The architecture of the vine bush and the phytoclimate of the vineyard

M K Karayev, G M Mustafaev, A Ch Sapukova, A A Magomedova and S M Mursalov
Department of Horticulture, Viticulture and Landscape Architecture, Dagestan State Agrarian University, Makhachkala, Russia
E-mail: karaev1955@mail.ru, g-mmmustafaev@mail.ru, Sapukova1967@mail.ru, asiat130773@mail.ru, sergdgsha@gmail.com

Abstract. The results of studying the phytoclimate of a vineyard depending on the architecture of the bush are shown. The architecture of grape bushes is estimated depending on the system of maintaining and forming the bushes. The influence of the shape of the bush and the method of maintaining growth on the daily course of the radiation regime and temperature both inside the crown and on the aisles of the vineyard is shown. It has been established that with semi-covering formations with free annual growth, the volume of the crown increases, which leads to improved illumination of the crown, contributes to a better phytoclimate inside the crown.

1. Introduction

Climatic conditions are among the main factors affecting the growth, development and fruiting of grapes. The magnitude and quality of the grape harvest is determined by the duration and intensity of sunshine, the amount of incoming heat and the degree of moisture in the air. Its moisture and soil moisture during the growing season is not the same. Along with this, the plants themselves also have a certain effect on the surface atmosphere surrounding them, forming around themselves a certain microclimate, sometimes differing in some climatic parameters (primarily hydrothermal conditions) from the general climate of the area [1, 3, 4, 10].

For a long time, between the supporters and opponents of the transition to a high-standard grape culture management system, there was a discussion about the nature of the microclimate created around and inside the crown of the bush, its effect on the processes of growth, development and fruiting of grapes. Opponents of this system note that increasing the height of the stem leads to a decrease in the accumulation of sugars in berries. Сторонники Proponents of the system considered the influence on the sugar content of grape berries to increase the growth of the stem by 60–120 cm was very insignificant [11]. Moreover, both of them took into account convection flow only outside the crown. Losing sight of the nature of the movement of air inside the crown. And it depends more on the placement of the sheet canopy in the crown, i.e. from the method of forming a bush [9].

The choice of the method of formation of the bush is dictated by the strength of the growth of the bush, soil fertility, radiation and hydrothermal conditions of the area. The spatial distribution of leaf-stem mass, expressed as a certain system for the placement of annual and perennial vines, should provide the optimal density (density) of the placement of assimilating organs on the trellis and in the crown so that they can make maximum use of the incoming photosynthetically active radiation, provide good gas exchange and optimal hydrothermal mode for productive photosynthesis [1, 2, 6].
In this regard, the aim of our research is to study the influence of the system of maintaining and forming bushes on the microclimate in the crowns of the grape bush.

2. Methods and materials
Research methods generally accepted in viticulture. Illumination was determined with a U-16 light meter, air temperature was measured with a mercury thermometer, relative air humidity was measured with an aspiration psychrometer. Along with these measurements, these parameters were determined at various depths inside the crown by semiconductor devices (photo- and thermistors) mounted on a meter rod and fed by galvanic current sources through a bridge circuit.

Various types of formations were tested, characterized by the nature of the arrangement of the structural elements of the crown, its external parameters and the density of the leaf canopy.

3. Results
As our studies have shown, depending on the formation of the bush, the method of maintaining annual growth with the same planting pattern, the width and height of the bush change.

So, in the Merlot breed with a landing pattern of 3x2 m, the highest crown height was noted in the formation of the Crimea semi-covering fan. СХИ (172 cm), where the vertical management of the growth and the Magarach-2 system was with two-tier placement of structural elements (166.5 cm). The height of the remaining formations was in the range of 150–160 cm (Fig. 1).

The width of the crown of the test variants also differs depending on the method of placing the growth and the design of the trellis: in the variant with the vertical placement of the growth (KSKhI half-covered fan) it was 77.5 cm; in the options for forming bushes according to the Ombrella type and the long-sleeved Kaz.NIIPIV-1, despite the free placement of the growth, the crown width is somewhat smaller (96.2 and 104 cm), the presence of only one tier of the double wire leads to a sharp overhang of the growth and a decrease in the external parameters of the crown. The width of the remaining forms of the bush ranges from 108.5–126.4 cm. In accordance with the parametric characteristics, the largest crown volume was formed by the Tauride high-standard semi-covering formation (3.98 m$^3$) and Magarach-2 (3.78 m$^3$), and the smallest crown volume was formed by the KSKhI semi-covering fan formation (2.64 m$^3$). Other options had close values (in the range of 3.1–3.5 m$^3$).
The density of placement of assimilating organs in the crown volume does not always correlate with the external parameters of the bush. So, when placing an increase on a vertical trellis in the variant with a KSKhI semi-covering fan, it is almost 1.5 times larger than in the variant with a free placement of growth, where it amounted to 2.64 m$^2$/m$^3$. In the version with the Tauride high-stanchion semi-covering formation and the high-stanght (120 cm) fan formation, the density, despite the larger number of shoots, was slightly lower compared to other formations. In options with a long-sleeve formation of Kaz. NIIPiV-1 and Ombrella had higher values of the density of the crown, especially in the upper zone, which is associated with the presence of a single layer of wire, with which the growth sharply hangs. Formations according to the Magarach-Ilcher system with one and two leads on the density of the leaf canopy had close values (Table 1).

