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EFFECT OF GIBBERELLIC ACID ON THE YIELD OF PARTENOCARPIC AND STENOSPERMOCARPIC GRAPE CULTIVARS

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ABSTRACT

The aim of this study was to determine the effects of gibberellic acid (GA_3) on yield of table grape cultivars at the relationships structure-function: Leaf ÷ Yield. The GA_3 was applied in "Flora", "Talisman" and "Kishmish luchistii" grapevine cultivars by spraying clusters 4-6 days after full bloom. The GA_3 treatments were at the 0 (control); 20; 40; 50; 60; 80; 100 ppm. The application GA_3 changes of grape yield, bunch compactness parameter, and quality of grape berries. Permissible values of ratio Leaf ÷ Yield will be equal to 0.8 m² for ripeness under normal conditions of 1 kg of table grapes. In "Flora", "Talisman" and "Kishmish luchistii" cultivars at the cordon trained system with a density of 2222 vines ÷ ha (3×1.5 m), the increase of the yields and quality of table grape occurred after the use of 40 ppm of GA_3 with one application after full bloom and norms 8-10 clusters per vine.

Keywords: Vineyards, yield, cultivar, partenocarpy, stenospermocarpy, gibberellic acid, exposable leaf area

INTRODUCTION

An individual grape inflorescence contains hundreds of flowers. But, not all of those will set fruit and develop into berries. Because nearly 40-80% of the flowers may not set fruit in a cluster, it is normal to have some flower abscission. The conditions during bloom can be a critical factor in how many flowers per inflorescence set fruit. These factors include parameter of vine nutrition, vine vigor status, weather, damaging, and events.

The amount of grape yield depends on the number and mass of fruits. There can be bisexual flowers that set and form small shot seedless berries (partenocarpy), induced production of fruit without fertilization of ovules. Similar fruit development is characteristic for grape cultivars with functionally female flowers. In some fruits the biological mechanism that produces seedlessnes after normal pollination and fertilization (stenospermocarpy).

The growth and development of the fruits of flowering plants is based on the hormonal regulation system. The fruit of seedless grapes is smaller than normal because seeds produce the plant hormones gibberellins (GAs). Most commercial seedless grape cultivars are sprayed with gibberellin to increase the size of the fruit and also to make the fruit clusters less tightly packed [1]. The application of synthetic GAs on plant-growing promotes to change of donor/acceptor relationships between plant organ systems. In the special case, GAs absorption on berry promotes to increase acceptor function of glucose to biomass formation, produced mainly in leaves [2]. Thus, since leaves (donor) are essential for photosynthesis and produce the glucose to yield formation.

Hypothesizing that the quantitative limits for obtaining quality yields after application of gibberellic acid (GA_3) in partenocarpic and stenospermocarpic table cultivars have been established according to relationships donor ÷ acceptor structure function: Leaf ÷ Yield.

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MATERIAL AND METHODS

Site Characterization

The studies were carried out on vineyard establishing in environmental conditions of Northern Black Sea region, during 2016-2018. The particularity of climate is limited to cultivation of some classical grape varieties by duration of vegetation and winter resistant. In practical of locality viticulture is spreading of grape cultivars with partenocarpic and stenospermocarpic berries, adapted to local environmental conditions.

The most characteristic soils are low-humus chernozems, loamy. The climate is humid continental. Cold winter, January average temperature is -2°C. Possible short-term, up to 7-15 days, frosts of approximately -25°C. Summer is mostly hot, dry; July average temperature 23°C; maximum up to 36-39°C. The average annual temperature is 10.8°C. The total precipitation is 340-470 mm per year, mainly in summer. The number of hours of sunshine is about 2200 per year. The duration of the vegetation is 168-210 days.

The biological material was represented by parthenocarpic “Flora”, “Talisman” and stenospermocarpic “Kishmish luchistii” grapevines, grafted on R×R 101-14 rootstock. The vine training systems on high trunk with vertical monoplane trellis. The planting distances between vine rows are of 3 m, the density of plantation is of 2222 vine ÷ ha, the training form is bilateral cordon on trunk with the height of 0.8 m.

The experimental design was randomized blocks with three repetitions for each treatment. The vines used within each block for the pulverization were the five average plants. GA_3 was derived from the commercial product “Florgib tablet”, containing 20% active ingredient. The application of GA_3 were made manual sprayer in all clusters of the grapevine. The spraying was performed 4-6 days after full bloom. Treatments were at the 0 (control); 20; 40; 50; 60; 80; 100 ppm (mgL^{-1}) of active ingredient.

