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ANALYSIS OF THE GENETIC DIVERSITY IN MAIZE LANDRACE CULTIVARS FROM NORTHERN RIO GRANDE DO SUL, BRAZIL

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Abstract – Maize landraces are important genetic resources for maize breeding. Many of these landrace varieties have not yet been properly studied to be distinguished from the others. In this study, multivariate statistical methods were used, beyond the analysis of variance, for estimating genetic dissimilarity among 27 maize landrace accessions. Principal Component Analysis and clustering analysis were performed using 16 evaluated quantitative traits. The Analysis of Variance results reported the existence of significant differences among the tested accessions for 14 evaluated traits. The first principal component and the second one almost explained 49% of found experimental phenotypic variance. Four different clusters were formed by the used clustering analysis. The clusters differed in 11 traits by the Analysis of Variance. This result and the graphical integration of this dendrogram with the Principal Component Analysis allowed to conclude that the phenotypic variation found may be due to the genotypic distinctions existing among the four groups of accesses determined in this study.

Keyworks: Multivariate technics, genetic diversity, maize breeding, *Zea mays* L.

ANÁLISE DA DIVERSIDADE GENÉTICA EM VARIEDADES DE MILHO CRIOULO COLETADAS NO NORTE DO RIO GRANDE DO SUL, BRASIL

Resumo - Variedades de milho crioulo são recursos genéticos importantes para o melhoramento de milho. Muitas dessas variedades crioulas não têm sido adequadamente estudadas, a fim de distingui-las umas das outras. Neste estudo foram utilizados métodos de estatística multivariada, além de análises de variância, para estimar a dissimilaridade genética entre 27 acessos de milho crioulo. Análise de componentes principais e análises de agrupamento foram realizadas usando-se 16 caracteres quantitativos. Os resultados da análise de variância indicaram a existência de diferenças significativas entre os acessos avaliados para 14 destas características. As duas primeiras componentes principais explicaram cerca de 49% da variância fenotípica experimental. Quatro diferentes grupos foram formados utilizando-se a análise de agrupamento. Pela análise de variância, os grupos diferiram entre si em 11 caracteres avaliados. Este resultado e a integração gráfica desse dendrograma com a análise de componentes principais permitiram concluir que a variação fenotípica encontrada pode ser devido a existência de diferenças genotípicas entre os quatro grupos de acessos determinados neste estudo.

Palavras-chave: Análise multivariada, diversidade genética, melhoramento de milho, *Zea mays* L.

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Maize (*Zea mays* L.) is one of the most important cultivated crops in the world. In Brazil, Rio Grande do Sul state has produced almost 6 million maize tons (Acompanhamento da Safra Brasileira [de] Grãos, 2019). Despite the major contribution of modern maize cultivars in total maize production, many local farmers have still been cultivating maize landraces, that are known in Brazil by "variedades crioulas de milho". These cultivars represent a great and secular genetic variability of cultivated maize in Rio Grande do Sul, whose study is fundamental for maize germoplasm conservation. In Northern Rio Grande do Sul, precisely in the great region of Passo Fundo (Passo Fundo, Sertão, Marau, Tapejara, etc.) there are many maize landraces there are many maize landraces cultivars whose differentiation is difficult in many cases. Local names of these cultivars can be interchangeable not reflecting their genetic variability. The same name can correspond to some different varieties and the opposite can be also true (Souza, 2015). In fact, the active genetic erosion by contamination and the low level of scientific knowledge over these landraces may be the causes of this situation.

Multivariate methods consist of very important statistical procedures used for calculating and measuring genetic differences and distances among accessions in plant germoplasm (Mohammadi & Prasanna, 2003; Balzarini et al., 2011). These methods include PCA (principal component analysis) and clustering methods (Mohammadi & Prasanna, 2003). In studies about genetic diversity in maize landraces there are some examples of the mentioned technics usage, particularly in works involving molecular Genetics (Teixeira et al., 2002; Carvalho et al., 2004; Netto et al., 2004; Coimbra et al., 2012). Despite the existence of these powerful technics for characterizing and evaluating genetic diversity of crops, there are not many examples applied to describe Brazilian maize landraces ("variedades crioulas"). Perhaps, a single example in Brazil was the work made by Coimbra et al. (2012), who evaluated accessions from the Embrapa's "Maize & Sorghum" active germoplasm bank. In this study, however, no evaluated accession came from Southern Brazil and its focus was not only landraces.