### Table 1. Grape crown crown parameters for various systems of management and formation of merlo

| Formations        | height  | Crone parameters, cm | longness | Bush crown volume, m$^3$ |
|-------------------|---------|-----------------------|----------|--------------------------|
| "Magarach-2"      | 166.5   | 114.2                 | 200      | 3.78                     |
| "Magarach-Ilcher-1" | 155.3   | 113.2                 | 200      | 3.50                     |
| "Magarach-Ilcher-2" | 145.1   | 108.5                 | 200      | 3.13                     |
| Kaz. NIIPiV-1     | 153.2   | 104.1                 | 200      | 3.18                     |
| High-Stem Semi-Cover | 158.0   | 126.4                 | 200      | 3.98                     |
| High-Stem Fan     | 144.9   | 119.1                 | 200      | 3.42                     |
| Ombrella          | 161.2   | 96.2                  | 200      | 3.09                     |
| Half-covered Fan  | 172.0   | 77.5                  | 200      | 2.64                     |

These differences in the density of the crown also determined the different nature of the regime of illumination of the leaf apparatus of the bush. As noted by G.A. Sarnetskii [1981], the lack of direct sunlight enhances the growth of shoots to the detriment of their bearing and reduces the productivity of photosynthesis. The direction of the rows in the vineyards is essential for the illumination of crowns and the productivity of photosynthesis. Rows oriented north-south receive approximately the same amount of photosynthetically active radiation per day from the east and west. Illumination from the sunny side of the bush reaches 60 thousand lux, while on the shadow side it is no more than 3–4 thousand lux, and inside the crown at noon does not exceed 400 lux.

According to our data, during daylight hours the illumination of the vineyard, depending on the formation of the bush, reaches 22–28 thousand. Lux, showing at the same time two maximums: about 10 and 16 hours. According to the light regime, semi-covering booth formations and the long-sleeved Kaz.NIIPiV-1 (in the range of 25.1–28.1 thousand lux), characterized by sharply expressed free drooping shoots and a relatively lower density of leaves in the crown of the bush, are in more favorable conditions. Formations according to the Magarach-2, Magarach-Ilcher system with a higher density of the leaf canopy had slightly lower values of the light regime (within 22–23 thousand lux). Close to them was characterized by a semi-covering fan KSHI (22.5 thousand lux.) (Table 2).

### Table 2. Phytometric indicators and crown lighting at various formations

| Formations            | On 1 bush, m$^2$ | Leaf area on 1 m$^2$ of horizontal projection | Leaf area for 1 m$^2$ crown on 1 m$^2$ of vertical projection | Illumination of the crown, thousand lux. | Integral radiation qi |
|-----------------------|------------------|---------------------------------------------|--------------------------------------------------------------|------------------------------------------|-----------------------|
| "Magarach-2"          | 6.5              | 2.85                                        | 1.96                                                         | 1.72                                     | 22.7                  |
| "Magarach-Ilcher-1"   | 5.8              | 2.56                                        | 1.87                                                         | 1.66                                     | 22.4                  |
| "Magarach-Ilcher-2"   | 5.5              | 2.54                                        | 1.89                                                         | 1.76                                     | 21.9                  |
| Kaz. NIIPiV-1         | 4.7              | 1.96                                        | 1.54                                                         | 1.48                                     | 26.7                  |
| High-Stem Semi-Cover  | 5D               | 2.01                                        | 1.59                                                         | 1.28                                     | 28.1                  |
| High-Stem Fan         | 4.9              | 2.06                                        | 1.75                                                         | 1.43                                     | 25.8                  |
| Ombrella              | 5.8              | 3.02                                        | 1.81                                                         | 1.88                                     | 25.1                  |
| Half-covered Fan      | 6.3              | 4.09                                        | 1.83                                                         | 2.39                                     | 22.5                  |
Along with measurements of the illumination of the crown of the bush, we also took into account the integral radiation \( (q_i) \). As A.G. Amirjanov noted [1], on a vertical trellis with the north-south rows oriented even during hours when the irradiation of the crown sides is greatest (8 and 16 hours), the integral radiation flux is 0.15–0.17 kcal / (cm min) and only in the afternoon hours in the upper tier of the crown does it reach 0.20 kcal / (cm min). In the middle and lower parts of the crown in the afternoon, the irradiation is significantly weakened – to 0.11–0.14 cal / (cm/min).

