Evaluation of the effect of micronutrient fertilizers based on chelates on grape and wine quality characteristics

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Abstract. Mineral nutrition plays an important role in the processes of growth and development of the grape vine. Our studies show that using microfertilizers based on chelates during the growing season contributes to an increase in the bunch weight by 3.9-18.2 g and in the grape yield by 5.4-18.9%. Experimental grape samples are characterized by a higher content of titratable acids (by 0.8-1.8 g/l) and anthocyanins in a berry (by 12-39%), the proportion of extractable anthocyanins (by 3-8%) and a low content of seed tannins (by 2-3 times) compared to the control. In the prepared wines, the content of the total dry extract and phenolic substances exceeded the control values by 1.3-6.1 g/l and 13-27%, respectively. Experimental systems of treatment had a positive effect on the quality characteristics of wines: red color, varietal aroma of berry direction, fresh and fuller palate compared to the control variant, which was reflected in the tasting assessment (5-7 points higher than the control).

1. Introduction

Mineral nutrition plays an important role in the growth and development of the vine. The correct nutrition regimen contributes to an increase in the productivity of the vineyards - increase in the cropping capacity and improvement in the quality of a primary produce [1-3]. Currently viticulturists are especially interested in foliar fertilizers in a chelated form. The advantage of chelate fertilizers is the easier assimilation by plants (up to 90%) which provides not only a high degree of transition of useful components, but also allows to improve the use of fertilizer as one of the main elements of intensive viticulture [4-6]. The effectiveness of treatment leaves with chelate micronutrient fertilizers in order to increase the resistance of grapes to biotic and abiotic stresses has been revealed [7]. At the same time, there is a limit of information on the effect of applied nutrition systems on the quality parameters of grapes (industrial and phenolic ripeness) of wine varieties in terms of raw materials for wine production. The aim of this work was to study the effect of various foliar fertilizers based on chelates on the quality parameters of grapes and wines.

2. Study objects and methods

Field experiments were carried out in commercial vineyards of wine variety ‘Cabernet-Sauvignon’ of the Livadiya branch of industrial-agrarian association "Massandra" in the conditions of the South Coast viticultural zone of Crimea in 2018-2020.
The objects of our research were the samples of grapes and dry wines prepared from these samples. Scheme of research included four experimental systems of nutrition (double treatment with the studied microfertilizers) and the control one (system of nutrition of the commercial farm unit).

The preparations tested are microfertilizers on a chelated basis aimed to increase the cropping power of grape plants. Preparations for testing were submitted by the National Research Center Kurchatov Institute (Table 1).

**Table 1. Preparation characteristics.**

| Title            | Description of the preparation                                                                 |
|------------------|------------------------------------------------------------------------------------------------|
| Tiaton           | Liquid microfertilizer, containing sulfur in chelate form (S) – 4.24 %, pH = 6.0-8.0.            |
| Chelate B        | Chelate microfertilizer, consisting of boron in organic form (B) – 9.9 %; nitrogen (N) – 4.2 %; pH = 3.8-5.5. |
| Chelate Zn       | Liquid concentrated solution, containing zink (Zn) in chelate form, intended for use as environmentally friendly microfertilizer. The proportion of micronutrient element in the preparation is 62.0 %; pH = 8.0-9.0. |
| Chelaton Extra   | Chelate microfertilizer, containing the complex of micronutrient elements: ferrum (III), zink (II), copper (II), cobalt (II), manganese (II), molybdenum (VI) in chelate form – for all by 0.6 % and for boron – 0.2 %. |

The fertilizers studied were introduced in the "end of flowering" and "berries pea-size" phenological stages of grapes at a rate of working fluid consumption - 800 l/ha (the rate of consumption of preparations is 1 l/ha).

Generally accepted in viticulture methods were used in the process of the research [8].

The scheme of red table wines preparation included the following process operations: destemming with crushing grapes, sulfiting of the pomace at the rate of 100 mg/l of total sulfur dioxide, maceration for 18 hours, fermentation at a temperature of 22-24°C using the ‘47-K’ yeast race (I -527, killer phenotype, from the Magarach collection of microorganisms of winemaking) up to 1/3 of residual sugars, pressing of the pomace, afterfermentation, sulfiting at the rate of 150 mg/l of total sulfur dioxide.

