Journal of Agricultural Sciences
Vol. 51, No 1, 2006
Pages 47-54

UDC: 634.8:575.1
Original scientific paper

COMPONENTS OF VARIANCE AND HERITABILITY OF RESISTANCE TO IMPORTANT FUNGAL DISEASES AGENTS IN GRAPEVINE

D. Nikolić[1]

Abstract: 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, resistance to important fungal diseases agents (*Plasmopara viticola* and *Botrytis cinerea*) were examined. Based on results of analysis of variance, for investigated characteristics, components of variance, coefficients of genetic and phenotypic variation and coefficient of heritability in a broader sense were calculated. It was established that for both characteristics and in all crossing combinations, genetic variance took the biggest part in total variability. The lowest coefficients of genetic and phenotypic variation were established for both properties in crossing combination Seedling 108 x Muscat Hamburg. The highest coefficients of genetic and phenotypic variation were determined for leaf resistance to *Plasmopara viticola* in crossing combination Muscat Hamburg x S.V.12375, and for bunch resistance to *Botrytis cinerea* in crossing combination Muscat Hamburg x Seedling 108. Considering all investigated crossing combinations, coefficient of heritability for leaf resistance to *Plasmopara viticola* was from 87.23% to 94.88%, and for bunch resistance to *Botrytis cinerea* from 88.04% to 93.32%.

Key words: grapevine, *Plasmopara viticola*, *Botrytis cinerea*, F_1 generation, variability, heritability.

Introduction

High and quality grape production in a first place depends on breeding results, or more exactly, on growing new high yielding and high quality cultivars resistant to unfavourable biotic and abiotic factors. Even G u z u n (1976) said that interspecies hybridization is the most promising method for creating new

[1] Dragan Nikolić, PhD, Assistant Professor, Faculty of Agriculture, 11081 Belgrade-Zemun, Nemanjina 6, Serbia and Montenegro

grapevine cultivars with combined resistance. Creating cultivars with certain resistance to fungal diseases and pests can make provisions for successful grapevine growing with low pesticide, or more exactly, cleaner human environment and obtaining healthier fruit. Of course, beside this humane, breeding work for creating resistant cultivars has very high economic significance, because growing of this kind of cultivars would be more stable and cheaper (Cindrić, 1977; Cindrić et al., 1997).

In breeding work, while creating resistant cultivars, special attention is paid to resistance to downy mildew and grey mould. Borgo et al. (1990) indicated that grapevine downy mildew is caused by fungus *Plasmopara viticola* (B. et C.) Berl. et de Toni, creating necrotic injuries of leaf tissue, flowers and berries, and it is one of the most important parasitic diseases that cause serious damages in numerous vineyards. Very similar to downy mildew, grey mould is caused by fungus *Botrytis cinerea* Pers.: Fr., and it seriously reduces yield and grape quality causing large damages in viticulture and wine making in numerous countries throughout the world (Boubals et al., 1978; Ristić and Stojanović, 1983; Bavaresco et al., 1997; Wolf et al., 1997). Grapevine expresses different susceptibility to cited diseases. Susceptibility degree of certain genotypes primarily depends on genetic background, meteorological conditions, organs development, agro-technical practices, etc.

While phenotypic value of certain property is the sum between genetic influence and environment effect, it is important to know which part of phenotypic value is determined like genetic background and whitch by 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. By calculating coefficients of heritability, genetic structure of progenies, obtained by crossing of parental partners that were chosen based on certain characteristics, can be predicted. If one characteristic has higher coefficient of heritability, it can be easily and much faster improved than characteristic with lower coefficient of heritability (Nyquist, 1991).

Considering all those facts, the aim of this work was to establish components of total variance and heritability of resistance to important fungal diseases agents (*Plasmopara viticola* and *Botrytis cinerea*) in four interspecies crossing combinations of grapevine.

Material and Methods

Seedlings of F_1 generation, from crossing combinations Seedling 108 x Muscat Hamburg (25 seedlings), Muscat Hamburg x Seedling 108 (17 seedlings), S.V.18315 x Muscat Hamburg (32 seedlings), and Muscat Hamburg x S.V.12375

(88 seedlings) 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 practices were done. All investigations were done on Experimental field "Radmilovac", property of Agricultural Faculty in Belgrade.

Resistance to important fungal diseases agents (*Plasmopara viticola* and *Botrytis cinerea*) in seedlings from examined crossing combinations was determined under conditions of natural infection. Leaf resistance degree to *Plasmopara viticola* was determined visually, three weeks after blooming time based on damages percentage of 5th and 6th leaf, counted from the shoot top. Mean value of damages percentage of all leaves from 10 shoots were used. Before the harvest, different distribution of *Botrytis cinerea*, based on mean value of damages percentage in all bunches from 10 shoots, was used.

