

Protection of Vine from Winter Stress with the Use of Silicate

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Abstract: The basic limiting factor of cultivation of grapes in the south of Russia it is low temperatures of the winter season that demands covering. The search for effective ways to protect grapes and fruit crops from winter stress is relevant for world science and production. The increasing of marginal winter temperature for vine which is bound by that on a grape vine the microporous film protecting from sharp temperature drops was formed is received. Capillary electrophoresis was used for determination of mobile forms ions and carbonhydrates in the vine of Chardonay and Moldova to establish the influence of the applied protection on these indicators. Visual studies carried out microscopy allowed us to establish the formation of a porous microfilm on the surface of the vine. In experiments a grape vine treated an aqueous emulsion of the silicate-carbonate preparation consisting of two components – liquid and a powder. The characteristic of a protective structure: is nontoxic, is non-combustible, inodorous. Testing of a physiological state of a grape vine has shown the following: the total concentration of carbohydrates in intercellular sap reached 20-70 g/kg of a grape vine, without treatment – 17-44 g/kg. The porous film in field conditions of a vineyard conserved mechanical stability about 3 months. The protecting film was destroyed in the spring, a natural path at the beginning sap flow in the plants.

Keywords: Vineyard, Frost, Polymeric Film, Treatment, Capillary Electrophoresis

1. Introduction

Viticulture needs to satisfy consumers' demands for environmentally sound grape and wine production while envisaging adaptation options to diminish the impacts of projected climate change on future productivity [1]. Cultivation of grape is subject to various stresses of the winter and early-spring season that is at the bottom of search of means of an avoidance of damage a grape vine from action of low temperatures. In the majority of the European countries (southern Europe, foothills) are marked the individual influences of low temperatures slightly influencing quantity of a crop. Cold damage has caused more economic losses to fruit crop growers in the U.S. than any other weather hazard, making it a perennial concern for producers [2]. The climate of Northern Europe, Canada, Russia, Ukraine, Romania, Czech, Bulgaria is characterized by is stable negative temperature in the winter and frequent significant decreasing of temperature to a critical level; additional stress – the early

spring frosts essentially damaging a crop. Means of struggle against negative influence of low temperatures of the winter season are constantly improved and conditionally share on short-term and the prolonged action. Among means of short-term action building of a water or smoke fog which is the most effective against spring frosts, application of large-sized thermal fans for the small areas, hothouse systems of the maintenance is realized. Among means of the prolonged action are most known: concealment of a grape vine by a ground, other stuffs till spring [3-5], use of an porous polymeric film it is offered to them to reverse each branches of vine [6], sheeting covering on a grape vine, for example, complex mineral compositions or dispersion of a water fog in frosty weather for the purpose of formation of an porous ice crust. This study presents the potential environmental impact of a novel late frost protection technique for vineyards that is currently under development. It consists of an organic coating made of sugar and straw to prevent vine damage due to frosts in vineyards in the coldest hours of late winter and early spring

[7]. The result of researches has been the identification of an insulating material able to cover the vine shoots during late frosts and thus prevent their freezing: the cotton candy has proved to be an excellent thermal insulator, extremely light, easy to produce, cheap and completely biodegradable in a few hours [8]. Remote sensing is used for vineyard microclimate monitoring; thermal sensors combined with UAVs, aircraft, or satellites are used for water management; soil electrical conductivity sensors have been developed for soil mapping [9]. Kaolin clay has been recognized as a promising short-term strategy for the sustainable alleviation of adverse abiotic stress [10]. Besides provide special preparation of a grape vine for winter microfertilizing's or a preparation which should be carried out in the summer or autumn season for achievement of necessary efficacy [11] or dispersion of special adhering materials; capable to create the polymeric coating of the various nature, at negative temperatures. It is necessary to notice that the basic limiting factor of cultivation of grapes in the south of Russia – low temperatures of the winter season that demands conducting covering culture. Non-covering high-stem the culture has complicated technology of viticulture, there were problems of location of vineyards, selection of varietal composition, forming vines and receptions of cultivation [12].

