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Original article

Morphological characterization of landrace maize (*Zea mays* L.) collected in the municipality of Tuchín, Colombia

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ABSTRACT

Maize landraces (*Zea mays* L.) constitute a potential of great genetic value for the indigenous communities of Colombia. The aim of this work was to characterize two collections of creole maize accessions in Tuchín municipality, Colombia. The germplasms evaluated were characterized under the practical guide for the preliminary description of maize collections. Taking into account four quantitative and seven qualitative characteristics, the information was processed using SAS® software (Statistical Analysis System, version 9.4). A UPGMA grouping analysis was performed and the cut height was defined in the dendrogram, using the Pseudo F index. The samples collected showed a great variability among the creole cultivars, due to the fact that in the first collection four groups were grouped and in the second one five groups were grouped within their dendrograms, indicating that accessions belonging to the same race occupy different sets. This is due to the fact that there are types that are phenotypically similar, but have different origins, since the phenotype reflects the combined action of the genotype and the environment where the individual exists, reflecting combinations of morphological characteristics in cob and grain type, with the presence of anthocyanins, which confer nutraceutical and agroindustrial properties.

Key words: phenotypes, varieties, seed characteristics, collections, genetic material

INTRODUCTION

The high diversity of maize in South America is related to its geography and history. The development of the cultures of the different American peoples, their migrations, and the discovery of America and the subsequent movement of Europeans were decisive factors in the creation of corn (*Zea mays* L.) germplasm diversity [1].

The germplasm of this species was published for the first time in Colombia, in 1957, by researchers Roberts and Torregrosa, where 23 maize races were identified, corresponding to 2 primitive races, 9 introduced races and 12 hybrid races [2]. Likewise, the characterization of varieties is of relevance in the species preservation that comprise it, these measures range from vegetative growth to grain and ear yield. Empirically, small producers select their grains visually, leaving the largest ones and those that come from long cobs with high grain content. These criteria have allowed the survival and adaptability of creole grains [3]. On the other hand, it is one of the most important phytogenetic resources used in food and agriculture by traditional and indigenous communities in South America [4].

In addition, genetic diversity comprises hereditary variation, both within and between populations of a species or group of species, and is what allows species to adapt. This variation is found in the DNA and can give better (or worse) adaptive characteristics to the following generations [5]; in turn, the genetic variability of maize constitutes a wealth for the world population and can be the basis for achieving food sovereignty, especially in the face of climate change [6].

In this sense, it is necessary to highlight the contribution of indigenous peoples in the conservation of maize landraces in Colombia, a matter that requires immediate attention to conserve their phenotypic and genotypic characteristics. Therefore, the aim of this study was to characterize two collections of creole maize accessions in Tuchín municipality, Colombia.

MATERIALES AND METHODS

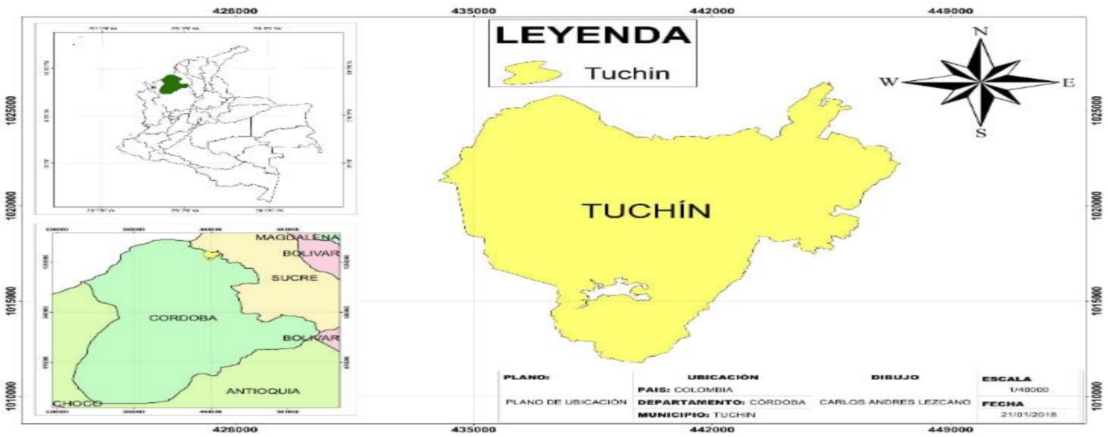
The study seeks to characterize cobs of creole corn, not to compare; therefore, the experimental design does not apply, based on their morphological characteristics; a descriptive research with a quantitative approach was used. Two collections were made in the storage sites (warehouses) of the indigenous councils, as shown in Table 1; each owner of the seeds was interviewed to characterize the production system.