Believing in the existence of significative genetic variability among the Brazilian maize landraces found in northern Rio Grande do Sul state, this study aims to characterize some common groups of maize landraces still sown and used in many rural communities of northern Rio Grande do Sul state.

Materials and Methods

The experimental trial was carried out along the agricultural year 2015/2016 (summer) in the experimental station belonging to the "Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul – campus Sertão". The soil of the experimental area is classified as an Oxisol and the climate is a Cfa Koeppen type. The sowing was made in October 20, 2015, according to a randomized block design with three replications. Two 8 meters' length lines constituted the plots (0.80 m was the interlinear distance). At least, the populational density was 40,000 plants per hectare. Fertilization procedures were performed according to the technical recommendations for maize crop and the soil analysis of the area (Reunião Técnica Anual do Milho, 2013).

Twenty seven maize landraces accessions were tested (Tables 1 and 2) and sixteen quantitative traits were evaluated as following: plant height (PH), height of ear insertion (EH), ear length (EL), ear diameter

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(ED), number of kernel rows (KR), number of ears per meter (EM), thousand grains weight (TGW), grain yield (GY), cob diameter (CD), prolificacy (PRO), days to male flowering (MF), days to female flowering (FF), leaves on upper ear (LOE), leaves under upper ear (LUE), foliar blade length (FBL) and total number of leaves (TL). The measurements were made with digital caliper rule and precision balance. For measuring the TGW and GY the values were fitted considering a humidity level of 13%.

At first, univariate analysis of variance (ANOVA) was used for detecting differences among the accessions respect to each variable. Graphical analysis of quantile-quantile plots verified residuals normality. When necessary, the means were compared by the Scott-Knott test at a significance level of 0.05.

Principal Component Analysis (PCA) is a multivariate technique that allows assessing the existing variability in a data set composed of multiple correlated variables (Kassambara, 2017). The specific aim of the PCA analysis was to explore graphicly differences among the accessions according to their evaluated quantitative traits. The most important characteristic of PCA is minimalizing the dimension numbers of datasets by the decomposition of total and multidimensional variance in components (Mohammadi & Prasanna, 2003; Sartorio, 2008). The PCA graphs obtained were used in order to explain important details in clustering analysis, which are the last multivariate technique followed. The squared cosines values are used for interpreting the quality of contribution of all evaluated variables on the PCA (Kassambara, 2017). The Bartlett's sphericity test preceded the PCA. This test evaluates the possibility of applying multivariate methods to the dataset (Sartorio, 2008).

In this work, the Euclidean distance and the Mahalanobis' distance were used at first. Average linkage algorithm (UPGMA) was used for building clusters. This algorithm links the groups components by their means and is very used by geneticists. Considering the cophenetic coefficient correlation (CCC) values obtained, the Mantel test results and the advantages of using the Euclidean distance in studies integrating PCA and clustering (Dias & Kageyama, 1998), the clustering procedures on PCA used the Euclidean distance matrix. The result dendrogram was cut according the Mojena's criterion (Faria et al., 2012). It was presented separately and on the PCA's factor graph, into a three-dimensional plot, whose axes represent the two first principal components (PCA's factor graph biplot) and the calculated distances among the accessions. The formed clusters were also presented graphicly on the factor graph biplot.

Finally, the clusters formed were tested by ANOVA for all evaluated traits at a 0.05 significance level (F-test and, when necessary, Calinski-Corsten test). Graphical analysis of quantile-quantile plots verified residuals normality. For plotting a graphic profile of the means belonging to the clusters, they were reparametrized, to fit in the range between 0 and 1, in order to better compare the mean profile of each group.

All the analyses were done by R program (R Core Team, 2016) using its associated programming language and specific packages and functions.

Results and Discussion

The resulting analyses of variance and the Scott-Knott tests applied to each variable under analysis suggested the existence of variability among the ascensions (Tables 1 and 2). Evaluating different

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Table 1 – Results for the Scott-Knott test to eight quantitative traits of twenty-seven maize landrace cultivars. Sertão, RS, 2015/2016.

