Genetic diversity of table grape based on morphoagronomic traits

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ABSTRACT: The conservation and characterization of grape (*Vitis* spp) genetic resources in germplasm banks have been the basis of its use in breeding programs that result in development of new cultivars. There are at least 10,000 grape cultivars kept in germplasm collection. The genetic diversity in 136 table grape accessions from the state of Bahia, Brazil, was evaluated. Continuous and discrete morphoagronomic traits were assessed. The clustering analysis by the Tocher otimization method resulted in 30 clusters (considering continuous morphoagronomic traits), and 9 clusters (taking into consideration multicategorical traits). There was no agreement between clusters obtained by both, continuous or discrete phenotypic descriptors, independent of the cluster method analysis used. A satisfactory genetic variability among the table grape accessions was observed.
Key words: *Vitis* spp., genetic resources, grape, multivariate analysis

Diversidade genética de acessos de uvas de mesa baseada em caracteres morfoagronômicos

RESUMO: A conservação e caracterização dos recursos genéticos de videira (*Vitis* spp.) em bancos de germoplasma tem sido a base para a sua utilização nos programas de melhoramento, que resultam no desenvolvimento de novas cultivares, estimando-se a existência de pelo menos 10.000 cultivares de uva mantidos em coleções de germoplasma. Avaliou-se a diversidade genética presente em 136 acessos de uvas de mesa de uma coleção de germoplasma do estado da Bahia, com base em caraterísticas morfoagronômicas de variação contínua e discreta. A análise de agrupamento pelo método de Tocher resultou na formação de 30 grupos utilizando-se descritores morfo-agronômicos de variação contínua e 9 grupos, com base em caracteres multicategóricos. Não houve concordância entre os grupos obtidos pela análise de descritores fenotípicos contínuos e discretos, independente do método de agrupamento utilizado. Detectou-se a existência de variabilidade genética satisfatória entre os acessos de uvas de mesa da coleção.
Palavras-chave: *Vitis* spp., recursos genéticos, uva, análise multivariada

Introduction

Methods based on morphoagronomic traits, used to study genetic diversity, have been used since Mendel's time. The ampelography is the field of botany concerned with identification and classification of grape anchored in morphological traits of leaves, apical shoot tips, bunches, and berries (IPGRI, UPOV, OIV 1997; Galet 1998). The ampelography was the predominant method for grape germplasm characterization, since XIX century, until the advent of molecular markers.

The predictive methods based on morphological, agronomical, physiological or genetical traits of genitors, determined prior to the crosses, may help breeders to focus in promising combinations (Cruz et al., 2004). The heterosis, expressed in hybrids, is directly related to the genetic diversity among their genitors (Falconer, 1989).

The multivariate techniques in the analysis of quantitative and qualitative characteristics have been applied in viticulture with several objectives: to assess the diversity of genotypes for disease resistance (Nascimento et al., 2006), management (Intrieri et al., 2001), and morphological and agronomic descriptors (Borges et al., 2008; Micheli et al., 1993; Cravero et al., 1994; Matheou et al., 1995a; Matheou et al., 1995b; Boselli et al., 2000; Coelho et al., 2004).

The diversity of 136 accessions was evaluated using twelve morpho-agronomic traits of continuous variation and six characters of discrete variation during four seasons, with the main objective to characterize and quantify the genetic variability among accessions of table grapes from the Grape Germplasm Collection of EMBRAPA Semiárido.

Material and Methods

One hundred and thirty six accessions of table grapes (*Vitis* spp.) from the grapevine germplasm collection of EMBRAPA Semi-Árido, with known geographical origin, species, and genealogies were evaluated (Table 1). The germplasm collection was located in Juazeiro, state

Table 1 – Table grape accession, classification according to origin, specie, and pedigree evaluated in this study.