Table 1. List of accessions, collected in Tuchín municipality, Colombia

Number	Accessions	Council	Collection Date
First Collection			
1	Huevito	Cruz del ramal	April 2018
2	Sangre de Toro	Cruz del ramal	April 2018
3	Negrito	Cruz del ramal	April 2018
4	Cariaco Amarillo	Campo la Cruz	April 2018
5	Tacaloa Amarillo	Campo la Cruz	April 2018
6	Vela Blanco	Esmeralda	April 2018
7	Vela Amarillo	Cerro Bomba	April 2018
8	Blanco Criollo	Cerro Vidales	April 2018
9	Berrendo	Flecha	April 2018
10	Cariaco Rayado	Carretal	April 2018
11	Azulito	Cerro Vidal	April 2018
Second Collection			
1	Piedrita	El Martillo	August 2018
2	Panó	Cerro Vidal	August 2018
3	Negrito	Carretal	August 2018
4	Cuba Hoja Blanca	El Chuzo	August 2018
5	Vela blanco	Nueva estrella	August 2018
6	Cariaco Rojo	Cerro Vidal	August 2018
7	Manteco	Carretal	August 2018
8	Berrendo	Esmeralda	August 2018
9	Blanco Mexicano	Flecha	August 2018
10	Tacaloa Amarillo	Cerro Bomba	August 2018
11	Cariaco Amarillo	El Martillo	August 2018
12	Huevito	Nueva Estrella	August 2018
13	Cariaco Rayado	Cerro Vidal	August 2018
14	Blanco Criollo	Cruz del ramal	August 2018
15	Vela Amarillo	El Chuzo	August 2018
16	Sangre Toro	Campo La Cruz	August 2018
17	Tacaloa Rojo	Campo La Cruz	August 2018
18	Tacaloa Mojoso	Cerro Bomba	August 2018
19	Cuba Hoja Negra	Cerro Bomba	August 2018
20	Cacho de Buey	Flecha	August 2018
21	Azulito	Flecha	August 2018

Source: authors' own

Councils are located in Tuchín municipality, Córdoba, Colombia at the coordinates north latitude 9° 08' and 57'' and west latitude 57° 30' and 44'' [7], in relation to the Greenwich Meridian (Figure 1), at 5 meters above sea level, with an average temperature of 37 °C, corresponding to a tropical dry forest (bs-T), with an average rainfall of 1200 millimeters per year [8]. Materials evaluated were characterized according to the practical guide for the preliminary description of maize collections [9], taking into account four quantitative and seven qualitative characteristics (Table 2).



Source: created with ArcGIS software

Fugure 1. Tuchín Córdoba Municipality

Table 2. Traits evaluated for the 21 maize accessions from Tuchín municipality, Colombia