ACCESSION	CLUSTER	PH (m)	EH (m)	EL (mm)	ED (mm)	KR (No.)	EM * (No.)	TGW (g)	GY (Kg ha^{-1})
AMARELO 3	1	2.04 a	0.99 b	155.98 b	48.64 a	12.53 b	9.00	311.05 a	4502.51 a
AMARELO 4	1	2.01 a	1.05 b	175.16 a	49.76 a	11.53 c	10.00	164.18 c	5890.51 a
RAJADO 2	1	1.81 a	0.93 b	162.20 b	48.35 a	11.20 c	11.00	232.26 b	5285.58 a
ROXO 3	1	1.98 a	0.99 b	171.61 b	49.55 a	11.20 c	8.00	345.93 a	4220.19 a
CLUSTER MEANS	*1*	*1.96B*	*0.99B*	*166.24 **	*49.07A*	*11.62C*	*9.50 **	*263.36B*	*4974.70A*
8 CARREIRAS BRANCO 2	2	2.20 a	1.21 b	179.27 a	41.69 c	9.01 d	9.33	261.94 b	5553.12 a
AMARELO 5	2	2.14 a	1.05 b	174.65 a	43.00 c	11.27 c	9.00	146.26 c	4125.25 a
BRANCÂO 2	2	2.18 a	1.22 b	179.33 a	44.27 b	10.13 d	9.33	347.66 a	7667.09 a
GRÃO DURO (GD) 1	2	2.37 a	1.23 b	185.56 a	41.14 c	10.67 d	10.00	141.55 c	5011.37 a
GRÃO DURO (GD) 2	2	2.20 a	1.12 b	161.36 b	37.35 d	10.56 d	10.67	330.97 a	2420.16 b
GRÃO DURO (GD) 3	2	2.25 a	1.25 b	180.45 a	38.12 d	10.27 d	9.33	245.79 b	3828.57 b
GRÃO DURO (GD) 4	2	2.30 a	1.22 b	180.77 a	38.50 d	9.80 d	9.67	307.21 a	4190.47 a
ROXO 5	2	2.31 a	2.20 a	168.03 b	42.56 c	10.53 d	9.33	363.19 a	5118.79 a
CLUSTER MEANS	*2*	*2.24A*	*1.31A*	*176.18 **	*40.83D*	*10.28D*	*9.58 **	*268.07B*	*4739.35B*
AMARELO 1	3	2.24 a	1.17 b	166.44 b	49.53 a	14.25 a	8.33	148.34 c	5622.44 a
AMARELO 2	3	2.26 a	1.17 b	175.31 a	47.49 a	13.67 b	9.00	280.32 a	5645.83 a
AMARELO 7	3	2.49 a	1.34 b	167.51 b	46.29 b	11.73 c	8.33	375.38 a	2999.04 b
AMARELO 8	3	2.18 a	1.28 b	189.83 a	45.46 b	13.00 b	9.00	192.53 c	7093.10 a
AMARELO 9	3	2.39 a	1.29 b	170.25 b	48.48 a	11.93 c	8.33	407.96 a	4894.27 a
BRANCÂO 1	3	2.31 a	1.30 b	152.73 b	45.24 b	12.73 b	9.00	336.20 a	2357.73 b
RAJADO 1	3	2.24 a	1.14 b	186.44 a	48.36 a	14.33 a	9.00	149.13 c	3302.48 b
RAJADO 3	3	2.17 a	1.14 b	170.48 b	47.22 a	12.07 c	7.67	422.33 a	1285.85 b
RAJADO 4	3	2.24 a	1.29 b	168.86 b	44.48 b	11.53 c	8.00	382.21 a	3478.90 b
ROXO 1	3	2.16 a	1.13 b	166.53 b	47.25 a	14.07 a	8.67	265.78 b	3572.28 b
ROXO 2	3	2.35 a	1.31 b	183.09 a	49.94 a	14.53 a	7.67	237.53 b	4138.31 a
ROXO 6	3	2.49 a	1.42 b	189.91 a	46.89 b	13.40 b	9.00	391.74 a	6138.98 a
ROXO 7	3	2.21 a	1.23 b	177.74 a	44.27 b	13.07 b	8.67	320.85 a	1750.69 b
ROXO-AMARELO	3	2.26 a	1.27 b	156.34 b	46.17 b	15.60 a	9.33	296.11 a	1972.39 b
CLUSTER MEANS	*3*	*2.28A*	*1.25A*	*172.96 **	*48.42C*	*13.28A*	*8.57 **	*300.36B*	*3875.16C*
CAIANO	4	2.48 a	1.30 b	165.31 b	48.54 a	11.87 c	8.67	426.37 a	1803.93 b
CLUSTER MEANS	*4*	*2.48A*	*1.30A*	*165.31 **	*48.54B*	*11.87B*	*8.67 **	*426.37A*	*1803.93D*

