Scientific Papers. Series B, Horticulture. Vol. LVIII, 2014
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

EFFECT OF A NEW COMPLEX OF TRACE ELEMENTS MICROCOM-V ON SOME METABOLIC PROCESSES AND PRODUCTIVITY OF *VITIS VINIFERA* L.

Sofia VELIKSAR, Simion TOMA, Dumitru BRATCO

Institute of Genetics and Plant Physiology, Academy of Sciences of Moldova
20 Padurii, MD 2002, Chisinau, Moldova, tel (373)22770447, fax (373)556180
Email: dechevas@rambler.ru; simiontoma@yahoo.com; dbratco@gmail.com

Corresponding author email: dechevas@rambler.ru

Abstract

The first local complex compound of trace elements Microcom-VA dedicated for grape has been tested in field conditions on 4 cultivars in comparison with two iron containing compounds – $FeSO_4$ and Dissolvin. The results of foliar treatment of vine, which were obtained in the 4 - year experiments (modification of content of photosynthetic pigments, microelements in the tissue, phosphor components and carbohydrates compounds, optimization of shoots growth and maturation, grape quality and quantity, winter resistance), let to assume, that complex of trace elements Microcom-VA led to optimization of plant nutrition, improving grape and wine quality, fuller realization of genetically based potential of frost and winter resistance.

Key words: *amino acids, carbohydrates, plant nutrition, sugar, trace elements*

INTRODUCTION

Vine is cultivated, in generally, on the soils with low fertility due to its morpho-physiological particularities, high level of plasticity and high adaptive potential. But such soils require permanent amelioration of the nutritive regime. Provision of grape plants with macro and microelements, prevention and attenuation of currency and sub currency of nutritive elements on the period of vegetation, increase of the quantity and quality of grape is possible through the foliar treatment of plants. The problem of fertilization is especially important for Moldova, because of high degree of soil degradation, slopes, and semi-arid conditions (Kuzneţov and Dmitrieva, 2006; Toma and Veliksar, 1992). Moreover, trace element content plays a very important role in many metabolic processes of plants and is the basic limitative factor (Alloway, 2006; Burzo and Toma, 2000; Toma et al., 2003).

Foliar fertilization is an important factor as supplementary and compensatory fertilization due to the high degree of uptake and utilization of the applied nutrients. Elaboration and utilization of the complex compounds for fertilization predominate actually in the world. Taking into account the insufficient supply of soils in mobile forms of microelements Fe, B, Mn etc. in our region, and also their high necessity for perennial plants, a special complex of microelements *Microcom-V* was created in the Institute of Genetics and Plant Physiology Academy of Sciences of Moldova (Patent MD: 2654).

From the other hand vine is frequently injured by the critical negative temperatures during the winter period. The majority of the varieties cultivated in the country, possess an enhanced genetic potential of producing capacity and relative resistance to frost. An eloquent objective provided for both intensive and ecological technologies within the strategies of a durable agriculture development in view of production of stable and high quality yields is to ensure the most complete manifestation of this potential.

The multiple studies (Burzo et al., 2000) have demonstrated that plant responses to stress are accompanied by accumulation of N-containing compounds (proline, other amino acids, polyamine compounds) and hydroxyl compounds (soluble glucides, oligosaccharides, sorbitol, inositol etc.) The problem is to provide evidence demonstrating the impact of nutrients

in this process. A specific microelement complex Microcom-V has been developed for this purpose. This study has been conducted to elucidate the impact of the Microcom-V microelement complex on some metabolic processes and productivity.
The main objective of this article is elucidation of some physiological aspects of the influence of specific complex of trace elements Microcom-V on grape metabolic processes and productivity.

