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Effect of foliar calcium and nitrogen treatments on yield and fruit quality of table grapes cv. 'Cardinal'

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Abstract

The foliar fertilization has been used as an important agrotechnical measure to avoid deficiencies and to improve quality. During the three consecutive years, a study has been performed on *Vitis vinifera L.* (cv. 'Cardinal') to examine whether a yield and grape berry quality have been affected by the foliar application of Ca and N fertilizers. A liquid mineral fertilizer containing 40% $Ca(NO_3)_2$ as Variant I and 31% N with 0,015 % Fe-chelate; 0,01 % Mg – chelat as Variant II (in text) has been sprayed four times during the growing period (before and after blooming, buckshot berries, and verasion). Results showed that foliar application of calcium and nitrogen increased the yield of table grapes in all three years of research, in comparison with a control variant. The highest yields of grapes in all three years of investigations were achieved in Variant II – 4.57 kg/vine (14.85 t/ha). During the tree years of investigations, the largest mass of grape bunch and berries were recorded in Variant II (382g and 368.68g), while the lowest cluster weight was in the control variant (344g and 330.92g). With a reference to the mechanical properties of the grape berries, the highest resistance to pressure (2229.70g) and breaking resistance (364.52g) were found in Variant I, treated with Ca fertilizer. The foliar application significantly affects the mechanical properties (resistance of the berry to pressure and breaking), especially in Variant I. The application of different types of foliar fertilizers did not have any significant effect on sugar contents and total acids, compared with the control variant.

Key words: foliar fertilization, nitrogen, calcium, table grapes, yields

Introduction

Types and amounts of fertilizer applied to crops are very important in crop production and play an important role in cropping systems. Relying on inorganic or chemical fertilizers is a major constraint due to its prohibitive costs, though identified as an important factor in meeting the food requirements of a growing population (Griengo et al., 2020). Foliar fertilization is an important tool for the sustainable and productive management of crops. The ability of plant leaves to absorb water and nutrients was recognized approximately three centuries ago (Fernández and Eichert, 2009).

The grapevine (*Vitis vinifera L.*) easily absorbs nutrients through the leaves, green berries, and buds. In vineyard nutrition management, soil fertilization is usually preferred for its low cost, but the application of nutrients with foliar sprays may be a valid alternative for ensuring macro and micronutrients promptly in order to sustain high photosynthetic activity and for improving the quantity and the quality of yield (Colapietra and Alexander, 2006, Leghari at al. 2016). Chokha et al. (2002) report that foliar application of some macro and micronutrients or their combination significantly improves grape yield and quality. The quality of berries in terms of total sugar content, acidity, juice, and tannin content was better in plants with foliar application of nutrients, compared to the control variant.

Concerning N, the foliar application can provide vines with an easy form of N to assimilate and overcome temporary deficiencies, since N is highly mobile and can be rapidly distributed throughout the entire plant. Some previous findings and results indicate that, when nitrogen (N) fertilizer is applied on leaves, it is more efficient because there are many possible pathways for N loss associated with the application of nutrients through the soil (Adesemoye et al., 2008). The highest N uptake in grapevines occurs between flowering and veraison, when the greatest vine biomass is achieved (Bates et al., 2002).

Calcium (Ca) is a nutrient considered important for determining the storage quality of fruits (Peryea & Neilsen, 2006) and this is why Ca fertilization is standard practice in all countries producing table grapes. Lara et al. (2004) reports that calcium enhances tissue resistance to fungal attack by strengthening the cell walls, making them more resistant to harmful enzymes produced by fungi and delaying the aging of fruits. When Ca is supplied to fruits, this must be done in the moment of its greater sink capacity. In grapes, the uptake rates are maximum at the beginning of berry growth, probably due to faster cellular activity and intense transpiration rate when berries are still young (Schaller et al., 1992).

There are many studies about the effects of Ca application on fruit quality, especially those related to application methods (soil versus foliar application), chemical formulations, timing, etc., but results in many cases are inconsistent. While some authors have reported that Ca applications increase its concentration in fruit and delay its deterioration (Gerasopoulos & Drogoudi, 2005; Hernandez-Munoz et al., 2006), others have concluded that no significant differences between various concentrations and the control variant (Hanson, 1995; Huang et al., 2005). There might be several explanations why Ca applications do not not necessarily increase fruit quality. For example, Ca might stay in the cuticular epidermis (Huang et al., 2005), or inside the fruit. It can be deposited inside vacuoles or cell walls (Franceschi & Nakata, 2005).

