The reaction norm of Augustine and Moldova grape varieties in the agroecological conditions of the moderate continental climate of the south of Russia

Valeriy Petrov*, *Dmitriy* Russo, *Aleksandr* Krasilnikov, and *Anna* Marmorshtein

Federal State Budget Scientific Institution «North Caucasian Federal Scientific Center of Horticulture, Viticulture, Wine-making», str. 40 Let Pobedy, 39, Krasnodar, 350901, Russia

Abstract. The grape plant reacts by modification variability of phenotypic traits to the variation of weather conditions. The reaction of the Augustine and Moldova grape varieties to the variability of natural conditions was ambiguous. In the Augustine, the lower limit of the modification variability of the cluster mass is 354 and the upper limit is 410 g, the grape yield is 8.1 and 11.5 kg/bush, the sugar content of the berry juice is 15.8 and 17.5 g/100 cm^3, in the Moldova, respectively, 387 and 457 g, 9.6 and 13.2 kg/bush, 16.4 and 17.8 g/100 cm^3. The reaction norm of the Augustine according to the phenotypic traits is following: the cluster mass is 56 g, the yield is 3.4 kg/bush and the sugar content is 1.7 g/100 cm^3, of the Moldova, respectively, 70, 3.6 and 1.4. Against the background of the application of fertilizers, the lower and upper limits of variability have increased as well as the reaction norm by cluster mass and yield, however reaction norm by sugar content decreased.

1 Introduction

The grape plant has a high plasticity in the conditions of the display of natural biotic and abiotic stressors. This biological character allows the plant to grow and bear fruit effectively in conditions of a lack of mineral nutrition and precipitation, to tolerate high maximum and low minimum air temperatures [1-6]. At the same time, grape plants respond positively to optimal environmental conditions [7-11]. Under the influence of changes in the habitat, as well as anthropogenic factors, grape plants react to the variability of phenotypic traits [12-17]. The modification variability can vary in a wide range and is expressed by the reaction norm. The reaction norm of table varieties, expressed by the indicators of the cluster mass, productivity and sugar content of berry juice, is of great scientific and practical importance for the creation of new varieties and the development of variety-oriented agricultural technologies for functionally directed grape cultivation.

The purpose of these studies is to establish the limits of the modification variability of the cluster mass, the yield and the sugar content of the berry juice of widely used grape varieties

* Corresponding author: petrov_53@mail.ru

in the agroecological conditions of the south of Russia. These studies were done for the first time.

2 Materials and methods

The introduced table grape varieties Augustine and Moldova were used as the object of research. The subject of research is the phenotypic reaction of grapes to unstable weather conditions and the nonroot application of AgroMaster and Lignohumate fertilizers.

The research was carried out using modern methods of field studies. Agrobiological records of plantings productivity and grape quality were carried out using methods of agrotechnical study of grape varieties and technologies.

The research was carried out in the conditions of the Black Sea agroecological zone of viticulture in the Krasnodar region on the Taman Peninsula, the Progress village. The climate at the research area is moderately continental. The annual average air temperature is 11.8 °C, during the growing season (May – September) – 20.8 °C, the maximum rises to plus 38.0 °C, the minimum during the wintering period of grapes falls to minus 24 °C. The annual amount of atmospheric precipitation is 526 mm, during the growing season – 209 mm, during the active growth of grape berries (II. June-III. august) – 161 mm. The soil is southern chernozem.

3 Results and discussion

During the research period, the average annual air temperature at the research area varied from 12.6 to 13.4 °C and was higher than the average annual norm by 0.8-1.6 °C, during the growing season – from 21.5 to 22.5 °C, which is higher than the norm by 0.7-1.7 °C, during the active growth of grapes – from 23.7 to 24.7 °C, higher than the norm by 0.8-1.8 °C. The maximum temperature during the growing season was below the norm by 2.0 – 4.0 °C, the minimum during the period of active growth of grapes exceeded the norm by 1.0-5.0 °C. Atmospheric precipitation varied in a wide range. The highest annual atmospheric precipitation reached 636 mm, the lowest 394 mm, which is respectively 21 % more and 25 % less than norm. During the period of active growth of grape berries, the largest amount of atmospheric precipitation exceeded the norm by 49 %, the lowest was below the norm by 67 %. In general, the research area has unstable weather conditions and there is a tendency of climate warming (Table 1).

