

APPLICATION OF NEW IMPROVED SOLUTIONS OF PREPARATIONS BASED ON ZEOLITH IN DIFFERENT PHASES OF PRODUCTION AT THE GRAPEVINE IN THE REPUBLIC OF NORTH MACEDONIA*

Biljana Korunoska*¹, Vladan Pešić², Krum Boškov³, Zlatko Prculovski³, Hristina
Trišeska¹

Original scientific paper

Abstract

In the period from 2018 to 2023, we conducted research on the effects of the application of the innovative formula from the mineral zeolite on different stages of production in the grapevine in the Republic of North Macedonia.

The mineral zeolite originates from the mine excavations in Serbia. In the period from 2017 to 2018, a „improved formula“ was made from the zeolite preparation with processing, it was crushed into a powder form, with a certain particle size for easy application in a dissolved state. This type of processed zeolite is registered as a soil improver and during that period it received an innovation award at a fair in Romania. We, in our country, continuously carry out tests using this preparation in several crops and it always gave positive results. In our study, the physico-chemical properties of this type of zeolite are shown, and then the results and the effect of the application on the vines are shown.

The main goal of applying this „ improved zeolite formula“ was to reduce the use and uncontrolled use of pesticides in the fight to suppress diseases, pests, harmful weeds, etc. This is achieved in such a way that with the application of zeolite, which is environmentally friendly, the properties of the soil are improved, the plant makes better use of useful substances and water, in fact stronger, more resistant and immune plants to diseases, pests, harmful weeds, drought, frost are obtained. etc. At the same time, the use of pesticides is reduced, and the pollution of the environment is also reduced.

Keywords: *zeolite, improved formula, property improver, pesticides, grapevine*

* Paper presented at the 34th International Scientific-Expert Conference of Agriculture and Food Industry, October 9-11, 2024, Sarajevo, Bosnia and Herzegovina

¹ University „Ss.Cyril and Methodius“, Institute of Agriculture - Skopje, Republic of North Macedonia

² University of Belgrade, Faculty of Agriculture, Beograd-Zemun, R. Serbia

³ University „Ss.Cyril and Methodius“ - Skopje, Faculty of Agricultural Sciences and Food, Skopje, Republic of North Macedonia

Correspondence: markovskabiljana@yahoo.com

INTRODUCTION

The basic direction at the global level is healthy food and an unpolluted environment, but above all, it is necessary to produce food, that is, during the cultivation of agricultural crops, pollution of the environment should not occur. Therefore, organic agricultural production is increasingly being applied and solutions are being found on a global scale for less use of harmful substances in growing crops.

Zeolite is a mineral of volcanic origin and is separated in sedimentary deposits where there used to be lava. There are several natural types of zeolite (Baerlocher *et al.*, 2007). Zeolites used in agriculture are most often from the group of clinoptilolite and chabazite. It is most often extracted as pieces of stone, and then crushed and ground to a certain size. Zeolite is sold in granules and powder form. Depending on the deposit, according to the chemical composition, zeolites are complex hydrolyzed silicates of sodium, potassium and calcium (Flanigen *et al.*, 1980). They may also contain magnesium, aluminum, phosphorus, zinc, etc. The differences between zeolites actually consist in the percentage representation of these elements and in the size of the particles.

Zeolite is very suitable for organic agricultural production and its application reduces the use of synthetic harmful chemical preparations for the destruction of diseases, pests and weeds, because stronger and healthier plants with improved immunity are obtained. Its method of use is by introducing it into the soil and by foliar application. It is also an improver of soil properties, because it increases the availability of nutrients, water, air, regulates porosity, reduces acidity, etc.

Our innovative zeolite formula consists of a balanced percentage of elements and the method of further processing (crushing and finalization). The Terra powder preparation showed excellent results in improving the properties of soil and plants during testing in grapevines (Korunoska and Pešić, 2017).