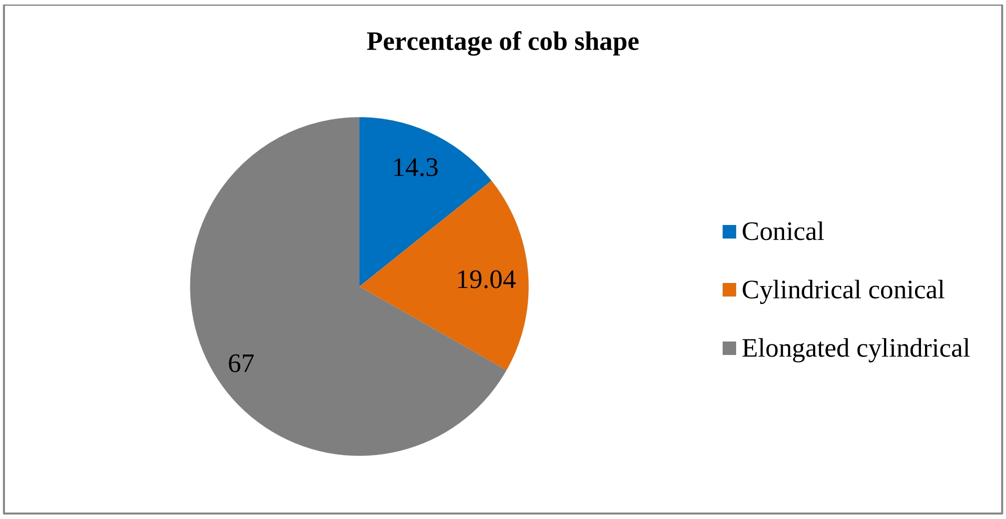
	Quantitative characteristics	Acronym	Sample size
1	Number of rows per cob	NHM	5 cobs /accesion
2	Number of grains per row	NGH	5 cobs /accesion
3	Cob diameter (cm)	DT	5 cobs /accesion
4	Cob length (cm)	LM	5 cobs /accesion
	Qualitative Characteristics		
5	Cob shape	FM	5 cobs /accesion
6	Arrangement of grain rows	DHG	5 cobs /accesion
7	Cob color	CT	5 cobs /accesion
8	Grain type	TG	10 grains/cob/ accesion
9	Grain color	CG	10 grains/cob/ accesion
10	Grain characteristic	CrG	10 grains/cob/ accesion
11	Cob characteristic	CO	5 cobs /accesion

Source: Practical Guide for the Preliminary Description of Maize Collections

Each of the morphological characteristics of cobs was measured three times in each accession, and the average was used as a representative measure. The data were entered in electronic sheets. Statistical processing was performed using SAS® software (Statistical Analysis System, version 9.4). Because of data presented different scales, the standardization process was applied, these were converted to variables with zero mean and variance one; with this information a cluster analysis was performed and the average Euclidean distance matrix was estimated. The dendrogram was obtained by the UPGMA grouping method, average of groups. To define the cut-off height in the dendrogram, the Pseudo F index was used, obtained using the SAS program.

RESULTS AND DISCUSSION

The maize (*Zea mays* L.) breeds collected (Table 1) were planted in association with multivariate cropping systems with yam (*Dioscorea* spp.), cassava (*Manihot esculenta* Crantz) and sweet potato (*Ipomoea batatas* L.), indicating that this species is the one that has had the greatest influence on production and food systems in the past and present among indigenous and peasant groups in Colombia. This food has been fundamental in food sovereignty, as evidenced by the great diversity of varieties present throughout the territory (2) and as shown in Figure 2.



Source: authors' own

Figure 2. Percentage of cob shape

Table 3 provides a description of the qualitative and quantitative characteristics of the germplasm evaluated. It is noteworthy that 14.28 % corresponds to dark colors of the azulito, negrito, pano, sangre toro and piedrita breeds, indicating their anthocyanin content in the corn kernel. It varies according to kernel color and genotype; deep purple kernels have higher total anthocyanin content than blue, purple or red kernels (10).

In turn, these pigments represent a potential for the competitive replacement of synthetic colorants in food, pharmaceutical and cosmetic products and for obtaining value-added products for human consumption. This product is recognized by the European Union with Code E-163 and also with the same Code by the Japanese Legislation (11).

These results are different from those reported by other authors in Ecuador (12), where corn was collected from 10 producers, presenting 61 % of cylindrical conical cob, the arrangement of the grains was regular in 75 %, the color of the husk was white in 91 % and the samples present a floury texture, the diameter of the ear was 3.9 cm, with 11.8 rows of grains per ear and 21.7 grains per row. Finally, the kernels are 1.6 cm long, 1.3 cm wide and 6.1 mm thick. Likewise, in the work carried out in 2017, most of them presented cylindrical conical cobs, with regular and irregular row arrangement, white ear and serrated kernel type [13].