For processing results of investigated characteristics, method of randomized block design of single factorial analysis of variance was used (Steel and Torrie, 1980; Hadživuković, 1991). From analysis of variance, mean squares (MS) were shown, and testing for significance of difference between genotypes and repetition (year) was done for probability level of 0.05 and 0.01.

From model of randomized block design of single factorial analysis of variance, according to Singh and Choudhary (1976), the following components of variance were calculated: year variance (δ_r^2), genetic variance (δ_g^2), error variance (δ_e^2) and phenotypic variance (δ_f^2). Coefficients of genetic and phenotypic variation (CV_g and CV_f), as relative indicator of variability, were determined according to Singh and Choudhary (1976). Coefficient of heritability in a broader sense (h^2) 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 and Discussion

Data presented in Table 1 show that, on average, lowest percentage of leaf damages caused by *Plasmopara viticola* and lowest percentage of bunch damages caused by *Botrytis cinerea* was established in crossing combination Muscat Hamburg x S.V.12375 (3.81% and 4.12%, respectively), which means that seedlings from this crossing combination were the most resistant to both diseases. The highest percentage of leaf damages caused by *Plasmopara viticola* was determined in crossing combination Muscat Hamburg x Seedling 108 (5.22%), and the highest percentage of bunch damages caused by *Botrytis cinerea* was established in crossing combination Seedling 108 x Muscat Hamburg

(7.54%). Seedlings from those two combinations were the most susceptible to both diseases.

T a b . 1. - Mean value of leaf resistance to *Plasmopara viticola* and bunch resistance to *Botrytis cinerea* in 4 crossing combinations of grapevine

Crossing combination	Characteristic	
	Leaf resistance to *Plasmopara viticola* (damage in %)	Cluster resistance to *Botrytis cinerea* (damage in %)
Seedling 108 x Muscat Hamburg	5.18	7.54
Muscat Hamburg x Seedling 108	5.22	6.25
S.V.18315 x Muscat Hamburg	4.27	5.75
Muscat Hamburg x S.V.12375	3.81	4.12

Based on results of analysis of variance shown in Table 2, it can be observed that for leaf resistance to *Plasmopara viticola* in all four examined crossing combinations, very significant differences between investigated genotypes, were established. Differences between year of investigations were very significant in crossing combinations S.V.18315 x Muscat Hamburg and Muscat Hamburg x S.V.12375, significant in crossing combination Seedling 108 x Muscat Hamburg and insignificant in crossing combination Muscat Hamburg x Seedling 108.

T a b . 2. - Mean squares from analysis of variance for leaf resistance to *Plasmopara viticola* 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	13.9339*	2	4.1045	2	18.3034**	2	52.0435**
Genotype	24	129.031**	16	133.431**	31	124.939**	87	140.917**
Error	48	3.92057	32	6.21011	62	2.85823	174	2.48775

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

Genetic variance of leaf resistance to *Plasmopara viticola* in all four examined crossing combinations took the biggest part in total variability (Table 3). The lowest coefficients of genetic and phenotypic variation were established in crossing combination Seedling 108 x Muscat Hamburg (56.11% and 58.68%, respectively), and the highest in crossing combination Muscat Hamburg x S.V.12375 (75.56% and 77.57%, respectively). K o z m a j r . (2000), by studying resistance to downy mildew in 9 crossing combinations, where both parental partners were resistant, obtained coefficients of variation from 16.0% to 56.0%, in 5 crossing combinations, where he crossed resistant with susceptible cultivars, he determined coefficients of variation from 27.0% to 36.0%, and in 8 crossing combinations, where he crossed susceptible with resistant cultivars, he determined coefficients of variation from 21.0% to 41.0%. In the present paper, in contrast to previous author, in all examined crossing combinations, where combinations between cultivars were resistant x susceptible and susceptible x resistant, for leaf resistance to *Plasmopara viticola*, we established higher coefficient of variation values. It ranged from 58.68% to 77.57%.

T a b . 3. - Components of variance, coefficients of variation and heritability for leaf resistance to *Plasmopara viticola* 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	0.87	90.61	8.52	56.11	58.68	91.41
Muscat Hamburg x Seedling 108	0.00	87.23	12.77	56.58	60.58	87.23
S.V.18315 x Muscat Hamburg	1.10	92.41	6.49	62.91	65.08	93.44
Muscat Hamburg x S.V.12375	1.14	93.80	5.06	75.56	77.57	94.88

Depending of examined crossing combination, heritability coefficient of leaf resistance to *Plasmopara viticola* was from 87.23% (Muscat Hamburg x Seedling 108) to 94.88% (Muscat Hamburg x S.V.12375). Approximately the same values of heritability coefficient for resistance to *Plasmopara viticola* (83.0% to 94.0%) were established by Eibach et al. (1989) during a two-year period of studying a large number of interspecies crossing combinations in grapevine. On the other hand, Eibach (2000) by examining progenies from 48 different crossing combinations, together with its parental partners, determined for resistance to *Plasmopara viticola* the following values of heritability coefficient in a limited sense [downy mildew-leaf (h^2 =0.43), berry (h^2 =0.32)].

