements, as well as the mutual binding of nutrients in compounds that are unavailable to plants are avoided (Fernandez, 2013; Stojanova, 2018).

The grapes ripen faster, the bunches are more developed, and the berries are larger, with a beautiful, characteristic colour, which tolerates transpiration better. Soil and foliar fertilizing has a positive effect on the timely ripening of grapevine clusters, which also enables an increase in the vines' resistance to low winter temperatures. In the ripening phenophase, it is very important, in particular, that the elements P, Ca, Zn, and B are available for the nutrition of the grapevines. The effects of foliar nutrition are fast, and the advantage is that it can be performed several times during the vegetation, and it has a wide range of positive effects (Stojanova, 2018).

In summary, the advantages of the foliar application of urea to grapevines are that the application costs are lower than those of soil fertilization, the uptake of the nutrients is not dependent on the roots, and a low quantity of fertilization is needed to supply N needs. Foliar

N fertilization is also preferred over soil N fertilization where the topsoil is dry, the soil has low nutrient availability, the grapevine root activity is decreasing or in vineyards cultivated on sandy soils. Some authors reported that foliar application of urea to grapevines increased the concentration of several amino acids in musts compared to the control (Gutiérrez-Gamboa et al., 2022).

In wine-growing regions with a continental and moderately continental climate, grapevine varieties are often damaged by low winter temperatures. In addition to the variety, the degree of maturation of the clusters influences the resistance to low winter temperatures. The frost resistance of grapevine is affected by genotype, organ, the duration and level of the low minimum temperatures, how low temperatures occur and pass, the variation of frost resistance during the winter, topographic conditions (Bucur and Dejeu, 2020) as well as optimal nutrition with macro and microelements.

The resistance of clusters to low winter temperatures is closely dependent on the content of water and organic substances and above all on the content of carbohydrates. The higher content of organic substances, primarily carbohydrates, in tissues and organs is linked to greater resistance of the vine to low temperatures. There is a positive correlation between the degree of maturation of the clusters and their resistance to low winter temperatures (Stojanova, 2023).

The aim of this research was to determine the influence of different concentrations of foliar fertilization on the chemical composition of the clusters and the resistance of the clusters to low winter temperatures in the grapevine variety *Afus Ali* grown in the conditions of the Tikves vineyard.

MATERIALS AND METHODS

The investigations were carried out in a vineyard in the Tikves vineyard area. The material for work was the *Afus Ali* grapevine variety. The vineyard was in full bloom. The planting distance of the grapevines in the plantation was 2.8 x 1.0 m with a total of 3571 grapevines/ha planted, the cultivation system was a trellis with a stem height of 70 cm. The *Afus Ali* grapevine variety is one of the highest quality and most widespread white table varieties originating from Asia Minor. The fruit is large (250–550 g), elongated with an amber-yellow colour, scattered or medium dense. In North Macedonia, it is mostly represented in warm vineyards. It is a late variety that ripens at the end of September and the beginning of October. In rainy and cold weather during the flowering phase, bunches become red.

In this study, 4 variants in 3 replications were included. In each variant, 10 grapevines were included, that is, a total of 120 grapevines.

The variants in the experiment were:

1. Control;
2. NPK 10-20-30+0.4% solution of NPK 18-9-27+2MgO+ME;
3. NPK 10-20-30+0.8% solution of NPK 18-9-27+2MgO+ME;
4. NPK 10-20-30+1.2% solution of NPK 18-9-27+2MgO+ME;
5. NPK 10-20-30+1.5% solution of NPK 18-9-27+2MgO+ME.

With the basic autumn tillage, the vineyard was fertilized with the NPK 10-20-30 fertilizer in the amount of 500 kg/ha. Soil fertilizing was performed in previously opened furrows at a depth of 40 cm and a distance of 60 cm from the vine. Foliar fertilization was carried out with 0.4%, 0.8%, 1.2% and 1.5% solution of the fertilizer NPK 18-9-27+2MgO+ME (1000 $mg \cdot kg^{-1}$ Fe; 200 $mg \cdot kg^{-1}$ B; 150 $mg \cdot kg^{-1}$ Zn; 500 $mg \cdot kg^{-1}$ Mn; 56 $mg \cdot kg^{-1}$ Mo; 110 $mg \cdot kg^{-1}$ Cu). Four foliar treatments were applied during the vegetation: 15 days before flowering, 15 days after flowering, in the phase of berries growth and the phase of verasion.

