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ORIGINAL PAPER

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INHERITANCE AND PHENOTYPIC CORRELATIONS OF AGRONOMIC TRAITS IN GRAPEVINE OFFSPRINGS

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ABSTRACT

The mode of inheritance and the degree of phenotypic correlation between some more important agronomic traits in two offsprings obtained by direct and reciprocal crossing of cultivars 'Smederevka' and 'Gewurztraminer' were investigated in this study. In 62 genotypes from direct crossing (Smederevka × Gewurztraminer) and 66 genotypes from reciprocal crossing (Gewurztraminer × Smederevka), the traits evaluated were as follows: time of bud burst, flowering time, ripening time, bunch weight, berry weight, grape yield, sugar content of must and total acidity of must. The genotypes of F_1 generation for the investigated traits were arranged into a number of categories by the OIV method. In both crossing combinations (direct and reciprocal) for most traits, the same mode of inheritance (partial dominance, dominance or heterosis) was determined. Differences in the mode of inheritance, depending on whether the parental varieties were used as a father or mother, were found only for ripening time (partial dominance and intermediate inheritance). The prevailing mode of inheritance established for most of studied traits, regardless of the crossing method, was negative heterosis. From all examined traits, a significant influence of maternal effect was determined for the inheritance of flowering time and ripening time. In both crossing combinations, statistically significant phenotypic correlations were found between some studied traits.

Key words: *Vitis vinifera*, F_1 generation, phenological phases, yield components, quality

INTRODUCTION

Genetic-statistical analysis of parental partners and produced offspring, which among others, includes determining the mode of inheritance and form of traits correlation, is an important step in the breeding work of grapevine. However, these analyses are still difficult to perform in grapevine due to a long juvenility growth period, large chromosome numbers, partial sterility of ovules, and low seed germination rates [Hadadinejad et al. 2011].

Few traits of viticultural importance are controlled by single genes or genes of major effect, including berry color [Doligez et al. 2002, Fischer et al. 2004], flesh development [Fernandez et al. 2006], flower hermaphroditism [Dalbó et al. 2000, Marguerit et al. 2009], and seedlessness [Doligez et al. 2002, Mejía et al. 2007]. Many traits of agricultural significance exhibit quantitative inheritance, which is often the result of multiple genes of minor effect [Costantini et

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al. 2009, Martínez-Zapater et al. 2010, Welter et al. 2011, Bayo-Canha et al. 2012].

During genetic analysis, it is also important to study the effect of cytoplasmatic factors (maternal effect) in the inheritance of a given trait. The most reliable data on maternal effect in the inheritance of a trait can be achieved by comparing the progeny obtained by direct and reciprocal crossing of two parental lines [Nikolić 2012].

It is known that modern grapevine breeding is based on the recombination of a large number of traits simultaneously. It is therefore of exceptional importance to determine the extent of their interdependence. The establishment of correlations between traits might reduce the number of characters that need to be evaluated in future genotypes or progenies. Furthermore, it is important to know these correlations given that the improvement of one trait could have unfavorable impact on other traits. Previous studies revealed the relationships between some of the quality parameters in grapevine [Firoozabady and Olmo 1987, Jones and Davis 2000, Wei et al. 2002, Fanizza et al. 2005, Costantini et al. 2008, Leão et al. 2010, Shiraishi et al. 2010, Bayo-Canha et al. 2012, Song et al. 2014].

Hybridization is the most suitable method for creating the new varieties of grapevine and research the mode of inheritance of certain traits [Nikolić 2012]. Breeding objectives varied by region and market class of grapes [Hadadinejad et al. 2011]. Intervarietal crossbreeding and bud mutation are still the best ways for developing new cultivars in grape breeding [Benéyei et al. 2003, Gómez-Plaza et al. 2008, Clark 2010]. Polyploid breeding and interspecific hybridization are also used [Lu et al. 2000, Luo and He 2004, Nikolić et al. 2009, Liang et al. 2012, Sinski et al. 2014].

New grapevine cultivars have been created for many years at the Experimental Station "Radmilovac", of the Faculty of Agriculture, University of Belgrade. A starting material used for the hybridization and selection of new genotypes, among others, is 'Smederevka' cultivar. 'Smederevka' is an autochthonous Serbian variety that is intended for producing the quality white wines. It is very suitable for blending with wines of other varieties, particularly those the acidity of which is to be corrected. On the other hand, the wine of 'Gewurztraminer' variety is very characteristic, highly aromatic, usually with low acid contents. Therefore, in order to get new, better genotypes, reciprocal crossings of these varieties were carried out. The goal of this work was to study the variability and inheritance of different agronomic traits in their offsprings, to determine the effect of cytoplasm factors in the expression of traits as well as the correlations between these traits, so as to improve the selection of hybrids of interest for future studies.

MATERIAL AND METHODS

Location of the experiment. All the investigations were carried out at the experimental field of "Radmilovac" (44°45'24.66" N; 20°34'54.50" E), of the Faculty of Agriculture, University of Belgrade during three consecutive years (2013–2015). Meteorological parameters (air temperature and precipitation) depended on the year of investigation. Mean annual air temperature varied from 12.5°C (2013) to 12.7°C (2014 and 2015). The hottest month was July 2015 with a mean monthly temperature of 24.6°C. The coldest was December 2013 (1.9°C) (Fig. 1). Precipitation varied between the examined years from 569 mm (2013) to 918 mm (2014). A significant increase in the total monthly sum of precipitation was recorded in May 2014 (266 mm) (Fig. 2).