MATERIALS AND METHODS

The tests in our paper were carried out in the period from 2018 to 2023 in grapevine plantations at individual producers in the Republic of Macedonia. Specifically, the effect of the application of zeolite with the marketing name - Terra powder on individual vines of the varieties Black Valandovo drenok, Muscat Italia, Chardonnay, Pinot noir was examined (Auerbach *et al.*, 2003). The following parameters were examined in the vines: soil pH, disease resistance and mass of removed mature shoots (kg/vine). Three vines were treated and 1 vine was left untreated for control. Treated vines are marked with T, and untreated vines are marked with U.

Four Treatments were carried out during the year, foliar - with the first treatment at the beginning of vegetation, the second treatment when there is a large green mass in summer, and the third before the end of vegetation (October - November) and the fourth is after the end of vegetation (December). If the soil is treated together with irrigation, it is necessary to make a previous detailed physicochemical analysis of it. But we performed an application with foliar treatment and treatment of the stem near the soil,

with a small manual pump (Gao *et al.*, 2024). Most often in viticulture, quantities of 1 to 3 tons per hectare are practiced, but for individual vines, the zeolite is applied in an amount of about 0.200 to 0.400 kg per vine. All measurements, analyses and comparisons were performed according to the usual tests of agrobiological properties according to the code system of OIV **Standards technical documents**. The statistical processing is Analysis of variance (ANOVA).

The zeolite in our tests comes from a mine near Kopaonik, R. Serbia and as such is a naturally very high-quality mineral. It is additionally processed by crushing it to microgranules and enriching it with certain elements that will further act by binding with other substances and form complex powder formulations. The processing was carried out in a small factory workshop in Skopje, R. N. Macedonia. The substance in powder easily turns into an agrogel and in a liquid state is easy to apply. Our „improved formula“ has a very favorable structure, suitable grinding and good chemical composition. When applied as an improver of soil properties, it gives it a uniform porosity and moderate permeability. Treatment with zeolite in viticulture is not only completely harmless but also purifies the environment – water, air and soil.

Our innovative zeolite formulation was first tested at the Department of Pedology at the Faculty of Agricultural Sciences and Food in Skopje, and appropriate reports for recognition and approval have been submitted to the Ministry of Agriculture, Forestry and Water Economy and the Ministry of Environment and Spatial Planning. The preparation is listed under the proposed name GAIA - Terra powder, and table 1 shows the laboratory analyses of its chemical and physical properties.

Figures 1 to 4 show a model representation of the molecular composition of various types of zeolite. Figures 5 to 7 show mine excavation, different structure, innovative formula - Terra powder (Ivanković *et al.*, 2013).

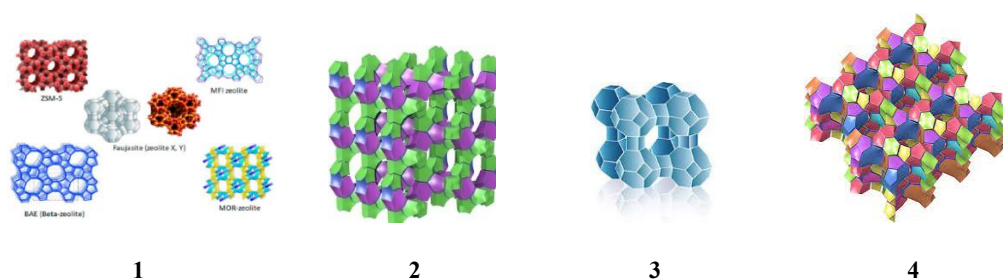


Figure 1 – 4. Model representation of the molecular composition of various types of zeolite

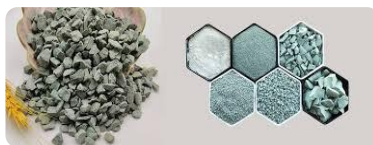
Table 1. Results from properties improvement - Terra powder

