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COMPONENTS OF VARIABILITY AND HERITABILITY OF PHENOLOGICAL PHASES IN INTERSPECIES PROGENIES OF F_1 GENERATION IN GRAPEVINE

Dragan NIKOLIĆ

Faculty of Agriculture, Belgrade-Zemun, Serbia

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In four interspecies crossing combinations of grapevine (Seedling 108 x Muscat Hamburg, Muscat Hamburg x Seedling 108, S.V.18315 x Muscat Hamburg and Muscat Hamburg x S.V.12375) during three years period, important phenological phases (bud burst, blooming time, veraison and ripening time) were examined. Based on results of analysis of variance, for all investigated characteristics, components of variability, coefficients of genetic and phenotypic variation and coefficient of heritability in a broader sense were calculated. Values of these parameters depended a lot on examined crossing combination. In majority of all investigated characteristics and almost for all crossing combinations, genetic variability took the biggest part in total variability. Only for blooming time, in crossing combinations Seedling 108 x Muscat Hamburg and Muscat Hamburg x S.V.12375, year variability participated the most in total variability. The lowest coefficients of genetic and phenotypic variation were established for blooming time (4.01%; 4.86%), and the largest for veraison (36.43%; 38.81%). Considering examined crossing combination, coefficient of heritability was from 63.08% up to 70.76% for bud burst, from 60.61%

Corresponding author: Dragan Nikolic, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade-Zemun, Serbia, e-mail: nikolicd@agrifaculty.bg.ac.yu

up to 87.71% for blooming time, from 84.58% up to 88.14% for veraison and from 56.86% up to 89.29% for ripening time.

Key words: grapevine, phenological phases, F_1 generation, variability, heritability

INTRODUCTION

Certain is the fact that cultivar in viticulture, like in other sectors of plant production, is the most important factor for yield and grape quality increasing (AVRAMOV, 1980). Existing fund of *Vitis vinifera* L. cultivars and rootstocks, besides outstanding number still does not satisfy present economic way of grapevine growing and modern demand in grape, wines and manufactured products consumption. Because of that many countries are paying more attention in creating new grapevine cultivars.

In breeding work, between agro-biological characteristics, phenological phases seem to be very important. It is well known that grapevine during its annual cycle goes through two periods: vegetation and rest period. Period of vegetation is consists of few phases, and each of them is characterized by expressive changes with special course and intensity. Course and intensity of some phenophases is a result of meteorological influences to a certain region, biologic characteristics of a cultivar and other factors (MILOSAVLJEVIĆ *et al.*, 1972; JONES *et al.*, 2005; ZORER *et al.*, 2005). Between all phenophases, the most important are: bud burst, blooming time, veraison and ripening time.

Grapevine, like other living organisms, is under influence of different external environment conditions. CALO *et al.* (1998) were investigated phenological phases in 80 grapevine cultivars for wine making, and confirmed importance of environment for detecting those characteristics. While phenotypic value of certain property is sum between genetic influence and environment effect, it is important to know which part of phenotypic value is determined like genetic background and which by external environment conditions. Reliable estimation of genetic variance and its components is important for determination of characteristics heritability and estimation of genetic improvement obtained by applied selection method. Considering all those facts, aim of this work was to establish variability and heritability of the most important phenological phases in four interspecies crossing combinations of grapevine.

MATERIAL AND METHODS

All investigation were done on Experimental field "Radmilovac", property of Agricultural Faculty in Belgrade. Seedlings of F_1 generation, from crossing combinations Seedling 108 x Muscat Hamburg, Muscat Hamburg x Seedling 108, S.V.18315 x Muscat Hamburg and Muscat Hamburg x S.V.12375, with 25, 17, 32 and 88 hybrid seedlings respectively were used as a material for investigation. All examined seedlings are self rooted, in orchard with Guyot single cordon. Planting distance is 3 x 0.5 m. During three year period of investigation in experimental filed usual agro-technical measurements were done.

Bud burst was determined when 50% of buds on vine were open and blooming time when 50% of flowers in inflorescence were open. Veraison was dated when 50% of berries become coloured and softened. Ripening time was determined as harvest date that is when berries have maximum sugar content.