Plant material. Two offsprings obtained by hybridization between wine grape cultivars 'Smederevka' and 'Gewurztraminer' were used in this study. Offspring of 62 genotypes resulting from direct crossing (Smederevka × Gewurztraminer) and offspring of 66 genotypes resulting from reciprocal crossing (Gewurztraminer × Smederevka) were used for genetic analysis. At the same time, together with 128 genotypes from the F_1 generation, to establish the mode of inheritance of the examined traits, their parental partners were studied as well. Plants of each genotype 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 investigated period in the experimental vineyard, standard agrotechnical and protection measures against diseases and pests were applied.

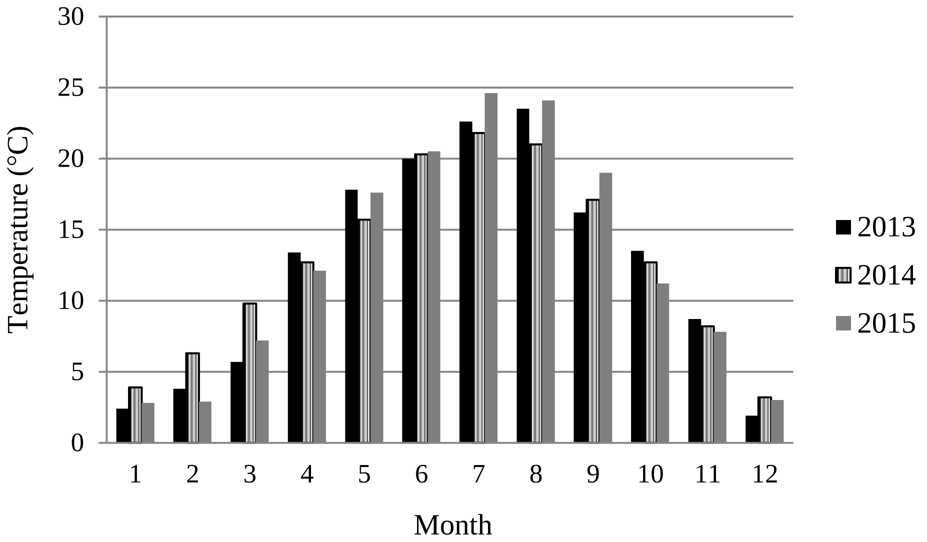

Fig. 1. Mean monthly air temperatures in 2013, 2014 and 2015 at the experimental field of "Radmilovac"

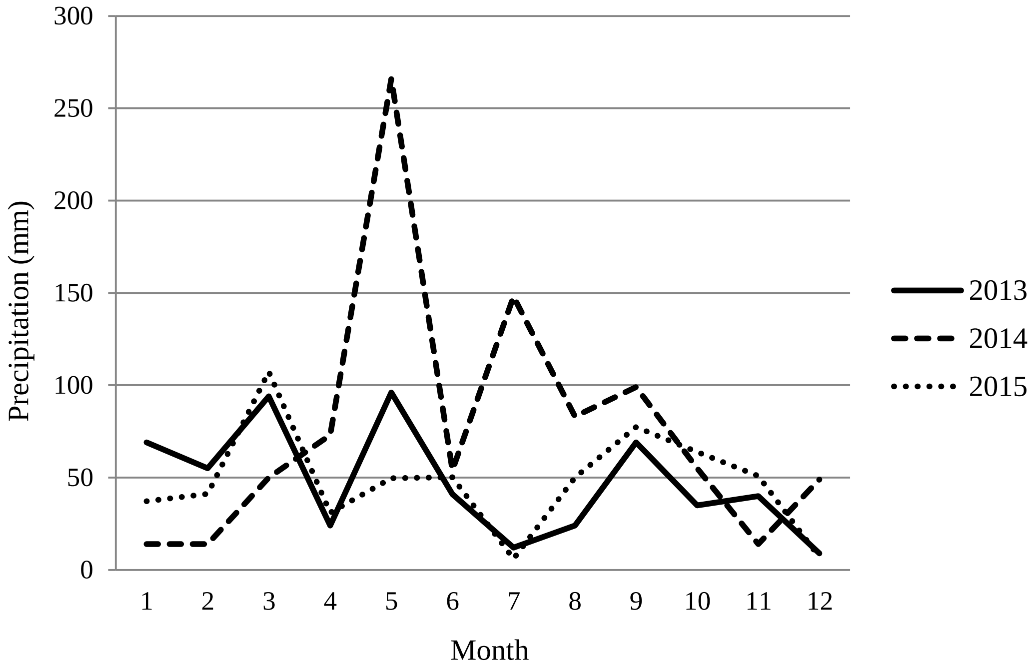

Fig. 2. Mean monthly sums of precipitation in 2013, 2014 and 2015 at the experimental field of "Radmilovac"

