UDC 575.630
https://doi.org/10.2298/GENSR1802549N
Original scientific paper

VARIABILITY AND HEREDITY OF SOME QUALITATIVE AND QUANTITATIVE GRAPEVINE CHARACTERISTICS

Dragan NIKOLIĆ[1]*, Tijana BANJANIN[2], Zorica RANKOVIĆ-VASIĆ[1]

[1]University of Belgrade, Faculty of Agriculture, Belgrade, Serbia
[2]University of East Sarajevo, Faculty of Agriculture, Bosnia and Herzegovina

Nikolić D., T. Banjanin, Z. Ranković-Vasić (2018): *Variability and heredity of some qualitative and quantitative grapevine characteristics*.- Genetika, Vol 50, No.2, 549-560.
Variability and mode of heredity of some important qualitative and quantitative grapevine characteristics in 45 seedlings of F_1 generation obtained from crossing combination Seedling 113 x Muscat Hamburg were investigated in this study. The seedlings of F_1 generation for the investigated characteristics were arranged in certain number of categories by the OIV method. As variability indexes, standard deviation (S) and coefficient of variation (V) were used. Evaluation of the mode of heredity was done by χ^2 test and t-test. Considering examined characteristics, the highest variability showed grape yield (V=58.9%), and the lowest sugar content in must (V=16.3%). Color of berry skin, cluster resistance to *Botrytis cinerea* and leaf resistance to *Plasmopara viticola* showed monogenic mode of heredity. Exception from the monogenic mode of heredity was determined for the flavor of berry. Grape yield, bunch weight and berry weight showed negative heterosis. For the sugar content in must, domination of the parent with low sugar content in must was determined.
Keywords: grapevine, heredity, F_1 generation, interspecies hybridization, variability

INTRODUCTION

Vitis vinifera L. is a temperate-climate species cultivated widely in many countries of the world, principally for wine and fresh fruit. Given this context, the development of new cultivars with new or improved attributes, caused by better combinations of alleles at multiple

Corresponding author: Dragan Nikolić, University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade-Zemun, Serbia, phone: +381 2615 315, fax: +381 2193 659, e-mail: nikolicd@agrif.bg.ac.rs

loci, is important (BAYO-CANHA *et al*., 2012). Grapevine breeding is a long term investment into viticulture. New crossings should at least be evaluated more than twenty five years before released to the public (REGNER *et al*., 2004).

Since the introduction of phylloxera and the mildew diseases from North America to Europe during the second part of the 19th century, grape breeders around the world are engaged to introduce into the gene pool of the European quality vines resistance traits existing in American and Asian wild species (EIBACH and TÖPFER, 2014). Today the selection for resistance is based mainly on interspecific crosses (LU *et al*., 2000; LUO and HE, 2004; NIKOLIĆ *et al*., 2009; GRAY *et al*., 2014). For this purpose, in addition to wild species, are increasingly being used hybrids from the first, second or even third generations for mutually or backcrossing with the Eurasian grapevine varieties.

Grape breeders use various breeding technologies to develop new table grape cultivars with superior quality traits, including suitable berry composition and content of sugars and organic acids, seedlessness, large berry size, favorable aroma and desirable berry colors (COSTANTINI *et al*., 2007). During the setting up a plan of crossing, special attention is a dedicated to the genetic structure of the parent and the mode of traits transmission to offspring.

Parentage analysis is important due to difficulties in grape genetic studies related to its long juvenility duration, high chromosome number (19 pairs), semi ovule sterility, and low germination of seeds, especially when progenies were used for important studies such as heritability, analysis of segregating population or gene and linkage map making (FIROOZABADY and OLMO, 1987; LODHI and REISCH, 1995; WEI *et al*., 2003; NIKOLIĆ, 2006; HADADINEJAD *et al*., 2011). Few traits of viticultural importance are controlled by single genes or genes of major effect, including berry color, flesh development, flower hermaphroditism and seedlessness (DOLIGEZ *et al*., 2002; FERNANDEZ *et al*., 2006; MEJÍA *et al*., 2007; MARGUERIT *et al*., 2009). Many traits of agricultural significance exhibit quantitative inheritance, which is often the result of multiple genes of minor effect (MARTÍNEZ-ZAPATER *et al*., 2009; WELTER *et al*., 2011; BAYO-CANHA *et al*., 2012).

Serbia has a long viticulture tradition (BEŠLIĆ *et al*., 2012). Although the grapevine assortments in Serbia is lot of rich (RAKONJAC *et al*., 2014), breeding work within this species is very intense (NIKOLIĆ *et al*., 2015). On the creation of new grapevine varieties with the aim of combining the desirable characteristics of the selected parental partners in the genotype of one of their descendants for many years working at the Faculty of Agriculture, University of Belgrade. Obtaining new high-yielding and high-quality cultivars with complex resistance, for various purposes and of different ripening time is the main objective of this breeding programme. Among the many crossing combinations for selection of resistant and quality genotypes intended for fresh consumption can be emphasized the combination Seedling 113 x Muscat Hamburg. The goal of this paper was to study the variability and mode of heredity of different qualitative and quantitative characteristics in this progeny, in order to facilitate work on the creation of new grapevine cultivars and improve the selection of hybrids of interest for future studies.

