

Analysis of on farm conservation of sweet corn in a diversity microcenter of *Zea mays* L. in Southern Brazil

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Abstract

Corn has a great diversity of types and races, being cultivated all around the world. In Brazil, corn is one of the main commodities, being produced practically by every rural family. In the Far West region of the Santa Catarina state, Southern Brazil, corn has several purposes that vary according to the type of grain. In the case of sweet corn, the grains are basically used for the family's own consumption. This study aimed at identifying the diversity of sweet corn in the region and analyzing the diversity indicators and the factors associated with *in situ* on farm conservation and genetic erosion. Therefore, a Diversity Diagnosis was performed through semi-structured interviews with 31 maintainers of corn previously indicated as sweeter. Thirty-one varieties were identified, among which twenty-one were classified as sweet corn of wrinkled kernels and ten as sweet corn of dent kernels. The varieties have been conserved on average for 8.8 years, and the main reason for conservation was self consumption of the grains as fresh corn. The main reasons for seed loss, according to the farmers, were the occurrence of drought and the non-multiplication of seeds by the family. The diversity microcenter of *Zea mays* L. in Southern Brazil hosts local sweet varieties of wrinkled and dent kernels under *in situ* on farm conservation, with agronomic, adaptive and market potential for *in natura* or canned consumption. However, such diversity is at risk of genetic erosion, and therefore strategies are presented to mitigate the impacts on this local germplasm.

Introduction

Corn has a high diversity of types and races, therefore is one of the species with the greatest genetic variability among the cultivated plants, allowing innumerable direct uses, such as animal feed, human food and raw material for agroindustries (Paterniani and Goodman 1977; Matsuoka et al, 2002). The diversity of this species is a result of the artificial selection made by the people of the Americas and adaptations undergone in their cultivation in diverse cultural contexts, to which they were subjected during their domestication (Doebly, 1990; Matsuoka et al, 2002; Vigouroux et al, 2008).

Among the various types of corn, some are special, because they have distinct characteristics and uses, such as popcorn, forage corn, mini corn, corn with high nutritional quality and sweet corn (Tracy, 2001; Teixeira et al, 2014). Typical sweet corn is distinguished from the others by the presence of one or more mutant genes that alter the synthesis of starch in the endosperm; it is also the one with the lowest diversity between the *Zea mays* L. species. There are only 300 open pollinated varieties of this corn type, many of them derived of

breeding programs (Tracy, 2001).

The Far West region of the state of Santa Catarina (FWSC), located in Southern Brazil, presents a rich diversity of local varieties of different types of corn and their wild relatives. This diversity has been conserved and managed by farmers for many generations (Kist et al, 2010; Ogliari and Alves, 2007; Ogliari et al, 2013) and reported in several studies over the last decades. Because of its importance, the region was recently indicated as a diversity microcenter of the genus *Zea* (Silva et al, 2015; Costa et al, 2016). The richness of local populations in 558 km² within the FWSC was emphasized by Costa et al (2016), who underlined out the existence of 61 local sweeter corn varieties of a total of 1,513 local populations with different endosperm types.

Identify the diversity and distribution of local crops at the community level is basic and necessary information to understand the management of agrobiodiversity by farmers (Sthapit and Rana, 2007), enrich the diversity of gene banks and support the genetic breeding programs. Therefore, the characterization and knowledge of the diversity of the local sweet corn varieties from FWSC are of great importance as basis for the deve-

lopment of integrated *in situ* on farm and *ex situ* conservation strategies and development of public policies for the their maintainers.

The finding of sweet corn in the FWSC region and the fact that there are few studies about this diversity conserved *in situ* on farm are the starting points for the development of this work. Its goal is to know the diversity of local varieties of sweet corn conserved in the diversity microcenter of FWSC, as well as identify the main indicators of diversity, factors associated to *in situ* on farm conservation and the main causes of genetic erosion of the varieties.

Materials and Methods

The study was performed from 2011 to 2016 in the municipalities of Anchieta (ANC) and Guaraciaba (GBA), located in the Far West region of the state of Santa Catarina, in the Southern Brazil.

Sixty-one local varieties were previously indicated by the farmers as being sweeter in the Census of Diversity 2011/2012 (Costa et al, 2016). In the Diagnosis of Diversity performed in this study, the 61 families of maintainers interviewed by Costa et al (2016) were again visited in 2013 in order to identify sweet corn of wrinkled kernel and sweet corn of dent kernel among the ones previously indicated as sweeter. Considering that many farmers had already lost their seeds since the Census of Diversity 2011/2012, a total of 31 interviews were performed in this step. The interviews were conducted with the family member responsible for the conservation of the variety (local informant) and here referred to as the maintainer. The questions of the semi-structured questionnaire were organized into groups of thematic questions concerning the identification of the property and farmer maintaining the local variety; the identification of the variety (name, cultivation time, seed origin) and; the use values that preferentially motivate farmers to preserve the varieties. The maintainers were also asked about the morphological characteristics of the kernel of their local varieties. Local varieties with dry kernel of wrinkled texture were reclassified as sweet corn, and those that presented dent type kernel and referred by the maintainer as sweeter corn were reclassified as sweet dent corn.