The field experiment was conducted in terms of watering in the system drip. During the vineyard vegetation period, all basic agricultural and ampelotechnical measures were applied.

To determine soil fertility, soil samples were taken before setting up the experiment at a depth of 0–30 cm, 30–60 cm, and 60–80 cm (Stojanova, 2019). In laboratory conditions, the soil samples were brought to an air-dry state and prepared for agrochemical analysis in which the following parameters were determined:

- pH value – determined potentiometric with pH-meter (Stojanova, 2017);
- content of easily available nitrogen – determined by the method of Tjurin and Kononova (Stojanova, 2017);
- content of easily available phosphorus – determined by AL method and reading of spectrophotometer (Stojanova, 2017);
- content of easily available potassium – determined by AL method and reading of spectrophotometer (Stojanova, 2017);
- content of humus – determined by the permanganese method of Kotzman (Bogdanović et al., 1966);
- content of carbonates – determined with Schaiblerov Calcimeter (Bogdanović et al., 1966).

With the aim of optimal application of fertilizers and proper nutrition of grapevine leaves and clusters, it is necessary to do a chemical analysis of the leaves, which indicates a possible deficit or surplus of an element (Stojanova, 2019). Leaves analyses, as an early and/or late tool to allow the diagnosis of potential deficiencies or excesses, were studied.

After harvesting, that is, in the period when there is the greatest stability of macro and microelements, leaf samples were taken to determine their chemical composition. The samples of the one-year mature clusters were taken in November. One average sample comprised clusters of 10 individual grapevines separately for each variant. Lower leaves versus the first cluster taken from all sides of the grapevine were used for analysis. In laboratory conditions, leaf samples were washed with 0.05% HCl solution, rinsed with distilled water, and then dried at room temperature. By grinding in an electric mill, they were brought to powder and ready for analysis.

In the leaves and clusters were determined the following parameters:

- content of nitrogen (N) – determined using Kjeldal the method (Stojanova, 2017);
- content of phosphorus (P_2O_5) – determined using atomic emission spectroscopy with inductively coupled plasma (ICP - AEC) (Stojanova, 2017);
- content of potassium (K_2O) – determined by incineration of the material with concentrated H_2SO_4 and phlamenphotometar (Stojanova, 2017);
- content of calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), boron (B), zinc (Zn) and molybdenum (Mo) – determined using atomic emission spectroscopy with inductively coupled plasma (ICP - AEC) (Sarić et al., 1989).

The resistance of buds to low winter temperatures was determined by treating the clusters in a controlled cold chamber at temperatures of –15 °C, –18 °C and –21 °C. For this purpose, 10 clusters with 10 seeds of each variant were placed for 2 hours in a refrigerator at a temperature of –5°C, and then for 6 hours at the tested temperature (–15, –18, –21°C) (Stojanova, 2001).

The obtained results were statistically processed using the software package SPSS 20. To determine the statistically significant differences of the obtained values ANOVA test *post hoc* Tukey's test ($p<0.05$) was performed.

RESULTS AND DISCUSSIONS

For the normal development of the grapevine, regular fruiting and obtaining high, stable yields and quality grapes, and certain conditions from the external environment (soil and climatic conditions) are necessary. From the point of view of climatic conditions, the grapevine is characterized by a wide area of distribution. Temperate, temperate-continental, subtropical and Mediterranean climates are the most suitable for growing grapevines. In the conditions of continental grapevine cultivation, low temperatures cause much greater damage to the grapevines.

Spring freeze events are a global challenge to grape production. As grapevine buds emerge from dormancy in spring, temperatures close to or below freezing can damage green tissues, decreasing yield potential and compromising fruit quality by harvest. Bud freeze damage may become more frequent if global warming accelerates budbreak without a concurrent decrease in spring freeze events (Persico et al., 2023).

Low winter temperatures cause different damages depending on the time of occurrence, intensity and duration. The grapevine suffers more from frosts of the same intensity at the end and beginning of winter than in the middle of winter. Temperatures of -15 °C in the middle of winter cause the grapevines to freeze and the amount of damage depends on the variety, the preparation of the grapevines for winter, etc. Different varieties show different resistance to low temperatures, and the endurance of the most resistant and most sensitive varieties differs by 5 to 10 °C.