2. Experimental Part

2.1. Materials and Chemicals

2.1.1. Chemicals

Used standard samples: HCl, NaOH, KOH (Sigma), Standard samples of solutions of cations of potassium MSO 0019:1998, ammonium MSO 0017:1998, sodium MSO 0018:1998, magnesium MSO 0085:1999, calcium MSO 0020:1998; benzimidazole (Sigma), 18-crown-6 (Sigma), potassium sorbate (Sigma), CTAB (Sigma), CTA-base (Sigma), tartaric acid (Sigma), malic acid (Sigma), succinic acid (Sigma), citric acid (Sigma), lactic acid (Sigma).

2.1.2. Equipment

Capillary electrophoresis was used for analysis [13, 14]. System of capillary electrophoresis of a series CAPEL (Russia) with the photometric detector (254 nm); the quartz capillar with an external polyimide coating (bore diameter of $75 \cdot 10^{-6}$ m, effective length of 0.5 m; aqueous thermostatic control) was used. Results were treated with Multichrome for Windows, version 1.5 (Open Company "AmperSand", Moscow). Visual investigations were fulfilled with using a microscope Olympus BX-41 (Japan). All research works was carried out at the collective use center at the Federal Research Center of Horticulture, Viticulture and Winemaking (Krasnodar, Russia).

2.1.3. Sample Preparing

For determination of organic acids, cations, carbohydrates the sample preparing carried out as follows: sample centrifuged 3-5 minutes at $6000-8000 \text{ n}^{-1}$ and subjected to the analysis.

2.2. Results and Discussion

For realization of protection against winter stresses treatment on vineyards of the central region of Krasnodar territory in the first decade of December of current year of research 2010-2022 have been made. In experiments a grape vine treated an aqueous emulsion of the silicate-carbonate preparation consisting of two components – liquid and a powder, as control the grape vine without treatment served. For treatment of a grape vine of a variety Moldova and Shadoney (marginal winter temperature for these variety minus $22-25^{\circ}\text{C}$) prepared an emulsion of a preparation as follows. In container of a sparger displacement volume of 600 liters, filled with water of quality is not worse water at temperature not more low 4°C , led a liquid silicate component in mass $14 (\pm 0,3) \text{ kg}$, carefully stirred before full dissolution within not less than 10 minutes. Then led in the received solution at constant mixing $14 (\pm 0,3) \text{ kg}$ a dry component on a carbonate basis (stiffener) without supposing formation of lumps. The received emulsion of a preparation treated a grape vine [15]. The covering of protective composition of an emulsion of a preparation carried out at positive temperatures in the afternoon and absence of rainfall within 48 hours. The rough expense at treatment carrying out: 600 liters of an emulsion on one hectare of a vineyard. Within 48 hours after carrying out of treatment an emulsion formed the porous film visually observed in the form of weak of a gloss coating, figure 1.

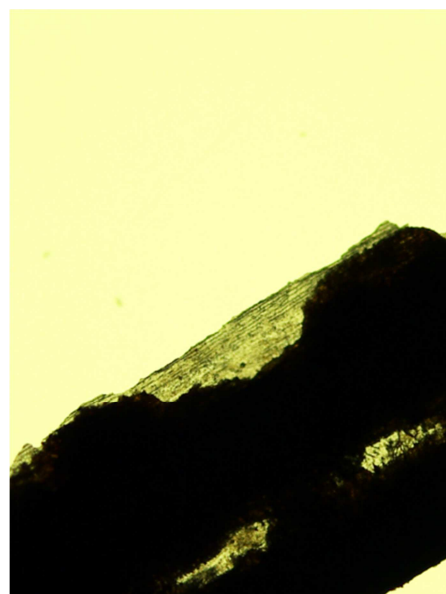


Figure 1. The View of porous film on the vine.