Table 1. Meteorological conditions at the research area

Years	Air temperature, °C						Atmospheric precipitation, mm		
	Average			max	min				
	In a year	may-september	II.june-III.august	may-september	june-august	january-march	In a year	may-september	II.june-III.august
2016	12.6	21.9	24.7	36.0	10.0	-14	636	308	42
2017	12.8	21.5	23.7	36.0	11.0	-15	503	152	77
2018	13.0	22.5	24.5	34.0	12.0	-8	453	135	36
2019	13.2	21.7	23.8	34.0	14.0	-6	394	134	67
2020	13.4	21.8	23.9	36.0	12.0	-11	415	228	161
long-term annual average	11.8	20.8	22.9	38.0	9.0	-24	526	209	108

The reaction of the studied grape plants to the variability of natural conditions during the growing period was ambiguous in terms of phenotypic characteristics. The modification variability of phenotypic traits was most strongly influenced by the temperature regime and precipitation in general for the year, as well as during the period of active growth of grapes. According to Table 2, the correlation dependence of the average cluster mass and the yield on the average annual air temperature and atmospheric precipitation during the period of berry growth was mainly medium and strong, especially in the Moldova variety. The sugar content of the berry juice was strongly dependent.

Table 2. Correlation dependence of the grape phenotypic characteristics on the weather

Phenotypic traits	Average air temperature, °C			Atmospheric precipitation, mm		
	In a year	may-september	II.june-III.august	In a year	may-september	II.june-III.august
Augustine without fertilizers						
Average cluster mass, g	-0.72	-0.37	-0.09	0.41	-0.21	-0.67
Yield, kg/bush	0.33	-0.11	-0.49	-0.35	-0.32	0.57
Sugar content, g/100 $см^3$	0.81	0.26	-0.24	-0.64	-0.16	0.75
Augustine on the background of fertilizers						
Average cluster mass, g	-0.49	-0.84	-0.43	0.35	0.04	-0.24
Yield, kg/bush	0.73	-0.52	-0.90	-0.71	-0.39	0.83
Sugar content, g/100 $см^3$	0.87	-0.28	-0.79	-0.84	-0.46	0.82
Moldova without fertilizers						
Average cluster mass, g	-0.69	-0.07	0.25	0.44	-0.08	-0.86
Yield, kg/bush	0.89	-0.30	-0.83	-0.89	-0.51	0.78
Sugar content, g/100 $см^3$	0.86	-0.03	-0.44	-0.65	-0.10	0.91
Moldova on the background of fertilizers						
Average cluster mass, g	-0.74	-0.12	0.07	0.39	-0.28	-0.82
Yield, kg/bush	0.83	-0.19	-0.58	-0.65	-0.14	0.94
Sugar content, g/100 $см^3$	0.71	-0.05	-0.63	-0.73	-0.52	0.69

The cluster mass under the influence of unstable weather conditions varied of the Augustine variety from 354 g to 410 g, of the Moldova variety from 387 g to 457 g. The difference between the lower and upper thresholds of modification variability reached 16% and 18%, respectively. Against the background of the fertilizers application, the cluster mass was higher than without fertilizers, but the range of variation was close to the variant without fertilizers. In the Augustine variety, the cluster mass varied from 424 g to 482 g, in the Moldova variety from 421 g to 498 g. The difference between the lower and upper thresholds of modification variability reached 14% and 18%, respectively. The reaction norm to changes in weather conditions in the Augustine variety was equal to 56 g and in the Moldova variety to 70 g, against the background of the use of fertilizers, the reaction rate increased and was equal to 58 g and 77 g, respectively (Fig. 1).

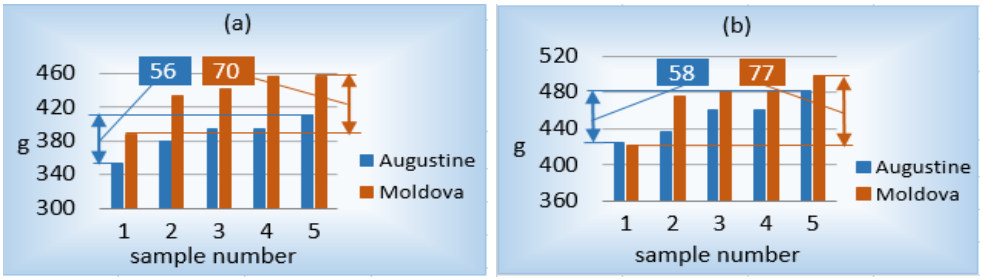

Fig. 1. The reaction norm of the grape cluster mass to natural conditions without the application of fertilizers (a) and against the background of the application of fertilizers (b)

The grape yield under the influence of changes in weather conditions of the Augustine variety varied from 8.1 kg/bush to 11.5 kg/bush (the difference between the lower and upper thresholds was 42 %), of the Moldova variety from 9.6 kg/bush to 13.2 kg/bush (38 %), against the background of the application of fertilizers, respectively, from 10.6 kg/bush to 17.9 kg/bush (69%) and from 11.9 kg/bush to 18.1 kg/bush (52%). The reaction norm to changes in weather conditions was 3.4 kg/bush of the Augustine variety, 3.6 kg/bush of the Moldova variety, and increased to 7.3 kg/bush and 6.2 kg/bush, respectively, against the background of the application of fertilizers (Figure 2).