Accession	N	Origin	Species	Pedigree	Accession	N	Origin	Specie	Pedigree
A 1105	1	USA	?		Centennial Seedless	24	USA	*V. vinifera*	Gold × Q25-6 (F2 de Emperor × 'Itália')
A 1118	2	USA	?		CG 28467 (Emperatriz)	25	Argentina	*V. vinifera*	Emperor × Sultanina
A1581	3	USA	?		CG 351 (Arizul)	26	Argentina	*V. vinifera*	Gibi × Sultanina
A Dona	4	Brazil	Hybrid	Soraya × IAC 544-14	CG 38049	27	Argentina	*V. vinifera*	Riesling × (Gibi × Sultanina)
Ângelo Pirovano	5	Italy	*V. vinifera*	Chasselas Rose × Muscat Hamburgo	CG 39915	28	Argentina	*V. vinifera*	Saint Jeannet × Sultanina
Aurora	6	Brazil	Hybrid	IAC 394-16 × Maria	CG 102024 (Dacari)	29	Argentina	*V. vinifera*	
Baresana	7	Italy	*V. vinifera*		CG 102295 (Moscatuel)	30	Argentina	*V. vinifera*	'Moscatel Rosada' no2 × (Cardinal × Sultanina)
Beauty Seedless	8	USA	*V. vinifera*	Reine des Vignes × Black Kishmish	CG 26858 (Pasiga)	31	Argentina	*V. vinifera*	Alphonsee Lavallee × Sultanina
Beni Fugi	9	Japan	Hybrid	Golden Muscat × Kuroshio	CG 40016 (Damarim)	32	Argentina	*V. vinifera*	Moscatel Rosado × Sultanina
Benitaka	10	Brazil	*V. vinifera*	Mutation of 'Itália'	CG 90450	33	Argentina	*V. vinifera*	
Benitaka	10	Brazil	*V. vinifera*	Mutation of 'Itália'	CG 90450	33	Argentina	*V. vinifera*	
Blue Lake	11	USA	Hybrid	*V. smalliana* O.P. × Caco	CG 4113	34	Argentina	*V. vinifera*	Lambrusco × Carignane
Blush Seedless	12	USA	*V. vinifera*	Emperor × (Alphonsee Lavallee × Italia) × Koen D. Wein	CG 33716	35	Argentina	*V. vinifera*	Dattier de Beiroth × Thompson Seedless
Branca Salitre	13	?	?		CG 87746	36	Argentina	*V. vinifera*	Moscato Rosa × Beauty Seedless
Brazil	14	Brazil	*V. vinifera*	Mutation of 'Benitaka'	CG 87908	37	Argentina	*V. vinifera*	
Bronx Seedless	15	USA	Hybrid	(Goff × Iona) × Sultanina	CG 26916 (Baviera)	38	Argentina	*V. vinifera*	
BRS Clara	16	Brazil	*V. vinifera*	CG87746 × Centennial Seedless	Crimson Seedless	39	USA	*V. vinifera*	Emperor × C33-199
BRS Linda	17	Brazil	*V. vinifera*	CG 87746 × Saturn	Christmas Rose	40	USA	*V. vinifera*	(Hunisa × Emperor × Nocera) × (Hunisa × Emperor × 'Itália')
BRS Morena	18	Brazil	*V. vinifera*	Marroo Seedless × Centennial Seedless	Dattier de Beiroth	41	Lebanon	*V. vinifera*	
Califórnia	19	USA	*V. vinifera*		Dattier de Saint Vallier	42	France	Hybrid	Panse de Provence × Seyve Villard 12375
Canner	20	USA	*V. vinifera*	Hunisa × Sultanina	Dawn Seedless	43	USA	*V. vinifera*	Gold × Perlette
Cardinal	21	USA	*V. vinifera*	Flame Tokay × Ribier	Delight	44	USA	*V. vinifera*	Reine des Vignes × Sultanina Branca
Catalunha	22	Brazil	*V. vinifera*		Dona Maria	45	Portugal	*V. vinifera*	Moscatel de Setubal × Rosaki
Ceilad	23	?	?		Dom Mariano	46	?	?	
Maria	85	Brazil	Hybrid	(Highland × Golden Queen) × Jumbo	Perlette	105	USA	*V. vinifera*	Regina del Vigneti × Sultanina
Maroo Seedless	86	Australia	Hybrid	Carolina Blackrose × Ruby Sds	Perlona	106	Italy	*V. vinifera*	Bicane × Muscat Madresfield
Mont Serrat	87	?	?		Piratininga	107	Brazil	Hybrid	Mutation of 'Eugênio' ((Seibel 7053 × Muscat Hamburgo) × Soraya)
Moscato de Alexandria	88	Egypt	*V. vinifera*		Seleção 01	108	?	?	
Moscatel Branca	89	Italy-Portugal	*V. vinifera*		Seleção 02	109	?	?	
Muscat de Hamburgo	90	German	*V. vinifera*	Schiava Grossa × Muscat de Alexandria	Seleção 04	110	?	?	
Moscato Grego	91	France	*V. vinifera*		Portuguesa Blanes	111	?	?	
Moscatel Nazareno	92	Portugal	*V. vinifera*	Muscat de Hamburgo × Joao Santarém	Princess	112	USA	Hybrid	Crimson Seedless × Fresno B40-208
Moscatel Rosada	93	Portugal	*V. vinifera*	Diagalves × Moscatel de Málaga	Queen	113	USA	*V. vinifera*	'Muscat de Hamburgo' × Sultanina
Muscat Caillaba	94	France	*V. vinifera*		Red Globe	114	USA	*V. vinifera*	(Hunisa × Emperor) × (Hunisa × Emperor × Nocera)