The characteristic of a protective structure: is nontoxic, is non-combustible, inodorous. As control of degree of influence of the made treatment on ability of counteraction of a grape vine to low temperatures carried out the following diagnostics on control indexes of an aqueous extract from samples of a grape vine for mobile forms:

Cations of potassium, sodium, magnesium, calcium;
Tartaric, malic, succinic, citric acids;

Glucoses, fructose, sucrose.

The received results compared to similar indexes for an untreated grape vine. Sampling carried out in the first decade of January and the second decade of February, Tables 1, 2. The appearance of a grape vine was healthy, without damages.

Table 1. Content of mobile forms of component in grapes vine, 1-st decade of January, aqueous extract mg/kg, $P=0.95$.

| Component | Shardonay | | Moldova | |
|-----------|-------------|-----------|-------------|-----------|
| | untreated 1 | treated 1 | untreated 2 | treated 2 |
| Potassium | 520 | 500 | 302 | 294 |
| Sodium | 76 | 74 | 71 | 76 |
| Magnesium | 190 | 218 | 96 | 137 |
| Calcium | 253 | 296 | 188 | 286 |
| Tartaric | 1570 | 1330 | 1425 | 860 |
| Malic | 4300 | 3300 | 2100 | 4590 |
| Succinic | 6 | 8 | 10 | 17 |
| Citric | 825 | 531 | 280 | 500 |
| Fructose | 25800 | 40000 | 30300 | 26000 |
| Glucoses | 12000 | 30600 | 39000 | 31800 |
| Sucrose | 5400 | 9300 | 5600 | 11100 |

In the first decade of January starch is found in all variants.

Table 2. Content of mobile forms of component in grapes vine, 2-nd decade of February, aqueous extract mg/kg, $P=0.95$.

| Component | Shardonay | | Moldova | |
|-----------|-------------|-----------|-------------|-----------|
| | untreated 1 | treated 1 | untreated 2 | treated 2 |
| Potassium | 445 | 417 | 285 | 254 |
| Sodium | 92 | 72 | 75 | 71 |
| Magnesium | 206 | 218 | 103 | 168 |
| Calcium | 280 | 347 | 213 | 318 |
| Tartaric | 1390 | 1700 | 400 | 1170 |
| Malic | 1590 | 480 | 544 | 113 |
| Succinic | 24 | 12 | 55 | 152 |
| Citric | 498 | 376 | 210 | 153 |
| Fructose | 10700 | 12300 | 9700 | 13300 |
| Glucoses | 7800 | 8000 | 4500 | 7300 |
| Sucrose | 60 | 340 | 200 | 500 |

Testing of a physiological state of a grape vine has shown the following: the total concentration of carbohydrates in intercellular sap reached 20-70 g/kg of a grape vine, without treatment – 17-44 g/kg. In the second decade of February concentration of tartaric acid was essentially above malic, magnesium and calcium in 1,5-2 times above control; the potassium and sodium concentration was almost identical. In intercellular sap starch that testified to readiness of plants for influence of low temperatures was not found. The analysis of an offered mean of treatment of vine from low temperatures of the winter season has allowed to find out the following. The increasing of marginal winter temperature for vine which is bound by that on a grape vine the microporous film protecting from sharp temperature drops was formed is received. Freezing tests in field conditions of an offered mean have shown absence of damages of a grape vine in the winters of 2010-2017 when the minimum temperature of air was below marginal for examinees of variety of grapes on 5°C. The same years damage of a grape vine of control on 90 %, with full destruction of fruit kidney was observed. After laboratory testing in a thermostat at low temperature of the shanks of

vines treated by a preparation their ability to maintain temperature below marginal on 8-10°C has been experimentally establishing. As a result it is not fixed damages of the treated of grape vine Moldova at -32°C, Shardonay at -29°C. The offered mean of treatment of a grape vine allows to minimize losses from damage of a grape vine by winter and spring frosts, to provide stability of a crop and by that to provide the profits of agricultural firms.

