Assessment of agricultural techniques of grape cultivation in arid conditions of southern Russia based on analysis of variance

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Abstract. The aim of the research was to assess the effectiveness of agricultural techniques for growing table grapes in the arid conditions of southern Russia. The research is relevant, since the improvement of agricultural techniques for growing grapes improves its growth and development, marketability of products, and increases plant resistance to diseases. The experiments were carried out in a vineyard located on the light chestnut soils of the Astrakhan region. The number of grape bushes is 1250.0 pieces / hectare. Water-soluble fertilizers were tested separately and in combination on plantings of table grape varieties of early, middle and late ripening. The concentration of aqueous solutions of fertilizers was 0.3 % for Plantafol and 0.1 % for Boroplus. The high efficiency of foliar dressings is achieved when they are carried out in certain phases of the plant's growing season. The background was a mineral fertilizer - Ca(H₂PO₄)₂ x H₂O at the end of each growing season (60.0 kg a. s. / he), as well as N₁₆P₁₆K₁₆ (64.0 kg a. s. / he) before bud break and before flowering. A strong dependence of the efficiency of growing grapes on the interaction of varietal samples and applied fertilizers has been established. At the same time, additional products were obtained according to the options for applying fertilizers for different varieties in the range of 2.5-6.1 t / hectare.

1. Introduction
Viticulture, which develops mainly in the southern regions, is a promising segment of the agro-industrial complex [1-3]. Russia takes the 120th place in terms of grape consumption and 6th in terms of its imports in the world with an import of more than 350 thousand tons and a consumption of about 3.0 kg / person per year. The intensification of viticulture should be aimed at creating favorable conditions for the sustainable development of competitive viticulture, providing the population with high-quality table grapes, reducing import dependence and developing export potential, reducing the number of products in the domestic market that do not meet quality standards. The modern development and formation of industrial wine-town in the southern regions of Russia, including the North-Western Caspian region, depends both on the rational use of the resource potential of the territory, and on water supply and the optimal nutritional regime of complex resistant varieties. The latter factors are successfully regulated when calculating the irrigation regime and the mineral nutrition system, which are an integral part of the technological map and the basis for an objective.
economic assessment of the studied methods of grape cultivation [4-6].

To reduce the degree of degradation of humus-depleted unstructured soils under vine plantations for a long time, as well as to replenish the used supply of nutrients, phosphorus-potassium or complex fertilizers are applied for the main soil cultivation [7-9]. However, practice has shown that with this use it is not always possible to obtain the optimal availability of nutrients to the main root mass. This often leads to a decrease in the efficiency of the use of mineral nutrition. The current situation can be corrected with the help of new water-soluble complex fertilizers, provided with trace elements in the required amount, used as foliar dressings. In the arid zone, this direction has not yet become widespread due to the poor study of the issue, therefore, it became necessary to determine the effect of these fertilizers on the growth processes, ripening of shoots, product quality and yield. This line of research is currently quite relevant [10].

2. Materials and methods
The aim of the research was to assess the effect of foliar nutrition on economic and biological indicators and the efficiency of cultivation of three table combs of grapes of different early maturity in the arid conditions of the North-Western Caspian region under irrigation. The study of the effectiveness of foliar nutrition in the cultivation of different grape varieties in the arid conditions of southern Russia based on the results of analysis of variance of yield allows solving the problems of state regulation of the agri-food market: increasing the share of domestic agricultural products in the domestic market and creating conditions for increasing export potential.

The methodological basis was the generally accepted methods [11-13]. Uvological surveys were carried out according to the following indicators: weight accounting of the yield, the mechanical composition of bunches and berries, the percentage of the ratio of ridges and berries, the average weight of a bunch, the number of berries in a bunch, the weight of one hundred berries, and the diameter of berries. The calculation of economic efficiency was carried out on the basis of the actual costs associated with the implementation of agrotechnical methods for growing varieties and the use of fertilizers for foliar dressing, taking into account technological operations, fertilization, irrigation, protective measures, collection of basic and additional products. In addition, the cost includes the cost of mineral and soluble fertilizers. The degree of reliability of the results obtained was confirmed by a significant amount of experimental data processed by the method of analysis of variance according to the method of B.A. Dospekhov using computer programs (Microsoft Office Excel 2007) [14].