Means followed by the same lowercase letter in a column do not differ from each other, according to the Scott-Knott test at 0.05 probability level. Cluster means followed by the same italic uppercase letter in a column do not differ from each other, by the Calinski-Corsten test at 0.05 probability level. PH (plant height); EH (high of ear insertion); EL (ear length); ED (ear diameter); KR (nº of kernel rows); EM (nº of ears per meter); TGW (1000 grains weight) and GY (grain yield). *Not significant by the ANOVA F-test (no letters).

Table 2 – Results for the Scott-Knott test to eight quantitative traits of twenty-seven maize landrace cultivars. Sertão, RS, 2015/2016.

ACCESSION	CLUSTER	CD (mm)	PRO * (No.)	MF (days)	FF (days)	LOE (No.)	LUE (No.)	FBL (m)	TL (No.)
AMARELO 3	1	20.00 a	2.44	61.67 b	64.00 b	6.42 a	7.03 b	0.72 c	13.44 b
AMARELO 4	1	17.41 c	1.69	64.00 b	64.00 b	5.47 a	6.72 b	0.86 a	12.19 c
RAJADO 2	1	20.59 a	2.08	57.33 c	62.00 b	4.94 a	6.86 b	0.69 c	11.80 c
ROXO 3	1	19.54 a	1.08	57.33 c	62.00 b	5.86 a	5.78 b	0.81 b	11.64 c
CLUSTER MEANS	*1*	*19.40B*	*1.83 **	*60.08B*	*63.00B*	*5.67B*	*6.60 **	*0.77 **	*12.27B*
8 CARREIRAS BRANCO 2	2	18.32 b	1.97	64.00 b	64.00 b	5.47 a	6.64 b	0.74 c	12.11 c
AMARELO 5	2	17.17 c	3.08	64.00 b	62.00 b	5.55 a	7.94 b	0.78 b	13.50 b
BRANCÂO 2	2	17.44 c	1.72	65.00 b	68.00 a	5.58 a	7.78 b	0.79 b	13.36 b
GRÃO DURO (GD) 1	2	17.42 c	2.69	70.67 a	72.00 a	5.64 a	7.95 b	0.79 b	13.58 b
GRÃO DURO (GD) 2	2	18.67 b	2.53	66.00 a	70.00 a	5.75 a	7.11 b	0.80 b	12.86 c
GRÃO DURO (GD) 3	2	19.60 a	2.64	70.33 a	74.00 a	5.28 a	8.03 b	0.75 c	13.31 b
GRÃO DURO (GD) 4	2	19.98 a	3.06	68.33 a	70.33 a	6.33 a	7.86 b	0.81 b	14.19 b
ROXO 5	2	20.03 a	2.17	68.67 a	70.67 a	5.30 a	8.06 b	0.84 a	13.36 b
CLUSTER MEANS	*2*	*18.58C*	*2.48 **	*67.12A*	*68.88A*	*5.61B*	*7.67 **	*0.79 **	*13.28A*
AMARELO 1	3	20.33 a	1.97	68.67 a	68.33 a	6.14 a	7.75 b	0.86 a	13.89 b
AMARELO 2	3	20.85 a	1.39	69.00 a	69.00 a	6.05 a	7.69 b	0.79 b	13.75 b
AMARELO 7	3	20.17 a	2.17	70.67 a	70.67 a	5.72 a	7.80 b	0.81 b	13.53 b
AMARELO 8	3	21.08 a	2.17	69.00 a	69.00 a	5.75 a	8.00 b	0.82 a	13.75 b
AMARELO 9	3	18.70 b	2.36	70.67 a	72.33 a	5.78 a	8.53 a	0.77 b	14.31 a
BRANCÂO 1	3	17.13 c	1.28	73.00 a	72.00 a	5.67 a	9.83 a	0.77 b	15.50 a
RAJADO 1	3	18.72 b	1.44	68.33 a	70.00 a	6.11 a	7.58 b	0.91 a	13.69 b
RAJADO 3	3	20.36 a	1.95	69.00 a	69.00 a	5.61 a	8.95 a	0.83 a	14.55 a
RAJADO 4	3	19.43 a	2.11	69.00 a	69.00 a	5.81 a	8.81 a	0.85 a	14.61 a
ROXO 1	3	20.74 a	2.00	66.33 a	70.67 a	5.42 a	7.22 b	0.89 a	12.64 c
ROXO 2	3	22.12 a	2.22	69.00 a	70.67 a	6.50 a	8.00 b	0.82 a	14.50 a
ROXO 6	3	19.99 a	1.86	73.00 a	72.33 a	5.89 a	9.61 a	0.79 b	15.50 a
ROXO 7	3	19.78 a	2.64	71.00 a	70.67 a	6.08 a	7.61 b	0.80 b	13.69 b
ROXO-AMARELO	3	16.74 c	1.55	69.00 a	69.00 a	6.00 a	7.94 b	0.89 a	13.94 b
CLUSTER MEANS	*3*	*19.73A*	*1.94 **	*69.69A*	*70.19A*	*5.90A*	*8.24 **	*0.83 **	*14.13A*
CAIANO	4	16.94 c	3.28	71.00 a	71.00 a	3.50 b	9.47 a	0.79 b	14.14 b
CLUSTER MEANS	*4*	*16.94D*	*3.28 **	*71.00A*	*71.00A*	*3.50C*	*9.47 **	*0.79 **	*14.14A*