Field and Laboratory Studies

The grape yield was counted using the average number and mass of clusters of the useful plot. After the harvest, the clusters were transported to the laboratory for the quality evaluations. The quality evaluations of the grape clusters were as follows: vine yield, the results being expressed in kg ÷ vine; mass of the clusters, rachis and berries in g. For the determination of the berries soluble solids, the refractometer was used and the results were expressed in g ÷ 1 dm^3; titrable acidity indicated by the titration with 0.1 N NaOH solution, and the results expressed in g ÷ 1 dm^3 of tartaric acid.

During the veraison stage of studied grape cultivars was evaluated the height and width of the vine canopy. Average values were calculated based on thirty measurements. The indicators of vine canopy were determinate refer to exposable leaf area (ELA). ELA is calculated by using the following relation [3]:

$ELA\ (m^2 \div ha) = 10000 \div E \times (1 - t) \times EA$, where
E - Row Width of Vineyard (m);
t - Lack of Canopy Index (0.1);
EA - External Area of the Canopy = 2 × Canopy Height (m) + Canopy Width (m).

Statistical analyses were conducted using dispersion method to determinate least significant difference between variants of studies.

RESULTS

Grape Yield

The grape yield presented higher values with the increase of GA_3 treatments compared to the control in the three years of studies, on average by 58-121% in plantation of “Flora”, 36-48% - of “Talisman”, 18-61% - of “Kishmish luchistii” grapevines. In “Flora” cultivar treated with the 20…100 ppm doses of GA_3, the average plant yield was 4.2-5.3 kg ÷ vine, “Talisman” - 7.6-8.3 kg ÷ vine, “Kishmish luchistii” - 3.3-4.5 kg ÷ vine, whereas the control resulted in an average of 2.4; 5.6 and 2.8 kg ÷ vine, respectively (Table 1). The increase of yields should be due to the GA_3 promote the growth of grape bunch, especially berry size (Figure 1). To increase the yield of table grapes have been treated with GA_3 since the late 1950s [4].

Bunch Compactness Parameter

The grapevines of “Flora” cultivar treated with the GA_3, the average bunch compactness (total berry mass ÷ rachis mass ratio) was 44-58, “Talisman” - 54-69, “Kishmish luchistii” - 23-30, whereas the control resulted in an average of 41; 51 and 32, respectively (Table 1). In plantation of

"Flora" and "Talisman" cultivars parameter of bunch compactness increased; the grapevines of "Kishmish luchistii" cultivar parameter decreased with GA_3 treatments compared to the control.

a

b

c

Figure 1. The effect of GA_3 treatments on yield of table grape cultivars "Flora" (a) "Talisman" (b) and "Kishmish luchistii" (c) a left control plants, on right - clusters is sprayed by active ingredient in dose of 40 ppm. Length and width of clusters and berries increase.

We observed in general that the clusters spraying after full bloom by high doses of GA_3 (50…100 ppm) showed postharvest dropping of berries.

Berry drop in bunches treated with GA_3 has been related to the hardening of the rachis and pedicel. The dosage of GA_3 no more 40 ppm could prevent the hardening of the rachis, but not the postharvest dropping of berries. In order to obtain the proper balance between the largest berry size and the minimal berry drop, it is necessary to determine the optimal harvest time.

Quality of Grape Berries

In "Flora" grapevines the application of GA_3 increased to 30% (dose of GA_3 60 ppm); in "Talisman" and "Kishmish luchistii" cultivars - decreased to 15% and 34% (dose of GA_3 100 ppm) the soluble solids values. Titratable acidity mainly decreased after application of the GA_3 doses compared to the control. However, the glucoacidometric index or grape maturation index (g soluble solids ÷ g tartaric acid on dm^3 of fruit juice) increased after application of GA_3 in plantation of "Flora" grape cultivar. In "Talisman" and "Kishmish luchistii" grapevines the application of GA_3 decreased ratio (Table 1).

When sprayed on grape clusters after full bloom, GA_3 could stimulate the development of parthenocarpic fruit (artificial parthenocarpy). Normally-seeded grape berries produce mainly seedless fruit. This effect can be used in partenocarpic cultivars to commercially produce of table grapes with seedless berries highness size (Figure 2).

