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Research Concerning the Bunch Weight Using Statistical Analysis Methods in Some Local Varieties and Biotypes in the Buziaş - Silagiu Area

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Abstract. During the last years the worldwide trend in viticulture research is to restore the local varieties due to the importance of obtaining quality products, typical, authentic, and so, their research has become a fundamental one. The research was conducted in Silagiu-Buzias viticultural area among 2008-2012, and the aim was to identify and enhance the productive potential and quality of local varieties and biotypes, cultivated in the Banat region, particular in the viticultural area Buziaş-Silagiu compared with control varieties. For the estimation and interpretation of genotype x environment interaction and stability of different studied traits, various models of linear regression analysis were used. This method is based on the finding that different components of genotype x environment interaction effects are linearly correlated with environmental conditions shown by the average performance of all genotypes for studied traits. Regression significance and genotypes drift from linear regression was performed using variance analysis by the *Hardwick -Wood model*. Another method used for assessing the stability was *ecovalence method or ecological valence*. Considering estimation for the six models used, on the rank sum differences is noted that the highest stability of this trait had varieties: Ochiul boului, Coarnă neagră, Alb crocant de Buziaş, Roşu crocant de Silagiu. A high influence of genotype x environment interaction on the achievement of this trait - high values of the sum of ranking differences according to statistical models used respectively - were observed in the varieties: Răşchirată albă, Coarnă vânătă and Conic auriu.

Keywords: vine, wine, vineyards, varieties, biotypes, local, genotype

INTRODUCTION

For growers local varieties and biotypes may be an important source of income, by obtaining wine sector products, typical, authentic, with features that can be attributed to a determined geographical area. Getting these products creates prerequisites for targeting niches in the specific global market where competition is very fierce (Dobrei *et al.,* 2005).

Local varieties have been cultivated for a much longer than improved varieties and appeared through natural selection and an artificial long primitive one, used by anonymous grapevine growers. They have been formed in some specific climatic conditions and have a limited spreading.

Thus have resulted a number of local varieties, which because of their special merit were preserved until now (Tămâioasă românească, Grasă de Cotnari, Galbenă de Odobeşti, Mustoasă de Măderat, Busuioacă de Bohotin, etc (Ţârdea and Rotaru, 2003).

Local varieties and biotypes may be an important source of planting material in the process of grapevine improvement by sexual crossbreeding method.

Besides the valuable traits like quantity, quality or resistance to pests and the environment, many local varieties have a functional shape type of female flower, which facilitate the work of hybridization: Coarnă albă, Coarnă neagră, Crâmpoşie, Ţâţa vacii, etc. (Moş and Dobrei, 2011).

MATERIALS AND METHODS

Fifteen local table grapes varieties and biotypes were studied, which were compared with the control Chasselas dore. A genotype relative adaptability to different environmental conditions is appreciated by three parameters: average performances; genotype reply to different environmental conditions (regression coefficient) and performances stability (deviations from regression).

Stability performances of a genotype in different environmental conditions can be also evaluated by the deviations variance from the regression:

$$s_{\delta}^{2}=\frac{1}{n-2}\left[\left(\sum F_{ij}^{2}-\frac{\left(\sum F_{ij}\right)^{2}}{n}\right)-\frac{\left(\sum F_{ij}t_{j}\right)^{2}}{\sum t_{j}^{2}}\right]-\frac{\sigma_{E}^{2}}{r};$$

where:

n – number of localities (years); *r* – number of repetitions; σ_E^2 - error variance.

The stability of genotypes performances is as higher as the values are lower, and draws down to zero. In conclusion, an ideal genotype is that with a high average production, bi = 1 and = 0. (1)

Significance of genotypes regression and deviation compared to the linear right regression (Tab.1) was performed by analysis of variance - Hardwick and Wood model (1972).