Contine...

Table 1 – Continuation.

Muscat Noir	95	France	*V. vinifera*		Regina dei Vigneti	115	Hungary	*V. vinifera*	Erzseber Kiralyne Emleke × Perle von Csaba
Muscat de Saint Vallier	96	France	Hybrid	Seyve Villard 12-129 × Panse	Regina Roma	116	?	?	
Neo Muscat	97	Japan	*V. vinifera*	Muscat de Alexandria × Koshu Sanjaku	Reliance	117	USA	Hybrid	Ontario × Suffolk Red
Neptune	98	USA	Hybrid		Rodi	118	Italy	*V. vinifera*	Zibibbo × Sultanina
Niagara Rosada	99	Brazil	*V. labrusca*	Mutation of 'Niágara'	Roni Redi	119	?	?	
Orange Muscat	100	France	*V. vinifera*		Rosaki Rosada	120	?	*V. vinifera*	
Panse Precoce	101	Italy	*V. vinifera*		Ruby Seedless	121	USA	*V. vinifera*	Emperor × Sultana Moscata
Patrícia	102	Brazil	Hybrid	Soraya × ((Muscat Hamburgo × V. cinérea) × (Red Niagara × Jumbo))	Saint Jeannet	122	France	*V. vinifera*	
Paulistinha	103	Brazil	Hybrid	'Niagara Branca' × Sultanina	Saturn	123	USA	Hybrid	Dunstan 210 × New York 45791
Perla de Gralia	104	?	?		Seyve Villard 12327	124	France	Hybrid	Seibel 6468 × Seibel 6905
Seyve Villard 12375	125	France	Hybrid	Seibel 6468 × Seibel 6905	Superior Seedless	131	USA	*V. vinifera*	Cardinal × ?
Seyve Villard 20365	126	France	Hybrid	Panse de Provence × Seyve Villard 12375	Sultanina Branca	132	Turkey	*V. vinifera*	Clone de Thompson Seedless
Soraya	127	Brazil	Hybrid	(Highland × Golden Queen) × Pirovano 215	Sultana Moscata	133	Italy	*V. vinifera*	Zibibbo × Sultanina
Sovrana Pirovano	128	Italy	*V. vinifera*	Frakenthal × Delizia de Vaprio	Tardia de Caxias	134	Brazil	Hybrid	Niagara Branca × Catawba Rosa
Stover	129	USA	Hybrid	Mantey × Roucaneuf	Thompson Seedless	135	Turkey	*V. vinifera*	
Suffolk Red	130	USA	Hybrid	Fredonia × Kishmish Chernyi	Vênus	136	USA	Hybrid	Alden × New York 46000

of Bahia, Brazil (9°24'S, 40°26'W, 365.5m a.s.l.). The climate is classified according to Koeppen, as Bswh, which corresponds to the semi-arid hot, with average annual precipitation of 505 mm, annual average relative humidity of 60.7%, annual average temperature, maximum, and minimum, respectively 26.7°C, 32.0°C, and 20.8°C (www.cpatsa.embrapa.br/servicos/dadosmet/cem-anual.html).