Figure 2. The effect of GA_3 treatments on stimulates the development of parthenocarpic berries of "Flora" cultivar: left control plants, on right-clusters are sprayed by active ingredient in concentration of 20, 40, 50, 60, 80, 100 ppm. The development of seeds is depressed

The Exposable Leaf Area

The exposable leaf area (ELA) has a constant value for each canopy management system, and by its reporting to the necessary of 1.0-1.2 m² ELA for ripeness under normal conditions of 1 kg of wine grapes [3], one may calculate the quantitative limits for obtaining quality yields.

GA_3 treatments presented higher values of yield. However, parameters of canopy exterior area (EA) not modified after application of GA_3, it differs from one canopy management system to another, according to training form and trellis type. At the canopy management: form is bilateral cordon on trunk with the height of 0.8 m on vertical monoplane trellis, EA is of 2.65 m² ÷ 1 m of row in "Flora" cultivar, 3.20 m² ÷ 1 m - "Talisman" cultivar, 2.80 m² ÷ 1 m - "Kishmish luchistii" cultivar. The vineyard had a percentage of 10% of gaps, the calculation of EA real value was necessary. The exposable leaf area is given by the product between the total length of rows (3333 m), the correction coefficients of gaps (0.9) and EA (Table 2):

- in "Flora" cultivar ELA = 3333×0.9×2.65=7949 m² ÷ ha;
- in "Talisman" cultivar ELA = 3333×0.9×3.20= 9599 m² ÷ ha;
- in "Kishmish luchistii" cultivar ELA = 3333×0.9 × 2.80=8399 m² ÷ ha.

The quantitative limits for obtaining quality yields have been established according to the ratio between ELA and necessary of 1 m² ELA for the maturation under best conditions of 1 kg of grapes. It resulted that the studied canopy management system allowed getting quality yields within the limits 7.95-9.60 t grapes ÷ ha.

We observed in general that for the variable of ratio Leaf ÷ Yield there were no significant differences between the GA_3 doses applied in the grape clusters; however, differences were verified between the control and GA_3 doses. "Flora" grapevines not treated with GA_3 showed a higher value of ratio 1.5 m² ELA ÷ 1 kg yield; "Talisman" and "Kishmish luchistii" - 0.8 and 1.3 m² ELA ÷ 1 kg yield, respectively. When GA_3 was applied the value of ratio ELA ÷ yield was decreased to 0.7-0.9 m² ÷ kg in "Flora" cultivar; to 0.5-0.6 m² ÷ kg in "Talisman" cultivar; to 0.8-1.0 m² ÷ kg in "Kishmish luchistii" cultivar (Figure 3).

Table 1. Effect of GA_3 cluster spray on yield and quality of grape cultivars with partenocarpic and stenospermocarpic berries. The GAs was applied by spraying clusters 4-6 days momentary after full bloom, at the stage of post-pollination of flowers. Values represent the mean observed during the years 2016-2018

Treatments	Cultivars		
GA_3 (ppm)	"Flora"	"Talisman"	"Kishmish luchistii"
Yield (kg ÷ vine)			
0 (Control)	2,4	5,6	2,8
20	4,2	7,7	3,3
40	4,5	7,8	3,9
50	5,3	8,1	-
60	4,8	8,3	3,8
80	3,9	7,6	4,3
100	3,8	8,1	4,5
LSD (0.5%)*	0.4	0.2	0,6
Bunch compactness parameter (total berry mass ÷ rachis mass ratio)			
0 (Control)	41	51	32
20	46	57	30
40	58	56	29
50	51	54	-
60	51	56	27
80	44	60	26
100	56	69	23
Soluble solids concentration (g ÷ dm³ of fruit juice)			
0 (Control)	137	182	177
20	143	122	170
40	158	141	155
50	167	136	-
60	171	122	145
80	141	150	143
100	132	138	150
Titrable acidity (g tartaric acid ÷ dm³ of fruit juice)			
0 (Control)	6.9	7.3	4.1
20	6.4	5.8	5.1
40	7.2	5.9	5.0
50	6.6	5.5	-
60	6.6	5.2	4.8
80	7.0	6.1	4.7
100	6.2	6.5	5.3

*values of least significant difference are calculated based on data sums for 2016-2018.