Table grapes were planted according to the arrangement of bushes 4.0 × 2.0 m (1250.0 pcs / he) on the territory of the orchard of the Precaspian Agrarian Federal Scientific Center of the Russian Academy of Sciences (Astrakhan region, Chernoyarsk district). The experience is two-factor. Varieties are taken as factor A, and foliar nutrition options are taken as factor B. The influence of water-soluble foliar fertilizers on the grape varieties Codryanka, Rizamat and Moskovsky 1 – control (water treatment), 2 – Plantafol, 3 – Boroplus, 4 – Plantafol + Boroplus was considered. Aqueous solutions of fertilizers were used in the following concentration: Plantafol – 0.3 %, Boroplus – 0.1 %. Processing was carried out in accordance with the recommended standards. The background was a mineral fertilizer - Ca (H$_2$PO$_4$) x H$_2$O at the end of each growing season (60.0 kg active substance / he), as well as N$_{16}$P$_{16}$K$_{16}$ (64.0 kg active substance / he) before bud break and before flowering.

3. Results and Discussion
According to the results of three-year studies and the obtained yield, a very strong influence of the interaction of the variety and foliar fertilizers is traced, especially on the varieties Rizamat and Kodryanka (table 1).

The highest yield of the Rizamat variety was obtained in 2015. So, when using Plantafol, it amounted to 17.7 t / he (+2.9 t / he to control), the introduction of Boroplus increased this indicator to 18.9 t / he (+4.1 t / he to control). Their combined action with foliar application provided a yield of 20.6 t / he of grapes, which is 5.8 t / he higher than the control value.
Table 1. Grape yield depending on the variety and the use of foliar dressings

| Factor A - grade | Factor B - foliar feeding | 2015     | 2016     | 2017     | average for 2015-2017 |
|-----------------|---------------------------|----------|----------|----------|----------------------|
|                 |                           | t / he   | ± to control, t / he | t / he   | ± to control, t / he | t / he   | ± to control, t / he |
| Codryanka       | control                   | 12.0     | –        | 11.2     | –        | 13.5     | –        | 12.2     | –        |
|                 | Plantafol (P)             | 15.3     | 3.3      | 14.7     | 3.5      | 15.8     | 2.3      | 15.3     | 3.1      |
|                 | Boroplus (B)              | 16.1     | 4.1      | 15.5     | 4.1      | 16.0     | 2.5      | 15.8     | 3.6      |
|                 | P + B                     | 18.7     | 6.7      | 16.5     | 5.3      | 19.8     | 6.3      | 18.3     | 6.1      |
| Rizamat         | control                   | 14.8     | –        | 12.4     | –        | 15.1     | –        | 14.1     | –        |
|                 | Plantafol (P)             | 17.7     | 2.9      | 14.6     | 2.2      | 17.6     | 2.5      | 16.6     | 2.5      |
|                 | Boroplus (B)              | 18.9     | 4.1      | 15.3     | 2.9      | 18.2     | 3.1      | 17.5     | 3.4      |
|                 | P + B                     | 20.6     | 5.8      | 16.4     | 4.0      | 19.9     | 4.8      | 19.0     | 4.9      |
| Moskovsky       | control                   | 9.8      | –        | 9.0      | –        | 10.4     | –        | 9.7      | –        |
|                 | Plantafol (P)             | 12.0     | 2.2      | 10.7     | 1.7      | 11.9     | 1.5      | 11.5     | 1.8      |
|                 | Boroplus (B)              | 14.0     | 4.2      | 12.0     | 3.0      | 13.2     | 2.8      | 13.1     | 3.3      |
|                 | P + B                     | 15.6     | 5.8      | 13.4     | 4.4      | 14.4     | 4.0      | 14.5     | 4.7      |

LSD05 AB 0.68 0.59 0.72 0.66

In 2017, the efficiency of using foliar nutrition on the Rizamat variety decreased slightly, although the general trend continued: the use of Plantafol increased the yield from 15.1 to 17.6 t / he, i.e. by 2.5 t / he, and Boroplus – by 3.1 t / he – up to 18.2 t / he. The combined action contributed to the yield of up to 19.9 t / he, which is 4.8 t / he higher than the control.

Variety Codryanka, on the contrary, showed a higher level of productivity when the variety interacted with foliar fertilizers in 2017 compared to 2015. Even in the control, the yield was 13.5 t / he, and the maximum value (19.8 t / he) was recorded for the variant of the combined action of fertilizers.

The yield of the Moskovsky variety in the context of the years of study was at a lower level. If in the control it was about 10.0 t / he, then the highest (15.6 t / he) was in 2015 on the option of joint use of fertilizers. From the data in table 1, the role of the variety (factor A) in obtaining the yield both by years and on average over three years according to the control option is well traced. Rizamat showed advantages in yield with an interval of 12.4 to 15.1 t / he and an average yield of 14.1 t / he. The yield of the control variant in the Kodryanka variety varied over the years from 11.2 to 13.5 t / he with an average of 12.2 t / he; for the variety Moskovsky interval, respectively was 9.0-10.4 and 9.7 t / he – the average level over the years.