Unlike most of the tested formations, in the variants with the Ombrella and Kaz.NIIPiV – 1 formations, a gradual decrease in the intensity of radiation in the afternoon was observed. This is due to the fact that, in their design, the trellis of these formations has only one layer of wire, with which, as noted above, shoots hang sharply. In addition, the dominant direction of the winds here is from the northwest to the southeast and the eastern sides of the crown.

Along with the illumination of the leaf canopy, the structure of different formations also has a significant effect on the temperature regime of the crown of the grape bush and the vineyard as a whole. T.I. Turmanidze [1] notes that the structure of the vineyard itself affects the temperature of the surface air layer, the upper (20 cm) soil layer and air humidity. However, differences in the effectiveness of various types of bush formations in optimizing the hydrothermal regime due to the different skeleton structure and assimilating surface area, especially in conditions of cover viticulture in Dagestan, have not yet been studied. Studies conducted in this regard showed certain differences in the microclimate, caused precisely by the structure and nature of the placement of the leaf canopy of the bush on the trellis (table 3).

The most favorable for the development of the grape bush is the relative humidity in the range of 60–80 %. Lower humidity leads to unproductive water loss by leaves and soil for evapotranspiration. According to G. A. Sarnetskiy [11], the natural correlation of the intensity of various physiological processes is violated. In our experiments, the relative humidity in the area where the bulk of the clusters are located varies between 54–64 %. The lowest values of this indicator (54 %) were noted in the variant with a high-standard fan formation. The remaining experimental options had values close to optimal.

Table 3. Microclimate of vineyards at different systems for management and formation of bushes, merlo

| "Magarach-2" "Magarach-Ilcher-1" | Air temperature, °C in the crown | Relative humidity, % in the crown | Soil temperature, °C in the crown | Air temperature, °C in the aisle | Relative humidity, % in the aisle | Soil temperature, °C in the aisle |
|---------------------------------|---------------------------------|----------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Magarach-Ilcher-2              | 27.8                            | 64.0                             | 20.8                            | 27.3                            | 52.0                             | 21.1                            |
| Kaz. NIIPiV-1                  | 28.1                            | 65.0                             | 21.1                            | 27.2                            | 52.0                             | 22.6                            |
| High-Stem Semi-Cover           | 26.7                            | 56.0                             | 22.4                            | 27.2                            | 52.0                             | 22.4                            |
| High-Stem Fan                 | 26.8                            | 56.0                             | 22.4                            | 27.0                            | 52.0                             | 22.9                            |
| Ombrella                      | 25.4                            | 56.0                             | 22.0                            | 27.1                            | 52.0                             | 22.0                            |
| Half-covered Fan              | 25.2                            | 52.0                             | 21.6                            | 27.0                            | 52.0                             | 21.6                            |
| Ombrella                      | 27.0                            | 58.0                             | 21.8                            | 26.9                            | 52.0                             | 22.8                            |
| Half-covered Fan              | 26.9                            | 64.0                             | 22.9                            | 27.3                            | 52.0                             | 22.9                            |

The air temperature in the crown of the bush (the area where the bulk of the clusters are located), depending on the method of formation, varied within 25–28 °C. High temperature in the version with the Magarach-Ilcher system with one lead (28.1 °C), which is explained by the close arrangement of the structural elements of the bush to the soil surface. In those cases where the overhanging shoots are more pronounced, and the leaf surface is less, lower relative humidity and air temperature are noted. It also affects the possibility of free convective movement of the air mass inside the crown. The temperature of the upper (20 cm) soil layer also changed. Depending on the formation of the bush, the soil in the row and row-spacing heats up with a maximum at noon. The top 5 cm of soil is very warm. During the day, the soil temperature in the horizon of 15–20 cm varies slightly and the influence on it of the method of forming a bush is practically not observed.
4. Conclusion
To optimize the production process of grapes and obtain the planned harvests, it is necessary to optimize the size of the area of leaves of the plantation (the number of shoots, their placement in space), ensuring the maximum economic yield without compromising quality. The microclimate of the vineyard under various systems of maintaining and forming bushes is characterized by close positive values. All studied formations create favorable conditions for radiation-air nutrition of grapes, although a slight increase in relative humidity and a decrease in temperature in the crown with an increase in leaf area are noticeable.

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