DISCUSSION AND CONCLUSIONS

The relation between soluble solids of the fruit juice and Leaf ÷ Yield ration is confirmed. However, a value of soluble solids of table grapes is lower compared to the wine cultivars. Permissible values of ratio between ELA and yield will be equal to 0.8 m² for ripeness under normal conditions of 1 kg of table grapes. The quality yields may be obtained within 9.9-12.0 t ÷ ha.

Table 2. Values of leaf area parameters according to canopy management system: plant densities 2222 vines per hectare (3×1.5 m). The training form is bilateral cordon on trunk with the height of 0.8 m. Vertical-shoot-positioned trellis with the height of 1.8 m. The canopy gaps represented 10%

Parameter	Measure	Cultivars		
		"Flora"	"Talisman"	"Kishmish luchistii"
Total length of vine rows	m ÷ ha	3333	3333	3333
Canopy height	m	1,10	1,30	1,15
Canopy width	m	0,45	0,60	0,50
External area of the canopy	m² ÷ m	2,65	3.20	2,80
Exposable leaf area	m² ÷ ha	7949	9599	8399

The application GA_3 changes of structure-function relationships of donor ÷ acceptor. The importance of doing careful evaluations of the yield values used by the table grape growers when adopting a cultivar, in order to obtain the proper balance between Leaf ÷ Yield ratios, not less 0.8 m² ÷ 1 kg. We observed that excessive yield increase after applying of GA_3 on low-vigor grapevines leads to the development of bunches and berries of different sizes, low quality.

This phenomenon is observed when the donor function (leaf area) is low; acceptor function (yield values) is high. For example, in vineyards of "Flora" cultivar, the values of ELA allowed getting quality yields within the limits 9.9 t grapes ÷ ha. The average mass of bunch amount to 0.4 kg. At least 25 thousand bunches are needed per hectare or 11 clusters per vine (with a density of 2222 vines ÷ ha). But, with an increase of bunch mass up to 0.6 kg after applying GA_3, is necessary to accept the norm of bunches at the level of 16.5 thousand per hectare or 7-8 clusters per vine.

In "Flora", "Talisman" and "Kishmish luchistii" cultivars at the cordon trained system with a density of 2222 vines ÷ ha (3×1.5 m), the increase of the yields and quality of table grape occurred after the use of 40 ppm of GA_3 with one application after full bloom and uses norms 8-10 clusters per vine.

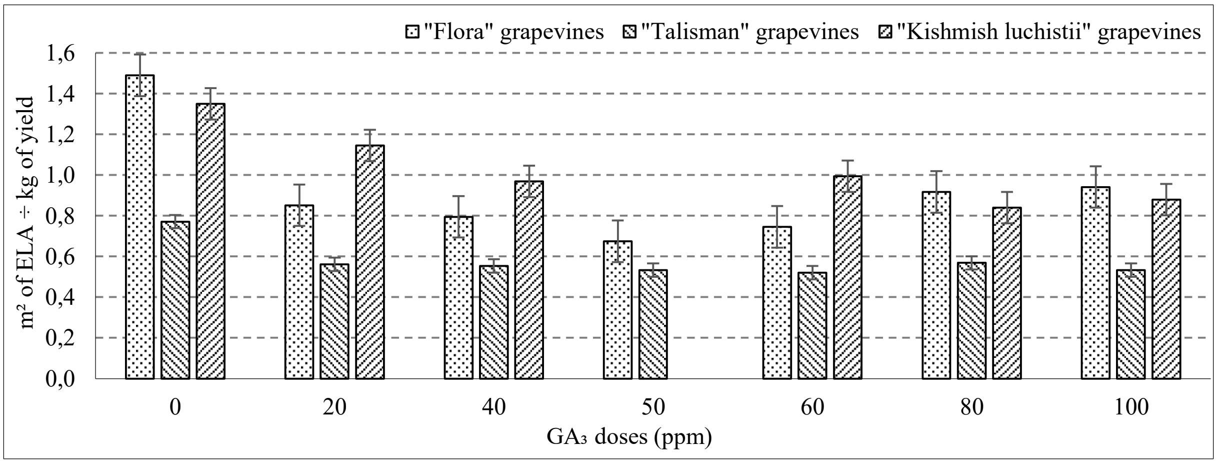

Figure 3. The ratio between exposable leaf area (m² ÷ ha) and yield of grape cultivars (kg ÷ ha). Values represent the mean observed during the years 2016-2018. Vertical bars represent ± SE

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