The yield of foliar nutrition (factor B) is presented in table 2, where the yield of varieties by variants of soluble fertilizers is reduced to average values.

Table 2. Average yield of grape varieties Kodryanka, Rizamat and Moskovsky when using foliar dressings (factor B)

| Factor B - foliar feeding | 2015     | 2016     | 2017     | average for 2015-2017 |
|---------------------------|----------|----------|----------|----------------------|
|                           | ± to control, t / he | ± to control, t / he | ± to control, t / he | ± to control, t / he |
| control                   | 12.2     | –        | 10.9     | –        | 13.0     | –        | 12.0     | –        |
| Plantafol (P)             | 15.0     | 2.8      | 13.3     | 2.4      | 15.1     | 2.1      | 14.5     | 2.5      |
| Boroplus (B)              | 16.3     | 4.1      | 14.2     | 3.3      | 15.8     | 2.8      | 15.4     | 3.4      |
| P + B                     | 18.3     | 6.1      | 15.4     | 4.5      | 18.0     | 5.0      | 17.2     | 5.2      |
| LSD05 B                   | 0.81     | 0.78     | 0.84     | 0.76     |

The yield of varieties on the control variant was the highest in 2017, amounting to 13.0 t / he, and the lowest in 2016 – 10.9 t / he. On average, over three years, this indicator was at the level of 12.0 t / he.

The action of the soluble fertilizer Plantafol contributed to an increase in yield up to 14.5 t / he,
exceeding the control by 2.5 t/he, and by years – by 2.1-2.8 t/he. The use of Boroplus also had a positive effect on increasing the crop yield up to 15.4 t/he, or 3.4 t/he above the control. The greatest effect was obtained from the joint use of soluble fertilizers: with a yield of 17.2 t/he, an additional 5.2 t/he was obtained to the control. In some years, the yield on this variant reached 18.0 and more t/he of grape products for varieties.

An important final stage of scientific research in applied agricultural sciences is the stage of implementation of the results obtained, the effectiveness of which depends on the availability of the information obtained. The more stable the logical connections between the data obtained, the more reliable the scientific component. We approached the economic assessment of the use of non-root fertilizers from these positions, establishing a direct logical relationship between the results of the analysis of variance of the conducted experiment on yield and the economic efficiency of the studied varieties.

Table 3 shows the results of an economic analysis of the effectiveness of foliar dressings on three grape varieties, taking into account the interaction of AB variety (factor A) and fertilization (factor B).

Table 3. Economic efficiency of the use of soluble foliar fertilizers on vine plantations of table varieties Codryanka, Rizamat and Moskovsky, AB interaction, average for 2015-2017

| Factor A – grade | Factor B – foliar feeding | Yield, t/ he | Cost of additional products, thousand rubles / he | Cost, thousand rubles / ton | Income, thousand rubles / he | Profit, thousand rubles / he | Profitability, % | Payback, rub / rub |
|------------------|---------------------------|-------------|-----------------------------------------------|-----------------------------|-----------------------------|-----------------------------|----------------|------------------|
| Kodryanka        | control                   | 12.2        | –                                              | 262.8                       | 21541.0                     | 610.0                       | 347.2           | 132.1            |
|                  | Plantafol (P)             | 15.3        | 155.0                                         | 276.9                       | 18098.0                     | 765.0                       | 488.1           | 176.3            |
|                  | Boroplus (B)              | 15.8        | 180.0                                         | 265.5                       | 16803.8                     | 790.0                       | 524.5           | 197.6            |
|                  | P + B                     | 18.3        | 305.0                                         | 277.7                       | 15174.9                     | 915.0                       | 637.3           | 229.5            |
|                  | control                   | 14.1        | –                                              | 279.4                       | 19815.6                     | 705.0                       | 425.6           | 152.3            |
|                  | Plantafol (P)             | 16.6        | 125.0                                         | 288.1                       | 17355.4                     | 830.0                       | 541.9           | 188.1            |
|                  | Boroplus (B)              | 17.5        | 170.0                                         | 280.2                       | 16011.4                     | 875.0                       | 694.8           | 212.3            |
|                  | P + B                     | 19.0        | 245.0                                         | 284.0                       | 14947.4                     | 950.0                       | 666.0           | 234.5            |
| Moskovsky        | control                   | 9.7         | –                                              | 241.0                       | 24845.4                     | 485.0                       | 244.0           | 101.2            |
|                  | Plantafol (P)             | 11.5        | 90.0                                           | 244.0                       | 21217.4                     | 575.0                       | 331.0           | 135.7            |
|                  | Boroplus (B)              | 13.1        | 165.0                                         | 242.0                       | 18473.3                     | 655.0                       | 413.0           | 170.7            |
|                  | P + B                     | 14.5        | 235.0                                         | 244.8                       | 16882.8                     | 725.0                       | 480.2           | 196.2            |
| LSD05 AB         |                           |             |                                               |                             |                             |                             |                 | 0.66             |