Results of analysis of variance shown in Table 4 show for bunch resistance to *Botrytis cinerea* in all four examined crossing combination, very significant differences between investigated genotypes.Differences between sdudy years were significant in crossing combination Muscat Hamburg x S.V.12375, while in other three crossing combinations differences between study years were insignificant.

T a b. 4. - Mean squares from analysis of variance for bunch resistance to *Botrytis cinerea* 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	1.0868	2	0.7410	2	2.6064	2	8.06584*
Genotype	24	151.237**	16	175.467**	31	127.915**	87	86.9642**
Error	48	5.76119	32	7.60351	62	3.19533	174	2.02496

* p<0.05; ** p<0.01

Genetic variance of bunch resistance to *Botrytis cinerea* in all four examined crossing combinations took the biggest part in total variability (Table 5). The lowest coefficients of genetic and phenotypic variation were determined in crossing combination Seedling 108 x Muscat Hamburg (48.32% and 51.11%, respectively), and the highest in crossing combination Muscat Hamburg x Seedling 108 (59.89% and 63.83%, respectively). Heritability coefficient varied from 88.04% in crossing combination Muscat Hamburg x Seedling 108 to 93.32% in crossing combination Muscat Hamburg x S.V.12375. Approximately similar results of heritability coefficient for resistance to *Botrytis cinerea* (82.0% to 92.0%) were established by Eibach et al. (1989) during a two-year period of studying a large number of interspecies crossing combinations in grapevine. On the other hand, much lower values of heritability coefficient for resistance to *Botrytis cinerea* were determined by Egger and Borgo (1986) while analysing 240 grapevine cultivars during a seven-year period of investigatious. Those two authors established that average heritability coefficient for resistance to *Botrytis cinerea* was 44.0% in 51 direct yielding hybrid, 47.0% in 66 table grapevine cultivars, and 58.0% in 123 wine cultivars.

Tab. 5. - Components of variance, coefficients of variation and heritability for bunch resistance to *Botrytis cinerea* 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	0.00	89.38	10.62	48.32	51.11	89.38
Muscat Hamburg x Seedling 108	0.00	88.04	11.96	59.89	63.83	88.04
S.V.18315 x Muscat Hamburg	0.00	92.86	7.14	52.21	54.18	92.86
Muscat Hamburg x S.V.12375	0.23	93.11	6.66	50.97	52.76	93.32

As it can be observed from our work, the mostly obtained high values of heritability coefficient for investigated characteristics are evidence of the low impact of environment conditions to emergence of those properties. It is well known that heritability coefficient values from 0.3 do 0.7, or more exactly from 30.0% to 70.0% produce better results in selection (Golodriga and Trochine, 1978), while high heritability coefficient values obtained for examined characteristics in investigated crossing combinations, like in our paper, show that these properties can be improved by selection and using investigated cultivars in further breeding work.

Conclusion

Between the examined crossing combinations, the largest leaf resistance to *Plasmopara viticola* and the largest bunch resistance to *Botrytis cinerea* was established in crossing combination Muscat Hamburg x S.V.12375.

In all crossing combinations, genetic variance took the biggest part in total variability.

The lowest coefficients of genetic and phenotypic variation were established for bunch resistance to *Botrytis cinerea* in crossing combination Seedling 108 x Muscat Hamburg (48.32% and 51.11%, respectively), but the highest for leaf resistance to *Plasmopara viticola* in crossing combination Muscat Hamburg x S.V.12375 (75.56% and 77.57%, respectively).

Considering all investigated crossing combinations, coefficient of heritability for leaf resistance to *Plasmopara viticola* was from 87.23% to 94.88%, and for bunch resistance to *Botrytis cinerea* from 88.04% to 93.32%.

The best crossing combination, with the highest values of heritability coefficient for both investigated characteristics, was Muscat Hamburg x S.V.12375.