The Diagnosis of Diversity' data were inserted in spreadsheets (Access software) and evaluated using descriptive and multivariate statistics, and non-parametric tests (chi-square) conducted at a significance level of 5%.

For the analysis of the diversity of the local varieties of wrinkled and dent kernels, the Shannon Index (H')

(Magurran, 1998) was used. H' was calculated from the morphological characteristics of the kernel, as indicated by the farmers, through the following formula: $H' = - \sum_{i=1}^s pi \ln pi$, where pi = relative abundance (proportion) of the characteristic i in the sample; $pi = ni/N$, where ni = number of varieties with the characteristic in sample I and; N = total number of sweet and sweet dent corn varieties of the sample.

The cluster study among the varieties was performed based on the morphological characterization described by the maintainers. The data matrix consisted of 31 samples (varieties) and eight descriptors (variables), among which four are nominal qualitative variables: grain color (GC), grain type (GT), row arrangement (RA) and spike type (ST); three are ordinal qualitative variable: plant height (PH), cycle (CY) and lodging (LO); and one is discrete quantitative variable: prolificacy (PL). The information was coded in multistate data and transformed by the standardization method (Legendre and Legendre, 1998). The distance matrix by the Gower method and the unweighted arithmetic averages (UPGMA) method were used to generate the dendrogram. The cut-off point was established based on the mean between the lowest and the highest value of the distance matrix.

In order to understand the variables responsible for the distribution and grouping of the varieties, a principal component analysis (PCA) was performed through a correlation matrix.

The facilitating reasons to the genetic erosion of the varieties were identified through interviews with the farmers during the Diagnosis of Diversity in 2013 and with new interviews during the seed collecting at different periods from 2013 to 2016.

Descriptive and multivariate analyzes were performed using PAST software 3.04 (Hammer et al, 2001). The DIVA-GIS 7.5.0 software (Hijmans et al, 2001) was used to obtain the spatial distribution map of the diversity of the local varieties of sweet corn and sweet dent corn in the municipalities of ANC and GBA. The geographical coordinates of the properties, where the varieties are maintained, were previously obtained with the aid of the Global Positioning System (GPS) during the Census of Diversity.

Results and discussion

Diversity, origins and cultivation time of sweet corn landraces

In this study it was observed that of the 61 varieties identified in the Census of Diversity by Costa et al (2016), 25 had been lost, 29 corresponded to varieties

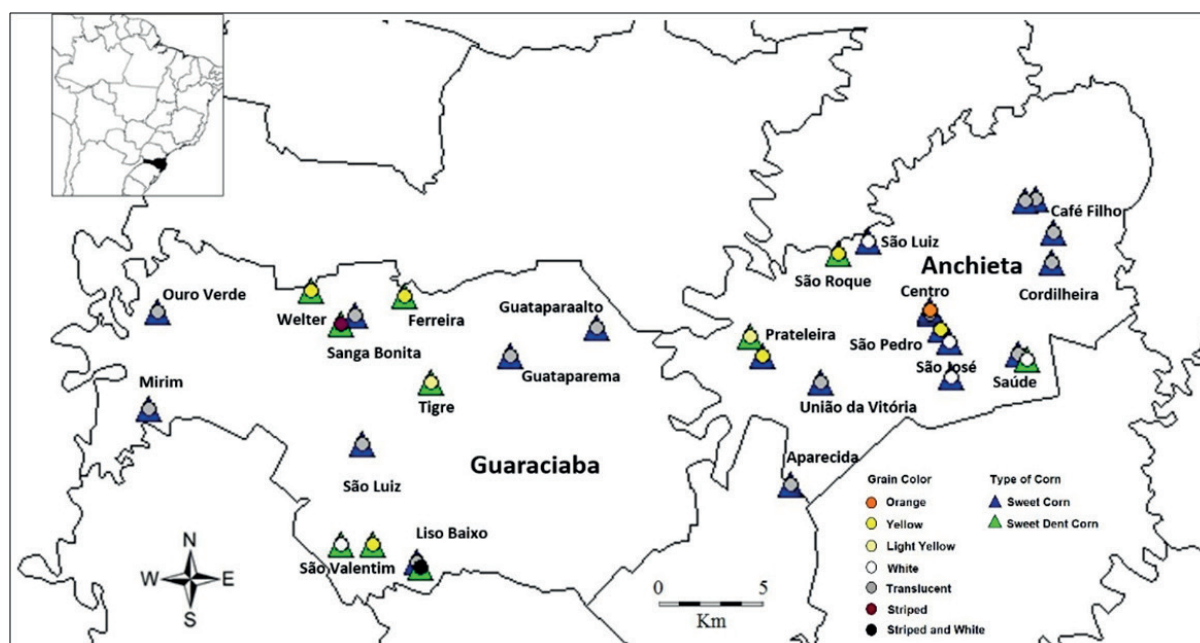


Fig. 1 - Spatial distribution of local sweet and sweet dent corn varieties according to corn type and grain color in the communities of the municipalities of Anchieta and Guaraciaba, Santa Catarina state, Southern Brazil.