Scattered, deep, weakly acidic and weakly basic soils that are easily heated, with good aeration, provided with a sufficient amount of water and nutrients, with a lighter mechanical composition and high microbiological activity are suitable for growing grapevines (Avramov, 1999; Stojanova, 2023).

From the data in Table 1 on soil fertility under *Afus Ali* grapevines, it can be seen that the soil samples are good fertile with available nitrogen (the average content at a depth of 0–80 cm is 7.17 mg/100g soil), medium fertile with available phosphorus (the average content at the depth of 0–80 cm is 15.43 mg/100g of soil). Good fertility of the soil with available potassium was determined (the average content at the depth of 0-80 cm is 25.02 mg/100g of soil). According to the content of humus, the soil is poorly fertile (the average content at a depth of 0–80 cm is 1.50%). According to the content of calcium carbonate, the soil samples are slightly carbonated (2.33%). Regarding the pH value, the soil is neutral and is favourable for the successful growth, development and fruiting of the grapevine.

Table 1. Agrochemical analysis of soil

Cultivar	Depth (cm)	pH		Available (mg/100g soil)			Humus (%)	$CaCO_3$ (%)
		H_2O	KCl	N	P_2O_5	K_2O		
Afus Ali	0–30	7.52	7.20	7.35	15.80	25.60	1.70	2.60
	30–60	7.45	7.30	7.15	17.00	24.90	1.60	2.40
	60–80	7.40	7.28	7.00	13.50	21.55	1.20	2.00
	Average 0-80	**7.46**	**7.26**	**7.17**	**15.43**	**25.02**	**1.50**	**2.33**

The macronutrients are essential elements that impact grapevine growth, grape yield and wine quality. Currently, plant tissue or soil sampling, followed up with chemical analysis, informs on whether a nutrient is deficient, adequate, luxurious or in toxic concentrations (Debnath et al., 2021). These nutrients, in particular N and K have high mobility and can be translocated rapidly from older to new leaves if the demand in young leaves or fruiting bodies is higher than the supply from the soil, resulting in chlorosis and necrosis (Jegadeeswari et al., 2020; Michopoulos and Solomon, 2019).

Nitrogen deficiency results in reduced vegetative growth and photosynthesis, small-thin and stiff leaves, slowed cluster growth, shortened internodes, and low berry set. A deficiency of N in grapevines, however, may affect key metabolic functions and retard cluster development and bunch formation (Keller, 2020).

Potassium can improve the effect of transferring other elements and cause better loading of photosynthetic products such as glucose and sucrose into the phloem vessels during flowering, fertilization, and fruit set (Keller, 2015). Calcium contributes to auxin activity and is involved in cell division and cell elongation, germination, and pollen tube growth. Calcium is effective in improving flowering, maturation, and transfer of carbohydrates from leaves to fruits. It seems that an adequate supply of nutrients during the plant growth period while increasing the effective pollination period has increased the percentage of fruit set. Calcium and potassium play an important role in many physiological and biochemical processes required for growth and development, including cell division and elongation, flowering and fruit set, which can directly affect the percentage of fruit set (Ma et al., 2019). Calcium deficiency has been reported to cause incomplete flowering, densely branched shortened roots, chlorosis, and necrosis (Duan et al., 2022).
The use of microelements in the nutrition of the grapevine conditions the rapid growth of the clusters in length and thickness. They improve the maturation of the clusters as well as the resistance of the buds to low winter temperatures (Hummes et al., 2019; Korchagin et al., 2020; Stojanova, 2023).
Soil fertilization in combination with different concentrations of foliar fertilization showed a positive effect on the examined macro and microelements in the clusters of the grapevine variety *Afus Ali*. Namely, at all concentrations of foliar fertilization, a higher content of the investigated elements was obtained in the clusters compared to the control variant. The highest content of nitrogen 1.49%, phosphorus 0.69%, potassium 1.12%, iron 131 $mg \cdot kg^{-1}$, manganese 58.50 $mg \cdot kg^{-1}$, boron 23.70 $mg \cdot kg^{-1}$, zinc 17.80 $mg \cdot kg^{-1}$ and Mo 15.20 $mg \cdot kg^{-1}$ was obtained in variant 4. NPK 10-20-30+1.20% solution of NPK 18-9-27+2MgO+ME compared to control and other tested variants. The highest content of calcium 1.57% and magnesium 0.40% was obtained in the clusters of variant 3. NPK 10-20-30+0.80% solution of NPK 18-9-27+2MgO+ME compared to control and other tested variants (Tables 2 and 3).