Determination of traits. Agronomic traits such as: time of bud burst, flowering time, ripening time, bunch weight, berry weight, grape yield, sugar content of must and total acidity of must at each investigated genotype and parental partner were evaluated. The time of bud burst was recorded on the date when 50% of buds of vine were opened, flowering time was recorded on the date when 50% of flowers in inflorescence were opened, and ripening time was the time of harvest at commercial maturity. Bunch and berry weight were determined by measurement on a digital scale using samples of 10 bunches and 100 berries. Yield per vine was determined by measuring the total weight of all bunches from vine, and then grape yield per m^2 was calculated. Sugar content of must was determined using an Atago, Pocket PAL-1 digital refractometer (Atago, Tokyo, Japan), and total acidity of must was established by titration with n/4NaOH. For the purpose of phenotypic evaluation of all examined traits, the genotypes and their parental partners were classified into the categories using the OIV Descriptor list for grape varieties and *Vitis* species [OIV 2009].

Statistical analysis. All values of analyzed traits in this study are shown as mean values of the parents and their offspring over three vintages. By comparing mean values of the offspring with one of the parents, or with mean value of the parents, using t-test, the mode of traits inheritance was determined. If the mean value of F_1 generation did not significantly differ from mean value of the parents, it was taken as an intermediate (i) mode of inheritance; if the average value of F_1 generation significantly deviated from the average parental value and the value of one of the parents, it was estimated as partial dominance (pd); if the deviation of the mean value of F_1 generation from value of one of the parents was not significant, it was taken as a case of dominance (d); if the mean value of the F_1 generation was significantly higher than parent with higher value or significantly lower than parent with lower value, it was rated as positive or negative heterosis (h). By t-testing the significance of differences of mean values in the F_1 offspring, obtained by direct or reciprocal crosses, the presence of maternal effect in the inheritance of traits was determined. The correlation between studied traits was calculated by the Pearson test at $P < 0.01$ and $P < 0.05$. All statistical analyses were performed using the software 'Statistica' (StatSoft, Inc., Tulsa, Oklahoma, USA).

RESULTS

The phenotypic data distributions for three phenological traits are shown in Fig. 3. Twenty-two point six percent of the genotypes in the offspring of F_1 generation obtained by direct crossing were distributed in the very early, 74.2% in the early and 3.2% in the medium time of bud burst. In the combination of reciprocal crossing, 45.4% of genotypes had very early, 44.0% early and 10.6% medium time of bud burst. 'Smederevka' showed very early and 'Gewurztraminer' medium time of bud burst. As for flowering time, in the combination of direct crossing, 44.8% of genotypes were very early, 53.8% early and 1.4% medium, while in the combination of reciprocal crossing, 74.2% of the genotypes were very early, 24.3% early and 1.5% medium. 'Gewurztraminer' had early and 'Smederevka' medium flowering time. In the combination of direct crossing, the ripening time ranged from medium (21.0% genotypes) to late (79.0% genotypes). In the combination of reciprocal crossing, 86.4% of genotypes had medium and 13.6% late ripening time. 'Gewurztraminer' showed medium and 'Smedere-vka' late ripening time.

The distribution of yield components is shown in Fig. 4. In both crossing combinations (direct and reciprocal), bunch weight ranged from very low (82.3%; 75.8% genotypes) to low (17.7%; 24.2% genotypes). 'Gewurztraminer' had very low and 'Smederevka' low bunch weight. With respect to berry weight, in the combination of direct crossing, 58.2% of the genotypes had very low and 41.8% low, while in combination of reciprocal crossing, 60.7% of genotypes had very low and 39.3% low berry weight. 'Gewurztraminer' had very low and 'Smederevka' low berry weight. Six point five percent of genotypes in the offspring obtained by direct crossing were distributed in very low, 69.3% in low, 22.6% in medium and 1.6% in high grape yield. In the combination of reciprocal crossing, 6.1% of the genotypes had very low, 56.0% low, 31.8% medium and 6.1% high grape yield. 'Gewurztraminer' exhibited medium and 'Smederevka' high grape yield.