Another method used to assess stability is ecovalence or ecological valence (Wi^2) proposed by Wricke (1962), for the genotype g_i grown in different environmental conditions (n), represents the contribution of each genotype to the sum of squared deviations for the genotype x environment interaction and is calculated with the formula:

$$W_i^2=\sum\left(Y_{ij}-Y_i-Y_j+Y\right);$$

where:

Y_{ij} – the average performance of the genotype *i* in the environment j;

Y_i – the average performance of the genotype *i* in all environment conditions tested;

Y_j – average of the village (year) *j*;

Y- overall average of the experience.

Tab. 1

Analysis of variance for the Hardwick and Wood (1972) model

Source of variation	GL	s^2	F
Total	*gn-1*		
Genotypes	*g-1*	M_1	M_1/M_5
Localities (environment)	*n-1*	M_2	M_2/M_5
Genotype x Environment	*(g-1)(n-1)*	M_3	M_3/M_5
Heterogeneity of regression	*g-1*	M_4	M_4/M_5
Error (regression deviation)	*(g-1)(n-2)*	M_5	

Low values of the W_i^2 coefficient show a high ecovalence and a high stability of the genotype performance in the environments studied (Ciulcă, 2006).

For establishing the significance of ecovalence, through the F test, it is necessary to calculate the ecovalence variance of each genotype (s_{Wi}^2), and also an average ecovalence (W_{im}^2) for all genotypes from the experiment:

$$s_{Wi}^2 = \frac{gW_i^2}{(g-1)(n-1)}; \qquad W_{im}^2 = \frac{W_1^2 + W_2^2 + ... + W_g^2}{g}; \qquad s_{Wim}^2 = \frac{gW_{im}^2}{(g-1)(n-1)}$$

The experimental value $F = s_{Wi}^2 / s_{Wim}^2$ is compared with the theoretical value for *n-1* and *gn-1* degrees of freedom (Ciulcă, 2002). For analysis of genotype x environment interaction was used method 1 of *model* developed by Muir *et al.,* (1992).

RESULTS AND DISCUSIONS

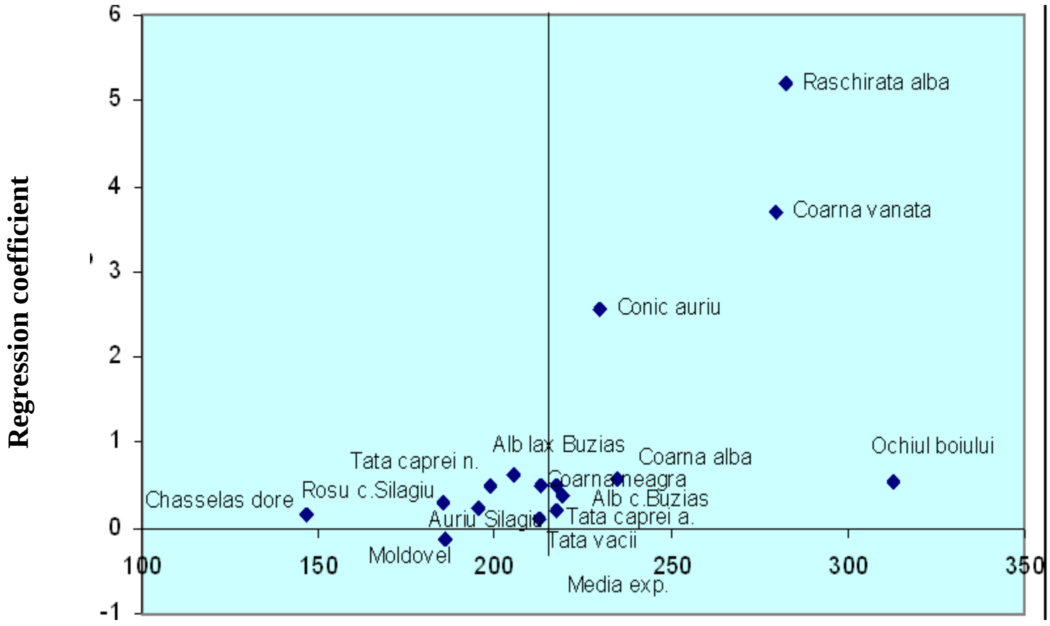
From Tab. 2 follows that the highest stability of type I for bunches weight was observed during experimental time in varieties: Ţâţa vacii, Moldovel, Chasselas dore, Ţâţa caprei albă and Auriu de Silagiu, in which this trait presented values close to the climatic conditions of the three years studied. Also varieties: Răşchirată albă, Coarnă vânătă, Conic auriu, Alb lax de Silagiu, have achieved different values of bunches weight from one year to another, showing a low static stability.