Table 2. Macroelements composition of grapevine clusters from *Afus Ali* (% of dry matter)

Variant	**n**	**N**	**P_2O_5**	**K_2O**	**CaO**	**MgO**
		$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
1	3	1.35 ± 0.06^a	0.37 ± 0.02^a	0.76 ± 0.03^a	1.21 ± 0.03^a	0.26 ± 0.05^a
2	3	1.49 ± 0.03^b	0.48 ± 0.01^b	0.95 ± 0.08^b	1.34 ± 0.04^b	0.35 ± 0.05^b
3	3	1.38 ± 0.07^a	0.55 ± 0.01^c	$0,87 \pm 0.09^c$	1.57 ± 0.09^c	0.40 ± 0.07^c
4	3	1.49 ± 0.03^b	0.69 ± 0.09^d	1.12 ± 0.08^d	1.49 ± 0.10^d	0.38 ± 0.01^d
5	3	1.42 ± 0.03^c	0.62 ± 0.05^e	0.90 ± 0.08^e	1.30 ± 0.03^e	0.34 ± 0.09^b

[a, b, c] – values for the same parameter of the different variants marked with different letters have statistically significant differences ($p<0.05$), ANOVA, *post hoc* Tukey's test.

Table 3. Microelements composition of grapevine clusters from *Afus Ali* ($mg \cdot kg^{-1}$ of dry matter)

Variant	**n**	**Fe**	**Mn**	**B**	**Zn**	**Mo**
		$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
1	3	120 ± 0.06^a	54.30 ± 0.16^a	17.55 ± 0.11^a	14.90 ± 0.12^a	11.20 ± 0.15^a
2	3	126 ± 0.08^b	55.70 ± 0.13^b	20.15 ± 0.13^b	15.20 ± 0.09^b	12.95 ± 0.20^b
3	3	135 ± 0.12^c	55.00 ± 0.09^b	19.55 ± 0.15^c	15.60 ± 0.16^b	14.65 ± 0.18^c
4	3	131 ± 0.06^d	58.50 ± 0.05^c	23.70 ± 0.23^d	17.80 ± 0.25^c	15.20 ± 0.21^d
5	3	125 ± 0.10^e	57.10 ± 0.09^d	21.80 ± 0.19^e	17.15 ± 0.17^c	14.80 ± 0.21^c

[a, b, c] – values for the same parameter of the different variants marked with different letters have statistically significant differences ($p<0.05$), ANOVA, *post hoc* Tukey's test.

After the end of vegetation, the vine goes into a state of winter dormancy. This condition is preceded by processes that were aimed at the maturation of the clusters, the formation of buds, the accumulation of reserve nutrients and the reduction of the amount of water. All these processes are greatly influenced by the microelements that influence the intensification of the accumulation of mineral substances, their migration and distribution in the individual organs of the grapevine, on which the degree of maturity of the clusters and other organs depends (Stojanova, 2023).

For a successful wintering of the grapevine, the following conditions must be ensured: timely ripening of the clusters and entry of the winter buds into physiological rest, proper maturation of the tissue of the clusters and proper hardening of the plant organism. The negative effects of low temperatures can be reduced by applying various agrotechnical measures (especially optimal nutrition) that contribute to better maturation and preparation of tissues and organs for wintering. Therefore, to increase the resistance of clusters, it is very important in the maturing phenophase, that the elements necessary for this phenophase are represented in an optimal amount. Of the macroelements, nitrogen, phosphorus, potassium and calcium have the greatest impact on resistance, and of the microelements, zinc and boron. With their optimal representation in the clusters, the processes of collecting reserve nutrients as well as their migration and distribution in the organs of the grapevine are intensified.

In this research, foliar fertilization with different concentrations had a positive effect on the degree of freezing of the grapevines at all investigated low winter temperatures in controlled conditions in all varieties of the grapevine variety *Afus Ali*.