Mean values were obtained from four plants in four seasons based on 12 morphoagronomic characteristics of continuous variation. The traits were chosen from the list of descriptors of the International Plant Genetic Resources Institute (1997), for its importance in the yield and fruit quality: i) duration of the phenological cycle (CD), measured from the date of pruning to harvest (days), ii) production of bunches per plant (PR) - weight of all bunches per plant (kg), iii) number of bunches per plant (NB); iv) mean bunches weight (BW) - total weight of all bunches divided by the total number of bunches per plant (g), v) bunches length (BL), measured between the top and bottom of the rachis (cm), vi) width of the bunches (WB), measured between both extremity side of the rachis (cm), vii) weight of berries (WBe) - mean weight of ten berries per bunch (g), viii) length of berry (LBe) - mean length of ten berries per bunch (mm), ix) diameter of berry (DBe) - mean diameter of ten berries per bunch (mm), x) total soluble solids (TSS), determined from a sample of ten berries per bunch in °Brix; xi) titratable acidity (TTA), determined from a sample of ten berries per bunch in percentage of tartaric acid / 100 mL of juice; and xii) the total soluble solids (TSS)/ total titratable acidity (TTA). Six discrete characteristics were also evaluated, coded as follows: i) consistency of the pulp: crisp (1), fleshy (2), muscilaginous (3), or juicy (4); ii) Presence of seeds: present (1) or absent (2); iii) Taste: neutral (1), special (2) muscat (3) or foxy (4); iv) Format of bunches: cylindrical (1), cylindrical winged (2) or cone (3); v) Format berries: ovoid (1), globose (2) or elliptical (3); vi) Color: Black (1), red (2), green (3) or green-yellow (4).

Statistical analysis was performed using the software Genes (http://www.ufv.br/dbg/genes/Genes) EUA.htm (Cruz, 2008). To carry out the multivariate analysis, the genetic distances between all pairs of accessions were obtained, using Mean Euclidean distance for continuous variables, and the index of dissimilarity for multicategorical variables. The index of dissimilarity between each pair of accessions was set according to the: agreement (A) and disagreement (D) of categories or statistical classes for the traits studied. Cluster analysis was performed by Tocher's optimization procedure.

The diversity among accessions based on discrete variables was visualized through graphical projection of distances in three dimensional spaces. The efficiency of the projection was estimated by the following statistics: i) Degree of distortion, ii) Coefficient of correlation between the original distances and those represented in the dispersion graph, and iii) Stress coefficient of Kruskal (1964).

Diversity was also analyzed using the method of multivariate analysis of principal components (Cruz et al., 2004) for continuous variable. The relative importance of characters, used in the discrimination of clusters, was assessed at the discretion of the weight variables in eigenvectors. The eigenvectors and eigenvalues were obtained from the correlation matrix of standardized data of original values. The characters with higher weights in the last five eigenvectors, up to a value less than or equal to 0.70, have lower contribution in the discrimination of groups and should be discarded (Cruz et al., 2004). Then, the dissimilarities between accessions were viewed by means of dispersion imaging in three dimensional space.

Results and Discussion

Thirty clusters were obtained by Tocher's optimization procedure for twelve continuous variables in 136 accessions of table grapes (Table 2). Cluster 1 included 30.14% of the accessions from the collection. In general, it was not possible to identify a trend in the formation of clusters such as genealogy or geographical origin. Clusters 1 and 2 grouped cultivars of different geographical origins, different species such as *Vitis vinifera*, *Vitis labrusca*, *Vitis* interspecific hybrids, and seeded and seedless grape cultivars. These results agree with those obtained in guarana (*Paullinia cupana* Kunth.) (Nascimento Filho et al., 2001) and cowpea (*Vigna unguiculata* L.) (Oliveira et al., 2003), where there was no occurrence of correlation between geographical and genetical diversity. Martinelli et al. (2002) also did not obtain a separation of the accessions of okra (***Abelmoschus** esculentus* Moench), according to their botanical specie, when using multivariate analysis of quantitative traits. According to Martinelli et al. (2002), characteristics controlled by many genes and affected by environmental factors may be a suitable explanation.

Table 2 – Grouping according to Tocher's optimization procedure, considering twelve characters of continuous variation evaluated in 136 accessions of table grapes.