MATERIALS AND METHODS

All the investigations concerning this study were carried out at the experimental fields of the “Radmilovac” of the Faculty of Agriculture, University of Belgrade. The investigation included 45 seedlings of F_1 generation from the crossing combination of Seedling 113 x Muscat Hamburg. At the same time, with the hybrid seedlings, to establish the mode of heredity of the examined characteristics, their parental partners were investigated as well. Seedling 113 is interspecific hybrid resistant to the causal agent of most important diseases and Muscat Hamburg is the standard variety which is intended for fresh consumption.

Plants of each seedling from F_1 generation and parental partners were grown on their own roots. The vine and row spacings were 3.0 and 1.0 m, respectively. The training system was double horizontal cordon with mixed pruning. During the three year investigation period in the experimental vineyards, standard agrotechnical and protection measures against diseases and pests have been applied.

From the studied qualitative characteristics visually compared to the reference cultivars were determined: color of berry skin, flavor of berry, cluster resistance to *Botrytis cinerea* and leaf resistance to *Plasmopara viticola*. In full rippening time color of berry skin and flavor of berry on samples of 100 berries from 10 bunches were determined. Resistance to important fungal diseases agents (*Botrytis cinerea* and *Plasmopara viticola*) in hybrid seedlings and their parental partners were determined under conditions of natural infection. Before the harvest, different distribution of *Botrytis cinerea*, based on mean value of damages percentage in all clusters from 10 shoots, was used. Leaf resistance to *Plasmopara viticola* was determined visually, three weeks after blooming time based on damages percentage of 5^{th} and 6^{th} leaf, counted from the shoot top. Mean value of damages percentage of all leaves from 10 shoots were used.

From quantitative traits, yield per vine was determined by measuring total weight of all bunches from one vine, and then calculated grape yield per hectare. Bunch weight was determined on samples of 10 bunches, and berry weight on samples of 100 berries measured on the scale. Sugar content in must was determined using an Atago, Pocket PAL-1 digital refractometer (Atago, Tokyo, Japan).

For the purpose of phenotypic evaluation of all examined traits, the seedlings and their parental partners were classified into the categories using the OIV Descriptor list for grape varieties and *Vitis* species (OIV, 2009). The standard deviation (S) and the variation coefficient (V) were used as the variability parameters. The significance of differences among the experimental values and the theoretical values of monogenic segregation ratio 1:1 of qualitative characteristics were evaluated by χ^2-test and the mode of heredity for quantitative characters was evaluated by the t-test. All statistical analyses were performed using the software 'Statistica' (StatSoft, Inc., Tulsa, Oklahoma, USA).

RESULTS AND DISCUSSION

The data from Figure 1 relating to phenotypic distributions of qualitative characteristics show that the Seedling 113 had a green yellow and Muscat Hamburg had a blue black color of berry skin. Considering the progeny of these two cultivars, 57.8% seedlings had green yellow, 4.4% seedlings had red, 11.1% seedlings had dark red violet and 26.7% seedlings had blue black color of berry skin. For establishing the heredity of this feature, grades 3, 5 and 6 are classified as black color of berry skin, and grade 1 is marked with the category white color of berry skin. From 45 seedlings of F_1 generation, 19 seedlings had black color of berry skin and 26 seedlings had white color of berry skin. The χ^2-test results indicate that the color of berry skin is determined by one gene. The achieved ratio of seedlings with black color of berry skin to seedlings with white color of berry skin (19:26) in the F_1 generation can be considered as theoretically expected ratio of 1:1 (Table 1). These results are consistent with the results obtained by GOLDY *et al.* (1989) who are proposed that grape color was controlled by a single pair of genes where white was recessive, and red and other colors were dominant. The hypothesis of monogenic inheritance of color of berry skin are confirmed by studies AVRAMOV *et al*. (1996), MILUTINOVIĆ *et al*. (2000), NIKOLIĆ (2001), and BEŠLIĆ *et al*. (2005). However, BARRITT and EINSET (1969) who reported that grape color was controlled by two pairs of genes, the ‘two gene pair model’ as shown by several groups (SANDHU, 1988; LUO and HE, 2004). A dominant gene B for black grape was epistatic over a dominant gene R for red grape, i.e., when the two pairs of genes were recessive, the grape was white. According to this hypothesis, all grapes could be classified into white, red and black: bbrr the white grape genotype, bbRR and bbRr the red grape genotypes, and BBRR, BbRR, BBRr, BbRr, BBrr and Bbrr the black grape genotypes.