The potential for the commercialization of the results obtained, characterizing the possibility of using developments in the production sphere with the maximum effect, is the highest and is guaranteed when using foliar dressings on the Rizamat and Kodryanka varieties, especially on the variants of the joint use of Plantafol and Boroplus.

The cost of additional production for the Kodryanka variety increased by 50.0 %, for the Rizamat variety – by 34.8 % relative to the control. The response to foliar feeding in the Moskovsky variety was also quite significant – 48.5 % to the control.

Income from the production of grape products of the Kodryanka and Moskovsky varieties increased by 50.0-49.5 %, the Rizamat varieties – by 34.8 %. Accordingly, the profit increased: for the Moskovsky variety – by 96.8 %, for the Kodryanka variety – by 83.6 %, for the Rizamat variety – by 56.5 %. The level of profitability was the highest in the Rizamat variety (234.5 %) with the maximum return on the invested ruble of 3.35 rubles / rub. The Kodryanka variety showed similar indicators: profitability was 229.5 %, payback was 3.30 rubles / rub.

The profitability of growing and obtaining products of the Kodryanka variety using Boroplus fertilizer was 197.6 % (+ 49.6 % to the control), the payback – 2.98 rubles / rub. (+ 28.4 % to control).
When using Plantafol, the profitability of growing and obtaining products of the Kodryanka variety was obtained in the amount of 176.3 % (+ 33.5 % to the control), the payback was 2.76 rubles / rub. (+19.0 % to control). The tendency to improve economic performance is noted with the combined use of Plantafol and Boroplus fertilizers.

The Rizamat variety turned out to be even more responsive to foliar dressing. When using Boroplus, a profitability of 212.3 % (+ 38.6 % to control) was obtained with a payback of 3.12 rubles / rub. The most profitable cultivation of the Rizamat variety is with the joint application of Plantafol and Boroplus fertilizers, when the average profitability for three years was 234.5 %, and the payback was 3.35 rubles / rub. Similar data were obtained for the Moskovsky variety.

The value of the choice of the variety (factor A) in obtaining a yield guaranteed regardless of soluble fertilizers is well traced in the control variants of the same table. It should be noted that the cultivation of all three grape varieties under irrigation conditions in the arid zone is highly profitable with a yield level of 9.7 (Moskovsky variety) to 14.1 t / he (Rizamat variety).

The economic effect of the use of water-soluble fertilizers Plantafol and Boroplus in leveling the yield of grape varieties is presented in table 4.

### Table 4. Economic efficiency of the use of soluble foliar fertilizers on grapes (the effect of factor B) on average for the varieties Codryanka, Rizamat and Moskovsky, average for 2015-2017

| Foliar dressing | Yield ± to control, tons / hec | Costs of additional products, thousand rubles / he | Costs, thousand rubles / he | Cost price, rubles / ton | Income, thousand rubles / he | Profit, thousand rubles / he | Profitability, % | Payback, rub / rub |
|-----------------|--------------------------------|-----------------------------------------------|-----------------------------|-------------------------|-----------------------------|-----------------------------|------------------|------------------|
| control         | 12.0                           | –                                             | 261.1                       | 21758.3                 | 600.0                       | 338.9                       | 129.8            | 2.30             |
| Plantafol (P)   | 14.5                           | 2.5                                           | 125.0                       | 269.7                   | 18600.0                     | 725.0                       | 4553             | 168.8            | 2.69             |
| Boroplus (B)    | 15.4                           | 3.4                                           | 170.0                       | 262.6                   | 17051.9                     | 770.0                       | 507.4            | 193.2            | 2.93             |
| P + B           | 17.2                           | 5.2                                           | 260.0                       | 268.8                   | 15627.9                     | 860.0                       | 591.2            | 219.9            | 3.20             |
| LSD05 B         | 0.76                           |                                               |                             |                         |                             |                             |                  |                  |

From the data presented, it can be seen that the use of soluble fertilizers provides additional production from 2.5 to 5.2 t / he, regardless of varieties, and in monetary terms, from the action of non-root dressings, an additional 125.0 thousand rub. / he to 260.0 thousand rub. / he were obtained. At the same time, profitability is high enough for all variants. The introduction of Plantafol helped to obtain a profitability of 168.8 % and a payback of 2.69 rub. / rub. costs, processing with Boroplus provided an even higher level of profitability – 193.2 % and a payback of 2.93 rub. / rub.