of dent-type kernel (only 10 were added to the present research) and seven corresponded to varieties of wrinkled kernel. Other 14 varieties of sweet corn with kernel of the wrinkled type were identified in the two municipalities and added during the Diagnosis of Diversity itself. Thus, the present study had 21 diagnoses for local varieties of sweet corn (wrinkled kernel) and 10 for local varieties of sweet dent corn, totaling 31

questionnaires. The 31 interviewed farmer families reside in 22 communities in ANC and GBA, being 11 in each of the municipalities (Figure 1).

The number of sweet corn varieties (21) found in FWSC is higher than the number of materials kept in the main Corn Germplasm Active Bank (CGAB) of Brazil (20), organized by Brazilian Agricultural Research Corporation (EMBRAPA), and among these 20 accesses, only five

Table 1 - Origin and average time of cultivation of the local sweet and sweet dent corn varieties of the municipalities of Anchieta and Guaraciaba, Santa Catarina. Diagnosis of Diversity, 2013.

Source	Sweet Corn		Sweet Dent Corn		Sweet Corn and Sweet Dent Corn	
	Nº ^a	Time ^b	Nº	Time	Nº	Time
Heritage	5 (24%)	25 (1-50)	1 (10%)	5	6 (19%)	22 (1-50)
Neighbor	4 (19%)	7 (1-15)	4 (40%)	2 (1-15)	8 (26%)	6 (1-15)
Relative	3 (14%)	7 (1-13)	-	-	3 (10%)	7 (1-13)
Subtotal 1	12 (57%)	15 (1-50)	5 (50%)	5 (1-15)	17 (55%)	12 (1-50)
Seed Fair	3 (14%)	4 (2-8)	2 (20%)	3 (2-4)	5 (16%)	4 (2-8)
EPAGRI	1 (5%)	3	1 (10%)	5	2 (7%)	4 (3-5)
Diversity Kit	-	-	1 (10%)	9	1 (3%)	9
Syndicate	1 (5%)	6	-	-	1 (3%)	6
Elderly Group	-	-	1 (10%)	4	1 (3%)	4
Subtotal 2	5 (24%)	4 (2-8)	5 (50%)	5 (2-9)	10 (32%)	7 (2-9)
Other Sources	2 (9,5%)	2 (2-3)	-	-	2 (6,5%)	2 (2-3)
Do not remember	2 (9,5%)	12 (11-12)	-	-	2 (6,5%)	12 (11-12)
Grand total	21 (100%)	11 (1-50)	10 (100%)	5 (1-15)	31 (100%)	9 (1-50)

a Number of varieties; b Average cultivation time in years and range of variation.

were collected in Brazil. The remaining varieties were introduced from other countries, in the 70's and 80's, or derived from Brazilian breeding programs (EMBRAPA, 2019).

The varieties maintained by family farmers do not have the same allelic frequencies of the varieties collected and later kept in gene banks, because of the adaptive and evolutionary processes by which they are dynamically exposed. Thus, collecting new germplasm, in regions where such varieties still exist, is fundamental for the conservation of this genetic resource.

Local varieties of sweet corn in FWSC were acquired by the maintainers in the community itself or provided by family inheritance ($\approx 24\%$), neighbor (19%), and relative ($\approx 14\%$) (Table 1). Two varieties are from distant localities of ANC and GBA, one from Paraná (state that borders with Santa Catarina state) and one from Argentina (country that borders with GBA). The sweet dent corn varieties were obtained mainly from neighbor (40%) and fair (20%).

The origin of the varieties, understood as the source from which the farmers obtain their seeds, is one of the factors that generate and maintain the diversity in a certain region, through the networks of seed exchange (Louette et al, 1997). The local sweet corn varieties of the present study were acquired in the community or provided by relatives in most cases, while the sweet dent corn, in addition to the neighbors and inheritance, came from donations from public institutions, seed fairs, unions and community meetings.

The high proportion of sweet and sweet dent corn varieties obtained from relatives or by inheritance in this study indicates the existence of family traditions linked to *in situ* on farm conservation practice. Badstue et al (2006) state that farmers prefer to acquire seeds with neighbors and relatives because they have a better guarantee of the quality of the material and the adaptation of the variety to the local agroecosystem.