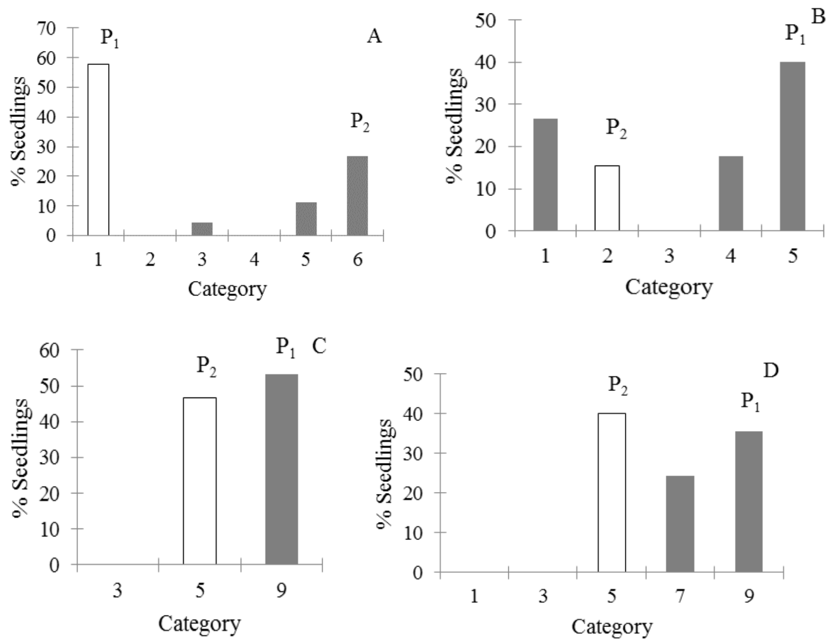

Figure 1. Distribution of the seedlings for different qualitative grapevine characteristics in hybrid progeny of cultivars Seedling 113 (P_1) and Muscat Hamburg (P_2); A) color of berry skin (1 - green yellow, 2 - rose, 3 - red, 4 - grey, 5 - dark red violet, 6 - blue black); B) flavor of berry (1 - none, 2 - muscat, 3 - foxy, 4 - herbaceous, 5 - other); C) cluster resistance to *Botrytis cinerea* (3 - very little or litle, 5 - medium, 9 - high or very high); D) Leaf resistance to *Plasmopara viticola* (1 - very low, 3 - low, 5 - medium, 7 - high, 9 - very high or total)

According to research by WAGNER (1967) inheritance of color of berry skin can be explained with at least three pairs of genes, predominantly complementary, of which two (XxYyzz, XxyyZz, xxYyZz) sufficient to give a red color. In contrast to him PENA and INDREAS (1980) showed that there are four loci that influence the color of berry skin: one for black, one for red, one for yellow and one for green. Each locus can be a complex locus with several suballels, or may have multiple allelic series which change the percentages of genetic recombination. SHI *et al*. (1984) classified all grape colors (including white) into nine subgroups belonging to three groups: (1) black, containing dark red, dark brown and dark blue; (2) purplish red, including red, purple and pink; and (3) white comprising cream color, yellowish green and dark green. Black and purplish red were dominant; red and purple were heterozygotes; white was a homozygous recessive. CARRENO and MARTÍNEZ (1995) cited that grape skin color is mainly decided by the composition and content of anthocyanins. Malvidin and petunidin derivatives are purple, peonidin and cyaniding derivatives are red, and delphinidin derivatives are blue (DENG and QU, 1996). The intensity of these colors depends upon the amount of anthocyanins, present in the grape skin. The presence or absence of anthocyanins in grape skin was inheritance of a quality character controlled by oligogenes (LIANG *et al*., 2009, 2012).

Table 1. The mode of heredity for different qualitative grapevine characteristics

Characteristic	Phenotype ratio			χ^2	
	Category	Achieved	Expected	Value	P
Color of berry skin	Black : White	19 : 26	1 : 1	1.1	>0.05
Flavor of berry	Nonmuscat : Muscat	38 : 7	1 : 1	21.34**	<0.01
Cluster resistance to *Botrytis cinerea*	Resistant : Nonresistant	24 : 21	1 : 1	0.20	>0.05
Leaf resistance to *Plasmopara viticola*	Resistant : Nonresistant	27 : 18	1 : 1	1.8	>0.05

**P<0.01

The flavor of berry is very often a complex trait and depends on many chemical components that are contained in the berries of a certain form of grapevine. Until today expressed several types of flavor of which are the most common: a) flavor characteristic of the chaselas, b) fox flavor, c) muscat flavor d) various other flavors that are often unclear, and which are in the berries of wild forms obtained by spontaneous crossing. The fox flavor is often present in the progeny obtained from the directly producer hybrids resistant to downy mildew, especially those whose one parent is species *Vitis labrusca*. It is dominant in the progeny and transmitted through several generations.

When it comes to the flavor of berry, in grapevine especially are significant varieties that are characterized by a pleasant muscat flavor. Obtaining hybrids with muscat flavor in the F_1 generation can easily be achieved when one of the parents has berries with muscat flavor (NIKOLIĆ, 2012). In our work, by crossing of Seedling 113 with other and Muscat Hamburg with muscat flavor of berry from 45 seedlings of F_1 generation 26.7% seedlings showed none, 15.5% seedlings showed muscat, 17.8% seedlings showed herbaceous, and 40.0% seedlings showed other flavor of berry (Figure 1). For establishing the heredity of this trait, grades 1, 4 and 5 are classified as nonmuscat flavor of berry. The achieved ratio of seedlings with nonmuscat flavor of berry and seedlings with muscat flavor of berry in the F_1 generation (38:7) considerably differed from theoretically expected 1:1 ratio, which corresponds to monogenic heredity (Table 1). Thus, one can conclude that a flavor of berry probably has polygenic heredity. Polygenic heredity for this character was determined by NIKOLIĆ (2001), and BEŠLIĆ *et al*. (2005), too.