For fresh consumption, mechanical properties are among the most important factors determining the eating quality of table grapes. Sensory attributes, such as skin friability, skin thickness, and flesh firmness have been utilized to characterize commercial table grape cultivars (Cliff et al., 1996). The most important properties of table varieties related to their market value are the transportability and shelf-life, which are predefined by their pressure and breaking resistance.

The overall flavour is one of the most important qualities for establishing a continuous consumer preference. Flavour composition has been defined as a complex attribute of quality, in which the mix of sugars, acids, and volatiles plays a primary role (Baldwin, 2002). Sugar and organic acid compositions, which are measured through total soluble solids (TSS) and titratable acidity (TA), are most commonly associated with the taste of fruits, including table grapes (Shiraishi et al., 2010).

Foliar fertilization is theoretically more environmentally friendly, immediate and target-oriented than soil fertilization since nutrients can be directly delivered to plant tissues during critical stages of plant growth. However, while the need to correct a deficiency may be well defined, determining the efficacy of the foliar fertilization can be much more uncertain (Fernandez et al. 2013).

The main objective of this research was to determine which variants of foliar treatments would achieve the best results in terms of the quantity and quality of grape yield of the Cardinal variety.

Material and Methods

Experimental site

A three-year field experiment was conducted in the Tikvesh region, which is one of the biggest viticulture regions in the Republic of North Macedonia. The favourable and harmonious climate coupled with dynamic soil and geographic conditions makes this region agro-ecologically suitable for growing many vine varieties with different periods of ripening.

The climate in the southern part of the valley is under the influence of a modified Mediterranean climate characterized with long and hot summers, while the northern part of the region is under the influence of a continental climate with mild and wet winters. The predominant soil type in the region is Rendzinic soil, formed on recent Pliocene sediments.

The field trial was carried out during the 2012-2014 period, on grape vines belonging to the Cardinal variety in a randomized complete block design, with three replications for each of the fertilization variants plus the control variant. The treated vines were 25 years old, planted at 2.80 x 1.10 m spacing, with a total 3247 vine/ha, with a “2-cordon” pruning system.

During the research period, standard commercial agro-technical practices were implemented in the vineyard. Soil tillage and soil fertilization with mineral fertilizers were performed each year in the autumn with 350kg/ha NPK 8-16-24 and during the spring, with 100 kg/ha ammonium nitrate 33%. Furrow irrigation was performed 2-3 times during the summer period and plant protection 5-6 times during the vegetation season.

Fertilization Treatments

The monitored variants were: Control (no foliar fertilizer); Variant 1: Calcium nitrate 40% solution (7% N, 10% Ca); Variant 2: Magnisal VI NPK 31-0-0+ME (31% N; 0.015% Fe-chelate; 0.01% Mg - chelat). The fertilizers were applied foliary at a concentration of 0.5%, four times during the growing period (before and after blooming, buckshot berries, and verasion). Applications were performed early in the morning, mostly on a dry and cloudy weather with no precipitation.

Soil Sampling and Analysis

Soil samples were collected during 2012 (before vegetation) and 2014 (after harvest) at depths of 0-30 cm, 30–50 cm, and 50-80 cm. Each soil sample was air-dried, lightly ground and sieved in the accredited laboratory at the Institute of agriculture - Skopje. Standardized laboratory methods were used to test the basic chemical soil properties: pH value - in 1:2.5 (v/v) suspension of soil in H2O and 1 MKCl was determined using a glass electrode (MKC ISO method 10390:2015); free CaCO3 contents were determined by the volumetric method; organic matter contents according to the Tyurin method, modified by Simakov; the content of easily available forms of phosphorus (P2O5) and potassium (K2O) by the AL method, according to Egner-Riehme, and available form of calcium by the ammonium acetate method.