Also, the different seed origin points to the existence of active seed exchange networks of sweet and sweet dent corn, as they had already been identified for the other maize types of this region (Costa et al, 2016). Seed exchange networks represent an important mechanism for maintaining *in situ* on farm conservation in the Far Western Santa Catarina, reducing the vulnerability of the varieties, strengthening the ties of solidarity among popcorn farmers through donations and seed exchanges (Silva and Ogliari, 2015), in parallel with the exchange of seeds, the exchange of knowledge among the maintainers, which is a fundamental part of human interrelations for the conservation of agrobiodiversity. Regarding the cultivation time in FWSC, the 21 local

varieties of sweet corn were in the same property for an average of 11 years, varying from 1 to 50 years (Table 1). Among the sweet dent corn varieties, the average time in the property and with the family was 5 years, ranging from 1 to 15 years (Table 1). In studies performed in Mexico, center of origin of *Zea mays* L., the maximum period of cultivation of dent corn found by Bellon et al (2003) and Louette et al (1997) were 67 and 40 years, respectively.

It is noteworthy that of the 21 local varieties of sweet corn, three were on the property for more than 20 years, one of them is with the same family for about 80 years, so the family planted before they move to the FWSC region. The time of cultivation is a determining factor in the adaptation of the local varieties that, when managed and selected for several years by the farmers in the same agroecosystem, acquire their own characteristics of adaptation to the agroclimatic and ecological conditions of the area of cultivation (Bellon and Bruschi, 1994; Zeven, 1998; Ogliari et al, 2013).

The analysis of the time of cultivation according to the origin of the seeds indicated that the average time of the varieties obtained from neighbor, relative or family inheritance (11 years) is higher than the average time of cultivation of the varieties obtained by other ways (5 years) ($p \leq 0.05$) (Table 1).

The study of the relation between cultivation time and seed origin showed that the recent acquisition of sweet corn varieties is partly due to the work done by local organizations and universities, such as the holding of seed fairs and the distribution of diversity kits.

The fairs represent an opportunity to the farmers know and expand diversity through seed exchanges (Neuendorf, 2000). The diversity kit, in turn, is a strategy initially developed by Sthapit et al (2006) in Nepal and after implanted in GBA in FWSC, which corresponds to the distribution of a package of seeds of different crops and varieties. This strategy encouraged the families of GBA cultivate again local seeds of numerous species, promoting the food security of the families through the production of foods for self consumption (Canci et al, 2013). In this sense, varieties that have been conserved for less than five years in the property could be cultivated and adapted in the region longer than that, since they were obtained from neighbors, public institutions and local organizations, from the same region.

Fourteen different local names attributed to the varieties were identified. For sweet corn, the name Doce (means Sweet) was the one with the highest occurrence (33%), followed by Branco Doce (means White Sweet) (19%) and Branco (means White) (19%). The other names (Comum, Comum Murcho, Branco Doceiro, Mur-

cho, Amarelo Doce e Milho Verde) presented a percentage of 5% each. For sweet dent varieties, the name Comum (means Common) was assigned the varieties in 40% of the cases, and the names Serrano, Oito Carreiras, Mato Grosso, Amarelo, Vermelho and Doce appeared once each (10%).

low (20%), striped (10%) and striped and white grains (10%). The estimated value of the Shannon Index (H') for color and grain type referring only to sweet corn was 0.9 and 1.2, respectively, and for sweet dent corn, it was 1.5 and 1.2, in that order. Despite the greater number of varieties of sweet corn analyzed, the translucent color was predominant. The analysis performed