The grapevine, among other manifests different susceptibility to diseases and pests. BORGO *et al*. (1990) reported that the downy mildew of grapevine caused by the fungus *Plasmopara viticola*, causing necrotic leaf tissue injury, flowers and berries, one of the major parasitic disease which causes serious damage to many vineyards. Similarly downy mildew and gray mould caused by the fungus *Botrytis cinerea*, is a disease that seriously reduces the yield and quality of grapes causing great damage to grape growing and winemaking in many countries of the world (WOLF *et al*., 1997). JEANDET *et al*. (2000) found that the resistance in grapevine at fungal penetration, especially penetration at *Botrytis cinerea*, determined rapid production of different types of phytoalexin compounds which belonging to the stilbene group. Among them resveratrol is quantitatively major component phytoalexin response of the grapevine, and as such it may be a good marker for diseases resistance (SÁRDI *et al*., 2000). Since the degree of sensitivity of individual genotypes depends primarily on hereditary basis in breeding work is important to determine the mode of heredity of resistance to deseases.

In our paper, Seedling 113 had high or very high cluster resistant to *Botrytis cinerea* and Muscat Hamburg had medium cluster resistant to *Botrytis cinerea*. From 45 seedlings of F_1 generation, 46.7% seedlings expressed medium (nonresistant) and 53.3% seedlings expressed high or very high cluster resistant to *Botrytis cinerea* (Figure 1). Twenty four seedlings were therefore with resistant and 21 seedlings were with nonresistant cluster to *Botrytis cinerea* (Table 1). χ^2-test results indicate that between obtained and theoretical expected ration of seedlings in the F_1 generation, slight deviation is occurs. On this basis, it can be concluded that the cluster resistance to *Botrytis cinerea* probably monogenic determined characteristic, which is contrary to the results BOUBALS (1976), who states that the cluster resistance to *Botrytis cinerea* polygenic determined traits.

Leaf resistance to *Plasmopara viticola* was also different in the parental partners. By crossing of Seedling 113 with very high or total leaf resistance to *Plasmopara viticola* and Muscat Hamburg with medium leaf resistance to *Plasmopara viticola* in obtained progeny 40.0% seedlings had medium, 24.4% seedlings had high and 35.6% seedlings had very high or total leaf resistance to *Plasmopara viticola* (Figure 1). For establishing the heredity of this feature, grades 7 and 9 are classified as resistant leaf to *Plasmopara viticola*, and grade 5 is marked with the category nonresistant leaf to *Plasmopara viticola*. The obtained ratio of resistant to nonresistant seedlings (27:18) in the F_1 generation can be considered as theoretically expected ratio of 1:1 that is valid for monogenic heredity (Table 1). That is in accordance to the results of FILIPPENKO and ŠTIN (1980). Contrary to these COSTACURTA *et al*. (1986), and CINDRIĆ *et al*. (1993) established polygenic control of resistance to *Plasmopara viticola.*

IONESCUE (1985) and SIVČEV *et al*. (2000) were showed that the grape yield is a complex feature consisting of quantity components which are polygenetic in character, and based on the great number of crosses KOZMA (1974) found that in the F_1 generation of grapevine prevailing low yield of grapes. This fact is confirmed by the results of our work which are shown in Figure 2 and Table 2. Muscat Hamburg expressed medium and Seedling 113 expressed high grape yield. Their progeny showed the following structure: 6.7% seedlings had very low, 62.2% seedlings had low, 22.2% seedlings had medium and 8.9% seedlings had high grape yield. The grape yield at Seedling 113 was 18889 kg/ha, and at Muscat Hamburg was 16573 kg/ha. Average for all seedling in F_1 generation grape yield was 12644 kg/ha. Since the t-test indicated that the mean value of grape yield in the F_1 generation was significantly lower than value for grape yield in Muscat Hamburg cultivar, one can conclude that in this crossing combination negative heterosis (-h) occurred in the heredity of this characteristic. NIKOLIĆ (2001) was also found negative heterosis for grape yield in the hybrid progeny Villard Noir x Muscat Hamburg.

The results in Figure 2 show that the bunch weight in obtained progeny ranged from very low (68.9% seedlings) to low (31.1% seedlings). Both parental partners had low bunch weight. In Seedling 113 average bunch weight was 232 g, and in Muscat Hamburg was 265 g (Table 2). The average bunch weight seedlings of F_1 generation was 183 g. Comparison of the mean value of the bunch weight seedling of F_1 generation and bunch weight parents showed that in the heredity of these trait appears negative heterosis (-h). These results differ from the results obtained by COSTACURTA *et al*. (1980) who determined the intermediary inheritance for bunch weight.

By crossing of Seedling 113 and Muscat Hamburg, both with medium berry weight in obtained progeny 4.4% seedlings had very low, 75.6% seedlings had low, and 20.0% seedlings had medium berry weight (Figure 2). From Table 2 it can be seen that the Seedling 113 had a berry weight of 4.5 g, and Muscat Hamburg had a berry weight of 4.3 g. The average berry weight in the F_1 generation was 2.9 g. When tested the mode of heredity of this trait was also established negative heterosis (-h). This is contrary to the results of MILUTINOVIĆ *et al*. (2000), and NIKOLIĆ (2001) who in investigated crossing combinations the partial domination of parent with low berry weight was determined.