Tab. 1. The soil properties of the experimental soil

Year	2012			2014		
Soil Characteristics	0-30cm	30-50cm	50-80cm	0-30cm	30-50cm	50-80cm
Texture	*clay loam*					
pH/ H_2O	8.06	8.09	8.10	8.10	8.10	8.11
Classification	*moderately alkaline*					
pH/ KCl	7.29	7.31	7.33	7.31	7.29	7.26
Classification	*alkaline*					
Organic matter (%)	2.54	2.23	1.86	1.97	1.69	1.58
Classification	*low*					
$CaCO_3$ (%)	17.33	17.28	18.53	21.39	19.70	21.49
Classification	*high*					
Total N (%)	0.15	0.13	0.05	0.12	0.10	0.07
Classification	*optimal*		*low*	*optimal*		*low*
Available P_2O_5 (mg/100g soil)	18.09	13.32	12.59	19.79	15.38	14.23
Classification	*optimal*	*medium*		*optimal*		*medium*
Available K_2O (mg/100g soil)	17.89	15.86	14.64	20.26	17.64	16.08
Classification	*optimal*					
Available Ca (ppm)	3941.86	3976.84	3915.86	3943.55	3978.79	3917.66
Classification	*high*					

Data Collection and Analysis

Total yield was calculated by counting clusters and their weight per vine. Representative random samples of 24 clusters per variant were analyzed to determine the cluster weight, berry weight per cluster, and percentage of berries per cluster. Random samples of 100 berries from each replication were analyzed in the laboratory to determine their mechanical properties: breaking resistance and resistance to pressure, and chemical properties of must, i.e., contents of sugar and total acids. The properties of clusters and berries were determined according to the CODE system issued by the International Organization of Vine and Wine (O.I.V). The sugar content was determined using the Axle's device, while the total amount of acids was determined by the volumetric method, using 0.025 mol/l solution of NaOH.

Statistical analysis

Analysis of variance was performed using the SPSS 20.0 software.

Results and Discussion

The results (mean value and statistical differences) for each measured parameter and for each treatment are shown in Tables 1-4.

The influence of different foliar treatments on yield and cluster structure were analyzed by measuring the exact weight of cluster/vine in kg and averaging it to a t/ha for each variant and year of examination (Table 2).

Grape yield is in close correlation to the biological characteristics of the variety, as well as the growing system, agro-ecological conditions, and applied agro-technical and ampelo-technical measures. According to Ćosić & Poljak (1999), under the influence of fertilizer nutrition, grape ripening takes place earlier, clusters are developed with bigger berries and intensive colour which is in line with our results. The results showed that tested foliar variants in the research period had a higher yield, compared with control the variant (4.18 kg/vine - 13.59 t/ha), but without significant differences.

A statistically significant difference at the probability level of $p < 0.05$ between variants was noted only in the last year of the research period. Despite bad weather conditions in 2014, foliar application of nitrogen in Variant III, significantly increased the grape yield compared to other two variants.

Tab. 2. Grape yield and cluster structure

Variant	2012		2013		2014		Average					
	kg/vine	t/ha	kg/vine	t/ha	kg/vine	t/ha	kg/vine	t/ha	Cluster weight, g	Berryweight/ cluster, g	% of berries	Rachis weight, g
Control	4.90^{a}	15.89^{a}	4.94^{a}	16.03^{a}	2.72^{b}	8.83^{b}	4.18^{a}	13.59^{a}	344^{a}	330.92^{b}	96.19^{a}	13.08^{a}
I	5.17^{a}	16.79^{a}	5.03^{a}	16.33^{a}	3.05^{b}	9.91^{b}	4.53^{a}	14.34^{a}	366^{a}	353.06^{b}	96.46^{a}	12.94^{a}
II	4.98^{a}	16.16^{a}	5.04^{a}	16.36^{a}	3.71^{a}	12.04^{a}	4.57^{a}	14.85^{a}	382^{a}	368.68^{a}	96.51^{a}	13.32^{a}

* values followed by the same letter are not statistically significant at $p < 0.05$

The unfavourable weather conditions during May 2014 and hail events at the beginning of the growing season as well as the outburst of *Plasmopara viticola* were the main reasons for low grape yield in this year, which was significantly lower compared to the previous two growing seasons (2012/2013). Despite bad weather conditions in the last year of the research period, the foliar application of N significantly increased the grape yield compared to other variants. The differences are most probably related to sufficient nutrition of the plants during the critical growing stages with nitrogen, which increased the process of photosynthesis and their ability to recover from hail damages and develop resistance to infections.

