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Yield structure and variability of quantitative traits in a cross between a seeded and seedless vine cultivar (*Vitis vinifera* L.)

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Summary

The application of Path-analysis for the investigation of yield structure and variability of quantitative traits in a cross between a seeded and a seedless vine cultivar is presented. Yield from parent cultivars and F1 progeny of the hybrid combination 'Armira' x 'Russalka 1', is most significantly influenced by the traits related to actual vine productivity, the ampelometric indices of cluster and berry, and shoot fertility coefficients. The parent cultivars 'Armira' and 'Russalka 1' specifically influence the phenotype of hybrid plants through various traits from almost all conditionally formed groups. Determination of the most important traits for the productivity of different vine cultivars as well as the relative participation of these traits in their total variation in F1 progeny, increases the efficiency of vine selection.

K e y w o r d s : yield, F1 progeny, quantitative traits, variability, Path-analysis, seeded and seedless vine cultivar.

Introduction

Grape yield in different vine cultivars depends to the greatest extent on factors determined by the genotype-environment interaction. Path-analysis has become one of the most effective methods for evaluation of the degree of dependency and interrelations between these processes. Path-analysis also makes it possible to determine the intensity of individual influences or provides an empirical test on hypotheses about their character. This method is suitable for an assessment of the direct and indirect influence of the environment on the genotype in case of a proven linear correlation, and it also allows carrying out an evaluation of the significance of variable values by eliminating the ones having minimal effect (Coshran 1951, Dewey and Lu 1959, Finlay and Wilkinson 1963, Pandewy and Gitton 1975, Larik 1978, Eliseeva 1982). Because of the enormous polymorphism observed, an effective and objective enough correlation model is needed in order to investigate the productivity of different table and wine cultivars (Troshin 1997). The purpose of the current research is to determine the possibilities for application of Path-analysis for determination of yield structure and variability of quantitative traits in the F_1 progeny of a cross between a seeded and a seedless vine cultivar.

Material and Methods

The experimental work was carried out using 30 plants from each population of the parent cultivars and seedlings from F_1 progeny of the hybrid combination 'Armira' (seeded) x 'Russalka 1' (seedless). For each hybrid plant during the period 2002-2006, 25 quantitative traits were reported (for the seeded plants) and 21 (for the seedless), these traits being related to the phenology, fertility, quality and yield of grapes. The observed traits were conditionally divided into seven groups according to the role they play in yield formation (Bulgarian Ampelography 1990). Assuming that the double independently changing state of variables is a fact, their influence on the result is decomposed through Path-analysis into two types of effect – direct and indirect. The sum of the direct and the indirect effect determines the proximity of the existing correlation between the resultant variable and each of the factors-reasons.

Results and Discussion

Path-analysis demonstrates not only the correlation coefficients between different factors-reasons, but also the interrelations among them, which makes it possible to specify the degree of variation of a certain variable within a group and to determine the variation of other variables – incorporated in a certain system. In the studied seeded and seedless cultivar and F_1 progeny of their hybrid combination mainly the traits from three groups connected with actual vine productivity, ampelographic indices of cluster and berry and shoot fertility coefficients, relatively participate in yield formation. The reported and analyzed effects on yield produced by the studied vine plant populations are predominantly based on the correlations between the direct and the total indirect effects of different traits. 65.3 % of the total relative participation (which is 89.0 %) of the most important traits in the formation of yield in the cultivar Armira (P_1), is formed by the group of traits connected with actual fertility (Tab. 1). The traits total number of clusters and number of fruiting shoots possess the highest shares – 27.4 % and 17.4 % respectively. From the first group shoot fertility coefficient has 5.0 % participation, and from the second group – average cluster weight has 18.7 %. The participation of the other traits is 11.0 %. The relative total participation of the most important factors (94.4 %) exerting a positive influence on the formation of grape yield in 'Russalka 1' (P_2), indicates that the traits in the group

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Table 1

Relative participation of traits in the formation of grape yield from the seeded 'Armira' (P_1)