Tab. 2

Stability of the bunches weight through (Finlay-Wilkinson) linear regression for the table varieties studied during 2008-2010

No.	Variety	Mean (g)	Regression Coefficient	Stability Type I (rank)	Stability Type II (rank)	Regression Constant	Residual Variance	Stability Type III (rank)
1	Alb crocant de Buziaş	219.27	0.372	7	7	136.98	8.00	6
2	Alb lax de Silagiu	205.37	0.616	13	1	69.15	104.10	12
3	Auriu de Silagiu	195.53	0.239	5	9	14.,66	27.64	8
4	Coarnă albă	234.43	0.573	12	2	10.73	65.96	11
5	Coarnă neagră	213.30	0.503	9	5	102.08	2.88	5
6	Coarnă vânătă	279.50	3.711	15	15	541.11	1743.99	16
7	Conic auriu	229.93	2.570	14	14	338.36	111.47	13
8	Moldovel	185.80	-0.135	2	13	215.61	56.10	10
9	Negru crocant de Buziaş	217.73	0.508	10	4	105.46	46.97	9
10	Ochiul boului	312.97	0.545	11	3	192.43	0.29	2
11	Răşchirată albă	282.60	5.199	16	16	867.01	223.55	15
12	Roşu crocant de Silagiu	185.60	0.298	6	8	119.81	2.66	4
13	Ţâţa caprei albă	217.50	0.219	4	10	169.06	1.45	3
14	Ţâţa caprei neagră	198.77	0.490	8	6	90.37	137.65	14
15	Ţâţa vacii	212.60	0.121	1	12	18.85	0.05	1
16	Chasselas dorė	146.76	0.169	3	11	109.30	14.85	7

Regression coefficient values close to unity showing a high dynamic stability, registered varieties: Alb lax de Silagiu, Coarnă albă, Ochiul boului, Negru crocant de Buziaş, at which the weight of bunches, was proportional to the suitability of environmental conditions in the experimental years. High values of genotype x environment interaction were observed in the varieties: Răşchirată albă, Coarnă vânătă, Conic auriu, which are showing a reduced dynamic stability, achieving different values of this trait, uncorrelated with the favorability of the environmental conditions during the experimental period. Minimum values of deviations from linear regression, respectively type III high stability of this trait was observed in the varieties: Ţâţa vacii, Ochiul boului, Ţâţa caprei albă, Roşu crocant de Silagiu, Coarnă neagră. Also, in the varieties: Coarnă vânătă, Răşchirată albă, Ţâţa caprei neagră, Conic auriu, which exhibits a type III reduced stability, the bunches weight values in the three experimental years shows large deviations from the linear regression. Considering fig, 1 is noted that varieties: Chasselas dore, Roşu crocant de Silagiu, Auriu de Silagiu, Moldovel, Ţâţa vacii, shows a high static stability associated with values for bunches weight below average of experience. Varieties Răşchirată albă, Coarnă vânătă and Conic auriu show a high instability associated with values of this trait higher than the average of the experiment, being specifically adapted to the more favorable environmental conditions.



Bunches weight (g)

Fig. 1. Diagram of average values and regression coefficients for bunches weight in the table grape varieties studied during 2008-2010

Based on the data presented in Tab. 3, given the significant value of F test is noted that there are real differences between the varieties studied and also among the climatic conditions of experimental years in terms of bunches weight. It also notes that genotype x environment interaction, and varieties x years respectively, did not have a distinct significant influence on this trait in table grape varieties.