Table 4. Degree of buds freezing in the *Afus Ali* variety (%) in controlled conditions

Variant	**n**	**–15 °C**	**–18 °C**	**–21 °C**
		$\bar{x} \pm$ SD	$\bar{x} \pm$ SD	$\bar{x} \pm$ SD
1	10	9.40 ± 0.01^a	15.08 ± 0.11^a	22.50 ± 0.01^a
2	10	6.50 ± 0.05^b	13.62 ± 0.02^b	19.40 ± 0.03^b
3	10	7.69 ± 0.03^c	9.75 ± 0.09^c	19.25 ± 0.07^b
4	10	5.80 ± 0.06^d	9.00 ± 0.02^d	17.87 ± 0.09^c

[a, b, c, d] – values for the same temperature of the different variants marked with different letters have statistically significant differences ($p<0.05$), ANOVA, *post hoc* Tukey’s test.

According to Table 4, it can be seen that all of the variants treated with different concentrations of foliar fertilizer, showed a positive influence on the resistance of the buds at the three tested temperatures and had higher ($p<0.05$) values compared to the control, untreated variant.

The lowest ($p<0.05$) percentage of frozen buds (5.80%) at a temperature of -15 °C, 9.00% frozen buds at a temperature of -18 °C ($p<0.05$) and 17.87% frozen buds at a temperature of -21 °C ($p<0.05$) was determined in the variant 4 NPK 10-20- 30+1.20% solution of NPK 18-9-27+2MgO+ME. The highest percentage ($p<0.05$) of frozen buds at the three tested temperatures was found in the control variant.

According to the research of Karimi et al. (2021) in the leaves of the grapevine variety Sultana, the highest content of Fe (146.5 mg·kg^{-1}), Zn (68.62 mg·kg^{-1}) was determined in the variant $V_1K_0C_0$ (1.00% mineral oil, 0.00% K_2SO_4, and 0.00% $CaSO_4$), and the highest content of Mn (136.5 mg·kg^{-1}), N 2.43%, Ca 2.84% and Mg 1.45% was determined in the variant $V_0K_1C_1$ (0.00% mineral oil, 3.00% K_2SO_4, and 2.00% $CaSO_4$). In the same variant, cluster number, cluster weight, cluster length, berry weight, and berry length were significantly affected.

Ekbic et al. (2018) investigated the effect of four different boric acid (H_3BO_3) doses (control, 0.1%, 0.2%, 0.3%) on yield, quality and leaf nutrients in a vineyard of Giresun Hazelnut

Research Institute on Isabella (*Vitis labrusca* L.) grape cultivar. The greatest yield, cluster length, cluster volume, cluster size, cluster width, berry width and leaf area were obtained from 0.3% boric acid treatments. In general, leaf nitrogen, phosphorus, calcium, magnesium, zinc and copper concentrations increased, but potassium and iron concentrations decreased with increasing boron doses.

Keller et al. (2022) have used a forced-convection, free-air cooling and heating system to manipulate the inflorescence temperature of field-grown Cabernet Sauvignon grapevines during the bloom period. Temperature regimes included cooling (ambient –7.5°C), heating (ambient +7.5°C), ambient control, and convective control. Cooling significantly retarded the time to fruit set and subsequent berry development, and heating shortened the time to fruit set and accelerated berry development relative to the two controls. The fruit set was decreased in cooled inflorescences, but although the cooling regime resulted in the lowest berry number per cluster, it also decreased seed and berry weight at harvest while not affecting seed number.

According to Lisek (2012) on the grapevines of 40 wine cultivars and 32 table grape cultivars grown in central Poland at the minimum winter temperature of –28.1°C cultivars were assigned to five classes of different frost tolerance, according to information on the percentage of frozen buds: very resistant (below 1.9%), resistant (2 –24.9%), medium susceptible (25–74.9%), susceptible (75–95.9%) and very susceptible (above 96%).

CONCLUSION

Based on the results for determination of the impact of soil and foliar fertilization on the chemical composition of the clusters and the resistance of the grapevines to low winter temperatures from the *Afus Ali* variety grown in the conditions of Tikves vineyard, it can be concluded that the different concentrations of foliar fertilization had a positive effect on the vegetative development of the grapevine. All investigated parameters had higher ($p<0.05$) values in clusters where foliar fertilization was applied compared to the control variant. Also, a lower ($p<0.05$) degree of freezing of the buds was achieved in all variants at all tested temperatures compared to the control variant.

Therefore, the optimal amounts and types of fertilizers determined based on the agrochemical analysis of the soil, regardless of the method of application (soil or foliar), represent a basic, significant prerequisite for high-quality and sustainable viticultural production.

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