Means followed by the same lowercase letter in a column do not differ from each other, according to the Scott-Knott test at 0.05 probability level. Cluster means followed by the same italic uppercase letter in a column do not differ from each other, by the Calinski-Corsten test at 0.05 probability level. CD (cob diameter); PRO (prolificacy); MF (days to male flowering); FF (days to female flowering); LOE (leaves on upper ear); LUE (leaves under upper ear); FBL (foliar blade length) and TL (total nº of leaves). *Not significant by the ANOVA F-test (no letters).

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common bean landraces cultivars, Sebim et al. (2016) found variability evidence by analyses of variance. Similarly, Silva et al. (2016) used the analysis of variance before the usage of multivariate methods for clustering half-sib progenies of green maize. Despite the initial importance of these analyses, they have no power to form homogenous clusters as intended here. It is important to observe the detection of significant differences for 14 variables in 16.

Bartlett's sphericity test proved the data adequacy to multivariate methods for a 0.05 significance level. The two principal components of PCA analysis realized explain almost 50% of total found variance. According to Cruz and Regazzi (1997), a value around 80% of total explained variance is desired for inferring about variability among groups of genotypes. Studying dissimilarity among oat genotypes, Benin et al. (2003) did not find such expected value, having even worked with 12 commercial cultivars. Considering the number of evaluated maize landraces in this work (27) and the complexity of maize variability (Buckler et al., 2006), these results really can serve as a basis for complementary multivariate analyses, such as the clustering. In the work of Iqbal et al. (2015), just 38.98% of total variance were explained by the two principal components. The value corresponding to the cumulative sum of the two principal components found by Syafii et al. (2015) was 49.17%. Iqbal et al. (2015) and Syafii et al. (2015) worked with 153 and 75 different maize genotypes, respectively.