Cluster	Accessions
1	49 76 77 75 60 89 63 100 124 96 101 2 83 8 104 91 59 125 62 118 37 80 82 39 58 123 12 135 36 103 117 136 15 43 20 24 32 22 133 105 132
2	90 95 92 94 86 7 93 88 61 13 57 67 106 9 127 116 84 78 111 97 122 71 107
3	10 14 113 72 114 45 33
4	6 66 79 68
5	41 46 40 38 53 52 42
6	5 19 126 25 112 98 1 51 26 28
7	23 35 128 34
8	108 109 110
9	16 65 18 99
10	21 115 131 29 3
11	44 130
12	64 81 27
13	4 102
14	55 56
15	11 129
16	69 85
17	50 73
18	87
19	121
20	54
21	120
22	30
23	74
24	47
25	119
26	70
27	31
28	17
29	48
30	134

Cluster 1 had a predominance of seedless grape cultivars, which represented 63.4% of this cluster; 'Thompson Seedless' and its synonyms 'Catalunha' and 'Sultanina Branca' were included in this group. Most cultivars of the muscat type were included in cluster 2. Cluster 3 was composed of clones of 'Itália' of red berries such as 'Benitaka' and 'Brasil', and 'Itália Muscat', which has soluble solids content and muscat flavor greater the cultivar 'Itália'. Predominant cultivars in this cluster are distinguished by the size of their berries. Besides those already mentioned, also belong to this group: 'CG 90450', 'Dona Maria', 'Queen', and 'Red Globe'. Clones and synonyms such as 'Dattier de Saint Vallier' and 'Seyve Villard 20365', 'Emperatriz' and 'CG 28467' were separated into distinct groups, showing that the technique of grouping morphoagronomic traits using continuous cluster was not efficient to group identical genotypes. The cluster 17, which has included the cultivars 'Itália clone 1' and 'Estevão Marinho', was highlighted by the production and bunches sizes.

Considering all the possible combinations for each accession, the majority presented maximum distances for two cultivars: 'Tardia de Caxias' (accession 134) and 'Itália clone 1' (accession 73), indicating that these cultivars were the more divergent of this table grape set. The maximum distance observed between both was d = 3.55,whereas, the cultivars Early Muscat and July Muscat showed the smallest distance (d = 0.21) between all pairs of accessions analyzed.

The mean value of a segregating population depends on the frequency of favorable alleles and the frequency of loci in heterozygosity. When the parents used are adapted, the frequency of favorable alleles is high. Vine has been selected and vegetatively propagated over thousands of years since the beginning of the process of domestication and cultivation, which contributed to the accumulation of favorable alleles. Being a species highly heterozygous, it is hoped, therefore, to obtain the maximum heterotic effect in segregating generations from the crossing of divergent parents. Considering the multivariate statistics, it is expected to find high similarity between the genotypes belonging to the same cluster. Thus, crossing within the same cluster should be avoided. According to Nascimento Filho et al. (2001), the crossing of more productive guarana clones, in the different clusters, allowed to obtain populations highly segregating.

There was genetic variability among accessions in this collection, revealed by the large number of clusters formed and satisfactory distribution of the accessions within these groups. This enables the identification of parents that may form segregating populations with broad genetic base. For the development of new table seedless grape cultivars, one of the strategies suggested is the use of 'Thompson Seedless' (cluster 1) as male parent, with cultivars that were more divergent, higher productive, and possess large berries such as 'Italy clone 1' (d = 2.60) and 'Estevão Marinho' (d = 2.50), both in cluster 17. Other recommended crosses would be: 'Thompson Seedless' with 'Itália melhorada' (d = 2.03) (cluster 23), 'Red Globe' (d = 2.22) or 'Dona Maria'(d = 2.08) (cluster 3).

Using multivariate analysis by principal components, most of the variability was retained in the first four principal components that explained 82.78% of the variance and were used to plot the accessions in the three-dimensional space (Figure 1). The principal component 1, representing 44.16% of total variance, and the variables with higher weight in this component were bunches weigh, berry weight, and berry diameter (Table 3). Component 2 explained 16.67% of the total variance, and it was associated with the following characteristics: TSS/TTA and titratable acidity (TTA). Component 3 explained 14.77% of the variance of the original data and was represented mainly by the variable number of bunches per plant, total soluble solids (TSS) and yield per plant. Component 4, represented 7.18% of total variance, and the variable with higher weight was the total soluble solids (TSS).