MATERIALS AND METHODS

The researches have been performed in field conditions (central region of Moldova) on the technical varieties of grape ('Codrinschi', 'Aligote', 'Traminer', 'Chardonnay') in the years 2007 - 2011. Three trace element compounds were used for plants foliar fertilization: $FeSO_4$, Dissolvin and Microcom-V. Dissolvine - universal fertilizer for the prevention and remedying of micronutrient deficiencies in plants (manufactured in the Netherlands). The last compound - Microcom-V is created in Moldova; it contains 6 especially necessary for grape trace elements (Fe, Mn, B, Zn, Mo, Ni, Co) in optimal combination. The foliar treatment by the micro fertilizers was conducted two or three terms – before flowering and at the stage of intensive growth with an interval of 12 to 14 days. Water treated plants were used as control. Working solutions for spraying: $FeSO_4$ and Dissolvin – 0,3%, Microcom-V – 0,15%.
Leaves for analyses were sampled three and six days after the foliar treatment, thoroughly rinsed with water, allowed to dry and used for analysis. The berries were collected in two steps - at the beginning of their maturation and at full maturity, rinsed with water, allowed to dry and analyzed.
The following analytical methods were used: the content of free amino acids - using an AAA-300 analyzer, the carbohydrate content - according to Bertan; photosynthetic pigments determination - using ethanol extraction (Foy, 1987), trace elements content - using an atomic absorption spectrophotometer Perkin Elmer after dry digestion at 480^{o}C. The results were analyzed statistically according to Statistica-7.

RESULTS AND DISCUSSIONS

The content of photosynthetic pigments in grape leaves. The content of photosynthetic pigments in leaves is one of the important indications of the plants status during the growing season. Determination of these indices in plant leaves revealed positive influence of plants foliar fertilization by micronutrients on plant photosynthetic activity. More effective were compounds containing several trace elements - Dissolvin and Microcom-V. The amount of chlorophylls $a + b$ in leaves of those variants increases after foliar treatment by 9.47 and 11.0 % compared to the control (Table 1). Ratio of chlorophyll forms essentially did not change. It was observed the tendency to decrease of the carotenoids content after treatment with micronutrients. Fertilization of plants by Microcom-V maintains the content of chlorophylls at a higher level during the vegetation.

Table 1. The content of photosynthetic pigments in vine leaves after the treatment with Fe - containing compounds, v. 'Aligote', % f. w. (15.06.2009)

Variants	Chlor."a"	Chlor."b"	Sum a+b	Carotenoids
Control	0,516 ± 0,009	0,202 ± 0,005	0,718± 0,009	0,302±0,004
$FeSO_4$	0,530 ±0,008	0,202 ±0,005	0,736± 0,008	0,304±0,004
Dissolvin	0,573 ±0,005	0,213 ±0,005	0,786 ±0,011	0,286±0,005
Microcom -V	0,588 ±0,033	0,209 ±0,005	0,797 ±0,035	0,285±0,010

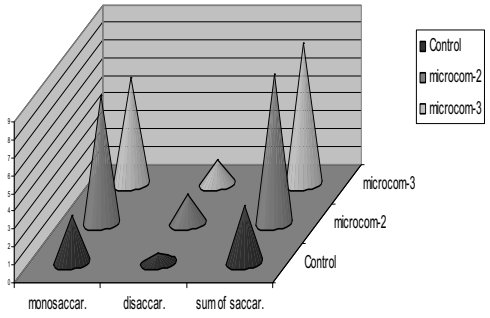
The content of sugars, free amino acids (FAA) and phosphoric compounds in grape leaves. The total sugar content in grape leaves changes quite significantly during the vegetation. The analyses performed three and six days after foliar fertilization of plants demonstrate that plant foliar treatment with Fe-containing solutions contributes to decrease of sugars in leaves immediately after treatment (after the first three-four days) and a subsequent increase in leaves and grape berries (after the sixth days). A dynamics evaluation of the sugars content in vine leaves after the foliar fertilization by trace elements has demonstrated that it increases in the course of vegetation (Table 2).

Table 2. The content of sugars in vine leaves and berries, mg/100mg d.w.