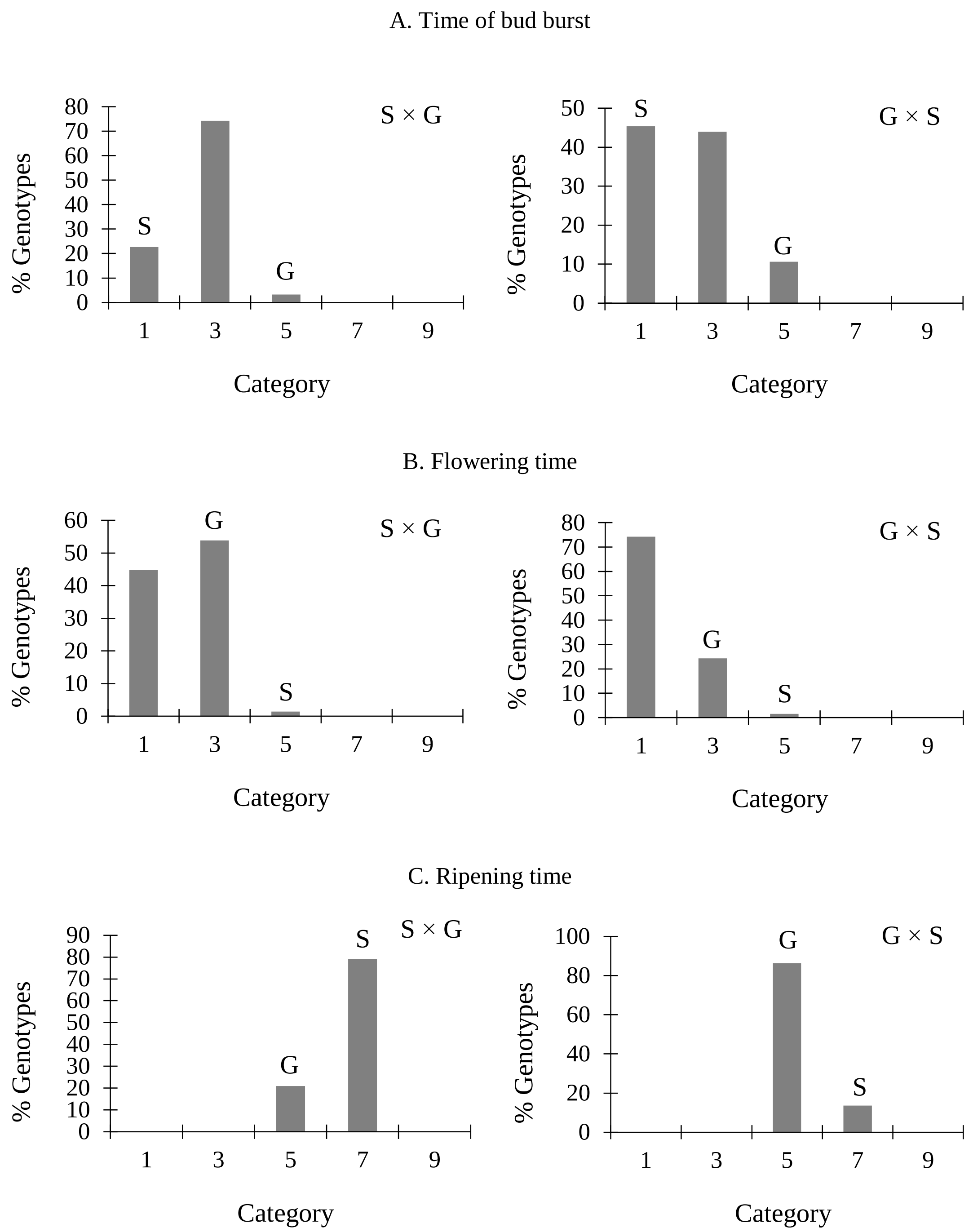

Fig. 3. Distribution of the genotypes for different phenological traits of grapevine in hybrid offspring obtained by direct and reciprocal crossing of cultivars 'Smederevka' (S) and 'Gewurztraminer' (G). Category is indicated as: 1 – very early, 3 – early, 5 – medium, 7 – late, 9 – very late