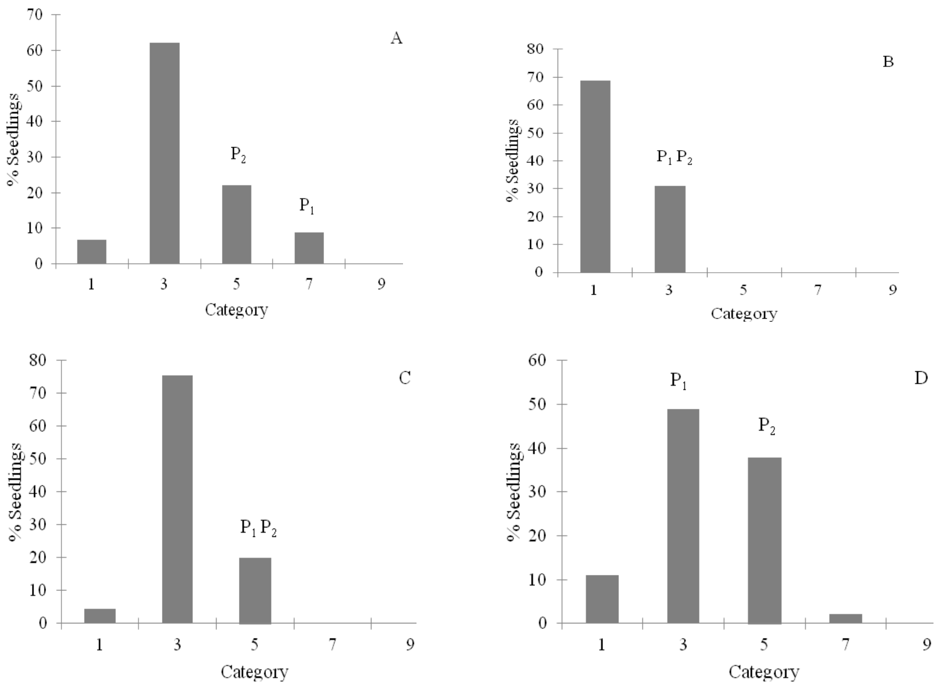

Figure 2. Distribution of the seedlings for different quantitative grapevine characteristics in hybrid progeny of cultivars Seedling 113 (P_1) and Muscat Hamburg (P_2); A) grape yield; B) bunch weight; C) berry weight; D) sugar content in must; (1 - very low, 3 - low, 5 - medium, 7 - high, 9 - very high)

Table 2. Average values of parents and F_1 generation, the mode of heredity and variability for different quantitative grapevine characteristics

Characteristic	Seedling 113	Muscat Hamburg	F_1		
			$\overline{X}$	S	V (%)
Grape yield (kg/ha)	18889	16573	12644 $^{-h}$	7450.0	58.9
Bunch weight (g)	232	265	183 $^{-h}$	63.1	34.5
Berry weight (g)	4.5	4.3	2.9 $^{-h}$	0.96	33.1
Sugar content in must (%)	16.8	20.9	17.5 $^{-d}$	2.9	16.3

d - domination, h - heterosis

The mode of heredity of sugar content in must is not yet reliably genetically determined, because this feature is one of the quantitative traits which depend on several factors. TODOROV (1987) stated that the sugar content in must of polygenic characteristic and that during its inheritance in the hybrid progeny is appear transgression. In addition, there are cases of intermediate heredity of this trait. CINDRIĆ (1981) cited that there is dependence in inheritance of sugar content in must from ecological and geographic origin of the cultivar. Namely, it was found that the high sugar content in must not to be expected from a group varieties of *Proles orientalis*, but varieties from group *Proles occidentalis*, and interspecific hybrids originating from *Vitis amurensis* their descendants transmitted high sugar content in must. In our paper, sugar content in must in Seedling 113 was low, while in Muscat Hamburg was medium. Considering the progeny of these two cultivars, 11.1% seedlings had very low, 48.9% seedlings had low, 37.8% seedlings had medium and 2.2% seedlings had high sugar content in must (Figure 2). Seedling 113 had 16.8%, and Muscat Hamburg had 20.9% sugar content in must. Average content sugar content in must in progeny of the F_1 generation was 17.5% (Table 2). Results of t-test showed that the heredity of this characteristic dominance of parent with low content of sugar content in must (-d) was determined, which is contrary to the results of NIKOLIĆ (2001) who in the crossing combination Villard Noir x Muscat Hamburg negative heterosis was established.

Of all the studied quantitative characteristics in our work, the greatest variability in the F_1 generation showed a grape yield (V=58.9%) and the least varied sugar content in must (V=16.3%). Varying the grape yield a high percentage (27.1% to 91.0%) in the F_1 generation was found IONESCUE (1985), and the small variability of sugar content in must (from 10.0% to 20.0%) is indicated CONSTANTINESCU *et al*. (1975).

CONCLUSION

On the basis of the investigation the variability and mode of heredity of some important qualitative and quantitative grapevine characteristics in hybrid progeny of Seedling 113 and Muscat Hamburg cultivars the following could be concluded:

Produced seedlings of F_1 generation showed a high degree of variability for almost all studied characteristics.

The heredity of the color of berry skin, cluster resistance to *Botrytis cinerea* and leaf resistance to *Plasmopara viticola* is monogenic, while the heredity of the flavor of berry is probably polygenic.

Negative heterosis was established for the grape yield, bunch weight and berry weight. The sugar content in must showed dominance of parent with low sugar content in must.