Tab. 3

Components of linear regression variance (Hardwick – Wood) for bunches weight in the table grape varieties studied during 2008-2010

Source of variability	SP	GL	S^2 (SP/GL	Test F
Total	916.66	47		
Varieties	764.42	15	50.96	F=29.46**
Years	40.76	2	20.38	F=11.78**
Varieties x Years	111.48	30	3.72	F = 2.15
Regression heterogeneity	85.51	15	5.70	F = 3.30*
Error	25.98	15	1.73	

The lowest significant values of ecological valence that indicate a high stability of bunch weight were recorded for varieties: Ochiul boului, Coarnă neagră, Alb crocant de Buziaş, Negru compact de Buziaş and Coarnă neagră. High values of genotype x environment interaction variance associated with bunch weight of table grape varieties were recorded for: Răşchirată albă, Coarnă vânătă, Conic auriu, which shows a low stability of this trait (Tab. 4).

Tab. 4

Stability of the bunches weight through ecovalence (Wricke) in the table grape varieties studied during 2008-2010

No.	Variety	Mean (g)	Ecovalence	Ecovalence variance	Test F	Stability rank
1	Alb crocant de Buziaş	219.27	108.42	21.64	4.41*	3
2	Alb lax de Silagiu	205.37	141.65	100.40	0.93	7
3	Auriu de Silagiu	195.53	175.13	21.10	0.53	9
4	Coarnă alba	234.43	112.40	74.81	1.27	5
5	Coarnă neagră	213.30	65.79	33.67	22.40**	2
6	Coarnă vânătă	279.50	3616.97	2626.63	2.01	15
7	Conic auriu	229.93	739.64	897.24	15.10**	14
8	Moldovel	185.80	384.19	30.37	0.08	13
9	Negru crocant de Buziaş	217.73	108.69	56.33	1.40	4
10	Ochiul boului	312.97	52.99	38.00	258.52**	1
11	Răşchirată alba	282.60	4716.29	3555.37	30.81**	16
12	Roşu crocant de Silagiu	185.60	128.37	12.61	8.46**	6
13	Ţâţa caprei alba	217.50	156.80	6.84	8.42**	8
14	Ţâţa caprei neagră	198.77	253.84	124.44	0.33	12
15	Ţâţa vacii	212.60	196.89	1.89	72.84**	11
16	Chasselas dorė	146.76	190.59	11.08	0.49	10

Based on analysis of genotype x environment interaction is noted that the highest stability of bunches weight, respectively a low genotype x environment interaction (less than 4% of the total value) is presented by varieties: Ochiul boului (3.36%); Coarnă neagră (3.42%); Alb crocant de Buziaş, (3.61%9; Negru crocant de Buziaş (3.61%), etc.

Highest values of genotype x environment interaction have registered varieties: Răşchirată albă (24.28 %), Coarnă vânătă (19.35 %) and Conic auriu (6.44 %) in which bunches weight showed very different values or reduced stability during the experimental period (Tab. 5).

For this trait, variance heterogeneity has major contributions (84.37%) to achieving the variability due to genotype x environment interaction, so it can be used effectively in assessing the stability of this trait.

Taking into account the heterogeneity of variance is observed that the most unstable bunches weight values were recorded again by varieties Răşchirată albă (25.76 %), Coarnă vânătă (18.29 %) and Conic auriu (6.01 %), which had a smaller contribution to the total variability of this trait throughout the experimental period, according to the analysis of genotype x environment interaction (Tab. 5).

Significant values of F-test, from the table of variance stability analysis (Tab. 6), reveals that have been significant differences between the experimental conditions in the three experimental years and among varieties in terms of average values of bunch weight.