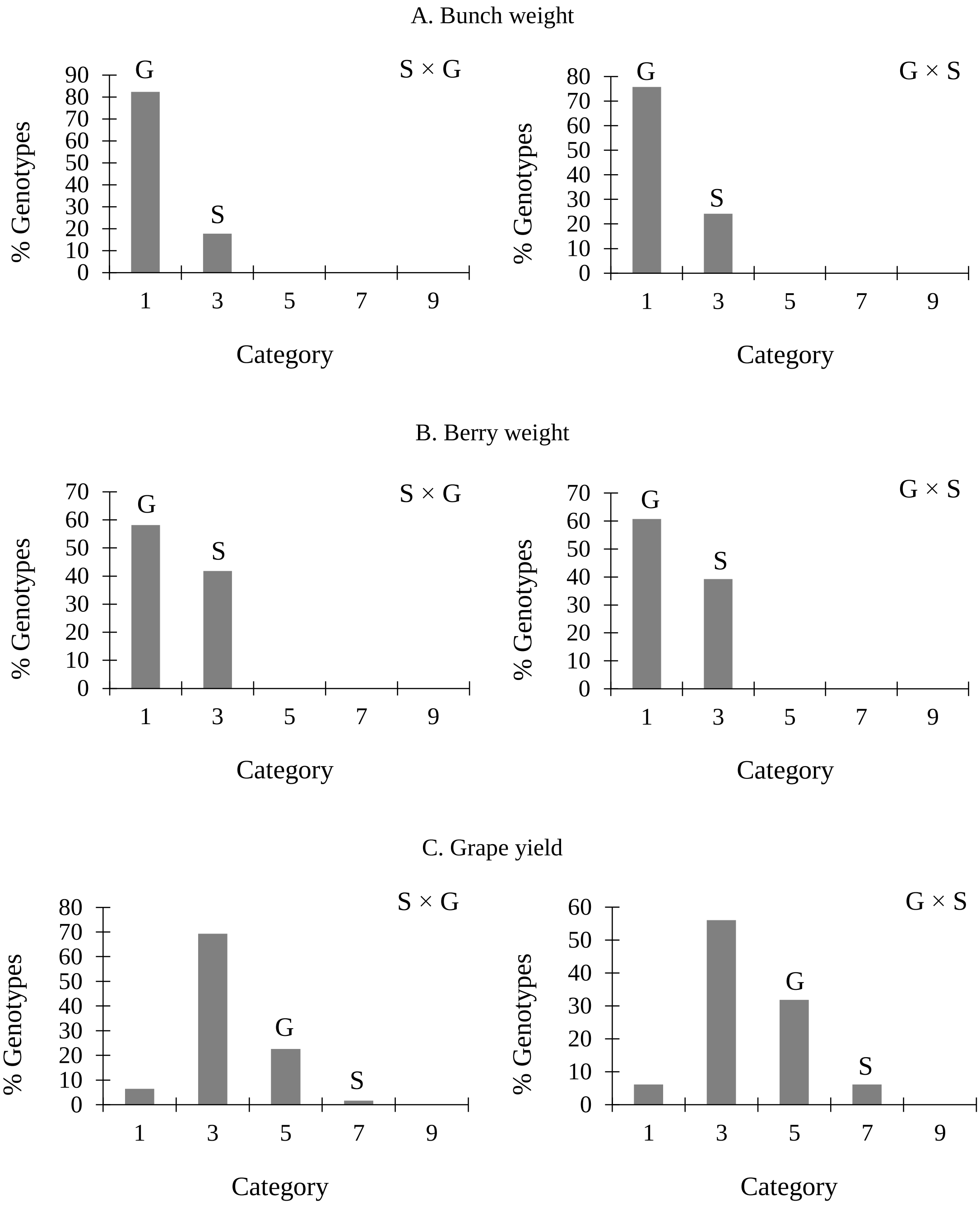

Fig. 4. Distribution of the genotypes for different yield components of grapevine in hybrid offspring obtained by direct and reciprocal crossing of cultivars 'Smederevka' (S) and 'Gewurztraminer' (G). Category is indicated as: 1 – very low, 3 – low, 5 – medium, 7 – high, 9 – very high

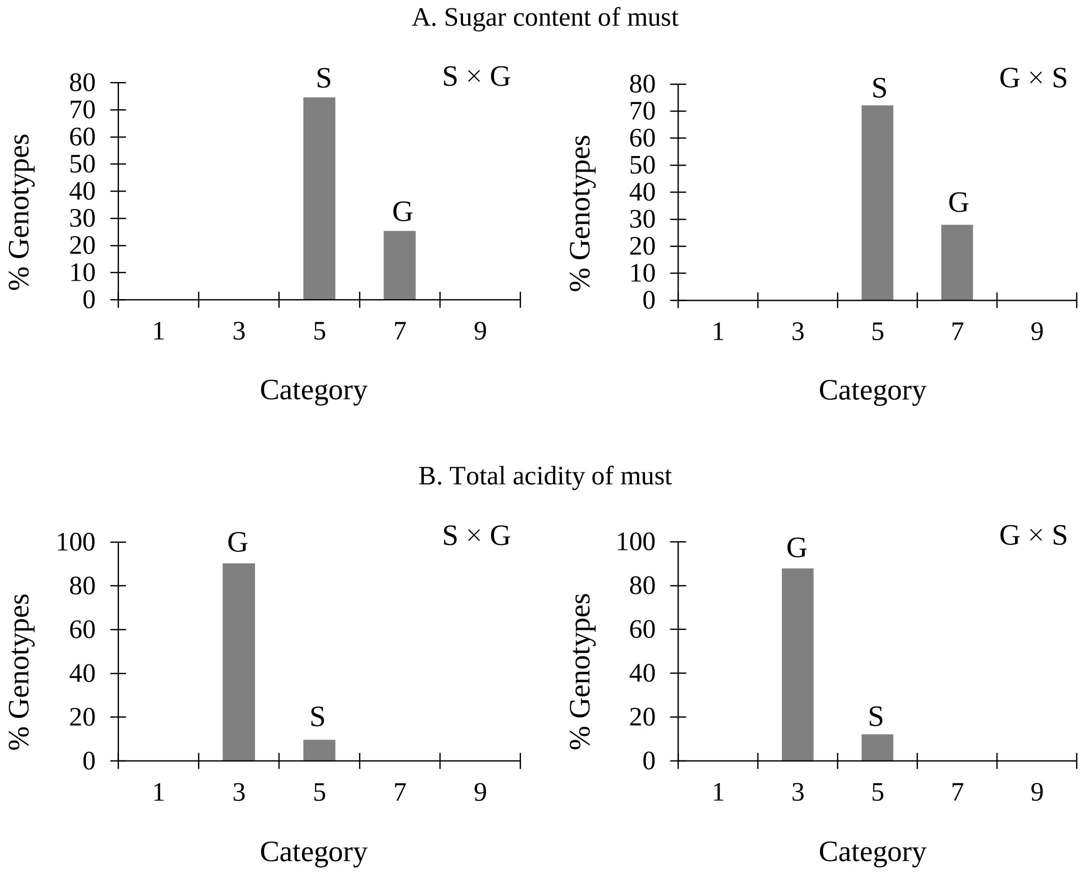

Fig. 5. Distribution of the genotypes for different technological traits of grapevine in hybrid offspring obtained by direct and reciprocal crossing of cultivars 'Smederevka' (S) and 'Gewurztraminer' (G). Category is indicated as: 1 – very low, 3 – low, 5 – medium, 7 – high, 9 – very high