Treatments	leaves			berries
	6 days after I foliar treatment	6 days after II foliar treatment	6 days after III foliar treatment	before harvesting
Control	0,67	0,80	2,40	18,77
$FeSO_4$	0,93	1,13	3,06	17,77
Dissolvin	0,67	0,87	2,73	18,23
Microcom-V	1,07	1,33	3,46	19,67

The most favorable effect has been obtained after the treatment with the trace element complex Microcom-V. Comparison of two-and three-fold foliar fertilization of plants by micronutrient complex Microcom-V showed that more effective is a three-fold processing (Figure 1).

a)



b)

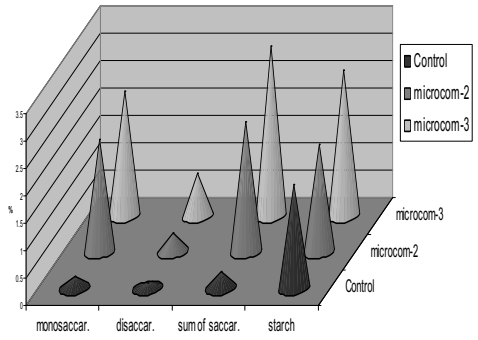


Figure 1. Carbohydrate content in grape leaves (a) and shoots (b) %, after 2 (Microcom 2) and 3 (Microcom 3) foliar treatments, v. Chardonnay

A concomitant increase of starch in shoots after fertilization of plants with Microcom-V indirectly denotes an intensification of synthetic processes in plants.

The total content of FAA in plant tissues is quite a mobile indicator and depends on many factors including the plant condition, vegetation stage, nutrition conditions etc. Determination of FAA in dynamic demonstrate that it decreases in leaves three days after foliar fertilization, especially that of non-essential ones, and increase after six days. Treatment of plants with trace element solutions maintains the total level of FAA at a higher level (Table 3).

Table 3. The content of free aminoacids (FAA) in vine leaves and berries, mg/100mg d.w.

Treatments	leaves			berries
	6 days after I foliar treatment	6 days after II foliar treatment	6 days after III foliar treatment	before harvesting
Control	0,244	0,022	0,05	0,020
$FeSO_4$	0,262	0,024	0,103	0,036
Dissolvin	0,266	0,024	0,133	0,041
Microcom-V	18,23	0,028	0,164	0,052

The quantitative and qualitative changes are more pronounced after the third treatment. Utilization of Microcom-V was more beneficial. The analysis of the qualitative content of FAA shows that the content of proline, valine, tyrosine, and phenylalanine increased in the treatments with trace elements. The content of glutamic acid + glutamine rises by 2-3 times after three days of treatment. It is a common knowledge, that accumulation of sugars and other compounds having a stress protective action is one of the mechanisms of plant resistance to the action of negative temperatures, as well as other stress factors (Bohnert et al., 1995; Mazzucotelli et al., 2006).

The content of FAA, particularly indispensable acids, and total sugars significantly increased in grapes, the highest value registered after the fertilization by the microelement complex Microcom-V. This evidences about improving the quality of berries under the influence of foliar fertilization of plants, in comparison with the control.

Importance of phosphorus for the synthesis processes activation, transport in plants, role of this element for the formation and manifestation of the level of frost resistance and wintering of perennial plants is known. The influence of foliar treatment by Microcom-V on the content of phosphoric compounds in grape leaves was studied in 2007-2008. The studies have revealed essential modifications in the content of some forms of these compounds in the vine organs after microelement treatment. A significant increase of the content of phosphorus lipids and nucleotides, acid soluble phosphorus and a significant reduction of etheric glucides has been established. The obvious modifications found in the content of the phosphorus compounds after the plants fertilization by Microcom-V attest a beneficial effect of the microelements on enhancement of plant resistance to frost and winter conditions.