Tab. 5

Stability of the bunches weight (Muir, 1992) through heterogeneous variances (HV) and imperfect correlations (IC) in the table grape varieties studied during 2008-2010

No.	Variety	Mean (g)	SP (HV)	(%)	SP (IC)	(%)	SP (GE)	(%)
1	Alb crocant Buziaş	219.27	371.95	3.95	30.66	1.76	402.61	3,61
2	Alb lax de Silagiu	205.37	305.94	3.25	113.28	6.50	419.22	3,76
3	Auriu de Silagiu	195.53	372.98	3.97	62.98	3.61	435.96	3,91
4	Coarnă albă	234.43	317.31	3.37	87.28	5.01	404.59	3,63
5	Coarnă neagră	213.30	352.95	3.75	28.34	1.63	381.29	3,42
6	Coarnă vânătă	279.50	1720.19	18.29	436.68	25.06	2156.87	19,35
7	Conic auriu	229.93	565.17	6.01	153.04	8.78	718.21	6,44
8	Moldovel	185.80	357.52	3.80	182.97	10.50	540.49	4,85
9	Negru crocant Buziaş	217.73	329.68	3.51	73.06	4.19	402.74	3,61
10	Ochiul boului	312.97	347.52	3.69	27.37	1.57	374.89	3,36
11	Răşchirată albă	282.60	2423.03	25.76	283.51	16.27	2706.54	24,28
12	Roşu crocant de Silagiu	185.60	392.61	4.17	19.97	1.15	412.58	3,70
13	Ţâţa caprei albă	217.50	412.08	4.38	14.72	0.84	426.8	3,83
14	Ţâţa caprei neagră	198.77	299.36	3.18	175.96	10.10	475.32	4,26
15	Ţâţa vacii	212.60	440.59	4.68	6.25	0.36	446.84	4,01
16	Chasselas dorė	146.76	397.07	4.22	46.62	2.68	443.69	3,98
Total			9405.95	84.37	1742.69	15.63	11148.64	100.00

Tab. 6

Components of variance stability (Shukla, 1972) for the bunches weight in table grape varieties studied during 2008-2010

Source of variability	SP	GL	S^2 (SP/GL)	Test F	Stability rank
Varieties	764.42	15	50.96	29.43**	
Years	40.76	2	20.38	11.77**	
Varieties x Years	111.48	30	3.72	2.15	
Alb crocant de Buziaş			0.35	0.2	3,5
Alb lax de Silagiu			0.54	0.31	7
Auriu de Silagiu			0.73	0.42	9
Coarnă albă			0.37	0.22	5
Coarnă neagră			0.11	0.06	2
Coarnă vânătă			20.40	11.78**	15
Conic auriu			3.96	2.29	14
Moldovel			1.93	1.11	13
Negru crocant de Buziaş			0.35	0.21	3,5
Ochiul boului			0.04	0.02	1
Răşchirată albă			26.69	15.41**	16
Roşu crocant de Silagiu			0.47	0.27	6
Ţâţa caprei albă			0.63	0.36	8
Ţâţa caprei neagră			1.18	0.68	12
Ţâţa vacii			0.86	0.50	11
Chasselas dorė			0.82	0.48	10

A high stability of this trait during the experimental period was recorded by varieties: Ochiul boului, Coarnă neagră, Alb crocant de Buziaş, Negru crocant de Buziaş, which present reduced variances in different experimental years for bunches weight. High values of this trait variance, indicating a pronounced instability in recorded varieties: Răşchirată albă, Coarnă vânătă and Conic auriu which present different values of bunches weight in the climatic conditions of the experimental period.

According to the significant F test values (Tab. 7) for the regression heterogeneity follows that this regression model used to estimate the stability of bunches weight, include a significant influence of environmental conditions in the experimental period (Dobrei, *et al.*, 2008). In this regard, varieties: Alb crocant de Buziaş, Chasseles dore, Coarnă neagră, Roşu crocant de Silagiu, Ţâţa caprei albă, presents low values of regression variance proving a good stability of this trait during experimentation. A strong influence of genotype x environment interaction in the expression of the bunch weight according to this model indicates a pronounced instability, which was found in varieties: Coarnă vânătă, Răşchirată albă and Ţâţa caprei neagră.