Sugar content of must in 'Smederevka' was medium, while in 'Gewurztraminer' was high (Fig. 5). In the combination of direct crossing, sugar content of must ranged from medium (74.6% genotypes) to high (25.4% genotypes). In the combination of reciprocal crossing, 72.1% of genotypes had medium and 27.9% high sugar content of must. Regarding total acidity of must, in the combination of direct crossing, 90.3% of the genotypes had low and 9.7% medium, while in the combination of reciprocal crossing, 87.9% of genotypes had low and 12.1% medium total acidity of must. 'Gewurztraminer' had low and 'Smederevka' had medium total acidity of must.

Data in Tab. 1 show that the average time of bud burst in 'Smederevka' cultivar was 9th April and for 'Gewurztraminer' cultivar it was 18th April. The offspring of F_1 generation from both crossing combinations (direct and reciprocal) had the same time of bud burst (14th April). When testing the mode of inheritance of this trait in both crossing combinations, partial dominance of the parent with later time of bud burst (pd) was determined. 'Smederevka' cultivar had later flowering and ripening dates (30th May; 25th September, respectively) than 'Gewurztraminer' cultivar (25th May; 6th September). The average flowering and ripening time in the offspring of F_1 generation obtained by direct cross-

Table 1. Mean values of parental partners and offspring, mode of inheritance and maternal effect of phenological traits of grapevine in hybrid offspring obtained by direct and reciprocal crossing of cultivars 'Smederevka' and 'Gewurztraminer'

Trait	Parents		Direct crossing $F_{1(P1 \times P2)}$	Reciprocal crossing $F_{1(P2 \times P1)}$	Maternal effect
	Smederevka (P_1)	Gewurztraminer (P_2)	Average	Average	
Time of bud burst (date)	09.04	18.04	14.04^{pd}	14.04^{pd}	0
Flowering time (date)	30.05	25.05	23.05^{-h}	22.05^{-h}	1**
Ripening time (date)	25.09	06.09	18.09^{pd}	16.09^{i}	2**

^{pd} partial dominance, ^{h} heterosis, ^{i} intermediate
** significant at the 1% level, respectively

Table 2. Mean values of parental partners and offspring, mode of inheritance and maternal effect of yield components and technological traits of grapevine in hybrid offspring obtained by direct and reciprocal crossing of cultivars 'Smederevka' and 'Gewurztraminer'

Trait	Parents		Direct crossing $F_{1(P1 \times P2)}$	Reciprocal crossing $F_{1(P2 \times P1)}$	Maternal effect
	Smederevka (P_1)	Gewurztraminer (P_2)	average	average	
Bunch weight (g)	252.45	103.56	84.69^{-h}	89.46^{-h}	4.77
Berry weight (g)	3.25	1.48	1.88^{-pd}	1.81^{-pd}	0.07
Grape yield (kg m^{-2})	2.10	1.03	0.71^{-h}	0.87^{-h}	0.16
Sugar content of must (%)	19.34	22.48	19.20^{-d}	19.11^{-d}	0.09
Total acidity of must (g l^{-1})	8.10	6.95	6.17^{-h}	6.02^{-h}	0.15

^{pd} partial dominance, ^{d} dominance, ^{h} heterosis

Table 3. Phenotypic correlations among agronomic traits (Pearson correlation coefficient) averaged over three years in hybrid offspring obtained by direct (above diagonal) and reciprocal (below diagonal) crossing of cultivars 'Smederevka' and 'Gewurztraminer'

Trait	Time of bud burst	Flowering time	Ripening time	Bunch weight	Berry weight	Grape yield	Sugar content of must	Total acidity of must
Time of bud burst		0.850**	0.719**	–0.055	0.101	0.043	0.052	–0.339**
Flowering time	0.907**		0.846**	–0.180	0.054	–0.050	0.154	–0.494**
Ripening time	0.735**	0.878**		–0.298*	0.016	–0.081	0.043	–0.457**
Bunch weight	–0.064	–0.170	–0.083		0.447**	0.553**	0.042	0.053
Berry weight	–0.233	–0.337**	–0.236	0.517**		0.374**	0.004	–0.073
Grape yield	–0.084	–0.113	–0.022	0.561**	0.486**		0.190	–0.050
Sugar content of must	0.046	0.007	–0.062	0.020	0.025	0.038		–0.214
Total acidity of must	–0.400**	–0.380**	–0.364**	0.171	0.282*	0.112	–0,331**	

$^{*}p < 0.05$, $^{**}p < 0.01$

ing (23rd May; 18th September) were higher than in the offspring of reciprocal crossing (22nd May; 16th September, respectively). Comparison of mean values between the flowering time of the offspring from both crossing combinations and the flowering time of parents showed that negative heterosis (-h) appeared in the inheritance of this trait. For ripening time in the combination of direct crossing, partial dominance of parent with later ripening time (pd) was determined, and for the combination of reciprocal crossing, the intermediate mode of inheritance (i) was determined. Among studied phenological traits, the presence of maternal effect was found for the flowering time and ripening time.