The characters with higher weights in the last five eigenvectors, up to a value less than or equal to 0.70, have lower contribution in the discrimination of groups and should be discarded (Cruz et al. 2004). They were, in decreasing order of importance: bunch weight (BW), weight of berries (WBe), TSS/TTA, width of bunch (WB), and length of berry (LBe).

The score graph of the four first principal components showed that there was consistency with the groups formed by Tocher's optimization procedure. Borges et al. (2008) also found correlation between groups obtained by Tocher's optimization procedure and principal components when studying a set of 58 accessions of this collection. This can be seen in Figures 1A and 1B, considering the groups with the highest number of accessions, clusters 1 and 4 positioned to the right side of the X axis, while clusters 2 and 3 were located on the left, and clusters 5 and 6 in the lower portion. The cultivars 'Tardia de Caxias' (accession 134) and 'Itália clone 1' (accession 73), which showed maximum distance, were positioned at opposite ends in three-dimensional space.

Significant correlations ($p < 0.05$ and $p < 0.01$) were observed among traits studied, but in general, they were of low magnitude (Table 4). In particular, the correlations ($p < 0.01$) between bunch weight and characteristics of size of bunches and berries were positive and significant: bunch length (r = 0.76), width of bunch (r = 0.86), weigh of berry (r = 0.76), length of berry (r = 0.61), and diameter of berry (r = 0.76). Other high positive correlations were obtained between length and width of bunches (r = 0.78), berry weight and berry length (r = 0.85), berry weight and berry diameter (r = 0.92), and length and diameter of berries (r = 0.81), whereas a significant negative correlation between titratable acidity and TSS/TTA (r = - 0.83) was observed. Considering the results obtained by analysis of principal components and correlations, the variable berry weight could in future work be refused in the evaluation accessions of

Table 3 – Estimates of eigenvalues (λ) and eigenvectors associated with the principal components in 136 accessions of table grapes and twelve morphological and agronomic of continuous variation. Bold values highlight the characteristic of greater weight in their eigenvector.

Trait	CP 1	CP 2	CP 3	CP 4	CP 5	CP 6	CP 7	CP 8	CP 9	CP 10	CP 11	CP 12
CD	0.2515	-0.1477	0.2658	-0.421	0.0973	0.7984	-0.022	0.0334	0.018	0.0719	0.0972	0.0644
PR	0.2563	0.3813	0.3874	-0.0758	-0.0627	-0.2582	0.1529	-0.1286	0.4327	0.0558	0.3082	0.4871
NB	-0.0108	0.3343	0.5801	-0.293	-0.226	-0.1949	0.2577	0.2214	-0.2835	-0.0724	-0.2192	-0.3572
BW	0.3999	0.141	-0.0072	0.1365	0.1242	0.0502	-0.3265	-0.1463	0.4547	-0.0843	-0.3521	-0.5637
BL	0.3233	0.2076	-0.0461	0.2754	0.4335	0.0559	-0.7424	-0.1519	-0.0211	-0.062	-0.0012	0.0535
WB	0.3525	0.2129	0.0039	0.2569	0.329	-0.0115	-0.4173	0.4571	-0.4995	0.0934	0.0705	0.099
WBe	0.3853	-0.0597	-0.1435	-0.0568	-0.3783	0.0033	-0.0233	-0.1811	-0.2253	-0.2826	-0.5689	0.4397
LBe	0.3407	-0.1866	-0.2233	0.0328	-0.3931	-0.06	0.2744	0.649	0.3205	0.169	0.1018	-0.0439
DBe	0.383	0.0016	-0.1555	-0.032	-0.3646	-0.0626	-0.0113	-0.4365	-0.3442	0.1123	0.5181	-0.3179
TSS	-0.0923	-0.1345	0.4423	0.7187	-0.3244	0.2636	0.0128	-0.0944	-0.0222	0.263	-0.0818	0.0323
TTA	-0.2049	0.5025	-0.1979	0.1898	-0.2716	0.3766	-0.0299	0.1456	0.0536	-0.5821	0.2238	-0.0275
TSS/TTA	0.1432	-0.5511	0.3334	0.1133	0.1202	-0.1826	-0.0347	0.0728	0.0072	-0.6601	0.2436	-0.0493
λ	5.30	2.00	1.77	0.86	0.78	0.52	0.25	0.16	0.12	0.09	0.08	0.06
λ (%) accumulated	44.16	60.84	75.60	82.78	89.27	93.64	95.73	97.09	98.10	98.88	99.53	100

CD = duration of the phenological cycle (days), PR = production of bunches per plant (kg), NB = number of bunches per plant, BL = bunches length, WB = bunches weight, WBe = weight of berries, LBe = length of berry, DBe = diameter of berry, TSS = total soluble solids, TTA = total titratable acidity, TSS/TTA = ratio total soluble solids (TSS) / total titratable acidity (TTA).