This study shows that high phenotypic variability for most of the studied traits found in this crossing combination may be useful in the development of new cultivars with improved attributes.

ACKNOWLEDGEMENTS

This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia Project TR 31063.

Received, December 20th, 2017
Accepted April 18th, 2018

REFERENCES

AVRAMOV, L.M., M.D., MILUTINOVIĆ, B.V., SIVČEV, N.M., GAŠIĆ, D.M., ŽUNIĆ, D.T., NIKOLIĆ, D.S., VUJOVIĆ (1996): Heredity of some berry characteristics in F_1 cross-breeding of grapevine variety Župa teinturier x Belgrade seedless. J. Wine Res., *7*(3): 197-200.

BARRITT, B.H. and J., EINSET (1969): The inheritance of three major fruit colors in grapes. J. Am. Soc. Hort. Sci., *94*(2): 87-89.

BAYO-CANHA, A., J.I., FERNÁNDEZ-FERNÁNDEZ, A., MARTÍNEZ-CUTILLAS, L., RUIZ-GARCÍA (2012): Phenotypic segregation and relationships of agronomic traits in Monastrell x Syrah wine grape progeny. Euphytica, *186*: 393-407.

BEŠLIĆ, Z., S., TODIĆ, V., RAKONJAC (2005): Inheritance of some morphological traits in hybridization of grapevine cultivars Drenak crveni and Afuz-Ali. Genetika, *37*(2): 137-144.

BEŠLIĆ, Z., S., TODIĆ, N., KORAĆ, S., LORENZI, F., EMANUELLI, M.S., GRANDO (2012): Genetic characterization and relationships of traditional grape cultivars from Serbia. Vitis, *51*(4): 183-189.

BORGO, M., S., CANCELLIER, A., COSTACURTA (1990): Search for genotypes resistant to *Plasmopara viticola* by crossbreeding. Proceedings of the 5th International Symposium on Grape Breeding, 12-16 September 1989, St. Martin/Pfalz, FR of Germany, pp. 254-261.

BOUBALS, D. (1976): Le point sur le *Botrytis* de la vigne. Biologie et méthodes de lutte. Prog. Agr. et Vitic., *93*(19): 561-571.

CARRENO, J. and A., MARTÍNEZ (1995): Proposal of an index for objective evaluation of the color of red table grapes. Food Res. Int., *28*: 373-377.

CINDRIĆ, P. (1981): Oplemenjivanje vinove loze. Poljoprivredni fakultet, Novi Sad. (Grapevine breeding.) (Faculty of Agriculture, Novi Sad.)

CINDRIĆ, P., N., KORAĆ, M., MEDIĆ (1993): Stvaranje kultivara vinove loze otpornih na gljivične bolesti. Zbornik radova Međunarodnog naučnog skupa zaštita životne sredine i poljoprivreda. Savremena Poljoprivreda, *1*(6): 97-100. (Production of cultivars of grapevine resistant to mycotic diseases.) (Proceedings of the International Scientific Conference on Environmental Protection and Agriculture. Contemporary Agriculture)

CONSTANTINESCU, G., A., PENA, A., INDREAS (1975): Ereditatea unor caractere calitative si cantitative la descendentele obtinute din incrucisarea soiurilor functional femele (ginodiname) cu soiuri apirene (androdiname). Probleme de Genetica Teoretica si Aplicata, *7*(4): 213-241. (Inheritance of some qualitative and quantitative characters in the progeny of crosses between functionally female (ginodynamic) and apyrene (androdynamic) varieties.)

COSTACURTA, A., S., CANCELLIER, R., DE LUCA (1980): Influenze genetiche nel determinismo del peso del grappolo in uve da tavola. Riv. Vitic. Enol., *33*(10): 481-485. (Genetic control of bunch weight in table grapes.)

COSTACURTA, A., S., CANCELLIER, L., CORINO, M., BORGO (1986): Resistenza a *Plasmopara viticola* in incroci di *Vitis vinifera* con ibridi. Riv. Vitic. Enol., *39*(12): 532-539. (Resistance to *Plasmopara viticola* in crosses of *Vitis vinifera* with hybrids.)

COSTANTINI, L., M.S., GRANDO, S., FEINGOLD, S., ULANOVSKY, N., MEJIA, P., HINRICHSEN, A., DOLIGEZ, P., THIS, J.A., CABEZAS, J.M., MARTINEZ-ZAPATER (2007): Generation of a common set of mapping markers to assist table grape breeding. Am. J. Enol. Vitic., *58*(1): 102-111.

DENG, J.Z. and H.G., QU (1996): Overview of anthocyanins in *Vitis*. Sino-Overseas Grapevine and Wine, *2*: 25-27.

DOLIGEZ, A., A., BOUQUET, Y., DANGLOT, F., LAHOGUE, S., RIAZ, C.P., MEREDITH, K.J., EDWARDS (2002): Genetic mapping of grapevine (*Vitis vinifera* L.) applied to the detection of QTLs for seedlessness and berry weight. TAG, *105*: 780-795.

EIBACH, R. and R., TÖPFER (2014): Progress in grapevine breeding. Acta Hortic., *1046*: 197-209.

FERNANDEZ, L., C., ROMIEU, A., MOING, A., BOUQUET, M., MAUCOURT, M.R., THOMAS, L., TORREGROSA (2006): The grapevine fleshless berry mutation. A unique genotype to investigate differences between fleshy and nonfleshy fruit. Plant Physiol., *140*: 537-547.