'Smederevka' and 'Gewurztraminer' cultivars varied very much in terms of the bunch weight, berry weight and grape yield (Tab. 2). The offspring of F_1 generation obtained by direct crossing had higher berry weight, and the offspring of F_1 generation obtained by reciprocal crossing had higher bunch weight and grape yield. Comparison of mean values of the bunch weight and grape yield of offspring from both crossing combinations and bunch weight and grape yield of parents indicated that in the inheritance of these two traits, negative heterosis (-h) appeared. When testing the mode of inheritance of the berry weight in both crossing combinations, partial dominance of the parent with low berry weight (-pd) was found. The sugar content of must and total acidity of must in 'Smederevka' cultivar were 19.34% and 8.10 g l^{-1}, and in 'Gewurztraminer' cultivar, they were 22.48% and 6.95 g l^{-1}. The average sugar content of must and total acidity of must in the offspring of F_1 generation obtained by direct crossing (19.20%; 6.17 g l^{-1}) were higher than in the offspring of reciprocal crossing (19.11%; 6.02 g l^{-1}). In the combination of direct and reciprocal crossing in the inheritance of sugar content of must, the dominance of the parent with low sugar content of must (-d) was established, while in the inheritance of total acidity of must, negative heterosis (-h) was found. Data in Tab. 2 suggest that none of the yield components and technological traits showed maternal effect in their heredity.

Based on the results shown in Tab. 3, it can be seen that among twenty-eight trait combinations, seventeen correlations in the combination of direct crossing and fourteen correlations in the combination of reciprocal crossing were below 0.200.

In both crossing combinations (direct and reciprocal), significant ($p < 0.01$) positive correlation coefficients were found between: time of bud burst and flowering time ($r = 0.850^{**}$; $r = 0.907^{**}$), time of bud burst and ripening time ($r = 0.719^{**}$; $r = 0.735^{**}$), flowering time and ripening time ($r = 0.846^{**}$; $r = 0.878^{**}$), bunch weight and berry weight ($r = 0.447^{**}$; $r = 0.517^{**}$), bunch weight and grape yield ($r = 0.553^{**}$; $r = 0.561^{**}$) and berry weight and grape yield ($r = 0.374^{**}$; $r = 0.486^{**}$), and significant ($p < 0.01$), but negative correlation coefficients between: time of bud burst and total acidity of must ($r = –0.339^{**}$; $r = –0.400^{**}$), flowering time and total acidity of must ($r = –0.494^{**}$; $r = –0.380^{**}$) and ripening time and total acidity of must ($r = –0.457^{**}$; $r = –0.364^{**}$).

In addition, a significant ($p < 0.05$) negative correlation coefficient in the combination of direct crossing was found between ripening time and bunch weight ($r = –0.298^{*}$), and significant ($p < 0.01$) negative correlation coefficients in the combination of reciprocal crossing were determined between: flowering time and berry weight ($r = –0.337^{**}$), and sugar content of must and total acidity of must ($r = –0.331^{**}$).

On the other hand, a significant ($p < 0.05$) positive correlation coefficient in the combination of reciprocal crossing was established between berry weight and total acidity of must ($r = 0.282^{**}$). The correlation coefficients among other traits were not significant.

DISCUSSION

The choice of parental partners for crossing in this work was appropriate considering divergent cultivars that were different in most of the analyzed traits. In 'Smederevka' cultivar, earlier time of bud burst was found, but later flowering and ripening time compared to 'Gewurztraminer' cultivar. The differences were especially noticeable in regard to bunch weight, berry weight and grape yield, for which it was established that 'Smederevka' cultivar has two or more times higher values for mentioned traits than

'Gewurztraminer' cultivar. Less differences between these two cultivars were recorded for sugar content of must and total acidity of must. Similar values for most of these traits in 'Smederevka' and 'Gewurztraminer' cultivars were determined by Cindrić et al. [1994].

Most of the evaluated phenological, productive, morphological, and enological parameters displayed continuous variation within the progeny, suggesting a polygenic inheritance [Bayo-Canha et al. 2012]. Polygenic inheritance of these traits was confirmed by Wei et al. [2002], Liu et al. [2007], Costantini et al. [2008], Liang et al. [2009], and Duchêne et al. [2012]. By analyzing the variability and mode of inheritance of the phenological, productive and technological traits in our work, it can be seen that genotypes of F_1 generation for the studied traits were placed into a number of categories by the OIV method. Negative heterosis was manifested as the prevalent type of inheritance. This type of inheritance was established for the flowering time, bunch weight, grape yield and total acidity of must. Besides, for most other traits, the assessment was done to include dominance (for sugar content of must) or partial dominance (for berry weight) of parents, which have lower values for a given trait. This is consistent with the results of Nikolić [2001], who also found negative heterosis for grape yield and partial dominance for berry weight of parent with low berry weight in hybrid progeny Villard Noir × Muscat Hamburg. Dominance of worse parent in the inheritance of grapevine traits was established by Milutinović et al. [2000] for bunch and berry weight. Partial dominance of the parent with higher value was determined in our work only for the time of bud burst. If one takes into account the fact that all the investigated properties in our work (phenological, productive and technological) are complex traits, then the mode of their inheritance may be the same or completely different in other crossing combinations of the grapevine.