In the process of research we assessed the parameters of industrial ripeness of grapes: pH, content of sugars, titratable acids and organic acids [8]. The phenolic ripeness of grapes was determined by the Glories Y method [9, 10], including the following indicators: mass concentration of anthocyanins in grape berry (ApH1.0), the potential amount of extractable anthocyanins in conditions of winemaking (ApH3.2), the proportion of seed tannins (Mp), the percentage of extractable anthocyanins (A). Tasting assessment (TA) of wines was carried out using 100-point scale [11]. The organic acid profile and glycerin content were determined using HPLC method on Shimadzu LC20 Prominance chromatograph (Japan).

The obtained experimental entries were subjected to mathematical processing by generally accepted methods of descriptive statistics using the Statistica 6.0 and Ms Excel software packages. The confidence level of statistical analysis was 0.95 (95%).

**3. Results and Discussion**

Double use of the studied chelate micronutrient fertilizers for foliar treatment of wine variety ‘Cabernet-Sauvignon’ contributed to an increase in the bunch weight by 3.9-18.2 g, leading to an increase in cropping capacity of grapes by 5.4-18.9% (Table 2). Statistical and mathematical processing of the data received showed a significant increase in the yield of grapes by 1.4 t/ha and 1.2 t/ha in experimental variants when using Chelaton Extra and Chelate B micronutrient fertilizers, respectively. The biggest yield gain was recorded in the variant with the use of Chelaton Extra preparation - 18.9%.
Table 2. The effect of chelate microfertilizers on production performance of grapes.

| Variant      | Average bunch weight, g | Number of bunches, pcs/bush | Yield, kg/bush | Cropping capacity, t/ha | Increase of control, % |
|--------------|-------------------------|-----------------------------|----------------|--------------------------|------------------------|
| Control      | 96.4                    | 38.4                        | 3.7            | 7.4                      | -                      |
| Tiaton       | 105.7                   | 38.8                        | 4.1            | 8.2                      | 110.8                  |
| Chelate B    | 111.7                   | 38.5                        | 4.3            | 8.6                      | 116.2                  |
| Chelate Zn   | 100.3                   | 38.9                        | 3.9            | 7.8                      | 105.4                  |
| Chelaton Extra | 114.6                 | 38.4                        | 4.4            | 8.8                      | 118.9                  |
| HCP05        | 10.9                    | 2.7                         | 0.4            | 0.5                      | -                      |

The study of grapes showed (Table 3) that all samples corresponded to the stage of industrial ripeness. The use of fertilizer systems Chelate Zn and Chelaton Extra had a positive effect on the process of sugar accumulation in grapes: mass concentration of sugars in samples was 1.4 and 1.8 g/l higher than similar control values.

Table 3. Physicochemical parameters of grapes.

| Parameter                  | Control | Tiaton | Chelate B | Chelate Zn | Chelaton Extra |
|----------------------------|---------|--------|-----------|------------|----------------|
| pH                         | 3.75    | 3.84   | 3.82      | 3.83       | 3.8            |
| mass concentration, g/l    | 21.5    | 20.1   | 21.1      | 22.9       | 23.3           |
| sugars                     | 6.3     | 7.1    | 7.1       | 8.1        | 7.4            |
| titratable acids           | 5.4     | 5.2    | 5.1       | 4.8        | 5.0            |
| tartaric acid              | 5.4     | 4.9    | 4.4       | 4.7        | 4.7            |
| malic acid                 | 0.1     | 0.2    | 0.2       | 0.2        | 0.2            |
| citric acid                | 0.1     | 0.2    | 0.2       | 0.2        | 0.2            |

All experimental grape batches were characterized by a higher content of titratable acids in comparison with the control (by 0.8-1.8 g/l). At the same time the control sample of grapes contained the maximum amount of organic acids due to higher content of tartaric and malic acids.