Groups	No.	Total yield variation	100
		Total relative participation of the most important traits 89.0 %, from which:	%
I	x_1	Shoot fertility coefficient	5.0
II	x_6	Average cluster weight (g)	18.7
VII	x_{22}	Total number of buds	8.0
	x_{23}	Total number of shoots	12.5
	x_{24}	Total number of fruiting shoots	17.4
	x_{25}	Total number of clusters	27.4
Other traits			11.0

presenting actual cultivar productivity possess the highest share (89.1 %) (Tab. 2). Among them the following traits have approximately the same percentages: total number of clusters - 27.9 %, total number of fruiting shoots - 23.8 % and total number of shoots - 23.7 %. Only one trait is presented from the remaining groups – average weight of 100 berries (5.3 %), and from others – 5.6 %. The relative total participation of factors (97.9 %) in grape yield formation from F_1 progeny of the hybrid combination 'Armira' (P_1) x 'Russalka 1' (P_2) includes traits from three groups (Tab. 3). The biggest share (45.9 %) is represented by the traits total number of clusters (22.7 %), total number of fruiting shoots (14.7 %) and total number of shoots (8.5 %), followed by traits connected with cluster parameters (31.2 %) – average cluster weight (19.6 %) and cluster width (11,6 %). Phenological traits contribute to the total variation of yield in F_1 progeny through a relative share of 20.8 %. It should be pointed out that in the studied cross a larger number of traits from different groups participate in the formation of yield from the plant population in the F_1 progeny.

Parent cultivars relatively influence the variation of the commercially-significant phenotype of seedlings through various traits from almost all conditionally formed groups. The correlation differences in the character of the direct and total indirect effects of separate traits on yield should be used when choosing cultivars for sex hybridization for

Table 2

Relative participation of traits in the formation of grape yield from 'Russalka 1' (P_2)

Groups	No.	Total yield variation	100
		Total relative participation of the most important traits 94.4 %, from which:	%
III	x_8	Average weight of 100 berries (g)	5.3
VII	x_{18}	Total number of buds	13.7
	x_{19}	Total number of shoots	23.7
	x_{20}	Total number of fruiting shoots	23.8
	x_{21}	Total number of clusters	27.9
Other traits			5.6

Table 3

Relative participation of traits in the formation of grape yield from F_1 progeny of the hybrid combination 'Armira' (P_1) x 'Russalka 1' (P_2)

Groups	No.	Total yield variation	100
		Total relative participation of the most important traits 97.9 %, from which:	%
II	x_5	Average cluster weight (g)	19.6
	x_7	Cluster width (cm)	11.6
V	x_{12}	Budding-flowering (d)	4,1
	x_{13}	Flowering-softening (d)	4.2
	x_{14}	Softening–technological maturity (d)	3.5
	x_{15}	Budding-technological maturity (d)	9.0
VII	x_{19}	Total number of shoots	8.5
	x_{20}	Total number of fruiting shoots	14.7
	x_{21}	Total number of clusters	22.7
Other traits			2.1

a certain breeding purpose as well as for the selection of commercially-valuable elite forms. The individual influence of each parent cultivar on the total variation of the phenotype of seedlings is quite specific and it should be taken into consideration in the course of the selection process aimed at the development of new vine cultivars. Specifying the traits essential for the productivity of different cultivars and hybrid combinations as well as for the phenotype variation in F_1 progeny enhances the efficiency of planning and conducting vine selection. Dividing the seedlings from F_1 progeny into seeded and seedless plants and application of Path-analysis yielded even more detailed information about the influence of separate factors on yield and on the variability of traits depending on parent cultivars (Roychev 2008). The collected experimental data has theoretical significance and it will also find practical application in vine cultivar agrotechnology. The most important traits in Armira (P_1) (96.9 %), which participate in the variation of phenotype in F_1 progeny, belong to four groups (Tab. 4). There is not a group whose traits are all includ-

Table 4

Relative participation of the traits of Armira (P_1) in their total variation in F_1 progeny of the hybrid combination 'Armira' (P_1) x 'Russalka 1' (P_2)

Groups	No.	Total variation of traits	100
		Total relative participation of the most important traits 96.9 %, from which:	%
I	x_3	Fruiting shoot fertility coefficient	10.8
II	x_6	Cluster length (cm)	35.1
V	x_{13}	Flowering-softening (d)	31.3
	x_{15}	Budding-technological maturity (d)	14.8
VII	x_{18}	Total number of buds	4.9
Other traits			3.1

ed. The share of flowering – berry softening (31.3 %) and budding – technological maturity (14.8 %) is the biggest – 46.1 %, followed by those of fruiting shoot fertility coefficient (10.8 %) and cluster length (35.1 %). Total number of buds has the lowest percentage in the variation of traits – 4.9 %. 'Russalka 1' (P_2) participates in the total variation of the phenotype of F_1 progeny with 97.3 % of the traits (Tab. 5). Sugars and acids possess the highest share and almost equal percentages – 21.3 % and 19.6 % respectively – a total of 40.9 % (sixth group), followed by the first group – fruiting shoot fertility coefficient (16.4 %). From the second, third and fifth group the following traits are presented: percentage of millerandage berries (4.7 %), average cluster weight (9.7 %), berry width (13.3 %) and budding – technological maturity (12.3 %). Analysis shows that the father cultivar Russalka 1 (P_2) participates with more traits in the total phenotype variation of F_1 progeny of the hybrid combination Armira (P_1) x Russalka 1 (P_2).