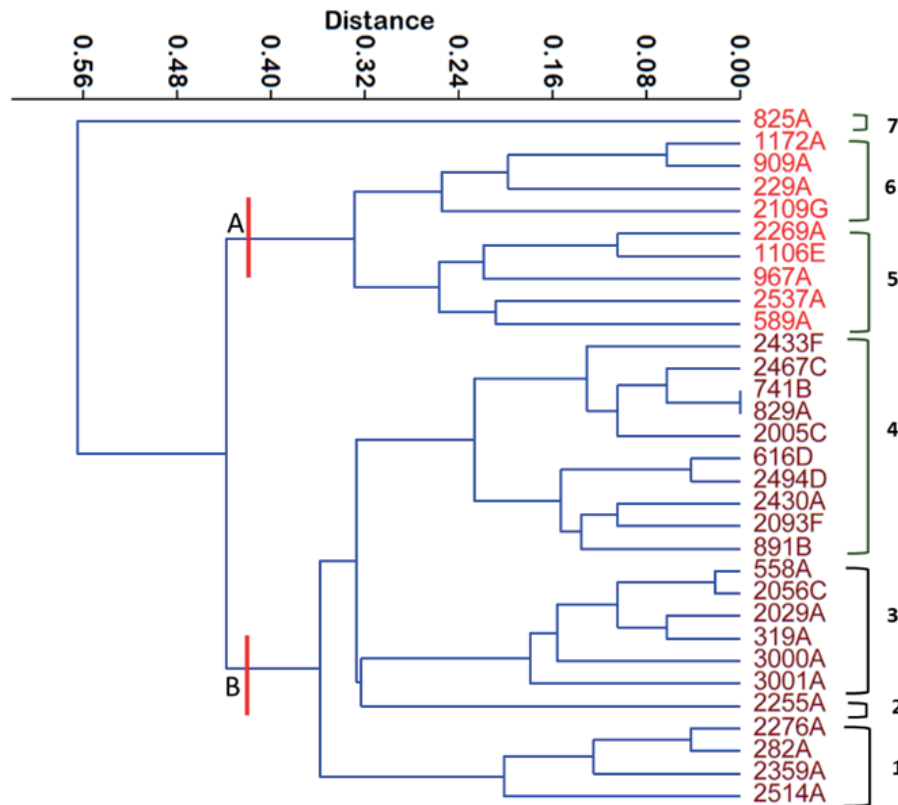


Fig. 2 - Distance between local sweet and sweet dent corn varieties of Anchieta and Guaraciaba, Santa Catarina state, using the Gower coefficient ($r = 0.76$) and UPGMA clustering method. A: sweet dent corn. B: sweet corn.

The diversity of local names can be used to measure the diversity of a given species in a production unit, community or region (Sthapit et al, 2006). At the FWSC, the local varieties of sweet corn were named according to their characteristic of use (Fresh Corn), grain appearance (White, Yellow, Wrinkled) or flavor (Sweet). The names attributed to sweet dent corn were more impersonal; generic names (Common or Crioulo) are used by farmers to distinguish their local varieties of commercial material such as hybrids and improved open pollinated varieties, as well as names associated to the geographical origin of the variety (Mato Grosso and Serrano).

Concerning the colour, sweet corn had translucent (71%), white (14%), yellow (10%) and orange (5%) grains, while sweet dent corn, white (20%), light yel-

low (20%), striped (10%) and striped and white grains (10%). The estimated value of the Shannon Index (H') for color and grain type, respectively.

The factors used by farmers to identify and represent varieties are complex, relate and combine with each other as a set of agromorphological criteria in defining a local variety. The names given can be related to morphological and phenological criteria of varieties (Louette et al, 1997), variation of uses for materials conserved *in situ* on farm (Sthapit et al, 2006) or origin of the material (Sadiki et al, 2007). The color of the grain also represents an important indicator of diversity and may be associated with the gastronomic use of the variety (Li et al, 2002; Louette et al, 1997).

In fact, analysis of diversity by Shannon (H') diversity index indicated a higher color diversity between sweet

dent corn varieties compared to sweet corn. This finding corroborates the fact that the sweet corn varieties have a striking characteristic of the translucent and wrinkled appearance of the dried grains, which the farmers refer to as "milho branco murcho" (means "white wilt maize") and are used almost entirely for gastronomic purposes.

The clustering analysis allowed to separate the varieties into two main groups, except the sweet dent corn variety 825A that was isolated (Figure 2). The group A was formed by the varieties of sweet dent corn, and the group B, by the sweet corn varieties of wrinkled kernel. A second dendrogram analysis was at the subgroup level. In this approach of analysis, three and four subgroups were formed within groups A and B, in that order. The two isolated varieties (2255A in group B and 825A in group A) presented the greatest dissimilarity in relation to the others.

variables responsible for the separation of the varieties within group A (sweet dent corn).

The study of the diversity by the clustering method, considering the characterization of the maintainers, showed that the type and the color of the grain are the main characteristics that differentiate the local varieties of wrinkled sweet corn from the sweet dent corn. The presence of one or more mutant genes in the endosperm blocks the conversion of sugars into starch, giving the grain sweetness as well as wrinkled appearance and translucent color in the dry grain stage (Tracy, 2001). Based on this gene pattern, sweet and sweet dent corn varieties of FWSC were differentiated and reclassified.

The formation of three subgroups and an isolated variety among the group formed by the sweet varieties suggests a greater amplitude of variation between the-