Numerous researchers have extensively studied the benefit of nitrogen in grapevine nutrition. The positive influence of nitrogen fertilizing was confirmed by Cocco et al. (2021), Delgado et al. (2004), Gay-Eynard (2000), etc. According the Cocco et al. (2021), nitrogen had a direct and positive effect on grape yield and vine mealybug development, highlighting the importance of integrated crop management and pest control practices to promote grape production. The amount of nitrogen fertilization supplied influenced the nitrogen status of vines and increased the pruning weight and leaf area, as well as the overall grape yield, by increasing the cluster weight. The positive influence of nitrogen application on the cluster structure was noted in our research, as well. The highest values were observed in Variant II, with 382g average cluster weight and 368.68g berry weight, significantly different from other variants. Cluster size, however, was improved with nitrogen nutrition, whereas the number of berries per cluster remained unchanged. The ‘Thompson Seedless’ vines produced the heaviest clusters and the highest cluster dimension when N rate increased (Delgado et al., 2004). Gay-Eynard (2000) noted there was a slight yield increase by about 10% in ‘Concord’ and 29% in ‘Niagara’ grapevines fertigated with nitrogen and this was attributable to increased cluster weight.

The cluster weight is an important indicator of table grape quality. According to Amiri & Fallahi (2007), the structure and the number of clusters per vine are important yield components and are under strong influence of mineral nutrition and application of macro elements. During the investigation in 2017-2018, Abou-Zaid and Shaaban (2019) noted that foliar treatments significantly increased the yield and quality of the berries compared to the control. The most elevated estimations of compactness coefficient 3.91%, number of berries 110.0, berry weight 98.9 g, cluster length 27.7 cm, berry set 10.97%, yield/vine 11.5 kg and cluster weight 456.5 g were obtained from combined foliar application twice, one at the beginning of growth and second at the flowering period.

Tab.3. Mechanical properties of the berry (g)

Variant	*Resistance of berry pressure*				*Berry breaking of resistance*			
	2012	*2013*	*2014*	*Average*	*2012*	*2013*	*2014*	*Average*
Control	2170.66[a]	1785.33[b]	1795.66[a]	*1917.22*[b]	363.00[a]	357.06[a]	306.53[a]	*342.20*[a]
I	2358.66[a]	2328.33[a]	2002.10[a]	*2229.70*[a]	392.04[a]	407.26[a]	294.24[a]	*364.52*[a]
II	2174.66[a]	1870.60[b]	1785.50[a]	*1943.58*[b]	337.68[a]	371.40[a]	292.17[a]	*333.75*[a]

* values followed by the same letter are not statistically significant at $p < 0.05$

The results presented in Table 3 prove the positive influence of continuous and balanced foliar fertilization on the resistance of berry pressure. Out of data presented, it can be concluded that in all years of investigation, Variant I, which included foliar application of Ca has had the significantly higher values of berry resistance to mechanical pressure (2229.70g), compared with the control variant (1917.22g) and Variant II (1943.58g). These results prove the importance of calcium on the strength of the grape berry to mechanical pressure, because the strength and thickness of the cell wall are directly affected by the content of calcium since this element is an essential component of its structure. Therefore, the lack of calcium can directly influence the reduction of shelf-life of table grapes and deformation of tissues of fast growing plants (Salisbury & Rose, 1992).

Variant I has shown the highest values in berry breaking resistance (364.52g), but also with no statistical difference, compared to the control. During the research period, Variant II, treated with N, continuously had the lowest breaking resistance (333.75g) compared with other variants. Such a low value can be attributed to the role of nitrogen in increasing the volume of berry and decreasing its mechanical properties. The results are consistent with the results of Baiano et al. (2010) who reported that fertilizing with a higher amount of nitrogen (120 and 180 kg/ha) significantly reduces mechanical properties on the grape berry.