FILIPPENKO, I.M. and L.T., ŠTIN (1980): Selekcionno-genetičeskie issledovanija vinograda. Vestnik Selskohozjajstvennoj Nauki, *10*: 51-61. (Breeding and genetical studies on grape.) (Bulletin of Agricultural Science)

FIROOZABADY, E. and H.P. OLMO (1987): Heritability and correlation studies of certain quantitative traits in table grapes, *Vitis* spp. Vitis, *26*(3): 132-146.

GRAY, D.J., Z.T., LI, S.A., DHEKNEY (2014): Precision breeding of grapevine (*Vitis vinifera* L.) for improved traits. Plant Sci., *228*: 3-10.

GOLDY, R.G., E.P., MANESS, H.D., STILES, J.R., CLARK, M.A., WILSON (1989): Pigment quantity and quality characteristics of some native *Vitis-roundifolia* Michx. Am. J. Enol. Vitic., *40*(4): 253-258.

HADADINEJAD, M., A., EBADI, M.R., NAGHAVI, R., NIKKHAH (2011): Genealogy and molecular diversity of Iranian grapevine progenies. J. Agr. Sci. Tech., *13*: 1147-1161.

IONESCUE, A. (1985): Variabilitatea ereditara a productiei strugurilor pe butuc la hibrizii intraspecifici F_1 de vita de vie. Productia Vegetala, Horticultura, *34*(12): 18-21. (Inherited variability in grape yield per vine in intraspecific F_1 hybrids.)

JEANDET, P., M., ADRIAN, A.C., BREUIL, M., SBAGHI, S., DEBORD, R., BESSIS, L.A., WESTON, R., HARMON (2000): Chemical induction of phytoalexin synthesis in grapevines: application to the control of grey mould in the vineyard. Acta Hortic., *528*(2): 591-596.

KOZMA, P. (1974): A szolo teljesítoképessége növelésének lehetoségei keresztezéses nemesítéssel. Agrártudományi Közlemények, *33*(2-4): 241-268. (Possibilities of improving grapevine performance by hybridization.) (Agricultural Notices)

LIANG, Z., C., YANG, J., YANG, B., WU, L., WANG, J., CHENG, S., LI (2009): Inheritance of anthocyanins in berries of *Vitis vinifera* grapes. Euphytica, *167*: 113-125.

LIANG, Z., M., SANG, B., WU, A., MA, S., ZHAO, G.Y., ZHONG, S., LI (2012): Inheritance of anthocyanin content in the ripe berries of a tetraploid x diploid grape cross population. Euphytica, *186*: 343-356.

LODHI, M.A. and B.I., REISCH (1995): Nuclear DNA content of Vitis species, cultivars, and other genera of the *Vitaceae*. TAG, *90*: 11-16.

LU, J., L., SCHELL, D.W., RAMMING (2000): Interspecific hybridization between *Vitis rotundifolia* and *Vitis vinifera* and evaluation of the hybrids. Acta Hortic., *528*(2): 479-486.

LUO, S. and P., HE (2004): The inheritances of fruit skin and must colors in a series of interspecific and intraspecific crosses between *V. vinifera* and the wild grape species native to China. Sci. Hortic., *99*: 29-40.

MARGUERIT, E., C., BOURY, A., MANICKI, M., DONNART, G., BUTTERLIN, A., NÉMORIN, S., WIEDEMANN-MERDINOGLU, D., MERDINOGLU, N., OLLAT, S., DECROOCQ (2009): Genetic dissection of sex determinism, inflorescence morphology and downy mildew resistance in grapevine. TAG, *118*: 1261-1278.

MARTÍNEZ-ZAPATER, J.M., M.J., CARMONA, J., DÍAZ-RIQUELME, L., FERNÁNDEZ, D., LIJAVETZKY (2009): Grapevine genetics after the genome sequence: challenges and limitations. Aust. J. Grape Wine Res., *16*: 33-46.

MEJÍA, N., M., GEBAUER, L., MUÑOZ, N., HEWSTONE, P., HINRICHSEN (2007): Identification of QTLs for seedlessness, berry size, and ripening date in a seedless x seedless table grape progeny. Am. J. Enol. Vitic., *58*: 499-507.

MILUTINOVIĆ, M., D., NIKOLIĆ, L., AVRAMOV, V., RAKONJAC (2000): Recombination of some characteristics in F_1 generation of grapevine. Acta Hortic., *528*(2): 641-644.

NIKOLIĆ, D. (2001): Nasleđivanje nekih osobina vinove loze u hibridnom potomstvu sorti Villard Noir i Muskat Hamburg. J. Sci. Agric. Research, *62*(3-4): 5-13. (Inheritance of some grapevine properties in the hybrid progeny of Villard Noir and Muscat Hamburg cultivars.)

NIKOLIĆ, D. (2006): Components of variability and heritability of phenological phases in interspecies progenies of F_1 generation in grapevine. Genetika, *38*(1): 49-58.

NIKOLIĆ, D. (2012): Oplemenjivanje vinove loze. Fleš, Zemun. (Grapevine breeding.)