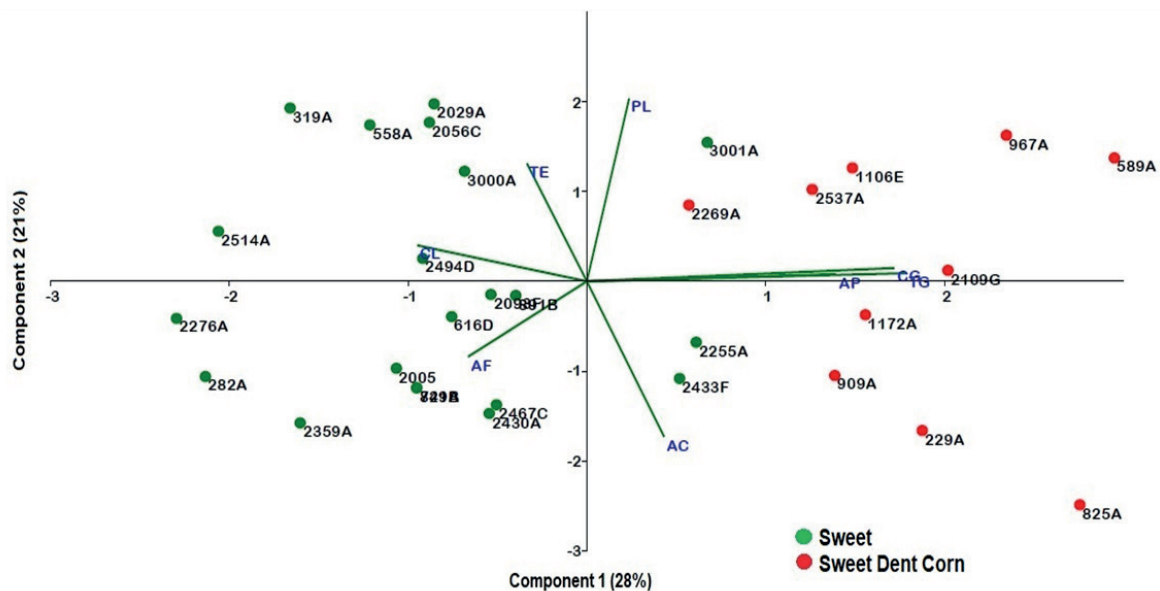


Fig. 3 - Analysis of the main components of the local sweet and sweet dent corn varieties of Anchieta and Guaraciaba, Santa Catarina state. Variables: Grain color (GC); Type of grain (TG); Row arrangement (RA); Ear type (ET); Plant height (PH); Cycle (CY); Prolificacy (PL); Lodging (LO).

According to the PCA ordering method, the principal components 1 and 2 together explained 49% of the variation between the varieties of sweet and sweet dent corn (Figure 3). Based on the correlation coefficients between the variables and the first two components of PCA sorting, grain color and grain type corresponded to the variables of greater effect in the first component, separating the varieties of sweet dent corn (A) from the varieties of sweet corn (B). Within component 2, ear type and row arrangement are the variables of greater effect in the differentiation of varieties within group B (sweet corn), and prolificacy and lodging were the main

se varieties when being included other attributes of the plant and ear.

Analyzing together the cluster analysis with the main components, it is possible to affirm that some characteristics perceived and indicated by the maintainers can be used as indicators of diversity, such as color and type of grain, type of ear and arrangement of rows, once that they were responsible for the differentiation of varieties into different subgroups.

This fact, besides allowing to study the diversity of local varieties of sweet corn, proves the high degree of knowledge of the maintainers and the importance of

the associated traditional knowledge on the diversity and conservation of plant genetic resources, reducing the risks of loss of landraces (N'Da et al, 2015; Mistura et al, 2015).

The dissimilarity found among the local varieties allows to speculate on possible breeding strategies directed to each of the two groups of sweet corn of FWSC. The characterization and evaluation of the genetic potential of the 31 local varieties and the realization of diversity studies are interesting strategies for the development of composite populations adapted to the region, development of intervarietal hybrids, intrapopulation recurrent selection and variety selection through participatory genetic improvement approaches. This type of improvement is targeted at local farmer communities and prioritizes the conservation, management and proper use of agrobiodiversity.

Usage Values and Preferences

The farmers computed 88 indications for usage values and preferences, 67 for sweet corn and 21 for sweet

dent corn. The indications were divided into eight categories, among the 13 established by Costa et al (2016) (Table 2), with 79 and 90% of the indications accommodated in the gastronomic category for sweet corn and sweet dent corn, respectively.

For sweet corn, the subcategories fresh corn, sweet, flavor and specific dishes ("canjica", soups, creams and sauces) were the ones that presented the highest number of indications within the gastronomic category. For the sweet dent corn, the subcategories fresh corn (43%), flavor (24%), softness (9%), flour (9%) and sweet (5%) were mentioned in the gastronomic category. The agronomic category (easy to thresh with 5%) and adaptive (weevil resistance with 5%) were also identified.

Local varieties of sweet corn are used almost exclusively for gastronomic purposes, especially for *in natura* consumption, in the form of fresh corn. Also, the culinary potential of the varieties can be proven with the indications for the preparation of specific dishes, such as soups, creams, sauces or mixed with rice. It is important to note that for the elaboration of these dishes,

Table 2 - Absolute frequency and percentage of categories and subcategories of use, adaptive and agronomic values of the local sweet and sweet dent corn varieties of the municipalities of Anchieta and Guaraciaba, Santa Catarina. Diagnosis of Diversity, 2013.