For processing results of all investigated characteristics, method of randomized block design of monofactorial analysis of variance was used (STEEL and TORRIE, 1980; HADŽIVUKOVIĆ, 1991). While all the data considering phenological phases were expressed in dates, for analysis of variance needed to be converted in absolute numbers. For bud burst, blooming time, veraison and ripening time days were counted from April 1st, May 1st, August 1st and September 1st respectively, up to noted phases. From analysis of variance results, mean squares (MS) were shown, and testing for significance between genotypes and repetition (year) was done for level of probability of 0.05 and 0.01.

From model of randomized block design of monofactorial analysis of variance, according to SINGH and CHOUDHARY (1976) following components of variance were calculated: year variance (), genetic variance (), error variance () and phenotypic variance (). Coefficients of genetic and phenotypic variation (and), as relative indicator of variability were determined according to SINGH and CHOUDHARY (1976). Coefficient of heritability in broader sense () was calculated according to BOROJEVIĆ (1992) as a ratio between genetic and phenotypic variance. All values of variance of components, coefficients of variation and coefficient of heritability were expressed in percentage (%) and presented in tables.

RESULTS

Based on results from Table 1 can be concluded that average the earliest bud burst was in crossing combination Muscat Hamburg x Seedling 108 (20th April), and the latest from crossing combination Seedling 108 x Muscat Hamburg (24th April). In crossing combination S.V.18315 x Muscat Hamburg the earliest blooming time (31st May), veraison (13th August) and ripening time (18th September) was determined, while the latest blooming time (2nd June), veraison (19th August) and ripening time (25th September) was determined in crossing combination Muscat Hamburg x S.V.12375.

Table 1. - Mean value of phenologic phases in 4 crossing combinations of grapevine

Crossing combination	Characteristic			
	Bud burst	Blooming time	Veraison	Ripening time
Seedling 108 x Muscat Hamburg	24.04	01.06	17.08	20.09
Muscat Hamburg x Seedling 108	20.04	01.06	15.08	19.09
S.V.18315 x Muscat Hamburg	21.04	31.05	13.08	18.09
Muscat Hamburg x S.V.12375	23.04	02.06	19.08	25.09

Results of analysis of variance, represented in Table 2, are showing that for bud burst in all four crossing combinations very significant differences between examined genotypes and between years of investigation were established.

Table 2. - *Mean squares from analysis of variance for bud burst in 4 crossing combinations of grapevine*

Sources of variation	Seedling 108 x Muscat Hamburg		Muscat Hamburg x Seedling 108		S.V.18315 x Muscat Hamburg		Muscat Hamburg x S.V.12375	
	df	MS	df	MS	df	MS	df	MS
Year	2	113.493**	2	234.588**	2	181.791**	2	383.003**
Genotype	24	47.8411**	16	54.8775**	31	45.6179**	87	36.2348**
Error	48	6.56277	32	7.98406	62	7.44758	174	4.38693

** $p<0.01$

In total variability of bud burst, in all four crossing combination, genetic variability had the highest values (Table 3). The lowest coefficients of genetic and phenotypic variation were established in crossing combination Muscat Hamburg x S.V.12375 (14.05%; 16.70%, respectively), and the highest in crossing combination Muscat Hamburg x Seedling 108 (20.25%; 24.89%, respectively). Coefficient of heritability was from 63.08% in crossing combination S.V.18315 x Muscat Hamburg up to 70.76% in crossing combination Muscat Hamburg x S.V.12375.

Table 3. - Components of variance, coefficients of variation and heritability for bud burst in 4 crossing combinations of grapevine

Crossing combination	δ_r^2	δ_g^2	δ_e^2	CV_g	CV_f	h^2
Seedling 108 x Muscat Hamburg	17.39	55.93	26.68	15.84	19.26	67.71
Muscat Hamburg x Seedling 108	36.08	42.31	21.61	20.25	24.89	66.19
S.V.18315 x Muscat Hamburg	21.27	49.66	29.07	16.54	20.82	63.08
Muscat Hamburg x S.V.12375	22.29	54.99	22.72	14.05	16.70	70.76

Like in bud burst, for blooming time in all four crossing combination very significant differences between genotypes and years of investigation were determined (Table 4).

In total variability of blooming time, genetic variability had the highest values in crossing combinations Muscat Hamburg x Seedling 108 and S.V.18315 x Muscat Hamburg. In other two crossing combinations, year variability participate the most in total variability of blooming time (Table 5). The lowest coefficients of genetic and phenotypic variation were established in crossing combination Muscat Hamburg x S.V.12375 (4.01%; 4.86%, respectively), and the highest in crossing combination S.V.18315 x Muscat Hamburg (5.92%; 7.25%, respectively). Variation interval of heritability coefficient ranged from 60.61%, in crossing combination Seedling 108 x Muscat Hamburg, up to 87.71% in crossing combination Muscat Hamburg x Seedling 108.