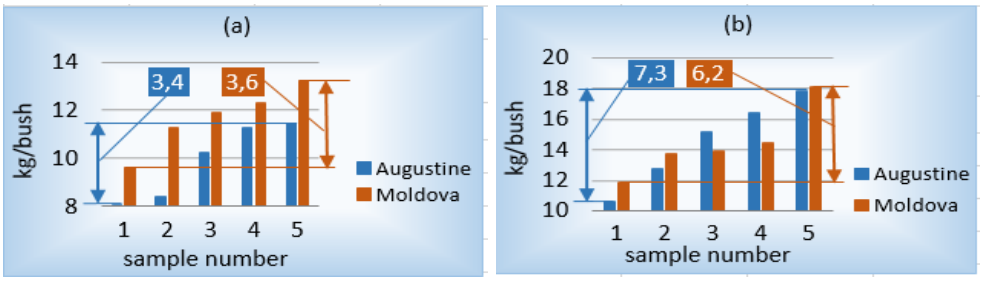

Fig. 2. The reaction norm of the grape yield to natural conditions without the application of fertilizers (a) and against the background of the application of fertilizers (b)

The sugar content of grape juice of the Augustine variety varied from 15.8 g/100 cm^3 to 17.5 g/100 cm^3 (11 %), of the Moldova variety from 16.4 g/100 cm^3 to 17.8 g/100 cm^3 (8%), against the background of the application of fertilizers, respectively, from 18.3 g/100 cm^3 to 19.4 g/100 cm^3 (6%) and from 18.1 g/100 cm^3 to 19.4 g/100 cm^3 (7%). The reaction norm was equal in the Augustine variety to 1.7 g/100 cm^3 and in the Moldova variety to 1.4 g/100 cm^3, against the background of the application of fertilizers, it decreased to 1.1 g/100 cm^3 and 1.3 g/100 cm cubic, respectively (Figure 3).

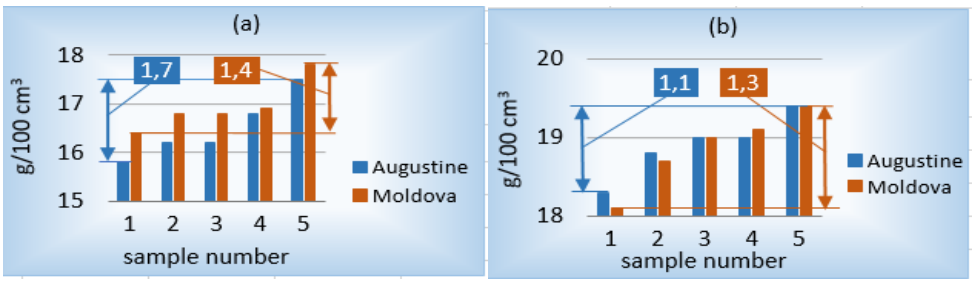

Fig. 3. The reaction norm of the sugar content of grape juice to natural conditions without the application of fertilizers (a) and against the background of the application of fertilizers (b)

4 Conclusion

The reaction norm of table grape varieties Augustine and Moldova in unstable weather conditions of the moderate continental climate of the south of Russia has been established. In the Augustine variety, the lower limit of the modification variability of the cluster mass is 354 g and the upper limit is 410 g, the grape yield is 8.1 kg/bush and 11.5 kg/bush, the sugar content of grape juice is 15.8 g/100 cm^3 and 17.5 g/100 cm^3, in the Moldova variety, respectively, 387 and 457 g, 9.6 and 13.2 kg/bush, the sugar content of grape juice is 16.4 g/100 cm^3 and 17.8 g/100 cm^3. Against the background of the application of fertilizers in the Augustine variety, the lower limit of the modification variability of the cluster mass is 424 g, the upper limit is 482 g, the grape yield is 10.6 kg/bush and 17.9 kg/bush, the sugar content of grape juice is 18.3 8 g/100 cm^3 and 19.4 8 g/100 cm^3, in the Moldova variety, respectively, 421 g and 498 g, 11.9 kg/bush and 18.1 kg/bush, the sugar content of grape juice is 18.1 g/100 cm^3 and 19.4 g/100 cm^3. The reaction norm of the Augustine grape variety according to the phenotypic traits is following: the cluster mass is 56 g, the grape yield is 3.4 kg/bush and the sugar content of the berry juice is 1.7 g/100 cm^3, of the Moldova variety is 70 g, 3.6 kg/bush and 1.4 g/100 cm^3, respectively. Against the background of the application of fertilizers, the reaction norm of phenotypic traits of the Augustine grape variety is following: the mass of the bunch is 58 g, the grape yield is 7.3 kg/bush and the sugar content of the berry juice is 1.1 g/100 cm^3, for the Moldova variety, respectively, 77, 6.2 and 1.3 g/100 cm^3.

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