* Unaccredited method

Parameter	Method	Received value	Declared value	Unit measure
Moisture	MKC ISO8190:1992	1.2	/	%
Mechanical composition (size in granules)	MKC ISO8397:2009	1 mm 98 min 0.25 mm 80 min	1 mm 98 min 0.25 mm 80 min	%
*Shape	Organoleptic	powder form	powder form	/
*Color	Organoleptic	white	white	/
*Smell	Organoleptic	no	no	/
*Solubility in water	Organoleptic	Very poorly soluble	poorly soluble	%
pH	MKC ISO13037:2011	10.78	/	/
*CaCO ₃	Volumetric ISO10693	83.31	/	%
* Total CaO	Rulebook on inorganic fertilizers of R.M. no. 96 from 31.06.2009	35.80	35±3	%
* Total MgO	Rulebook on inorganic fertilizers of R.M. no. 96 from 31.06.2009	5.08	5±1.25	%



5



6



7

Figure 5 – 7. Mine excavation, different structure, innovative formula - Terra powder

RESULTS AND DISCUSSION

The presented table 2 shows the soil pH test during application to the vines near the soil in the area where the seedling was once grafted. Before the application, the soil condition was tested in terms of physical and chemical properties, i.e. the presence of the necessary elements in it. The table shows that in all varieties treated with the preparation - T, the pH value increased compared to those varieties that were not treated - U.

This corrects the acidity of the soil, which leads to better use of water and nutrients, resulting in stronger and healthier vines. The table also shows the results of scoring the resistance of the varieties to Botrytis and Oidium (Inglezakis, 2005). From this, it can be seen that in all varieties that were treated, an increase in the score occurs, i.e. the resistance to diseases increases, only in the Chardonnay variety this is insignificant, most likely due to the action of other factors (Pirsaheb *et al.*, 2021). The presented table 3 shows the results of measuring the removed mass of mature shoots after regular pruning of the vines. It is a parameter that shows how much growth a vine has in a year. Also, this parameter shows how much there was an increase in green mass, wood mass and fertility in the previous year and should be removed by pruning in the current year. The higher this parameter is, the stronger and more productive the vines may be. The table shows that the application of the preparation in all varieties increased the growth of the treated vines compared to those vines that were not treated and that represented the control (Inagaki *et al.*, 1996).

This effective action of the zeolite shows that it is of good quality, that is, that it is naturally free and is not saturated with a large amount of certain harmful substances that it has the ability to bind to itself and remove them from the soil or the organism (plant). The more harmful elements the zeolite has bound to itself, the lower its quality (occupied). Quality zeolite provides favorable regulation of water, air and nutrients (Chatterjee *et al.*, 2023).

The mass of removed shoots is also shown visibly in graph 1. Figures 8 to 14 show the varieties and the positive impact of the preparation on inflorescences, leaf mass, green and ripe berries in the bunch, and above all the strength and straightness of the shoots.

Table 2. Correcting soil pH and disease resistance (score)

Varieties	Correcting soil pH		Disease resistance (score)	
	U	T	U	T
Black Valandovo drenok	6.3	7.1	2	3
M. Italia	5.7	6.8	1	2
Chardonnay	5.2	6.3	2	3
Pinot noir	5.5	6.5	1	2