Analyzing the qualitative contribution (Table 3) of all variables by the square cosine values one observes the following notes: The estimated variability for morphophysiological traits (PH, MF, FF, LUE and TL) was best explained by the first main component. Otherwise, the second and third principal components explained better the estimated variability for the traits (directly) linked to the grain yield of the accessions (ED, KR, EM, PRO, EL, TGW and GY). While the third principal component was the most related to the variation of yield, some well-known components of the corn yield as KR, PRO and EM were related more to the second principal component. It must be remembered that this trait (EM) can be greatly influenced by environmental factors. The accessions should be the cause of this behavior by existing differences among certain groups of genotypes. About that point, Balbinot Júnior et al. (2005) affirmed that the KR was the most important grain yield component in open pollinated corn varieties. The existence of groups presenting different performances in different yield components and other quantitative traits could explain why some genotypes were aggregated along to some specific ears traits related to the yield as TGW, KR, etc. (Figure 1a). On the other hand, some accessions are dispersed around other variables that compound the grain yield (EM and even the PRO). The clusters generated by the following analysis, as described in the next paragraph, point to this direction (Figure 1b). Syafii et al. (2015) found indicia of differences among 75 maize genotypes using PCA. These authors reported that PCA is an important technique to evaluate those differences.

Clustering dendrogram revealed the presence of different groups in the accessions set (Figure 2a). Applying Mojena's criterion to the resultant dendrogram for cutting it, 4 groups were formed. The cophenetic coefficient correlation verified were greater than 0.7. Using the Euclidean distance, 0.73, and 0.75 using the Mahalanobis' distance. Both results were significative at 0.01 level of significance by the Mantel test. This level of significance is the

Table 3 – Quality of the traits' contribution on the three principal components by the squared cosines values (between 0 and 1) of all variables and the variance explained according the estimated eigenvalues to the first three principal components. Sertão, RS, 2015/2016.

Traits	Cos²		
	1st.	2nd.	3rd.
Plant height	0,79	0,02	0,02
Ear high insertion	0,32	0,04	0,04
Ear length	0,01	0,00	0,69
Eear diameter	0,01	0,55	0,10
Kernel rows number	0,10	0,64	0,01
Ears per meter number	0,20	0,31	0,03
1000 grains weight	0,19	0,03	0,27
Grain yield	0,12	0,00	0,41
Foliar blade length	0,10	0,27	0,01
Cob diameter	0,00	0,18	0,11
Days to male flowering	0,89	0,00	0,03
Days to female flowering	0,74	0,01	0,04
Leaves on upper ear	0,00	0,30	0,18
Prolificacy	0,03	0,41	0,01
Leaves under upper ear	0,74	0,02	0,02
Total nº of leaves	0,76	0,01	0,00
Explained variance (%)	31.20	17.50	12.23
Cumulative explained variance (%)	31.20	48.70	60.93

minimum critical value, as reported by Faria et al. (2012). If other cutting patterns had been applied to the dendrogram, more clusters would have been formed, thus the Mojena's criterion is a very judicious pattern (Faria et al., 2012).

As expected, it is found an interesting relationship between the clusters formed on the dendrogram and the groups of landraces cultivars influenced the PCA results. The spatial representation of the dendrogram on the PCA biplot shows that there is not any intersection among the formed groups of accessions (Figures 1a, 1b and 2a). This graphical observation is important because some variables (GY, KR and EL) contributed less to first and second principal components of variance than others. In fact, each formed cluster seems to be differentially related to certain variables (Figure 1a). Cluster number 1 comprised the genotypes which obtained the highest performance in final GY variable. In the opposite direction is the Cluster number 4, whose GY obtained by all its genotypes were statistically lower than that of the number 4, represented by the "Caiano" landrace (Tables 1 and 2). On the other hand, cluster number 2 is more related to the general number of ears per area (EM and PRO). Other traits were more influenced by the genotypes containing into clusters number 3 and 4. The "Caiano" landrace appeared single, forming the cluster number 4, in this