Table 4. - Mean squares from analysis of variance for blooming time in 4 crossing combinations of grapevine

Sources of variation	Seedling 108 x Muscat Hamburg		Muscat Hamburg x Seedling 108		S.V.18315 x Muscat Hamburg		Muscat Hamburg x S.V.12375	
	df	MS	df	MS	df	MS	df	MS
Year	2	54.4933**	2	23.5490**	2	88.2604**	2	190.640**
Genotype	24	6.28000**	16	7.63480**	31	11.1061**	87	5.9826**
Error	48	1.11833	32	0.34068	62	1.58299	174	0.80873

** p<0.01

Table 5. - Components of variance, coefficients of variation and heritability for blooming time in 4 crossing combinations of grapevine

Crossing combination	δ_f^2	δ_g^2	δ_e^2	CV_g	CV_f	h^2
Seedling 108 x Muscat Hamburg	42.93	34.59	22.48	4.08	5.23	60.61
Muscat Hamburg x Seedling 108	33.00	58.77	8.23	4.93	5.27	87.71
S.V.18315 x Muscat Hamburg	36.28	42.52	21.20	5.92	7.25	66.72
Muscat Hamburg x S.V.12375	45.99	36.77	17.24	4.01	4.86	68.08

Based on results of analysis of variance showed in Table 6, can be concluded, considering veraison, that in all four crossing combination very significant differences between investigated genotypes were established. Differences between years of investigation were very significant in crossing combination Muscat Hamburg x S.V.12375, significant in crossing combination Muscat Hamburg x Seedling 108, and insignificant in crossing combinations Seedling 108 x Muscat Hamburg and S.V.18315 x Muscat Hamburg.

Table 6. - Mean squares from analysis of variance for veraison in 4 crossing combinations of grapevine

Sources of variation	Seedling 108 x Muscat Hamburg		Muscat Hamburg x Seedling 108		S.V.18315 x Muscat Hamburg		Muscat Hamburg x S.V.12375	
	df	MS	df	MS	df	MS	df	MS
Year	2	7.2933	2	18.9019*	2	8.82292	2	204.681**
Genotype	24	116.563**	16	82.6617**	31	75.9354**	87	73.2261**
Error	48	5.00166	32	4.73529	62	3.70463	174	3.99982

* p<0.05; ** p<0.01

In total veraison variability, in all four crossing combinations, genetic variability participate the most in total variability (Table 7). Coefficients of genetic variation were from 25.28% in crossing combination Muscat Hamburg x S.V.12375 up to 36.43% in crossing combination Seedling 108 x Muscat Hamburg, while coefficients of phenotypic variation ranged from 27.39% in crossing combination Muscat Hamburg x S.V.12375 up to 38.81% in crossing combination S.V.18315 x Muscat Hamburg. The lowest heritability coefficient was determined in crossing combination Muscat Hamburg x Seedling 108 (84.58%), and the highest in crossing combination Seedling 108 x Muscat Hamburg (88.14%).

Table 7. Components of variance, coefficients of variation and heritability for veraison in 4 crossing combinations of grapevine

Crossing combination	δ_r^2	δ_g^2	δ_e^2	CV_g	CV_f	h^2
Seedling 108 x Muscat Hamburg	0.22	87.95	11.83	36.43	38.80	88.14
Muscat Hamburg x Seedling 108	2.64	82.35	15.01	34.07	37.04	84.58
S.V.18315 x Muscat Hamburg	0.57	86.17	13.26	36.13	38.81	86.66
Muscat Hamburg x S.V.12375	7.77	78.61	13.62	25.28	27.39	85.23

Results of analysis of variance represented in Table 8, are showing that for ripening time, in all four crossing combination, very significant differences between examined genotypes were established. Significant differences between years of investigation were determined only in crossing combination Muscat Hamburg x Seedling 108, while in all other three combinations differences between years of investigation were very significant.