3. Conclusion

Preparation application has allowed to increase stability of a grape vine to winter stresses, marginal winter temperatures to decrease to 10°C. The porous film in field conditions of a vineyard conserved mechanical stability about 3 months. The protecting film was destroyed in the spring, a natural path at the beginning sap flow in the plants. The applied silicate-carbonate preparation containing catalyst and a stiffener, and being a basis for formation of the polymeric porous film, does not demand the special technics for processing carrying out in field conditions, non-toxic, nonflammable, inodorous, is stable during all winter season. The use of this method of protection the vine ensure the stability of the harvest. Silicate-carbonate composition will reduce the cost of renovations of vineyards.

References

- [1] Santos V., Renaud-Gentié C., Roux Ph., Levasseur A., Bulle C., Deschênes L., Boulay A.-M. Prospective life cycle assessment of viticulture under climate change scenarios, application on two case studies in France. *Science of The Total Environment*, 2023, 880, 1. 163288 DOI: 10.1016/j.scitotenv.2023.163288.
- [2] Arnoldussen B., Alhamid J., Wang P., Mo C., Zhang X., Zhang Q., Whiting M. Internal freezing and heat loss of apple (*Malus domestica* Borkh.) and sweet cherry (*Prunus avium* L.) reproductive buds are decreased with cellulose nanocrystal dispersions. *Front. Plant Sci*, 2022, 13, 949537. doi: 10.3389/fpls.2022.949537.
- [3] The patent of the Russian Federation № 2140732 A01G13/00 A01G17/00 The Mean of protection of a grapevine from frosts, Mamilov B. B., 1999.
- [4] The patent of the Russian Federation № 2060632 Mean of alighting and the maintenance not enough cold-resistant and thermophilic perennial cultures, Tsapko V. Z, Tsapko V. V., 1996.
- [5] Patent UM RU No 134001. Yakuba Yu. Th., Yakuba D. Yu. 2013.
- [6] The copyright certificate of the USSR № 522837, Lavrejchuk I. I., Kretov I. A., 1976.
- [7] Frota de Albuquerque Landi F., Di Giuseppe A., Gambelli A. M., Palliotti A., Nicolini A., Pisello A. L., Rossi F. Life Cycle Assessment of an Innovative Technology against Late Frosts in Vineyard. *Sustainability*, 2021, 13, 5562. doi: 10.3390/su13105562.

- [8] Giuseppe A., Gambelli A., Rossi F., Nicolini A., Ceccarelli N., Palliotti A. A natural organic coating to control and minimize late frost damages on wine shoots. *Heat Trans Res.*, 2020, 51, 18, p. 1625-1635. DOI: 10.1615/HeatTransRes.2020034721.
- [9] Sun Q., Granco G., Groves L., Voong J., Van Zyl S. Viticultural Manipulation and New Technologies to Address Environmental Challenges Caused by Climate Change. *Climate*, 2023, 11 (4), 83 DOI: 10.3390/cli11040083.
- [10] Brito C., Dinis L., Moutinho-Pereira J., Correia C. Kaolin, an emerging tool to alleviate the effects of abiotic stresses on crop Performance, *Scientia horticulturae*, 2019, 250, 310-316 Doi.org/10.1016/j.scienta.2019.02.070.
- [11] The patent of the Russian Federation №2198499, The Mean of protection of fruit-trees from spring frosts, Stepanov V. A., Menshikov A. E., Meshcherjakova M. V., Kramarenko J. P., Polgorodnik O. G., 2003.
- [12] Pavlukova T. P., Tjagilev O. A., Yakuba Yu. Th. Cold resisting of a kind of grapes in cognac production. *The Bulletin of the Russian Academy agricultural sciences*, 2012, № 6, P. 42-44.
- [13] Warren Ch. R., Adams M. A. Capillary electrophoresis of the major anions and cations in leaf extracts of woody species. *Phytochemical analysis*, 2004, 15, P. 407-413.
- [14] Kandl T., Kupina S. An improved capillary electrophoresis procedure for the determination of organic acids in grape juice and wine. *American Journal of Enology and Viticulture*, 1999, 50 (2), P. 155-161.
- [15] Patent RU No 2522522, Yakuba Yu. Th., 2014.