No statistically significant differences in concentration of sugar in the grape must have been observed. Sugar contents is an essential element of the table grape quality and even more for wine varieties. Data related to the chemical properties of must are presented in Table 4. The individual treatments within foliar applications have not statistically influenced the sugar contents during the investigation period. The nitrogen treatment (Variant II) has had positive effect on the sugar contents during the research period (Table 4) compared with other variants, with highest average total of 194g/l sugar.

Tab.4. Sugar and total acids in the grape must (g/l)

Variant	*2012*		*2013*		*2014*		*Average*	
	Sugar	*Total acids*	*Sugar*	*Total acids*	*Sugar*	*Total acids*	*Sugar*	*Total acids*
Control	199.33[a]	4.03[a]	193.41[a]	3.60[a]	176.00[a]	2.70[a]	191.55[a]	3.44[a]
I	198.33[a]	3.86[a]	200.33[a]	3.50[a]	174.66[a]	2.50[b]	191.44[a]	3.28[b]
II	202.00[a]	3.90[a]	201.33[a]	3.00[b]	179.66[a]	2.56[b]	194.00[a]	3.15[b]

* values followed by the same letter are not statistically significant at $p<0.05$

Some previous investigations confirmed that the contents of sugar and acids are primarily dependent on variety specifics, growing conditions, and the applied agro-technical and ampelo-technical measures. Foliar feeding is another very significant factor which has a direct effect on achieving higher sugar contents in grapes (Duletić and Mijović, 2014). The total acid content in the must is an important indicator for the taste of grapes and its overall quality. The acidity of must is defined with the free acids content and their salts present in it and to a smaller extent based on some other acidic substances.

The concentration of total acids exhibits minimal differences between control and the treatments, but is statistically significant (Table 4). Higher values of total acids in the grape must have been recorded in the control variant, while significantly lower total acidity values have been found in the variants with foliar treatment. In general, higher average content of total acids was 3.44g/l in the control and the lowest in Variant II, with 3.15g/l. which is in line with the results reported by Krempa et al. (2009). In the two-year field trials, the authors detected minimal differences in acid contents between the unfertilized cv. Muscatel yellow and Furmint (8.09 and 9.20 g/l, respectively) after the application of N, Mg (8.04 and 9.31 g/l, respectively) and N, Mg, and S (8.22 and 9.26 g/l, respectively).

Conclusion

Increasing Ca and N supply has enhanced the grape yield and cluster structure compared with the control. Despite bad weather conditions in the last year of the research period, foliar application of N significantly increased the grape yield compared to other variants. The differences are most probably related to sufficient nutrition of the plants during the critical growing stages with nitrogen, which increased the process of photosynthesis and their ability to recover from hail damages and resistance to infections. The foliar application with Ca has significantly affected the resistance of berry pressure and proved the importance of calcium on the strength of the grape berry to mechanical pressure. The application of foliar Ca and N has not had a significant effect on the sugar contents, compared with the control. On the contrary, higher values of total acids in the grape must have been recorded in the control variant, while the significantly lower total acidity values have been recorded in variants with foliar treatment.

Generally, the foliar treatments achieved the best results in terms of the quantity and quality of grape yield of the Cardinal variety.

References

Abou-Zaid A. A. E. & Shaaban M. M. (2019). Growth, yield and berries quality in Red Roomy grapevines improved under different foliar application of Spirulina algae, zinc and boron. *Middle East Journal of Agriculture Research*. 8 (2), 654-661. https://curresweb.com/mejar/mejar/2019/654-661.pdf

Adesemoye, A., Torbert, H. & Kloepper, J. (2008). Enhanced plant nutrient use efficiency with PGPR and AMF in an integrated nutrient management system. *Can. J. Microbiol*., 54, 876-886. https://doi.org/10.1139/w08-081

Amiri M.E. & Fallahi E. (2007). Influence of Mineral Nutrients on Growth, Yield, Berry Quality and Petiole Mineral Nutrient Concentrations of Table Grape. *Journal of Plant Nutrition*. 30 (3), 463-470. https://doi.org/10.1080/01904160601172031

Baiano A., Nottel. L. E., Coletta. A. & Antonacci. D. (2011). Effects of Irrigation Volume and Nitrogen Fertilization on Redglobe and Michele Palieri Table-Grape Cultivars. *American Journal of Enology and Viticulture*, 62(1), 57-65. https://doi.org/10.5344/ajev.2010.09127

Baldwin, E.A. (2002). Fruit flavor, volatile metabolism and consumer perceptions. p. 89-106. In Knee, M. (ed.) Fruit quality and its biological basis. Sheffield Academic Press, Sheffield, UK.