Table 4 – Pearson's correlation coefficients obtained among twelve traits, of continuous variation, in 136 accessions of table grapes from the vine germplasm collection of EMBRAPA Semi-Árido.

Trait	DC	PR	NB	BW	BL	WB	WBe	LBe	DBe	TSS	TTA
CD	0.24**										
PR	0.28**	0.1^{ns}									
NB	0.46**	0.59**	0.23^{ns}								
BW	0.30**	0.43**	0.07^{ns}	0.76**							
BL	0.34**	0.57**	0.12^{ns}	0.86**	0.78**						
WB	0.45**	0.31**	0.23**	0.76**	0.51**	0.58**					
WBe	0.34**	0.14^{ns}	0.17*	0.61**	0.43**	0.46**	0.85**				
LBe	0.39**	0.36**	0.19*	0.76**	0.54**	0.61**	0.92**	0.81**			
DBe	-0.05^{ns}	-0.01^{ns}	0.05^{ns}	-0.18*	-0.17*	-0.16*	-0.22**	-0.19*	-0.24**		
TSS	-0.44**	-0.09^{ns}	-0.1^{ns}	-0.28**	-0.18*	-0.19*	-0.36**	-0.39**	-0.31**	0.03^{ns}	
TTA	0.40**	0.01^{ns}	0.07^{ns}	0.16^{ns}	-0.05^{ns}	0.09^{ns}	0.24**	0.30**	0.16^{ns}	0.33**	-0.83**

** and * significant at 1 and 5% of probability, respectively, by the t test. CD = duration of the phenological cycle (days), PR = production of bunches per plant (kg), NB = number of bunches per plant, BL = bunches length, WB = bunches weight, WBe = weight of berries, LBe = length of berry, DBe = diameter of berry, TSS = total soluble solids, TTA = total titratable acidity.

table grapes using morpho-agronomic traits of continuous variation.

Cluster analysis by the Tocher's optimization procedure resulted in the formation of 9 groups, concentrating 35.3% of accessions in group 1 (Table 5). Cluster 3 consisted only of accessions with muscilaginous and juicy pulp consistency and the vast majority of muscat type cultivars. The American cultivars were also included in this cluster. Cluster 4 was formed exclusively by seedless grape cultivars. The red clones of the cultivar Itália, 'Benitaka' and 'Brasil' were included in cluster 1 together with 'Itália' and clone 'Itália 1', both of white berries. However, the clones 'Itália melhorada' and 'Itália Muscat', which are differentiated by the more accentuated moscatel taste, were placed in cluster 7. It was not possible to group the accessions that are synonyms, i.e., they represent the same phenotype when using discrete variables.

The projection of the distances (Figure 2) demonstrated the formation of two distinct groups in the three-dimensional space, considering as a classificatory variable: presence/absence of seeds in the berries. The correlation between original and estimated distances was 0.71, while the degree of distortion was 13.21%, and the

Table 5 – Grouping according to Tocher's optimization procedure, based on six multicategorical variables evaluated in 136 accessions of table grapes.

Cluster	Accessions
1	1 38 42 116 47 57 84 127 87 10 14 40 52 102 41 53 25 61 26 107 45 115 46 78 113 114 5 71 96 82 100 3 2 13 101 29 21 33 105 60 134 73 27 83 104 76 120 50
2	8 86 44 108 125 19 109 110 126 111 23 12 124 128 55
3	9 99 48 81 11 68 69 129 97 119 95 117 94 91 49 56 89 92 67 106 79 62 90 93 75 88 63 36
4	16 43 112 18 54 39 22 24 135 28 17 70 98 20 35 131 58 118 121 4 51 123 59 132 77 65 133
5	6 122 7 37 32 80 31 85 130 30
6	34 103 15
7	72 74 66
8	64
9	136