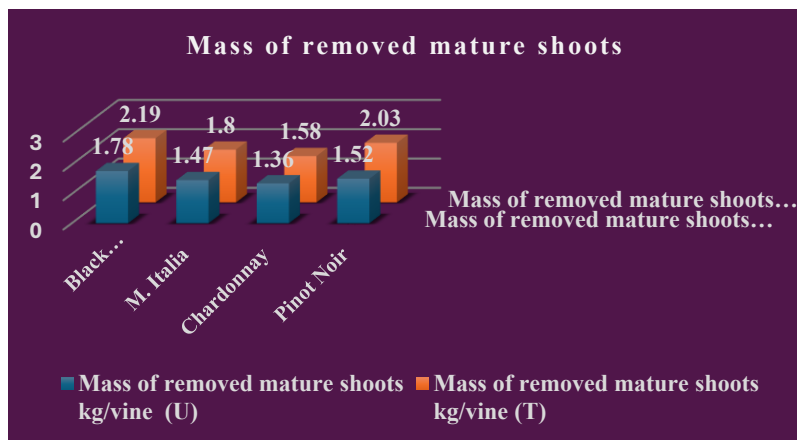
*T = Treated, *U = Untreated

Scoring with a number: 1-weak, 2-average, 3-good, 4-very good

Table 3. Mass of removed mature shoots kg/vine

Varieties	Mass of removed mature shoots kg/vine (U)	Mass of removed mature shoots kg/vine (T)
Black Valandovo drenok	1.780	2.190
M. Italia	1.470	1.800
Chardonnay	1.360	1.580
Pinot noir	1.520	2.030
Σ	6.130	7.600
$\bar{h}$	1.533	1.900
$s \bar{h}$	0.089	0.134
σ	0.178	0.267
CV%	11.616	14.037
Xmin-	1.360	1.580
Xmax	1.780	2.190
VŠ	0.420	0.610

*T = Treated, *U = Untreated



Graph 1. Graphical representation of the mass of removed mature shoots in grapevines



8



9



10

Figure 8 – 10. Positive results in flowers, shoots and bunches



11



12



13



14

Figure 11 – 14. Black Valandovo drenok, M. Italia, Chardonnay, Pinot noir

CONCLUSIONS

From the previous analyses and obtained results, the following conclusions can be drawn:

- The preparation (the innovative formula) is a naturally good and high-quality mineral, with a good chemical composition, favorable physical properties and with its appropriate processing with certain finesse and correct application, it is a favorable means for improving the properties of the soil and grapevine.
- In our tests, the preparation showed an increase in the pH value and regulated the acidity of the soil.
- The preparation also had a favorable effect on increasing the number (scoring) for the resistance of the vines in the tested varieties. It was shown that the treated vines are plants with increased immunity to diseases.
- The treated vines also have a greater mass of removed mature shoots, thus having a greater average growth, greater green mass, larger, more beautiful and uniform berries and clusters. In fact, stronger vines are obtained, with good structure and habitus, with correctly placed shoots, without thickening, but also without rarely placed shoots.
- The preparation is suitable for use in organic grapevine production, because it can replace the use of many harmful chemicals (pesticides, herbicides, etc.). The use of this preparation does not have harmful consequences and pollution of the soil, water and air. Of course, excessive use is not necessary, because it can result in greater alkalization, and if the dosage is incorrect, it can "eat" some of the metals and a small imbalance of ions can occur. However, the negative effects are so minor in comparison to the positive effects that can be obtained from its use. This preparation is a transporter and eliminator of harmful substances and influences, it gives healthy and strong plants and also gives fertile and healthy soil. It is a boon for nature and food production.

REFERENCES

- Auerbach, S.M., Carrado, K.A., Dutta, P.K., eds. (2003). Handbook of Zeolite Science and Technology. Boca Raton: CRC Press. p. 16. ISBN 9780824740207
- Baerlocher, C., Mc Cusker, L.B., Olson, D.H. (2007). Atlas of Zeolite Framework Types, 6th edition, Elsevier, Amsterdam.
- Chatterjee, P., Han, Y., Kobayashi, T., Verma, K., Mais, M., Beher, R., Johnson, T., Prozorov, T., Evans, J., Slowing, I.I., Huang, W. (2023). Capturing Rare-Earth Elements by Synthetic Aluminosilicate MCM-22: Mechanistic Understanding of Yb (III) Capture. ACS Appl. Mater. Interfaces. 15 (46): 54192-5, 4201.
doi:10.1021/acsami.3c14560. PMID 37934618. S2CID 265050410.
- Flanigen, E.M. (1980). Molecular sieve zeolite technology-the first twenty-five years" in Proc. 5th Int. Conf. on Zeolites, Naples, Italy, ed. L.V.C. Rees, Heyden, London, 760-780.