Table 3. Quantitative and qualitative characteristics of the materials collected in Tuchín Colombia

Arrangement of the grain rows	Cob color	Grain type	Grain color
Straight 61,90 %	White 90,4 %	Floury 61.88 %	Yellow 42,85 %
Espiral 14,29 %	Beige and purple 9,6 %	Crystalline 38,12 %	White 19,04 %
Regular 14,29 %			Red 19,04 %
Irregular 9,52 %			Dark 14,28 %
			Mosaic 4,79 %
Grain features	Cob features	Cob shape	
Length 1,6 (cm)	Diameter 1,89 cm	Elongated cylindrical 66,66 %	
Width 0,44 (mm)	# rows 16	Cylindrical-Conical	19,04 %
Thickness 0,61 (mm)	# Seeds*row 26,5	Conical 14,3 %	

Fuente: propia de los investigadores

In the work carried out, it was found that the cob tended to be conical in the 12 creole breeds [14] evaluated at the Center for Agricultural and Forestry Development of the University of Magdalena-Colombia, the arrangement of the rows tended to be straight and the colors of the grain yellow; in our case, one breed was found to be purple and two with a mixture of colors (white, yellow and purple). The kernel surface tended to be jagged; the purple kernels were round. Likewise, other authors reported dark colored kernels, with the presence of anthocyanins [15,16].

Analysis of clusters or clusters of indicators

Group formation for the classification of the 11 and 21 breeds collected are represented in a dendrogram, where the accessions are grouped based on the distances measured according to their morphological characteristics. The scales of the distance coefficient (R^2) range from 0.00 to a value of 0.20. A line was drawn at a distance of approximately 0.17 (R^2), forming four groups for the first accession and five for the second (Figure 3a and b).

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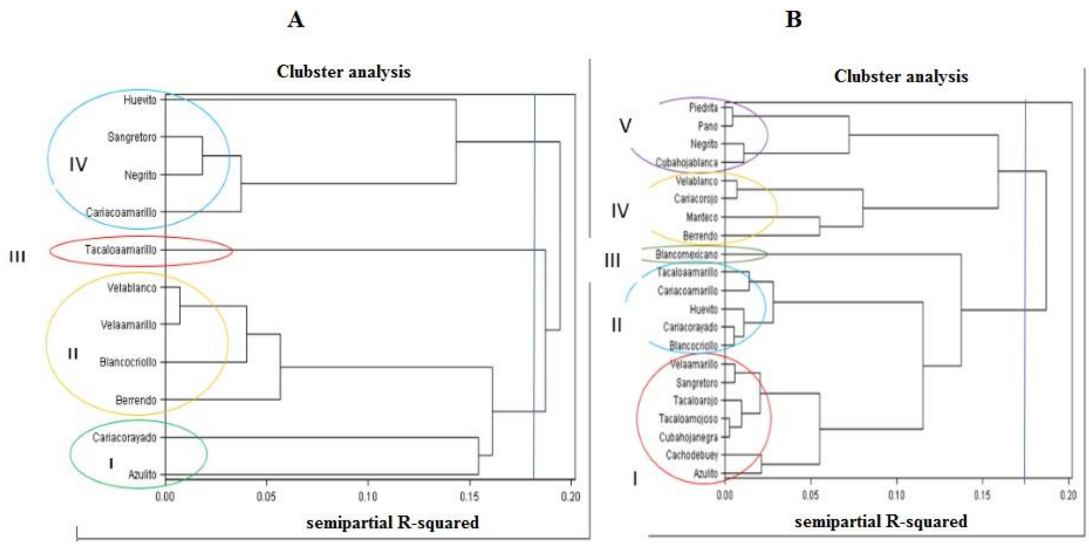

Source: Norbey Marín Arredondo, Statistician

Figure 3. Dendrogram of 11 and 21 maize breeds from the indigenous reserves of Tuchín Córdoba municipality

Table 4 shows the main characteristics of the groups formed; in Figure 3a, the first group showed similarity in cob shape, cob color and grain texture, diameter and width. The second group showed similarity in cob color, with a predominance of crystalline grain texture. For group four, similarity was observed in floury texture and cylindrical cob. Group three presented only one breed Tacaloa yellow with floury grain.

In Figure 3b, the first group showed similarity in the white color of the cob and cylindrical cob, the difference was marked in the type of floury and crystalline grain. For group two, there was similarity in the color of the ear and the predominant type of grain was floury. Group three was characterized by the predominance of straight rows of grains in the ear, with characteristics of floury and crystalline grains. In group five there was a predominance of cylindrical cobs, dark-colored kernels and floury texture. Group three consisted of a single white Mexican race with crystalline grains.