The assessment of phenolic ripeness of grapes indicates (Table 4) that the use of fertilizers in the growing season contributes to a higher accumulation of anthocyanins in a grape berry and transition of extractable anthocyanins into the must (by 3-8%). In addition, there is a decrease in the proportion of seed tannins, imparting bitter relish to wine, in experimental samples of the must by 2-3 times compared to the control, which is also a positive aspect.

Table 4. Parameters of industrial ripeness of grapes.

| Parameter                  | Standard (the control) | Tiaton | Chelate B | Chelate Zn | Chelaton Extra |
|----------------------------|------------------------|--------|-----------|------------|----------------|
| A<sub>pH</sub> (mg/l)      | 2469                   | 2508   | 2597      | 2240       | 2900           |
| A<sub>280</sub> (mg/l)      | 949                    | 1183   | 1066      | 919        | 1321           |
| A<sub>230</sub>, %          | 38                     | 47     | 41        | 41         | 46             |
| A<sub>280</sub>, %          | 0.195                  | 0.245  | 0.218     | 0.189      | 0.250          |
| M<sub>p</sub>, %            | 36.3                   | 18.3   | 15.2      | 12.2       | 16.2           |

Treatment of grapes with Chelate Zn and Chelaton Extra preparations provides a statistically significant increase in the mass concentration of the total dry extract in wine (Table 5). The increase in the content of phenolic substances in experimental samples when using Chelate B, Chelate Zn and Chelaton Extra preparations was 13, 18 and 27%, respectively. Experimental treatment did not lead to a significant increase in the mass concentration of volatile acids (acetic).
Table 5. Values of physicochemical parameters of wines.

| Parameter                      | Control | Tiaton | Chelate B | Chelate Zn | Chelaton Extra |
|--------------------------------|---------|--------|-----------|------------|----------------|
| volume ratio of ethyl alcohol, % | 11.5    | 10.8   | 11.1      | 12.1       | 11.1           |
| pH                             | 3.61    | 3.83   | 3.63      | 3.85       | 3.8            |
| mass concentration, g/l        |         |        |           |            |                |
| total dry extract              | 27.9    | 29.7   | 32.7      | 34.0       | 29.2           |
| titratable acids               | 6.1     | 6.8    | 7.0       | 7.4        | 6.9            |
| phenolic compounds             | 1.45    | 1.45   | 1.64      | 1.72       | 1.84           |
| monomeric anthocyanins         | 0.43    | 0.42   | 0.35      | 0.45       | 0.43           |
| glycerin                       | 8.5     | 9.3    | 8.1       | 9.1        | 8.3            |
| tartaric acid                  | 1.2     | 1.2    | 0.9       | 1.1        | 0.9            |
| malic acid                     | 1.7     | 0.2    | 2.0       | 2.3        | 2.3            |
| citric acid                    | 0.8     | 0.7    | 0.3       | 1.3        | 0.4            |
| acetic acid                    | 0.3     | 0.3    | 0.5       | 0.4        | 0.3            |
| TA                             | 77      | 75     | 77        | 85         | 82             |

The wines obtained from experimental grape samples were characterized by more intense color, varietal aroma of berry direction, fresh and full palate. The highest tasting assessment was given to the experimental variants treated by Chelate Zn and Chelaton Extra preparations - 85 and 82 points, respectively.

4. Conclusion

The studies provided show that the use of microfertilizers based on chelates increases the production performance of grapes: the bunch weight gain and the following increase in the cropping capacity. Experimental grape samples are characterized by a higher content of titratable acids and anthocyanins. Using of the studied fertilizers provides higher phenolic ripeness of berries, expressed in an increased transition of extractable anthocyanins into the must (by 3-8%) and a decrease in the content of seed tannins (by 2-3 times) compared to the control. The prepared wines are distinguished by a higher content of the total dry extract and phenolic substances. Experimental systems of treatment had a positive effect on the qualitative characteristics of wines and were assessed at the level of the control and higher (by 5-7 points for Chelate Zn and Chelaton Extra preparations).

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