Plant productivity and resistance to wintering. The results obtained in our long-term experiments on the different varieties of grapes in production conditions of Moldova shoved stimulating effect of foliar fertilization by Microcom-V on the metabolic processes in the grape leaves during the growing season. Improvement of metabolic processes contributed to increasing of plant productivity. A part of conducted records of grape yield under the influence of foliar fertilization by micronutrient complex Microcom-V are presented in table 4. A beneficial action of the specific microelement complex on the yield volume and grape fruit quality has been detected. Depending on the variety and year conditions, the number of clusters from one bush grows by 103-120% as compared to control bushes and the average yield per bush - by 108-140%. Some increase of bunches number took place as foliar treatment before flowering influenced the additional development of buds because of better mineral status of plants and improvement of leaf photosynthetic activity.

Table 4. Effect of Microcom-V on the grape quantity

Treatment	The quantity of bunches	The average weight of bunches, g.	Average yield, kg/ bush
2007, cv. Aligote			
Control	48,86±3,22	144,44±7,50	7,05
Microcom-V	56,40±3,63	156,33±7,64	8,82
2008, cv. Codrinschi			
Control	38,03±2,15	189,17±11,61	7,19
Microcom-V	42,10±1,97	240,54±11,04	10,13
2009, cv. Codrinschi			
Control	32,33±2,65	149,56±17,65	4,84
Microcom-V	33,05±2,67	160,58±15,51	5,31

The optimization of the metabolic processes in the course of plant vegetation through application of trace elements has influenced shoot growth and maturation. Table 5 summarizes the results of the estimation of the trace elements effect on the length and maturation degree in the shoots in 2009. The effect of complex of trace elements Microcom-V is much more pronounced than Fe-containing substances ($FeSO_4$ and Dissolvin). Best shoot maturation provides a higher resistance of plants to conditions of wintering.

Table 5. Growth and maturation of vine shoots depending on the foliar treatment, October 31, 2009

Treatment	Total mean shoot length, cm	Mean mature shoot length, cm	Shoot maturation degree	
			cm	± to control
Control	134,5±6,13	110,4±4,73	82,1	
FeSO4	167,1±7,64	151,1±5,92	90,4	8,3
Dissolvin	152,3±5,34	131,7±3,41	86,5	4,4
Microcom -V	173,4±9,53	159,2±7,86	91,8	9,7

The state of buds after wintering in the plants treated with trace elements during the preceding vegetation period has been assessed. The data obtained in the years 2008 and 2009 demonstrate that buds viability has increased significantly, the number of dead buds has decreased; the plants treated during the vegetation period of 2008 with Microcom-V or $FeSO_4$ saved the highest number of viable buds. Eloquent results have been obtained regarding the condition of vine buds after the action of critical negative temperatures in the winter of 2009-2010,

which proves a significant increase of bud viability and reduction of the number of dead buds in the plants treated during the vegetation period with Microcom-V, Dissolvin, and $FeSO_4$ in comparison with the control. It has been found that the number of viable buds constituted only 38.39% in the control (Table 6). In the plants treated with Microcom-V, this index reached a value of 44.56%, a significant increase of 16.07% being recorded. It should be also mentioned that a high number of injured buds was detected in the treated plants in comparison with the control. The high number of injured buds, in which the central bud died as a result of the freezing action on January 26, but at least a lateral bud remained viable, developed in annual buds in the control treatment, while in the treated plants, the percentage made 23.59% of the number of the completely injured buds detected in January, 22.48% and 25.15% respectively. The action of the negative critical temperature of -27^o has been found to provoke a loss of 39,13% of buds in the control, while in the treated plants it made only 30.29%, which is by 22.59% lower in comparison with the control.