Bates, T. R., Dunst, R. M., & Joy, P. (2002). Seasonal dry matter, starch and nutrient distribution in Concord grapevine roots. *HortScience* 37, 313–316. https://doi.org/10.21273/HORTSCI.37.2.313

Chokha S., Sharma V.P., Usha K. & Sagar V.R. (2002). Effect of macro and micronutrients on physico chemical characters of grape. *Indian Journal of Horticulture*, 59 (3), 258-260.

Cliff, M.A., Dever, M.C. & Reynolds, A.G. (1996). Descriptive profiling of new and commercial British Columbia table grape cultivars. *American Journal of Enology and Viticulture*, 47, 301–308. https://doi.org/10.5344/ajev.1996.47.3.301

Colapietra M. & Alexander A. (2006). Effect of foliar fertilization on yield and quality of table grapes. *Acta Hortic*. 721, 213-218. https://doi.org/10.17660/ActaHortic.2006.721.28

Cocco A., Mercenaro L., Muscas E., Mura A.a, Nieddu G. & Lentin A. (2021). Multiple Effects of Nitrogen Fertilization on Grape Vegetative Growth, Berry Quality and Pest Development in Mediterranean Vineyards. *Horticulturae* 2021, 7, 530. https://doi.org/10.3390/horticulturae7120530

Ćosić T. & Poljak M. (1999). Hranidbeni potencijal tala na podrucju grada Iloka i okolice za potrebe vinove loze. Znanstveni skup u povodu 100 obljetnice Poljoprivredne skole u Iloku. pp. 80-90.

Delgado, R., Martin, P., Del Alamo M. & M. Gonzalez (2004). Changes in phenolic composition of grape berries during ripening in relation to vineyard nitrogen and potassium fertilization rates. *J. Sci. Food and Agric*., 84, 623-630. https://doi.org/10.1002/jsfa.1685

Duletić D. & Mijović S. (2014). Yield and quality of grapes of the cardinal variety depending on different foliar fertilizers. *Agriculture and forestry*, Podgorica, 60(2), 85-91. http://89.188.43.75/agricultforest/20140628-08%20Duletic%20and%20Mijovic.pdf

Fernandez, V. & Eichert, T. (2009). Uptake of hydrophilic solutes through plant leaves: Current state of knowledge and perspectives of foliar fertilization. *Critical Reviews in Plant Sciences*. 28, 36-68. https://doi.org/10.1080/07352680902743069

Fernandez V., Sotiropoulos T. & Brown H. P. (2013). Foliar Fertilization: Scientific Principles and Field Practices. Book First Edition Publisher: International Fertilizer Industry Association.

Franceschi, V. & Nakata P. (2005). Calcium oxalate in plants: Formation and function. *Annual Reviewof Plant Biology*, 56, 41–71. https://doi.org/10.1146/annurev.arplant.56.032604.144106

Gay-Eynard, G. (2000). Nitrogen effects on yield and canopy of White Muscat grapevines. XXV International Horticultural Congress, Part 2: Mineral Nutrition and Grape and Wine Quality. *Acta Hort.*, 512, 47-54. https://doi.org/10.17660/ActaHortic.2000.512.5

Gerasopoulos, D. & Drogoudi P. (2005). Summer-pruning and preharvest calcium chloridesprays affect storability and low temperature breakdown incidence in kiwi fruit. *Postharvest Biology and Technology*, 36, 303–308 https://doi.org/10.1016/j.postharvbio.2005.01.005