Table 8. - Mean squares from analysis of variance for ripening time in 4 crossing combinations of grapevine

Sources of variation	Seedling 108 x Muscat Hamburg		Muscat Hamburg x Seedling 108		S.V.18315 x Muscat Hamburg		Muscat Hamburg x S.V.12375	
	df	MS	df	MS	df	MS	df	MS
Year	2	30.0933**	2	54.4117*	2	29.3854**	2	996.284**
Genotype	24	92.7088**	16	54.2696**	31	93.9889**	87	101.063**
Error	48	3.56555	32	10.9534	62	5.58971	174	14.3377

* $p<0.05$; ** $p<0.01$

In total variability of ripening time, in all four crossing combination, genetic variability had the highest values (Table 9). Coefficients of genetic variation were from 20.38% in crossing combination Muscat Hamburg x Seedling 108 to 30.19% in crossing combination S.V.18315 x Muscat Hamburg, while coefficients of phenotypic variation ranged from 25.89% in crossing combination Muscat Hamburg x S.V.12375 up to 32.93% in crossing combination S.V.18315 x

Muscat Hamburg. As for the last characteristic, the lowest heritability coefficient for ripening time was determined in crossing combination Muscat Hamburg x Seedling 108 (56.86%), and the highest in crossing combination Seedling 108 x Muscat Hamburg (89.29%).

Table 9. - Components of variance, coefficients of variation and heritability for ripening time in 4 crossing combinations of grapevine

Crossing combination	δ_r^2	δ_g^2	δ_e^2	CV_g	CV_f	h^2
Seedling 108 x Muscat Hamburg	3.09	86.53	10.38	27.39	28.99	89.29
Muscat Hamburg x Seedling 108	9.15	51.66	39.19	20.38	27.03	56.86
S.V.18315 x Muscat Hamburg	2.08	82.31	15.61	30.19	32.93	84.05
Muscat Hamburg x S.V.12375	20.51	53.14	26.35	21.17	25.89	66.85

DISCUSSION

Grapevine breeding success, considering noted phenological phases and other properties depends on, in a first place, of genetic variability of the population where selection is started. That is why genetic-statistical analysis of grapevine population, that is genetic evaluation of initial forms and obtained progeny one of the most important characteristics of breeding work (GOLODRIGA, 1984). Considering kinship of investigated progenies for evaluation of genetic variance components, mono-and multifactorial experiments can be used. Exactly with the help of randomized block design of monofactorial analysis of variance, different values of components of variance were established in this paper for all characteristics and in all crossing combinations.

So, between examined properties, the lowest participation of genetic variability in total variability was for blooming time (34.59%), and the highest for veraison (87.95%). The lowest variability caused by error was determined also for blooming time (8.23%), and the highest for ripening time (39.19%). Variability caused by year ranged from 0.22% for veraison, up to 45.99% for blooming time. Also LEFORT and BRONNER (1981) established the highest participation of genetic variability of veraison (26.2%) in total variability between examined phenological phases in crossing combination Riesling x Muscat Otonel. For this property, like in our paper, they established the lowest variability caused by year (2.0%).

Comparing genetic variances between the same characteristics in different selected material, and between different characteristics is not always possible because its can be in various units of measure, and can range a lot. That is why comparing of genetic variances can be possible only over coefficients of variation.

In our investigations, the lowest coefficients of genetic and phenotypic variation are determined for blooming time (4.01%; 4.86%, respectively), but the highest for veraison (36.43%; 38.81%, respectively). Otherwise, for bud burst, in our experiment, in dependence of crossing combination, coefficient of phenotypic variation ranged from 16.70% up to 24.89% and those values are higher than values of coefficients of variation from 2.0% do 2.2% for bud burst obtained by ALLEWELDT and KOEPCHEN (1978) for 1518 seedlings from crossing combination Bacchus with 6 different pollenizers, and also higher than values of coefficient of variation from 12.3% obtained by LEFORT and BRONNER (1981) for the same property from crossing combination Riesling x Muscat Otonel. Similar relationship was determined for veraison. Our investigations showed that coefficient of phenotypic variation was from 27.39% to 38.81%, but LEFORT and BRONNER (1981) for this property obtained coefficient of variation 9.9%.