Table 6. The grape buds state following the action of the temperature of -27^o, January 26, 2010, %

Treatment	Viable buds	Injured buds	Dithered buds
Control	100.00	100.00	100.00
FeSO4	104.58	127.58	79.66
Dissolvin	105.34	134.12	75.16
Microcom-V	116.07	111.88	77.41
LSD 0.5	3.07	5.33	6.63
C I	2.03	3.53	4.4

Content of trace elements in leaves and grapes.
The content of trace elements in the grape leaves is one of the indices that testify about the conditions of plants mineral nutrition and stipulate the realization of potential of plants productivity and ecological resistance. It was showed that foliar treatment influenced first of all the concentration of introduced element in leaf blades of treated plants - Fe, Mn and Zn. The content of Cu decreased in comparison with the control plants. It is well manifested the antagonism between Fe and Cu, that was mentioned in our previous investigations too. It is necessary to take into consideration in the elaboration of the technology of Microcom-V application on the vineyard.
As a rule the content of trace elements in generative parts of plants is lower, than in vegetative ones. We determined the amount of trace elements Fe, Mn, Zn, Ni and Cu in the berries of three grape varieties ('Traminer', 'Aligote' and 'Codrinschy'). Foliar fertilization of plants by micronutrient solution to our knowledge has not significant effect on the content of trace elements in grape berries. The weak tendency to the increase of Fe and Mn quantity in berries of treated bushes was marked, that is very important to improve the process of fermentation and wine quality. Our data showed relatively high level of Ni in grape. After the foliar treatment with trace elements clear tendency to the efflux of Ni, Cu and Zn from generative parts was evident.

CONCLUSIONS

Foliar treatment of grape during vegetation period with the complex of trace elements Microcom-V induces more significant modifications in same metabolic processes in plants in comparison with two iron containing compounds – FeSO4 and Dissolvin.
The modifications in the content of photosynthetic pigments, amino acids, carbohydrates, phosphorus compounds in vine leaves under the influence of micronutrients, especially the Microcom-V were revealed.
The obtained results let to assume, that complex of trace elements Microcom-VA led to optimization of plant nutrition, improving grape quality, fuller realization of genetically based potential of productivity and winter resistance.

REFERENCES

Alloway B., 2006. Micronutrient deficiencies around the world: current situation and outlook. New Ag. International, Murch, p. 26-41.
Bohnert H.J., Nelson D.E., Jensen R.G., 1995. Adaptation to environmental stresses, Plant Cell 7, p. 1099–1111.
Burzo I., Toma S., 2000. Fiziologia plantelor de cultură, Ştiinţa, Chişinău.
Foy R.H., 1987. Spectrophotometric determination of chlorophyll-a and phaeopigments in ethanol extractions. Ann Bot Fennici. 18, p. 221-227.

Mazzucotelli E., Tartari A., Cattivelli L., Forlani G., 2006. Metabolism of γ- amino butyric acid during cold acclimation and freezing and its relationship to frost tolerance in barley and wheat, J. of Experimental Botany. 57(14), p. 3755-3766.

Kuznețov Vl.V., Dmitrieva G.A., 2006. Plant physiology. M. (in Russian)

Toma S.I., Veliksar S.G., 1992. Ecology and application of fertilizers in viticulture. Ecology and environmental protection. Romania., p 63-65

Toma S., Veliksar S., Lisnic S., Lupan A., 2003. Rolul microelementelor în optimizarea nutriţiei minerale, formarea rezistenţei şi productivităţii plantelor agricole. Conferinţa corpului didactico-ştiinţific al USM "Bilanţul activităţii ştiinţifice în anii 2000-2002". Chişinău, p. 357-358.

Toma S., Lisnic S, Veliksar S., 2004. Microelemente ca component al tehnologiile fitotehnice. Bul. Academiei de Ştiinţe a Moldovei, 1(292), p. 70-74.

Veliksar S.G., Syrcu R.F., Busuioc V.M., Zemshman A.I., 1995. Iron content in grape tissue when supplied with iron – containing compounds. J. Plant Nutrition, 18 (1), p. 117-125.

Veliksar S.G., Toma S.I., Syrcu R.F., Busuioc V.M., 2000. Metabolism of chlorotic vine plants supplied by trace element containing compounds. Acta Horticulture, 526. Proceeding of the Fifth International Symposium of Grapevine Physiology, p. 255-260.