- Gao, Z.R., Yu, H., Chen, F.J., Mayoral, A., Niu, Z., Li, X., Deng, H., Marquez-Alvarez, C., He, H., Xu, S., Zhou, Y., Xu, J., Xu, H., Fan, W., Balestra, S.R.G., Ma, C., Hao, J., Li, J., Wu, P., Yu, J., Cambor, M.A. (2024). Interchain-expanded extra-large-pore zeolites. *Nature* 628, 99-103.
- Inagaki, S., Koiwai, A., Suzuki, N., Fukushima, Y., Kuroda, K. (1996). Synthesis of highly ordered mesoporous materials, FSM-16, derived from Kanemite. *Bull. Chem. Soc. Jpn* 69, 1449-1457.
- Inglezakis, V.J. (2005). The concept of capacity in zeolite ion-exchange systems, *Journal of Colloid and Interface Science*, Vol.281, pp. 68-79
- Ivanković, T., Hrenović, J., Matonićkin-Kepčija, R. (2013). Resistance of bioparticles formed of phosphate-accumulating bacteria and zeolite to harsh environmental conditions. *Biofouling: The Journal of Bioadhesion and Biofilm Research* 29, 641-649.
- Korunoska, B., Pešić, V. (2017). Effects of new organic preparations based on zeolite and dolomite over some characteristics of the grape in R. Macedonia, 3rd International Symposium for Agriculture and Food (Proceedings) Ohrid, 125-131 .
- Pirsaheb, M., Hossaini, H., Amini, J. (2021). Operational parameters influenced on biogas production in zeolite/anaerobic baffled reactor for compost leachate treatment. *Journal of Environmental Health Science & Engineering*. 19 (2):1743-1751.
Bibcode:2021JEHSE..19.1743P. doi:10.1007/s40201-021-00729-3. PMC 8617091. PMID 34900303.

<http://www.iza-structure.org/databases/>

<http://www.iza-online.org>

<https://www.britannica.com/science/clinoptilolite>

<http://www.lenntech.com/zeolites.htm>

<https://www.ncbi.nlm.nih.gov/books/>

PRIMJENA NOVIH POBOLJŠANIH RJEŠENJA PREPARATA ZEOLITA U RAZLIČITIM FAZAMA PROIZVODNJE VINOVE LOZE U REPUBLICI SJEVERNOJ MAKEDONIJI

Sažetak

U periodu od 2018. do 2023. godine sprovedi smo istraživanje o efektima primjene inovativne formule od minerala zeolita na različite faze proizvodnje vinove loze u Republici Sjevernoj Makedoniji.

Mineral zeolit potiče iz rudnika u Srbiji. U periodu od 2017. do 2018. godine napravljena je „nova formula“ od preparata zeolita uz preradu, usitnjen je u prah, sa

određenom veličinom čestica za laku primjenu u otopljenom stanju. Ova vrsta prerađenog zeolita je registrovana kao đubrivo i poboljšivač svojstava zemljišta i u tom periodu je dobila nagradu za inovaciju na sajmu u Rumuniji. Mi, u našoj zemlji, u kontinuitetu vršimo ispitivanja sa ovim preparatom u nekoliko usijeva i uvijek su davali pozitivne rezultate. U našem istraživanju prikazana su fizičko-hemijska svojstva ove vrste zeolita, a zatim rezultati i učinak primjene na vinovu lozu.

Osnovni cilj primjene ove „poboljšane formule zeolita“ bio je smanjenje upotrebe i nekontrolisane upotrebe pesticida u borbi protiv bolesti, štetočina, korova i sl. To se postiže na način da se primjenom zeolita, koji je ekološki prihvatljivih svojstva, zemljišta poboljšaju, biljka bolje koristi korisne tvari i vodu, zapravo dobiju se jače i otpornije biljke, rezistentne na bolesti, štetočine, korove, sušu, mraz itd. Istovremeno se smanjuje upotreba pesticida, a smanjuje se i zagađenje životne sredine.

Ključne riječi: *zeolit, poboljšana formula, poboljšivač svojstava, pesticidi, vinova loza*