Category	Subcategories	Sweet		sweet dent	
		N°	(%)	N°	(%)
Gastronomic (GAST)	Fresh Corn	20	30	9	43
	Sweet	12	18	1	5
	Flavor	8	12	5	24
	Softness	3	4	2	9
	Flour	2	3	2	9
	Thin Shell	1	1,5	-	-
	Specific Dishes	7	10	-	-
Subtotal 1		53	79	19	90%
Health (HEA)	Free of Agrochemicals	1	1,5	-	-
	Healthy food	1	1,5	-	-
Subtotal 2		2	3	-	-
Agronomic (AGRO)	Fresh Corn	3	4	-	-
	Thin Cob	1	1,5	-	-
	Yield	1	1,5	-	-
	Easy to Tresh	-	-	1	5
Subtotal 3		5	7	1	5
Adaptive (ADAPT)	Weevil Resistant	1	1,5	1	5
Economic (ECON)	Sell	1	1,5	-	-
Cultural (CULT)	Tradition	2	3	-	-
Conservation of Diversity (COD)	2	3	-	-	
Nutrition		1	1,5	-	-
Grand Total	67	100		21	100

the farmers reported that the ears are harvested when they are in fresh corn point, precooked and frozen.

The division of the gastronomic category into indications related to "use" and indications related to "why you like" shows that the farmers in FWSC generally assigns two indications to the variety, one related to the "use" (fresh corn, flour or some specific dish) and another to the "why you like" (softness, sweet, tasty). The families use the varieties for fresh corn because they are sweeter and softer, presenting better flavor, emphasized as the main characteristic of the varieties.

The conservation of the local varieties of sweet and sweet dent corn of the municipalities of ANC and GBA is related to the use value of the varieties, mainly by their flavor and culinary potential. Lázaro (2018) also states that landraces of tomatoes maintained by farmers in the Madrid Region in Spain were selected because of the taste of the fruits, associated with their morphology. Neuendorf (2000) reports that the varieties are maintained by farmers as a matter of necessity of use, being part of the family food security.

Still, the use of varieties as fresh corn suggests that commercial maize cultivars are not as palatable as the local varieties for this kind of consumption. When asked about the use and reason for preference for their local variety of sweet corn, one farmer mentioned that "the genetically modified corn has a bad taste".

The local varieties of sweet and sweet dent corn identified in this work present a high potential of commerce in the line of special corn, which represents an important market niche. Of the 31 varieties studied, 29 are used by farmers for consumption as fresh corn, highlighting the high market potential of these sweet and sweet dent corn varieties for consumption *in natura*.

Among the sweet varieties, there was only one indication of adaptive characteristics and biotic resistance. On the other hand, some varieties were indicated with agronomic values, among them the characteristic to stay longer in fresh corn point. The characteristic of staying in the field for a longer period in fresh maize point is of extreme importance for the use of varieties for *in natura* consumption, since it allows the farmer greater period of commercialization of the ears. This characteristic is also well received by breeding programs to produce fresh corn.

However, the development of studies focused on a more accurate assessment of the potentials of these sweet corn varieties as well as characterization trials are likely to provide better data related to adaptive traits of interest for breeding programs. In addition, a market analysis is necessary to verify the prospects of insertion of farmers into new production chains.

Genetic erosion of FWSC local sweet corn varieties

The Census of Diversity was held in 2011 and early 2012 by Costa et al (2016) and the Diagnosis of Diversity in 2013. Over the course of these two years, 25 varieties classified in the census as sweeter by farmers were lost or were no longer planted by their maintainers. Of these, four were identified in the Diagnosis of Diversity with kernel of the wrinkled type, nine with kernel of the dentate type, and for 12 of them it was not possible to identify the grain type. Among the different reasons for loss or abandonment of the variety, 11 (44%) farmers reported having been due to drought, six (24%) did not multiply the seed because they did not like it, replaced by a hybrid or because it was very laborious, and eight (32%) did not report the reasons.

After completing the Diagnosis of Diversity at the end of 2013 and start of the seed collecting period, nine varieties were recollected due to loss. Among the reasons cited for loss of the varieties, three farmers cited "that they did not multiply the seed", two farmers "stopped planting due to advanced age", one farmer "lost the variety by drought", and three farmers "lost for other reasons".

In 2016, a new collect of five local varieties of sweet corn was required because the amount of seed was insufficient to the required analyses. Among them, three varieties had been lost: one variety because the farmer no longer lived in the municipality; one second variety because the seeds presented low germination; and other variety was no longer planted because the farmer had started to cultivate other crops. Thus, a total of 37 varieties of sweet corn were lost or abandoned by farmers during five years of research. It is worth mentioning that of these, 16 had rarer wrinkled-type kernel.

Like sweet corn, other types of corn conserved in FWSC are in constant threat of genetic erosion. Among the concerns are the fact that a large part of the diversity of local varieties is being managed by few farmers and in small areas, rural exodus, lack of successors in the property, the age of the maintainers, the occurrence of frequent climatic disturbances in the region (dry and hail) and contamination by crossing with other varieties (Reichert Jr. et al, 2020).