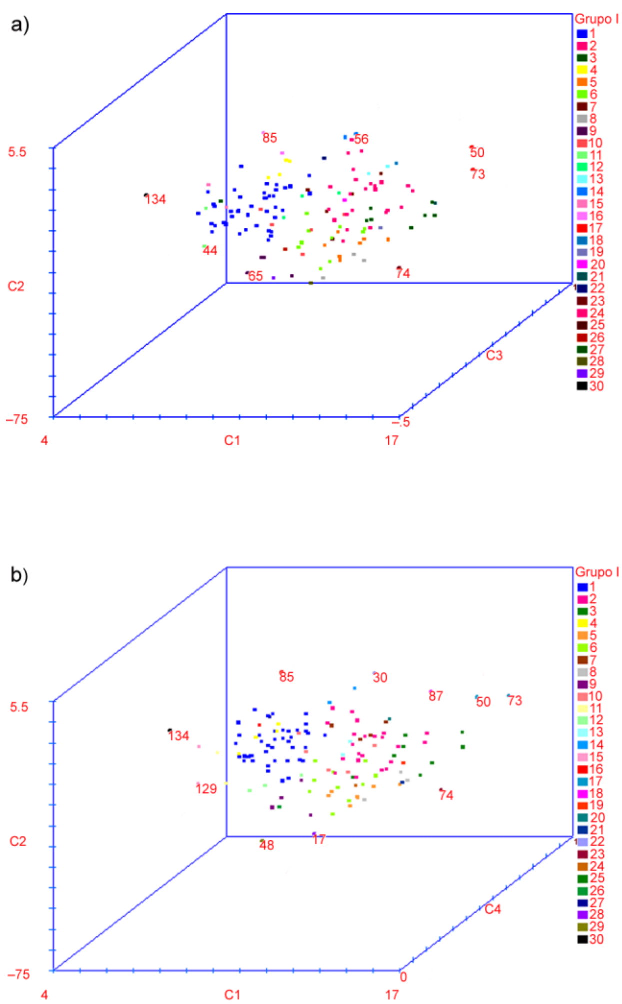

Figure 1 – Graphical dispersion of 136 accessions of table grapes in relation to principal components 1, 2, and 3 (a) and 1, 2, and 4 (b) established by the linear combination of 12 morphoagronomic characters of continuous variation. The colors differentiate the groups according to the Tocher's cluster analysis.

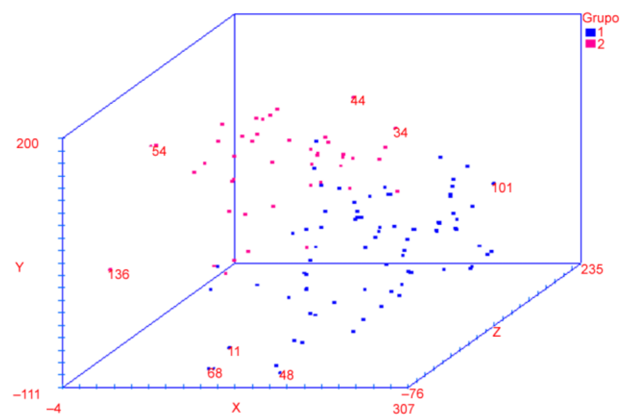

Figure 2 – Graphical projection of the distances of 136 accessions of table grapes, estimated from six morphoagronomic discrete traits using as a classificatory variable: presence (group 1) or absence of seeds (group 2).

stress coefficient was 27.88. According to Cruz et al. (2004), the dispersion process of dissimilarity measures in the plan can be considered satisfactory, when the coefficients that express the degree of distortion and stress, are less than 20%.

Conclusions

The multivariate techniques to study genetic diversity applied to continuously variable characters are consistent with each other. However, there is no correlation between the formation of the clusters using continuous and multicategorical variables. The characteristic 'weight of berry' can be refuse in future work on morpho-agronomic evaluation of accessions of table grapes. Cluster analysis based on morpho-agronomic characters resulted in the separation of accessions according to common characteristics such as weight and berry production (continuous variables), consistency of the pulp and the presence of seeds (multicategorical variables), but is not efficient in group identical or synonyms genotypes.

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