NIKOLIĆ, D., M., MILUTINOVIĆ, V., RAKONJAC, M., FOTIRIĆ (2009): Evaluation of resistance to low temperatures in promising interspecies grapevine hybrids. Acta Hortic., *827*: 461-464.

NIKOLIĆ, D., Z., RANKOVIĆ-VASIĆ, Z., ATANACKOVIĆ (2015): New Serbian grapevine genotypes for red wine production. Vitis, *54*: 165-168.

OIV (2009): Second edition of the OIV Descriptor list for grape varieties and *Vitis* species. Paris, France: Organisation International de la Vigne et du Vin.

PENA, A. and A., INDREAS (1980): Cercetari privind ereditatea culorii boabelor la vita de vie. Lucrari Stiintifice, Institutul Agronomic "Nicolae Balcescu", Horticultura, *23*: 95-97. (Investigation of the inheritance of berry colour in the grapevine.)

RAKONJAC, V., N., KORAĆ, S., TODIĆ, M., MEDIĆ, Z., BEŠLIĆ, I., KULJANČIĆ, D., IVANIŠEVIĆ, M., POPOV (2014): Genetic diversity of a Serbian grapevine germplasm collection based on morphoagronomic characteristics. Genetika, *46*(3): 719-730.

REGNER, F., R., HACK, C., EISENHELD (2004): Traditional and innovative grapevine breeding. Bulletin O.I.V., *77*(885-886): 811-819.

SANDHU, A.S. (1988): Inheritance of berry color in grapes (*Vitis vinifera*). J. Res. Punjab Agric. Univ., *25*(1): 37-39.

SÁRDI, É., J., KORBULY, ZS.K., VÉGHELY, E., MINCSOVICS (2000): Effect of different stresses on the resveratrol level in various parts of *Vitis* genotypes. Acta Hortic., *528*(2): 597-603.

SHI, Y., Y., LI, Q., WANG (1984): Mutation breeding of fruit tree. Shanghai Scientific and Technology Publisher, Shanghai, China.

SIVČEV, B., D., ŽUNIĆ, S., JOVIĆ (2000): Production-technological characteristics of some promising grapevine seedlings in the condition of Experimental Station "Radmilovac". J. Agric. Sci., *45*(2): 93-99.

TODOROV, D.I. (1987): Sort Bolgar v selekcijata na lozata (*Vitis vinifera* L.). Blgarskata Akademija na Naukite, Sofija. (The Bolgar variety in the selection of the vine (*Vitis vinifera* L.) (Bulgarian Academy of Sciences, Sofia)

WAGNER, R. (1967): Étude de quelques disjonctions dans des descendances de Chasselas, Muscat Ottonel et Muscat a petits grains. Vitis, *6*(4): 353-363. (A study of some genetic segregations in progenies of Chasselas, Muscat Ottonel and Muscat a petits grains.)

WEI, X., S.R., SYKES, P.R., CLINGELEFFER (2003): Effects of selection on early stage genetic evaluation for berry weight in breeding table grapes. Plant Breeding, *122*: 77-82.

WELTER, L.J., M.S., GRANDO, E., ZYPRIAN (2011): Basics of grapevine genetic analysis. In: KOLE, C. (Ed.), Genetics, genomics, and breeding of grapes. 1st eds. Science Publishers, New Hampshire, pp. 137-159.

WOLF, T.K., A.B.A.M., BAUDOIN, N., MARTINEZ-OCHOA (1997): Effect of floral debris removal from fruit clusters on *botrytis* bunch rot of Chardonnay grapes. Vitis, *36*(1): 27-33.

VARIJABILOST I NASLEĐIVANJE NEKIH KVALITATIVNIH I KVANTITATIVNIH OSOBINA VINOVE LOZE

Dragan NIKOLIĆ[1], Tijana BANJANIN[2], Zorica RANKOVIĆ-VASIĆ[1]

[1]Univerzitet u Beogradu, Poljoprivredni fakultet, Beograd, Srbija
[2]Univerzitet u Istočnom Sarajevu, Poljoprivredni fakultet, Bosna i Hercegovina

Izvod

U ovom radu proučavani su varijabilnost i način nasleđivanja važnijih kvalitativnih i kvantitativnih osobina vinove loze kod 45 sejanaca F_1 generacije iz kombinacije ukrštanja Sejanac 113 x Muskat hamburg. Za sve ispitivane osobine sejanci F_1 generacije svrstani su u određen broj kategorija pomoću OIV metode. Kao pokazatelji varijabilnosti upotrebljeni su standardna devijacija (S) i koeficijent varijacije (V). Ocena načina nasleđivanja proučavanih osobina obavljena je pomoću χ^2 testa i t-testa. Među proučavanim osobinama najveću varijabilnost ispoljio je prinos grožđa (V=58,9%), a najmanju sadržaj šećera u širi (V=16,3%). Za boju pokožice bobice, otpornost grozda na *Botrytis cinerea* i otpornost lista na *Plasmopara viticola* ustanovljeno je monogensko nasleđivanje. Odstupanje od monogenskog nasleđivanja utvrđeno je za ukus bobice. Prinos grožđa, masa grozda i masa bobice pokazali su negativan efekat heterozisa. Za sadržaj šećera u širi utvrđena je dominacija roditelja sa niskim sadržajem šećera u širi.

Primljeno 20.XII.2017.
Odobreno 18. IV. 2018.