Also, a tendency was observed that most traits are inherited by the same type of crossing, by both direct and reciprocal crossing. Only for ripening time there is a difference in the mode of inheritance, depending on which cultivar is used as a mother. Thus, in direct crossing, partial dominance of later parent ('Smederevka' cultivar) was manifested, whereas in the reciprocal crossing, the intermediate type of inheritance was displayed. The intermediate mode of inheritance of ripening date was also found by Nikolić [1997].

Similar mean values for the offsprings and the same mode of inheritance for most traits identified in both direct and reciprocal crossing proved the absence of maternal effects. Only for flowering and ripening time, the difference between mean values of the offspring direct and reciprocal crossings were very significant, indicating the presence of maternal effects.

Phenotypic correlations between the traits of interest may be used to reduce the number of these to be evaluated in future studies. Also, phenotypic correlations between traits may also restrict breeding progress given that the improvement of one trait could have unfavorable impact on other ones. Thus, it is important to know the relationships between the traits of interest and to define the breeding objectives [Bayo-Canha et al. 2012].

Obtained positive correlation coefficients in our work, in both crossing combinations, between the time of bud burst and flowering time, the time of bud burst and ripening time, and flowering time and ripening time suggest that the stages of development of grapevine have a similar duration, so that the genotypes start earlier moving with vegetation, earlier blooming and earlier maturing than genotypes which commence the phenophase of bud burst later. This is in accordance with results of Bock et al. [2011], who stated that the time of bud burst significantly correlated with the ripening date.

In accordance with results of Firoozabady and Olmo [1987], Goldy [1988], and Bayo-Canha et al. [2012] as well as our work, in both crossing combinations, significant positive correlations were found between bunch weight and berry weight. Significant correlation coefficients between bunch weight and grape yield and between berry weight and grape yield in both crossing combinations, suggest that these two traits are important components of yield in grapevine. Similar conclusions came from Firoozabady and Olmo [1987], Goldy [1988], Fatahi et al. [2004], Fanizza et al. [2005], Leão et al. [2010], and Song et al. [2014].

Significant negative correlation coefficients determined in both crossing combinations between the time of bud burst and total acidity of must, flowering time and total acidity of must and ripening time and total acidity of must show that a reduction in the total acidity of must can come with prolonged duration of the mentioned phenophases. A similar situation is with significant negative correlation coefficient determined between ripening time and bunch weight in the combination of direct crossing, as well as with significant negative correlation coefficient determined between flowering time and berry weight in the combination of reciprocal crossing. The negative correlation between ripening time and acidity is in agreement with data published by Wei et al. [2002] and Bayo-Canha et al. [2012] and in contrast to positive correlation reported by Jones and Davis [2000].

A significant positive correlation coefficient in the combination of reciprocal crossing determined between berry weight and total acidity of must shows that the increase in berry weight can also increase the total acidity of must. Firoozabady and Olmo [1987] have also found a positive correlation coefficient between mentioned traits. On the other hand, significant negative correlation coefficient established between the sugar content of must and the total acidity of must in the same crossing combination shows that the increase in sugar content can reduce the total acidity of must. This is consistent with results obtained by Firoozabady and Olmo [1987], Shiraichi et al. [2010], and Bock et al. [2011]. A positive correlation coefficient between sugar content and total acidity of must was determined by Wei et al. [2002]. While it is difficult to determine the cause of these differences, positive correlations are not surprising.

Obtained results relating to the inheritance of studied traits indicate that there is a tendency for offsprings to have, on average, lower values or at the level of the poorer parent, which represents a difficulty in grapevine breeding. Encouraging, however, is the fact that individual genotypes with their values surpass even better parent, whereby vegetative propagation allows this trait to be preserved, so that combining breeding should be a significant way to create the new improved cultivars of grapevine. The fact that it manifested maternal effect in the inheritance of flowering and ripening time suggests that if this is the major goal of breeding, then which parent is used as a mother should be taken into account. For other traits, the parent contribution to the values of F_1 generation is equal. In both crossing combinations, the same types of traits connection are generally present. The obtained results of correlation analysis indicate that also bunch and berry weight are among the most important yield components, and the absence of correlation between grape yield and sugar content of must allows for simultaneously working to create high yielding and high quality cultivars.

CONCLUSIONS

Produced genotypes of F_1 generation from both crossing combinations showed high degree of variability for almost all studied traits. The most common mode of inheritance was negative heterosis (flowering time, bunch weight, grape yield and total acidity of must). From all examined traits, a significant influence of maternal effect was determined for the inheritance of flowering time and ripening time. In both crossing combinations, statistically significant phenotypic correlations were found between some studied traits. The study shows that based on the established mode of inheritance and a certain number of significant correlations among traits, more efficient selection in creating the new grapevine cultivars is possible.

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