Table 5

Relative participation of the traits of Russalka 1 (P_2) in their total variation in F_1 progeny of the hybrid combination Armira (P_1) x Russalka 1 (P_2)

Groups	No.	Total variation of traits	100
		Total relative participation of the most important traits 97.3 %, from which:	%
I	x_3	Fruiting shoot fertility coefficient	16.4
II	x_4	Millerandage berries (%)	4.7
	x_5	Average cluster weight (g)	9.7
III	x_{10}	Berry width (mm)	13.3
V	x_{15}	Budding-technological maturity (d)	12.3
VI	x_{16}	Sugars (%)	21.3
	x_{17}	Acids ($g \cdot l^{-1}$)	19.6
Other traits			2.7

Path-analysis offers a way to obtain a clear and accurate picture of the actual interrelations among the studied traits. Its application in the current investigation provides the best opportunity to evaluate the influence of variable values and to eliminate those of them making a minor contribution to the regression equation. Path-analysis makes it possible to choose variables for the construction of the model of the production function, since the result from the influence of a given factor depends on how it is combined with the other factors. As a result of the performed analyses it can be stated that yield formation in vine depends to a great extent on the total indirect effects of a large number of traits.

Conclusions

The traits connected with actual vine productivity, ampelometric indices of cluster and berry and shoot fertility coefficients exert the strongest influence on the formation of yield from parent cultivars and F_1 progeny of the hybrid combination 'Armira' x 'Russalka 1'. The direct and indirect effects of some of these traits very often eliminate each other. Yield also depends to a large extent on the total indirect effects of many traits.

Parent cultivars 'Armira' and 'Russalka 1' relatively influence the phenotype of hybrid plants through different traits from almost all conditionally formed groups – cluster parameters and average cluster weight, duration of the phenological periods flowering – berry softening and budding – technological maturity, fruiting shoot fertility coefficient, amount of sugars and acids, percentage of millerandage berries and number of buds. The share of the remaining traits in the variability of commercially-important ampelographic characteristics of seedlings is considerably smaller.

Determination of the traits of the greatest importance for the productivity of different vine cultivars and of their relative participation in their total variation in F_1 progeny improves the efficiency of vine selection. The correlation peculiarities related to the direct and total indirect effects of separate traits on yield and the specific influence of parent cultivars on the total phenotype variation of seedlings should be used for the development of new commercially valuable seedless and seeded elite vine forms. The obtained results can also be applied for the correct performing of certain agrotechnological and phyto-sanitary procedures, for introduction and microregional distribution of different vine cultivars.

References

Bulgarian Ampelography; 1990: General Ampelography, Vol. I. Bulgarian Acad. Sci., Sofia.

Coshran ,W. G.; 1951: Testing a linear relation among variances. Biometrics **7**, 17-32.

Dewey, D. R.; Lu, K. H.; 1959: A correlation and path coefficient analysis of components of crested wheat grass seed production. Agronomy J. **51**, 515-518.

Eliseeva, I.; 1982: Statistical Methods for Measuring Relations. Leningrad, Leningrad University Press.

Finlay, K. W.; Wilkinson, G. N.; 1963: The analysis of adaptations in a plant breeding programme. Aust. J. Agric. Res. **14**, 742-754.

Larik, A. S.; 1978: Correlation and path coefficient analysis of yield components in mutants of *Triticum aestivum*. Struct. Equation Modeling **6**, 1-55.

Pandewy, P.; Gitton, L.; 1975: Correlation, multiple correlation and path coefficient analysis of yield components in wheat (*Triticum aestivum* L.). J. Human Genet. **35**, 695-732.

Roychev, V.; 2008: Cytoembryological, biotechnological, ampelographic and genetical-breeding investigations of seedless vine cultivars (*Vitis vinifera* L.). Diss. Plovdiv, Part I and Part II.

Troshin, L. P.; 1997: Analysis of hereditary data on vine. Grape Wine Russia **1**, 17-21.

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