The present study demonstrated that the loss of seeds of sweet corn varieties conserved in FWSC has also been common among farmers. The causes of loss are varied and increase the risk of erosion of this germoplasm. Among the loss reasons, drought and not multiplied were the most cited. When the farmer reports that he has lost the seed because he has not multiplied, many things may be embedded in this statement, one

of which is old age coupled with health problems, which prevents the farmer from continuing to grow his varieties.

It is important to highlight that among the varieties of sweet corn lost, over the course of five years, 16 presented grains of the wrinkled type, which characterize as varieties of corn of sweet genotype. As mentioned previously, the diversity of sweet corn in the world is small, and in Brazil, only 20 accessions are kept in the CGAB of EMBRAPA.

The discovery of the existence of a great diversity of sweet corn in FWSC, where is located a diversity microcenter of the genus *Zea* (Costa et al, 2016), indicates the need to include this region in a conservation plan. *In situ* on farm conservation strategies, in parallel with *ex situ* conservation, can reduce the imminent risks of loss of varieties, alleles and/or gene combinations.

The scenario found for sweet corn in FWSC is a specific case of study because it is a small sample (21 varieties), compared with the high number of dent corn varieties (337) and popcorn (1078) identified by Costa et al (2016) during the Census of Diversity. This fact allows the conservation of 100% of the varieties in gene banks, in order to guarantee the diversity of this type of maize.

In addition, varieties are conserved by use, as they are related to family consumption. The motto "use not to lose", the basis of conservation in the design of the Convention on Biological Diversity, is one of the reasons for the conservation of agrobiodiversity, the promotion of sustainable use and the fair and equitable sharing of its benefits (CBD, 2006). Clement et al (2007) draws attention to the fact that the scientific community is concerned that the large proportion of genetic resources are losing importance even in subsistence due to the advance of commercial agriculture, political-economic integration and changes in customs inherent in globalization. When they lose their importance, they are candidates for genetic erosion and local extinction, and opportunities for future use are extinguished. In this context, the authors advocate the proposal to spread and expand on farm conservation as a strategy to conserve the genetic resources used by farmers in their own habitat.

With regard to *in situ* on farm conservation, booklet preparation and seed distribution through diversity kits can strengthen the consumption and conservation of sweet corn diversity in this diversity microcenter of *Zea* genus in the FWSC region. Communities that maintain a greater number of varieties are indicated as strategic regions for future conservation actions, serving as the basis for the work of disseminating the existence

of this type of maize in the region. Within the communities, maintainers who have indicated many uses for the varieties, those who have mentioned keeping them by tradition, conservation, donation or seed exchange, are also potential farmers for the development of dissemination and diffusion works of sweet and sweet dent corn seeds.

Collect actions, coupled with the characterization and storage of sweet corn diversity of the FWSC region in local and institutional seed banks, are tools that can strengthen both the *in situ* and *ex situ* conservation of this local plant genetic resource, and may assist in the development of participatory genetic breeding programs.

Within the context of participatory breeding, maintainers reporting the highest number of indications for use of varieties are, for the most part, observant farmers and important agents in the conservation and indication of high potential varieties. Two of the 21 varieties of sweet and sweet dent corn identified in the present study were highlighted with a greater number of citations of use values, mainly within the subcategory specific dishes, with citations of use to make creams, soups, sauces and use with rice.

Still within the strategies of conservation of the agrobiodiversity, as well as of preservation of the traditional knowledge, the Geographical Indication (GI) is being suggested by Ogliari (2019) for the set of local corn varieties of the diversity microcenter in FWSC. Geographical Indication (GI) in Brazil is used to identify the origin of products or services when the place has become known or when a certain characteristic or quality of the product or service is due to its origin (INPI, 2018). In the context of the present study, the Geographical Indication suggested by Ogliari (2019) is a proposal to promote the conservation of agrobiodiversity, as economic value is added to the diversity microcenter of the *Zea* genus of FWSC and not only to one or a few varieties.

The Geographical Indication of corn in FWSC could reverse the logic of local varieties to have a primary role only as an item of food security of these families, but also as an income generating activity. In this context, the conservation of the diversity of local landraces in this region, including sweet and sweet dent corn, would be consolidated as a crop of economic value added and not only as a cultivation in use for subsistence.

Conclusions

The local varieties of sweet corn identified in the diversity microcenter of the *Zea* genus in Southern Brazil is of crucial importance for the conservation and diversification of the gene pool of this species due to the low

diversity of this type of corn in the world.

The conservation of sweet corn is due to its direct use as food of the families within the farms, being consumed *in natura* as fresh corn or in the elaboration of specific dishes.

The time of cultivation and the origin of the varieties are indirect evidences of the adaptative potential of the local varieties of sweet and sweet dent corn to the agricultural ecosystems of the Far West of Santa Catarina, Southern Brazil.

Despite the importance of local varieties of sweet and sweet dent corn as genetic resources used for food and agriculture, they have been suffering from significant genetic erosion in the last five years in Far Western Santa Catarina, either for reasons related to the loss of seeds by their maintainers or by the abandonment of the variety.

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