REFERENCES

1. Bavaresco, L., Petegolli, D., Cantu, E., Fregoni, M., Chiusa, G., Trevisan, M. (1997): Elicitation and accumulation of stilbene phytoalexins in grapevine berries infected by *Botrytis cinerea*. Vitis 36(2):77-83.
2. Borgo, M., Cancellier, S., Costacurta, A. (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.
3. Borojević, S. (1992): Principi i metode oplemenjivanja bilja. Naučna knjiga, Beograd.
4. Boubals, D., Bernard, A., Mur, G., Dallas, J.-P. (1978): Transgression pour la résistance a la Pourriture grise (*Botrytis cinerea*) dans le croisement entre le "Cabernet-Sauvignon" et le "Grenache". II[e] Symposium International sur l'Amélioration de la Vigne Bordeaux, 14-18 juin 1977, pp. 265-269.
5. Cindrić, P. (1977): Stvaranje otpornih sorti međuvrsnom hibridizacijom. Jugoslovensko Vinogradarstvo i Vinarstvo 5:15-18.
6. Cindrić, P., Korać, N., Kolarov, R. (1997): Stone sorte tipa interspecies hibrida. Poljoprivreda 46(386-387):33-40.
7. Egger, E., Borgo, M. (1986): Sensibilita alla *Botrytis cinerea* di cultivars di vite di origine diversa. Vignevini 13(4):29-33.
8. Eibach, R. (2000): Investigations on the inheritance of resistance features to mildew diseases. Acta Horticulturae 528(2):455-465.
9. Eibach, R., Diehl, H., Alleweldt, G. (1989): Untersuchungen zur vererbung von resistenzeigenschaften bei reben gegen *Oidium tuckeri*, *Plasmopara viticola* und *Botrytis cinerea*. Vitis 28(4):209-228.
10. Golodriga, P.Ia., Trochine, L.P. (1978): Héritabilité des caracteres quantitatifs chez la vigne. II[e] Symposium International sur l'Amélioration de la Vigne Bordeaux, 14-18 juin 1977, pp. 113-117.
11. Guzun, N.I. (1976): Metodi vivedenija sortov vinograda s gruppovoj ustojčivostju. V sb. Sortoizuč. i selekcija vinograda. Kišinev, Štiinca, str. 3-15.
12. Hadživuković, S. (1991): Statistički metodi. Poljoprivredni fakultet, Novi Sad.
13. Kozma jr., P. (2000): Winegrape breeding for fungus disease resistance. Acta Horticulturae 528(2):505-510.
14. Nyquist, W. E. (1991): Estimation of heritability and prediction of selection response in plant populations. Critical Reviews in Plant Sciences 10(3):235-322.

15. Ristić, B., Stojanović, M. (1983): Prilog proučavanju osetljivosti sorata vinove loze prema prouzrokovaču sive truleži grožđa *Botrytis cinerea* Pers. Nauka u Praksi 13(2):183-190.
16. Singh, R.K., Choudhary, B.D. (1976): Biometrical techniques in genetics and breeding. International Bioscience Publishers, Hissar (India).
17. Steel, R.G.D., Torrie, J.H. (1980): Principles and procedures of statistics. McGraw-Hill Book Company, New York.
18. Wolf, T.K., Baudoin, A.B.A.M., Martinez-Ochoa, N. (1997): Effect of floral debris removal from fruit clusters on *botrytis* bunch rot of Chardonnay grapes. Vitis 36(1):27-33.

Received March 10, 2006
Accepted May 18, 2006

KOMPONENTE VARIJANSE I HERITABILNOST OTPORNOSTI PREMA PROUZROKOVAČIMA VAŽNIJIH GLJIVIČNIH BOLESTI VINOVE LOZE

D. Nikolić[1]

Rezime

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 ispitivana je otpornost na prouzrokovače važnijih gljivičnih bolesti (*Plasmopara viticola* i *Botrytis cinerea*). Na osnovu rezultata analize varijanse za ispitivane osobine izračunate su komponente varijanse, koeficijenti genetičke i fenotipske varijacije i koeficijent heritabilnosti u širem smislu. Utvrđeno je da je u ukupnoj varijabilnosti obe ispitivane osobine, u svim kombinacijama ukrštanja, najviše učestvovala genetička varijansa. Najmanji koeficijenti genetičke i fenotipske varijacije za obe osobine ustanovljeni su u kombinaciji ukrštanja Sejanac 108 x Muskat hamburg. Najveći koeficijenti genetičke i fenotipske varijacije za otpornost lista prema *Plasmopara viticola* ustanovljeni su u kombinaciji ukrštanja Muskat hamburg x S.V.12375, a za otpornost grozda prema *Botrytis cinerea* u kombinaciji ukrštanja Muskat hamburg x Sejanac 108. U zavisnosti od ispitivane kombinacije ukrštanja, koeficijent heritabilnosti za otpornost lista prema *Plasmopara viticola* kretao se od 87,23% do 94,88%, a za otpornost grozda prema *Botrytis cinerea* od 88,04% do 93,32%.

Primljeno 10. marta 2006.
Odobreno 18. maja 2006.

[1] Dr Dragan Nikolić, docent, Poljoprivredni fakultet, 11081 Beograd-Zemun, Nemanjina 6, Srbija i Crna Gora