With the combined use of Plantafol and Boroplus, the prime cost amounted to 15,627.9 rub. / t (28.2 % below the reference value). Accordingly, the profitability increased from 129.8 % to 219.9 %, the return on the invested ruble – from 2.30 rub. / rub. under control up to 3.20 rubles / rub. on the option of sharing fertilizers.

### 4. Conclusion

One of the main factors in increasing the profitability of the viticulture sub-industry is the cultivation of adapted varieties with high sustainable yields. The analysis of three-year field studies on the use of Plantafol and Boroplus fertilizers for foliar dressing revealed their significant influence on the preservation of the yield and the increase in production per unit area. As a result of the analysis of the yield of table grape varieties, the most significant relationship (AB) between varieties and fertilizers in the Rizamat and Kodryanka varieties was established. Additional products were obtained for fertilization options from 2.5 to 4.9 t / he for the Rizamat variety and from 3.1 to 6.1 t / he for the Kodryanka variety.
The economic efficiency of the use of foliar nutrition on grape plantations (factor B) on average for varieties based on mathematically proven yield is also very high. The use of Plantafol contributes to the receipt of additional products in the amount of 125.0 thousand rubles / he, the profitability of the option is 168.8 % and the payback is 2.69 rubles / rubles. With Boroplus treatments, additional products were obtained for 170.0 thousand rubles / he with a profitability of 193.2 % and a payback of 2.93 rubles / rubles. The most cost-effective option is the joint use of soluble fertilizers: the cost of the additional crop amounted to 260.0 thousand rubles / he, the profitability increased to 219.9 %, the cost recovery – up to 3.20 rubles / rubles.

The impact on the economic efficiency of the choice of table grape variety (factor A) is also confirmed by statistically processed yield. The highest level of profitability, 152.3 %, was obtained for the Rizamat variety (control variant), the production cost of 1 ton of product was 19815.6 rubles / he with a maximum payback of 2.52 rubles / rubles. Slightly inferior to it in terms of economic efficiency, the Kodryanka variety was with the following indicators: profitability – 132.1 %, cost price – 21541.0 rubles / ton, payback – 2.32 rubles / rub.

References
[1] Delmas J 1971 Recherches sur la nutrition minerale de la vigne Vitis vinifera var. Merlot en equiculture These prsent a l’Universite de Bordeaux I 148
[2] Fregoni M and Scienza A 1974 Il rame nella nutrizione delia vite Economia Trentina 2 84
[3] Fregoni M and Scienza A 1976 Aspetti delia micronutrisione di alcune zone viticole italiane Vigne 1 41
[4] Ivanenko E N, Mukhortova T V and Polukhina E V 2018 Efficiency of cultivation of table grapes using agrochemicals of a new generation Vestnik of Kursk State Agricultural Academy 3 65-69
[5] Ivanenko E N, Tutuma N V, Tumanyan A F and Polukhina E V 2017 Influence foliar dressing on susceptibility of grapes to diseases in irrigated conditions of Astra-Khan region Theoretical and applied problems of agro-industrial complex 3(32) 31-36
[6] Kurapina N V 2013 Optimization of the irrigation and fertilization regime of the grape School fundamental research 11 120-125
[7] Malykh G P, Titova L A, Magomadov A S and Kerimov I S 2013 Root feeding of grapes with boron and its influence on the productivity of plantations Horticulture and grape vineyards 5 29-35
[8] Radchevsky P P, Matuzok N V, Troshin L P, Bazoyan S S, Taran Yu and V Dust A V 2016 Influence of foliar dressing with mineral fertilizers of a new generation on the main agrobiological and technological indicators of Chardonnay grapes Fruit and viticulture of the South of Russia 40(4) 111-129
[9] Serputkhovitina K A 1991 Mineral fertilizers and grape quality Problems of agricultural chemistry in the North Caucasus region 42-46
[10] Zelenyanskaya N and Kirillov Yu 2011 Influence of foliar dressing on the productivity and quality of table grapes Vegetable growing 9 32-34
[11] Khanin V F 1990 Determination of the economic efficiency of varieties of fruit and berry crops: guidelines 59 p
[12] Kostyakov A N 1960 Basics of land reclamation 621 p
[13] Lazarevsky M A 1963 Study of grape varieties 151 p
[14] Dospelkov B A 1985 Field experiment technique (with the basics of statistical processing of research results) 351 p