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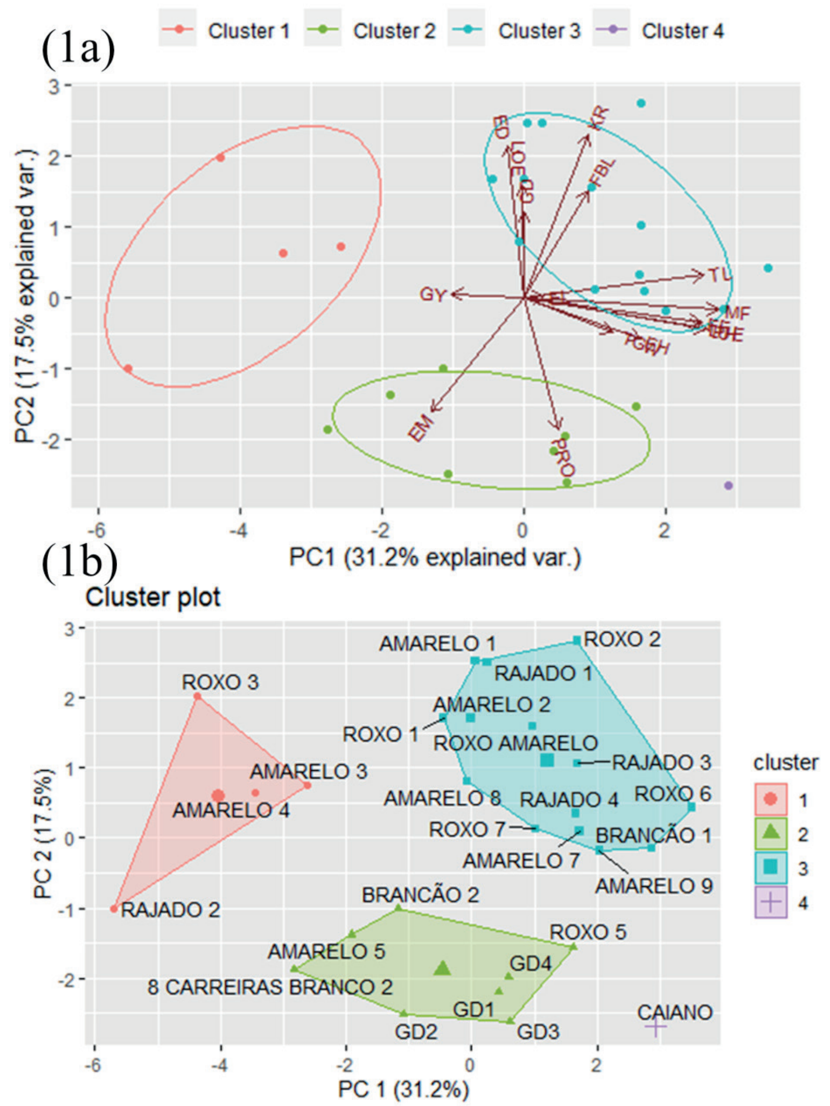

Figure 1 – Principal component analysis (PCA) biplot (1a) and individualized clusters on PCA biplot (1b). Sertão, RS, 2015/2016.

PH (plant height); EH (high of ear insertion); EL (ear length); ED (ear diameter); KR (nº of kernel rows); EM (nº of ears per meter); TGW (1000 grains weight); GY (grain yield); CD (cob diameter); PRO (prolificacy); MF (days to male flowering); FF (days to female flowering); LOE (leaves on upper ear); LUE (leaves under upper ear); FBL (foliar blade length) and TL (total nº of leaves).

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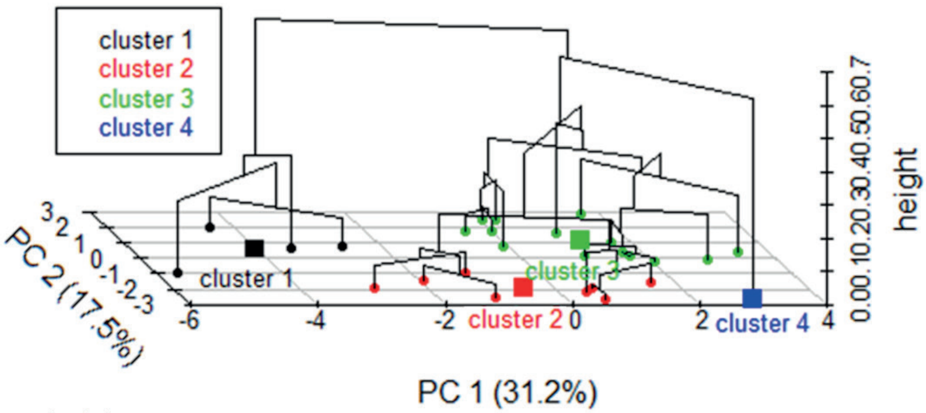
(2a)