Considering all cited so far, breeders are interesting in probability, more exactly is reliability, which characteristics of selected parental partners will be inherited in its progeny. That probability represents coefficient of heritability, which according to FALCONER (1981) represents degree of coincidence of individual phenotypic values in certain population with its additive, which is breeding value. Literature is full of different values for this parameter but for the same characteristic, and this can be explained by using different material for selection, different ways of estimation and calculating genetic, more exactly additive variance and influence of environment conditions. So, for bud burst, in our paper, in dependence of examined crossing combination, coefficient of heritability was from 63.08% to 70.76%, while CALO and COSTACURTA (1974) determined coefficient of heritability for the same characteristic 27.7%, CALO *et al.* (1978) 84.0%, CALO *et al.* (1979) from 24.2% to 73.2% and LEFORT and BRONNER (1981) 23.0%.

For blooming time, in our paper, obtained values of coefficient of heritability were from 60.61% to 87.71%, and were within the limits of heritability coefficient values of 27.5% that were determined by CALO and COSTACURTA (1974), of 87.0% that were determined by CALO *et al.* (1978), from 17.6% to 71.9% that were determined by CALO *et al.* (1979) and of 52.0% that were determined by SCHNEIDER and STAUDT (1979).

LEFORT and BRONNER (1981), for veraison, determined values of heritability coefficient 27.0%, CALO *et al.* (1979) from 28.3% to 80.7%, CALO and COSTACURTA (1974) 32.6%, EIBACH (1990) 51.0%, and CALO *et al.* (1978) 84.0%. From our results for veraison can be concluded that in all examined crossing combinations higher results of heritability coefficient (84.58% to 88.14%) are obtained, than in cited papers.

Considering all examined crossing combinations in our paper, heritability coefficient for ripening time ranged from 56.86% to 89.29%. Considerably lower values for heritability coefficient of this property (11.1%) determined CALO and COSTACURTA (1974), like WEI *et al.* (2003), who established heritability coefficient of 35.00% in investigated crossing combinations. FANIZZA and RADDI (1973), in population of 2200 plants from 55 families, obtained by crossing of 35 parental partners, for ripening time, determined heritability coefficient of 49.7%, and during investigation of different phenologic phases in grapevine CALO *et al.* (1978) determined heritability coefficient of 72.0%.

As it can be seen from our work, mostly obtained high values of heritability coefficient for majority of investigated characteristics are proof of low impact of environment conditions to those properties appearance. It is well known that heritability coefficient values from 0.3 do 0.7, more exactly from 30.0% to 70.0% give better results in selection (GOLODRIGA and TROCHINE, 1978), while relative high heritability coefficient values obtained for majority of examined characteristics in investigated combinations are showing that these properties can be improved by selection and that those cultivars can be used for further breeding work.

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KOMPONENTE VARIJABILNOSTI I HERITABILNOST FENOLOŠKIH FAZA U INTERSPECIES POTOMSTVIMA F_1 GENERACIJE VINOVE LOZE

Dragan NIKOLIĆ

Poljoprivredni fakultet, Beograd-Zemun, Srbija i Crna Gora

Izvod

U četiri kombinacije interspecies ukrštanja vinove loze (Sejanac 108 x Muskat hamburg, Muskat hamburg x Sejanac 108, S.V.18315 x Muskat hamburg i Muskat hamburg x S.V.12375) tokom trogodišnjeg perioda istraživanja ispitivane su važnije fenološke faze (vreme kretanja okaca, vreme cvetanja, šarak i vreme sazrevanja). Na osnovu rezultata analize varijanse za sve ispitivane osobine izračunate su komponente varijabilnosti, koeficijenti genetičke i fenotipske varijacije i koeficijent heritabilnosti u širem smislu. Vrednosti ovih parametara umnogome su zavisile od proučavane kombinacije ukrštanja. U ukupnoj varijabilnosti većine ispitivanih osobina u skoro svim kombinacijama ukrštanja najviše je učestvovala genetička varijabilnost. Jedino je u ukupnoj varijabinosti vremena cvetanja u kombinacijama ukrštanja Sejanac 108 x Muskat hamburg i Muskat hamburg x S.V.12375 najviše učestvovala varijabilnost uslovljena godinom. Najmanji koeficijenti genetičke i fenotipske varijacije utvrđeni su za vreme cvetanja (4,01%; 4,86%), a najveći za šarak (36,43%; 38,81%). U zavisnosti od ispitivane kombinacije ukrštanja, koeficijent heritabilnosti za vreme kretanja okaca kretao se od 63,08% do 70,76%, za vreme cvetanja od 60,61% do 87,71%, za šarak od 84,58% do 88,14% i za vreme sazrevanja od 56,86% do 89,29%.

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