The above characteristics were due to the fact that there are breeds that are phenotypically similar, but have different origins, due to heritability, which is an important genetic parameter, expressing the proportion of phenotypic variance, due to the average effect of genes, which establishes the similarity degree between relatives; that is, the degree to which the phenotypes of individuals are determined by the genes inherited from the parents to their descendants [17]. In turn, races can be grouped into racial complexes or groups, based on geographic and climatic distribution and evolutionary history [13].

The above characteristics are different from those reported by some authors [18-21] and similar to those reported in 2016 [14]. Likewise, works carried out in Colombia reported 2 and 3 groups, respectively [22,23].

Finally, this study showed that the 21 breeds described in Table 1 are part of the cultural heritage of indigenous communities, natural promoters of the conservation and generation of biodiversity *in situ* [24].

Table 4. Morphological characteristics of the 21 accessions of creole corn collected in Tuchín Colombia

	Variety	FM	NH	FH	NGH	DO	CO	AG	GG	LG	CL	CrG
1	Huevito	Cylindrical conical	20	Irregular	30	1,5	White	4	2	6	Assorted	Floury
2	Negrito	Elongated cylindrical	16	Spiral	20	2	Brown	4	2	6	Glossy black	Floury
3	Azulito	Cylindrical conical	22	Spiral	25	2,5	White	4	2	6	Dark blue	Floury
4	Blanco mexicano	Conical	10	Regular	40	1	White	7	3	6	White	Crystalline
5	Cacho de buey	Cylindrical conical	18	Straight	25	2,2	White	5	4	8	Semi-settled yellow	Crystalline
6	Manteco	Elongated cylindrical	12	Straight	36	1	White	5	2	10	Bright yellow	Crystalline
7	Tacaloa mojoso	Cylindrical conical	18	Elongated	25	2,2	White	4	4	7	Opaque orange	Floury
8	Cariaco amarillo	Cylindrical	18	Straight	28	2,2	White	3	3	6	Opaque yellow	Floury
9	Blanco criollo	Elongated cylindrical	22	Straight	30	1,5	White	4	2	5	Crystalline white	Crystalline
10	Tacaloa amarillo	Conical	22	Straight	30	1,5	White	4	3	8	Opaque yellow	Floury
11	Cariaco rayado	Conical	22	Regular	30	1,5	White	4	2	5	Red stripe yellow	Floury
12	Piedrita	Cylindrical	12	Straight	20	1,25	White	5	2	5	Violet	Floury
13	Cariaco rojo	Conical	14	Straight	28	1,85	Purple	5	1	9	Dark red	Floury
14	Pano	Cylindrical	10	Straight	20	1,15	White	5	2	7	Bright purple	Floury
15	Tacaloa rojo	Cylindrical conical	16	Regular	26	2,2	White	4	3	6	Red	Crystalline
16	Cuba hoja blanca	Elongated cylindrical	16	Spiral	17	2,2	White	5	3	7	Bright yellow	Crystalline
17	Cuba hoja negra	Elongated cylindrical	16	Straight	27	2,5	White	5	4	7	Burnt yellow	Crystalline
18	Vela amarillo	Cylindrical conical	20	Straight	30	2,5	White	4	3	6	Light orange	Crystalline
19	Sangre toro	Cylindrical	20	Regular	28	2,5	White	3	3	6	Red	Floury
20	Vela blanco	Elongated cylindrical	15	Straight	20	2	White	5	2	7	Crystalline white	Crystalline
21	Berrendo	Cylindrical conical	13	Regular	22	2,5	White	8	3	11	Striped yellow	Floury

CONCLUSIONS

The morphological characteristics of the corn from the Tuchín Córdoba municipality, show a great variability among the creole cultivars of the area, which is explained by five principal components for the second collection and four principal components for the first collection; nevertheless, the groupings obtained reflected combinations of morphological characteristics in the type of cobs and type of grain, with the presence of anthocyanins, which confer nutraceutical and agroindustrial properties.

RECOMMENDATION

These maize varieties represent the identity of a people for food security, so the work of multiplication and cleaning of the collected materials must continue in order to maintain their genetic purity and conserve the genes of interest to plant breeders in the germplasm bank.

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