Tab. 7

Analysis of regression heterogeneity (Shukla, 1972) for the bunches weight in the table grape varieties studied during 2008-2010

Source of variability	SP	GL	S^2 (SP/GL)	Test F	Stability rank
Regression heterogeneity	85.51	15	5.70	3.92*	
Balance	25.98	15	1.73	1.00	
Variety x Years	111.49	30	3.71	2.15	
Alb crocant de Buziaş			0.03	0.02	1
Alb lax de Silagiu			1.07	0.62	12
Auriu de Silagiu			0.19	0.11	8
Coarnă albă			0.63	0.36	11
Coarnă neagră			0.09	0.05	3.5
Coarnă vânătă			19.81	11.44**	16
Conic auriu			1.15	0.66	13
Moldovel			0.52	0.30	10
Negru crocant de Buziaş			0.41	0.24	9
Ochiul boului			0.12	0.07	6.5
Răşchirată albă			2.43	1.40	15
Roşu crocant de Silagiu			0.09	0.05	3.5
Ţâţa caprei albă			0.11	0.06	5
Ţâţa caprei neagră			2.02	1.17	14
Ţâţa vacii			0.12	0.07	6.5
Chasselas dorė			0.05	0.03	2

Analysis of additive main effects and multiplicative interactions, combined with the average of experience for the three experimental years (Fig. 2) indicates that the most favorable conditions for the expression of bunches weight for table grape varieties were recorded in 2009.

On the basis of corresponding vectors for different experimental years is noted that higher variability of bunches weight among varieties were registered in 2009, while in 2010 differences among varieties for this trait were lower.

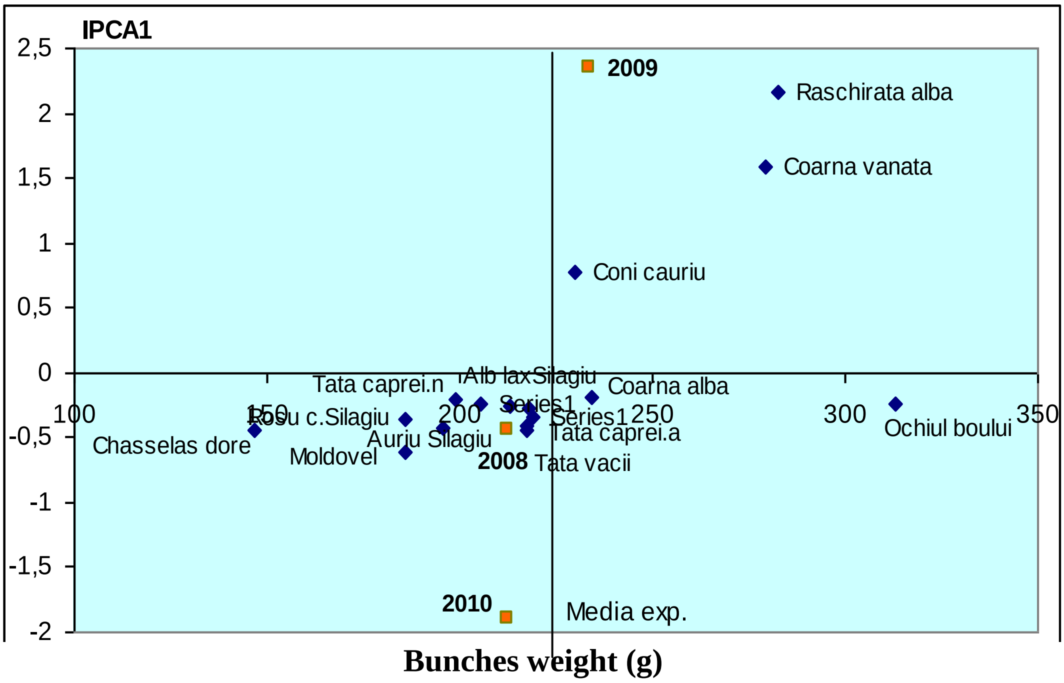


Fig. 2 Biplot diagram of bunches weight and interaction of the main axis components (IPCA1) for the table grape varieties studied during 2008-2010