Griengo G. S., Bandera D. A. & Magolama A. A. (2020). Application of Different Fertilizer Types and Levels on Vegetable Production: A Critical Review. IEEE-SEM, 8(10), 150-157.
Hanson E. (1995). Preharvest calcium sprays do not improve highbush blueberry (*Vaccinium corymbosum* L.) quality. *HortScience*, 30, 977–978. https://doi.org/10.21273/HORTSCI.30.5.977
Hernandez-Munoz, P., Almenara E., Ociob M., & Gavaraa R. (2006). Effect of calcium dips and chitosan coatings on postharvest life of strawberries (*Fragaria x ananassa*). *Postharvest Biology and Technology*, 39, 274–253. https://doi.org/10.1016/j.postharvbio.2005.11.006
Huang, X-M., Wang H-C., Yuana W-Q., Lu J-M., Yin J.H., Luo S. & Huang H. (2005). A study of rapidsenescence of detached litchi: Roles of water loss and calcium. *Postharvest Biology and Technology*, 36,177–189. https://doi.org/10.1016/j.postharvbio.2004.12.005
Krempa P., Lozek O., Slamka P. &Varga L. (2009). Effectiveness of N-P-K-Mg-S fertilizers on yield and quality of grace-vine in Tokaj viniculture region. *Agrochemistry*, 49, 23-27.
Lara, I., Garcıa P. & Vendrell M. (2004). Modifications in cell wall composition after cold storage of calcium-treated strawberry (*Fragaria ananassa Duch.*) fruit. *Postharvest Biol. Technol.*, 34, 331-339. https://doi.org/10.1016/j.postharvbio.2004.05.018
Leghari, S.J., Wahocho, N.A., Laghari, G.M., HafeezLaghari, A., MustafaBhabhan, G., HussainTalpur, K. & Lashari, A.A. (2016) Role of Nitrogen for Plant Growth and Development: A Review. *Advances in Environmental Biology*, 10, 209-219. http://www.aensiweb.net/AENSIWEB/aeb/aeb/2016/September/209-218.pdf
Peryea, F. J. & Neilsen G. H. (2006). Effect of very high calcium sprays just before harvest on apple fruit firmness and Calcium concentration. *Acta Horticulturae*, 721, 199–205. https://doi.org/10.17660/ActaHortic.2006.721.26
Salisbury F.B., Ross C.W (1992). *Plant Physiology*. 4th Edition Wadsworth Publishing Company, USA.
Schaller, K., Löhnertz O. & Chikkasubbanna V. (1992). Calcium absorption by the grape berries of different cultivars during growth and development. *Viticulture and Enology Science*, 47, 62–65.
Shiraishi, M., Fujishima H. & Chijiwa H. (2010). Evaluation of table grape genetic resources for sugar, organic acid, and aminoacid composition of berries. *Euphytica*, 174, 1-13. https://doi.org/10.1007/s10681-009-0084-4

Утицај фолијарних третмана калцијумом и азотом на принос и квалитет стоног грожђа сорте Кардинал

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Сажетак

Током три узастопне године, спроведено је истраживање код Vitis vinifera L. (сорте Кардинал) да би се утврдио утицај фолијарне примјене Ca и N ђубрива на принос и квалитет грожђа. Течна минерална ђубрива које садрже: 40% $Ca(NO_3)_2$ као варијанта I и 31% N са 0,015% Fe-хелата; 0,01 % Mg – хелат као варијанта II (у тексту), аплицирана су четири пута током вегетације (прије и послије цвјетања, пораст бобице и фазе прошарак). Резултати су показали да калцијум и азот у фолијарној примјени повећавају принос стоног грожђа у све три године истраживања, у поређењу са контролном варијантом. Највећи приноси грожђа током истраживања остварени су код варијанте II – 4,57 kg/лози (14,85 t/ha). Највећа маса грозда и бобица утврђена је код варијанте II (382g и 368,68g), док је најмања маса грозда била код контролне варијанте (344g и 330,92g). С обзиром на механичка својства зрна грожђа, највећа отпорност на притисак (2229,70g) и отпорност на ломљење (364,52g) измјерени су код варијанте I, третиране Ca ђубривом. Фолијарна примјена значајно утиче на механичка својства (отпорност зрна на притисак и ломљење отпорности), посебно код варијанте I. Примјена различитих врста фолијарних ђубрива није имала значајнији утицај на садржај шећера и укупних киселина у поређењу са контролном варијантом.

Кључне ријечи: фолијарно ђубрење, азот, калцијум, стоно грожђе, приноси

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