(2b)

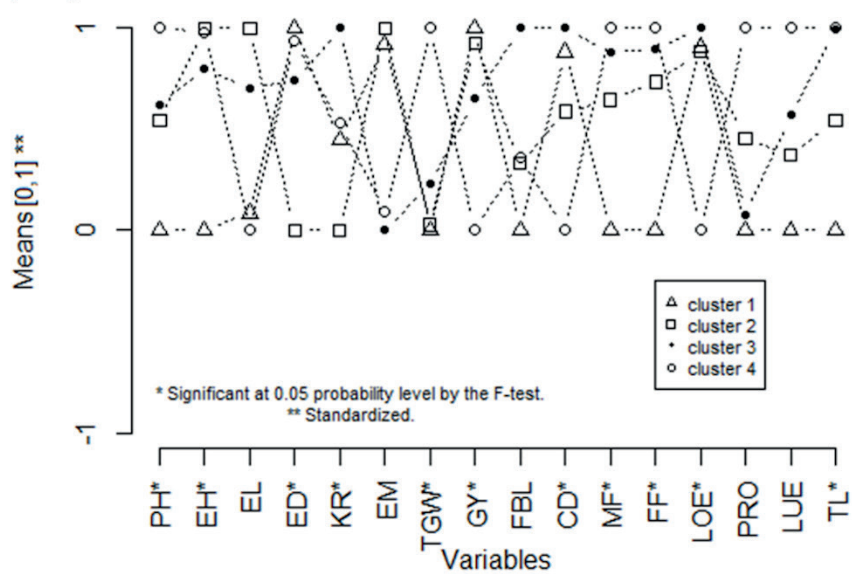


Figure 2 – Hierarchical cluster dendrogram on PCA biplot (2a) and standardized mean profile of each formed cluster (2b). Sertão, RS, 2015/2016.

PH (plant height); EH (high of ear insertion); EL (ear length); ED (ear diameter); KR (nº of kernel rows); EM (nº of ears per meter); TGW (1000 grains weight); GY (grain yield); CD (cob diameter); PRO (prolificacy); MF (days to male flowering); FF (days to female flowering); LOE (leaves on upper ear); LUE (leaves under upper ear); FBL (foliar blade length) and TL (total nº of leaves).

work. Interestingly, this landrace variety is known by the regional farmers from every Rio Grande do Sul regions, having the same name wherever it is cultivated, without variations unlike other varieties. Similar results were not found in specialized works. Moreover, the distribution of the 27 accessions into the suggested (four) groups evidences the existing low relationship between the common names of the maize landraces and their quantitative traits. An exception in this matter can be the case of landraces known as "grão duro". In fact, the four "grão duro" cultivars belong to the same cluster (group or cluster number 2).

The mean profile of each trait analyzed confirms the dissimilarities verified among these groups (Figure 2b). Cargnelutti Filho et al. (2008) also used a similar type of mean profile for reporting significant differences between two groups of common bean genotypes. Comparing the four clusters obtained, they differed in 11 traits (Tables 1, 2 and Figure 2b). It suggests the possibility of using this divergence in further works (as the development of open pollinized varieties, for example). Briefly, on average, cluster 1 contains smaller plants than the plants belonging to the other clusters (short stature, few leaves, etc.), ears insert in low position, presenting the best grain yield among the four clusters and balanced yield components. Cluster 2 contains plants of medium stature, presenting good grain yield and balanced yield components. Group 3 also presents plants of medium stature, less productive, on average, than the plants belonging to the clusters 1 and 2. The "Caiano" landrace – cluster 4 – can be characterized by vigorous plants, respect to the vegetative traits, however, less productive than the others, despite having present the best performance on TGW.

Conclusions

There are differences among maize landraces cultivars from Northern Rio Grande do Sul. Because of these differences, the genotypes can be clustered in four groups whose mean profiles present relevant differences. The "Caiano" landrace constitutes a single group and all the four "grão duro" cultivars seem to be strictly related, justifying their popular appellations. The divergences among the four groups may be explored in further breeding programs, in particular, those belonging to clusters 1 and 2.

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