Tab. 8

Concordance among different models ranks for assessing the stability of bunches weight for table grape varieties studied in 2008-2010 period

No.	Variety	Mean (g)	Stability ranks						Ranks amount	SP_R
			Tip I	Tip II	Tip III	Ecovalence	Shukla 1	Shukla 2		
1	Alb crocant de Buziaş	219.27	7	7	6	3	3.5	1	27.5	552.25
2	Alb lax de Silagiu	205.37	13	1	12	7	7	12	52	1.00
3	Auriu de Silagiu	195.53	5	9	8	9	9	8	48	9.00
4	Coarnă albă	234.43	12	2	11	5	5	11	46	25.00
5	Coarnă neagră	213.30	9	5	5	2	2	3.5	26.5	600.25
6	Coarnă vânătă	279.50	15	15	16	15	15	16	92	1681.00
7	Conic auriu	229.93	14	14	13	14	14	13	82	961.00
8	Moldovel	185.80	2	13	10	13	13	10	61	100.00
9	Negru cro-cant Buziaş	217.73	10	4	9	4	3.5	9	39.5	132.25
10	Ochiul boului	312.97	11	3	2	1	1	6.5	24.5	702.25
11	Răşchirată albă	282.60	16	16	15	16	16	15	94	1849.00
12	Roşu crocant de Silagiu	185.60	6	8	4	6	6	3.5	33.5	306.25
13	Ţâţa caprei albă	217.50	4	10	3	8	8	5	38	169.00
14	Ţâţa caprei neagră	198.77	8	6	14	12	12	14	66	225.00
15	Ţâţa vacii	212.60	1	12	1	11	11	6.5	42.5	72.25
16	Chasselas dorė	146.76	3	11	7	10	10	2	43	64.00
	Media	221.10	136	136	136	136	136	136	816	7449.50

χ^2 =54.64***; $\chi^2_{0,1\%}$ =37.70.

Varieties Coarnă neagră, Alb crocant de Buziaş, Alb lax de Silagiu, Roşu crocant de Silagiu have achieved a constantly below average bunches weight compared with the varieties from experiment, given the low values for the interactions of main components (IPCA1) with a high stability.

At the same time in variety Ochiul boului, stability is associated with high levels of this trait higher than the average in the experiment. Răşchirată albă and Coarnă vânătă varieties perform higher than the average values for this trait, strongly controlled by genotype x environment interaction, and presents a specific adaptability to favorable climatic conditions.

Moldovel variety presents the best specific adaptation to unfavorable environmental conditions. Among the results of six models for assessing the stability of bunches weight in studied varieties (Tab. 8) there is a very tight concordance as evidenced by the very significant difference $\chi2 = 54.64$ *** compared to the control.

Considering the six models used, estimations on the rank-sum is observed that the highest stability trait is present in varieties: Ochiul boului, Coarnă neagră, Alb crocant de Buziaş, Roşu crocant de Silagiu.

A high influence of genotype x environment interaction on the achievement of this trait, respectively high values of the rank-sum according to statistical models used, were observed in the varieties: Răşchirată albă, Coarnă vânătă and Conic auriu.

CONCLUSION

Table grape varieties Coarnă neagră, Alb crocant de Buziaş, Alb lax de Silagiu, Roşu crocant de Silagiu, showed a high stability associated with a bunch weight lower than the average of the experiment.

At the same time in variety Ochiul boului the high stability is associated with levels of this trait higher than the average of the experiment.

Răşchirată albă and Coarnă vânătă varieties perform values of this trait higher than the average of the experiment, strongly controlled by genotype x environment interaction, and show a particular adaptability to more favorable climatic conditions.

Variety Moldovel shows the best specific adaptation to unfavorable environmental conditions.

Local varieties and biotypes from Buziaş-Silagiu area represent a valuable genetic heritage due to their productive traits, quality and biological resistance. They are both a source of authenticity and geographic exclusivity, a source of variety and ancestry, in the process of vine improvement.

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